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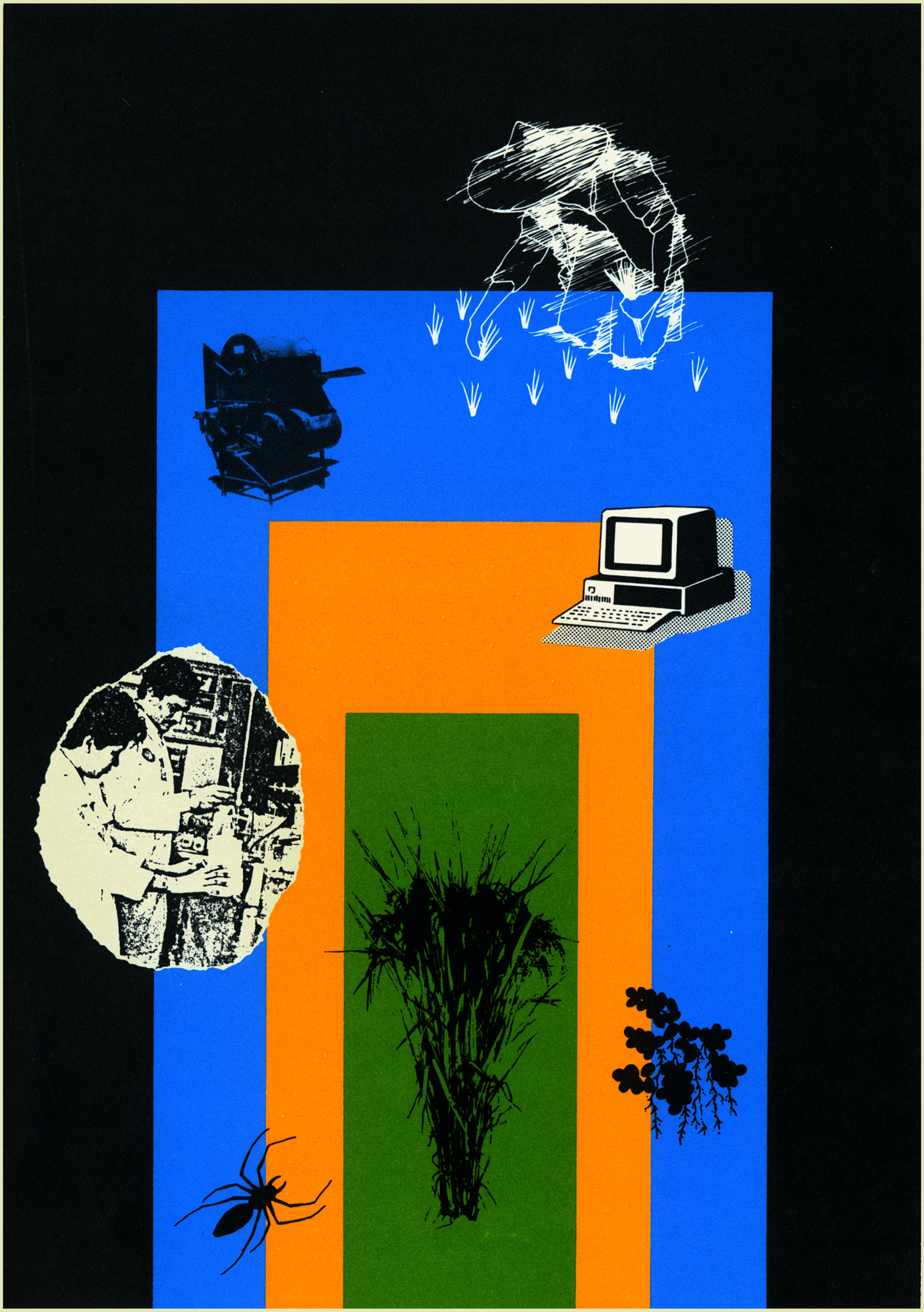

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IRRN GUIDELINES

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 reports

- 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
- farming systems
- farm machinery
- postharvest technology
- economic analysis

ENVIRONMENT

SOCIOECONOMIC IMPACT

EDUCATION AND COMMUNICATION

RESEARCH METHODOLOGY

CONTENTS

GERMPLASM IMPROVEMENT

Genetics

Polymorphism in *Oryza malampuzhaensis*

P. T. Annie and P. G. Nair, Botany Department, Kerala University, Kariavattom, Trivandrum 695581. Kerala, India

Studies on *O. malampuzhaensis* Krishn. et Chandn., a tetraploid wild rice from South India, are scanty because it is poorly represented in germplasm and herbarium collections. We compared recent collections of this taxon: Ac 42 from the National Bureau of Plant Genetic Resources Regional Station, Trichur, India, and four accessions collected from natural habitats along the western Ghat, South India (Ac 51 from Parambikulam, Ac 55 from Nilambur, Ac 56 from Vellani, and Ac 57 from Peechi).

Tillers at the 3-leaf stage were separated from the perennial parent plant and grown in pots, with four replications. A minimum 5 tillers/plant were observed at appropriate stages of development (see ,table).

Accessions varied in all characters evaluated except chromosome number. Meiotic studies showed regular formation of 24 bivalents at diakinesis. It is evident this taxon is polymorphic, with much wider distribution than was hitherto known. Further studies are needed to elucidate its taxonomic status and evolutionary position. ■

Variation in quantitative and qualitative characters of 5 accessions of tetraploid wild rice from South India.

Character	Mean					LSD (p=0.05)
	Ac 42	Ac 51	Ac 55	Ac 56	Ac 57	
Boot leaf length (cm)	27.5	25.3	20.1	23.3	21.0	2.28
Boot leaf width (cm)	2.0	1.5	1.6	1.5	1.5	0.09
Peduncle length (cm)	60.1	64.7	47.2	50.9	57.9	6.59
1st internode length (cm)	28.2	25.0	20.0	20.5	23.2	2.73
Culm length (cm)	127.7	115.0	73.1	80.9	88.5	10.21
Panicle length (cm)	21.8	19.7	17.8	21.4	18.7	1.93
Av length of primary branch (cm)	12.3	13.5	9.1	10.7	9.9	1.96
No. of primary branches/ panicle	9.7	6.6	6.7	6.1	6.2	0.74
No. of spikelets/panicle	166.6	118.3	81.0	88.2	82.9	16.02
Ligule length (mm)	3.1	2.9	1.8	2.7	2.7	0.17
Spikelet length (mm)	6.1	5.6	4.9	5.8	5.4	0.16
Spikelet width (mm)	2.3	2.5	2.2	2.3	2.4	0.12
Spikelet length/width ratio	2.6	2.3	2.2	2.5	2.2	0.15
Spikelet thickness (mm)	1.5	1.5	1.3	1.4	1.4	0.05
Sterile glume length (mm)	1.2	1.5	1.0	1.5	1.3	0.12
Awn length (cm)	0.4	1.4	0.7	0.7	0.9	0.18
Chromosome number (n)	24	24	24	24	24	
Pollen sterility (%)	8.9	5.4	10.9	26.4	65.7	
Ligule fringing	Long, very dense	Short, sparse	Short, dense	Short, very sparse	Very long, moderately dense	
Stigma color	Very dark purple	Dark purple	White	Purple	Dark purple	
Blooming time	0730-1030 h	0800-1200 h	0800-1200 h	0800-1400 h	0730-1500 h	

Breeding methods

Identifying maintainers and restorers of CMS lines for hybrid rice breeding

J. B. Tomar, Birsa Agricultural University, Kanke, Ranchi 834006, India (present address: National Bureau of Plant Genetic Resources Regional Station, Hinoo House, Hinoo, Ranchi 834002, India); and S. S. Virmani, IRRI

We crossed 40 rice cultivars as pollen parents with cytoplasmic male sterile (CMS) lines V20 A, V97 A, Pankhari 203 A, IR46826 A, IR54752 A, and IR54753 A, to identify maintainers and restorers for varying agroclimate and

Table 1. Maintainers and restorers in the CMS lines of rice.

Cultivar	Classification [a]					
	V20 A	V97 A	Pankhari 203 A	IR46826 A	IR54752 A	IR54753 A
Bala	PR	M	PR	PR	R	R
Kiran	PR	PR	PR	PR	R	PR
Kanchan	PR	R	PM	PR	PM	PM
Browngora	PM	R	PR	PR	PR	PR
Birsa Dhan 101	PM	PR	PM	PR	PR	PR
Birsa Dhan 202	PM	PM	PM	PM	PM	PM
Basmati 370	R	PR	PM	PM		PM
Rajendra Dhan 202	R	PR	PM	R	R	PR
Sita	PR	PR	PM	PM	PR	PM
BR8	PM	PM	PR	R	M	PR
BR9	PM	M	PR	PR	PR	PM
RAU4045-10	M	M			PM	PR
Akashi	M	PR		R		PR
Rasi	PR	PR	PR	PR	PR	M
Ratna	PR	R	PM	R	R	PR
Mahsuri	PM	R	PM	PR	PR	PR

continued next page.

Table 1 continued

Cultivar	Classification[a]					
	V20 A	V97 A	Pankhari 203 A	IR46826 A	IR54752 A	IR54753 A
Kalinga 3	PM	PR	PM	PR	PR	R
Dular	PR	PM	PM	PR	PM	R
Jaya	PM	PM	-	PM	PM	-
BG380-2	PR	PR	-	PR	PR	PR
BAU4045-2BI	PR	PR	PM	PR	PR	PM
BAU151-52	M	PM	PM	PR	PR	PM
NDR85	R	PM	PR	PM	R	PR
BAU148-28	R	PR	PR	PM	PR	PR
BAU148-30	PM	M	PM	PR	R	PM
ZHU XI-26	PR	PR	PM	PR	PR	M
IET7564	M	PM	PR	R	PM	R
Saket	PR	PM	-	R	PM	R
IET9789	R	PR	PR	PR	PR	-
IET9810	R	PR	PR	R	R	R
IET9815	R	R	PR	PR	PR	PR
VLK39	PR	PR	-	R	PR	PR
Sattari	PR	PR	-	PR	-	PR
Kalkari	PM	PR	-	-	M	PM
Neela	M	PR	PM	-	PR	PR
Sujata	PR	PR	PR	PR	-	PR
Archana	PR	PR	PR	PR	-	PR
RR51-1	PR	PR	-	R	PR	-
OR164-5	PR	PM	-	PM	PR	-
HPU734	PR	PM	PR	M	PR	-
IR50	R	R	-	-	-	-
IR88-30-3- 1-4-2	PR	PR	-	-	-	-
IR24594-204- 1-3-2-6-2	PM	PR	-	-	-	-
IR64	PR	PM	-	-	-	-
BG367-7	PR	R	-	-	-	-
Kalimeksi 77-5	PR	PR	-	-	-	-
IR62	PR	PR	-	-	-	-
SR4095-19-2-3-5-4	R	R	-	-	-	-
K438	R	PR	-	-	-	-
IR27078-3-6	PR	PM	-	-	-	-
IR19746-28-2-2-3	PM	PM	-	-	-	-
IR32093-B-1-B-23	PM	M	-	-	-	-
TKM6	PR	PM	-	-	-	-
IR912Y-KI	PR	PR	-	-	-	-
Tres Meses	PR	PM	-	-	-	-
IR29423-B-3-B-2-5-1	M	PM	-	-	-	-
S290	PR	PM	-	-	-	-
AC19-1-1	PM	PR	-	-	-	-
IR13155-60-3-1-3-1-1-3	M	PM	-	-	-	-
IR20897-B-6	PR	PM	-	-	-	-
IR29416-B-3-B-6-5-12	PR	PM	-	-	-	-
IR7790-18-1-2	PM	PR	-	-	-	-
IR28224-3-2-3-2	R	R	-	-	-	-

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

Table 2. Isolation of maintainers and restorers of IR46828 A and IR54752 A.

Designation	Cross	Classification
TN8891	IR46828 A/IR36 P_1	PR
TN8893	IR46828 A/IR36 P_2	R
TN8895	IR46828 A/IR36 P_3	PR
TN8897	IR46828 A/IR36 P_4	R
TN8971	lR54752 A/IR35454-18-1-2-2-2 P_1	R
TN8973	IR54752 A/IR35454-18-1-2-2-2 P_2	PR
TN8983	IR54752 A/IR35293-178-2-3-1 P_1	PR
TN8985	IR54752 A/IR35293-178-2-3-1 P_2	R
TN9003	IR54752 A/IR28224-3-2-3-2 P_1	R
TN9005	IR54752 A/IR28224-3-2-3-2 P_2	PR
TN9015	IR54752 A/IR2307-247-2-2-3 P_1	PR
TN9017	IR54152 A/IR2307-247-2-2-3 P_2	R

biotic stresses. In addition, 23 more cultivars were crossed with V20 A and V97 A.

Pollen of each CMS line (tested by 1% iodine solution before crossing) was found to be highly sterile. The pollen parents and the F_1s were transplanted together to determine maintainers and restorers. Panicles were bagged before emergence.

On the basis of spikelet fertility, the cultivars were classified as effective restorer (>80% spikelet fertility), weak or partial restorer (40-79%), weak or partial maintainer (1-39%), and effective maintainer (<1%).

Effective restorers and maintainers for the CMS lines are in Table 1. IR46826 A, IR54752 A, and IR54753 A were found suitable for rainfed lowlands in the plateau region of Bihar.

Spikelet fertility was observed at IRRI on F_1 progenies (10 plants each) of IR46828 A and IR54752 A and single plant selections of elite cultivars. Single plant selections of cultivars showed R to PR reaction (Table 2), indicating different restoring ability. It is necessary to purify cultivars for fertility restoration ability before using them in developing F_1 rice hybrids. ■

Yield potential

Seed dormancy of rice varieties released by Andhra Pradesh Agricultural University (APAU)

P. S. S. Murthy, P. J. R. Reddy, and S. S. R. Prasad, Agricultural Research Station, Maruteru 534122, W.G. Dt., Andhra Pradesh (AP), India

Seed dormancy is needed in rice varieties grown during wet season (kharif) in AP coastal districts, which are prone to suffer cyclones and heavy rains at harvest.

We evaluated seed dormancy of all rice varieties released by APAU. Seed samples were collected 30 d after flowering and moisture content brought to 13-14% by sun drying. Dormancy duration (period required

Duration of dormancy of varieties released by APAU, India.

Variety with indicated dormancy					
1 wk	2 wk	3 wk	4 wk	5 wk	6 wk
Puskala	Sowbhagya	Dhanya	Gowthami	Vasista	Gutti Akkulu
Hamsa	Prathibha	Lakshmi	Chaitanya	Kotha-	Kothamolakolukulu 72
Tella-Hamsa	Sona	Kakatiya	Vajram	Bayahunda	Kothamolakolukulu 74
	Mahsuri	Vamsi	Mahendra		
Rajendra	Pothana	Prabhath	Krishnaveni		Pinakini
Sathya	Saleema	Vijaya-Mahsuri			Tikkana
Badva		Nagavali			
Mahsuri		Lakshmi			
Mahsuri		Surekha			
		Samba -			
		Mahsuri			
		Swarna			

for 80% germination) was estimated by germination percentage.

Germination was tested weekly starting 1 wk after harvest, by sowing 100 seeds of each variety on a petri dish with four replications. Samples were maintained at a constant 30°C.

In general, long-duration varieties had longer seed dormancy (4-6 wk) than medium-duration varieties (2-3 wk) and short-duration varieties (1-2 wk) (see table). Exceptions are some long-duration varieties (Badva Mahsuri, Mahsuri, Sowbhagya, Prathibha, and Sona Mahsuri) that exhibited shorter dormancy (1-2 wk). ■

Effect of variety, nitrogen, and stubble height on ratoon rice yield

R. Balasubramanian and A. Mohamed Ali, Agricultural College and Research Institute, Killikulam 627252, Tamil Nadu, India

Short-duration varieties ADT36, ASD16, and ADT37; N (75, 100, and 125 kg/ha), and 20- and 30-cm stubble height were tested in a split-plot design with three replications. The main crop followed recommended practices.

ADT37 had the highest ratoon crop grain yield, straw yield, and productive tillers and highest daily productivity (see table).

Nitrogen at 125 kg/ha gave significantly higher grain yield, straw yield, and daily productivity than 75 kg N/ha.

Stubble height had no effect on ratoon yields and productive tillers.

The high grain yield in ADT37 could be due to greater number of productive tillers. ■

Effect of variety, nitrogen, and stubble height on ratoon rice yield.

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Productive tillers (no./hill)	Days to maturity (no.)	Productivity (kg/d)
ADT36	2.5	2.5	8.7	77.4	32.3
ADT37	2.8	2.6	10.2	76.5	36.6
ASD16	2.2	2.3	8.5	89.4	24.6
LSD	0.1	0.1	1.2	2.3	-
75 kg N/ha	2.4	2.4	8.8	80.2	29.9
100 kg N/ha	2.5	2.5	9.1	81.1	30.8
125 kg N/ha	2.7	2.5	9.4	82.1	32.9
LSD (0.5)	0.1	0.1	ns	2.3	-
20-cm stubble	2.5	2.4	9.2	81.3	30.8
30-cm stubble	2.5	2.5	9.1	80.9	30.9
LSD	ns	ns	ns	ns	-

Pest resistance — diseases

Resistance of some rice varieties to sheath blight (ShB)

Xue-Yan Sha and Li-Hong Zhu, Nanjing Agricultural University, Nanjing 210014, China

ShB caused by *Rhizoctonia solani* is an increasingly serious disease of rice in the Yangtze River Basin, especially hybrid rice. In the search for resistance genes to transfer into commercial

Reaction [a] of varieties to ShB during 1987-89 in China.

Cultivar	Disease ratings (mean and SD) [b] 1987	1988	1989	Average [a]
Ta-poo-cho-z	1.43±0.389	0.46±0.190	1.35±0.293	1.08 a
Tetep	2.05±0.315	0.57±0.157	1.65±0.245	1.19 a
Guyanal	1.19±0.304	1.72±0.198	1.93±0.305	1.61 a
IET4699	2.47±0.249	0.49±0.153	2.53±0.233	1.72 ab
Ratna	1.92±0.283	0.98±0.222	2.58±0.287	1.83 ab
Jawa no. 14	2.51±0.214	0.74±0.153	2.50±0.292	1.93 ab
IR64	2.47±0.294	1.01±0.282	2.35±0.201	1.94 ab
Kataktara Da-2	2.9 ±0.206	0.96±0.240	2.51±0.180	2.12 ab
Mian-Hua-Tiao	2.96±0.227	1.58±0.218	2.90±0.200	2.48 ab
Ye-Dao	2.91±0.224	1.90±0.255	3.15±0.275	2.65 ab
P5275	2.85±0.304	2.16±0.335	3.01±0.401	2.67 ab
Nampungbyeo	2.78±0.316	2.15±0.279	3.21±0.248	2.71 ab
IR9752-71-3-2	4.24±0.411	3.76±0.327	4.56±0.309	4.22 b

[a] 0 = no lesion, 5 = lesions extend to top sheath. [b] Mean of 10 random hills/treatment with 2 replications. [c] Means followed by the same letter are not significantly different by new Duncan's multiple range test at the 1% level.

varieties, we field-tested 12 resistant varieties and susceptible IR9752-71-3-2. We examined disease variation within year and interaction between year and variety during May-Oct 1987-89 in a randomized complete block design with two replications. Plants were inoculated by stem-tape-inoculation method at maximum tillering and evaluated 2 wk later on 0-5 scale.

The results show differences among the tested varieties, although the differences varied from year to year. Tetep, Ta-poo-cho-z, and Guyanal were best resistance donors in this test (see table).

Because the interaction between variety and year was highly significant, data for several years are essential in screening. ■

Pest resistance — insects

Resistance in rice to gall midge (GM) under natural conditions

C. R. Elsy, C. A. Rosamma, and N. R. Nair, Regional Agricultural Research Station, Pattambi, Kerala, India

We evaluated 16 medium-tall rice varieties from the Directorate of Rice Research, Hyderabad, during 1989 wet season to identify donors of resistance to rice GM and leaffolder (LF). Entries were planted in 13 rows at 10- × 15-cm spacing with three replications. Pest infestation was scored at 40 d after transplanting.

