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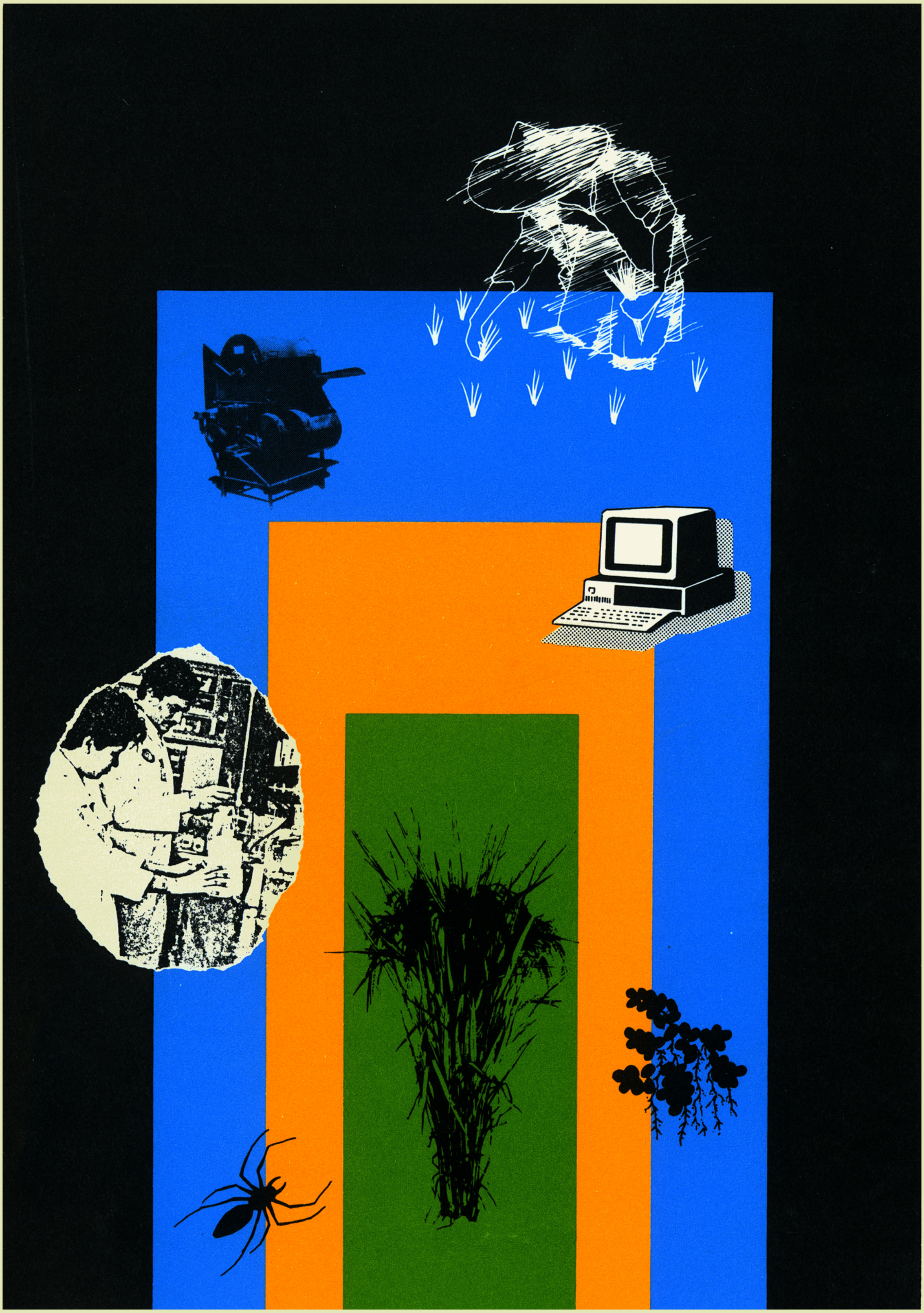

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IRRN GUIDELINES

The *International Rice Research Newsletter* objective is:

"To expedite communication among scientists concerned with the development of improved technology for rice and for rice-based cropping systems. This publication will report what scientists are doing to increase the production of rice, inasmuch as this crop feeds the most densely populated and land-scarce nations in the world . . . IRRN is a mechanism to help rice scientists keep each other informed of current research findings."

The concise reports contained in IRRN are meant to encourage rice scientists and workers to communicate with one another. In this way, readers can obtain more detailed information on the research reported.

Please examine the criteria, guidelines, and research categories that follow.

If you have comments or suggestions, please write the editor, IRRN, IRRI, P.O. Box 933, Manila, Philippines. We look forward to your continuing interest in IRRN.

Criteria for IRRN research report

- has international, or pan-national, relevance
- has rice environment relevance
- advances rice knowledge
- uses appropriate research design and data collection methodology
- reports appropriate, adequate data
- applies appropriate analysis, using appropriate statistical techniques
- reaches supportable conclusions

Guidelines for contributors

The International Rice Research Newsletter is a compilation of brief reports of current research on topics of interest to rice scientists all over the world. Contributions should be reports of recent work and work-in-progress that have broad, pan-national interest and application. Only reports of work conducted during the immediate past three years should be submitted.

Research reported in IRRN should be verified. Single season, single trial field experiments are not accepted. All field trials should be repeated across more than one season, in multiple seasons, or in more than one location, as appropriate. All experiments should include replication and a check or control treatment.

All work should have pan-national relevance.

Reports of routine screening trials of varieties, fertilizer, and cropping methods using standard methodologies to establish local recommendations are not accepted.

Normally, no more than one report will be accepted from a single experiment. Two or more items about the same work submitted at the same time will be returned for merging. Submission at different times of multiple reports from the same experiment is highly inappropriate. Detection of such submissions will result in rejection of all.

Please observe the following guidelines in preparing submissions:

- Limit each report to two pages of double-spaced typewritten text and no more than two figures (graphs, tables, or photos).
- Do not cite references or include a bibliography.
- Organize the report into a brief statement of research objectives, a brief description of project design, and a brief discussion of results. Relate results to the objectives.
- Report appropriate statistical analysis.
- Specify the rice production environment (irrigated, rainfed lowland, upland, deepwater, tidal wetlands).
- Specify the type of rice culture (transplanted, wet seeded, dry seeded).
- Specify seasons by characteristic weather (wet season, dry season, monsoon) and by months. Do not use local terms for seasons or, if used, define them.
- Use standard, internationally recognized terms to describe rice plant parts, growth stages, environments, management practices, etc. Do not use local names.
- Provide genetic background for new varieties or breeding lines.
- For soil nutrient studies, be sure to include a standard soil profile description, classification, and relevant soil properties.
- Provide scientific names for diseases, insects, weeds, and crop plants. Do not use common names or local names alone.
- Quantify survey data (infection percentage, degree of severity, sampling base, etc.).
- When evaluating susceptibility, resistance, tolerance, etc., report the actual quantification of damage due to stress that was used to assess level or incidence. Specify the measurements used.
- Use generic names. not trade names, for all chemicals.
- Use international measurements. Do not use local units of measure. Express yield data in metric tons per hectare (t/ha) for field studies and in grams per pot (g/pot) or per specified length (in meters) row (g/row) for small scale studies.
- Express all economic data in terms of the US$. Do not use local monetary units. Economic information should be presented at the exchange rate US$:local currency at the time data were collected.
- When using acronyms or abbreviations, write the name in full on first mention, followed by the acronym or abbreviation in parentheses. Thereafter, use the abbreviation.
- Define any nonstandard abbreviations or symbols used in a table or graph in a footnote or caption/legend.

Categories of research published

GERMPLASM IMPROVEMENT
genetic resources
genetics
breeding methods
yield potential
grain quality
pest resistance
  diseases
  insects
  other pests
stress tolerance
  drought
  excess water
  adverse temperature
  adverse soils
integrated germplasm improvement
  irrigated
  rainfed lowland
  upland
  deepwater
  tidal wetlands
seed technology

CROP AND RESOURCE MANAGEMENT
soils
soil microbiology
physiology and plant nutrition
fertilizer management
  inorganic sources
  organic sources
crop management
integrated pest management
  diseases
  insects
  weeds
  other pests
water management
fanning systems
farm machinery
postharvest technology
economic analysis

ENVIRONMENT

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EDUCATION AND COMMUNICATION

RESEARCH METHODOLOGY

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GERMPLASM IMPROVEMENT

Breeding methods

Maintainers for WA cytoplasmic male sterility

T. S. Bharaj and G. S. Sidhu, Punjab Agricultural University Rice Research Station, P.O. Box 34, Kapurthala, Punjab, India

PR108, released in the Punjab for general cultivation in 1986, has been found to be a maintainer for WA cytoplasmic male sterility from V20 A/PR 108. PR106-1, a secondary selection from popular high-yielding variety PR106, exhibited F_1 sterility in the cross V20 A/PR 106-1. Three backcrosses of these lines have been added to WA cytoplasm. The progeny of each backcross was totally sterile, with no stained pollen grains.

Another promising line, HKR 126, also acted as maintainer for WA cytoplasmic male sterility and is in the pipeline for conversion into a CMS version by recurrent backcrossing/nucleus substitution method. The main features of the three new CMS lines are compared with those of PR106 (most popular rice variety) in the table. ■

Characteristics of 3 maintainer lines. Kapurthala, India.

Cytoplasm source	Maintainer line	Yield[a] (t/ha)	Duration (d)	Plant height (cm)	Spikelets/ panicle (no.)
V20 A (WA)	PR108	7.0	142	104	180
PMS3 A (WA)	HKR126	7.1	144	105	140
V20 A (WA)	PR106-1	6.9	144	100	175
	PR106 (check)	6.9	144	100	172
	LSD (0.05)	0.7	–	–	36

[a] Av of 3 replications over 4 locations.

Influence of syringomycin on differentiation of androgenic cultures in rice

P. Boyadjiev and V. Vassilev, Institute of Introduction and Plant Genetic Resources, 4122 Sadovo, Plovdiv, Bulgaria

We investigated the influence of different concentrations of syringomycin isolated from *Pseudomonas syringae* on the regeneration of calli obtained by anther culture from dihaploid rice cultivar Mariana.

Anthers were excised and placed on N6 medium supplemented with 2 mg 2.4-D/liter for callus induction. Toxin was added at 10, 20, and 30 active units in ml active ingredient/ml in the MS regeneration medium (without other stimulators). For control, no toxin was added. pH of the test variants was reduced to 5.6.

Calli measuring 2-3 mm were transferred to the regeneration medium. After 20 d at 26-28°C, calli were transferred to a fresh nutritive medium.

Rhizogenesis and regeneration were measured before and after appearance of plantlets. Syringomycin stimulated rhizogenesis and plant regeneration (see table). Resistance in the dihaploid lines obtained is being field-tested. ■

Rhizogenesis and regeneration of rice anther calli with 3 levels of syringomycin.

Parameter	Control	10 ppm	20 ppm	30 ppm
Calli set (no.)	108	111	113	114
Calli (no.) with rhizogenesis	12	18	17	46
Green regenerants (no.)	1	2	2	13
Albino regenerants (no.)	1	2	3	20

Seed set on different rice CMS lines

T. S. Bharaj, G. S. Sidhu, and S. S. Gill, PAU Rice Research Station, P.O. Box 34, Kapurthala, Punjab, India

We compared seed set on different cytoplasmically male sterile (CMS) lines during 1989 wet season. Ten (PMS1 to 10) CMS (A) and their maintainer (B) lines were transplanted in 6.2- × 4.0-m plots with four replications. Row ratio was 2 female: 1 male. Each plot had 10 pairs of female rows and 11 male rows at 20- × 20-cm plant spacing. Row direction was perpendicular to the prevailing wind direction during anthesis. The CMS lines were allowed to be naturally pollinated by the B lines.

Twenty panicles were taken at random from the center five pairs of rows of the female lines and seed set calculated as number of filled spikelets divided by total number of spikelets.

Seed set ranged from 7.4% in PMS7 A to 18.5% in PMS10 A (see table). ■

Seed set on different A lines. Kapurthala, India.

PMS line	Seed set (%)	Days to 50% flowering	
		A line	B line
PMS1	12.7	105	101
PMS2	8.2	105	101
PMS3	13.3	105	100
PMS4	11.8	106	102
PMS5	9.2	106	102
PMS6	9.4	106	102
PMS7	7.4	105	101
PMS8	14.6	104	100
PMS9	17.2	101	97
PMS10	18.5	104	100
LSD			
0.05	1.4		
0.01	1.9		

Isolation distance for producing hybrid rice seed

H. S. Muker and H. L. Sharma, Punjab Agricultural University, Ludhiana, India

The isolation distance for producing pure breeder and foundation seed of rice is 5 and 3 m, respectively. But these isolation distances do not apply to hybrid rice seed production that involves the use of CMS lines. We studied the present isolation distance for hybrid seed during 1988 and 1989 wet seasons. Pollinator V20 B was sown 1 wk after CMS V20 A, to synchronize flowering. V20 A was transplanted in rows against V20 B in the prevailing wind direction. In 1988, V20 A was transplanted in 25-m rows. Seed set along the whole row length (Table 1); it was highest (6.24%) at 1 m from V20 B and lowest (1.03%) at 25 m.

In 1989, V20 A was planted in 50-m rows. Highest seed set was 8.95% at 1 m; the lowest was 0.3% at 31 m (Table 2). Temperature during flowering ranged from 28 to 31 °C, relative humidity was 64-77%, and wind velocity 4.4-8.0 km/h.

The data indicate that rice can disperse its pollen up to 31 m: isolation distance should not be less than 31 m for producing pure hybrid rice seed. ■

Table 1. Seed set on male sterile line (V20 A) by distance from pollinator (V20 B). Ludhiana, India, 1988.

Distance from pollinator (m)	Seed set (%)			
	Row I	Row II	Row III	Mean
1	6.0	8.3	4.4	6.2
2	4.5	4.6	4.1	4.4
3	5.3	4.0	4.0	4.4
4	4.1	2.5	4.2	3.6
5	4.0	3.1	2.7	3.2
6	5.1	3.8	3.3	4.1
7	2.8	1.7	1.4	2.0
8	2.7	-	2.0	2.4
9	2.4	1.4	3.5	2.4
10	4.2	1.1	1.5	2.3
11	3.1	1.6	2.8	2.5
12	1.6	1.7	2.1	1.8
13	2.4	2.4	1.6	2.1
14	1.6	1.9	2.1	1.9
15	2.1	1.3	1.5	1.8
16	1.4	1.0	-	1.2
17	1.2	1.1	2.2	1.5
18	2.3	1.3	1.4	1.7
19	1.2	2.9	0.7	1.6
20	-	1.4	1.1	1.2
21	2.8	1.6	1.0	1.8
22	1.5	1.7	1.9	1.7
23	2.9	1.2	1.3	1.8
24	1.4	1.2	1.4	1.2
25	1.1	1.0	1.0	1.0

Table2. Seed set on male sterile line (V20 A) at various distances from pollinator (V20 B). Ludhiana, India, 1989 wet season.

