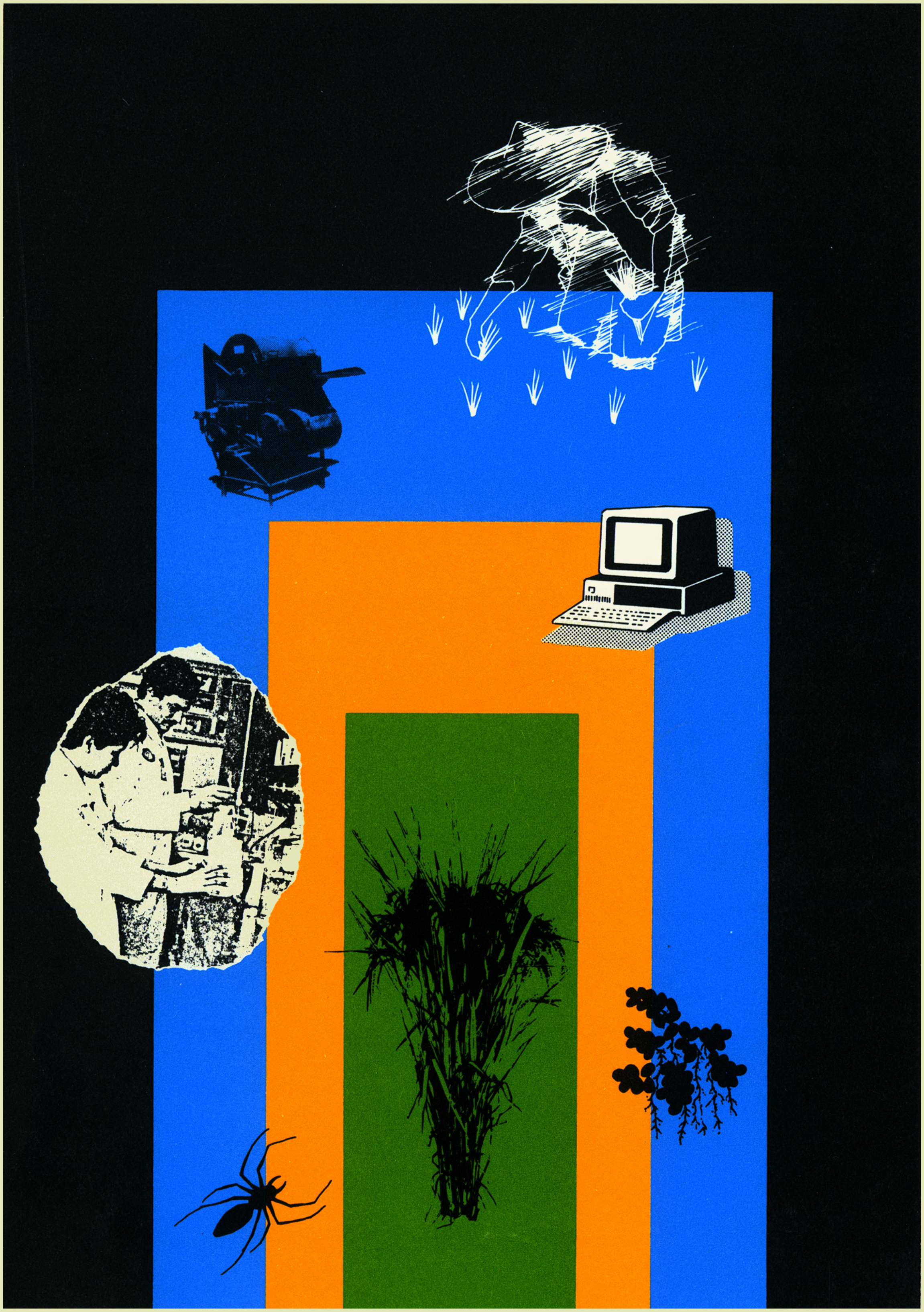
INTERNATIONAL RICE RESEARCH NEWSLETTER

VOLUME 16 NUMBER 5

OCTOBER 1991



PUBLISHED BY THE INTERNATIONAL RICE RESEARCH INSTITUTE, P.O. BOX 933, MANILA, PHILIPPINES

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, in as much as this crop feeds the most densely populated and land-scarce nations in the world . . . IRRN is a mechanism to help rice scientists keep each other informed of current research findings."

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

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

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

Criteria for IRRN research report

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

Guidelines for contributors

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

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

All work should have pan-national relevance.

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

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

Please observe the following guidelines in preparing submissions:

- Limit each report to two pages of double-spaced typewritten text and no more than two figures (graphs, tables, or photos).
- Do not cite references or include a bibliography.
- Organize the report into a brief statement of research objectives, a brief description of project design, and a brief discussion of results. Relate results to the objectives.
- Report appropriate statistical analysis.
- Specify the rice production environment (irrigated, rainfed lowland, upland, deepwater, tidal wetlands).
- Specify the type of rice culture (transplanted, wet seeded, dry seeded).
- Specify seasons by characteristic weather (wet season, dry season, monsoon) and by months. Do not use local terms for seasons or, if used, define them.
- Use standard, internationally recognized terms to describe rice plant parts, growth stages, environments, management practices, etc. Do not use local names.
- Provide genetic background for new varieties or breeding lines.
- For soil nutrient studies, be sure to include a standard soil profile description, classification, and relevant soil properties.
- Provide scientific names for diseases, insects, weeds, and crop plants. Do not use common names or local names alone.
- Quantify survey data (infection percentage, degree of severity, sampling base, etc.).
- When evaluating susceptibility, resistance, tolerance, etc., report the actual quantification of damage due to stress that was used to assess level or incidence. Specify the measurements used.
- Use generic names, not trade names, for all chemicals.
- Use international measurements. Do not use local units of measure. Express yield data in metric tons per hectare (tha) 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

Genetic resources
5 Genetic studies of flag leaf angle in indica and japonica rice crosses
5 Genetic variability in root and shoot characters of selected rice genotypes

Breeding methods
6 Development of dihaploid rice lines through anther culture (I)
6 Development of dihaploid rice lines through anther culture (II)
7 Interaction of media for callus induction and for plant regeneration in rice anther culture
8 Hybrid rice yield trials in the Mekong Delta

Yield potential
8 Performance of different height rice lines under intermediate deep water levels

Grain quality
9 Attaining higher volume expansion in popped rice
10 Procedures for quality selection of aromatic rice varieties
11 Relationship of transplanting time to grain quality in Basmati 385
11 Rapid viscometric analysis of rice flour

Pest resistance—diseases
12 Genetics of bacterial blight (BB) resistance in two land races of rice from India

Pest resistance—insects
13 Screening of rice varieties and advanced breeding lines in Cambodia for resistance to gall midge (GM) *Orseolia oryzae*

Stress tolerance—adverse temperature
14 Breeding for cold tolerance at reproductive phase in the high hills of Nepal

Stress tolerance—adverse soils
15 Germination and growth of some salt-resistant selections in high salt concentration solutions
15 Effect of abscisic acid (ABA) application on salt tolerance of rice varieties

Integrated germplasm improvement—irrigated
16 MDU4, a high-yielding, cold-tolerant rice for Tamil Nadu
16 Xiangwanxian 2, an excellent grain quality rice variety derived from an IR line
16 HKR228, a semidwarf aromatic rice strain for Haryana, India

Integrated germplasm improvement—rainfed
17 Neeraja, a high-yielding rice variety for poorly drained rainfed fields in Kerala

CROP AND RESOURCE MANAGEMENT

Soil microbiology
17 Response of blue-green algae (BGA) in wetland rice culture in Himachal Pradesh, India

Integrated fertilizer management
18 Long-range effect of continuous cropping and fertilizer application on yield stability of wet season (WS) rice

Crop management
18 Effect of tillage practices on deepwater rice (DWR) yield and return

Integrated pest management—diseases
19 Using single hills to determine an equation for estimating yield loss caused by rice blast
20 A new sheath rot (ShR) disease of rice identified in Tamil Nadu
20 Effect of asynchronized rice planting on vector abundance and tungro (RTD) infection
21 Field evaluation to control "red stripe," a new rice disease in Vietnam

Integrated pest management—insects
22 A parasitoid of stalk-eyed fly eggs in West Africa
22 A population of brown planthopper (BPH) biotypes 1 and 2 mixture in Guangdong, China
23 Wild rice: a new host for *Hysteroneura setariae* (Thomas)[Hemiptera:Aphididae] in the Philippines
23 Comparing parasitoid-host responses in laboratory experiments
24 Co-variation between insects in a ricefield and important spider species
25 Distribution of *Tetragnatha maxillosa* webs in ricefields

Integrated pest management—weeds
26 Effect of nitrogen uptake by weeds on rice yield

Integrated pest management—other pests
26 Crushing snail eggs with a "snail egg clapper"

Farming systems
27 Hybrid rice ratoon exploited in Sichuan, China

Farm machinery
28 Ideal seed drill for direct sowing rice in semidry fields
28 Efficiency of a compartment-type rice separator

SOCIOECONOMIC IMPACT

Environmental impacts
29 Impact of agrochemicals on mosquito larvae populations in ricefields

ANNOUNCEMENTS

30 A new handbook for identifying rice leafhoppers and planthoppers published
30 The IRRI blue-green algae (BGA) collection: strains available for distribution
31 Rodents and rice
31 New IRRI publications

GERMPLASM IMPROVEMENT

Genetic resources

Genetic studies of flag leaf angle in indica and japonica rice crosses

Yan Yueming, Agronomy Department, Southwest Agricultural University, Chongqing, Sichuan, China

Flag leaf angle is an important trait in a rice ideotype. We studied the genetic behavior of flag leaf angle in five indica/ japonica crosses 1987-90.