LF incidence was low during the season. GM infestation varied greatly among the entries (see table). Damage to the susceptible check exceeded the minimum threshold score of 3.

Resistance of rice cultivars to GM. Pattamhi, Kerala, India.

Designation	Cross	Mean score[a]	Average yield (t/ha)
RP2432-85-3-1	IR36/1ET7916	0	2.3
R320-298	Samridhi/IR36	2	2.9
RP1579-1633-55-4-3	Phalguna/ARCC6650	2	1.5
UP2431-6-6-2	IR36/IET7918	3	2.2
RP2199-104-64-18-1	Phalguna/TKH6	3	0.85
RP1579-1633-55-43	6-I7/ARC6650	4	1.4
RP2439-22-3-3	IR50/IET7918	4	2.2
RP1506-2709-688	TN1/ARC147668	5	2.6
RP2439-22-3-3	IR50/IET7918	5	1.7
HKRl19	IR36/IET7916	5	2.3
Ratna		5	2.3
RP1990-979-1097-2	Sona/ARC14528	6	2.1
R296-471-2	CRl57-329/OR67-21	6	1.6
R321-43	Samridhi/IR36	6	2.8
R321-49	Samridhi/IR36	6	2.5
Sasyasree		6	1.1
LSD (P = 0.0.5)			0.5

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

RP2432-85-3-1 exhibited a high degree of resistance in all three replications. Susceptible checks Ratna and Sadyasree scored S and 6, respectively. R320-298 had the highest yield. The average yield of RP2432-85-3-1 was comparable. The two cultivars could be used as donors of GM resistance and for commercial cultivation in endemic areas. ■

Reactions of rice varieties to rice moth *Sitotroga cerealella*

W. A. Gillani and M. Irshad, National Agricultural Research Center, Islamad, Pakistan

We studied eight rice varieties in the laboratory for resistance to Angoumois grain moth *S. cerealella* (Oliv.).

Adult moths from a laboratory culture reared at 29 ± 2 °C and 65 ± 5% relative humidity were released in small glass jars for egg laying. Two hundred 24-h-old eggs were placed on 30 g of rice in glass jars, in a randomized complete block design with three replications. Hatched and unhatched eggs were counted 1 wk later.

Adults started emerging after 25 d. Loss in grain weight was considered an index of susceptibility. Damaged grains were also determined.

Dry weight loss in all rices except KS282 and DR82 differed significantly, (see table). JP5 was most susceptible and DR82 least susceptible to *S. cerealella* attack. DR82, KS282, and Lateefy seem suitable for storage. A strong positive correlation existed between number of adults that emerged and weight loss ($r = 0.93$), number of adults that emerged and grain damage ($r = 0.92$), and percent damaged grains and percent weight loss ($r = 0.98$).

These results conform with those from similar studies. ■

Dry weight loss, damaged grains, and numher of *S. cerealella* adults that emerged in storage of rice varieties in Pakistan.[a]

Variety	Dry wt lost (%)	Damaged grains (%)	Adults that emerged (no.)
DR82	6.1 a	14.1 b	21 bc
KS282	6.3 a	12.9 a	13 a
Lateefy	7.3 b	14.4 c	17 ab
DR83	13.3 c	14.5 c	24 cd
IR6	15.8 d	15.2 d	38 e
Bas 370	20.5 c	16.3 e	38 e
K. Bas	22.6 f	15.1 d	39 e
JP5	25.4 g	20.1 f	59 f

[a] In a column, means with the same letter are not significantly different from each other at the 1% level by DMRT.

Reaction of rice varieties to whitebacked planthopper (WBPH) *Sogatella furcifera* in the greenhouse

Truong Thi Ngoc Chi and Luong Thi Phuong, Entomology Department, Cuulong Delta Rice Research Institute, Omon, Haugiang, Vietnam

We screened 181 rice varieties and lines against WBPH, using the seedling bulk test. Test lines were sown in 10-cm-long rows at 20 seeds/row in iron seedboxes 40 × 30 × 5 cm, filled 3 cm deep with fine soil.

Seedlings were infested 7 d after sowing with second- to third-instar WBPH nymphs at 5 nymphs/seedling. Plant damage was assessed when all plants of susceptible check TN1 had died.

Twenty-four lines showed resistance to WBPH (see table). ■

Resistance of rice varieties to WBPH in the greenhouse in Vietnam, 1990 wet season.

Variety	Damage score[a]	Variety	Damage score[a]
OM732-5-2-1-1-2-1-2-1	1	OM725-12-5-3-1-1-2	3
OM734-10-12-4-3-1	1	OM850-8-7-1	3
OM739-18-1-1-1-1	1	IR64	3
IR19661-10-1-2-3-2	1	IR68	3
OM35-1	3	IR49500	3
OM86-9	3	S.499B	3
OM554	3	NC492	3
OM723-3	3	DD1397	3
OM723-11	3	0005 Ba tuc ran	3
OM576	3	0581 C_2	3
OM732-25-1-5-3-2-1	3	0855 Ca dung	3
OM732-29-9-3-5-7-9	3	TN1	9
OM732-41-2-5-3-2	3	Ptb 33	1

[a]*Standard evaluation system for rice.*

Stress tolerance — excess water

Tolerance of rice varieties for submergence

M. A. Hassan, A. K. Roy, N. C. Ghosh, and R. Thakur, Plant Breeding Department, Bihar Agricultural College, Rajendra Agricultural University, Sabour (Bhagalpur), India

Rice varieties cultivated in deepwater and lowland situations are prone to submergence by floods or heavy rains. In Bhagalpur region of Bihar, 1987 had abnormal rainfall: the average is 1.125 mm; in 1987, precipitation reached 1.990 mm. Lowland and deepwater areas were inundated three to four times during Jun-Oct.

Altogether, 225 rices were under observation in replicated trials in the Rice Breeding Section of Agricultural College, Sabour, in various testing programs. The varieties or strains that survived submergence for 4-7 d 3-4 times are listed in the table.

These lines should perform well in areas prone to submergence and may also be useful as donor parents in crossing programs. Most of the tolerant lines are derived from crosses with 64-117 (28%), FR13A (22%), and FR43B (11%) as one parent. Lines involving these parents but did not survive formed only 2.6% of the 225 lines.

Many of the submergence-tolerant lines have good grain quality and improved plant type. Small quantities of seed can be made available on request. ■

Survival percentage of tolerant lines that survived 4-7 d submergence each time. along with other details.

Variety or culture	Parentage	Submergence score	Times (no.) of submergence
SBR3012-120-2-1	IR20/Pankaj	2	3
SBR3013-11-11-1-2	Pankaj/64-117	2	3
SBR3013-493-66-1-1	Pankaj/64-117	2	3
SBR3014-6-1	64-117/CN540	2	4
SBR3015-35-35-2-1-1	64-117/IR36	2	4
SBR3015-604-74-4-3-1	64-117/IR36	2	4
PTIR18-218-20-58-1-68	BS41/BKN19-3-4//IR4219-35-3-2	3	3
IR33383-9-1-1-3	IR52/IR13426-19-2//IR50	2	3
IET10164	FR13A/CN540	3	3
IET10168	FR13A/CN540	3	3
IET10172	FR13A/CNM539	2	3
IET10177	FR13A/CNM539	2	3
IET10180	FR43B/CNM539	2	3
IET10181	NC496/CNM539	2	3
IET10547	FR43B/CNM539	2	3
IET10567	CR94/Mahsuri	3	3
IET10596	CR94/Mahsuri	3	3
64-117 (Janki)	Pureline selection	2	3

Stress tolerance — adverse temperature

Phytohormone analog for protection of photosynthetic capacity and water use efficiency in rice during chilling

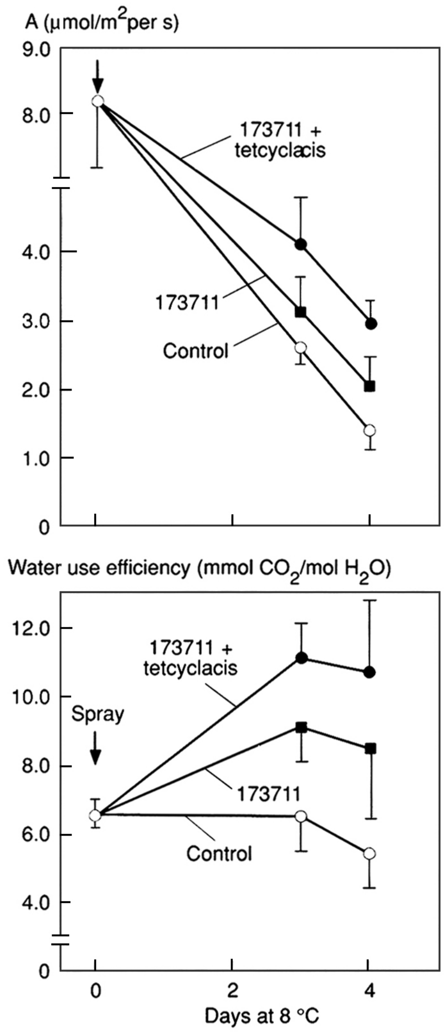
A. A. Flores-Nimedez and B. S. Vergara, Agronomy, Plant Physiology, and Agroecology Division, IRRI; and K. Doerffling, Institut fuer Allgemeine Botanik, Universitaet Hamburg, FRG

We investigated the effects of a new synthetic analog of the phytohormone abscisic acid (ABA) (provided by BASF, Ludwigshafen, FRG, coded LAB173711) alone and in combination with tetcyclacis (BASF), a growth retardant, on leaf photosynthetic rate and water use efficiency by rice plants during chilling.

Pregerminated seeds of IR36 were sown in trays. Two-week-old seedlings were sprayed with 10^{-4} mol LAB 173711/liter and with LAB173711 + tetcyclacis. After 24 h, the trays were transferred to a water tank at 8 °C root temperature and 25 °C air temperature, 12 h photoperiod and kept there for 3 and 4 d, respectively. Net leaf photosynthetic rate and water use efficiency were measured using a steady state CO_2/H_2O porometer (Walz, Effeltrich, FRG) and a BINOS infrared gas analyzer (Heraeus, Hanau, FRG: provided by M. Dingkhun, IRRI).

Chilling caused leaf yellowing, leaf wilting, and finally death of the seedlings. Net photosynthetic rate was 2.58 µmol/m^2 per s in the chilled but not chemically treated control and to 4.05 µmol/m^2 per s in plants sprayed with LAB173711 + tetcyclacis and kept at 8 °C for 3 d (see figure).

As chilling was prolonged, photosynthetic rate continued to decline to 2.86 µmol/m^2 per s in plants treated with LAB173711 + tetcyclacis and to 1.45 µmol/m^2 per s in the chilled but not chemically treated control. The water use efficiency was higher (10.7) in plants treated with LAB173711 + tetcyclacis than in control plants (5.5).



Changes in photosynthesis and water use efficiency of IR36 plants treated with LAB 17311 and LAB 17311 + tetcyclacis and kept at 8 °C for 3 and 4 d. Data are means ± S.E. of 5 measurements. IRRI, 1990

Use of abscisic acid analog LAB173711 alone was less efficient than combining it with tetcyclacis; that resulted in higher photosynthetic rate and water use efficiency. ■

Stress tolerance — adverse soils

Iron toxicity tolerance of rice cultivars in acid sulfate soils of Indonesia

H. Rosmini and Mukhlis, Banjarharu Research Institute for Food Crops, P.O. Box 31, Banjarbaru, South Kalimantan, Indonesia

We screened 73 rice varieties and breeding lines for Fe toxicity tolerance in acid sulfate soils (Table 1) at Unit Tatas substation, Central Kalimantan, during 1987 wet season.

Seedlings were transplanted 21 d after seeding at 20- × 20-cm spacing in 1- × 3-m plots/variety. Fertilizer was urea at 90 kg N/ha and TSP at 60 and 0 kg P/ha. The experiment was laid out in a split-plot design with two replications. Fe toxicity was scored 8 wk after transplanting.

Of the 73 entries, 18 were found tolerant of Fe toxicity (Table 2).

IR18349-53-1-3-1-3, IR19661-13-3-2, IR31917-31-3-2, IR9217-6-2-2-2-3, ITA212, and Pankaj did not respond to P fertilization. ■

Table 1. Some chemical characteristics of the acid sulfate soil at Unit Tatas substation, Central Kalimantan, Indonesia.

Characteristic	0-20 cm deep	20-40 cm deep
pH (H_2O)	3.95	3.90
Total N (%)	0.41	0.19
Organic C (%)	2.78	1.70
Available P (ppm)	17.63	32.96
Exchangeable K (meq/100g)	0.19	0.13
SO_4^+ (%)	0.12	0.05
Al_3^+ (meq/100g)	14.19	15.70
Fe (meq/100g)	6.16	5.59
Na (meq/100g)	0.2I	0.26
Particle size (%)		
Sand	0.22	0.21
Silt	33.41	31.14
Clay	66.37	68.65

Table 2. Fe toxicity tolerance and yield of rice on acid sulfate soils. Tatas, Central Kalimantan, Indonesia.

Variety or line	Fe toxicity score [a]		Grain yield [b] (g/plot)	
	With P	Without P	With P	Without P
BR51-120-2	4	5	609 f	357 h
BW267-3	3	4	2166 a	1887 a
CR261-7039-236	4	5	1932 b	1653 bc
lRl3146-45-2	4	5	1167 de	1068 e
lR18349-53-1-3-1-3	4	4	1143 de	1512 c
IR19657-87-3-3	4	6	1833 b	1275 d
IR19661-13-3-2	3	5	1311 cd	1764 ab
IR21836-90-3	3	5	1179 de	1047 ef
IR31917-31-3-2	3	5	729 f	858 fg
IR6023-10-1-1	3	5	1878 b	1578 bc
lR9217-58-2-2	4	5	1104 e	804 g
IR9217-6-2-2-2-3	4	5	1110 e	1479 c
ITA212	4	5	1443 c	1608 bc
ITA230	4	5	1317 cd	1194 de
Pankaj	4	5	1317 cd	1605 bc
Rohyb15-WAR-3-3	4	5	1335 cd	1179 de
WAR52-384-3-2-2	4	4	1392 c	1107 de
Kapuas	3	4	2184 a	1650 bc

[a] By the *Standard evaluation System for rice.* [b] In a column, values followed by the same letter are not significantly different at the 5% level by DMRT.

Mukti-CTH1, a rice with cold tolerance and blast resistance for winter and ratoon cropping in Karnataka, India

M. Mahadevappa, Agricultural Botany Department, University of Agricultural Sciences (UAS), G.K.V.K., Bangalore 560065, India

More than 700 genotypes from local germplasm and entries of the International Rice Cold Tolerance Nursery were screened at the UAS research stations, Bangalore. The work to develop cold-tolerant and blast-resistant varieties was done in collaboration with IRRI and the Indian Council of Agricultural Research.

Under natural conditions, the cultivars CTH1, CTH3, and CTH4 were identified as tolerant of cold and resistant to blast, besides being nonlodging. During a 1986 winter trial at Bangalore, CTH1 (B2983b-SR-85-3-2-4 from Indonesia, derived from Sirendah Merah/IR2153-159-1-4) was outstanding. It has 90-100 cm plant height and medium slender grain type. It has been in multilocation trials and in farm trials in Sep and Oct plantings in the southern districts of Karnataka.As IET 11220, it was in All India Coordinated Trial (AICT) for hills. Its blast score at Ponnampet was 3, compared with 7 for Intan.

Under winter conditions, CTH1 yielded 1.3-4.3 t/ha, against 0.0-2.5 t/ha of the best local or currently grown winter variety. It ranked first in 10 plantings in Bangalore and was the only variety to produce some yield (3.2 t/ha) when planted in Oct at Nagenahalli. It ranked second in two of five locations in the hill region in the AICT. CTH1 matures 125-130 d from sowing. Its cooking quality is good and the grain is reportedly very good for puffed rice. Its kernel is red and falls under mid-fine category. Its excellent ratooning ability is yet another potential that can be exploited. ■

Divya (WGL 44645), a newly released rice variety for gall midge (GM) endemic areas

P. P. Reddy, N. Kulkarni, N. S. Reddi, D. V. S. R. Rao, A. G. Ram, K. S. Rao, T. N. Rao, C. P. Rao, P. S. Rao, and P. S. Rao, Andhra Pradesh Agricultural University Agricultural Research Station (ARS), Warangal 506007, India

Divya (WGL 44645), derived from WGL 23022/Surekha, is a short-duration (125-130 d) rice variety, suitable for year-round cultivation. It has the gall midge *Orseolia oryzae* Wood-Mason resistance from Eswarakora in WGL 23022 (CR44/W 12708) and from Siam 29 in Surekha (IR8/Siam 29). With its high resistance (zero infestation at 8 of 10 sites), Divya is suitable for GM (biotype I) endemic areas.

Divya is semidwarf with compact plant type, photoperiod-insensitivity, fertilizer-responsiveness, and grain yield potential of 6.0 t/ha. The kernel is long slender (length:breadth = 4.21) with no abdominal white.

In 1981-86 trials, Divya gave consistently high yields (see table). During 1988 wet season, it ranked first at the Directorate of Rice Research (DRR), Hyderabad Centre; third at Agricultural Research Institute, Rajendranagar, Hyderabad; and ninth among 64 entries in the preliminary variety trial 2 of DRR. During 1989 wet season, Divya ranked first at Pondicherry, fourth at Pattambi, and fifth at Mandya and at 8 other sites among 15 entries, and was superior to Vikas and Ratna in the uniform variety trial 2 of DRR.

It gave higher grain yield than checks in multilocation trials (1983, 1984) and minikit trials (1985-88) at different sites in Andhra Pradesh. It is popular among farmers of the Northern Telangana Zone. ■

Performance of Divya (WGL 44645) in yield trials at ARS, Warangal, India.

Variety	Yield (t/ha)						
	1981	1982	1983	1984	1985	1986	Mean
Divya (WGL 44645)	4.8	4.5	4.1	4.3	4.0	4.2	4.2
Pothana	3.2	-	-	-	-	-	3.2
Telia Hamsa	-	2.7	-	-	-	-	2.7
Vijay Mahsuri	-	-	3.4	3.2	2.3	3.8	3.2
LSD (0.05)	0.7	0.4	0.3	0.5	0.4	0.2	
% increase over check	29.3	52.5	21.4	33.6	73.9	10.7	

Chaite 4, a short-duration, high-yielding rice variety for double-cropped areas in Nepal

S. P. Khatiwada and G. L. Shrestha, National Rice Improvement Program, Parwanipur, Birganj, Nepal

Nearly 90% of the total rice area of Nepal is located in the tropical to subtropical region; two crops of rice are grown with assured irrigation, followed by one winter crop. The first rice crop, known as *Chaite dhan,* is planted in Mar in the southern plain area (the Tarai).

Farmers in the inner Tarai and river basin areas (altitude 250-1,000 m) in the mid-hills start seeding the first week of Feb. The early season rice crop (Feb/Mar to Jun/Jul) is followed by the main season rice crop (Jun/Jul to Oct/Nov). Intermediate-tall, traditional type rice variety CH45 (China 45) is the most widely planted. Short-duration rice varieties are needed for the *Chaite dhan* crop, to allow timely planting of main season rice.

Recently released semidwarf rice variety Chaite 4 (IR9729-67-3), a cross of BG34-8/IR28//IR2095-625-1-252, and CH45, along with other test entries, were evaluated in multilocation trials in agricultural research stations and farmers' fields in the Tarai, inner Tarai, and river basin areas of the mid-hills Feb/Mar to Jun/Jul 1989.

Chaite 4 had a duration similar to that of CH45 in both the Tarai and the mid-hill regions. It produced an average 4.7 t/ha, 25% higher than CH45, with better yield performance at all sites (see table).

Chaite 4 has slender, medium-size grain with acceptable cooking and eating quality, is resistant to bacterial leaf blight and blast, and has longer grain dormancy than CH45. ■

Performance of Chaite 4 in on-station (Coordinated Varietal Trial) and on-farm trials at agricultural research stations, and farmers' field trial during 1989 Chaite dhan season.