Distance (m)	Seed set[a] (%)					
	Row I	Row II	Row III	Row IV	Row V	Mean
1	5.7	12.3	9.4	8.0	9.4	9.0
2	2.6	1.4	7.5	8.2	4.8	5.3
3	-	3.4	5.2	10.1	1.5	5.0
4	2.8	1.9	2.3	8.4	2.1	3.5
5	-	4.8	2.6	5.2	1.9	3.6
6	1.3	-	0.9	2.6	3.6	2.1
7	1.7	4.8	1.6	0.9	5.3	2.9
8	3.2	5.6	1.9	1.3	4.9	3.4
9	3.6	2.3	2.5	1.1	3.5	2.6
10	1.9	0.8	2.4	3.9	1.4	2.1
11	3.8	2.6	1.5	1.7	-	2.4
12	1.8	1.2	4.6	4.1	2.1	2.8
13	2.8	1.6	4.0	2.5	3.8	2.9
14	2.2	1.4	1.6	2.1	1.6	1.8
15	2.2	5.1	1.1	1.4	1.1	2.2
16	-	1.8	2.2	0.7	0.8	1.4
17	1.9	3.5	1.9	1.3	2.6	2.3
18	2.5	-	1.9	2.0	1.9	2.2
19	0.8	2.0	1.7	0.8	-	1.3
20	3.0	1.1	2.0	1.5	-	2.0
21	3.9	2.1	0.8	1.2	1.7	1.9
22	0.6	4.5	0.9	0.8	1.2	1.3
23	1.1	0.9	1.5	1.6	0.7	1.2
24	1.3	0.9	0.5	1.1	1.4	1.0
25	1.2	1.2	2.1	1.1	-	1.7
26	0.5	1.4	2.2	1.0	0.5	1.2
27	1.7	1.8	1.5	1.4	0.5	1.4
28	1.9	1.1	1.3	-	-	1.3
29	0.8	0.8	0	0.9	1.0	0.7
30	0	1.3	0.9	0	0	0.4
31	0	0.6	0	1.0	0	0.3

[a] No seed set on rows 32-50 m from V20 B.

Identification of potential maintainers and effective restorers for CMS lines

W. W. Manuel, V. Palanisamy, T. B. Ranganathan, and M. N. Prasad, Paddy Breeding Station, Coimbatore 641003, Tamil Nadu, India

We evaluated spikelet sterility and pollen sterility of 25 CMS lines during kar (Jul-Oct) 1989 to identify stable CMS lines. Five showed male sterile stability:

	Pollen sterility (%)	Spikelet sterility (%)
V20 A	98.0	98.4
ZS97A	98.0	98.7
IR46828 A	97.1	95.6
IR46830 A	97.3	96.7
IR58025 A	96.0	94.0

Spikelet sterility in the other lines did not correlate with pollen sterility. There was also plant-to-plant differences in pollen sterility in the same CMS line.

During late samba (Nov-Mar) 1989-90 we evaluated spikelet fertility in the F_1 s of 24 crosses involving CMS lines V20 A, IR46828 A, IR46830 A, IR54752 A, IR58025 A, and MS577 A and varieties IR36, IR50, IR64, CO 37, CO 43, Rasi, Jaya, ASD16, ADT36, AS34011, and TM4309. Potential maintainers were identified as having >90% pollen sterility and <10% spikelet fertility and effective restorers as having <10% pollen sterility and >90% spikelet fertility.

Rasi, CO 37, ASD 16, and TM4309 were identified as potential maintainers; IR36 and IR50 as effective restorers for CMS line V20 A. IR50 was identified as an effective restorer for CMS line IR46828 A.

The potential maintainers identified for V20 A are being used in the backcross program to develop new CMS lines. The restorers identified for V20 A and IR46828 A are being used to develop new hybrid combinations. ■

Identification of maintainers and restorers for two cytoplasmic-genetic male sterile rice lines

D. Muñoz, Annual Crop Division - ICA until April 1989 (now Genetics and Plant Breeding Program of National Rice Producers Federation [FEDEARROZ]), A.A. 52772, Bogota; and L. Lasso, Palmira Valle, Colombia

To identify maintainers and restorers for CMS lines V20 A and Shan 97 A, we evaluated pollen sterility of florets located in the upper third part of the panicle before dehiscence, florets stored at 2-11°C, and their pollen grains stained with IKI.

Maintainers and restorers[a] for V20 A and Zhen Shan 97 A CMS lines at National Research Center, Palmira, Colombia.

Male parent[a]	V20 A	Zhen Shan 97 A
Fortuna blanco	M	M
Fortuna morado	M	M
Inamono	M	M
Taipei 309	M	M
Cacao Pelao	M	M
Taichung 176	M	M
IRAT 13	M	M
IRAT 12	M	M
Moroberekan	M	M
Monolaya	M	M
Miramono	M	M
Palawan	M	M
Suakoko	M	M
IRAT121	M	M
IRAT124	M	M
IRAT120	M	M
IRAT122	M	PR
Colombia 1	M	PR
Rexoro	M	M
Costa Rica	PR	M
Canilla	PR	M
L-5685	PR	PR
Monorecao	PR	PR
Llanero 501	PR	PR
Tapuripa	PR	PR
Blue-Bonnet 50	PR	PR
Araure	PR	PR
Metelapuya	PR	PR
Rustic	PR	PR
Tadukan	PR	PR
Cica 7	PR	PR
Cica 4	PR	PR
L-17388	PR	R
IR262	PR	PR
Metica 1	PR	R
Oryzica 1	PR	PR
Cica 9	PR	PR
Chianung Sen Yu 23	R	PR
IR22	R	R
Campeche A 80	R	R
L-11972	R	R
Cica 8	R	PR

[a]M = maintainer, PR = partial restorer, R = restorer.

Hybrids were obtained from two CMS lines crossed with 42 standard native varieties and elite breeding lines with different growth durations.

Hybrids were transplanted in rows of 16 plants each, spaced 0.30 × 0.30 m. Eight plants, three panicles per plant, and three flowers per panicle were evaluated for sterility in the fields.

Male parents of the F_1 that showed 90-100% pollen sterility were designated maintainers. Male parents showing 21-89% pollen sterility were designated partial restorers. Male parents showing 0-20% pollen sterility were designated restorers. Maintainers were more frequent than restorers (see table). ■

Yield potential

Ratooning ability of some rice cultivars and hybrids

S. Arumugachamy, P. Vivekanandan, and M. Subramanian, Agricultural Botany Department, Agricultural College and Research Institute, Madurai 625104, Tamil Nadu, India

We assessed ratooning yield on the basis of ratooning ability and a ratoon vigor scale. Rice genotypes Bhavani, MDU3, IET6262, IET6709, IET7552, and IET9239 and their 30 hybrids developed on diallel crosses were planted in two rows of 10 plants each at 20- × 10-cm spacing in a randomized block design replicated three times. Recommended practices were followed for both main and ratoon crops.

The main crop was cut 20 cm from the ground at physiological maturity and allowed to ratoon. Ten randomly selected plants of each parent and hybrid from each replication were used to measure regenerated tillers and ratoon yield and to estimate ratooning ability and ratoon vigor.

Ratooning ability was assessed as number of ratoon tillers regenerated from stubble. Ratoon vigor was recorded as 1 = ratoon very vigorous (basal + nodal ratoons); 5 = ratoon normal or intermediate (only basal ratoons); and 9 = ratoon very weak or few (no counting).

A composite ratooning rating was estimated:

Ratooning rating = (1–(0.1 ratoon vigor) × (av no. ratoon tillers/plant)

All parents except MDU3 and IET9239 showed high number of regenerated tillers. The parents IET6709, IET7552, and Bhavani recorded ratoon

Ratooning ability and yield of parents and hybrids.[a] Madurai, India, 1988.

Parent or cross	Regenerated tillers (no./plant)	Ratoon vigor scale	Ratoon rating	Ratoon yield (g/10 plants)
Bhavani	8.7	1	7.8	14.4
MDU3	7.5	5	3.7	12.3
IET6262	8.9	5	4.5	12.8
IET6709	10.0	1	9.0	13.6
IET7552	9.1	1	8.2	15.1
IET9239	6.4	5	3.2	11.7
Bhavani/MDU3	9.1 (8.7)	1 (1)	8.2 (7.8)	14.5 (12.5)
Bhavani/IET6262	12.3 (10.8)	1 (1)	11.1 (9.7)	16.1 (13.2)
Bhavani/IET7552	10.1 (11.4)	1 (1)	9.1 (10.3)	14.9 (16.3)
Bhavani/IET6709	11.0 (12.7)	1 (1)	9.9 (11.5)	15.4 (15.1)
Bhavani/IET9239	8.5 (8.1)	1 (1)	7.6 (7.7)	14.3 (12.8)
MDU3/IET6262	10.4 (12.3)	5 (5)	5.2 (6.2)	12.8 (13.5)
MDU3/IET6709	9.8 (11.8)	1 (1)	8.8 (10.3)	13.1 (13.7)
MDU3/IET7552	8.7 (10.4)	5 (1)	4.3 (9.4)	12.4 (15.0)
MDU3/IET9239	8.9 (7.5)	5 (5)	4.4 (3.8)	12.5 (11.9)
IET6262/IET6709	13.1 (13.2)	1 (1)	11.8 (11.9)	14.4 (15.2)
IET6262/IET7552	10.4 (12.4)	1 (1)	9.4 (11.1)	13.0 (15.1)
IET6262/IET9239	10.1 (9.3)	5 (5)	5.1 (4.7)	12.8 (12.5)
IET6709/IET7552	15.3 (14.3)	1 (1)	13.8 (12.8)	15.2 (16.8)
IET6709/IET9239	10.2 (9.3)	1 (1)	9.2 (8.4)	13.5 (12.6)
IET7552/IET9239	10.8 (7.9)	1 (5)	9.7 (4.0)	15.9 (12.0)
Mean: Parent	8.4			13.3
Hybrids	10.6			14.0
LSD (P = 0.05)	0.8			0.8

[a] Figures in the parentheses are for the reciprocal cross.

vigor scale of 1 and high ratoon rating. Crosses involving IET6709 and IET7552 as one of the parents had high ratooning ability and ratoon yield. Among the hybrids, IET6709/IET7552 and its reciprocal registered maximum tillers, with a ratoon vigor scale of 1 and with good ratoon rating; that resulted in high ratoon yield. ■

Influence of variety, irrigation, and N level on production of effective ratoon tillers

A. Palchamy, S. Purushothaman, and A. Kajagopal, Agricultural College and Research Institute, Madurai, India

We studied the production of effective ratoon tillers in a field trial 1984-85 and 1985-86. Rice varieties Bhavani, Ponni, and IR20 were grown under normal management for the main crop. The ratoon crops were grown with two irrigation schedules (5 cm water throughout the crop period and 5 cm water 1 d after the disappearance of ponded water) and four N levels (50, 75, 100, and 125 kg N/ha) in a split-plot design with three replications. Main crop plots were harvested separately, at 20-cm high, with one border row left on all sides.

Number of productive ratoon tillers had a direct bearing on productivity. More productive tillers/hill were recovered in the second year than in the first year (Table 1). ■

Table 1. Effect of variety, irrigation, and N level (50, 75, 100, 125 kg N/ha) on productive ratoon tillers/hill.

Treatment	Productive tillers (no./hill)									
	1984-85					1985-86				
	50	75	100	125	Mean	50	75	100	125	Mean
Bhavani	9.4	10.4	11.3	11.7	10.7	10.1	11.8	13.1	14.8	12.5
Ponni	6.6	7.6	8.0	8.8	7.7	9.7	11.0	13.0	13.9	11.9
IR20	5.2	5.5	5.6	6.7	5.8	9.9	11.0	12.4	13.4	11.7
Continuos Irrigation (C)	7.3	7.7	7.6	8.3	7.7	10.2	11.5	12.4	13.6	11.9
Intermittent Irrigation (I)	6.8	8.4	9.0	9.8	8.4	9.7	11.0	13.2	14.5	12.1
Bhavani-C	10.1	10.2	10.1	10.6	10.2	10.1	11.3	12.3	13.6	11.8
Bhavani-I	8.8	10.7	12.5	12.7	11.2	10.1	12.4	14.0	16.0	13.1
Ponni-C	6.7	7.5	7.6	8.0	7.5	9.3	11.4	12.7	13.8	11.8
Ponni-l	6.4	7.7	8.3	9.7	8.3	10.1	10.6	13.3	14.1	12.0
IR20-C	5.1	5.3	5.2	6.3	5.5	11.1	12.0	12.3	13.5	12.2
IR20-I	5.4	5.7	6.1	7.0	6.1	8.8	9.9	12.4	13.3	11.1
Mean	7.1	7.9	8.3	9.1		9.9	11.3	12.8	14.0	

	1984-85 LSD	1985-86 LSD
Variety (V)	2.0	NS
lrrigation	NS	NS
V × C	NS	NS
Nitrogen (N)	0.8	0.8
V × Irrigation	NS	NS
N × V	NS	NS
N × Irrigation	NS	NS

During the first year, Bhavani had the most productive tillers/hill. This may have been due to higher carbohydrate content in the stubble crop and more regeneration capacity. Irrigation level and the interaction of varieties and irrigation level did not influence number of productive tillers. Tiller production under different N levels varied significantly, with an increase in productive tillers with increasing N.

The ratoon crop produced more productive tillers than the main crop both years (Table 2), perhaps because the ratoon crop produced tillers from the top as well as from the basal nodes. Almost all tillers formed in the ratoon crop bear panicles. ■

Table 2. Productive tillers and yield of main and ratoon crops.

Variety	1984-85				1985-86			
	Tillers (no.)		Yield (t/ha)		Tillers (no.)		Yield (t/ha)	
	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop
Bhavani	10.5	10.7	2.92	1.60	10.5	12.5	5.14	2.94
Ponni	7.2	7.7	2.49	0.96	9.2	11.9	5.33	1.25
IR20	4.5	5.8	3.83	0.32	11.2	11.7	5.57	0.314
LSD	1.5	2.0	0.400	0.073	1.1	ns	ns	0.158

Growth and yield of rice varieties grown in deep water

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We evaluated growth and yield of 13 promising rice lines developed at different research stations under deep water (up to 80 cm) at Cuttack. The photoperiod-sensitive, long-duration (170-180 d), tall (150-200 cm) cultivars and a local check were sown on 26 May at 400 seeds/m^2, 20-cm row spacing, and fertilized with 40 kg N, 9 kg P/ha in the furrow. The experiment was laid out in randomized complete block design with three replications.