The parents and the F_1 and F_2 of five crosses were grown in a randomized block design with three replications; the F_3 was grown with one replication. Seedlings were transplanted at 16.5- × 26.0-cm spacing, one seedling/hill. The angle between the flag leaf base and the stalk was measured at full heading.

Flag leaf angle tended to be similar to the shorter parent in the F_1 (Table 1). The frequency distribution in the F_2 was continuous, suggesting that flag leaf angle is controlled by multiple genes. Broad-sense heritability was 66.7-82.5%, and genetic advance based on 5% selection differential for flag leaf angle was 29.8-57.3% in the F_2. Narrow-sense heritability, calculated by the F_2-F_3 regression, was 61.4-70.9%.

In the F_3, flag leaf angle did not correlate with flag leaf length, width, area, plant height, or 1000-grain weight. It was, however, correlated positively and significantly with second and third leaf angle, and negatively and significantly with single plant yield (Table 2).

This heritability and genetic advance of flag leaf angle imply that direct selection for flag leaf angle in early generations is effective. □

Table 1. Genetics of flag leaf angle in different generations of indica × japonica crosses. Chongqing, China, 1990.

Cross[a]	Parents		F_1		F_2				F_3	
	P_1	P_2	$\bar{X}$	H[b]	$\bar{X}$	h^2_B[c]	GA[d]	GA[e]	$\bar{X}$	h^2_N[f]
Yumidao/C Pei 211, japonica/ indica	45.7	9.5	26.2	–0.08	21.3	82.5	–12.2	–57.3	23.9	70.9
C Pei 211/Yigen 3, indica/japonica	9.5	52.6	22.7	–0.39	18.4	77.8	–9.5	–51.7	20.4	65.5
Milyang 23/Yigen 3, indica/ japonica	12.0	52.6	28.5	–0.19	32.4	66.7	–13.8	–42.6	30.1	61.4
02428/Erliuzezao, japonica/indica	12.4	21.8	15.2	–0.40	14.6	75.2	–5.5	–37.7	15.8	68.2
Erliuzezao/02428, indica/japonica	21.8	12.4	16.5	–0.13	17.1	73.4	–5.1	–29.8	16.3	61.9

[a]C Pei 211 and 02428 are wide compatibility lines. [b]Dominance. [c]Broad-sense heritability. [d]Genetic advance. [e]% of mean (negative GA indicates tendency to small angle). [f]Narrow-sense heritability.

Table 2. Correlations[a] between flag leaf angle and other traits in F_3, Chongqing, China, 1990.

Crosses	Flag leaf			Plant height	1000-grain weight	Single-plant yield	S[b]	T[c]
	Length	Width	Area					
Yumidao/C Pei 211	0.12	0.20	0.20	0.10	–0.23	–0.31*	0.52**	0.67**
C Pei 211/Yieen 3	0.26	0.21	0.22	0.16	–0.26	–0.37**	0.48**	0.56**
Milyang 23/Yigen 3	0.24	0.21	0.14	0.20	–0.19	–0.31*	0.66**	0.70**
02428/Erliuzezao	0.18	0.20	0.19	0.17	–0.24	–0.28*	0.82**	0.60*
Erliuzezao/02428	0.17	0.19	0.15	0.19	–0.24	–0.30*	0.71**	0.61*

[a]Significant at the 5% (*) and 1% (**) levels. [b]Second leaf angle. [c]Third leaf angle.

Genetic variability in root and shoot characters of selected rice genotypes

R. K. Das and N. M. Miah, Plant Breeding Division, Bangladesh Rice Research Institute, Gazipur 1701, Bangladesh; and G. C. Loresto, IRRI

We evaluated the genetic variability and heritability of nine traits in 22 rice genotypes grown in an aeroponic culture system for 45 d in the IRRI phytotron glasshouse.

All traits showed wide variation (see table). The phenotypic coefficients of variation (PCV) were higher than the genotypic coefficients of variation (GCV).

Radicle length, root length, root dry weight, shoot dry weight, root-to-shoot ratio, and tiller number showed comparatively higher environmental coefficients of variability (ECV). This indicates that these traits were more sensitive to environmental and agroecotypic factors.

Comparatively high heritability for root length, root thickness, and plant height indicates that these characters are governed by additive gene effects; and high recovery for these traits can be expected in early generation selection. □

Range, mean, coefficients of variability, and heritability of 9 traits in 22 rice genotypes grown under aeroponic culture. IRRI, 1987.

Character	Range	Grand mean	SE	PCV	GCV	ECV	Heritability (%)
Radicle length (cm)	2.53 - 4.75	3.32	0.29	22.68	16.67	15.36	54.05
Radicle thickness (mm)	0.43 - 0.60	0.49	0.01	8.90	7.64	4.56	73.08
Root length (cm)	25.81 - 45.35	35.21	2.11	18.0	14.69	10.40	66.62
Root thickness (mm)	0.50 - 0.87	0.73	0.04	16.21	12.85	9.88	62.86
Root dry weight (g)	0.17 - 0.50	0.35	0.05	31.30	18.95	24.91	36.67
Shoot dry weight (g)	0.57 - 1.36	1.00	0.12	29.27	20.52	20.74	49.12
Root-to-shoot ratio	0.21 - 0.42	0.36	0.02	14.96	10.39	10.76	48.28
Tiller number	1.67 - 4.00	2.40	0.42	40.71	27.71	30.40	44.43
Plant height (cm)	46.02 - 90.01	74.11	2.95	13.55	11.66	6.80	74.06

Breeding methods

Development of dihaploid rice lines through anther culture (I)

A. E. Draz, Rice Research and Training Centre, Sakha, Kafi- El-Sheikh, Egypt; F. J. Zapata and G. S. Khush, IRRI

We developed homozygous rice lines through anther culture, using crosses of blast (Bl)-resistant (indica/japonica) Korean varieties with Bl-susceptible Egyptian varieties.

Anthers from five F_1 crosses were inoculated on callus induction media G1, Fj, and L8, used routinely in the IRRI Tissue Culture Laboratory. The media varied in their basal composition and in 2,4-dichlorophenoxyacetic acid (2,4-D). naphthaleneacetic acid (NAA), and kinetin (Kin) concentrations. Calli were plated in eight regeneration media differing in Kin, NAA, and indole-3-acetic acid (IAA) concentrations.

Callus induction efficiency in all three media was relatively high, indicating that all could be used for these crosses (Table 1). Callus induction percentage varied with genotype; those with a japonica female parent were more responsive. For example, Giza 171/C731135 had the highest callus production percentage on G1 and L8.

Green plant regeneration ranged from 0.4% to 7.7% (Table 2). Genotypes differed in their response to different plant regeneration media. Media M6, M7, and SK-11 gave the highest green plant percentages. Kin concentrations of M6, M7, and SK-11 were 8, 16, and 1 mg/liter, respectively. BAP (1 mg/liter) and casein hydrolysate (500 mg/liter) were added to the SK-11 medium.

This study produced 794 homozygous diploid plants from 190 calli derived from the anther culture of five F_1 crosses. These anther culture-derived lines will be tested against available Bl races under Egyptian conditions.☐

Table 1. Calli induced from F_1 crosses in different callus induction media.[a] IRRI, 1990 dry season (DS).

Cross combinaton (F_1)	G1		Fj		L8		Av calli produced[b] (%)
	Anthers plated (no.)	Calli produced (%)	Anthers plated (no.)	Calli produced (%)	Anthers plated (no.)	Calli produced (%)	
Nahda/Milyang 85	660	27.3	660	39.3	1080	50.5	41.1
Giza 14/Milyang 85	2040	41.4	1320	37.1	1320	37.8	39.2
GZ1343-8/C731135	840	33.3	1020	30.8	900	43.3	35.6
Giza 171/C731135	1440	60.4	2220	30.3	1500	51.3	44.8
GZ3030-11-l-3/Suweon 346	600	19.1	720	18.7	720	11.1	16.1
Total	5580		5940		5520		
Average[a] (%)		41.4		40.6		41.4	

[a] Concentrations of 2,4-D, NAA, and Kin (mg/liter) = G1 = 2.0, 2.5, 0.75, Fj = 0.5, 2.5, 0.5, L8 = 0.5, 3.5, 2.0.
[b] $\frac{\text{Anthers producing callus}}{\text{Total anthers plated}} \times 100$

Table 2. Green plant regeneration from 5 F_1 crosses in 8 media. IRRI, 1990 DS.