Site	Tarai region (5 sites on-station[a] and 2 sites on-farm[b])			Inner Tarai and river basin areas (2 sites on-station[c] and 4 sites on-farm[d])			Mean			Yield increase (%) over CH45
	Grain yield (t/ha)	Crop duration (d)	Plant height (cm)	Grain yield (t/ha)	Crop duration (d)	Plant height (cm)	Grain yield (t/ha)	Crop duration (d)	Plant height (cm)	
				Chaite 4						
On-station	4.5	122	82	4.0	153	78	4.4	132	81	22
On-farm	5.4	125	–	4.9	144	–	5.0	137	–	29
Mean	4.7	123	82	4.6	147	78	4.7	134	81	25
				CH45						
On-station	3.7	123	114	3.4	154	104	3.6	131	111	
On-farm	3.4	130	–	4.2	139	–	3.9	136	–	
Mean	3.6	125	114	3.9	144	104	3.7	133	111	

[a]Kankai (altitude 90 m), Tarahara (100 m), Hardinath (93 m), Parwanipur (115 m), and Bhairahdwa (105 m) agricultural research stations. [b]Jhapa (90 m) and Dhanusha (93 m). [c]Ghorlekharka (600 m) area of Pakhribas Agriculture Center and Tapu (1000 m) area of Lumle Agriculture Center. [d]2 sites in Chitawan (256 m), Yampa Phant Tanahu (475 m), and Tapu (1000 m).

Jingmazhan, a high-yielding, good quality indica rice for China

Liao Changli, Ni Keyu, Liu Yuankun, and Huang Zonghong, Guizhou Academy of Agricultural Sciences (GAAS), Guiyang City, Guizhou, China

Jingmazhan, a new superlong, large-grain rice variety released in Guizhou Province, has been awarded the prize for high quality production by the Chinese Ministry of Agriculture.

The variety was developed from (Reimei/Gui 630)B_3F_4//Zun 7201. Reimei is a japonica variety from Japan; Gui 630 and Zun 7201 are Guizhou native indica type cultivars. Jingmazhan is now planted in 35,000 ha.

Jingmazhan is 100 cm tall with 149-d duration, good plant type, and heavy tillering ability. Its 1,000-grain weight is 30.4 g and yield, 7.5 t/ha. Jingmazhan is moderately resistant to blast, sheath blight, cold temperature, and drought.

Appearance, milling recovery, chemical properties, and cooking and eating quality meet the China National Index for high quality rice. Grain length is 7.5 mm, with 3:1 length-to-breadth ratio. Hulling recovery is 79.5%; milling recovery, 72.8%; and head rice recovery, 56.3%. Its grain is translucent, with 18.08% amylose, 8.0% protein content, low-gelatinization temperature (7.0 alkali spreading value), and medium gel consistency (60 mm). ■

Integrated germplasm improvement—upland

Promising upland rice varieties for the North West Province of Cameroon

D. Janakiram, National Cereals Research and Extension Project (NCREP), B.P. 44; F. Jeutong, Institut de la Recherche Agronomique (IRA), B.P. 44, Dschang; M. P. Jones, NCREP; and J. A. Ayuk-Takem, IRA, B.P. 44, Dschang, Cameroon

Upland rice is cultivated as a subsistence food crop in areas with altitudes of 600-1200 m. Farmers tend to cultivate tall, low-tillering, upland varieties and, in some cases, irrigated varieties in the uplands. Trials at Babungo (1150 m) and Befang (700 m) in the last 4 yr sought to identify adapted, high-yielding, disease-tolerant varieties with good grain quality.

Both sites have fertile and free-draining soils. Because of its higher altitude, Babungo has lower temperatures. Cultural practices at both sites were similar.

Performance of promising upland rice varieties in North West Cameroon.[a]

Genotype	Babungo			Befang		
	Plant ht (cm)	Days to 50% flowering (DAS)	Av yield (t/ha)	Plant ht (cm)	Days to 50% flowering (DAS)	Av yield (t/ha)
IRAT109	74	108	3.8	75	89	4.1
IRAT112	76	102	3.8	80	80	3.8
M55 (check)	102	125	3.7	108	96	3.0
ITA208	86	123	3.5	88	94	4.3
ROK16	116	125	2.9	119	99	3.7

[a]Data averaged over 4 yr (1985-88). DAS = days after sowing.

In 1985-88 trials, grain yields were generally slightly higher at Befang. Plants were shorter and growth duration much longer at Babungo (see table), reflecting the cooler temperatures that adversely affected crop growth there. The highest yielding entries were ITA208 and IRAT109 at Befang and IRATll2 and IRAT109 at Babungo. Across sites, the highest yields were from IRATl09, ITA208, and IRAT1 12.

IRAT 109, a derivative of IRAT 13/ IRAT10, has medium-long grain with white bran. IRAT112 from IRAT13/ Dourado Precoce is similar to IRAT109 in agronomic trait, but has slender grain, which is more acceptable to consumers. ITA208, a derivative of 63-83/(Vijaya, Dourado Precoce, Jumai) has medium-long, bold grain with white bran. ROK16, a selection from the traditional varieties of Sierra Leone, has broad leaves, awned spikelets, and medium and bold grains.

M55 is an improved upland variety currently grown by a few farmers. It is a mutant of 63-83 and has medium and bold grains.■

Surveys of disease or insect incidence/ severity in one environment are useful only if the information is related to other variables (e.g., climatic factors, crop intensification, cultivars, management practices, etc.). By itself, information on incidence in one environment does not increase scientific knowledge.

Integrated germplasm improvement — deepwater

Three promising deepwater rice varieties for Sichuan

Zheng Jiakui, Deng Jutao, Liu Yongsheng, Yin Guoda, and Yu Jiaqi, Rice Research Institute (RRI), Sichuan Academy of Agricultural Sciences, Luzhou, Sichuan, China

About 200,000 ha of tanks, weirs, and lakes in Sichuan Province with water depths of 50- 150 cm are the primary source of irrigation water for a large hectarage of irrigated ricelands. The introduction of deepwater rice cultivation could increase total production, and better meet the food needs of a rapidly growing population.

In 1988-89, we evaluated promising deepwater rice cultivars IR41336-6-2-1-1-1, B4406D-MR-2-7, and B5278- 13D-MR-6-3 selected from the International Rice Deep Water Observational Nursery (IRDWON). IR41336-6-2-1-1-1 was derived from RD19/Badal 116; B4406D-MR-2-7 from SML Tomerin/B2360-6-7-l//Tetep/B2474B- 1-PN-2-3-2-2-5; and B5278-13D-MR-6-3 from Lagos/lR9129-457-2-2-1-2//FR13A/IR3351-38-3-1.

They appear to be adaptable to Sichuan circumstances and are being recommended for demonstration trials in farmers' fields (see table). IR41336-6-2-1-1-1 has strong culms and dark green leaves, with medium slender, fine, white grain. B4406D-MR-2-7 and B5278-13D-MR-6-3 have medium bold grain. All three cultivars have very good submergence tolerance, kneeing ability, and plant type. They are moderately resistant to blast.■

Agricultural characteristics of 3 promising deepwater rice cultivars in Luzhou, Sichuan, China (mean of 1988-1989).

Character	IR41336-6-2-1-1-1	B4406D-MR-2-7	B5278-13D-MR-6-3
Culm length (cm)	155.4	136.3	141.7
Growth duration (d)	175.0	184.0	174.0
Panicles/plant (no.)	6.8	6.2	5.5
Panicle length (cm)	30.6	26.8	32.4
Filled spikelets/panicle (no.)	178.3	138.6	161.2
1000-grain weight (g)	24.7	25.4	27.8
Grain yield (t/ha)	3.4	3.3	3.2

CROP AND RESOURCE MANAGEMENT

Soils

Exchangeable Al as a criterion of lime requirement for rice in acid sulfate soil

B. K. Laskar, Agricultural Chemistry and Soil Science Department, Bidhan Chandra Krishi Viswavidyalaya, P.O. Kalyani, Nadia (WB) 741235, India

A field study was conducted to determine whether exchangeable A1 can serve as basis for lime requirement to maximize the yield of rice in an acid sulfate soil.

Effects of lime levels on yield and nutrient uptake of rice grown in acid sulfate soil. Nirdeshkali, West Bengal.

Lime rate (t $CaCO_3$/ha)	Grain yield (t/ha)	Nutrient uptake (mg/kg)				
		N	P	K	Fe	AI
No lime	1.7	21.0	6.7	47.1	10.2	8.1
3.6	2.0	22.2	7.4	49.8	9.8	7.5
5.5	2.3	25.0	7.7	50.2	8.9	7.5
7.3	2.3	28.2	9.5	60.2	7.8	6.6
9.1	4.0	51.6	20.0	70.4	4.5	4.2
11.0	3.8	48.4	19.9	70.7	4.5	5.0
12.8	3.7	47.8	19.3	70.9	5.0	4.9
14.6	3.3	48.6	18.4	72.9	4.6	5.1
16.4	3.0	46.5	11.3	73.4	5.1	5.2
18.2	2.8	35.9	7.1	59.4	5.3	5.3
LSD (0.01)	6.7	6.7	3.5	5.7	1.4	2.1

The experimental site was a lowland ricefield with irrigation facilities in Nirdeshkhali in the coastal area of West Bengal. The soil belonged to mixed, hyperthermic acidic family of Typic Haplaquept. Important characteristics were pH (1:2 water) 3.3, 1.95% organic C, 63% clay (illite dominant), CEC 28.9 meq/100 g, 0.123% total N, 9.8 mg available P/kg, exchangeable K 2.12 meq/l00 g, and exchangeable A1 0.911 meq/l00 g. Lime required to raise soil pH to 5.5 was 33.21 t $CaCO_3$/ha.

The experiment was laid out in 20- m^2 plots, in a randomized block design with four replications. The field was plowed thoroughly, and required lime ($CaCO_3$) applied before the field was puddled. At harvest, grain yield was sampled and uptake of N, P, K, Fe, and Al determined.

Grain yield of rice MW10 was highest when lime corresponding to 10 times the amount of exchangeable Al (9.11 t $CaCO^3$/ha) was applied. That amount increased soil pH and counteracted the ill effects of Fe and AI. Nutrient uptake by grain was also highest at that lime level (see table). The results indicate that yield was maximized with lime equivalent to or less than the amounts theoretically needed to neutralize toxic quantities of Fe and Al and supply adequate Ca.

Exchangeable Al served as a good estimator of lime required for economic productivity of rice in this acid sulfate soil. ■

Soil microbiology

Response of *Azolla pinnata* to herbicide and time of inoculation

G. Srinivasan, S. Ranganayaki, and P. Pothiraj, Tamil Nadu Agricultural University, Coimhatore 3, India

We evaluated the response of azolla to rice herbicides—anilofos alone and in combination with 2,4-D EE (ethyl ester) and thiobencarb + 2,4-D EE—in terms of fresh biomass (FB), relative growth rate (RGR), and chlorophyll content 20 d after herbicide application. Azolla was inoculated 0, 3, and 6 d after herbicide application.

Untreated control recorded the highest FB (see table), but FB with anilofos alone and in combination with 2,4-D EE were comparable. FB was significantly reduced with thiobencarb + 2,4-D EE.

Effects of herbicides and time of azolla inoculation on fresh biomass, RGR, and chlorophyll content of *Azolla pinnata*.[a] Coimbatore, India.

Treatment	Fresh biomass (t/ha)	RGR (g/g per d)	Chlorophyll (mg/g) 'a'	Chlorophyll (mg/g) 'b'
Herbicides				
Thiobencarb + 2,4-D EE (1.00 + 0.51 kg/ha)	11.22 c	0.20 b	2.30 a	1.39 a
Anilofos + 2.4-D EE (0.30 + 0.51 kg/ha)	17.14 ab	0.22 a	2.29 a	1.40 a
Anilofos (0.40 kg/ha)	15.70 b	0.22 a	2.26 a	1.40 a
Control	17.62 a	0.22 a	2.30 a	1.40 a
Time of azolla inoculation (d after herbicide application)				
On the day	0.61 c	0.06 c	2.32 a	1.42 a
3d day	16.33 b	0.22 b	2.35 a	1.44 a
6th day	23.91 a	0.24 a	2.41 a	1.47 a

[a]In a column within a factor, any two means followed by a common letter are not significantly different from each other by LSD (P = 0.05).

Irrespective of herbicide, inoculation of azolla 6 d after herbicide application had the highest FB.

The highest RGR (0.22 g/g per d) was in untreated control and in treatments with anilofos. Azolla inoculation 6 d after herbicide application had the highest RGR.

Herbicides and times of inoculation had no effect on chlorophyll content. ■

Vesicular-arbuscular mycorrhizae (VAM) colonization in lowland rice roots and its effect on growth and yield

P. Sivaprasad, K. K. Sulochana, and M. A. Salam, College of Agriculture, Vellayani, Trivandrum 695522, India

VAM association is less frequent in submerged environments than in uplands. To study the colonization pattern of VAM and its effect on lowland rice growth and yield, we raised mycorrhizal seedlings in concrete pots (75 × 75 × 2.5 cm) filled with clay loam soil and pre-inoculated with the VAM fungus *Glomus fusciculatum* (3000 spores/0.25 m^2). Dry nursery method was followed to facilitate VAM infection. Control seedlings were raised without VAM inoculation. Percent mycorrhizal colonization was recorded 21 d after.

Three sets of 20 seedlings each of mycorrhizal-infected plants and control were transplanted under flooded condition for observation of VAM 15, 30, and 45 d after transplanting (DT).

Crop response with and without NPK was tested in pots using inoculated and uninoculated seedlings. The six treatments were laid out in a completely randomized design with four replications.

Inoculated seedlings recorded 16.2% VAM infection 21 d after inoculation. Infection persisted and further increased after transplanting. Infection was 20.8% at 15 DT, 28% at 30 DT, and 46% at 45 DT, indicating that flooding did not affect colonization. Control seedlings were also positive for infection at 21 DT because of native VAM. Infection was 8.6% at 30 DT and 14.2% at 45 DT.

Seedling growth and yield with and without NPK application were measured

Effect of VAM inoculation on growth and yield of lowland rice.

Treatment[a]	Plant ht (cm)	Productive tillers (no./plant)	Mycorrhizal infection at harvest (%)	Grain yield (g/pot[b])	Straw (g/pot[b])
No NPK, no M	88	9	16.1	66.9	55.90
No NPK, with M	103	9	49.3	87.6	72.93
				(31)	(30)
With NK, no M	103.5	10	13.6	83.5	68.25
With NK, with M	104.5	12	50.0	103.5	79.75
				(24)	(17)
With NPK, no M	103	10	12.8	85.2	63.00
With NPK, with M	104	11	43.0	106.2	75.50
				(25)	(20)
LSD (P = 0.05)	ns	ns	23.6	18.1	15.3

[a] M = inoculated with *G. fasciculatum*. [b]Figures in parentheses are percent increase over control.

in a separate experiment. Inoculation with *G. fasciculatum* raised mycorrhizal colonization (see table), but its effect on plant height and productive tillers was not significant. Grain and straw yield increased significantly with VAM inoculation. Facilitating VAM infection by nursery inoculation, following the dry nursery method, can be used to achieve VAM benefits in lowland rice. ■

Row seeding generally resulted in higher germination rate than broadcast seeding, with more plants/m^2 and biomass/m^2 at 20 and 40 kg seed/ha. However, row seeding with 30 cm between rows had germination similar to broadcast seeding at 60 kg seed/ha.

When seed was broadcast or sown in rows with 15-cm spacing, increasing the seeding rate from 20 to 60 kg/ha increased the number of plants and plant biomass/m^2. But with 30 cm between rows, higher seeding rate increased the two parameters only up to 40 kg/ha (see figure); overcrowding within rows resulted in lower germination. Increasing the number of rows (i.e., decreasing the distance between rows to 15 cm) minimized crowding of seeds within rows. This explains why, at 60 kg seed/ha, plant density and biomass/m^2 were higher with 15 cm than with 30 cm between rows.

Planting method significantly affected ARA/plant, but seeding rate had no effect. Averages of ARA at three seeding rates were 12.1, 10.3, and 97 µmol C_2H_4/plant per h for broadcast, 15-cm row seeding, and 30-cm row seeding, respectively, with a standard error of the mean of 0.6. This seems to be related to the lower plant density, when seed was broadcast.

Planting method and seeding rate produced significant effects on ARA per unit area and on biomass per unit area. Estimated ARA per m^2 was 597, 823, and 746 µmol C_2H_4/plant per h for broadcasting, 15-cm seeding, and 30-cm seeding treatments, respectively, with a standard error of 50. ■

Effect of planting method and optimum seeding rate on biomass production and nitrogen fixation in *Sesbania rostrata*

A. Tirol-Padre and J. K. Ladha, Soil Microbiology Division, IRRI

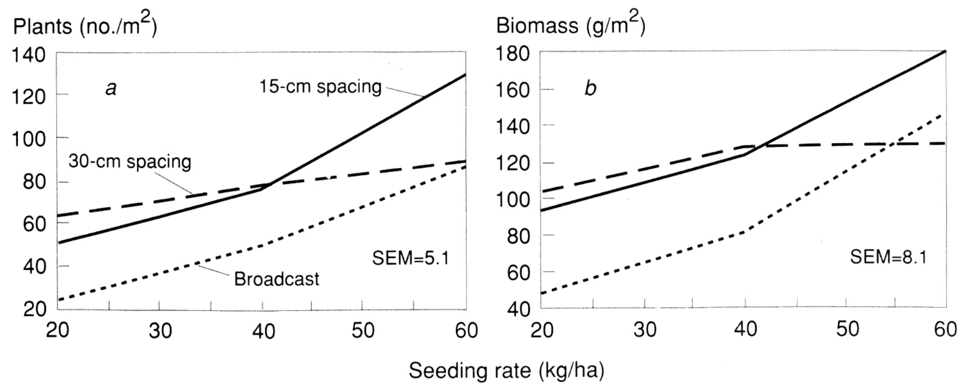
We experimented with *S. rostrata* at IRRI Nov 1987-Jan 1988 to determine 1) optimum sampling size for measuring plant density, biomass, and acetylene-reducing activity (ARA), and 2) optimum seeding rate and planting method for higher biomass and N_2 fixation.

Seeding rates were 20, 40, and 60 kg/ha and planting methods were broadcast, row seeding with 15 cm between rows, and row seeding with 30 cm between rows. The experiment was laid out in a split-plot design with 3 replications. Plot size was 2 × 6 m. Biomass and ARA were measured 41 d after seeding (DAS).

For estimating plant density, the 30- × 30-cm sampling unit gave better precision than 30- × 60-cm or 60- × 60-cm for the same sampling area in all treatments. Efficiency appears higher with small samples taken many times rather than big samples taken a few times. Small sampling units are especially recommended for plots with uneven plant distribution. With the 30- × 30-cm sampling unit, the coefficients of variation (CV) of the mean ($\bar{x}$) for 4, 8, and 12 samples/block were 12.4, 8.8, and 7.2%, respectively.

For determining plant biomass, the two-plant sampling unit generally gave better precision than the four-plant unit when seed was broadcast or planted in rows. CV ($\bar{x}$) for 2, 4, and 6 samples/block were 14.6, 10.3, and 8.4%, respectively.

For ARA measurements, the 4-plant sampling unit generally gave better precision when seed was planted in rows (15-30 cm apart) and plant samples were taken from adjacent rows. CV ($\bar{x}$) for 2, 4, and 6 samples/block were 13.6, 9.6, and 7.9%, respectively. When plants were sampled from the same row or when seeds were broadcast, however, the two-plant sampling unit gave higher precision.



Effect of seeding rate and planting method on a) plant density of *S. rostrata,* b) biomass per unit area of *S. rostrata.* IRRI, 1988.

Effect of organic manure on natural occurrence of *Azolla pinnata* and its effect on rice yield

A. Varghese, Kerala Agricultural University, Rice Research Station, Kayamkulam 690502, Kerala, India

We studied the long-term effects of organic manure and inorganic fertilizer in a rainfed rice - rice - fallow cropping system trial starting in 1972. The dry season rice crop Apr-Jul was dibble seeded; the wet season crop Aug-Nov was transplanted.

The agroclimatic zone toward the western coastal belts is characterized by sandy soil, low organic matter, with low N and K and medium P, and pH 5.3.