Water started accumulating in the field at 7 d after emergence (DE) and increased rapidly to 40 cm at 25 DE. It reached maximum depths of 76 and 83 cm at 60 and 100 DE, respectively, then receded gradually to near zero at crop maturity.

Yields in general were low, because panicles/m^2 were few. Water stress at very early growth stages caused seedling death and adversely affected tillering. Tall cultivars (IET10084, IET10030, IET10029, IET10008, and IET10003) yielded more than 3 t/ha; relatively short cultivars (IET10006, IET9071, IET9017, IET11184. and local check Hathipanja) produced less than 2

Growth and yield attributes of rice cultivars under deep water conditions. Cuttack, India, 1988.

Variety	Cross	Flowering date (DE)[a]	Plant height at maturity (cm)	Panicles (no./m^2)	Panicle weight (g)	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
IET10084	Bashpair/Pankaj	31 Oct (159)	201	70	4.41	25.6	3.2	11.0
IET10030	Velki/Mahsuri	4 Nov (163)	197	83	3.20	25.8	3.0	8.5
IET10029	Patnai 23/Jaladhi 2	2 Nov (161)	196	75	3.44	26.4	3.0	8.7
IET10008	CN644/Patnai 23	31 Oct (159)	187	100	3.25	26.2	3.1	8.5
IET10003	Jaladhi 2/CN644	3 Nov (162)	193	70	3.82	26.7	3.0	8.5
IET10028	Jaladhi/Pankaj	1 Nov (160)	197	104	3.55	26.9	2.5	10.0
IET10009	CN644/Patnai 23	28 Oct (156)	190	75	3.00	26.6	2.2	7.7
IET9018	Selection from tall composite	1 Nov (160)	187	66	3.34	26.1	2.1	9.2
IET10027	Jaladhi/CN644	1 Nov (160)	172	79	3.00	27.3	2.0	7.8
IET10006	Pankaj/Patnai 23	1 Nov (160)	177	101	2.54	26.5	1.9	8.3
IET9071	Purelineselection	28 Oct (156)	185	79	2.91	16.1	1.9	7.8
IET9017	Selection from tall composite	30 Oct (158)	183	64	2.48	29.3	1.6	8.0
IET11184	Waihoku/CR1014	30 Oct (158)	150	81	1.86	19.9	1.5	6.8
Hathipanja (check)	–	26 Oct (154)	163	70	2.51	31.0	1.7	8.0
SE			10	9	0.60	0.5	0.4	1.3

[a] DE = days after emergence.

t/ha (see table). Straw yields were much higher than grain yield and did not vary significantly among cultivars.

There was a significantly positive correlation of grain yield with plant height at maturity (r = 0.77 1**) and panicle weight (r = 0.842**). Panicles/m^2 (considered to be the major yield attribute of medium-duration dwarf varieties under shallow water conditions) did not show any relationship with grain yield (r = 0.142 ns).

The results suggest that tall stature and panicle weight types are suitable for deepwater areas where water level increases abruptly. Work is needed to improve panicle numbers for higher productivity. ■

Stability for yield of medium-long-grain rice varieties and advanced lines

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Cultivars JP5 and DR83 and advanced lines VT1, IR9729-63-3, DR47, Pakhal, and Kunhar were tested over nine locations. Plot size was 5 × 3 m, with 20 cm between and within rows. Twenty-five-day-old seedlings were transplanted at 2 seedlings/hill in a randomized complete block design with three replications. Fertilizer was applied at 120-60-0 NPK kg/ha.

The slope of the regression of genotype mean on site mean yield (bi) is a measure of' stability. Pakhal and IR9729-63-3 had slope (0.97 and 1.01, respectively) closest to 1.00 among all genotypes (see table). They also contributed least to genotype × environment interaction, as measured by ecovalance (wi^2) and interaction variance (δi^2).

In addition. the genotypes had the smallest deviation from regression on the site index, as measured by the deviation mean square ($S^{-2}d$) of all genotypes. Pakhal was the most stable, followed by IR9729-63-3.

Genotypes DR47, DR83, VT1 , and JP5 had regression coefficients greater than 1.0, indicating that they were more responsive under favorable environments and high fertility conditions. Kunhar, with a lower regression coefficient (b< 1.0) seemed suitable for poor environments. These cultivars should be tested across environments for a few years before their release for general cultivation. ■

Stability parameters for grain yield of medium-long-grain rice varieties and advanced lines.

Genotype	Grain yield (t/ha)				
	Mean	Wi	δi	bi	S^2d
VT1	4.6	7560101.39	1175547.81	1.16	710828.10
IR9729-63-3	5.5	4610464.15	659361.30	1.01	394547.70
DR47	4.8	6021657.15	906320.07	1.17	404016.24
Pakhal	4.8	1858478.68	177763.84	0.97	187024.95
Kunhar	5.4	4749940.25	683769.61	0.57	253366.54
DR83	5.3	5719242.00	853397.42	1.27	539474.99
JP5	4.1	4872898.51	705287.31	1.14	484018.75

Space limitations prevent IRRN from publishing solely yield data and yield component data from routine germplasm screening trials. Publication is limited to manuscripts that provide either a) data and analysis beyond yield and yield components (e.g., multiple or unique resistances and tolerances, broad adaptability), or b) novel ways of interpreting yield and yield component data across seasons and sites.

Pest resistance – diseases

Reaction of rice germplasm to leaf blast (Bl) in West Bengal

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We tested 496 rice varieties and lines for resistance to leaf Bl caused by *Pyricularia oryzae* Cav. in hot-spot areas under weather conditions conducive to disease during 1983 and 1985 wet seasons at Kalimpong and 1987 and 1988 dry seasons at Pandua. Test entries included 45 mutants of CBl and 34 of Latisail.

Nursery beds were fertilized with 20-22 kg NP/ha. Three rows of susceptible checks Pusa 2-21 and IR50 surrounded the nursery beds.

Under high disease pressure, 34 lines showed resistance to moderate resistance to leaf Bl (see table). Fifty percent of CB1 mutants and 90% of Latisail mutants (data not shown) gave resistant reaction when CB1 was resistant and Latisail was susceptible to leaf Bl. ■

Reaction of rice cultivars to Bl.

Cultivar	Cross	Disease score[a]
IET7293	Ponni mutant	0
IET6658	Nira/TN1	2
IET7590	RP5-32/Pankaj	0
IET6010	IR8/W1263	3
IET2254	T90/IR8	0
IET2815	TKM6/IR8	3
IET2233	Beli Patna/IR6	3
IET8669	Ratna/Jachum white	0
Munal	CI 5310 (Introduction from USA)	2
NC507	Pureline selection	4
NC513	Pureline selection	4
NC493	Selection from Najani	0
IR54		0
IR42		3
CN835-2-9-4-11	IR20 mutant	3
CN701-1-8	Kumargore/Jalaplaban//CR1002	0
CN695-2-17	CN540/IET6213	1
CN506-147-14-2	IR30/Leb Mue Nahng III//IR1514A-E 666	3
CN844-94-8-13	IR36/Jaya	3
CN840-9-1-A	IR50/IR36	3
CN849-77	Patnai 23/Bhasamanik	1
CN840-9-1-B	IR50/IR36	3
CN772-4	IET2895/CB1	3
CN772-6-1	IET2895/CB1	0
CN772-6-3	IET2895/CB1	0
CN722-1	CB1/Ratna	3
CN722-8	CB1/Ratna	0
CN722-3	CB1/Ratna	3
CN741-2-1	Jaya/Latisail	0
CN936-5-1	CB1 mutant	1
CN936-5-2	CB1 mutant	1
CN936-5-3	CB1 mutant	1
CN937-6-3	IR50 mutant	3
CN937-6-6	IR50 mutant	3
CB1		0
Latisail		7
Pusa 2-21	Susceptible checks	8
IR50		8

[a] By the *Standard evaluation system for rice.*

Rapid screening for rice tungro resistance using viruliferous green leafhopper (GLH) nymphs

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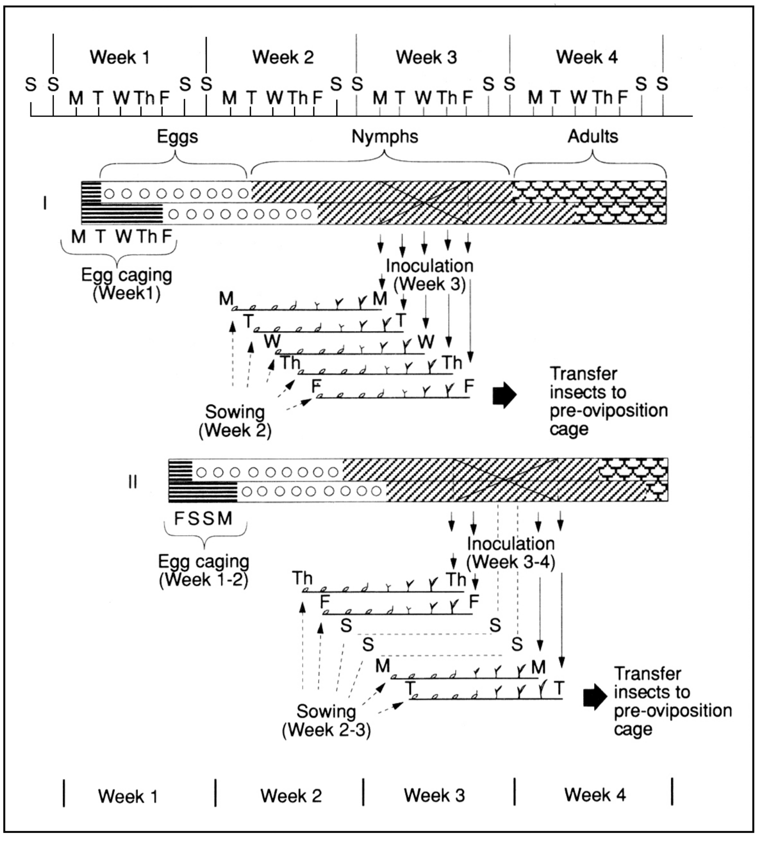
GLH *Nephotettix virescens* (Distant) nymphs can efficiently transmit tungro viruses to rice seedlings, and are easier to handle than adults for germplasm screening. Nymphs can be produced in large numbers using simple rearing procedures.

Gravid GLH females were caged for 3-4 d on 50-d-old tungro-infected TN1 rice plants for egg-laying (Fig. 1). One week later, 15-20 seeds each of rice varieties for test were sown in a 110- × 65- × 5-cm aluminum seedbox in 10-cm-long rows, 4.5 cm apart. Each seedbox contained 130 rows of seedlings.

At 7 d after sowing, the seedbox was placed in a 240- × 75- × 30-cm galvanized-iron tray. The last seedling in each row was enclosed in a mylar-film cage (17-cm-long, 2.5-cm diam) to serve as a mechanically excluded, disease-free check. Seedboxes were infested at 10 viruliferous nymphs/seedling for a 3-4 h inoculation feeding. To ensure efficient disease transmission, nymphs were disturbed manually at hourly intervals so that they were uniformly redistributed among the seedlings.



1. Synchronized tungro resistance screening activities using viruliferous GLH nymphs. IRRI, 1990.

At the end of inoculation feeding, the seedbox was covered with a 120- × 70- × 35-cm wooden-frame, mylar-film cage with 2-mm-thick, 20-cm-long galvanized-iron wires hanging vertically from the roof of the cage 10 cm apart. The iron tray was filled with water (water level increased at 2 cm/min). As the water level rose, the nymphs gradually moved toward seedling tips and transferred to the overhanging wires. When seedlings were submerged in 5-cm water, the cage was raised and the seedbox gently pulled out. The small cages enclosing the check seedlings were removed.

Another seedbox with fresh seedlings was slid under the cage, water in the iron tray was siphoned out, and the cage was lowered. The cage top was tapped to dislodge the nymphs hanging from the wires and ceiling onto fresh seedlings.

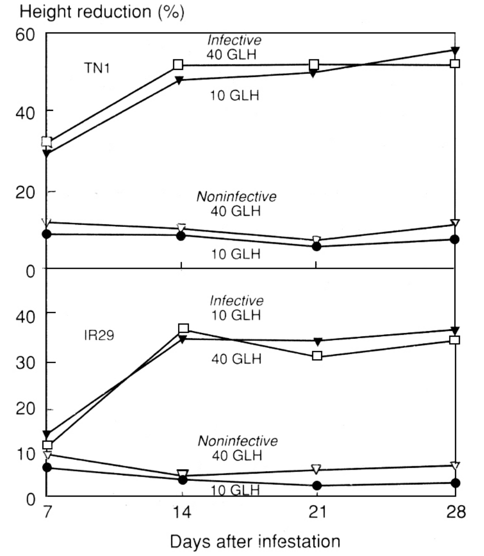
After virus transmission in two batches of seedlings, nymphs were allowed to feed overnight on tungro-infected plants to reacquire the virus.

Seedlings exposed to viruliferous nymphs were compared with control seedling 3 wk after inoculation and scored on percentage of infected plants.

Two batches of viruliferous nymphs a week can be produced on tungro-infected source plants in an oviposition cage (Fig. 1). The first batch consists of nymphs emerging from eggs laid Mon to Fri; the second, from eggs laid Fri to Mon. Each batch can be used for 2-3 daily inoculations for 5 d. Older nymphs are transferred to TN1 plants in pre-oviposition cages; emerging adults are transferred to oviposition cages to restart the culture.

Using this method, we have screened more than 4,000 germplasm collections and advanced breeding lines. Two accessions of *Oryza latifolia* (IRRI Acc. nos. 105141 and 105142) and one accession of *Oryza officinalis* (IRRI Acc. no. 105220) showed tungro resistance.

To differentiate stunting due to insect feeding from stunting caused by tungro infection, IR29 (vector-resistant but tungro-susceptible) and TN1 (susceptible to both vector and tungro) seedlings were infested for 6 h with 10 or 40 viruliferous or nonviruliferous nymphs/seedling. In both cultivars, direct damage by 10 to 40 nymphs/seedling was insignificant. Height reduction due to tungro was significantly higher than that caused by nymphs alone (Fig. 2). ■



2. Plant height reduction caused by GLH feeding and tungro-infection damage on GLH-resistant IR29 and GLH-susceptible TN1. IRRI, 1990.

Blast (Bl) and bacterial blight (BB) reactions in some wild rices

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We tested 33 wild rice accessions from IRRI for reactions to leaf Bl (*Pyricularia oryzae*) and leaf BB (*Xanthomonas campestris* pv. *oryzae*).

To measure Bl reactions, entries were grown in the Bl nurseries as the IRBN entries are grown and inoculated at 3- to 4-leaf stage with chopped infected leaf pieces as well as with a spore suspension of *P. oryzae*. Nursery beds were irrigated lightly every afternoon and covered with polyethylene sheets at night to maintain high humidity.