Cross combination (F_1)	Regeneration frequency (%)								Calli producing green plants	
	MI	M2	M3	M4	M5	M6	M7	SK-11	no.	%[a]
Nahdamilyang 85	4.2	5.9	6.0	1.7	5.6	8.4	9.5	8.7	61	6.2
Giza 14/Milyang 85	3.6	4.3	6.5	5.1	4.6	7.6	3.1	4.7	87	4.7
GZ1343-8/C731135	0	1.2	2.5	0.6	0.7	0	0	2.8	9	0.8
Giza 171/C731135	0.5	0.3	0.5	0.2	0.7	0.4	0.3	0.6	10	0.4
GZ3030- 11-1-3/Suweon 346	8.9	2.9	2.2	6.7	2.0	1.5	1.8	5.7	23	7.7
Calli producing green plants (no.)	18	24	27	20	20	25	27	29	190	
Average[a] (%)	2.7	2.8	3.0	2.4	3.1	4.1	3.3	3.6	-	3.1

[a] $\frac{\text{Calli (no.) producing green plants}}{\text{Calli (total no.) transferred}} \times 100$

Development of dihaploid rice lines through anther culture (II)

A. E. Draz, Rice Research and Training Centre, Sakha, Kafr El-Sheikh, Egypt; F. J. Zapata and G. S. Khush, IRRI

Saline areas worldwide are increasing for several reasons, including high water tables. Such areas need high-yielding rice varieties with satisfactory levels of salinity tolerance as well as other characteristics, such as short stature, high tillering ability, blast resistance, and

Table 1. Percentage callus induction of F_1 crosses in different callus induction media. IRRI, 1990 dry season (DS).

Cross combination (F_1)	G1		Fj		L8		Av calli produced[a] (%)
	Anthers plated (no.)	Calli produced (%)	Anthers plated (no.)	Calli produced (%)	Anthers plated (no.)	Calli produced (%)	
Giza 159/C732048	1800	34.7	2040	26.8	1380	37.3	32.3
Agami M-1/C731135	1080	25.9	960	21.8	1620	33.6	28.3
GZ1368-5-4/Niigatawase	1860	11.8	2880	14.4	3120	20.8	12.9
GZ1368-5-4/C731135	1260	13.5	2520	11.1	2040	16.9	13.7
GZ2447S-17/C732048	960	12.2	1320	14.2	1560	17.6	15.1
Total	6960		9720		9720		
Average[a] (%)		19.9		16.9		23.5	

[a] $\frac{\text{Anthers producing callus}}{\text{Total anthers plated}} \times 100$

acceptable grain shape and quality. Anther culture through doubled-haploid breeding could help achieve these objectives.

In Egypt, saline areas represent more than 30% of the total rice-growing area. Five crosses for these areas were selected to study callus and plant regeneration efficiencies and to get homozygous lines tolerant of salinity. The cross combinations were japonica//indica/japonica (crosses 1 and 2); indica/japonica//japonica (cross 3); and indica/japonica//indica/japonica (crosses 4 and 5).

Anthers were plated in media routinely used in the IRRI tissue culture laboratory, three for callus induction and eight for plant regeneration.

On average, the L8 medium induced the highest rate of calli (Table 1). Highest callus induction rates were in Giza 159/C732048 (32.3%) and Agami M-1/C731135 (28.3%). These crosses have japonica female parents. Efficiencies were lower in crosses with indica/japonica parents (GZ1368-5-4 and GZ2447S-17).

Table 2. Percentage and number of green plants produced in 8 plant regeneration media for 5 F_1 crosses. IRRI, 1990 DS.

Cross	Green plant regeneration frequency (%)								Calli producing green plants	
	M1	M2	M3	M4	M5	M6	M7	SK-I1	no.	% [a]
Giza 159/C732048	0.4	1.7	5.4	2.3	1.3	0.6	1.4	2.1	32	2.0
Agami M-1/C731135	0.9	0.6	1.0	0.7	0.7	1.4	1.2	2.9	10	1.0
GZ1368-5-4/Niigatawase	0.7	1.7	4.2	6.3	2.0	2.0	0	0	19	1.5
GZ1368-5-4/C731135	0	0	0	0	0	0	1.0	0	1	2.0
GZ2447S-17/C732048	0	0	0	6.3	4.0	2.2	1.2	0	8	2.0
Calli producing green plants (no.)	3	9	18	16	5	6	6	7	70	
Average[a] (%)	0.8	1.2	2.3	2.4	1.2	1.3	0.9	1.3		1.6

[a] $\frac{\text{Total calli producing green plants}}{\text{Total calli plated for regeneration}} \times 100$

For plant regeneration, eight media differing in kinetin (Kin), indole-acetic acid (IAA), and naphthaleneacetic acid (NAA) concentrations were used. Green plant regeneration efficiency was generally low (Table 2). The M3 and M4 media gave the highest regeneration percentages. M3 has 5 mg Kin and 1 mg IAA/liter; M4 has 2 mg Kin and 1 mg NAA/liter. Plant regeneration capacity of the media varied according to genotype. A total of 325 plants were regenerated from 70 calli. □

Interaction of media for callus induction and for plant regeneration in rice anther culture

A. E. Draz, Rice Research and Training Centre, Sakha, Kafr El-Sheikh, Egypt; F. J. Zapata and G. S. Khush, IRRI

The response of a genotype grown in vitro depends to a large extent on the composition of the culture medium. Usually, callus induction is in a medium different from that for plant regeneration. This makes it important to identify the best combination of media for tissue culture.

We plated anthers of five F_1 rice crosses bred for Egyptian conditions on three callus induction media and eight plant regeneration media. The callus induction media G1, Fj, and L8 differed in their basal composition as well as in hormone concentrations, The basal medium of Fj is B5, that of L8 is N6, that of G1 is a combination of B5 and MS. Respectively, G1, Fj, and L8, have 0.75, 0.5, and 2 mg kinetin (Kin)/liter; 2,0.5 d 0.5 mg of 2,4-dichlorophenoxyacetic acid (2,4-D)/liter; and 2.5, 2.5, and 3.5 mg of naphthaleneacetic acid (NAA)/liter.

Table 1. Callus induction efficiency of 5 F_1 crosses in 3 callus induction media.

Cross	Callus induction[a] (%)			Average[b] (%)
	G1	Fj	L8	
Nahda/Milyang 85	13.48	38.79	50.79	34.55
Giza 14/Milyang 85	36.50	38.97	58.60	44.38
Giza 159/C732048	38.50	29.10	37.80	35.55
Giza 171/C731135	45.60	35.10	37.50	40.00
GZ2175-5-3/C731135	27.80	41.30	25.64	30.61
Average (%)[b]	32.40	36.67	42.06	

LSD (crosses) 0.05 = ns. 0.01 = ns
LSD (media) 0.05 = 1 .67.0.01 = 2.20

[a] Six hundred anthers per cross were plated on each medium.
[b] $\frac{\text{Total anthers with calli}}{\text{Total anthers plated}} \times 100$

The basal medium for plant regeneration was Murashige and Skoog's. Kinetin concentrations (mg/liter) differ for M1, M2, M3, M4, M5, M6, M7, and SK-11: 1, 10, 5, 2, 4, 8, 16, and 1, respectively. All the media have 1 mg NAA/1 except M3, which has 1 mg indole 3-acetic acid (IAA)/1 instead of NAA. SK-11 also includes benzylamino purine (1mg/liter) and casein hydrolysate (500 mg/liter).

In callus induction, there was a significant interaction between crosses and media, and significant differences among the three media (Table 1).

Table 2. Interaction between callus induction medium and plant regeneration medium in anther culture of 5 cross combinations.

Callus induction medium	Green plants (%) from regeneration medium								Total (no.)	Av (%)[a]
	M1	M2	M3	M4	M5	M6	M7	SK-11		
G1	1.8	2.3	4.8	1.4	4.3	1.8	5.8	2.4	79	2.9
Fj	0.9	0.7	2.5	3.5	2.0	1.8	3.6	3.6	58	2.2
L8	3.0	4.5	4.9	4.3	4.5	4.1	2.9	5.1	108	4.1
Total no.	16	30	43	31	26	29	35	35	245	
Av (%)[a]	3.0	1.8	2.4	4.1	3.0	3.1	3.9	2.8		3.3

[a] $\frac{\text{Total calli producing green plants}}{\text{Total calli plated for regeneration}} \times 100$

The interaction between callus induction and plant regeneration media is shown in Table 2. Calli produced in G1 medium could be regenerated on either M3, M5, or M7 regeneration media. Calli produced in Fj should be regenerated on M4, M7, or SK-11; those produced in L8 should be regenerated on M2, M3, M4, M5, or SK-11. The highest percentages of green plants were produced on M4 and M7. ■

Hybrid rice yield trials in the Mekong Delta

Pham Thi Mui, Vu Minh Hung, Bui Chi Buu, and Nguyen Van Luat, Cuu Long Rice Research Institute, Omon, Haugiang, Vietnam

We compared seven IRRI-bred rice hybrids and two check varieties in 1990 wet (WS) and dry (DS) seasons. Twenty-day-old seedlings were transplanted at 20- × 15-cm spacing, in a randomized complete block design with three replications.

In WS, IR58025 A/IR29723-143-3-2-1 R had the highest yield, followed by IR62829 A/IR29723-143-3-2-1 R (see table). Both hybrids had positive standard heterosis. Hybrids from IR58025 A also carried the aromatic trait.

In DS, IR62829 A/lR29723-143-3-2-1 R had significantly higher yield than check variety OM576. Hybrids from IR62829 A had long and slender grains.

IR62829 A and IR58025 A are promising cms lines for producing high-yielding, good grain quality rice hybrids in Vietnam. ■

Yield performance of F_1 rice hybrids in Vietnam, 1990-91.