Jaya was the test variety. NPK was applied at 80:40:40 kg/ha. Cattle manure (CM), ammonium sulfate, superphosphate, and muriate of potash were the fertilizers used (see table for treatments).

In the wet season, *Azolla pinnata* usually grows naturally for 60 d from 10–15 d after transplanting until water dries out with the cessation of the monsoon. Azolla was not seen in plots that received no P where the soil P status was also low.

Cattle manure apparently acted as a buffer, maintaining a soil pH that favored the growth of azolla.

Azolla growth was highest in plots without applied N, maintaining moderate yield. ■

Data on azolla, soil pH, P, and grain yield. Kerala, India.

Treatment[a]	Fresh azolla 35 d after transplanting (t/ha)	Soil pH	Available P (kg/ha)	Mean grain yield (t/ha)		
				1989 wet season	1972-89	
					Semidry season	Wet season
CM @ 80 kg N/ha	2.1	5.45	18.8	2.8	2.1	2.3
N	–	4.73	8.4	0.1	0.8	0.6
NP	0.1	4.65	20.4	0.7	0.9	1.0
NK	–	4.68	9.4	0.9	1.1	0.7
PK	2.8	5.18	18.8	1.8	1.2	1.4
NPK	0.1	4.90	19.2	1.2	1.7	1.6
CM to supply 25% N + 75% N+PK	1.3	5.00	18.1	2.2	2.2	2.1
LSD (0.05)		0.24	6.6	0.5	–	–

[a]CM = cattle manure.

Standardization of acetylene reduction assay with field-grown aquatic legume

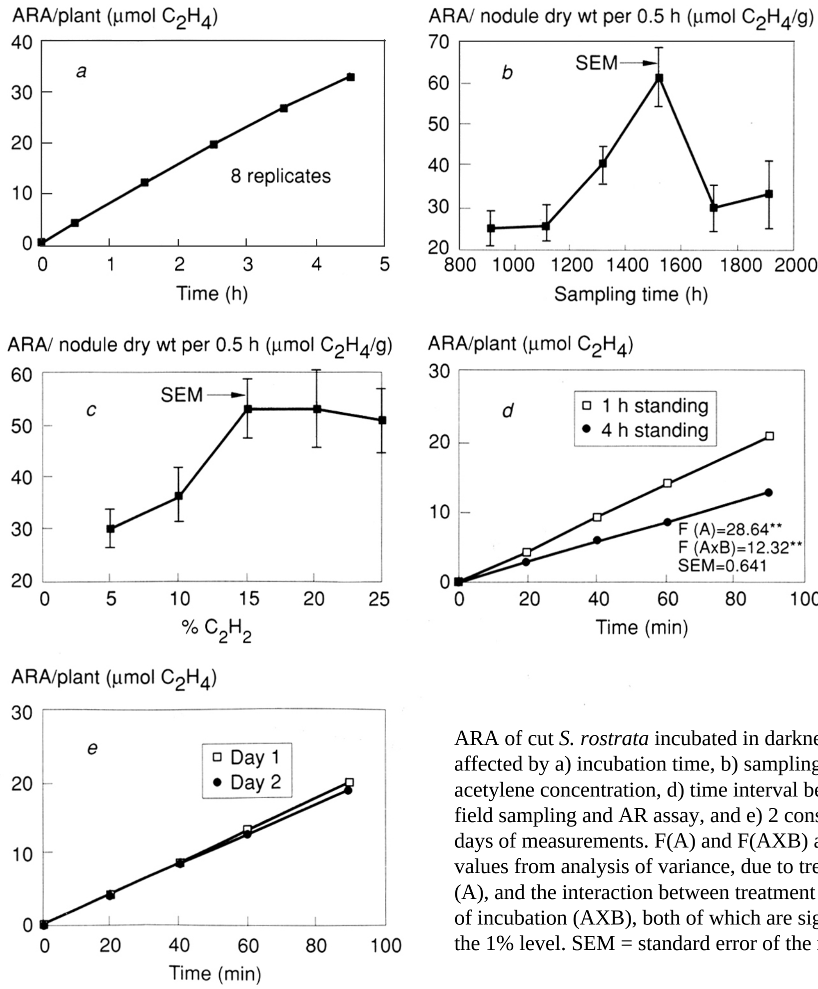
J. K. Ladha and A. Tirol-Padre, Soil Microbiology Division, IRRI

To standardize a simple and efficient acetylene reduction assay for routine measurements of N_2 fixation by root- and stem-nodulating green manure leguminous plants, we determined optimum time for plant sampling, duration, and conditions for acetylene reduction assays.

Sesbania rostrata was grown in a lowland ricefield Jan-Feb 1988. Scarified seeds (40 kg/ha) were broadcast on saturated soil; the field was kept flooded starting 10 d after seeding.

The field had been transplanted to *S. rostrata* for 3 yr, but had been inoculated with *Azorhizobium caulinodans* strain IRBG46 only the first year. Plants in this experiment showed profuse spontaneous nodulation without inoculation. Measurements were taken on eight plants at 41 d after seeding.

Stem and root nodule acetylene-reducing activity (ARA) increased linearly from 0 to 2.5 h of incubation, after which it was slightly reduced



ARA of cut *S. rostrata* incubated in darkness as affected by a) incubation time, b) sampling time, c) acetylene concentration, d) time interval between field sampling and AR assay, and e) 2 consecutive days of measurements. F(A) and F(AXB) are F values from analysis of variance, due to treatment (A), and the interaction between treatment and time of incubation (AXB), both of which are significant at the 1% level. SEM = standard error of the mean.

(fig., a). This indicates a short incubation period of 1 h can be recommended.

ARA of whole and cut plants incubated in darkness did not differ significantly. However, ARA of whole plants incubated in darkness was significantly lower (about 40%) than that of whole plants in light. It is more convenient to use cut plants in measuring ARA because they require smaller incubation vessels (plastic bags) and less acetylene-air mixture than whole plants. Dark incubation also eliminates the need for extra light facilities.

ARA was highest between 1300 and 1600 h (fig. b), and at acetylene concentration of 10-15% (fig., c). A 4-h interval between sampling and assay significantly reduced ARA compared with a 1-h interval (fig., d). It seems important to process the plants (field sampling, washing, cutting, and sealing in plastic bags, etc.) as quickly as possible. Four persons can sample and assay about 40 plants/h.

If an experiment involves ARA measurements on a large number of plants, it may be advisable to assay only half the desired number one day and half the following day: no significant difference in ARA was obtained from samples taken two consecutive days (fig., e). ■

Physiology and plant nutrition

Effect of leaf cutting for rice herbage on grain yield of deepwater rice

T. Kupkanchanakul, K. Kupkanchanakul. and S. Roontun, Huntra Rice Experiment Station, Ayutthaya 13000, Thailand

Rice herbage could be very important in deepwater areas where natural pasture for grazing is minimal. We studied the effect of time and frequency of leaf cutting for herbage on grain yield of deepwater rice in 1987 wet season.

Dry seeds of Thai variety Pin Gaew 56 were broadcast at 120 kg/ha on plowed soil 25 May. Seedlings emerged 4 Jun.

Five treatments were arranged in randomized complete block design with four replications (see table). Rice leaves were cut at the collar of the last fully developed leaf, at different times.

Effect of leaf removal on herbage yield, grain yield, and yield components of Pin Gaew 56.[a] Huntra Rice Experiment Station, Ayutthaya, Thailand, 1987 wet season.

Cutting time	Herbage (t/ha)	Grain yield (t/ha)	Yield components				
			Panicles (no./m^2)	Spikelets (no./panicle)	Fertility (%)	1000-grain wt (g)	Plant height (cm)
No cutting	–	2.02 bc	127	91	79	26.6	237 a
40 DAE	0.7 c	2.13 abc	134	85	84	26.8	221 b
70 DAE	0.7 c	2.20 ab	135	85	77	26.5	223 b
100 DAE	1.0 b	2.24 a	143	92	82	27.1	223 b
40 + 100 DAE	1.4 a	1.94 c	126	83	81	26.5	217 b
CV (%)	11.0	6.30	25.5	15.0	6.9	8.4	6.9

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

Grain yield was significantly improved by leaf cutting 100 d after emergence (DE), and was not affected by leaf cutting at 40 and 70 DE nor by double cutting at 40 and 100 DE.

Herbage yield was highest with double cutting at 40 and 100 DE. Herbage production in one cutting and grain yield were highest with cutting at 100 DE. Plant height was significantly reduced by leaf cutting. This might have contributed to increased panicle number, which improved yield. ■

Fertilizer management

Nitrogen substitution with *Sesbania rostrata* in rice production

A. S. Halepyati and M. N. Sheelavantar, Agronomy Division, University of Agricultural Sciences, Dharwar 580005, Karnataka, India

We studied the effect of *S. rostrata* incorporation on N economy of irrigated transplanted rice. Field experiments were conducted during 1987 and 1988 wet season in a factorial randomized block design with four replications. Soil was black clay loam with pH 7.8, 541.0 kg total N, 12.9 kg available P/ha, and 323.6 kg K/ha. Rice received varying N, 22 kg P, 41.5 kg K/ha.

S. rostrata was sown the last week of Jun and incorporated at 55 d old, 1 d before rice was transplanted. Total biomass and N accumulation were determined at incorporation.

S. rostrata with higher plant density had the highest biomass production and N accumulation at incorporation (Table 1).

Table 1. Biomass and N accumulation in *S. rostrata*.

Sesbania population density	Biomass (t/ha)			N accumulation (kg/ha)		
	1987	1988	Pooled mean	1987	1988	Pooled mean
Low (333,000 plants/ha)	15.33	16.36	15.84	129.72	139.41	134.57
Medium (444,000 plants/ha)	18.07	19.07	18.57	151.49	160.73	156.11
High (666,000 plants/ha)	22.43	23.61	23.02	172.03	183.37	177.70
Mean	18.61	19.68	19.14	151.08	161.17	156.13
LSD (0.05)	0.41	0.51	0.34	15.24	11.74	11.17

Table 2. Effect of *S. rostrata* (SR) on rice grain yield, straw yield, and nutrient uptake of rice.

Treatment	Grain yield (t/ha)			Straw yield (t/ha)			N uptake (kg/ha)		
	1987	1988	Pooled mean	1987	1988	Pooled mean	1987	1988	Pooled mean
SR only	3.6	5.5	4.6	5.8	7.5	6.7	35.60	55.86	45.78
SR + 25 kg N/ha	3.9	5.9	4.9	6.1	8.0	7.0	35.34	58.79	47.06
SR + 50 kg N/ha	4.2	6.3	5.3	6.1	8.3	7.2	39.57	63.17	51.37
SR + 75 kg N/ha	4.5	6.7	5.6	6.4	8.4	7.4	43.49	67.49	55.49
SR+ 100 kg N/ha	4.9	6.9	5.9	6.0	8.8	7.4	43.62	71.94	57.78
Control (100 kg N/ha)	3.8	5.2	4.5	6.0	8.1	7.1	17.91	35.70	26.80
LSD at (0.05)	0.4	0.2	0.2	0.3	0.5	0.3	1.33	2.19	1.26

Incorporation of *S. rostrata* alone gave as much grain yield as did control. Increasing applied N with *S. rostrata* further increased grain yield. However straw yields in control and with 50 kg N/ha at *S. rostrata* incorporation were similar (Table 2).

S. rostrata gave significantly higher N for plant uptake than did control. ■

Rice response to N application with different irrigation schedules

L. R. Bhuiyan, N. Islam, and G. Mowla, Bangladesh Rice Research Institute, Gazipur 1701, Bangladesh

To determine a suitable time for N and irrigation water application to maximize yield, we conducted studies at two sites in the Ganges-Kobadak (G.K.) irrigation project area.

BR11 was used in T. aman season (Jul-Dec) plantings in 1988 and 1989, and BRl in aus (Mar-Jul) 1988. Soil was silty loam with pH 7.5-8.0, 0.80-0.85% organic matter, and CEC 18-20 meq/100 g soil. The experiment was laid out in a randomized complete block design with three replications.

NPK were applied at 80-26-33 kg/ha as urea (45% N), TSP (20% P), and KC1 (50% K). All the TSP and KC1 were applied basal and urea was topdressed in three equal splits at 10-d intervals from transplanting. The treatments are in the table. Approximately 5-7 cm water was applied during each irrigation.

Soil incorporation of fertilizer N (T3) produced the highest rice yield in both locations. Compared with the control (TI), rice yield increased by 11-38% for T3 and by 5-29% for T2.

The low yield in T1 may be attributed to denitrification and washing out of N with deep percolating water and surface runoff. T3 may have minimized such loss of N.

This study suggests that to maximize yields in rotational gravity irrigation systems like the G.K. project, fertilizer N should be applied at the end of irrigation and should be incorporated. ■

Yield response of modern rice varieties to fertilizer N applied at different times of irrigation at 2 sites in the G.K. project area.

Treatment no.[a]	Mean yield[b] (t/ha)	
	Swastipur	Shailkupa
	T. aman 1988	
1	4.3 c	3.7 c
2	5.0 b	4.5 b
3	5.4 a	4.8 a
	Aus 1989	
1	3.4 b	3.9 b
2	4.3 a	4.4 b
3	4.6 a	5.5 a
	T. aman 1989	
1	4.2	4.9 b
2	4.5	5.8 a
3	4.7	6.3 a

[a] 1 = fertilizer N applied 1 d before irrigation: 2 = fertilizer N applied after completion of irrigation, 3 = fertilizer N applied after completion of irrigation, followed by incorporation the following day. [b] In a column, values followed by a common letter letter do not vary significantly (LSD).

Integrated pest management — diseases

Effect of inoculum source on sheath blight (ShB) development

N. R. Sharma and P. S. Teng, Plant Pathology Division, IRRI; and F. M. Olivares, Philippine Rice Research Institute, Muñoz, Nueva Ecija, Philippines

IR72 (highly susceptible), IR64 (susceptible), and IR26957-86-2 (moderately resistant) were inoculated at booting stage with four ShB inoculum sources in a screenhouse experiment during 1989 dry season. The sources were 1) mycelial blocks of *Rhizoctonia solani* from a 5-d-old culture on potato dextrose agar (PDA), 2) sclerotia from a 10-d-old culture on PDA, 3) 1-wk-old culture from rice grain-hull mixture, and 4) freshly infected rice stems from a field of IR72.

Rice grain-hull inoculum and infected stems were placed directly at the base of each hill. Mycelial discs and sclerotia were placed in tissue paper at the base of the rice plant.

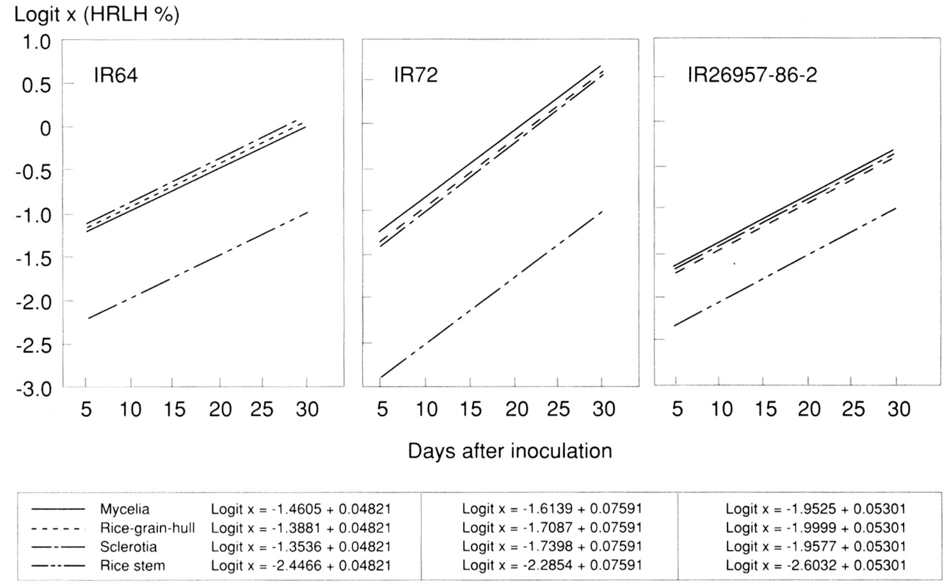
Highest relative lesion height was used to determine disease development from 5 plants in each pot up to 6 times at 5-d intervals.

Disease development differed significantly (see table). In control pots where

Area under disease progress curve (AUDPC) based on highest relative lesion height (%) of 3 rice cultivars inoculated with different inoculum sources in the screenhouse, 1989.[a]

Treatment	AUDPC		
	IR64	IR72	IR26957-86-2
Mycelia	922.94 ay	1121.06 ax	703.25 az
Rice grain-hull	971.19 ax	1068.63 ax	680.00 ay
Sclerotia	974.69 ax	1046.38 ax	780.50 ay
Infected rice stem	422.63 bx	378.81 bx	420.81 bx
Control	0.00cx	0.00cx	0.00cx
CV (%)			
Cultivar - 15.49			
Treatment - 19.66			

[a] Mean of 4 replications. Means followed by a common letter in a column (a, b, c) or in a row (x, y, z) are not significantly different at the 5% level by DMRT.



Relationship between ShB disease development, logit × (HRLH%) and time with different inoculum sources on IR64, IR72, and IR26957-86-2 in the screenhouse.

plants were sprayed weekly with triphenyltin acetate at 1 kg formulated product/ha, no disease developed. Infected rice stem inoculum differed significantly from the other inoculum sources and produced the lowest area under the disease progress curve (AUDPC) in all three cultivars and for all sources of inoculum. The three other inoculum sources were equally effective for ShB development under screenhouse conditions.

Among cultivars, highly susceptible IR72 had significantly higher AUDPC in response to mycelial inoculum. Cultivars IR64 and IR72 did not differ significantly in response to rice grain-hull and sclerotia inocula but had significantly higher AUDPC than IR26957-86-2. There were no varietal differences in response to rice stem inoculum.

The regression analysis of ShB development (Logit x) with time for different inoculum treatments on the three cultivars are presented in the figure.

The regression coefficient or apparent infection rate (*r*)/unit per day for all inoculum sources was 0.0482 for IR64, 0.0759 for IR72, and 0.0530 for IR26957-86-2. However, mycelia, rice grain-hull, and sclerotia had similar *r*, which were higher than that for rice stem inoculum source in all cultivars. The R^2 value for the cultivars ranged from 0.75 to 0.78.

IR72 had the highest *r*, followed by IR64 and IR26957-86-2. This confirms that IR72 is more susceptible than the two other cultivars, regardless of inoculation method. ■

Effect of rice growth stage on sheath blight (ShB) development and yield loss

N. R. Sharma and P. S. Teng, Plant Pathology Division, IRRI; and F. M. Olivares, Philippine Rice Research Institute, Muñoz, Nueva Ecija, Philippines

To determine the effect of time of ShB infection on disease development and yield loss, we inoculated rice cultivars IR42 and IR72 with *Rhizoctonia solani* grown on a rice grain-hull mixture (rice:hull = 1:3) at tillering, panicle initiation, booting, and flowering during 1989 dry season.

Percent infected tillers and the *Standard evaluation system for rice* (SES) scale were used to score disease development in 24 hills from 8- × 4-m plots at 5-d intervals up to 6 times. At maturity, 20 randomly selected plants from each plot were harvested and their yield components measured. A 2- × 1-m area from the center of each plot was harvested to measure yield per hectare. Disease progress curves of each treatment were used to calculate area under the disease progress curve (AUDPC).

Highly significant differences in AUDPC were found between treatments and between cultivars (Table 1). In IR42, inoculation at flowering ranked first (AUDPC value 1958.06). Inoculation at panicle initiation had the lowest AUDPC (1622.13).

In IR72, AUDPC at flowering and panicle initiation stages were significantly higher than those at tillering and booting. Among growth stages, tillering had the lowest AUDPC. IR42 had significantly higher AUDPC than IR72 at all growth stages except panicle initiation.

The results indicate that rice is more susceptible at booting and flowering than at tillering and panicle initiation.

In IR42, AUDPC based on SES scale showed no significant differences between treatments. Inoculation at tillering stage gave the lowest AUDPC value (62.00).