To measure BB reactions, entries were grown in pots following normal cultural practices. They were inoculated at the booting stage with isolate Bxo9 of *X. c.* pv. *oryzae* by the clipping method.

Reactions of some wild rices to leaf Bl and BB in Bangladesh.

Name	IRRI acc. no.	Bl (% DLA)	BB (% DLA)
O. officinalis	100179	–	–
O. barthii	100117	20.0	–
O. latifolia	100962	–	–
O. minuta	101089	8.0	–
O. barthii	101380	20.0	12.2
O. nivara	102171	65.0	21.7
O. officinalis	102460	65.0	16.2
O. nivara	102463	65.0	15.9
O. nivara	102465	8.0	9.8
O. rufipogon/O.nivara	102467	20.0	9.5
O. rufipogon/O.nivara	102468-2	2.0	25.2
O. rufipogon/O.nivara	102468-3	2.0	35.0
O. rufipogon/O.nivara	102468-5	20.0	22.5
O. rufipogon/O.nivara	102468-6	15.0	28.7
O. rufipogon/O.nivara	102468-7	20.0	26.1
O. rufipogon/O.nivara	102468-8	20.0	15.8
O. rufipogon/O.nivara	102471	20.0	14.8
O. rufipogon/O.nivara	103406	15.0	6.4
O. nivara	103821	40.0	15.8
O. nivara	103826	–	20.2
O. rufipogon	103827-1	35.0	27.6
O. rufipogon	103827-2	40.0	33.2
O. rufipogon	103828	20.0	21.1
Hybrid Swamp	103829	60.0	33.1
O. nivara	103830	65.0	–
O. sativa f. *spontanea*	103831	65.0	–
O. sativa f. *spontanea*	103833	20.0	–
O. sativa f. *spontanea*	103834	65.0	–
O. nivara	103835	60.0	–
O. nivara	103836	15.0	22.0
O. nivara	103837-1	2.0	25.7
O. nivara	103837-2	2.0	20.6
O. nivara	103840-1	1.0	12.7

Percent diseased leaf area (%DLA) for both B1 and BB was measured three times at 5-d intervals, beginning with initiation of lesions. The table shows final DLA due to B1 and BB. Most entries appear susceptible to Bl and BB. IRRI Acc. No. 102468-2, 102468-3 (*O. rufipogon/O. nivara*) and 103837-1, 103837-2, and 103840-1 (*O. nivara*) showed resistance to B1; No. 102465 (*O. nivara*) and 102467 and 103406 (*O. rufipogon/O. nivara*) showed resistance to BB.

These wild rices may be used in wide hybridization to transfer resistance genes to cultivated rices. ■

Pest resistance – insects

Evaluation of brown planthopper (BPH)- and whitebacked planthopper (WBPH)-resistant hybrid rices for resistance to Angoumois grain moth (AGM)

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AGM *Sitotroga cerealella* Olivier is a major pest of stored rice in China. We evaluated 15 rice hybrids with resistance to BPH or WBPH (Table 1) for their resistance to AGM.

AGM were reared on wheat seeds in the laboratory. Moisture content of rice grain was adjusted to 13%, and 5 g of tested hybrid seed were infested with 100 eggs of AGM. Treatments were in a split-plot design with four replications. After infestation, the samples were stored at 27°C and 75% relative humidity.

Resistance was evaluated on several parameters, including percentage emerging adults, grain weight loss, development period, and susceptibility index (SI). SI was based on the formula

$$SI = \frac{\text{natural log number of emerging adults}}{\text{average development period}} \times 100$$

Susceptibility was determined by this scale:

Damage scale	Emerging adults (%)
Resistant	<10
Moderately resistant	10-20
Susceptible	>20

Table 1. Resistance of hybrids of BPH and WBPH.

Hybrid	CMS/restorer	Reaction[a]	
		BPH	WBPH
Shan You 6	Zhen Shen 97 A/IR24	1	6.3
Shan You 30	Zhen Shen 97 A/IR30	3	7.7
Shan You 54	Zhen Shen 97 A/IR54	1	7
Shan You 56	Zhen Shen 97 A/IR56	2.3	3
Shan You 63	Zhen Shen 97 A/Ming Hui 63	7.7	4.3
Shan You 64	Zhen Shen 97 A/Ce 64[b]	1.7	2.3
Shan You 177	Zhen Shen 97 A//IR26/Zhai Ye Qing 8	1	1.7
Shan You 6161-8	Zhen Shen 97 A/Gui 8	1.7	3.7
Shan You Zhu Hui Zao	Zhen Shen 97 A/Zhu Hui Zao	1	6.3
Wei You 6	V20 A/IR26	1	3
Wei You 35	V20 A/26 Zhai Zao	1	1.7
Wei You 64	V20A/Ce64[c]	1	1.7
Wei You 98	V20 A/98	6.3	1.7
Xin You 6	Xin Qing Ai A/IR26	3	4.6
Liu You 30	6064 A/IR30	1.7	9

[a]Score1-9 : 1 = highly resistant, 9 = highly susceptible. [b] IR9761-19-1-64. [c]IR2061/IR661.

Table 2. Resistance of hybrids to AGM.

Hybrid	Emerging adults (%)	Development period (d)	Susceptibility index	Grain weight loss (%)	Damage scale[a]
Shan You 6	18.8	35.2	8.18	3.2	MR
Shan You 30	37.5	27.0	13.45	13.5	S
Shan You 54	23.3	33.3	9.41	8.2	S
Shan You 56	11.0	28.6	8.40	3.4	MR
Shan You 63	25.5	38.4	8.35	9.4	S
Shan You 64	40.5	28.2	13.19	13.6	S
Shan You 177	24.5	33.7	9.48	7.4	S
Shan You 6161-8	25.3	37.9	8.53	9.1	S
Shan You Zhu Hui Zao	42.0	33.1	11.25	11.3	S
Wei You 6	28.0	35.3	9.47	9.3	S
Wei You 35	20.5	34.7	8.68	7.5	S-MR
Wei You 64	34.5	34.3	10.32	12.5	S
Wei You 98	40.5	33.2	10.95	13.3	S
Xin You 6	34.8	26.6	13.30	13.3	S
Liu You 30	39.8	31.7	11.63	13.0	S
Cauvery[b] (resistant check)	4.7	35.6	4.37	0.4	R
Xing Hui Zhan 1 (susceptible check)	43.5	27.4	13.73	8.9	S

[a] R = resistant, MR = moderately resistant, S = susceptible. [b] Pureline variety.

No resistant hybrids were found, and only Shan You 6 and Shan You 56 were rated moderately resistant to AGM (Table 2). Shan You 56 was also resistant to both BPH and WBPH, and Shan You 6 exhibited resistance to BPH. The hybrids were more susceptible to the AGM than were pureline varieties. When 63 pureline varieties were screened for resistance, 36 exhibited resistance and 19 moderate resistance. ■

Influence of light on expression in rice of resistance to brown planthopper (BPH)

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In a seedling bulk screening test to evaluate resistance to the BPH under natural conditions, daylength shorter than 5 h reduced resistance in Mudgo, IR26, ASD7, Babawee, PTB33, and Sudu Honderwala. To confirm this result, we set up an experiment with TN1 (susceptible), Baoxuan 2 and Fubao 78-2-1 (moderately resistant), IR26 and ASD7 (resistant). About 15 seeds of each variety were sown in 8-cm-long rows in 30- × 25- × 5-cm seedboxes. Treatments were laid out in a split-plot design with three replications (each seedbox served as a replication). Seedlings were thinned to 10/row 7 d after sowing (3-leaf stage) and infested with second- to third-instar BPH nymphs at 5 nymphs/seedling. Plants were grown in the phytotron at 30°C with varying light intensities and length. Damage was measured on a visual rating of 0-9.

Table 1. Damage rating of rice seedlings grown under different light regimes (8, 12, 16 hof light/d).

Variety	Damage rating[a] at							
	5,000 lux			7,000 lux			10,000 lux	
	8-h	12-h	16-h	8-h	12-h	16-h	4-h	8-h
TN1	9.0 a	9.0 a	9.0 a	9.0 a	9.0 a	9.0 a	9.0 a	9.0 a
Baoxuan 2	9.0 a	8.3 a	7.7 a	9.0 a	7.0 a	3.0 c	9.0 a	3.6 b
Fubao 78-2-1	9.0 a	9.0 a	7.0 a	7.0 a	7.0 a	4.3 b	9.0 a	3.0 b
IR26	8.3 a	5.0 b	1.7 b	7.7 ab	1.7 b	1.0 d	5.0 a	1.0 b
ASD7	9.0 a	5.0 b	1.7 b	6.3 b	3.0 b	1.0 d	5.0 a	1.6 b

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

Table 2. Effect of seedling stage on the resistance under different light conditions.

Light regime	Leaf stage	Damage rating[a]				
		TN1	Baoxuan 2	Fubao 78-2-1	IR26	ASD 7
7,000 lux, 8 h	2	9.0 a	7.0 a	7.0 a	3.0 a	3.0 a
	4	9.0 a	3.6 b	5.0 b	1.6 b	1.6 b
7,000 lux, 10 h	2	9.0 a	8.3 a	7.6 a	3.0 a	1.0 b
	4	9.0 a	3.0 b	3.0 b	1.0 b	1.0 b
15,000 lux, 10 h	2	9.0 a	6.3 a	6.3 a	3.0 a	1.0 b
	4	9.0 a	3.0 b	3.6 b	1.0 b	1.0 b

[a] Within each light regime and in a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

Resistance in IR26 and ASD7 decreased in seedlings grown under 5,000 lux for 8-12 h, 7,000 lux for 8 h, and 10,000 lux for 4 h (Table 1).

When moderately resistant and resistant plants were grown under weak light, resistance at the 4-leaf stage was higher than at the 2-leaf stage (Table 2). When using the seedbox bulk screening test, attention should be paid to light conditions at different seedling stages. ■

Gall midge (GM) resistance in rice

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We evaluated nine rice genotypes, two potential resistance donors, and one susceptible check for resistance to GM *Orseolia oryzae* Wood Mason biotype 1 during 1988 and 1989 wet seasons (Jun-Jul to Oct-Nov).

Genotypes were tested in irrigated fields. Seedlings (27 d after seeding) were transplanted in 3-m rows at 20- × 15-cm spacing with one seedling/hill. All recommended crop management practices were followed except plant protection. Each entry was scored at 30 and 50 d after transplanting (DT) for number of hills with silvershoots and for number of silvershoots/infested hill. GM infestation was highest from the last week of Sep to the first week of Oct.

Reaction of selected rice genotypes to GM. India, 1988-89.

Designation	Cross	GM incidence[a] (% silvershoots)							
		1988				1989			
		30 DT		50 DT		30 DT		50 DT	
		HB	TB	HB	TB	HB	TB	HB	TB
BPT4220	BPT3301/WGL 26888	25	16.7	100	21.0	39	12.5	95	28.8
BPT4301	BPT3301/WGL 26888	20	10.8	90	22.4	20	12.5	85	29.1
R296-260	CR157-392/OR57-21	5	14.3	35	10.5	0	0	10	15.2
R302-103	Samridhi/IR8608-298	0	0	5	28.0	0	0	0	0
R321-108	IR36/Samridhi	0	0	85	12.7	25	11.9	60	17.7
R435-756	IR54/Surekha	0	0	10	16.7	0	0	0	0
RP2333-36-18-9	Ratna/ARC10659	0	0	0	0	0	0	5	7.7
RTN84-5-1	Phalguna/Mahsuri	0	0	0	0	0	0	0	0
RTN121-1-1-1-1-1	CR57-MR1523/IR36	15	15.8	80	11.7	0	0	85	12.8
Aganni	Donor	0	0	25	5.1	0	0	0	0
ARC5984	Donor	0	0	0	0	5	7.7	0	0
TN1	Susceptible check	35	21.9	100	24.8	50	14.1	100	32.6

[a] HB = hill basis, TB = tiller basis, DT = days after transplanting.

Only RTN84-5-1 was highly resistant to GM biotype 1 (see table). It showed no damage at 30 and 50 DT. ■

Transmission of rice tungro by green leafhopper (GLH) on successive days

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We studied transmission of tungro by viruliferous GLH *Nephotettix virescens* (Distant) to 25 rice varieties and cultures on successive days of inoculation feeding, and insect survival in the greenhouse.

Fifth-instar nymphs were allowed to feed on tungro-infected plants for 4 d for virus acquisition. One viruliferous insect was released in a test tube containing one 10-d-old rice seedling for inoculation (100 seedlings per variety). Seedlings were removed after 24 h (taking care to retain the live insect inside the test tube) and transplanted in pots. A fresh seedling of the same variety and age was immediately placed in the test tube for the viruliferous GLH to transmit tungro on successive days. This procedure was repeated at 24-h intervals until the death of all insects.

Infected seedlings were counted 21 d after transplanting (see table).

For testing insect longevity, third-instar GLH nymphs 9-11 d old were allowed to feed on tungro-infected TN1 plants for 4 d. Each insect was released into a test tube containing one 10-d-old seedling. For each variety, 20 seedlings and 20 viruliferous insects were used. Surviving insects were counted at 24-h intervals and seedlings replaced, until the death of all insects.

Viruliferous insects could transmit tungro only on the first and second days to 7 varieties (see table). They transmitted tungro up to 5 d on ADT36 and TN1. Transmission to the rest of the varieties ceased after 3 or 4 d.

Insect longevity was shortest (12-14 d) on IR72 and IR33043-46-1-3. The insect survived for more than 20 d on most of the popular varieties, with a maximum of more than 41 d on TN1.

GLH could transmit tungro up to only 2 d and survive the shortest time (12-18 d) on IR72, IR50, IR33043-46-1-3, TNAU831521, IR52431-60-1-2-1, IR39657-91-3-2-3, and TNAULFR842718. ■

Transmission of tungro to rice plants on successive days (1-5). Coimbatore, Tamil Nadu, India.

Variety	Mean life span[a] (d)	Tungro transmission (%) on successive feeding days				
		1	2	3	4	5
IR72	12.1 a	20	10	0	0	0
IR33043-46-1-3	12.6 ab	20	10	0	0	0
IR50404-57-2-2-3	15.8 c	30	20	20	0	0
IR52431-60-1-2-1	15.9 c	20	20	0	0	0
IR34686-56-2-2-2	16.6 c	30	20	20	0	0
CRM25	16.8 c	30	10	10	0	0
TNAULFR842718	18.0 d	30	30	0	0	0
AS33773	21.2 ef	30	20	20	0	0
IR32429-148-13-3	22.0 efg	20	20	10	0	0
IR37865-29-3-13	20.9 c	30	30	10	0	0
IR39357-91-3-2-3	16.0 c	20	10	0	0	0
TNAU831520	22.3 fg	30	30	20	0	0
TNAU831521	13.4 b	20	10	0	0	0
IR50	18.8 d	20	10	0	0	0
IR64	13.8 h	30	20	10	0	0
ASD17	22.0 efg	30	30	20	0	0
MDU3	31.6 i	50	40	20	0	0
Ponni	23.1 g	40	20	20	0	0
White Ponni	25.8 h	50	30	30	0	0
IR20	35.1 j	70	50	50	30	0
CO 37	35.0 j	80	60	40	20	0
CO 43	35.1 j	70	70	40	10	0
ADT36	38.1 l	80	70	50	30	20
ADT38	36.3 k	60	50	30	30	0
TN1	41.4 m	100	70	70	04	30

[a]Means followed by the same letter are not significantly different (P = 0.05) by DMRT.