Cross	Duration (d)	Panicles (no./m^2)	Filled grains (no/panicle)	1000-grain wt (g)	Yield (t/ha)	Standard heterosis (%)
		1990 wet season[a]				
IR58025 A/IR29723-143-3-2-1 R	125	429 abc	118.6 a	28.0	7.6 a	+41.83
IR62429 A/IR29723-143-3-2-1 R	116	396 abc	92.4 cde	26.6	6.7 b	+26.26
IR58025 A/IR9761-19-1 R	106	407 abcd	111.0 ab	28.8	6.0 bc	+16.40
IR62829 A/IR9761-19-1 R	106	473 a	97.3 bc	25.0	5.9 bcd	+13.89
IR62829 A/IR24 R	113	451 ab	80.0 bc	27.2	5.6 cd	+5.62
V20 A/IR9761- 19-1 R	104	418 abc	96.0 bc	28.0	5.5 cd	+6.75
V20 A/Milyang 46 R	104	352 cd	87.6 e	30.4	5.4 cd	+4.42
MTL 58 (check)	120	369 bcd	89.0 cde	26.0	5.3 cd	
MTL 61 (check)	104	334 d	83.6 cde	22.6	5.2 d	
CV (%)		11.80	8.14			
		1990-91 dry season				
IR62829 A/IR29723-143-3-2-1 R	100	14	107.6	23.8	6.67	+17.02
IR62829 A/IR9761-19-1 R	99	12	99.7	21.1	5.70	+5.60
IR58025 A/IR29723-143-3-2-1 R	107	13	113.1	24.9	5.40	
IR58025 A/IR9761-19-1 R	99	13	94.7	22.5	4.87	
IR62829 A/IR24 R	99	11	86.6	22.7	3.93	
V20 A/IR9761-19-1 R	87	11	85.2	24.7	3.40	
V20 A/Milyang 46 R	89	12	82.5	27.5	3.00	
OM576 (check)	101	13	103.4	24.0	5.40	
MTL 58 (check)	105	12	95.9	24.2	5.70	
cv (%)			10.0		5.4	
LSD (0.05)			14.5		0.40	
LSD (0.01)			14.5		0.53	

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

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.

Yield potential

Performance of different height rice lines under intermediate deep water levels

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We evaluated 12 promising rice lines with different plant heights (semidwarf, semitall, and tall) and growth durations (90-180 d), and N level (0 and 40 kg N/ha) under intermediate deep water (up to 80 cm) during 1988. The experiment was laid out in a split-plot design with three replications, with rice cultivars in the main plot and N level in 15.8-m^2 subplots.

Experimental lines were direct seeded in dry soil 6 Jun, at 400 seeds/m^2 with 20-cm row spacing, and fertilized basally with 9 kg P and 17 kg K/ha. Germination was good.

Water in the field increased gradually from mid-Jun, to 76 cm on 10 Aug and 83 cm on 25 Sep. During most of the crop growth period, water level was 30-60 cm. Water receded gradually from early Oct. The crops matured in mid-Dec.

Application of N increased plant height and yield attributes significantly (see table). The four tall cultivars had significantly higher yields. They elongated faster as water level rose and flowered during the first week of Nov.

Grain yield decreased linearly with decreasing plant height, and the three semidwarfs had very low yields. Popular, short-duration upland cultivar Kalinga 3 virtually failed under deep water. Although this variety had panicle numbers similar to those of other varieties, its panicle size was considerably reduced, partly because of seed germination of matured panicles lying on the water surface and partly because of damage by birds after early maturity.

Local semitall cultivar Hathipanja had the highest 1000-grain weight but had

Growth and yield attributes of rice varieties under intermediate deepwater conditions (up to 80 cm). Cuttack, India, 1988.

Treatment	Cross	Flowering date (DAS)[a]	Plant height at maturity (cm)	Panicles (no./m^2)	Panicle weight (g)	Grains (no./panicle)	1000-gram weight (g)	Grain yield (kg/15.8 m^2 plot)	Straw yield (kg/m^2)
Tall varieties									
CN573-2-21	Patnai 23/ Jaladhi 2	2 Nov (161)	170	81	3.22	146	25.8	3.71	6.17
CN579-363-3-1	Jhingasail/ Jaidhi 2	4 Nov (163)	160	90	2.99	139	25.8	3.48	5.50
ET10002	Jaladhi 2/ Pankaj	2 Nov (161)	167	72	2.93	136	25.6	3.70	5.26
IET10006	Patnai 23/ Pankaj	2 Nov (161)	176	68	3.26	149	25.5	3.49	5.25
Semitall varieties									
CR292-805l	Pankaj/ Mahsuri	20 Oct (148)	129	91	2.65	130	21.2	2.81	4.34
CR687-2-10	Savitri/ Jagannat// CR333	15 Nov (174)	137	68	2.37	151	20.1	2.15	3.50
CR1030	Waikoku/ CR210-1014	25 Oct (153)	138	63	2.50	145	19.1	2.28	4.13
Hathipanja (check)		28 Oct (156)	143	65	2.81	99	30.1	2.48	3.92
Semidwarf varieties									
CR210-1016	Pankaj/ Jagannath	28 Oct (156)	98	60	2.18	123	19.0	1.79	2.34
CR260-171	CR151-791 CR210-1014	2 Nov (161)	120	52	2.32	126	22.2	1.63	2.82
CR527-18-2	Agahania/ Savitri	24 Oct (152)	121	64	2.47	101	26.1	1.72	2.92
Kalinga 3	AC540/Ratna	1 Aug (68)	113	71	0.89	37	18.9	1.01	1.16
SE	-	-	5	5	0.22	10	0.2	0.30	0.43
N fertilizer (kg/ha)									
0	-	-	135	62	2.52	115	23.2	2.20	3.47
40	-	-	142	76	2.74	131	23.4	2.83	4.41
SE	-	-	1	2	0.08	3	0.1	0.06	0.12

[a] DAS =days after sowing.

fewer grains per panicle, for a yield similar to that of other semitall cultivars with relatively finer grain types. CR687-2-10, although it flowered very late (mid-Nov), produced a yield similar to that of semitall cultivars that flowered in mid-Oct.

Application of N hastened flowering by 4-6 d but increased stem borer incidence by 42%.

Grain yield had a significant positive correlation with plant height at maturity ($r = 0.904^{**}$), panicle weight ($r = 0.869^{**}$), and grains per panicle ($r = 0.665^{*}$). Panicles per m^2 (considered a major yield attribute of medium-duration dwarf varieties under shallow water and irrigated conditions) had no significant relationship with grain yield under excess water ($r = 0.572$ ns). Panicles per m^2 was low (less than 100/m^2), which ultimately led to heavier panicles, and that influenced yield most.

These results indicate that tall, elongating cultivars with good panicle size that flower during the first week of Nov are better suited to intermediate deep water conditions. Panicle number appears to be the limiting factor for higher yields. □

Grain quality

Attaining higher volume expansion in popped rice

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Popped, puffed or expanded, and flaked rice products are prepared widely throughout major rice consumption areas in India. Appropriate varieties account for nearly 10% of the total rice produced. Parameters characteristic of the popping quality of rice include maximum proportion of popped grains, volume expansion (ml of popped fraction from 100 g rough rice), and separation of husk from the product.

The factors associated with popped rice quality may be variety, machinery, and processing techniques. We studied the optimum conditions for several processing variables, using a grain roaster.

Volume expansion was maximum when grains with 14% moisture were roasted at 275 °C for 40 s with sand of 0.35-0.60 mm size, at a ratio of 1 rice:2 sand.

Using these standard conditions, we screened 28 varieties for popping quality. Six varieties with volume expansion 900-1,300 ml were considered good poppers. The remaining varieties with volume expansion 20-765 ml were poor poppers.

In samples of seven varieties harvested late, volume expansion ranged from 80 to 770 ml. This reduction appears to be due to the number of cracked grains in the late harvested samples (see table). Cracking-resistant and cracking-susceptible varieties harvested at optimum moisture content (22-24%) did not show significant differences in popping quality. Late harvesting at 16-17% moisture content, however, resulted in a greater reduction of volume expansion in crack-susceptible than in crack-resistant lines.

In four varieties, germinated or parboiled rough rice showed 50% reduction in volume expansion, probably due to loosened husk and other factors related to changes brought about during these processing operations. Samples of seven varieties stored for 12 mo under ambient conditions showed enormous improvement in volume expansion.

Popular varieties Intan (volume expansion 1,300) and FT 12, a selection from Vani (volume expansion 935), proved to be good poppers with maximum husk separation. They can be recommended for yield and improved popping quality. CRHP-8 and White Puttu were good poppers, but are agronomically poor. They could be used as donors for good popping gene.

The recommended practice of harvesting at optimum moisture content for high yield and good milling quality also applies to high volume expansion. □

Effect of variety, harvest moisture, and grain cracking on popping quality of rough rice.[a]

Variety[b]	Volume (ml) of popped fraction[b]			Cracked grains (%)	
	Fresh rough rice	Stored rough rice	Late harvested and stored	Optimally harvested Mean ± SD	Late harvested Mean ± SD
Inran	970	1300	—	—	—
CRHP-8 (waxy)	900	1040	770	0.4 ± 0.5	6.00 ± 1.2
FT-14 (CS)	870	1000	80	10.2 ± 1.0	50.00 ± 3.1
White Puttu (waxy)	—	965	—	—	—
FT-12 (CR)	55	935	590	0.2 ± 0.4	4.2 ± 0.8
FT-125	880	900	—	—	—
Y-4	—	765	640	0.4 ± 0.5	4.2 ± 0.8
S-701	—	755	—	—	—
ES-18	—	750	—	—	—
IR20	—	715	—	—	—
FT28 (CS)	630	600	170	1.8 ± 1.3	23.0 ± 2.4
Madhu 43	—	600	—	—	—
FT19 (CR)	215	555	320	0.4 ± 0.5	4.0 ± 0.7
Halubbulu	500	530	—	—	—
FT1	320	465	—	—	—
FT2	170	450	—	—	—
Vani	—	410	—	—	—
Bharani	—	345	—	—	—
IET4699	—	390	—	—	—
S199	—	270	—	—	—
Puspha	—	270	—	—	—
Purple Puttu (waxy)	—	230	—	—	—
Pusa 150	—	335	230	1.0 ± 0.7	12.0 ± 1.5
Rajmudi	—	235	—	—	—
Madhu	—	200	—	—	—
Pankaj	90	75	—	—	—
FT199c (completely chalky)	—	20	—	—	—
Sona	—	20	—	—	—

[a] Av of duplicate values. [b] CS =cracking susceptible, CR = cracking resistant.