Table 1. Area under disease progress curve (AUDPC) based on disease incidence (%) and SES scale for 2 rice cultivars inoculated at different growth stages, 1988-89.[a]

Growth stage	AUDPC	
	IR42	IR72
Percent disease incidence		
Tiller	1651.50 cx	1465.25 cy
Panicle initiation	1622.13 cy	1692.75 ax
Booting	1727.38 bx	1588.06 by
Flowering	1958.06 ax	1735.44 ay
Control	0.00 dx	0.00 dx
CV (%)		
Cultivar - 2.7		
Treatment - 3.0		
SES		
Tiller	62.00 ax	51.94 cy
Panicle initiation	63.31 ax	61.06 bx
Booting	62.31 ax	63.44 abx
Flowering	65.94 ax	65.31 ax
Control	0.00 dx	0.00 dx
CV (%)		
Cultivar - 4.1		
Treatment - 5.2		

[a]Mean of 4 replications. Means followed by a common letter in a column (a, b, c, d) or in a row (x, y) are not significantly different at the 5% level by DMRT.

There was no cultivar difference except at tillering.

Effect on yield components of different treatments are presented in Table 2. Percent productive tillers and grain weight per plant were highest in control plots and lowest with inoculation at booting in both IR42 and IR72.

Filled grain number per panicle did not significantly differ among treatments in both IR42 and IR72, but there were significant differences in 1000-grain weight, filled grain percentage, and total biomass per plant.

Control had the highest biomass/plant, followed by tillering and panicle initiation, in both the cultivars. Inoculated plants had the lowest biomass values at booting and flowering, but IR42 and IR72 did not differ significantly. Inoculations at booting and flowering produced the lowest yield parameters.

Yields ranged from 3.8 to 5.6 t/ha in IR42 and from 3.7 to 5.6 t/ha in IR72.

Table 2. Yield components and yield loss in 2 rice cultivars inoculated at different growth stages, 1988-89.[a]

Treatment	Productive tillers (%)	Grain wt/plant (g)	Filled grains/ panicle (no.)	1000-grain weight (g)	Filled grains (%)	Total biomass/ plant (g)	Yield (t/ha)	Yield loss (%)
IR42								
Tillering	89.30 b	18.22 ab	49.00 a	17.98 ab	72.90 a	50.68 a	4.2 b	24.01 a
Panicle initiation	81.30 bc	17.10 b	46.00 a	17.60 bc	72.80 a	49.20 a	4.2 b	23.08 a
Booting	79.00 c	12.98 c	47.00 a	16.53 c	62.80 b	39.18 b	4.2 b	23.01 a
Flowering	87.50 b	16.15 b	46.00 a	18.13 a	64.80 b	42.50 b	3.8 b	32.15 a
Control	100.00 a	20.45 a	51.00 a	19.13 a	76.30 a	52.48 a	5.6 a	
IR72								
Tillering	91.30 b	21.97 b	41.00 a	23.75 a	71.2 b	46.70 ab	4.9 b	13.53 b
Panicle initiation	88.50 b	17.50 c	42.00 a	22.15 b	69.90 bc	42.00 bc	4.8 b	15.40 b
Booting	83.80 b	13.83 d	37.00 ab	21.73 bc	63.80 cd	42.40 bc	4.4 b	21.05 b
Flowering	89.30 b	12.98 d	28.00 b	20.68 c	62.00 d	37.95 c	3.7 c	34.83 a
Control	99.90 a	24.95 a	41.00 a	24.25 a	82.60 a	54.20 a	5.6 a	
CV (%)								
Cultivar	10.6	16.5	13.5	6.8	13.2	17.5	7.2	61.7
Treatment	6.2	10.6	14.2	3.8	7.0	9.4	9.6	30.0

[a] Mean of 4 replications. In a column, mean followed by a common letter are not significantly different at the 5% level by DMRT.

Yields of control plots were significantly higher. In both cultivars, inoculation at flowering resulted in the lowest yields and highest yield loss.

Yield loss due to ShB may occur at any stage, but is higher when infection occurs at booting or flowering. ■

Comparison of rice sheath blight (ShB) assessment methods

N. R. Sharma and P. S. Teng, Plant Pathology Division, IRRI; and F. M. Olivares, Philippine Rice Research Institute, Muñoz, Nueva Ecija, Philippines

We evaluated five methods for assessing ShB on three rice cultivars—highly susceptible IR72, susceptible IR64, and moderately resistant IR26957-86-2-in a pot experiment in the screenhouse during 1989 dry season. The methods were highest relative lesion height (HRLH %), disease severity (DS %), disease incidence (DI %), *Standard evaluation system for rice* (SES), and real area infected (RAI %). RAI % was calculated by measuring the length and width of infected area.

Rice plants (5/pot) were inoculated with *Rhizoctonia solani* grown on rice grain-hull mixture (rice:hull = 1:3) at booting. Disease development was measured at 3-d intervals from inoculation, up to eight times. The area under the disease progress curve (AUDPC) was used to compare the three cultivars.

All assessment methods except DI gave the lowest AUDPC value in IR26957-86-2, confirming that IR26957-86-2 was more resistant to ShB infection than either IR64 or IR72 (see table).

All methods showed variable results among cultivars and also within each cultivar at different times of assessment (see table and figure).

Assessment by HRLH (%) is easy but tedious because each tiller in a hill must be evaluated.

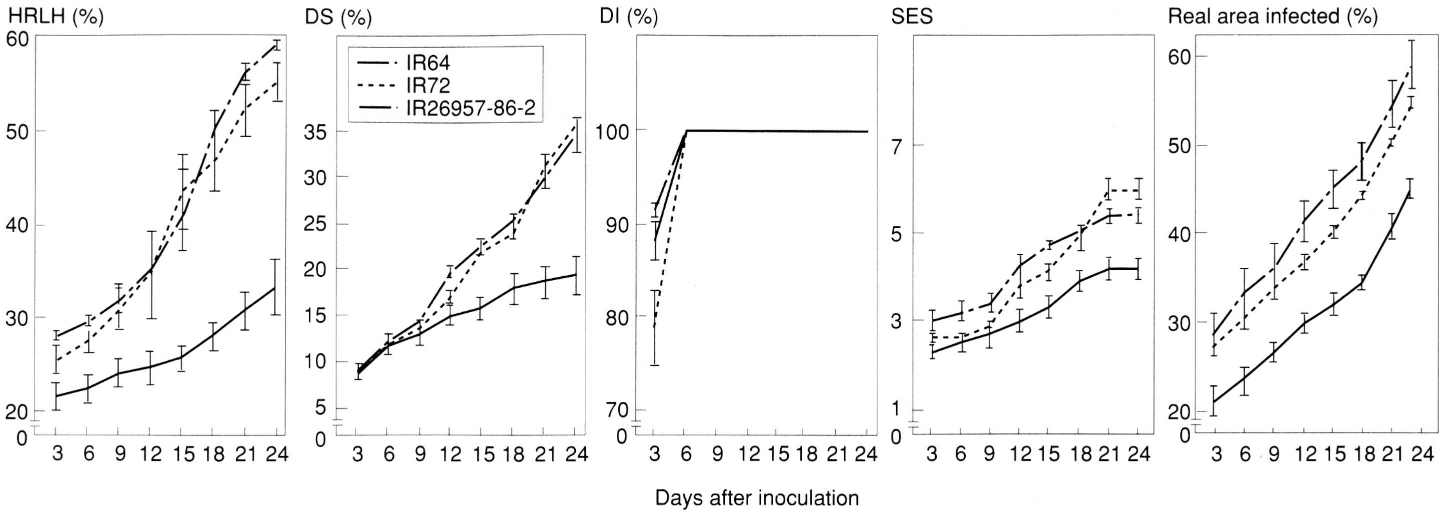
Estimation of percent leaf and sheath area infected (DS) was faster than HRLH % and more efficient for evaluating a large amount of material within a short time. Assessment by DI showed that all tillers in a hill were infected within a few days of inoculation. But this method does not give total infection or an accurate assessment of DS — important data in epidemiological and yield loss studies.

ShB assessment by SES scale was easy and quick, but that method does not give a quantitative measure of real infection. For

AUDPC and standard error of 5 assessment methods applied to 3 rice cultivars, measured in a screenhouse experiment, 1988-89.[a]

Method	AUDPC		
	IR64	IR72	IR26957-86-2
HRLH (%)	861.86 bx ± 29.00 (6.7)	828.11 bx ± 56.10 (13.5)	545.78 byp 31.50 (11.5)
DS (%)	437.81 cx ± 30.50 (14.0)	424.88 cx ± 19.30 (9.1)	317.63 cy p 51.20 (32.1)
DI (%)	2086.88 ax ± 1.88 (0.2)	2068.13 ax ± 12.25 (1.2)	2082.00 ax p 6.36 (0.6)
SES (0-9)	90.60 dx ± 5.20 (11.5)	85.91 ex ± 7.95 (17.6)	68.55 dx p 9.60 (28.1)
RAI (%)	386.01 cx ± 24.22 (12.7)	347.29 dxy ± 20.15 (11.6)	294.67 cy p 10.01 (6.7)

[a]Mean of 4 replications. Means followed by a common letter in a column (a, b, c) or in a row (x, y, z) are not significantly different at the 5% level by DMRT. Figures within parentheses indicate CV (%).



Disease progress curves based on HRLH (%), DS (%), DI (%), SES, and real area infected for vertical development of ShB on 3 rice cultivars in the screenhouse. Each point is the mean of four replications. Vertical lines indicate standard errors.

quantitative data, actual measurement of injury is necessary.

Some difficulties were encountered in using RAI. Because infected leaves and sheaths have to be detached from the plant, the plant may be damaged before maturity. The method is also tedious. At later growth stages, infected leaves and sheaths of lower plant parts cause difficulties in determining RAI. This method needs to be modified and tested for improved efficiency.

HRLH and DS are the most convenient and dependable assessment methods: they are easy to use and discriminate among cultivars. ■

Rice yellow mottle virus (RYMV) on swamp rice in Guinea

S. N. Fomba, West Africa Rice Development Association, Mangrove Swamp Rice Research Program, P.M.B. 678, Freetown, Sierra Leone

Symptoms of presumed RYMV were observed on cultivated rice in mangrove and inland swamps of Coyah and Koba Districts, lower Guinea, 1982-1986. The chrysomelid beetle vectors of RYMV, *Chaetocnema* sp., were also observed at the same sites.

In 1986, some naturally infected rice plants were collected from a mangrove swamp at Yelimangeya, Coya District, and maintained in buckets on a 180-d duration, virus-susceptible rice cultivar CP4 at Rokupr, Sierra Leone. Similar naturally virus-infected rice plants were collected at Rokupr and Makoth in Kambia District and at Kabala in Koinadugu District in the Northern Province of Sierra Leone in 1988 and 1989 cropping seasons. These isolates were maintained on CP4 by the same method.

In 1989, agar-gel double diffusion tests were done with crude extracts from virus-infected rice plants that had typical pale yellow mottling symptoms. Viruliferous saps were extracted in 0.01 M phosphate buffer solution, pH 7. (Antiserum was obtained from IITA.)

Reactions of virus antigens and antiserum were strongly positive. No spur formation was observed between the virus isolates of Guinea and Sierra Leone and the antiserum from Nigeria. This indicates serological similarity between RYMV isolates and probably their common identity. ■

Hosts of rice tungro-associated viruses (RTVs) in Thailand

A. Parejarearn, D. Chettanachit, M. Putta, W. Rattanakarn, J. Arayapan, and S. Disthaporn, Rice Pathology Group, Plant Pathology and Microbiology Division, Agriculture Department, Bangkhen Bangkok 10900, Thailand

We used enzyme-linked immunosorbent assay (ELISA) and latex agglutination test to detect rice tungro spherical virus (RTSV) and rice tungro bacilliform virus (RTBV) in 10 weed species, 12 species of wild rice, 27 lines of wild rice, wheat, barley, and maize.

The plants were inoculated separately with viruliferous *Nephotettix virescens* that had fed on RTVs-infected rice plants for 4 d. Each species had uninoculated plants as control. The vectors were confined on test plants at 5 insects/seedling for 24 h of inoculation. Inoculated seedlings were kept in the greenhouse.

The second youngest leaf of each plant was collected 30 days after inoculation and homogenized with phosphate buffer saline. Extracts of weed species, wheat, barley, and maize were indexed by ELISA. The latex agglutination test was used to detect RTVs in wild rice.

Of 10 weed species, 3—*Ischaemum rugosum, Echinochloa crus-galli,* and *Leptochloa chinensis*—had only RTSV. No RTVs were detected from wheat and barley. Maize had only RTSV (Table 1).

Results of latex agglutination test showed that nine species of wild rice were infected with RTBV + RTSV (Table 2). *Oryza officinalis* had only RTBV; *O. eichingeri* had only RTSV. No virus was found in *O. ridleyi.* All lines of wild rice found in Thailand had RTBV + RTSV. ■

Table 1. Detection of RTBV and RTSV in extracts of weed species and cereal crops by enzyme-linked immunosorbent assay. [a]

Plant species	Inoculated plants (no.)	Plants (no.) infected with RTSV
Chloris barbata	57	0
Digitaria adscendens	54	0
Ischaemum rugosum	49	1
Echinochloa crus-galli	36	2
Leprochloa chinensis	36	2
Imperata cylindrica	23	0
Jussiaea linifolia	15	0
Leersia hexandra	5	0
Sphenoclea zeylanica	15	0
Fimhristylis milliacea	5	0
Zea maydis	54	4
Wheat	180	0
Barley	180	0

[a] Extract that gave yellow color in a well compared with extract of an uninoculated plant of the same species was considered positive in ELISA.

Table 2. Detection of RTV-associated virus in extracts of wild rice by latex agglutination test.

Entry	Inoculated plants (no.)	Infected plants [a] (no.)		
		RTBV	RTSV	RTBV+RTSV
O. nivara	17	3	0	14
O. barthii	12	0	6	4
O. gluberrima	31	4	8	7
O. rufipogon	34	26	6	38
O. punctata	33	3	5	6
O. minuta	35	4	8	6
O. perennis	10	3	0	4
O. eichingeri	12	0	3	0
O. officinalis	15	1	0	0
O. ridleyi	6	0	0	0
P. nivara/O. sativa	17	3	3	3
O. sutiva/O. spontanea	26	1	4	6
TN1 (check)	53	3	11	35
Ayy-82-35	20	11	0	9
Ayy-82-36	25	0	0	25
Ayy-82-37	19	2	11	5
Ayy-82-38	10	4	2	3
Ayy-82-39	17	3	4	9
SRB-82-44	26	1	3	20
PSL-82-47	26	5	12	9
PSL-82-48	30	0	12	18
PSL-82-49	28	0	3	24
PSL-82-50	4	2	0	2
PSL-82-52	26	0	1	25
PSL-82-53	35	0	15	8
PSL-82-54	18	0	1	17
SPR-83-113	9	0	4	4
SRB-83-114	16	0	5	11
SRB-83-115	7	0	0	6
SRB-83-116	4	0	0	4
SRB-83-117	19	1	7	11
SRB-83-118	8	1	3	4
SPR-83-119	14	1	6	6
SPR-83-120	10	0	8	2
SPR-83-121-2	5	3	1	1
SPR-83-122	18	0	2	16
SRB-83-141	4	0	0	4
SRB-83-142	10	0	0	10
SRB-83-143	8	0	1	1
SRB-83-144	17	0	11	5

[a] Test samples that showed clumping under the microscope compared with uninoculated samples were conridered positive.

Integrated pest management—insects

Dynamics of major predator and prey species in ricefields

K. L Heong, A. T. Barrion, and G. B. Aquino, Entomology Division, IRRI

We studied populations of important predator and prey species at five rice-growing sites in the Philippines. All arthropods inside a mylar enclosure (0.5 x 0.5 x 0.9 m) were sucked up using the FARMCOP suction device, with 10 samples/site. A total of 540 samples taken at weekly intervals were obtained, sorted into species, and identified.

Three species of Cicadellidae and two of Delphacidae accounted for most of the phytophagous Homoptera (Table 1). Two main groups of predators-Heteroptera and Araneae—were recorded. The three Heteroptera families were represented by one species each: *Cyrtorhinus lividipennis, Microvelia atrolineata,* and *Mesovelia vittigera.* Of 13 spider species, *Pardosa* (= *Lycosa) pseudoannulata,* three species of *Tetragnatha,* and members of family Linyphiidae were dominant.

The counts of delphacids and cicadellids in each sample were aggregated and the linear relationships with *C. lividipennis* (Miridae), spiders, and veliids + mesoveliids determined. Correlations ($p<0.005$) were significant and positive in all cases. Regression coefficients are shown in Table 2.

High positive correlations or numerical responses to hopper density indicate that densities of the three groups of predators were directly related to hopper densities. *C. lividipennis* had strong numerical responses in Bayombong and Kiangan, but were negligible in IRRI, Cabanatuan, and Banaue. Because *C. lividipennis* is a predator of hopper eggs, a delayed instead of a direct numerical response may be expected.

For spiders, responses were high in Kiangan, IRRI, and Bayombong, but significantly lower in Cabanatuan and

Table 1. Proportion of major species in the arthropod guilds collected in 5 rice cultivation sites in the Philippines, 1989.

	Proportion (%)				
	IRRI (Laguna)	Cabanatuan, Nueva Ecija	Bayombong, Nueva Vizcaya	Mountain Province	
				Kiangan	Banaue
Phytophages					
Hornoptera					
Cicadellidae	**44.9**	**84.6**	**69.1**	**40.6**	**68.0**
N. virescens	63.7	77.1	74.1	56.3	75.1
N. nigropictus	22.1	13.7	14.1	12.3	19.3
R. dorsalis	2.5	8.3	8.9	29.0	2.3
Delphacidae	**55.1**	**15.4**	**30.9**	**59.4**	**32.0**
N. lugens	27.8	28.7	49.0	25.3	25.1
S. furcifera	57.8	70.5	46.5	72.6	74.7
Diptera					
Ephydridae	**2.4**	**52.3**	**48.8**	**45.5**	**38.2**
H. philippina	7.5	49.7	6.7	67.0	28.8
N. spinosa	50.3	10.7	4.6	13.6	19.3
Psilopa sp.		11.2	70.5	13.99	11.8
Chironomidae	**4.5**	**36.5**	**31.3**	**49.8**	**60.2**
Chironomus sp.1	0.0	100.0	100.0	99.8	2.5
Chimnomus sp.2	82.1	0	0.0	0.0	0.8
Chironomus sp.3	10.1	0	0.0	0.0	88.8
Cryptochironomus sp.	5.3	0	0.0	0.0	7.9
Phoridae	**42.5**	**2.5**	**0.0**	**0.0**	**0.9**
Sciomyzidae	**42.8**	**2.5**	**8.2**	**1.1**	**0.2**
Agromyzidae	**0.0**	**6.2**	**11.8**	**3.6**	**0.5**
Predators					
Heteroptera					
Miridae	**3.0**	**4.3**	**10.7**	**27.4**	**29.2**
Veliidae	**90.6**	**95.5**	**82.2**	**62.2**	**29.7**
Mesoveliidae	**6.4**	**0.1**	**7.0**	**10.5**	**41.0**
Araneae					
Lycosidae	**39.8**	**33.0**	**24.4**	**43.8**	**54.1**
Tetragnathidae	**16.8**	**22.2**	**41.7**	**37.7**	**34.1**
Dyschiriognatha	41.4	4.5	7.5	2.4	3.0
T. maxillosa	26.1	47.8	31.9	45.5	36.4
T. javana	29.1	23.4	12.8	17.1	24.2
T. virescens	3.4	24.3	47.8	35.0	36.4
Linyphiidae	**39.7**	**35.1**	**23.0**	**9.1**	**6.9**

Table 2. Linear regression coefficients[a] of relationships between abundance of plants and leafhoppers and associated predators at different sites[b] in the Philippines.