Resistance of breeding lines derived from *Oryza officinalis* to brown planthopper (BPH)

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We evaluated 195 breeding lines derived from *Oryza officinalis* for resistance to the Indian population of BPH *Nilaparvata lugens* (Stal). PTB33 and TN1 served as the resistant and susceptible checks.

Seeds of each test line were sown in 12-cm rows in 60- × 40- × 10-cm wooden seedboxes. The experiment was laid out in a randomized complete block design with five replications.

Seedlings were thinned to 30/row 7 d after sowing and infested with about 8 second-instar BPH nymphs per seedling. When 90% of TN1 seedlings were dead, all breeding lines were rated for plant damage.

Of the breeding lines evaluated, 54 exhibited high levels of resistance (score 1) to the Indian population of BPH:

IR54742-1-18-12-11-2	IR54745-1-20-17-8-3
IR54742-23-19-16-10-3	IR54742-11-8-7-3-3
IR54742-1-20-10-11-1	IR54745-2-21-12-17-2
IR54742-23-19-16-12-1	IR54742-11-10-13-21-1
IR54742-1-20-10-11-2	IR54745-2-23-19-8-1
IR54742-23-19-16-12-2	IR54742-11-15-3-7-2
IR54742-1-20-10-11-3	IR54745-2-34-3-10-3
IR54742-25-1-23-7-1	IR54742-13-29-12-9-1
IR54742-4-7-9-7-1	IR54745-2-45-3-24-3
IR54742-25-1-23-7-3	IR54742-13-29-12-9-2
IR54742-5-36-4-17-2	IR54751-2-41-10-5-1
IR54742-31-9-26-15-3	IR54742-18-3-8-10-3
IR54742-5-36-4-17-3	IR54751-2-41-10-5-2
IR54742-31-16-25-22-3	IR54742-18-17-20-15-1
IR54742-6-1-14-15-1	IR54751-2-41-10-5-3
IR54742-31-21-20-10-2	IR54742-18-17-20-15-3
IR54742-6-1-14-15-2	IR54751-4-6-7-21-2
IR54742-33-9-14-26-2	IR54742-22-19-3-7-2
IR54742-6-1-14-15-3	IR54751-4-6-7-21-3
IR54742-33-9-14-26-3	IR54742-22-19-3-7-3
IR54742-6-20-3-9-1	IR54751-4-22-10-17-2
IR54742-33-9-14-26-4	IR54742-22-19-3-15-3
IR54742-11-2-8-2-1	IR54751-4-25-4-17-1
IR54745-2-2-25-26-3	IR54742-23-11-19-6-3
IR54742-11-2-8-2-2	IR54752-50-19-19-1
IR54745-2-10-17-8-1	IR54742-23-19-16-10-2
IR54742-11-8-7-3-2	IR54742-50-19-19-3

Feeding behavior of green leafhopper (GLH) on rice varieties resistant to rice tungro

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Viruliferous GLH *Nephotettix virescens* insects were allowed to feed on rice cultures and varieties and their feeding from phloem/xylem ascertained by the quality of honeydew (acidic or basic) excreted. Insects that feed on phloem content excrete honeydew with basic properties that caused blue patches in bromocresol-treated filter paper. Insects that feed on xylem content excrete honeydew with acidic properties that caused brown or orange spots.

Basic honeydew excretion was higher in rice varieties that were more severely infected by tungro (see table). This indicates that the insect vector had fed on the phloem content of varieties susceptible to RTV.

Among the cultures tested. IR33043-46-1-3 showed the lowest tungro infection and had no GLH feeding on the phloem. ■

Honeydew excretion of viruliferous GLH feeding on different rice varieties. [a]

Variety	Tungro infection (%)	Area of basic honeydew spots (mm^2)	Area of acidic honeydew spots (mm^2)
IR72	20.00	12 b	219 hij
IR33043-46-1-3	20.00	0 a	228 lm
IR50404-57-2-2-3	30.00	17 bcd	226 klm
IR52431-60-1-2-1	20.00	19 cde	220 hij
IR34686-56-2-2-2	30.00	17 bcd	223 ijkl
CRM25	30.00	20 cdef	221 hijk
TNAULFR84278	30.00	17 bcd	230 mn
AS33773	30.00	25 f	225 klm
IR32429- 148-13-3	20.00	23 ef	224 jke
IR37865-29-3-1-3	30.00	22 def	239 o
IR39357-91-3-2-3	20.00	21 def	218 hi
TNAU831520	30.00	31 g	217 b
TNAU831521	20.00	17 bcd	230 mn
IR50	20.00	15 bc	234 n
IR64	30.00	16 bc	223 ijkl
ASD17	30.00	30 g	211 g
MDU3	50.00	130 f	135 f
Ponni	40.00	108 h	137 f
White Ponni	50.00	124 j	124 e
IR20	70.00	170 m	88 c
CO 37	80.00	162 l	98 d
CO 43	70.00	153 k	92 c
ADT36	80.00	184 n	76 b
ADT38	60.00	165 l	91 c
TN1 (susceptible check)	90.00	245 o	30 a

[a] Means of 3 replications. In a column, means followed by same letter are not significant different (P = 0.05) by DMRT.

Stress tolerance – excess water

Screening of advanced rice lines against natural flooding

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We screened 60 advanced breeding lines for submergence tolerance in 1989 wet season. The test cultivars and check FR13A were seeded in three 3-m-long rows. The first flooding was on 30 Jul; the field remained inundated until 7 Aug. Peak water depth was 60 cm; 45-50 cm water was maintained for 6 d.

Plant height of advanced lines ranged from 12 to 22 cm; FR13A was 25 cm tall. Submergence tolerance was scored after the flood receded and regeneration ability, 7 d after water recession.

Among the advanced lines, 6 scored 5, 28 scored 7, and 26 scored 9. IR43439-99-23-1-1, IR56723-1, and IR313228-474-3P had excellent regeneration ability; IR59037-1, IR57741, IR43470-7-3-5-1, and IR46292-24-2-2-1-2 had good regeneration ability (see table).

In the second flood 20-31 Aug, maximum water depth was 58 cm. Plant heights ranged from 28 to 36 cm. The two best entries were IR43439-99-23-1-1 and IR56723-1.

Entries with regeneration ability scores 1 and 3 should be useful for flood-prone areas where fields are flooded at the early vegetative stage for 1 wk or longer. ■

Submergence tolerance and regeneration ability of various promising rainfed lowland lines. 1989.

Promising advanced line or cultivar	First flood [a] (30 Jul-8 Aug)			Second flood [a] (20-31 Aug)			Grain yield (g/plot)
	Plant ht (cm)	Submergence score [b]	Regeneration ability	Plant (ht)	Submergence score [b]	Regeneration ability	
IR43439-99-23-1-1	12	5	1	35	1	1	400
IR56723-1	14	5	1	34	1	1	380
IR59037-1	11	5	3	32	3	1	490
IR313228-474-3P	16	5	1	36	3	3	600
IR57741	15	5	3	28	7	1	300
IR43470-7-3-5-1	13	5	3	34	5	1	420
IR46292-24-2-2-1-2	17	5	3	36	3	3	700
FR13A	25	1	1	45	1	I	2I0

[a] Age of seedlings at first flooding was 13 d: at second flooding, 26 d. [b] Scale for submergence and recovery: 1 = 90-100%, 3 = 70-89%, 5 = 50-69%, 7 = 30-49%, 9 = less than 30%.

Screening rice cultivars for tolerance for waterlogging

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Tolerance for partial submergence is an essential trait for rainfed lowland rice in eastern India. We screened 22 elite cultures obtained from the Directorate of Rice Research, Rajendranagar, Andhra Pradesh, at the Baruipur Experimental Farm during 1989-90 wet season.

Seedlings were transplanted at 30 d in an especially created depression in the field where water depth could be maintained at 50 cm. Plot size was 5 m × 2 m. Traditional local cultivar Kumargore was the check. Varieties were assessed on yield and yield attributes (see table).

Seven IET cultures that could withstand waterlogging, in order of grain yield in g/m^2, were IET10016 (640), IET10102 (592), IET10009 (586), IET10003 (545), IET10084 (543), IET10109 (541), and IET10233 (527). ■

Grain yield and yield components of rice cultivars under waterlogged conditions. Calcutta, India, 1989-90.

Culture	Cross	Productive tillers (no./m^2)	Spikelets/m^2 (* 10^3)	Grains/m^2 (* 10^3)	Test weight (g)	High-density grain/m^2 (* 10^3)	Yield (g/m^2)
IET9017	Selection from composites	210	23.4	19.4	17.6	4.9	331
IETl0003	Jaladhi 2/Pankaj	260	25.7	23.2	31.7	11.7	545
IET10006	Pankaj/Patnai 23	280	33.4	29.4	20.1	8.4	497
IET10008	CN644/Patnai 23	280	34.9	32.0	28.7	11.5	433
IET10009	CN644/Patnai 23	250	35.2	32.3	23.5	10.0	586
IET10016	Jajati/Mahsuri	290	44.2	37.8	26.1	16.8	640
IET10027	Jaladhi 2/CN644	280	30.1	26.6	26.1	11.9	508
IET10029	Patnai 23/Jaladhi 2	260	28.4	23.9	22.4	7.0	444
IET10084	Bashpair/Pankaj	240	27.5	24.4	32.2	12.1	543
IET10091	CN644/Patnai 23	270	42.1	36.9	18.5	8.6	502
IET10097	Patnai 23/Jaladhi 2	210	23.1	16.4	23.1	4.9	445
IET10102	Jhingasail/CN644	240	50.4	46.1	25.9	18.6	592
IET10109	Jhingasail/Patnai 23	240	34.6	30.1	25.2	10.4	541
IET10115	Jhingasail/CN644	250	29.3	27.1	28.3	7.6	373
IET10173	FR43B/CNM539	180	21.8	11.4	12.0	1.5	263
IET10233	JaIamagna/IET4060	180	25.5	24.2	23.6	7.9	527
IET10234	Selection from local	270	25.4	20.6	28.5	8.7	517
IET10530	IET4060/Jalamagna	200	19.2	16.0	23.4	5.6	412
IET10536	Not known	190	31.8	23.4	29.2	9.7	419
IET10030	Velki/Mahsuri	230	19.4	13.9	23.3	5.1	298
	Sabita	300	31.7	28.6	26.9	10.7	526
	Utkaiprava	270	21.7	19.6	26.5	5.7	342
	Kumargore (local check)	290	28.2	34.6	25.2	11.9	496
LSD (0.05)		50	7.1	7.7	0.2	2.9	182

Stress tolerance — adverse soils

Screening rice varieties for salt tolerance in the greenhouse

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We screened more than 100 local and exotic rice varieties for salt tolerance in the greenhouse, using a coastal saline soil from Taishan County, Guangdong Province. Soil was clay loam with pH 8.0, 0.6% water-soluble salt content, EC 5.4 dS/m, 2.4% organic matter, 0.11 % total N, 8.8 ppm available P, 326.9 ppm available K, CEC 16.7 meq/100 g soil. Screening was carried out in two steps.

In preliminary screening, 102 varieties were tested. Dried soil (15 kg) was put into each 41- × 37- × 15-cm plastic container and soaked with deionized water 2 wk before transplanting. Three days before transplanting, urea and superphosphate were added at 50-11 mg NP/kg soil.

Rice seedlings were generated from sand culture with a modified nutrient solution. When the 5th to 6th leaf appeared, the seedlings were transplanted into the containers at 6- × 9-cm spacing, 9 seedlings/variety in a randomized block design with three replications. Deionized water was maintained 2-3 cm above the soil surface throughout growth.

At 5 wk after transplanting, plants were evaluated for salt tolerance (Table 1) and the damage index (DI) calculated for each variety. DI ranged from 50 to 100% (data not shown).

Further screening of 28 relatively salt-tolerant varieties (DI £ 60% in the preliminary screening) and two salt-sensitive varieties (DI = 100%) was

Table 1. Criteria for salt tolerance evaluation of rice plants.

Plant response to salinity	Plant appearance	Salt tolerance class (C_i)[a]
Normal	Normal growth.	1
Slight	Growth and tillering slightly affected. Tips of bottom leaves dried out.	2
Medium	Growth and tillering significantly inhibited. Bottom leaves withered. Tips of middle and upper leaves dried out.	3
Serious	Growth completely stops. Middle or upper leaves withered or dried out.	4
Dead	Whole plant dead or dying.	5

[a] Damage index (DI) was calculated for each variety as

$$DI\ (\%) = \frac{R c_i n_i}{N C_{max}} \times 100$$

where c_i is class of salt tolerance for a plant. n_i is number of plants in that class, N is total number of plants of the given variety in each replication, and C_{max}, is highest c1ass observed.

carried out using the same soil salinized with NaCl to make water soluble content 0.8% (EC 6.1 dS/m). The soil also was washed with deionized water to reduce salt content to 0.2% (EC <2.0 dS/m) to check varietal vigor without salt stress. Experimental procedures were the same as for preliminary screening.

All varieties grew normally on the soil whose soluble salt had been mostly washed out with deionized water, but badly on the soil with added NaCl.

Although rice growth was generally inhibited by salt, marked differences in salt tolerance were observed (Table 2). Local hybrid Liuyou 33 was one of the most salt-tolerant varieties, comparable with well-known salt-tolerant Pokkali. Local conventional variety Mafeizhan and breeding line IR36/Meijiangzao 3//Guichao also showed relatively high salt tolerance. Moderate salt tolerance was found in widely used local hybrids Liuyou 63, Shanyou 2, Shanyou 63, and Shanyougui 34.

The validity of these results must be verified under field conditions. ■

Table 2. Damage index of varieties or lines in response to salinity.