Procedures for quality selection of aromatic rice varieties

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Aromatic or fragrant rice varieties have an associated flavor. The Basmati rices of Pakistan and India and the jasmine-type rices of Thailand are the aromatic cultivars commonly encountered in world trade.

Changing immigration patterns have created a demand for aromatic rices within the Australian domestic market, presenting the local rice industry with a challenge to breed a temperate climate-adapted aromatic cultivar.

The physicochemical properties of Australian non-aromatic long grain rices are similar to those of some traditional good quality Asian aromatic rice varieties (see table). The fragrant varieties usually have soft to intermediate cooked grain texture and high elongation on cooking.

During the last 8 yr, we have used a number of fragrant lines in our breeding program. Quality selection has concentrated on subjective odor and taste tests, as well as on normal tests for appearance and for milling and eating quality.

Selection for fragrance has some unique demands. While the major chemical components of fragrance have been identified, we do not use a gas liquid chromatography technique to quantify the active compounds, for fear of selecting against other odor or taste components traditionally associated with high quality, aromatic rices. We believe that taste is as important as aroma, and that these characters vary in type as well as in intensity. Consequently, taste analysis is the most reliable approach for new variety selection.

To ensure selection of pure fragrant lines, the presence of the fragrant character must be subjectively assessed and quantified at each stage of development. Fortunately, the character is present in vegetative material as well as in grain and can be determined by tasting the lower sections of tillers at about the flowering stage. This makes it possible to harvest only those lines with the highest probability of having aromatic grain.

Testing procedures allow experienced taste panels to assess breeding lines for aroma and flavor characteristics. Because of the limited quantity of seed available in early generations, polishing

Physicochemical properties of some fragrant rices and some Australian nonfragrant varieties.

Variety	Milled rice property		
	Amylose (% db)	Alkali spreading value	Gel consistency (mm)
Khao Dawk Mali 105 (Thai aromatic)	19	7.0	94
Milagrosa (Flipino aromatic)	24	4.7	60
Seratus malam (Indonesian aromatic)	24	6.0	40
Kulu (Australian nonaromatic)	19	7.0	100
Inga (Australian nonaromatic)	21	6.8	100
Pelde (Australian nonaromatic)	22	6.8	100
Goolarah (Australian aromatic)	21	6.5	100

of the rice is not practical: taste tests are performed on 16 grains of brown rice.

Small quantities of rough rice are dehulled using a hand-turned Kett rice husker. This allows screening of single panicle selections for the presence of the flavor trait and for uniformity within the panicle. When larger quantities are available (10 g or more brown rice), the grain is polished using a Kett "Pearlest" model rice and barley pearler.

Grains are placed individually in the wells of a 96-well, polystyrene, "V"-bottom tissue culture plate with lid and 25 µl of distilled water added. The shape of the wells ensures that one end of each grain is positioned in the water droplet. For uniformity of water uptake, the grains are positioned so that the embryo is in the droplet.

The covered plates are enclosed in self-sealing plastic bags and refrigerated at 3 °C overnight to allow the grain to soften. Each grain is tasted and scored for flavor.

Tasting individual seeds allows us to screen panicles for the presence and intensity of aroma, as well as to measure the proportion of flavored seeds/panicle. In early-generation lines segregating for aroma, we can select only those seeds that will produce aromatic plants in the next generation.

To obtain pure seed of fragrant selections, only half of each seed is tested. The embryo halves of seeds found positive for aroma are grown into plants using a sterile agar-culture technique, then transplanted in the glasshouse.

All selections are also tested for amylose, gelatinization temperature, cooked grain elongation, and, in later generations, cooked grain texture.

Taste tests have shown that most fragrant rices traded internationally contain a proportion of nonfragrant grains. By adopting a pure-seed scheme based on single seed descent of taste-tested grains, it is possible to develop pure fragrant varieties.

Fragrant variety Goolarah was developed using this approach. Its locally adapted long-grained parent is Kulu. Goolarah has cooking properties similar to those of many Southeast Asian jasmine-type rices: good milling quality, excellent appearance, and medium-strong fragrance. ☐

Relationship of transplanting time to grain quality in Basmati 385

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Normally 30-d-old seedlings of Basmati varieties are transplanted during the first half of Jul. With the release of Basmati 385, we experimented to determine its optimum transplanting time, compared with standard variety Basmati 370. The irrigated trial was laid out in a randomized complete block design with four replications.

Early and late transplanting significantly affected milling recovery and cooking quality (see table). Highest milling recovery and best cooking quality were with samples of Basmati 385 transplanted 16 Jul and Basmati 370 transplanted 1 Jul. This may be due to Basmati 385's short duration: a crop transplanted early matures when the ambient temperature is high.

Aroma in both varieties was also lower in the crop transplanted early. Amylose content and alkali spreading values increased with delay in transplanting, but remained in the intermediate category. The effect of transplanting time on protein content was not significant. ☐

Effect of transplanting date on grain quality attributes of Basmati varieties.[a]

Transplanting date	Total milled rice (%)	Head rice (%)	Cooked grain length (mm)	Bursting upon cooking (%)	Aroma score	Protein content (%)	Amylose content (%)	Alkali spreading score
			Basmati 385					
1 Jun	66.1 e	48.3 d	13.0 c	20.0 a	3.4 c	9.5 a	23.7 c	4.1 d
16 Jun	68.1 d	50.0 c	13.6 b	17.0 a	4.0 b	9.1 b	24.1 bc	4.2 cd
1 Jul	70.1 b	54.0 b	14.2 a	12.0 b	4.8 a	9.0 bc	24.5 ab	4.5 bc
16 Jul	70.8 a	55.3 a	14.5 a	10.0 b	5.0 a	8.7 c	24.8 a	4.8 ab
1 Aug	69.2 c	50.0 c	14.0 ab	13.0 b	4.9 a	8.9 bc	25.0 a	5.0 a
			Basmati 370					
1 Jun	67.2 c	49.2 c	13.4 c	18.0 a	4.0 c	8.2 a	23.0 c	4.2 a
16 Jun	68.9 b	51.4 b	14.0 ab	14.0 bc	4.4 b	8.0 a	22.9 c	4.4 a
1 Jul	70.6 a	53.4 a	14.4 a	11.0 d	5.0 a	8.1 a	22.9 c	4.5 a
16 Jul	69.0 b	51.7 b	14.2 a	12.0 cd	5.0 a	7.8 a	24.5 b	4.7 a
1 Aug	65.8 d	46.8 d	13.6 bc	16.0 ab	4.6 b	7.9 a	25.3 a	4.8 a

[a]In a column, means for each variety followed by the same letter are not significantly different at the 5% level (DMRT).

Rapid viscometric analysis of rice flour

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The Rapid Visco Analyser (R.V.A.) is a new instrument designed in Australia (Newport Scientific, 29 Gondola Road, Narrabeen, NSW 2101) for determining the viscous properties of starches, gels, syrups, shortenings, batters, and foams. The basic instrument has the advantages of small sample size and rapid test time, but it has limited control of heating and cooling.