	Linear regression coefficient				
	IRRI (90)	Cabanatuan (80)	Bayombong (110)	Kiangan (100)	Banaue (130)
Cyrtorhinus	0.02 ± 0.01	0.03 ± 0.01	0.29 ± 0.03	0.48 ± 0.05	0.11 ± 0.01
Spiders	0.34 ± 0.04	0.14 ± 0.05	0.34 ± 0.05	0.54 ± 0.09	0.12 ± 0.01
Veliids and mesoveliids	0.29 ± 0.14	0.73 ± 0.25	0.54 ± 0.23	0.57 ± 0.13	0.26 ± 0.02

[a]±SEs. [b]In all occasions, data fitted the linear model, $y = mx + C$ at probability $p<0.005$. Numbers in parentheses under each site indicate number of observations.

Banaue. Strong positive correlations for veliids and mesoveliids were obtained at all sites. Because spiders constitute a large proportion of all predators and their relative biomass is likely to be larger than that of mirids and veliids, their impact may be greater than what the coefficients imply.

Predator-prey relationships appeared to be significantly lower in IRRI and Banaue. These two sites had the highest and lowest predator-prey loads. Compared with Cabanatuan, Bayombong, and Kiangan, the two sites may be considered atypical of rice production areas: IRRI is an experimental farm with high diversity in plant stages and germplasm; Banaue has significantly lower median temperatures because of its elevation (1,524 m above sea level); Cabanatuan, Bayombong, and Kiangan are extensive rice cultivation areas. ■

Influence of lunar phase on green leafhopper (GLH) incidence

R. Saroja, S. Raguraman, and K. S. Paramasivan, Rice Research Station (RRS), Tamil Nadu Agricultural University, Tirur 602025, India

We studied the influence of lunar phase on GLH attraction to light traps at RRS, Tirur, during 1987. A modified Robinson light trap, fitted with a 200-watt ordinary incandescent lamp, installed in the middle of ricefields was operated daily from 1800 to 0600 h. Daily collections were recorded during the 12 lunar cycles of 1987.

Three days on either side of the date of a new moon was taken as a new moon week and 3 d on either side of a full moon day constituted a full moon week. In-between periods formed the last and first quarter moon weeks.

Table 1. Effect of lunar cycle on population dynamics of rice GLH. RRS, Tirur, 1987.

Lunar cycle no.	Period	Mean incidence	
		Actual no.	Transformed value (log x)
1	12 Jan-9 Feb	529.8	2.427
2	10 Feb-11 Mar	51.3	1.489
3	12 Mar-10 Apr	198.5	2.028
4	11 Apr-9 May	574.3	2.465
5	10 May-7 Jun	9.53	1.932
6	8 Jun-7 Jul	329.8	2.425
7	8 Jul-5 Aug	1124.0	3.047
8	6 Aug-3 Sep	6379.8	3.437
9	4 Sep-3 Oct	722.0	2.356
10	4 Oct-l Nov	83.5	1.826
11	2 Nov-1 Dec	931.3	2.688
12	2 Dec-30 Dec	2526.5	3.208
	LSD		0.589

GLH occurrence was significantly higher during the eighth lunar cycle (6 Aug-3 Sep), closely followed by the twelfth (2 Dec-30 Dec) and seventh (8 Jul-5 Aug) cycles (Table 1). Moonlight had a significant influence on GLH nocturnal activity: it was lowest during the new moon week and highest in the full moon week (Table 2). The ratio of activity between new moon and full moon weeks was 1:8.1. ■

Table 2. Effect of lunar phase on light trap catches of GLH. RRS, Tirur, India, 1987.

Week	Mean incidence	
	Actual no.	Transformed value (log x)
New moon week	280.8	2.026
First quarter week	358.5	2.187
Full moon week	2273.4	2.790
Last quarter week	1602.4	2.772
LSD		0.336

Rice ratoons as potential host for African rice gall midge (GM)

R. C. Joshi, Rice Research Program (RRP), International Institute of Tropical Agriculture (IITA), Ibadan; M. N. Ukwungwu, National Cereals Research Institute (NCRI), Badeggi; and M. D. Winslow, RRP, IITA, Ibadan, Nigeria

African rice GM *Orseolia oryzivora* Harris and Gagné recently caused substantial yield losses in Anambra, Cross River, Imo, and Niger States. We measured African GM infestation on rice varieties from Asia reported to be resistant to the closely related Asian GM *Orseolia oryzae* (Wood-Mason).

Observations covered the main crop and the dry season ratoon crop at Badeggi, Niger State. Percentage silvershoots was calculated as the ratio of silvershoots to total number of tillers in 20 hills for each variety at 45 d after transplanting the main crop and 15 d after ratooning.

African GM damage was encouraged by maintaining standing water and by high fertilizer application (120 kg N/ha as urea).

In general, damage on ratoons was higher than on the main crop in all varieties except ARC5988, ARC14421, PTB18, and Warangal Culture 1251 (see table).

Dissection of galls and ratoons showed pupae and, in some cases, diapausing larvae. This suggests that ratoons as well as volunteer plants may help African GM survive until the next rainy season. ■

African GM damage on Asian rice varieties resistant to it. Badeggi, Nigeria, 1989 rainy season.

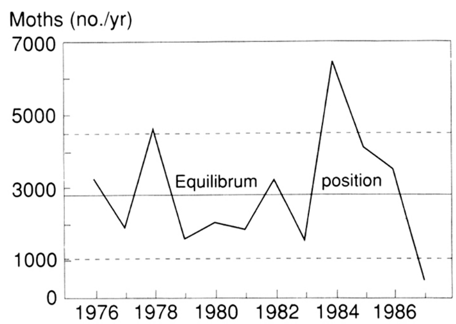
Variety	Silvershoots (%)	
	Main crop[a]	Ratoons[b]
AC1423	4.8	10.5
ARC5842	8.2	12.0
ARC5951	8.6	25.0
ARC5988	9.0	0.0
ARC6010	5.9	14.3
ARC6I36	5.7	23.1
ARC6157	6.1	24.7
ARC6557	12.9	20.0
ARC6632	7.0	11.6
ARC7213	4.2	11.1
ARC10227	9.6	19.2
ARC10360	9.0	13.2
ARC10377	8.7	17.3
ARC10963	6.3	14.9
ARC14421	11.7	11.1
ARC14725	5.9	20.0
ARC14748	6.6	8.1
ARC15159	3.0	15.1
ARC18601	5.7	9.1
DNJ 45	5.5	15.4
Eswarakora	6.5	18.4
Malalwariyan	5.8	11.5
Muey Nawng 62	7.1	37.0
Nigersail	5.8	14.1
PTB10	7.1	19.6
PTB18	12.5	0.0
PTB21	5.4	22.3
PTB28	3.9	23.1
Siam 29	10.7	11.7
T10	8.6	15.6
Warangal Culture 1251	13.6	0.0
Warangal Culture 1257	6.1	16.2
Warangal Culture 1263	7.0	27.1

[a]Transplanled 23 Nov 1989. [b]Ratooned on 22 Jan 1990.

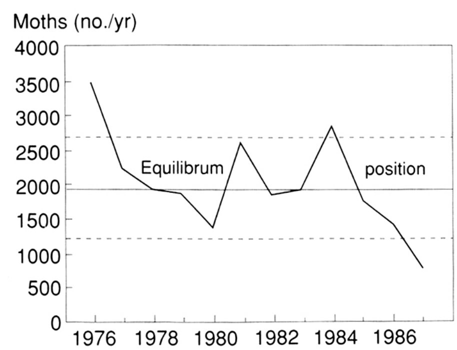
Fluctuations in rice stem borer density in the Punjab

C. Inayatullah, Entomological Research Laboratories, National Agricultural Research Centre, Islamabad; A. Majid, Rice Research Institute, Kala Shah Kaku, Lahore; and M. S. Moughal, Plant Protection Institute, Faisalabad, Pakistan

Fluctuations in population density of yellow stem borer (YSB) *Scirpophaga incertulas* (Walk.) and white stem borer (WSB) *S. innotata* (Walk.) (based on the number of moths trapped in a light trap between 1976 and 1977) are plotted in Figures 1 and 2. YSB population was highest in 1984 and lowest in 1987. The mean of the series, 2,897.92 ± 1654, may be designated as the equilibrium position of YSB (Fig. 1). WSB population was highest in 1976 and lowest in 1987. The mean, 1998.67 ± 728.71, may be designated as the equilibrium position of WSB (Fig. 2). ■



1. YSB catches, 1976-87.



2. WSB catches, 1976-86.

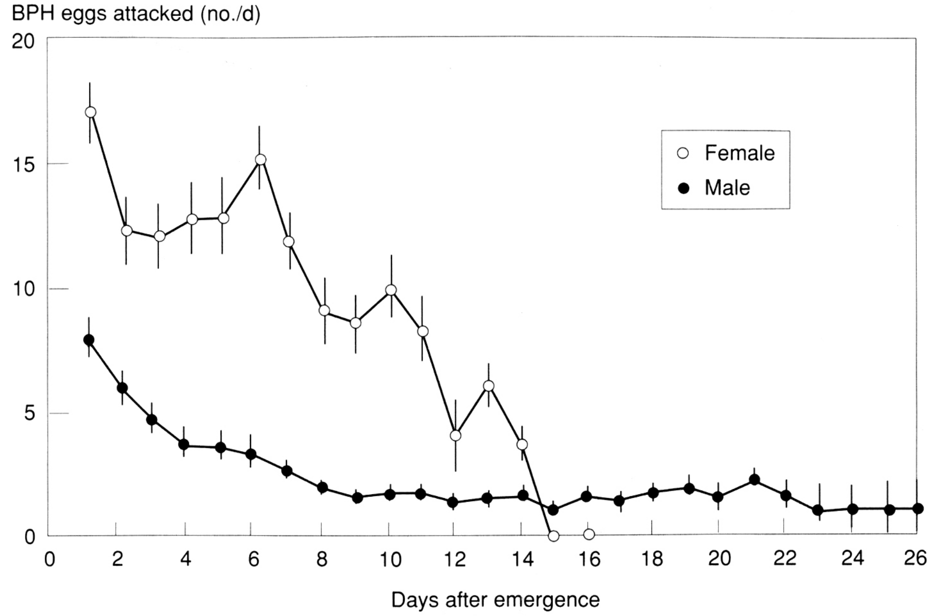
Space limitations prevent IRRN from publishing solely yield data and yield component data from routine germplasm screening trials. Publication is limited to manuscripts that provide either a) data and analysis beyond yield and yield components (e.g., multiple or unique resistances and tolerances, broad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

Predation of brown planthopper (BPH) eggs by *Cyrtorhinus lividipennis* reuter

I. Manti, Sukarami Research Institute for-Food Crops (SARIF), P.O. Box 34, Padang, West Sumatra, Indonesia; and B. M. Shepard, Coastal Research and Education Center, 1865 Savannah Highway, Charleston, South Carolina 29407, USA

We measured mirid predator consumption of BPH eggs. Females had higher daily and total consumption of BPH eggs than males. But maximum longevity was shorter in females (16 d) than in males (26 d). Egg consumption by both females and males was highest 1 d after the mirid emerged.

Egg consumption by mirid females was relatively high the first week, then decreased (see figure). Total lifetime consumption by females was 143.68 ±17 eggs; that of males was 61.23 ± 12.7 eggs. Average consumption per day was about 8.98 ± 1.06 for females and 2.36 ± 0.49 for males. ■



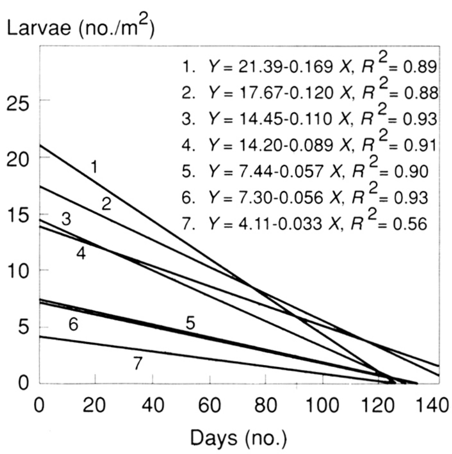
Predation of BPH eggs by *C. lividipennis* adults. Vertical lines are standard error of the mean. IRRI, 1988.

Survival of overwintering rice stem borer (SB) larvae in conventional and no-tillage wheat

C. Inayatullah and Ehsan-ul-Haq, Entomological Research Laboratories, National Agricultural Research Centre, Islamabad, Pakistan

Survival of overwintering SB *Scirpophaga incertulas* Walk. and *S. innotata* Walk. larvae in wheat stubbles (live larvae/m^2, 10 samples/plot) was monitored in no-tillage and conventional tillage wheat at 4 sites Dec-May 1987-88. Larvae density was higher in no-tillage wheat plots in Dec-Jan, but was almost equal in no-tillage and conventional tillage wheat plots at end of the larvae hibernation period (Feb-Mar) (see figure).

Regression analysis indicated a linear trend in larval mortality over time. Regression lines for both tillage systems were identical, indicating no significant difference in survival of larvae between tillage systems. ■



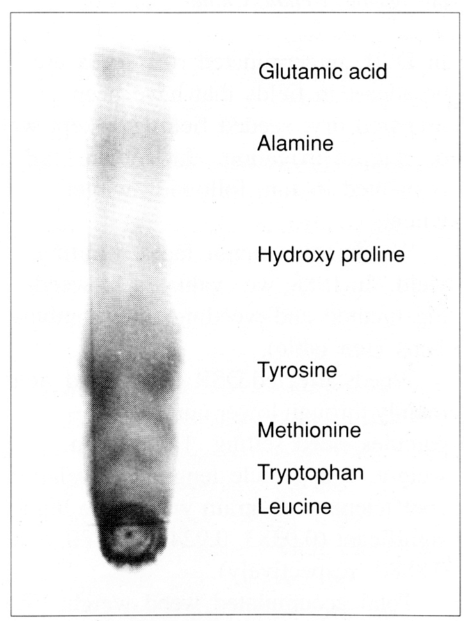
Survival of SB larvae in conventional and no-tillage wheat. 1, 2 = no tillage at Motra sites I and II; 3 = conventional tillage at Muslimanian; 4 = no tillage at Muslimanian; 5, 7 = no tillage at Quinkey sites I and 11; 6 = conventional tillage at Quinkey.

Protein accumulation in developing oocytes of *Nilaparvata lugens*

R. Jeyaraj, T. Thangaraj, R. Thangamani, and M. Aruchami, PG & Research Department of Zoology, Kongunadu Arts and Science College, Coimvatore 641029, India

Not much attention has been paid to the reproductive physiology of brown planthopper (BPH) *Nilaparvata lugens.* Protein content and free amino acids at different stages of ovary have been estimated, and the possibility of an antibody against the yolk protein in the ovary has been raised.

Female BPH possess a pair of telotropic ovaries, and the oocytes develop in association with two kinds of supporting cells. An ovariole consists of a single



1. Free aminoacids identified in the mature ovary (butanol:acetic acid:water solvent system).

strand of several oocytes. At the apex of each ovariole is a syncytium of nurse cells (tropharium) that connect provitellogenic oocytes by strands of cytoplasm (trophicards).

We homogenized mature oocytes in ovaries in a microhomogenizer containing 1.0 ml of 80% ethanol. Chromatogram run in butanol, acetic acid, and water (12:3:5) were localized using 0.2% ninhydrin. Protein content was estimated at different stages of ovary development.

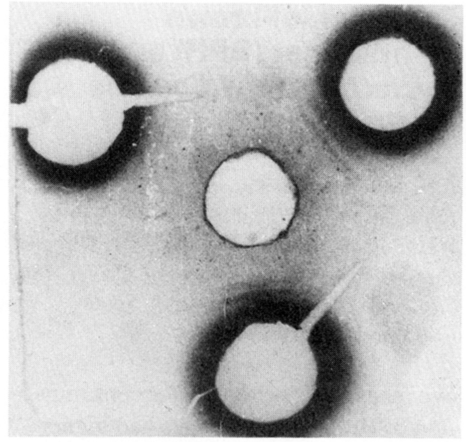
Protein from mature oocytes in the ovary was immunized in a rabbit. One ml sample from the homogenized mixture and an equal volume of complete adjuvant (Sigma) were used for primary injection. Two subsequent booster doses of incomplete adjuvant (Sigma) were given at 10-d intervals. Ouchterlony's immunodiffusion method was followed. Ten microliters of the serum and sample was applied as well. Precipitated proteins were washed in phosphate saline buffer (pH 7, 0.01 M), dried, and stained in coomassie brilliant blue R-250 (methanol, acetic acid, and water 18:7.5:48.5).

Amino acids increased as ovary growth advanced. In immature and premature ovaries, free amino acid content was, respectively, 39% and 72.25% that of the mature ovary. The increase in amino acids at all stages was statistically significant.

Protein content also increased as the ovary matured. The immature ovary had a minimum value of 17.1% protein, and the premature ovary, 44.4%, that of the fully mature ovary. Protein increase at all stages was significant.

Chromatographic study showed seven free amino acids in the mature ovary: glutamic acid, alanine, hydroxy proline, tyrosine, methionine, tryptophan, and leucine (Fig. 1).

The immunodiffusion study showed antivitellin for vitellin of BPH. Two bands were observed after staining in coomassie brilliant blue. Further study is under way to elucidate the role of lytic enzymes in yolk utilization during embryogenesis (Fig. 2). ■



2. Immunodiffusion of ovarian proteins against the antiserum raised in the rabbit.

Integrated pest management — weeds

Preliminary study on weed control in dry seeded rice (DSR) after winter wheat

Fang Zhiyong and Wang Shengxuan, Grain Crop Institute, Henan Academy of Agricultural Sciences, No. 1 Nongye Road, Zhenghou, Henan, China

In DSR, ungerminated rice seeds are broadcast in fields that have been prepared dry; seeded fields are kept wet by interim irrigation. In Henan, DSR is planted in Jun, following winter wheat.

Weeds are a major factor limiting yield. In 1988, we evaluated 11 weeding method and weeding time combinations (see table).

Weeds affected DSR growth and yield mainly through lower numbers of panicles, seed setting, 1,000-grain weight, and panicle length: correlation coefficients with grain yield were highly significant (0.9383, 0.9243, 0.9180, and 0.8880, respectively).

Total accumulated weed weight (X_1) and grasses weight (X_2) correlated negatively with rice grain yield (Y). Simulated equations were

$$Y\,(\text{t/ha}) = 4.6221\text{-}0.0068X_1\,(\text{g/m}^2)\quad (r = 0.9271^{**})$$

$$Y\,(\text{t/ha}) = 4.0561\text{-}0.0072X_2\,(\text{g/m}^2)\quad (r = 0.9762^{**})$$

We suggest total weed weight or grasses weight be used as a criterion for assessing crop losses caused by weeds (the higher the weed weight, the lower the rice yield).

Effect of weeding times and methods on weed growth and yield of DSR Yujing 2.[a] Zhengzhou, Henan, China, 1988.

Treatment[a]	Grain yield (kg/20 m^2)	Panicles (no./m^2)	Seed set (%)	1,000-grain wt (g)	Panicle length (cm)	Weed weight[d] (g/m^2)
Unweeded check	0 d	0	–	–	–	611.53
Weed-free	7.9 a	380.85	94.20	27.53	16.36	
Hoeing 2 WAS + hand weeding 5 WAS	5.6 bc	254.10	92.19	26.41	15.90	343.42
Hoeing 3 WAS + hand weeding 5 WAS	5.2 c	272.40	90.77	26.80	16.20	318.82
Hoeing 3 WAS	1.3 d	137.55	77.79	24.38	15.23	520.55
Hoeing 3 WAS + hand weeding 5 and 7 WAS	7.0 ab	354.15	94.10	27.18	16.44	226.29
Nitrofen + hoeing 3 WAS	6.6 abc	274.95	92.06	26.70	16.32	257.84
Nitrofen + hoeing 3 WAS + hand weeding 5 WAS	6.2 abc	289.20	92.01	27.57	16.55	189.34
Weed-free 10.25 DAS	5.8 bc	272.55	93.04	27.11	16.23	180.19
Weed-free 25-40 DAS	7.6 a	333.30	92.49	27.27	16.27	174.73
Weed-free 40-55 DAS	5.1 c	214.20	91.19	2.5.89	15.90	376.34

[a]Av of 3 replications. [b]WAS = weeks after sowing, DAS = days after sowing. [c]Means followed by a common letter are significantly different at the 5% level by LSD. Total accumulated dry weed weight at each weeding time and harvest individually.