Group	Variety or line	Seed source [a]	Damage index (%) [b]	Remarks
1	Liuyou 33	LH	66.7 a	Relatively salt-tolerant
	Pokkali	IR		
2	Mafeizhan	LC	73.3 a	
	IR36/Meijiangzao 3//Guichao	LL		
	Nona Bokra	IR		
	IR29725-22-3-3-3	IR		
3	Liuyou 63	LH	80.0 ab	Intermediate in salt tolerance
	Suomali/Daqu//Hongyangai	LL		
	CSR4	IR		
4	Shanyou 2	LH	86.7 ab	
	Shanyou 63	LH		
	Shanyougui 34	LH		
	IR50	IR		
	IR19085-107-1	IR		
5	Shanyou 30	LH	93.3 b	Salt-sensitive
	Shanyou 64	LH		
	Liuyou 6	LH		
	Guanghuaqinglan Fo	LH		
	Liuyou 437	LH		
	Shuanggui 36	LC		
	Siguiai 44	LC		
	Hongyangai 402/Shuangmei	LL		
	Aizaipu/Meifeizao 2//Guichao 2	LL		
6	Shuangfei 1/Kezhan	LL	100 b	
	IR36	IR		
	IR54	IR		
	IR2307-247-2-2-3	IR		
	Qingyouzhi	LC		
	Hongyangai 4/Xinmei 1	LL (CK)		
	Qingeraixuan/Meifeizao 2	LL (CK)		

[a] LH = local hybrid variety, LC = local conventional variety, LL = local hybrid line, IR = variety or line from IRRI, CK = sensitive check. [b] Statistical analysis done after are sin change of percentage data. Means followed by the same letter are not significantly different. Duncan's test, P = 0.05.

Integrated germplasm improvement – irrigated

Liaogeng 287, a high-yielding rice variety for north China

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Liaogeng 287 fits farmer demands for a high-yielding cultivar with multiple resistance and wide adaptability. It was developed from Quling//Sejangke/Songqian and released in 1988.

In a 4-yr demonstration 1986-89 in north China, yields were 9.2-9.7 t/ha (see table). Liaogeng 287 matures in 145-160 d and is adapted to the band between 35° and 41° N latitude, where one crop rice and rice - wheat cropping prevail. It is acceptable to farmers in Hebei, Shandong, Beijing, Tianjin, and Liaoning Provinces, where it has been planted on more than 53,000 ha.

It is semidwarf (95 cm tall), erect and nonlodging with dark green foliage. Panicle length is 19 cm; 1,000-grain weight, 25.5 g; seed set, 82.3%; protein content, 6.7%; amylose content, 21.8%; alkali spreading value, low; gel consistency, 74 mm. ■

Performance of Liaogeng 287 in farmers' fields. North China, 1989.

Location	Liaogeng 287		Local check			Increase over check (%)
	Yield (t/ha)	Duration (d)	Designation	Yield (t/ha)	Duration (d)	
Suangqiao, Beijing	8.3	145	Jingdao 1	7.2	145	15.5
Dongyeng, Shandong	11.4	142	Zhongguo 91	9.3	145	22.6
Yangge, Tianjin	9.2	146	Jingdao 1	8.1	144	13.4
Yinkou, Liaoning	10.1	160	Liaogeng 5	8.6	160	17.4
Shenyang, Liaoning	9.4	160	Liaogeng 5	8.2	160	13.6

Integrated germplasm improvement – rainfed lowland

Multiple-resistance Ruchi released in Madhya Pradesh, India

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Most of the traditional or improved varieties that farmers cultivate in Madhya Pradesh have little or no pest resistance. Recent epidemics of gall midge (GM) *Orseolia oryzae* Wood Mason and bacterial blight (BB) *Xanthomonas campestris* pv. *oryzae* have threatened yield stability.

Newly released variety Ruchi (IET 10449, R269-12-1-1) has high resistance to GM, BB, and blast (Bl) and is tolerant of drought. It was derived from the cross R1924/RP9-4. It is

Yield of Ruchi in All India Coordinated trials, state trials, local verification trials, farmer's field, and maximization demonstrations.

Variety	Yield (t/ha)							
	All India Coordinated Trials				State trials[e]	LVT[f]	Farmer's field[g]	Maximization demonstration[h]
	1986[a]	1087[b]	1988[c]	1989[d]				
Ruchi	5.2	4.0	4.7	5.2	3.9	6.0	5.2	8.7
Jaya	5.3	3.8	4.4	4.7	3.3	–	–	–
Local check	4.9	3.8	4.5	4.6	3.4	5.3	4.3	–

[a] Av over 13 locations. [b] Av over 12 locations [c] Av over 15 locations. [d] Av over 4 locations. [e] Av over 6 yr, 19 trials, 4 locations. [f] Av over 2 yr, 6 locations. [g] Av over 30 farmers' fields of 0.4 ha. [h] Av over 2 yr.

semitall (105 cm ± 10 cm) and, when direct seeded, can compete well with weeds at the early vegetative phase. Grain yield averages 5-6 t/ha (see table).

It matures in 130 d, is nonlodging even under high fertility because of its thick culms, and suits the rainfed lowland conditions of the state.

Ruchi grain is long, bold 35 g/1,000 grains, and suitable for puffed rice. It registered 4th in All India Coordinated trials in 1986 and first in 1989.

Ruchi may replace medium-duration, high-yielding varieties like IR8, Jaya, Pragati, and Phalguna, and has been recommended for release in 1990. ■

Integrated germplasm improvement – upland

Evaluation of early rice genotypes for upland conditions in rolling fields of Karnataka, India

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We evaluated 25 short-duration rice genotypes (< 125 d) during rainy season (May-Nov) 1987-89. The area (15°-50' N, 74°-40' E, and 697 m above sea level) has rolling fields that retain moisture for 3 to 3 1/2 mo during the normal cropping season. Annual precipitation averages about 950 mm. Total precipitation during the three cropping seasons of the experiment was 738.0, 1,034.3, and 607.3 mm, respectively. Soil is a silty clay loam, with pH 6.3, 0.75% organic C, 9 kg P/ha, and 170 kg K/ha.

Rice was drilled in 20-cm rows at 100 kg seed/ha. The crop was fertilized with 100-50-50 kg NPK/ha.

IET7991-11-2 and CR544-1-5 matured about 17 d earlier than high-yielding local check Rasi (IET1444) (see table). Neela matured about 10 d earlier. These three genotypes significantly outyielded other early genotypes, and yielded as high as the local check.

In view of their earliness, IET7991-11-2 and Neela have been recommended for multilocation trials. CR544-1-5 was not considered because its grain tends to shatter when harvest is delayed. ■

Grain yield and plant characters[a] of a few early rice genotypes under rainfed conditions in Mugad, Karnataka, India.

Genotype	Plant height (cm)	Panicle length (cm)	Panicles/m² (no.)	Duration (d)	Grain yield (t/ha)
IET7991-11-2	74.1	17.9	321.5	101	3.7
CR544-1-5	74.9	19.7	241.5	102	3.3
Neela	62.0	20.2	307.3	108	3.2
Rasi (IET1444) (local check)	79.7	18.2	250.0	118	3.1
LSD (0.05)	7.1	7.8	75.5	4.0	0.9
CV (%)	6.1	20.0	11.3	3.1	1.5

[a] Av of 1987, 1988, and 1989 rainy seasons.

CROP AND RESOURCE MANAGEMENT

Fertilizer management

Impact of nursery nutrients on growth and yield of rice crop

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Nursery management is an important factor in crop production. In very thickly populated nurseries, plant roots spread out on the soil surface and intensively exploit soil fertility. If soil fertility is low, seedlings will be thin and pale. A considerable amount of the nursery may be spoiled during pulling.

We studied the use of N and P by the rice nursery and the impact of nursery nutrition on the subsequent crop in a field experiment at Saraimiara farm. Soil of the experimental field was sandy loam,

Table 1. Effect of fertilizer applied to nursery on growth parameters of 25-d-old rice seedlings.[a]

Seedling treatment	Leaves/plant (no.)	Height (cm)	100-seedling weight (g)	N content (%)	P content (%)
No N	3.8	19.2	65	1.86	0.251
100 kg N/ha	4.7	30.4	152	2.28	0.258
200 kg N/ha	5.1	31.9	243	2.34	0.312
No P	4.8	30.8	141	2.08	0.323
21.5 kg P/ha	5.0	31.3	153	2.12	0.338
43.0 kg P/ha	5.3	31.7	166	2.15	0.345
LSD (0.05)	0.3	1.01	20	0.04	0.005

[a] 2 yr pooled data.

pH 7.8 with 176 kg available N, 5.13 kg P, and 164.3 kg K/ha. A bed 5 × 1 m was prepared to raise the nursery (Jaya variety). Treatments are given in the table. Farmyard manure (FYM) was applied at 15 t/ha to all treatments, to ease uprooting of seedlings. Treatments were sampled 25 d after sowing to analyze growth and N and P content.

Seedlings were transplanted in the main field with 90 kg N, 13.04 kg P, and 24.89 kg K/ha. The experiment was laid out in a randomized block design with three replications.

Seedlings responded significantly to N and P (Table 1). Height and weight of seedlings increased, and N and P contents increased.

Yield of grain and straw was significantly higher with N-fertilized seedlings (Table 2). No response to P was found, possibly because of the FYM added to the nursery. ■

Table 2. Effect of fertilized seedlings on grain and straw yield.

Nursery treatment	Yield (t/ha)					
	Grain			Straw		
	Year 1	Year 2	Av	Year 1	Year 2	Av
No N	2.5	2.5	2.5	4.4	4.3	4.4
100 kg N/ha	2.8	2.7	2.8	5.0	4.8	4.9
200 kg N/ha	3.1	3.1	3.1	5.5	5.4	5.4
No P	2.7	2.7	2.7	7.8	4.7	4.7
21.5 kg P/ha	2.8	2.8	2.8	5.0	4.8	4.9
43.0 kg P/ha	2.9	2.8	2.9	5.1	5.0	5.1
LSD (0.05)	0.2	0.2		0.3	0.3	

Crop management

Effects of number of axillary buds and main crop cutting time on ratoon crop yield

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We studied the effects on ratoon crop yield of the number of axillary buds sprouting and of different cutting times for the main crop of hybrid rice variety Shanyou 63. Planting density of the main crop was 28 hills/m^2 with 120-60-60 kg NPK/ha as basal fertilizer and 69 kg N/ha as topdressing 15 d after full heading, to promote bud sprouting. The crop was cut at 33 cm height at different times after main crop heading. The experimental results are shown in the table.

Number of axillary buds were significantly correlated with carbohydrate content and weight of stem and sheath, which increased as cutting time of the main crop was delayed. The correlation coefficients were $r = 0.9676$ and $r = 0.9950$.

These results show that starch content of the axillary buds was increased by the photosynthate of leaves before the main crop matured.

Cutting time of the main crop was significantly correlated with yield of the main crop and number of axillary buds sprouting, number of productive panicles, and yield of the ratoon crop. Regression equations were

Number of axillary buds and productive panicles, and yield of ratoon rice with different cutting times of the main crop. Southern Sichuan, China, 1989.

Item	Cutting time (d after main crop heading)				
	22 d	25 d	28 d	31 d	34 d
Dry weight of stem and sheath of main crop (g/hill)	12.51	12.31	12.88	13.87	16.91
Carbohydrate content of stem and sheath of main crop (%)	1.6	2.2	1.8	2.1	8.6
Maturity of main crop grain at cutting (%)	61.5	64.7	77.6	84.7	100.0
Number of axillary buds sprouting before main crop harvest (no./m^2)	0.00	0.00	0.84	3.64	27.16
Maximum number of axillary buds sprouting (no./m^2)	221.2	126.0	128.8	207.2	274.4
Productive panicles in ratoon crop (no/m^2)	187.6	123.3	126.0	187.6	257.6
Grain yield of ratoon crop (t/ha)	1.5	1.4	1.1	1.3	1.8
Grain yield of main crop (t/ha)	6.4	7.3	7.7	7.7	8.1

Grain yield of the main crop: $\hat{y} = 257.8133 + 8.4867x$

Number of axillary buds sprouting: $\hat{y} = 87.4946 - 6.1322x + 0.1135x^2$

Ratoon crop panicle number: $\hat{y} = 68.8988 - 4.83x + 0.0906x^2$

Grain yield of ratoon crop: $\hat{y} = 772.9456 - 50.8443x + 0.9274x^2$

Cutting the main crop 34 d after heading, when axillary buds began sprouting, resulted in the highest yields for both the main crop and the ratooning crop. Yield of the ratoon crop was attributed to higher numbers of productive panicles. ■

Integrated pest management – diseases

Diseases of rice in Cameroon

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Rice is a relatively new crop in Cameroon; it is currently grown on about 20,000 ha of irrigated and upland fields. Irrigated rice accounts for more than 90% of the land area under rice and contributes about 94% of annual production (Table 1). Upland rice is grown as a subsistence crop by peasant farmers in isolated areas of the country.

The Cameroonian farmer is constrained by a number of abiotic, biotic, and socioeconomic factors. Among the biotic factors, diseases pose the most problems, causing yield losses of 10-30% every year.

Development of varieties with resistance to major diseases would help stabilize rice production. We carried out disease surveys in 1988 wet season (Jul-Dec) and 1989 dry season (Jan-May) to more precisely define the rice disease situation for input to the rice improvement program.

At 20 locations selected to represent different climatic conditions, cultivation techniques, varieties, and soil types, 6-12 ricefields were sampled at nine spots—the four corners, midway along each edge, and at the center—and disease incidence or severity recorded.

Leaf and neck blast (Bl) caused by *Pyricularia oryzae,* leaf scald (LSc) caused by *Rhynchosporium oryzae,* and brown spot (BS) caused by *Helminthosporium oryzae* occurred everywhere, although severity was low in the Extreme North Province (Table 2). These diseases are thought to cause significant losses in yield, particularly at Mbo Plain in the West Province and at Karewa and Laqdo area in the North Province.

Disease was most severe under upland conditions, especially at Mbo Plain in the West Province. Irrigated fields suffered more severe disease incidence in the dry season crop, which coincides with low temperatures.

Sheath rot (ShR) caused by *Acrocylindrium oryzae* Saw. and glume discoloration (GlD) caused by several pathogenic fungi, including *Cochliobolus miyabeanus* were serious at Ndop Plain in the North West Province. The relatively high incidence of these diseases at Ndop Plain in the wet season and elsewhere in the dry season was probably due to low temperatures, which predisposed the crop to the fungi. ShR and GlD are believed to cause some direct yield losses, especially at Ndop Plain, because infected panicles fail to fully exsert.

Table 1. Rice production in different rice-growing areas of Cameroon.

Ecology and province	Area (× 10^2 ha)		Production (× 10^2 t)	
	1981-82	1986-87	1981 -82	1986-87
Irrigated rice				
Extreme North	172	105 (87)[a]	416	780
North	-	40	-	86
North West	26	34	58	104
West	10	10	10	20
Upland rice	7	10	14	24

[a]Double-cropped areas

Table 2. Distribution and severity of diseases in the major rice-growing areas[a] in Cameroon.