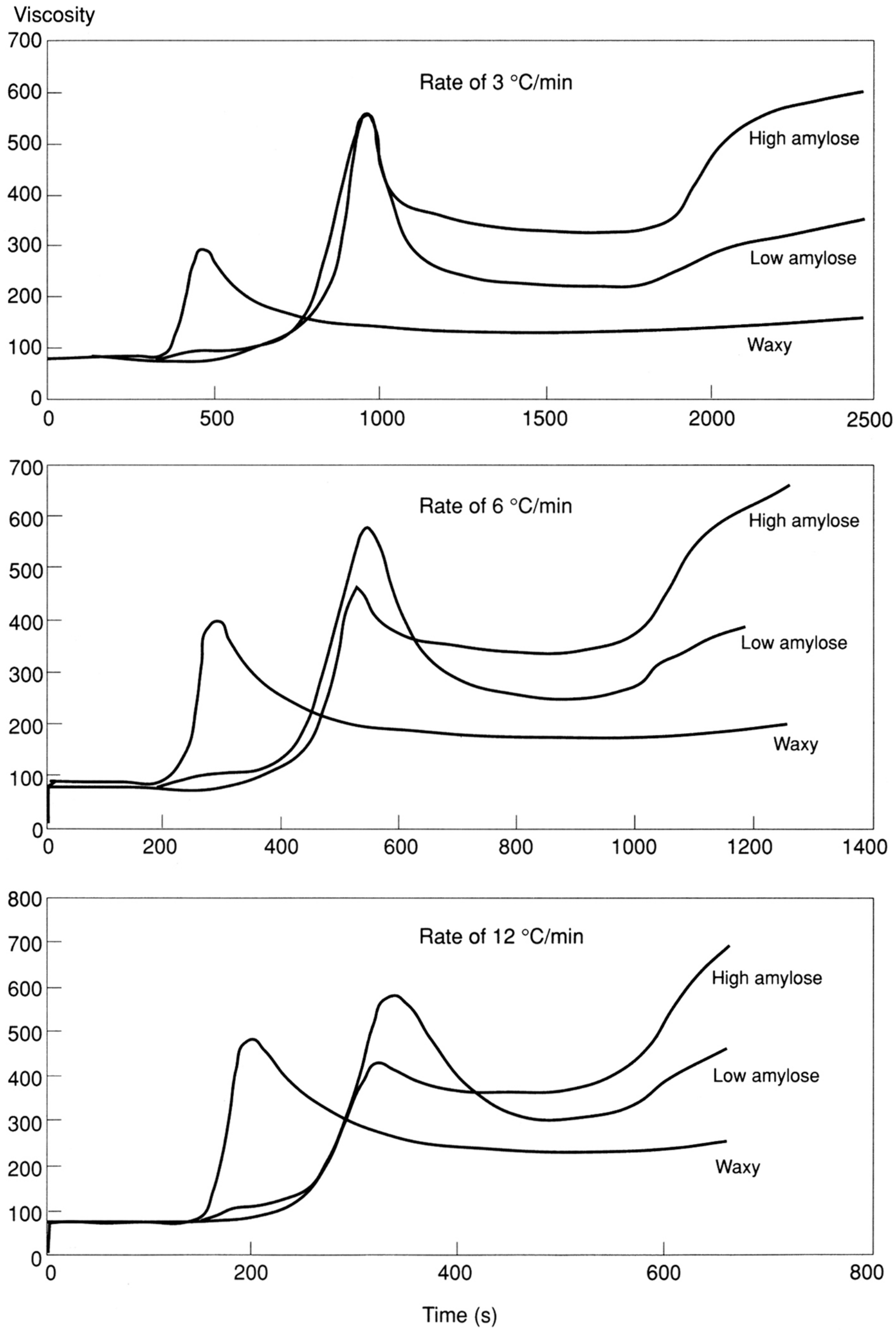
We modified an R.V.A. to allow the heating and cooling rates of a testing cycle to be precisely controlled. A computer equipped with an additional input/output card is connected to an R.V.A. New software allows the R.V.A. to be fully controlled by signals from the computer (the R.V.A.'s internal control system is disabled).

The instrument has been used for viscometric analysis of rice flour from our breeding program. Viscometric properties had been measured using a Brabender Visco-Amylograph. The length of analysis (11/2-2 h) and the relatively large sample size (50 g) severely limited the number of tests that could be performed and the generation of the breeding program to which it could be applied.

The R.V.A. analysis uses a smaller sample (3 g) and is much quicker. By selecting a heating rate, cooking time, and cooling rate proportional to, but much faster than, the Visco-Amylograph, it is possible to obtain similar information.

The heating/cooling computer program allows wide variability. The initial temperature can be set at 0-100ºC, with a hold delay of any number of minutes. Heating rates of 0-20ºC/min in two independent ramps, with an optional hold period between the ramps, are possible. Cooking at the top temperature can be maintained for any period before cooling at 0-20ºC/min to the initial temperature.

The figure shows the curves obtained when flour from three samples of rice with different amylose content were heated, cooked, and cooled under different sets of parameters. The flour slurries (3 g/25 ml) were heated and cooled at rates of 3, 6, and 12ºC/min, with cooking times at 95ºC of 10, 5, and 2.5 min, respectively.



Curves obtained when 3-g samples of rice flour were processed in a computer-controlled Rapid Visco Analyser.

When the R.V.A. is programmed at heating and cooling rates of 12ºC/min, the complete testing cycle takes only 11 min and produces viscosity curves very similar to those produced using a conventional Amylograph with a heating rate of 1.5ºC/min. To obtain similar viscosity curves, it appears necessary to combine precise control of heating rate with the amount of shear that the testing instrument imparts to the starch slurry.

The R.V.A. viscosity curves adequately discriminate between rices with different textural properties. Its ability to process small samples will allow data on paste viscosity to be obtained from earlier generations and many more samples. The modified R.V.A. has the added advantage that data acquisition, analysis, and comparison with standard varietal samples are done automatically, and appear on the computer screen. □

Pest resistance—diseases

Genetics of bacterial blight (BB) resistance in two land races of rice from India

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We studied the inheritance of resistance to Indian pathotype IXO5 of *Xanthomonas oryzae* pv. *oryzae* in two land races of rice, ARC 10464 and CNGS20083. The land races were crossed with susceptible Taichung Native 1 (TN1) and among themselves. The F_2s from resistant/susceptible and resistant/resistant crosses were transplanted at 40 d after seeding in 3-m-long rows, 50 cm apart.

Plants were inoculated 30 d after transplanting with a 48-h-old culture of pathotype IXO5, by clipping method. The bacterial concentrations were maintained at 10^6-10^8 cells/ml. Pathotype IXO5 is virulent to genes *Xa*-1, *Xa*-3, *Xa* (Ka), *Xa*-4, *Xa*-5, *Xa*-9, and *Xa*-10; lines carrying genes *Xa* -2, *Xa* -6, *Xa* -7, and *Xa*-11 show moderate resistance.

Level of resistance was determined by lesion length in centimeters on three inoculated leaves 14 d after inoculation: resistant (R) = mean lesion length less than 25% of that on TN1; moderately resistant (MR) = mean lesion length 26-50% that of TN1; susceptible (S) = mean lesion length greater than 50% that of TN1. To compute genetic ratios, R and MR plants were grouped as resistant.

Segregation patterns in different F_2s are given in the table. The F_2 from the cross ARC10464/TN1 segregated in a 15R:1S ratio, suggesting the presence of two independently inherited dominant genes in ARC10464. The F_2 from CNGS20083/TN1 segregated in a 1R:3S ratio, suggesting the presence of a recessive gene. The F_2 from the cross of the two resistant lines segregated in a 61R:3S ratio, confirming the presence of two dominant genes in ARC10464 and a recessive gene in CNGS20083.

ARC10464 is a semidwarf type; CNGS20083, a tall rice with very poor plant type. ARC10464 is not resistant to all the pathotypes of BB reported from India; CNGS20083 is resistant to all the BB pathotypes. Use of such lines with simple genetic control of resistance in breeding programs could help improve resistance of new varieties. ☐

Mean lesion length on parents and segregation for BB resistance in F_2 from different crosses.

Parent, cross	Resistant		Susceptible		Ratio	χ^2 value
	Plants (no.)	Mean lesion length (cm)	Plants (no.)	Mean lesion length (cm)		
ARC10464	10	1.32	-	-	-	-
CNGS20083	10	1.48	-	-	-	-
TN1	-	-	10	10.10	-	-
ARC10464/TN1	178	3.23	15	8.16	15:1	0.76
CNGS20083/TN1	63	2.00	161	9.05	1:3	1.16
ARC10464/CNGS20083	90	3.15	3	9.15	61:3	0.49

Pest resistance–insects

Screening of rice varieties and advanced breeding lines in Cambodia for resistance to gall midge (GM) *Orseolia oryzae*

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We screened 907 varieties and advanced breeding lines being tested in Observational Yield Trials (early, medium, mixed, and late), the International Irrigated Rice Observational Nursery, and the International Rice Lowland Observational Nursery, during a serious GM outbreak in 1990 wet season.

Entries were transplanted at 20- × 20-cm spacing, one seedling/hill in field plots. GM damage was scored at the maximum tillering to heading stage. Damage on hill basis considered all hills in a plot; damage on tiller basis was evaluated on 20 randomly selected hills per plot. Percentages of infested hills and

Table 1. Varieties showing resistance to GM on hill as well as tiller basis.

Variety	Infestation: Hill %	Hill Score	Tiller %	Tiller Score	Origin
174 BAA	10	3	5	3	Tanzania
79007-TR7-40-4-1-1	5	1	5	3	Turkey
7901-TR16-1-1	0	0	0	0	Turkey
7906-TR11-1-1	0	0	0	0	Turkey
80023-TR166-2-1-4	5	1	4	3	Turkey
80055-TR198-5-1-1	5	1	5	3	Turkey
Badshabhog (Acc 285431)	10	3	4	3	Bangladesh
Chhuthana 1-078-1-1-1-1	4	1	3	3	Cambodia
Chhuthana 1-078-3-1-1-2	4	1	2	3	Cambodia
Dunasan	0	0	0	0	China
Hua Lien Yu164	5	1	4	3	Taiwan
HURI 370	0	0	0	0	Hungary
HURI 386	0	0	0	0	Hungary
IB 15B	0	0	0	0	Burundi
IB 15C	0	0	0	0	Burundi
IB 17	0	0	0	0	Burundi
IB 28	0	0	0	0	Burundi
IB 33	0	0	0	0	Burundi
IB 44	0	0	0	0	Burundi
IR35366-28-3-1-2-2	5	1	3	3	IRRI
IR41996-50-2-1-3	10	3	5	3	IRRI
IR51079-35-2-3-3-3	4	1	3	3	IRRI
IR51130-SKN-24-B-1-5-1	0	0	0	0	IRRI
IR51130-SKN-31-B-1-6-1	2	1	3	3	IRRI
IR51640-153-1-2-2	5	1	3	3	IRRI
IR52256-190-2-2-1	10	3	5	3	IRRI
IR53901-14-1-1-2	5	1	3	3	IRRI
IRS6381-155-1-2-2	10	3	2	3	IRRI
IR59081-CPA-2-B-1-2	0	0	0	0	IRRI
Kankai 12-11-84	10	3	3	3	Nepal
Khao Pong Krai	0	0	0	0	Thailand
Mahsuri	8	3	5	3	Malaysia
Neang Mon l-027-3-1-1-2	0	0	0	0	Cambodia
ORC	0	0	0	0	Chile
Quella-Inia	5	1	3	3	Chile
RD 27	10	3	3	3	Thailand
RP1057-391-1	10	3	5	3	India
RP2107-14-12	10	3	4	3	India
Somaly 2-023-3-5- 1-2- 1	4	1	4	3	Cambodia
Somaly 2-023-6-2-2-1-1	4	1	2	3	Cambodia

tillers were converted to 0-9 damage scales.