In number of weeds in DSR, broadleaf weeds > grasses > sedges; in weed weight, grasses > broadleaf weeds > sedges. Weed weights correlated closely with rice yield, and integrated analysis indicated that grasses were the most severe problem and the predominant weed species, in spite of lower density.

The major weeds found in association with DSR and their relative density (RD) and relative dry weight (RDW) were: grasses—*Echinochloa crus-galli, Eleusine indica,* and *Digitaria sanguinalis* (RD = 29.58%, RDW = 66.83%); broadleaf weeds—*Rorippa islandica* and *Portulaca oleracea* (RD = 62.75%, RDW = 25.63%); and sedges—*Cyperus rotundus* and *C. difformis* (RD = 7.67%, RDW = 7.54%).

Weeds injured the rice crop most severely 25-40 d after sowing.

Weed control recommendations for DSR farmers are to maintain the crop weed-free during the critical period; or to apply nitrofen immediately after sowing, before weed and rice seedlings emerge, then hoe weeds once within 3 wk after sowing; or hoe within 3 wk of sowing and hand weed 5 and 7 wk after sowing. ■

Integrated pest management — other pests

Comparing arthropod diversity in rice ecosystems

K. L. Heong, G. Aquino, and A. T. Barrion, Entomology Division, IRRI

Diversity reflects two common components: species richness (the number of species in a community) and species evenness or equitability. Diversity indices attempt to combine both components.

We obtained arthropod samples from five rice cultivar IR8866 cultivation sites at weekly intervals from the vegetative stage to panicle initiation. A mylar enclosure 0.5 × 0.5 × 1 m trapped all arthropods on 9 hills each.

The arthropods were sucked up using the FARMCOP suction device. Ten samples from each site were taken weekly, for a total of 540 samples. The arthropods in each sample were identified, counted, and diversity indices computed.

We used Hill's diversity numbers to describe the relationship between indices. These numbers are

$$N_0 = S \quad (1)$$

where S is the total number of species

$$N_1 = e^H \quad (2)$$

where H is Shannon's index, and

$$N_2 = 1/l \quad (3)$$

where h is Simpson's index

Shannon's index (H^1) is based on information theory. It measures the average degree of uncertainty in predicting to what species an individual chosen at random from a collection of S species and N individuals will belong. Thus, Hill's diversity number N_1 measures the number of abundant species in a sample. H^1 is defined as

$$H^1 = \underset{i=1}{\overset{S}{S}}(p_i/1np_i) \quad (4)$$

where S is the number of species and p_i is the proportion of the total number of individuals in the i^{th} species.

Simpson's index is defined as

$$l = \underset{i=1}{\overset{S}{S}} p_i^2 \quad (5)$$

Table 1. Mean values of species diversity indices for 5 rice cultivation sites in the Philippines, 1989.

Site	Mean values of diversity indices			
	N_0	N_1	N_2	E_5
Banaue	8.52	5.70	4.85	0.86
Kiangan	16.77	10.08	7.32	0.70
Bayombong	20.41	10.65	7.07	0.62
Cabanatuan	15.90	4.70	2.82	0.52
IRRI, Los Baños	30.66	12.75	8.09	0.58
LSD	2.69	1.24	0.55	0.051
F	86.8	70.2	28.5	60.6
	<0.01	<0.01	<0.01	<0.01
(%)	45.8	43.7	28.0	23.7

Table 2. Relative abundance of the most common arthropod species for 5 rice cultivation sites in the Philippines, 1989.

Arthropod species	Relative abundance[a] (%) in				
	Banaue	Kiangan	Bayombong	Cabanatuan	IRRI
Nephotettix virescens	12.6^{2}	2.4^{8}	8.2^{2}	21.0^{2}	8.9^{4}
N. nigropictus	3.2	0.5	1.7	3.7^{3}	1.8^{9}
Nilaparvata lugens	2.0	1.6^{10}	2.6^{8}	1.4	4.7^{7}
Sogatella furcifera	5.9^{3}	0.1	2.5^{9}	3.5^{4}	8.7^{5}
Cyrtorhinus lividipennis	3.3	4.8^{5}	4.3^{5}	2.2^{6}	0.5
Microvelia atrolineata	3.3	10.9^{2}	23.1^{1}	49.5^{1}	15.6^{2}
Mesovelia vittigera	4.6^{5}	1.8^{9}	2.9^{7}	0.1	1.1^{11}
Micronecta sp. 1	4.0^{6}	0	2.1^{10}	0.4	1.7^{10}
Micraspis sp. 1	2.8	3.4^{7}	1.9	1.5	0.2
Chironomus sp. 1	7.6^{4}	7.2^{3}	4.4^{4}	0.8	16.7^{1}
Smithurus sp. 1	24.1^{1}	30.8^{1}	0	0	11.9^{3}
Entomobryinid sp. 1	0.1	0	0	0	0.1
Staphylinidae sp. 1	0	0.1	4.9^{3}	0	0
Hydrellia philippina	1.5	4.4^{6}	0.5	0.5	0.1
Pandosa (= *Lycosa*) *pseudoannulata*	2.7	5.3^{4}	3.1^{6}	2.1	2.9^{8}
Tetragnatha maxillosa	0.6	2.1	1.7	0.7	2.9^{8}
Atypena (= *Callitrichia*) *formosana*	0.3	1.1	2.9^{7}	2.3^{5}	5.5^{6}
Very abundant species (no.)	5	7	7	3	8
Abundant species (no.)	6	10	11	5	12
% contribution of abundant species	58.8	73.1	60.0	80.0	82.4
Total arthropods, N	5811	11321	8294	15500	21849

[a] Numbers in superscript represent ranking of relative abundance.

where p_i is the proportional abundance of the i^{th} species. Thus N_2 is the number of very abundant species.

For evenness,

$$E5 = \frac{N_2 - 1}{N_1 - 1} \qquad (6)$$

is appropriate, since E5 will approach zero when a single species is most dominant.

Diversity was lowest in Cabanatuan, followed by Banaue; IRRI farm had the highest diversity (Table 1).

The units of indices N_0, N_1, and N_2 are in numbers of species, representing the number of species in the samples (species richness), abundant species, and very abundant species, respectively. In Cabanatuan, where N_1 was 4.70, five species accounted for 80% of the abundance (Table 2). In Banaue, six species accounted for 59% of the abundance. On IRRI farm, eight very abundant species accounted for 75% of the abundance.

A total of 240 species were found at the five sites. Because the sampling procedure was constant, N_0, the total number of species in the community or species richness, may be used for comparison. IRRI farm was significantly "richer" in arthropod species than other sites (Table 1); Banaue was the "poorest." The sites differed significantly, with Banaue having the highest mean value. In general, E5 is sensitive to the number of species in a sample, which probably accounts for the lower means in IRRI and Cabanatuan. Similarities between Banaue and Kiangan may be related to co-dominance of *Smithurus* sp.; for Bayombong, Cabanatuan, and IRRI, co-dominance by *Microvelia atrolineata* may have played an important role.

Cabanatuan had the lowest diversity (as determined by N_1, N_2, and E5). However, its species richness (N_0,) is almost twice that of Banaue. Five species accounted for 80% of all arthropods in Cabanatuan: in Banaue, it required more than 16 species to account for 80%. Lower arthropod densities in Banaue are probably a result of lower ambient temperatures due to elevation; Banaue is 1,524 m above sea level; Cabanatuan, 61 m.

However, elevation does not appear to be the only factor affecting arthropod diversity. IRRI has an elevation of 22 m above sea level, but has the highest diversity. The greater diversity in germplasm and plant stages on the IRRI farm may have accounted for this difference. ■

Farming systems

Survival of rice stem borer (SB) in different cropping systems in Sindh

A. Rehman and M. Salim, Rice Programme, NARC, Islamabad, Pakistan

Rice in Sindh is grown in two distinct tracts: Lower Sindh and Upper Sindh. Among rice pests, the yellow SB *Scirpophaga incertulas* is predominant. Larvae hibernate in rice stubbles during winter (Nov-Mar) and emerge as adults in mid-Mar, depending on environmental conditions.

An extensive survey in Jan 1988 examined the carryover of SB in different rice-based cropping systems. SB incidence, larval population, and larval mortality were measured in seven cropping systems at 20 locations in Lower Sindh and 33 in Upper Sindh. The stubbles of 50 rice hills were randomly collected in each field. Similar observations were made in no-tillage and conventional tillage wheat fields at four locations in Upper Sindh.

Data show that of 1,260 larvae collected in both tracts, 1,182 (98%) were *Scirpophaga* and only 24 (2%) were *Sesamia* (Table 1). Overall mortality was higher in Lower Sindh (56%) than in Upper Sindh (34%). Number of live larvae per 50 stubbles and tiller infestation were higher in Upper Sindh. Low larval mortality in lathyrus may be due to crop canopy shading the stubbles. Larval mortality was low in ricefields that were not properly plowed, and where stubbles were not fully uprooted. Mortality was higher in fields that were properly prepared and left fallow.

Table 1. Survival of SB larvae in cropping systems in Lower and Upper Sindh, India.

Cropping system	Larval density (no./50 stubbles)				
	Scirpophaga		Live *Sesamia*[a]	Mortality (%)	Tiller infestation (%)
	Live	Dead			
			Lower Sindh[b]		
Fallow (unplowed)	35	11	3	22	32.92
Fallow (plowed)	12	31	–	72	28.94
Berseem	19	23	4	50	28.49
Wheat/barley	15	30	2	64	24.92
Lentil	13	15	–	54	18.01
Mustard (plowed)	4	9	–	69	12.89
Sugarcane	9	14	–	61	17.03
Mean	15	19	1	56	23.31
			Upper Sindh[c]		
Fallow (unplowed)	41	10	4	18	49.34
Fallow (plowed)	6	21	2	72	18.39
Berseem	16	9	3	32	15.34
Wheat	29	21	5	38	26.27
Lathyrus (unplowed)	92	22	–	19	38.12
Mustard (unplowed)	15	1	–	6	22.65
Chickpea	10	11	1	50	23.71
Mean	30	14	2	34	27.68

[a]No dead *Sesamia* [b]Mean of 20 locations. [c]Mean of 33 locations.

No larval parasitization was found in larvae reared in the laboratory.

Sesamia larvae were more numerous in wheat fields than in other cropping systems, but no infestation on wheat was recorded.

Larval mortality was higher (30%) in conventional-tillage wheat fields than in no-tillage wheat fields (7%). However, there were more live larvae in no-tillage wheat fields (Table 2).

Part of the reason for low rice yields in Pakistan may be high SB carryover. ■

Table 2. Survival of SB larvae in no-tillage and conventional tillage wheat in Sindh, India.

	Larval density/m							
Location	No tillage				Conventional tillage			
	Live (no.)	Dead (no.)	Mortality (%)	Tiller infestation (%)	Live (no.)	Dead (no.)	Mortality (%)	Tiller infestation (%)
Jamra I (Shikarpur)	15	1	6	42.15	10	5	33	48.82
Jamra II (Shikarpur)	39	2	5	47.01	32	10	28	46.67
Dokri (Larkana)	14	1	7	24.09	3	1	25	8.97
Arija (Larkana)	33	4	11	27.10	17	8	32	17.51
Mean	25	2	7	35.09	16	6	30	30.49

Cropping patterns for Cuu Long Delta, Vietnam

Nguyen Van Dan and Dang Kim Son, Cuu Long Delta Rice Research Institute, Omon Haugiang, Vietnam

In the Cuu Long Delta, favorable rainfall and river water level patterns make double-cropped rice the normal practice on alluvial soils near the Hau and Tien Rivers. We thought it possible to grow three crops a year, using short-duration rice varieties and relay cropping in a *sa ngam* method of crop establishment (seeds broadcast on soil flooded 20-30 cm deep, 7-12 d before complete water subsidence).

We compared two cropping patterns—rice - soybean + rice and rice - mungbean - rice—with the existing farmers' pattern of rice - rice during 1987-88 wet (WS) and dry seasons (DS) in Thuanhung, Haugiang (see figure).

Soil of the experimental field had 3.21% organic C and 0.22% N, 0.068% P, and 1.842% K. Available P was 11.0 mg/100 g. Varieties used were rice IR64, soybean MTD65, and mungbean DX102. The experiment was laid out in a randomized complete block design with six replications.

DS rice was planted by *sa ngam* method 22 Nov 1987 and harvested 5 Mar 1988. DS soybean and mungbean were sown 10 Mar 1988 and harvested 29 and 15 May 1988, respectively. WS rice was broadcast 16 May 1988 (13 d before harvesting soybean), without tillage. Recommended fertilizer rates were used: 100 kg N + 40 kg P on rice, 60 kg N + 60 kg P on soybean, and 40 kg N + 60 kg P on mungbean.

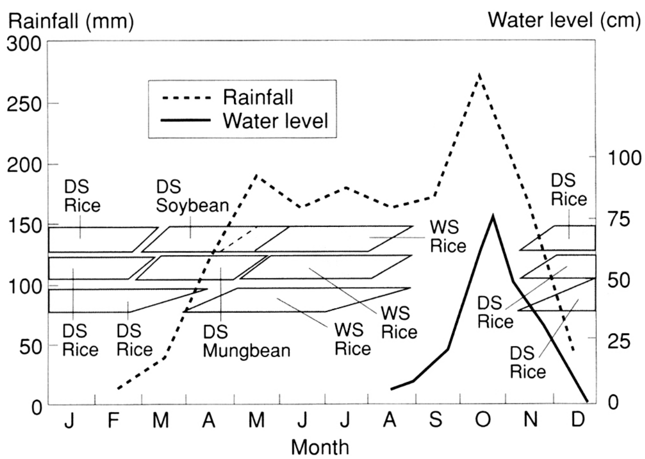
Grain yield of WS rice differed significantly with cropping pattern (see table). The pattern with soybean produced the highest rice equivalent yield (17.3 t/ha). Lowest yield (9.3 t/ha) was with two crops of rice.

This pattern also had the lowest cost (US$92.2/ha), especially for labor. Total costs of triple cropping were about double that of two rice crops.

Net return of rice - soybean + rice was highest (US$444.5/ha). ■

Average grain and rice equivalent yield, and economic efficiency of 3 cropping patterns. Thuanhung, Vietnam, 1987-88.

Cropping pattern	Yield (t/ha)			Rice equivalent yield (t/ha)	Labor cost (t/ha)	Material and power costs (S/ha)	Total cost ($/ha)	Net return ($/ha)
	Crop 1 DS rice	Crop 2 soybean or mungbean	Crop 3 WS rice					
DS rice - DS soybean + WS rice	6.4	2.4	3.7	17.3	268.0	213.1	482.3	444.5
DS rice - DS mungbean + WS rice	6.3	1.3	3.2	15.2	244.8	237.3	183.4	330.4
DS rice - WS rice	6.4		2.8	9.3	92.2	175.3	267.7	230.5



Rainfall and water level pattern, and cropping pattern in Thuanhung, Haugiang, Vietnam.

Evaluation of stream-driven spiral pumps under field conditions

L. C. A. Naegel, Farming Systems and Soil Resources Institute (FSSRI), University of the Philippines at Los Baños (UPLB), College, Laguna, Philippines

In many countries, there is potential for using stream-driven devices to lift irrigation water. These pumps use no fossil energy and can be constructed by local craftsmen using available materials.

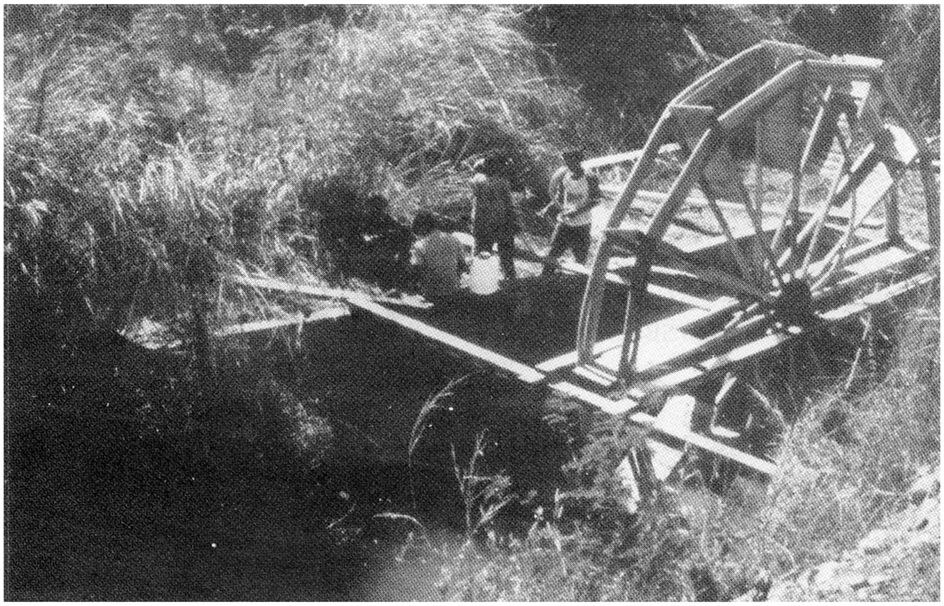
The concept of utilizing the energy of water flow to drive rotating direct-lift water pumps is not new. But conventional low-speed rotating pumps cannot raise water much higher than the pump structures themselves. Low-speed, rotating, positive displacement pumps, such as spiral pumps, can deliver irrigation water to a much higher total head (Fig. 1).

Parameters for a spiral pump were evaluated in the laboratory. We evaluated the performance of spiral pumps in cooperation with the Abra River Irrigation Project.

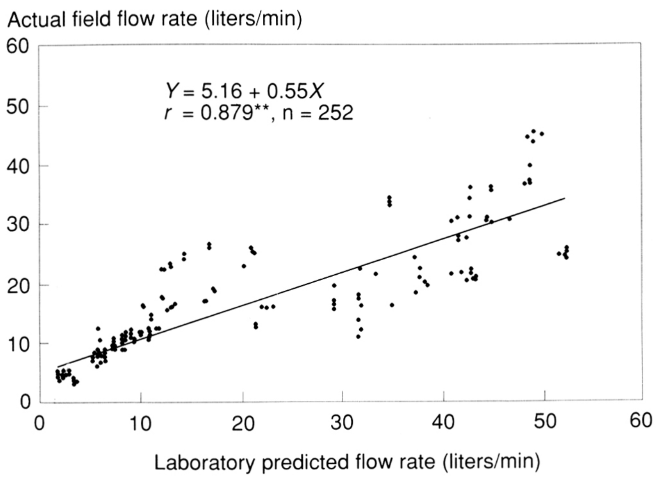
Diversion canals there feed several thousand hectares of agricultural fields. However, fields situated above the irrigation canals cannot benefit. The spiral pumps could supply water to these fields.

Three spiral pumps were installed into a 3.00-m-wide main diversion canal. Water depth fluctuates from 1.20 to 1.60 m. At a velocity of about 1.59 m/s, approximately 7.5 m^3 of water per second passes through the canal.

Spiral pumps with 2.5, 4.0, and 5.0 m outer diameter, matching conditions of the dike, were constructed and tube diameters and the influence of the size of the water intake spouts tested.



1. A stream-driven spiral pump in Bangued, Abra River, Philippines. Wheel diameter = 5.00 m; tube material = PVC hose with 2" diameter, 50-m-long tube: required total head= 8.50 m; delivered water volume = 22.4 liters/min with intake spout and one tube attached.



2. Actual versus laboratory flow rates. Bangued, Abra, field tests, Feb-May 1990.

The tube diameter, the height of the water delivery, and the water volume scooped into the tube resulted in varying speeds of rotation of the wheel, and different volumes of water delivered. The results agreed with data from laboratory tests (Fig. 2).

Given the kinetic energy of a stream and the drag coefficient designed into the paddles of the pump, it is possible to design a spiral pump with all factors adapted to existing natural conditions and the needs of a farmer. ■

Space limitations prevent IRRN from publishing solely yield and yield component data from fertilizer field trials that are not conducted for at least two cropping seasons or at two differing sites. Publication of work in a single season or at one site is limited to manuscripts that provide either a) data and analysis beyond yield and yield components (e.g., floodwater parameters, microbial populations, soil mineral N dynamics, organic acid concentrations, or mineralization rates for organic N sources), or b) novel ways of interpreting yield and yield component data across seasons and sites.