Disease	Disease severity[b]					
	Extreme North (300 m), irrigated	North (200 m), irrigated	North West (1200 m)		West (600 m)	
			Irrigated	Upland	Irrigated	Upland
Leaf blast	1	3/5	3	3/5	3/5	3/5
Neck blast	1	3/5	3	3/5	3/5	3/5
Sheath rot	1	3	5	5	3	3
Glume discoloration	1	3	5	5	3	3
Leaf scald	0	3	3	5	5	5/7
Brown spot	0	3	3	5	3	3
Bacterial blight	3	0	0	0	0	0

[a]Numbers in parentheses indicate altitude. [b]By the *Standard evaluation system for rice* scale 1-9.

Bacterial blight (BB) caused by *Xanthomonas oryzae* was only found in the Extreme North Province, on test varieties in experimental fields at Yagoua and Maga. IR46 is the only recommended variety grown on about 11,000 ha of irrigated fields in the Extreme North; it was found to be resistant to BB. Most recommended and promising rice varieties with better qualities than IR46 are susceptible.

In general, disease incidence or severity varied among the different rice-growing areas. The relatively low occurrence of diseases in the Northern Provinces may be due to several factors. High soil fertility results in healthy and vigorous plants better able to resist invasions by disease pathogens. Low humidity and higher wind velocities may prevent water droplets from being retained on leaf surfaces long enough to facilitate spore germination.

In the Western Highlands, the climate is more conducive to disease establishment. Mbo Plain in the West Province was found to be suitable for screening for rice Bl, LSc. and BS; Ndop plain in the North West. for ShR and GlD. ■

Collar rot of rice in Manipur

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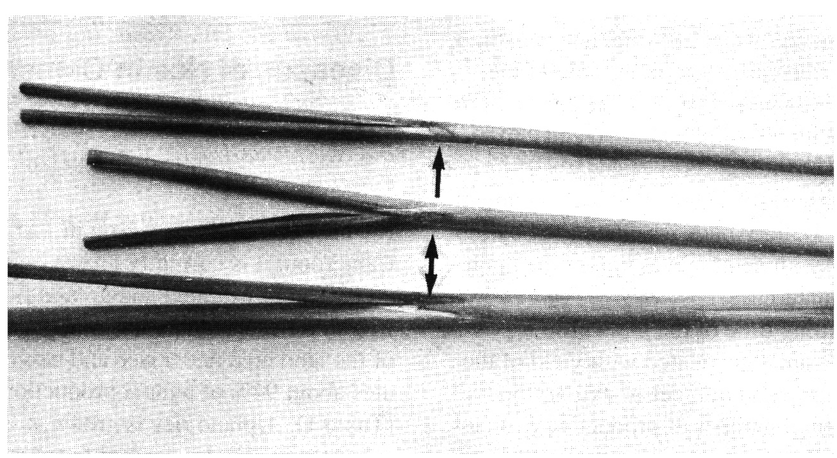
Rice varieties China and Akhanphou, and some new breeding lines of rice in experimental fields were affected by collar rot disease during 1989 wet season.

The disease appeared as small brown lesions at the collar joining the leaf blade and leaf sheath. As the disease advanced, lesions increased in size, turned dark brown, and caused rot (see figure).



Rice collar rot caused by *Ascochyta oryzae* Catt.

Eventually, the affected leaf blade withered and dropped off.

The causal organism was isolated on potato dextrose agar. A pathogenicity test was performed by placing a drop of mycelial fragment prepared from 7-d-old culture at the collar region during the late booting stage. Affected collar regions were collected and placed in sterile petri dishes lined with moist filter paper.

The fungus produced numerous pycnidia on the affected tissue. Pycnidia were dark, separated, immersed in host tissue, and ostiolate. Conidia were hyaline, oblong, rounded at both ends, 14-15 × 4 um.

The causal fungus was identified as *Ascochyta oryzae* Catt. This is the first record of its occurrence in Manipur. ■

Effect of some leguminous crops on number and viability of *Sclerotium oryzae* sclerotia

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Table 1. Effect of leguminous crops on number and viability of *Sclerotium oryzae* sclerotia. [a] **Sheikhupura, Pakistan.**

Crop rotation [b]	1986 wet season		1986-87 dry season		1987 wet season	
	Population	Viability (%)	Population	Viability (%)	Population	Viability (%)
R-W-R	9 a	63 a	8 a	70 a	8 a	87 a
R-L-R	8 a	60 a	10 a	78 a	7 a	74 a
R-G-R	9 a	52 a	10 a	64 a	13 a	83 a
R-B-R	14 b	73 a	8 a	41 b	6 a	89 a

[a] In a column, means followed by the same letter are not significantly different at P <0.05 by Duncan's Multiple Range Test. [b] R = rice, W = wheat, L = lentil, G = gram, B = berseem.

In the crop rotation pattern of Pakistan, rice usually follows wheat. Leguminous crops which have the ability to restore soil fertility by fixing N from atmosphere also are planted as dry season crops.

We studied the effect on rice of growing a leguminous crop in soil infested with sclerotia of *S. oryzae* (the cause of stem rot in rice). Wheat was planted as a control. The experiment was laid out in a complete block design with four replications.

Berseem (*Trifolium alexandrinum*) gram (*Cicer arietinum*), lentil (*Lens culinaris*), and wheat (*Triticum aestivum*) were planted in Nov and harvested in Apr. Rice (*Oryza sativa*) was transplanted in Jun and harvested in Oct. Recommended NPK was applied. Sclerotia were separated from soil by sieving and flotation technique after harvest of each crop. Their viability was tested on water agar supplemented with streptomycin sulfate and penicillin at 3,000 ppm each.

Population and viability were reduced up to 43% after berseem; there were no significant reductions in sclerotia after rice (Table 1). Rice yields increased significantly when berseem was used in the rotation (Table 2). ■

Table 2. Effect of a leguminous crop on rice yield. Sheikhupura, Pakistan.

Crop rotation	Rice yield [a] (t/ha)	Yield Increase (%)
Wheat - rice	5.1 c	-
Lentil - rice	5.2 bc	3
Gram - rice	6.0 b	17
Berseem - rice	6.9 a	35

[a] Means followed by the same letter are not signiftcantly different at P <0.05 by Duncan's Multiple Range Test.

Etiology of grain discoloration in upland rice in West Sumatra

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Rice grain discoloration is becoming a serious problem in tropical rice production areas, particularly in upland rice. In Indonesia, it is common to find the disease in upland rice grown in acid soils, such as the red-yellow Podzolic soils of West Sumatra.

We collected seeds of susceptible upland rice cultivar Tondano and panicles of local upland rice cultivars Arias and Simariti showing different levels of disease severity. The seeds were seeded after the agar plate test and incubated in a

Microorganisms associated with grain discoloration levels (1, 10, 30, 60, 100%) in upland rice. West Sumatra, Indonesia.

Microorganism	Microorganisms (%) at indicated level of grain discoloration				
	1%	10%	30%	60%	100%
Helminthosporium oryzae	14 [a]	17	22	41	40
Trichoconis padwickii	50	30	14	5	7
Phoma sp.	12	34	24	30	2
Nigrospora sp.	12	8	13	8	7
Curvularia sp.	9	7	15	7	8
Torula sp.	3	1	1	3	9
Mycovellosiella oryzae	1	4	0	3	0
Cercospora janseana	2	2	0	1	0
Phyllosticta sp.	0	2	1	2	0
Chaetomium sp.	0	0	0	5	0
Gerlachia oryzae	1	0	2	0	0
Phomopsis sp.	0	2	0	1	0
Cercosporaoryzae	0	0	1	2	0
Penicillium sp.	2	0	0	0	1
Gonatobotrys sp.	1	0	0	0	0
Macrophoma sp.	0	1	0	0	0
Memnoniella sp.	0	1	0	0	0
Helicoceras oryzae	0	0	1	0	0
Fusarium sp.	0	0	0	0	1
Diplodia oryzae	0	0	0	0	1

[a] Data from 100 seeds.

chamber at 20-25 °C and a 12-h day/night NUV light cycle. Pathogenicity tests were carried out.

Twenty fungi genera were identified (see table). *H. oryzae* was the most common fungus isolated. Pathogenicity tests reproduced typical grain discoloration symptoms. ■

Integrated pest management — insects

Leaffolder (LF) outbreak in Punjab, Pakistan

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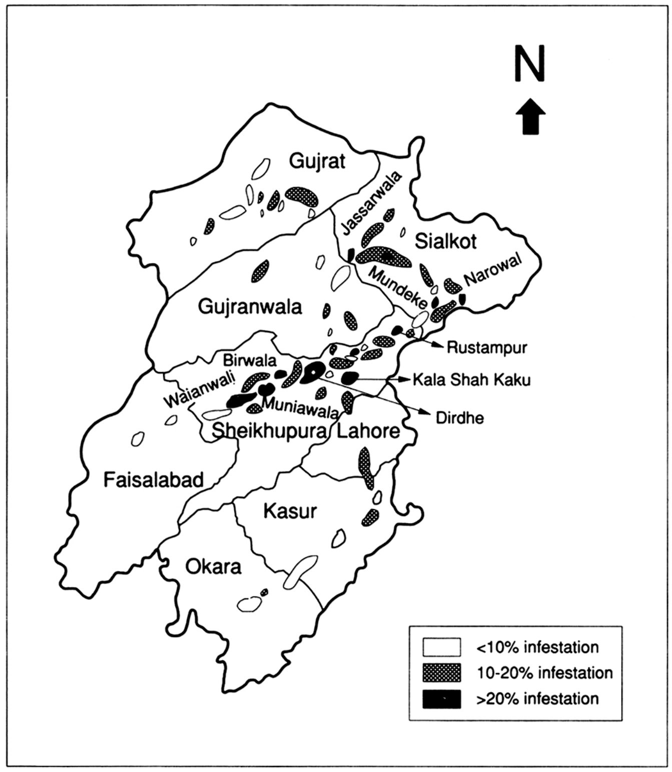
The rice LF *Cnaphalocrocis medinalis* (Gn), long considered a minor pest of rice in Pakistan, has attained the status of a major pest in the last few years, and has caused considerable losses to the rice crop. During the 1989-90 crop season, the pest multiplied enormously, with severe incidence observed during Aug-Sep.

We conducted a survey of LF incidence on 2,941 ricefields at 73 locations in eight rice-producing districts of the Punjab.

The crop was severely damaged in Sheikhupura, Sialkot, and Gujranwala Districts (see figure). Infestation was 51% at Dirdhe Dogran in Sheikhupura. In Sialkot, Jassarwala showed 25% infestation. In Faisalabad, Okara, Kasur, Lahore, and Gujrat Districts, infestations were less than 10%.

About 80% of the rice area was planted to Basmati 385, a fine, aromatic, and high-yielding variety. Average damage to this crop was 16.6%; damage on Basmati 370, Kashmira, and Palman was 12.7, 5.7, and 57.3%, respectively (see table). Infestation in the late crop was higher than in the early crop. Infestation in shady areas was much higher than in nonshaded areas. ■



Leaffolder incidence in the Punjab, 1989.

Leaffolder infestation as affected by different factors in ricefields. Punjab, Pakistan, 1989-90.

	Infestation (%)							
	Variety				Cultural		Environmental	
	Basmati 370	Basmati 385	Kashmira	Palman	Early crop	Late crop	Shady areas	Nonshaded areas
	13.7	15.6	5.3	70.3	10.3	35.0	40.7	13.7
	10.9	15.5	4.7	45.9	7.5	23.5	55.9	13.9
	15.1	16.2	8.5	85.0	7.2	27.2	72.3	15.3
	15.7	20.5	7.2	40.5	6.3	39.1	42.0	17.2
	8.5	13.4	6.3	57.9	13.8	40.2	45.9	10.3
	10.7	10.6	3.4	55.9	10.9	24.3	65.1	20.5
	17.2	19.7	6.3	55.0	12.1	20.5	70.5	17.2
	8.7	20.3	3.7	47.5	9.0	29.5	69.2	21.0
	11.5	17.5	5.6	69.7	13.4	40.0	50.1	15.3
	14.5	16.7	5.8	45.2	8.5	22.2	49.5	10.2
Mean	12.7	16.6	5.7	57.3	9.9	30.2	56.1	15.5

Sugarcane pest found in Sulawesi ricefields

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The sugarcane mite *Aceria* (= *Eriophyes*) *saccharini* (Wang) was first reported in Java by van Hall in 1923. It was discovered on rice at Maros Experimental Farm in 1988. Damage symptoms had been noticed for several years before identification.

In 1989, the mite damaged more than 775 ha of rice in South and Central Sulawesi. Rice plants show brownish yellowing leaves about 3-4 wk after transplanting. In heavier infestations, plants exhibit stunting. Up to 1,000 mites/leaf can occur. Infestations are heavier in the dry season.

Indonesian rice varieties Cisadane, Pelita I-1, and Cisanggurang are more resistant to the mite than are IR26, IR42, IR48, and IR64. ■

A potential fungus agent for natural control of cutworm *Pseudaletia unipuncta*

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In 1989, *P. unipuncta* (also known as *Mythimna separata, Mythimna unipuncta, Cirphis unipuncta, Leucania unipuncta, P. separata*) occurred in abundance (3-5 larvae/hill) in mature rice in experimental fields. Heavy rains (174.5-246.5 mm) the first week of Nov inundated all the fields, and might have created a favorable climatic condition for pest multiplication.

But observations in the field showed many caterpillars died naturally (see figure). We examined the dead caterpillars and found them infected with a fungus, tentatively identified as green muscardine by the Pathology Laboratory.

Fields were left without pest control to assess the potential of the fungus to control cutworms. During the period, prevailing temperatures were 31.3-28 °C (maximum) and 20.8-17.4 °C (minimum); relative humidity was 73-95% at 0830 h and 44-73% at 1730 h. No rain fell. All caterpillars were infected within 15 d.

Simultaneously, a laboratory experiment on potted plants assessed the potential of the fungus. Infected caterpillars were collected, ground, mixed with water at 2 caterpillars/liter, and sprayed on 10 potted plants. Control plants were sprayed with water. Healthy *P. unipuncta* caterpillars were released on the potted plants at 5 caterpillars/plant.

All caterpillars in all treated pots died within 48 h.

Infected caterpillars were sent to the Plant Health Clinic for isolation and positive identification of the pathogen. ■

Dead, pathogen-infected caterpillar on a rice plant.