Of the 907 entries tested, 7.5% were rated resistant (scores 0, 1, and 3) on hill basis and 8.8% on tiller basis (Table 1).

More entries were rated as resistant on tiller basis than on hill basis. This noncorrespondence was marked in some varieties (Table 2). Whether these varieties have a resistance mechanism whereby most hills get infested, but with the infestation limited to a few tillers needs further study. □

Table 2. Noncorrespondence of varietal infestation by GM as measured on hill and tiller basis.

Variety	Infected hill		Infected tiller		Variety	Infected hill		Infected tiller	
	%	Score	74	Score		%	Score	%	Score
20B	55	9	5	3	IRS4883-8-2-3	35	7	4	3
61759	30	7	5	3	IRS6382-112-1-3-2	15	9	4	3
Cisokan	25	7	5	3	IR56455-69-2-2-1	25	7	5	3
IR42	4	1	13	7	IR57311-99-1-3	40	7	4	3
IR19319-5-3-3-2-1	65	9	2	3	OR367-SP-11	25	7	4	3
IR33059-26-2-2	35	7	4	3	RP1125-1012-2-1-4	40	7	5	3
IR35353-94-2-1-3	45	7	3	3	RP1821-9-1-1-2	35	7	3	3
IR44426-35-3-3-2	24	7	5	3	RP2069-16-9-5	45	7	5	3
IR49631-B-B-30-1	26	7	5	3	RP2107-8-12	35	7	5	3
IR51075-29-1-1-2-1	4	1	14	7					

Stress tolerance—adverse temperature

Breeding for cold tolerance at reproductive phase in the high hills of Nepal

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Injury caused by low temperature is a major constraint to improving rice production in the high hills of Nepal. Most cold-tolerant materials fail to set grains because minimum air temperatures (<15°C) are low from booting (Aug on) to maturity (Table 1).

We are now screening introduced and segregating materials in the field at four altitudes (1,250 m, 1,400 m, 1,675 m, and 2,000 m asl). At 2,000 m in Chhomro, almost all inte-rnationally known cold-tolerant exotic and indigenous varieties were sterile.

We crossed indigenous cold-tolerant varieties Chomrong, Dhunge dhan, and Jumli Marshi with exotic cold-tolerant varieties Fuji 102, Akiyudaka, K332, and NR10157-2B-2, and with high-yielding varieties IR36 and NR10078-100-3-3. Seeds of F_1 generations grown at Khumaltar (1,350m) were divided into two lots for testing at 1,400-m and 2,000 m.

Table 1. Average air and water temperatures (°C) at Lumle (1,400 m) and Chhomro (2,000 m) testing sites of the Lumle Regional Agricultural Research Centre. Nepal, 1990.[a]

Month	Lumle			Chhomro		
	Air		Water	Air		Water
	Max	Min		Max	Min	
May	23.3	14.6	NR	24.4	12.0	NR
Jun	24.7	17.1	NR	24.8	I1.4	NR
Jul	24.0	17.6	22.0	23.4	15.3	21.2
Aug	23.7	17.4	20.8	24.4	14.7	20.8
Sep	23.5	16.6	19.6	22.3	14.2	NR
Oct	21.1	12.2	17.8	19.9	10.0	NR
Nov	19.3	11.4	NR	17.5	8.3	NR
Mean	22.8	15.3	20.1	22.4	12.3	21.0

[a]NR = not recorded.

Results with segregating materials from crosses between Chhomrong and exotic materials and from crosses of cold-tolerant K332 with moderately cold-tolerant Nepalese breeding line NR10157-2B-2 were promising (Table 2).

The crosses of indigenous cold-tolerant Chhomrong with exotic cold-tolerant Fuji 102 and with susceptible IR36 both set grain at the Chhomro site; progenies of other cold-tolerant materials (except K332/NR10157-2B-2) did not set grain. At 1,400 m in Lumle, most of the F_2 population produced grain. Some promising plants were selected from all crosses.

At Chhomro, segregation for cold tolerance at anthesis in Fuji 102/Chhomrong and K332/NR10157-2B-2 fitted a simple inheritance ratio of 3:1. This suggests that cold tolerance at anthesis in those crosses could be governed by a single dominant gene.

At Chhomro, progenies of K332 and NR10157-2B-2 produced several plants with good seed set, while the individual parents failed to produce grain. This suggests that inheritance of cold tolerance for spikelet fertility can be accumulated by crossing moderately cold-tolerant parents.

The genetics of cold tolerance at anthesis in Chhomrong and other promising indigenous varieties is being studied at Lumle. □

Table 2. Cold tolerance[a] of selected crosses at Lumle (1,400 m) and Chhomro (2,000 m). Nepal, 1990.

Cross	Lumle[b]	Chhomro[c]	
	Resistant (no.)	Resistant[d] (no.)	Susceptible[e] (no.)
Fuji 102/Chhomrong	7	14	26
Fuji 102/Dhunge dhan	6	0	40
NR10078-100-3-3/Jumli Marshi	4	0	40
Akiyudaka/Dhunge dhan	3	0	40
Akiyudaka/Jumli Marshi	2	0	40
IR36/Jumli Marshi	5	0	40
IR36/Chhomrong	7	4	36
K332/NR10157-2B-2	9	16	24

[a]Measured in terms of failure to set grain or grain set at maturity. [b]Chilling injury at reproductive phase. [c]Chilling injury from booting to ripening stages. [d]Resistant = plant sets grain. [e]Susceptible = plant fails to produce any grain.

Germination and growth of some salt-resistant selections in high salt concentration solutions

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In coastal areas of West Bengal, most ricelands are below the high tide level. Although earthen embankments prevent tidewater from entering the fields, there are chances for an increase in salinity of seedbeds. Seawater often enters the plots through lateral seepage or through upward percolation from nearby drainage channels, riverines, or estuaries. This hampers germination and seedling growth. Salinity increases are more pronounced when rain is scanty or erratic.

We evaluated three promising selections for coastal tidal wetlands and Hamilton, an improved selection from local cultivar Nona Bokra, under high salt concentrations in the laboratory (see table).

Germination was tested by the glass plate method. Two 25-seed sets/line were immersed in distilled water and salt solutions of 5, 10, and 15 dS/m.

The solutions were prepared by dissolving sodium chloride, calcium chloride, and sodium sulfate at 7:2:1 to obtain the derived estimates of electrical conductivity values.

Germinated seeds were counted 10 d after immersion and root length, seedling height, and seedling dry weight measured.

Overall, germination decreased with an increase in salt concentration. But the loss of germination was much slower in IR51194-CN930-44-16-B. Germination was significant even at 10 dS/m.

Root length was also severely affected at 15 dS/m in all test entries except IR51194-CN930-44-16-B.

Rate of shoot growth was not much affected, except in Hamilton. Dry matter accumulation also was not much affected. Differences in rate of dry matter accumulation, however, were conspicuous. ☐

Effect of salt concentration on seed germination and seedling characters of 4 rice entries.

Entry	Treatment (dS/m)	Mean gemination (%)	Root length (cm)		Seedling height (cm)		Dry weight (g) of 100 seedlings (mean × 100)
			Mean	± SD	Mean	± SD	
IR4630-22-5-1-3/1 -CN-1	Control	72	4.30	1.131	4.26	2.878	1.66
	5	32	2.30	1.389	4.07	0.750	1.45
	10	12	3.34	1.333	3.98	1.374	1.72
	15	4	2.74	1.146	4.08	1.616	1.62
IR51194-CN930-44-16-B	Control	66	2.33	0.533	5.13	0.883	0.95
	5	64	3.04	2.020	4.12	1.630	0.59
	10	48	2.84	2.418	4.82	2.586	1.40
	15	40	4.89	0.448	5.99	1.227	1.31
IR13198-66-2-CN939-2-1	Control	65	5.10	3.690	4.46	2.832	1.77
	5	55	4.68	2.124	4.46	1.326	2.09
	10	15	6.50	1.000	3.82	0.832	1.86
	15	5	2.75	-	5.75	-	1.17
Hamilton	Control	88	3.90	1.482	8.33	3.474	1.79
	5	60	10.94	2.225	12.04	2.586	1.63
	10	76	4.40	2.227	11.05	1.640	1.93
	15	8	0.75	-	4.75	-	1.75

Effect of abscisic acid (ABA) application on salt tolerance of rice varieties

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Cation ratios, mainly the K:Na ratio, play a vital role in reducing rice growth and yield under saline conditions. We studied the effect of applying ABA on dry matter accumulation and cation concentrations and ratios.