Methane production and emission in coastal ricefields of Texas

F. M. Fisher, Jr., R. L. Sass, and P. A. Harcombe, Ecology and Evolutionary Biology Department, Rice University, Houston; and F. T. Turner, Texas Agricultural Experimental Station, Beaumont, Texas, USA

Atmospheric methane, an important "greenhouse" gas, is increasing at a rate of about 1 % per yr. Flooded ricefields may be an important source of atmospheric methane, through anaerobic microbial processes.

Agricultural wetlands also provide a model system that can be used to examine the biological and physical processes that regulate methane production and emission.

A study in summer 1989 focused on two irrigated ricefields with different soil types: Lake Charles, a Typic Pelludert, and Beaumont Clay, an Entic Pelludert.

Jasmine 85 was drill-seeded (67 kg/ha) in rows 18 cm apart. Both fields received 39, 59, and 51 kg urea N/ha applied before planting, at flooding, and at panicle differentiation, respectively. An additional 51 kg N/ha was applied to the Beaumont Clay field when N appeared to be deficient after panicle differentiation. Thiobencarb and propanil were applied before flooding to control weeds.

The study ended at 130 d after sowing, shortly after field drainage before harvest. Grain yields were 7 t/ha on the Lake Charles soil and 6 t/ha on the Beaumont Clay soil.

Mean daily soil temperature 2 cm below the soil surface ranged from 27 to 30°C. Daily minimum temperature showed no seasonal trend, with an average of 24°C; daily maximum temperature decreased from an early season average of 31°C to an end-of-season average of 26°C. Water temperatures showed similar trends, but variations were more pronounced. Decreases in soil and water temperatures were attributed to development of the rice crop canopy.

Water depth in the Lake Charles field was relatively stable at 6-14 cm. That in the Beaumont Clay field was more variable because damage to the levee system during tropical storm Allison early in the season resulted in water drainage. After restabilization, water depth ranged from 3 to 15 cm.

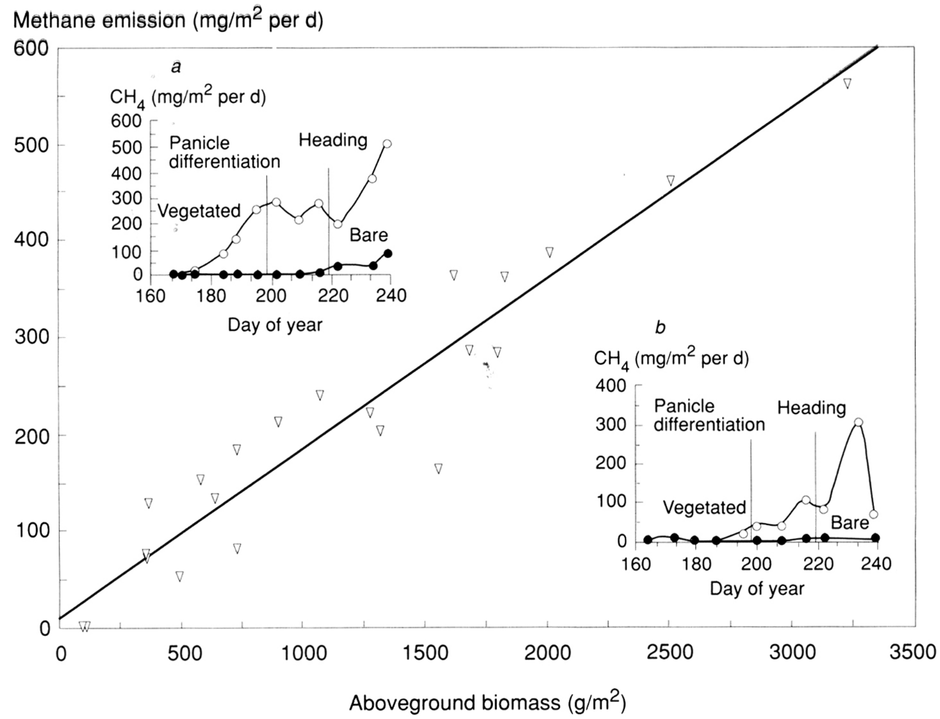
Methane emission (flux) and above- and below-ground biomass were measured at four random locations in each field. Integrated annual methane emissions ranged from 4.5 (Beaumont Clay) to 15.9 (Lake Charles) g/m^2 per season (determined by static flux box measurements).

Methane emission was detected from vegetated plots shortly after flooding in the Lake Charles field and was strongly related to aboveground biomass throughout the growing season (Fig. 1). Virtually no methane flux could be detected in nonvegetated plots until late in the season (Fig. 1, insert *a*).

No significant emission was observed in vegetated plots in the Beaumont Clay field until panicle differentiation. This delay may have been caused by the field drainage and soil aeration that resulted from levee damage (Fig. 1, day 177, insert *b*). The effect of field drainage and intense rainfall on exposed soils will be further examined as weather conditions permit.

Methane production, measured in laboratory-incubated soil core segments from both fields, was spatially and temporally related to live root biomass (Fig. 2). Early methane production was highest in the 0-2.5 cm soil layer associated with the dense fibrous root system near the soil surface and lowest in the 7.5-10 cm depth and between plant rows.

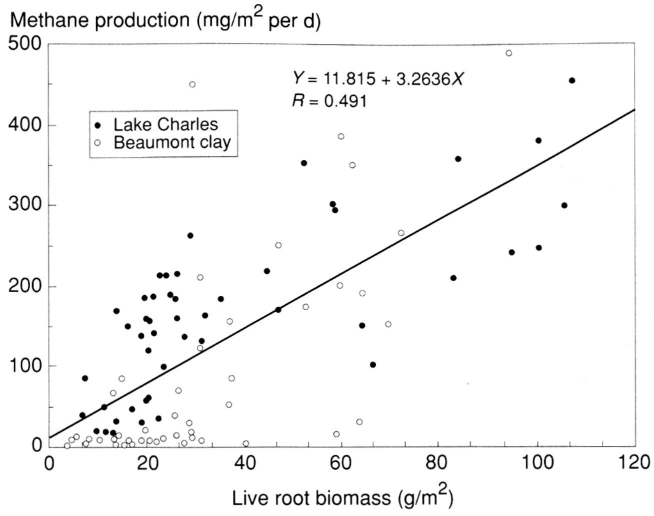
As the growing season progressed, methane production at lower depths and farther away from the plants increased in proportion with root density. Seasonal integrated emission in the laboratory was 42% that of the methane production measured by static flux boxes in both fields.



1. Correlation of aboveground biomass with methane emission ($r^2 = 0.92$) in the Lake Charles field and seasonal methane flux for vegetated sites (o) and nonvegetated sites (•) in the Lake Charles field (a) and the Beaumont clay field (b).

Methane production ceased when fields were drained before harvest. No methane was emitted even following prolonged incubation in the laboratory under an anaerobic nitrogen atmosphere. But when exogenous acetate was provided, methane production immediately resumed.

These results indicate that methane production and emission from flooded ricefields are dependent on plant root distribution and aboveground biomass. Soil properties and water management also affect methanogenesis. Further research relating these effects to rice cultivars and farmer practices is needed to form a basis for designing technology that would help mitigate the currently increasing levels of methane in the atmosphere. ■



2. Correlation of live root biomass with methane production from the lake Charles field (•) and the Baumont clay field (o). Data points represent measurements taken from 4 soil depths (0-10 cm) at 3 distances from plants at 4 times during the growing season. Regression line is for the combined data set.

ANNOUNCEMENTS

Tropical crop research and biotechnology symposium planned.

The new International Society for Tropical Crop Research and Development (ISTCRAD), with headquarters in Trivandrum, Kerala, India, is organizing a symposium to coincide with its formal inauguration in September 199 1.

Organizing secretary is Dr. N. K. Nayar, Department of Agricultural Botany, College of Agriculture, Kerala Agricultural University, Trivandrum 695522, India. ■

Recommendations of IRRC 1990 research discussion groups

Nearly 200 scientists from 30 countries participated in the International Rice Research Conference 27-31 August in Seoul, Korea. They discussed the research results reported in about 40 papers and posters, and identified directions for future work.

Summaries of discussion group recommendations are given below.

Direct seeded rice. A matrix was used to target problems, opportunities, and research priorities, with plant characteristics and crop management on one dimension, and agroecological zone, inputs, and direct seeding methods on the other (see table).

Participants agreed on the need to establish a universally accessible data base: where and how is direct seeding presently practiced, where is the practice increasing, what is the yield loss or benefit, and what is the time-and-cost benefit (particularly in low-input, tropical systems with unreliable technology and low opportunity cost of labor).

Features of an ultrahigh tillering plant ideotype deserving research priority include

- Quick early growth at seedling establishment.
- Tiller population/ha = tillers/plant × plant population × tiller death.
- Nitrogen use efficiency in terms of uptake and utilization and redistribution (tied to the value of the stem as a sink/source for both N and carbohydrate and to synchronous seed filling).
- Patterns of root growth and their benefit.

Rice blast disease. Research needs include

- Integrated control — developing on-farm decision aids, agroecological zoning, and management of panicle blast.
- Quantitative epidemiology, modeling, and forecasting — disease assessment methods, conditions affecting host susceptibility, interactions with other pests, sources of initial inoculum, crop losses, coupling blast models to crop models, fungicide dynamics, and disease forecasting.
- Host plant resistance and pathogen population virulence — gene development, genetics, screening methods, and durable resistance.

The group decided to form working groups for each area; members may undertake joint trials or other direct cooperation. The working groups and their coordinators are as follows:

Integrated control: Fernando Correa, CIAT-Rice Program, P.O. Box 6713, Cali, Colombia; and Arunee Surin, Rice Pathology Research Branch, Plant Pathology and Microbiology Division, Department of Agriculture, Bangkhen, Bangkok, Thailand.

Quantitative epidemiology: P. S. Teng, Plant Pathology Division, IRRI, P.O. Box 933, 1099 Manila, Philippines; and K. Manibhushanrao, Centre for

Priority/research for dry seeded rice (DSR) and wet seeded rice (WSR).

Characteristic	Tropical climate				Temperate climate	
	Low input		High input			
	DSR	WSR	DSR	WSR	DSR	WSR
Land preparation						
When to plow?	+	+				
How to control seed depth?	+					
Germination						
Timeliness	+	+				
Control of pests	+	+				
Emergence						
Fast emergence	+	+	+	+	+	+
Elongation	+	+	+	+	+	+
Cold tolerance					+	+
Submergence (tolerance for aerobic then reduced condition)	+	+	+	+	+	
Tillering[a]	+	+	+	+	+	+
Nutrition[b]	+	+	+	+	+	+
N/water control			+	+		
Weed control[c]	+	+				
Herbicides[d]	+	+	+	+	+	+
Insects and diseases[e]	+	+	+	+		

[a]Necessarily desirable to move to low tillering as we move to more sophisticated system. [b] Need to consider efficiency of N fertilizer in all direct seeding systems, particularly in relation to water management at the seedling stage of dry seeded low input rice in the tropics. Use of legume crops before rice for efficient N release after soil becomes flooded. [c] Weed control is more critical in direct seeded than transplanted rice, in all systems. Early canopy closure is desirable to combat weeds but may predispose crop to disease and result in excessive leaf growth and low harvest index. [d] Increasing environmental concern pressures use of traditional herbicides: research needed on less environmentally damaging control agents (e.g., fungi, allelopathy). [e] Pest control in dry seeded low input crop; seed harvesting pests; seedling damage. e.g., ducks.

Advanced Study in Botany, University of Madras-Guindy Campus, Madras 600025, India.

Host plant resistance: J. M. Bonman, Plant Pathology Division, IRRI, P.O. Box 933, 1099 Manila, Philippines; and K. Maruyama, National Agriculture Research Center, Yatabe, Tsukuba 305, Japan.

Improving rice grain quality. Research needs include

- Rice grain quality preferences — correlate data base on high quality rices of different countries with physicochemical properties of milled rice.
- Varietal classification — six groups based on allelic combinations at 14 isozyme loci are most useful to breeders (intergroup crosses show sterility and restriction to recombination).
- Grain quality improvement — genetic diversity for amylose content.
- Milling yield and head rice recovery — cracking resistance and tolerance for moisture absorption stress; selection for lower hull weight.
- Aromatic rices — many traditional aromatic rices belong to group 5, most improved indicas belong to group 1; identify donors of aroma for group 1.
- International standards — develop common categories for classifying rice grain quality.

International coordinating committee for rice genetic resources

The International Board for Plant Genetic Resources (IBPGR) and IRRI are organizing an international rice germplasm committee to coordinate collection and conservation of rice genetic resources.

Conservation is especially important where new varieties threaten the extinction of native varieties. Also, increasing urbanization and accelerating development are endangering the wild relatives of domestic crops that could be sources of desirable genetic material needed to improve future varieties.

IRRI and IBPGR regularly cosponsor the International Rice Germplasm Workshop to assess the status and directions of global rice germplasm conservation. The workshop also strengthens linkages among national and international scientists.

At the 10-12 May 1990 workshop at IRRI, 35 participants from 15 major rice-growing countries of Asia, Africa, and North and South America planned future field collection and developed a network approach to conservation, evaluation, and use of rice germplasm. ■

International rice genetics symposium II recommendations

Some 300 rice geneticists from 24 countries met at IRRI 14-18 May 1990, and presented 65 research papers and 75 posters. Twelve topics were covered:

- varietal differentiation and evolution
- genetic markers, linkage groups, and aneuploids
- genetics of stress tolerance
- genetics of morphological and physiological traits
- genetics of disease and insect resistance
- tissue and cell culture
- molecular genetics of cytoplasmic genomes
- molecular genetics of nuclear genomes
- RFLP analysis of rice genomes
- molecular genetics of rice proteins
- molecular genetics of disease resistance
- transformation techniques

Proceedings of *Rice genetics II* will be published by IRRI. The following recommendations were made by conference participants:

- Adopt a unified system of numbering rice chromosomes and linkage groups.
- Follow a uniform nomenclature for isozyme loci and alleles.
- Prepare a comprehensive RFLP map of rice, combining the two now available.

A small workshop to discuss problems remaining in gene nomenclature will be held in 1992. International Rice Genetics Symposium III will be scheduled in 1995. (The first symposium was held in 1985.)

During the year's symposium, members of the International Rice Genetics Cooperative that coordinates research collaboration evolved a unified system of numbering rice chromosomes and linkage groups. Cooperative coordinating committee members are M. E. Takahashi, chairman, Hokkaido Green-Bio Institute, East 5, North 15, Nagamuna, Hokkaido 068-13, Japan; K. J. Lampe, co-chairman, IRRI; G. S. Khush, secretary and editor, IRRI; H. I. Oka, editor, c/o National Institute of Genetics, Yata 1, 111 Mishima, Sizuoka-ken 411, Japan; Y. Futsuhara, secretary, Faculty of Agriculture, Nagoya University, Nagoya 464-01, Japan; D. Senadhira, treasurer, IRRI; T. Kinoshita, Plant Breeding Institute, Hokkaido University, Kita 9, Nishi 9, Sapporo 060, Japan; Min Shao-Kai, China National Rice Research Institute, Hangzhou, Zhejiang, China; G. Toenniessen, The Rockefeller Foundation, 1133 Avenue of the Americas, New York, N.Y. 10036, USA; M. Jacquot, IRAT-CIRAD, BP 5035,34032 Montpellier Cedex, France; R. S. Paroda, ICAR, Krishi Bhawan, Dr. Rajendra Prasad Road, New Delhi 110 011, India; and M. H. Heu, College of Agriculture, Suweon, Korea.

The fourth annual meeting of the Rockefeller Foundation network on rice biotechnology preceded the symposium. ■

DTCP/UNDP training courses for 1991

The UNDP Asia and Pacific Programme for Development Training and Communication Planning (DTCP) provides a wide range of consultancy and training services to agriculture, forestry, health, family planning, and other rural development projects supported by the United Nations and other international aid agencies.

Regional training courses planned for 1991 include

- Communication planning 3-21 Jun
- Monitoring and evaluation of projects and programs 1-26 Jul
- Field- and middle-level management and supervision 5-30 Aug
- Planning and management of training programs 2-20 Sep
- Production and utilization of audio-visual materials 23 Sep - 1 Nov
- Training methods 4-23 Nov

Brochures describing course content. methods, and participation are available from the Training Coordinator, DTCP/UNDP, cable UNDEVCOM Manila, FAX (632) 8 16-406 1, or write

5th Floor, Bonifacio Building
University of Life Campus
Meralco Avenue, Pasig, Metro Manila
Philippines ■

INSURF Planning Meeting 11-14 Sep

The planning meeting of the International Network on Soil Fertility and Sustainable Rice Farming (INSURF) focused on subnetworks of INSURF working on key research areas (see table). Collaborating scientists from six countries and a representative of the Swiss Development Cooperation, INSURF's sponsoring agency, participated.

Following are some highlights of the meeting:

- The five existing subnetworks will continue, and satellite site work will be strengthened. There will be greater ecosystem focus, in coordination with the ecosystem-based research programs at IRRI.
- The subnetwork on soil fertility management technologies for favorable rainfed lowland rice-based systems will start with the 1990-91 cropping seasons; the Sukamandi Research Institute for Food Crops at West Java, Indonesia, will be the lead center.
- A subnetwork on research issues of soil fertility management in direct-seeded rice has been proposed, in anticipation of trends toward more direct seeding of rice in some Southeast Asia countries. The Malaysian Agricultural and Research Development Institute (MARDI) would be the lead center.
- Mechanisms for closer interaction with ARFSN will be primarily in terms of joint training programs, information exchange, and perhaps common sites. Greater synergism and less duplication are the desired outcome of efforts toward closer interaction between INSURF and ARFSN. ■

INSURF research areas, lead centers, and satellite sites.

Research area	*Lead center (test sites)*
Genetic enhancement and integrated use of azolla in lowland rice-based farming systems	National Azolla Research and Training Center, China (India, Thailand, Pakistan, Philippines)
Green manure improvement and utilization for rice-based farming systems	Tamil Nadu Agricultural University, India (Thailand, Indonesia, Bangladesh, Philippines, Pakistan)
Soil fertility management for acid upland rice-based farming systems	Agency for Agricultural Research and Development (CRIFC & CSR), Indonesia, (Philippines, Madagascar, India, Thailand)
Soil fertility management for rice-based farming systems in infertile rainfed lowland soils	Department of Land Development, Thailand (Indonesia, India, Bangladesh)
Soil fertility management for lowland rice-based farming system, with emphasis on sulfur and other micronutrients	Philippine Rice Research Institute/University of the Philippines at Los Baños, (Pakistan, Malaysia, Sri Lanka, Nigeria, India)
Soil fertility management for rice-based farming systems in favorable rainfed lowland soils	Agency for Agricultural Research and Development (CRIFC & CSR), Indonesia (Philippines, Bangladesh, India, Myanmar)

New IRRI publications

IRRI 1989 — planning for the 1990s

Crop loss assessment in rice

Seeds and seedlings of weeds in rice in South and Southeast Asia, by R. L. Zimdahl, R. T. Lubigan, K. Moody, and M. O. Mabbayad

1990 supplement to publications of the international agricultural research and development centers ■

ERRATA

Chilo auricilius Dudgeon (Lepidoptera: Pyralidae), the correct name for the dark-headed stem borer (SB) found in the Philippines, by A.T. Barrion, J.L.A. Catindig, and J.A. Litsinger. 15 (4) (Aug 1990), 29.

In Table 2, references to a figure should be omitted; no figure was published. Under host plant range, the plus (+) sign after *Hymenachne pseudo-inrerrupta C. Muell* should be in the column under *C. polyhrysus.* ■

New IRRI publications, 15:5 (Oct 1990), p. 27: *Research Highlights 1989* should be deleted. That annual series has been replaced by a new series of yearly corporate reports on the International Rice Research Institute. The first is *IRRI 1989: Planning for the 1990s.* ■

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P.O. BOX 933, 1099 MANILA, PHILIPPINES

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