Farming systems

Intercropping a green manure with direct seeded rice

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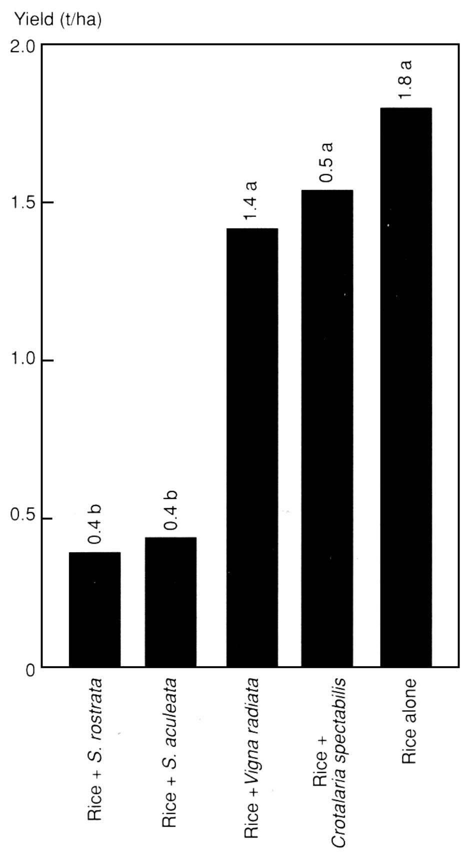
Upland rice is inefficient in Bangladesh where the organic matter content of soil is very low and the crop is subjected to various adverse environments. Intercropping or mixed cropping of legumes with rice could increase total land productivity.

We experimented with four legume intercrops under upland conditions during aus (wet season first crop) 1989. The experiment was laid out in a randomized complete block design with four replications. Rice variety BR21 was wet seeded (60% germination) 26 May at 100 kg/ha in rows 30 cm apart in 3- × 3-m plots. Legumes were sown between alternate rice rows the same day.

Radiation interception by *S. rostrata* and *S. aculeata* was measured 50 d after emergence. Dry aboveground biomass of legumes except mungbean was measured. Sun-dried grain yields of rice and mungbean were recorded; rice yields were adjusted to 14% moisture.

Vigna radiata (cultivar Mubarik) and *Crotalaria spectabilis* can be intercropped with rice without significant rice yield loss (see figure). Slow-growing *C. spectabilis* and dwarf Mubarik offer rice little competition for space and light.

The luxuriant growth of *S. rostrata* and *S. aculeata* suppressed rice growth severely. They intercepted most of the radiation (79.62 and 83.77%, respectively) at the reproductive stage of rice. *S. aculeata* produced the highest shoot biomass (2.2 t/ha) (see table). ■



Effect of intercropping with legume green manuring crops on grain yield of rice variety BR21.

Dry shoot weight of green manure crops intercropped with rice. Bangladesh, 1989.

Crop	Yield (t/ha)
Vigna radiata (cultivar Mubarik)	0.4[b] d
Crotalaria spectabilis	1.4 c
Sesbania aculeata	2.2 a
Sesbania rostrata	2.0 b
CV (%)	5.0

[a] Means followed by the same letter are not significantly different at the 1% level by DMRT. [b] Grain yield.

Alternate crops for an upland rice-based cropping system in Karnataka

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Drought in recent years has caused very low rice yields (around 1 t/ha), leading to low income for farmers in upland rice areas. We evaluated 12 alternative low water-requiring crops and rice varieties Champakali and Rasi for yield potential and return during the 1987-89 wet seasons.

The field experiment was laid out in a randomized block design with three replications. Practices recommended for the transitional area (a narrow strip at 400-900 m elevation with 620-1300 mm annual rainfall) were followed.

Total precipitation during the cropping seasons was 738 mm in 1987, 1034 mm in 1988, and 607 mm in 1989. Rainfall early in the 1987 and 1989 seasons was far below average, leading to lower rice yields (see table). In those years, hybrid maize gave the highest mean yield, followed by ragi, groundnut, red gram. and hybrid cotton. Gross returns were highest for groundnut, followed by hybrid cotton, hybrid maize, red gram, and ragi.

In 1988, continuous heavy rainfall from Jun to Sep 1988 resulted in complete failure of all crops except rice. Average rice yield was 4.5 t/ha for Champakali and 3.5 t/ha for Rasi.

Our conclusion is that other crops cannot always replace rice in the uplands, but there is scope to include other crops like hybrid maize, ragi, groundnut, red gram, and hybrid cotton in rice-based systems, to stabilize yield and income across seasons. ■

Yield and gross returns from crops in a rainfed upland rice system. Mugad, Karnataka, India, 1987-89.

Crop	Mean of 1987 and 1989		Mean of 1987, 1988, and 1989	
	Yield (t/ha)	Return ($/ha)	Yield (t/ha)	Return ($/ha)
Ragi	3.3	373	2.2	248
Green gram	0.6	242	0.4	161
Niger	0.5	196	0.3	131
Groundnut	2.0	791	1.4	527
Soybean	0.7	171	0.4	114
Black soya	0.6	161	0.4	107
Cowpea	0.4	123	0.3	82
Sunflower	0.4	111	0.3	74
Red gram	1.4	391	0.9	261
Hybrid maize	4.5	565	3.0	376
Castor	0.7	324	0.5	216
Hybrid cotton (DCH-32)	1.4	694	0.9	463
Cotton (DB-3-12)	0.5	238	0.5	238
Rice (Champakali)	0.6	73	1.9	220
Rice (Rasi)	1.1	122	1.9	215

Rice-based cropping systems for irrigated ricelands

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We studied the effect of irrigation on the performance of wheat and mustard under zero tillage after drill sown and transplanted rice in 1989-90.

The soil was clay with pH 6.7, 0.64% organic C, and 17.3 kg available P_2O_5 and 148 kg available K_2O/ha. The experiment was laid out in a split-plot design with three replications.

Abhilash rice (150 d duration) was harvested 7 Dec 1989. HD-2189 wheat (115 d duration) was sown in 20-cm rows and Sita mustard (85 d duration) was sown in 40-cm rows on 29 Dec. Both crops received 50 kg N and 13 kg P/ha. Total precipitation during 1989-90 was very low (687.9 mm), which necessitated two common irrigations to all plots in the early vegetative phase, for crop establishment.

Wheat recorded the highest grain yield with irrigation at seeding, vegetative, flowering, and grain filling stages. Skipping one irrigation at the vegetative phase reduced yield 23%; skipping irrigations at vegetative and at grain filling stages reduced yield 41% (see table). Mustard yields did not differ significantly with irrigation. Monetary returns were higher for wheat. ■

Production potential of irrigated wheat and mustard after irrigated rice. Karnataka, India, 1989-90.

Treatment	Grain yield (t/ha)		Net profit ($/ha)	Benefit-to-cost ratio
	Wheat	Mustard		
Rice planting method				
Drill seeding	2.2	0.6	270	3.02
Transplanting	2.2	0.4	208	2.64
Irrigation level				
At seeding and flowering	1.7	0.5	170	2.30
At seeding, flowering, and grain filling	2.2	0.5	222	2.71
At seeding, vegetative phase, flowering, and grain filling	2.9	0.6	325	3.47
Average				
Wheat			316	3.68
Mustard			162	1.97

Farm machinery

Hydrotillers for wetland ricefields

G. R. Quick and H. T. Manaligod, Agricultural Engineering Division; and L. B. Aclan, Experimental Farm, IRRI

The IRRI Hydrotiller is a semifloating rototiller designed to puddle and level soil and to incorporate residues, weeds, or green manure in waterlogged or submerged ricefields. Two models—1.0 m working width (requiring 7-10 hp engine) and 0.8 m working width (requiring 5-6 hp)—are now in commercial production in Southeast Asia.

IRRI has used these Hydrotillers on its research farm field plots and seed increase areas. Advantages are as follows:

- High maneuverability, for speedy puddling and land preparation.
- Capable of working in areas inaccessible to wheeled tractors or water buffalo.
- The entire area of plot or farm field parcel is worked over because the machine cultivates to the edges of bunds, trims edges and corners, and controls and incorporates weeds.
- Two passes at right angles can prepare well-soaked fields or plots for transplanting or direct seeding. without plowing and harrowing.

New IRRI hydrotiller (1.m working width) being used to incorporate stubbles in a puddled ricefield.

The 0.8-m Hydrotiller is small enough to be carried by two people. It is maneuverable enough to work in very small plot areas, even as small as 10 m^2. The regular Hydrotiller can work up to 2 ha with two passes in an 8-h day. It can incorporate *Sesbania rostrata* up to 1.5 m tall (the 0.8-m Hydrotiller cannot work tall green crops or heavy weeds). The twin hulls of the hydrotillers leave no permanent trails, and normal transplanting or direct seeding operations can follow shortly after working with the machines.

Costs in the Philippines are around US$1300 for the 1.0-m Hydrotiller, including 10-hp gasoline engine, and $700 for the 0.8-m Mini Hydrotiller, including 5-hp engine with half-speed power takeoff. Blueprints are available free to potential manufacturers from IRRI's Agricultural Engineering Division. ■

ENVIRONMENT

Meteorological aspects of wet season rice cultivation in Sunderbans region, India

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We used three dual-purpose volumetric type rectangular metallic lysimeters (1.2 × 1.2 × 0.90 m) sunk in the middle of well-exposed fields to record crop data. Daily meteorological data of weeks 30-43 for 6 yr 1982-88 were collected from the CSSRI meteorological observatory at 88°40' E longitude. 22°15' N latitude, and 3 m altitude.

Local improved, salt-resistant, waterlogging-tolerant varieties CSR4 and CR6 were planted in the lysimeter at 15- × 15-cm spacing during the wet seasons. Abstracted mean weekly values of rainfall (R), pan evaporation (PE), lysimetric evapotranspiration [ET(L)], and calculated crop coefficient (Ckp) were recorded Jul-Oct (Table 1).

Weekly PE ranged from 25 mm (Oct) to 31 mm (Aug). ET(L) ranged from 29 mm (Jul) to 39 mm (Oct). Based on ET/PE, Ckp ranged from 1.08 (Jul) to 1.57 (Oct), with an average of 1.30 for the season.

Observed ET(L) was compared with computed potential evapotranspiration (PET) (unadjusted/grass reference/alfalfa reference) by nine empirical methods: Blaney-Criddle (2), Christiansen Default Option, Hargreaves, Jensen-Haise, Turc, Modified Penman, Radiation, and Thornthwaite (Table 1). Coefficient of variation (CV) ranged from 5.7% (Blaney-Criddle) to 43% (Turc), with an average of 17.3%. Observed ET(L) gave a CV of 17.4%. Observed ET(L) was at par with computed PET values by the Blaney-Criddle, Jensen-Haise, and Turc methods.

ET(L) was at par with PET by Modified Penman and EV or PET by Christiansen Default Option, but computation through these methods requires weather data not commonly available at all agrostations.

We observed that ET(L) had a close relationship with the increasing crop period (weeks 1-14) and produced the relationship ET(L) = 30.6224 + 0.6224 W ($r = 0.411^{**}$ at 82 df). Regression relationships between computed PET (X variable) and observed ET (Y variable) were also established (Table 2). ■

Table 1. Abstracted mean of rainfall, pan evaporation, lysimetric evapotranspiration, and crop coefficient for Sunderbans, India, 1982-88.

Item[a]	Weekly average (mm)				Weekly average for season	CV (%)
	Jul	Aug	Sep	Oct		
Rainfall	91	80	54	20	55	117.7
PE	27	31	30	25	28	17.5
ET(L)	29	33	37	39	35	17.4
CkP	1.08	1.14	1.29	1.57	1.30	17.4
Ev (Blaney-Criddle, 1950)	45	47	45	41	44	5.7
Ev (Christiansen Default Option, 1968)	46	38	38	39	39	19.0
ETO (Hargreaves 1985)	27	28	26	26	27	9.6
ETO (Blaney-Criddle, 1977)	59	66	66	72	66	12.4
ETO (Blaney-Criddle, 1950)	58	58	49	37	49	18.4
ETO (Radiation)	40	45	43	45	43	17.2
ETr (Jensen-Haise, 1963)	29	34	34	34	33	18.3
PET (Modified Penman)	36	38	36	32	35	16.0
PET (Christiansen Default Option, 1968)	60	47	42	35	46	24.6
PET (Turc 1960)	26	41	48	69	46	43.5
PET (Thornthwaite)	40	41	39	32	38	19.0

[a]PE = pan evaporation, ET(L) = evapotranspiration (lysimetric), Ev = evaporation equivalent to potential pan evaporation, ETO = grass reference potential evapotranspiration, ETr = alfalfa reference potential evapotranspiration.

Table 2. Regression relationships between computed potential evapotranspiration and observed lysimetric evapotranspiration.[a]

Method		Relationship	Correlation coefficient
Blaney-Criddle (1950)	:	ET (L) = Exp (4.8193-0.0205 * EV)	$R = 0.587^{*}$
Jensen-Haise	:	ET (L) = 1.4834 * ET-14.2668	$R = 0.782^{**}$
Turc	:	ET (L) = Exp (2.3415 + 0.3155 Log PET)	$R = 0.796^{**}$
Blaney-Criddle (1977)	:	ET (L) = Exp (-2.4723 + 1.4353 Log ETr)	$R = 0.763^{**}$
Blaney-Criddle (1950)	:	ET (L) = Exp (3.9608-0.0081 ETO)	$R = 0.572^{*}$

[a] Data for weeks 30-43 for 1982-88. * = significant at the 5% level, ** = significant at the 1% level.

ANNOUNCEMENTS

Intensive Weed Management Course at Oregon State University

The International Plant Protection Center at Oregon State University (USA) will conduct an intensive 3-wk, "hands-on" Weed Management Strategies short course 8-26 Jul 1991. The course emphasizes appropriate research strategies and methods for developing countries and is specifically designed for specialists in agriculture.

A free descriptive brochure is available from WMS91 Course, International Plant Protection Center, Oregon State University, Corvallis, OR 97331-3904/USA.

Environmental studies directory

The *1990 Directory of Country Environmental Studies* is now available from the World Resources Institute's Center for International Development and Environment.

The book is a desk-top guide to environmental assessments, profiles, and strategies completed within the last 10 yr or currently under way. The annotated bibliography presents key information about the content and availability of more than 240 studies on environmental and natural resource conditions in developing countries.

Environmental studies featured cover biological diversity, forestry, natural resources, environmental quality, infrastructure, natural disasters, landforms and use, oceans and coasts, pollution, energy, soil, and water—and their links to economic development. The Directory covers 110 countries in Africa, Central and South America, the Caribbean, Asia, and Oceania, as well as selected multinational and subnational regions.

A companion IBM-compatible diskette of the data base is also available.

For purchasing information, write CIDE Publications, 1709 New York Ave., NW, 7th floor, Washington, D.C. 20006, USA.

New IRRI publications

Program report,for 1989
Phosphorus requirements for sustainable agriculture in Asia and Oceania
Rice: then and now, by R.E. Huke and E.H. Huke
Index of varieties, cultivars, and lines, IRRN Vol. 1, 1976-Vol. 12, 1987
Sharing innovation: global perspectives on food, agriculture, and rural development. Copublished by the Smithsonian Institution Press and IRRI

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