The experiment in the phytotron involved IR28 (salt-sensitive), IR20 (semitolerant), and Pokkali (tolerant); salinity levels of EC 10 and 15 dS/m; without ABA and with five weekly sprayings of ABA at 10^{-4} mol/liter, starting from 17 d after sowing (DAS). The experiment was laid out in a completely randomized block design with three replications.

Earthen pots were filled with 2.5 kg air-dried soil and puddled. Ten seeds were sown/pot. At 12 DAS, plants were thinned to three/pot.

Salinity treatments beginning 18 DAS were one irrigation/wk with 300 ml NaCl solution. On other days, pots were irrigated with plain water. Three pots of each variety were not treated.

Temperature in the growth chamber was maintained at 30/25 °C day/night, 12 h photoperiod, and 70-80% relative humidity.

Plants were harvested 48 DAS. Cation concentrations were determined by atomic absorption spectrophotometry (AAS).

ABA application significantly increased shoot dry weight and K:Na ratio in IR28 and IR20; it did not affect Pokkali (see table). K and Na concentrations in shoots were reduced 3.1% in IR28 and 29.7% in IR20. The K:Na ratio increased 17.7%. The benefit may be attributed to a lower transpiration rate, with a consequent reduced flux of Na through the root.

Pokkali had significantly higher shoot dry weight and K:Na ratio under saline conditions than IR28 and IR20. In general, the highest salinity level resulted in much lower shoot dry weights and K:Na ratios. Semitolerant variety IR20 responded best to ABA. □

Effect of salinity and abscisic acid (ABA) application on shoot dry weight and K:Na ratio of 3 rice varieties.

Treatment	Shoot dry weight (mg/plant)				K:Na ratio (shoot)			
	IR28	IR20	Pokkali	Mean	IR28	IR20	Pokkali	Mean
Control[a]	855	912	1095	–	176.1	187.5	125.0	–
Without ABA	409	395	774	526	10.69	8.44	14.21	11.11
With ABA	526	565	764	618	12.39	12.37	14.48	13.08
Mean	468	480	769		11.54	10.41	14.35	
LSD (0.05)								
Variety				81.2				1.10
ABA				66.3				0.90
Variety × ABA				114.8				1.55
Salinity level (dS/m)								
EC10				642				15.27
EC15				502				8.92
LSD (0.05)				66.3				0.90

[a] Control values were not included in analysis of variance.

Integrated germplasm improvement – irrigated

MDU4, a high-yielding, cold-tolerant rice for Tamil Nadu

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Screening for cold tolerance in rice in the high area of Cumbum valley in Madurai district of Tamil Nadu, India (nocturnal temperature 12-14 °C Nov-Feb, during the rice crop flowering phase), identified the high-yielding, cold-tolerant line ACM16 (AC2836/Jagannath). It has been named MDU4 and released for planting in cooler regions of Tamil Nadu.

MDU4 is semidwarf, high tillering, and nonlodging. Average yield in adaptive trials was 5.9 t/ha, 17.3% higher than that of IR20 (Table 1). Maximum yield potential is 10.5 t/ha. It matures in 125-130 d.

MDU4 is highly tolerant of low temperature and has lower spikelet sterility than IR20 and MDU2 (Table 2). In addition, it exhibits little grain discoloration, which is a problem in IR20 and MDU2 in low-temperature areas.

MDU4 is resistant to leaf blast, neck infection, sheath rot, and brown leaf spot under field and artificial conditions. It shows moderate resistance to gall midge and brown planthopper. □

Table 1. Yield of MDU4 (ACM16) in adaptive field trials, Tamil Nadu, India.

Trial site	Yield (t/ha)		
	ACM16 (MDU4)	MDU2	IR20
Madurai district			
Dharmapuri	6.4	6.1	5.7
Salem	6.4	5.9	5.7
	8.2	7.9	6.4
Overall mean	7.0	6.3	6.1
State seed farms (Keelagudalur) Cumbum Valley	5.4	4.3	4.4
National trials	5.3	–	4.5
Mean	5.9	5.3	5.0

Table 2. Reaction of MDU4 (ACM16) to low temperature.

Variety	Reaction[a]			
	1985-86	1986-87	1987-88	Mean
ACM16(MDU4)	6.6	7.2	9.6	7.8
MDU2	12.4	11.8	14.1	12.7
IR20	16.4	19.5	15.7	13.7

[a] Based on % chaffy grain.

Xiangwanxian 2, an excellent grain quality rice variety derived from an IR line

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Xiangwanxian 2, a short-duration, late rice variety derived from IR19274-26-2-3-1-2 (IR2071/IR2153//IR36) introduced from IRRI, was released Mar 1991 in Hunan. Average yield at 15 locations of the regional provincial test was 6 t/ha in 1990. It has 1000-grain weight of 21.2 g, with 83.8% seed fertility.

Grain quality is superior to that of most indica varieties in China: milled head rice is 58.2%, translucent endosperm, length/width ratio 3.9, 16.1 % amylose content, 6% chalky grain, 0.7% area with chalkiness, alkali spreading value 3, 9.1% protein content. These characterize Xiangwanxian 2 as a low-amylose, high to intermediate gelatinization-temperature type similar to international market rices. Cooked grains of Xiangwanxian 2 are soft and cohesive.

Xiangwanxian 2 is semidwarf (90-99 cm), erect and nonlodging, heavy tillering, with 110-d duration. It is suitable as a late crop in Hunan. □

HKR228, a semidwarf aromatic rice strain for Haryana, India

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HKR228 (IET10367) is a semidwarf aromatic rice derived from Sona/ Basmati 370. In wet season varietal trials 1985-90, HKR228 yielded 50% more than local check Basmati 370 (Table 1).

HKR228 has 143-d duration, 131 grains/panicle, and 1000-grain weight of 19.0 g. Its grain is long and slender with higher hulling and milling recovery than

Table 1. Yields of HKR228 and Basmati 370 in varietal trials at Kaul and Karnal, Haryana, India.

Year	Location	Yield (t/ha)		LSD (0.05)	CV (%)
		HKR228	Basmati 370		
1985	Kaul	4.9	3.5	0.5	6.8
	Karnal	4.7	2.9	1.2	14.8
1986	Kaul	5.2	3.0	0.3	4.0
	Karnal	5.5	4.8	0.7	6.4
1987	Kaul	6.1	4.3	0.8	6.8
1988	Kaul	4.8	3.5	0.7	8.0
1989	Kaul	5.1	3.6	0.2	2.87
	Karnal	5.5	3.4	0.4	4.02
1990	Kaul	2.8	1.1	0.1	3.20
	Karnal	4.9	2.8	0.6	7.57
Mean		4.95	3.29		

that of Basmati 370. Kernel elongation after cooking is 1.76, with 25.41% amylose content.

HKR228 is resistant to blast, stem rot, and whitebacked planthopper (Table 2). □

Table 2. Characteristics of HKR228 and Basmati 370.

Character	HKR228	Basmati 370
Days to maturity	143	144
Plant height (cm)	116	144
Panicles (no./m^2)	251	269
Grains (no./m^2)	131	89
1 000-grain weight (g)	19.0	21.5
Brown rice (%)	77.8	73.3
Milled rice (%)	72.5	65.0
Kernel length (mm)	7.06	6.70
Kernel breadth (mm)	1.58	1.62
L/B ratio	4.47	4.13
Kernel length after cooking (mm)	12.43	13.54
Kernel elongation ratio	1.76	2.02
Alkali value	6.50	5.05
Amylose content (R)	25.41	19.84
Grain type	Long slender	Long slender
Leaf blast resistance (0-9 scale)	3.0	7.0
Stem rot resistance (0-5 scale)	2.25	2.25
Bacterial leaf blight resistance (0-9 scale)	8.0	9.0
Whitebacked planthopper resistance (0-9 scale)	1.0	0.0

Integrated germplasm improvement–rainfed

Neeraja, a high-yielding rice variety for poorly drained rainfed fields in Kerala

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In Kerala, rainfed rice is cultivated on 320,000 ha during the wet season (Apr-May to Sep-Oct). Flooding is a major problem during early crop growth.

We screened 500 entries under poorly drained conditions. After transplanting, the experimental field was flooded to 50 cm for 2 wk.

Promising cultivars were tested for yield at Pattambi and in farmers' fields. Bangladesh line BR51315-4 was most promising, and has been released as Neeraja (Ptb 47).

Neeraja is semitall (110-120 cm), nonlodging, with 140-d duration (see table). Its grain is white and slender. Yields are 4-5 t/ha under average management (40-9-17 kg NPK/ha). Straw yields are 8-10 t/ha. Ratoon yields average 1.5 t/ha within 50-55 d. It is moderately resistant to blast and sheath blight.

Neeraja is recommended for poorly drained fields and double-cropped wetlands. □

Performance of Neeraja in station and adaptive trials.

Culture or variety	Parentage	Plant height (cm)	Tillers (no./plant)	Duration (d)		Grain yield (tha)		Mean grain yield (t/ha) from adaptive trials
				Main crop	Ratoon crop	Main crop	Ratoon crop	
Neeraja (BR51-315-4)	IR20/Pankaj	115	8	140	55	3.9	1.6	4.9
BR52-96-3	IR20/IR5	108	7	145	55	3.5	1.4	4.4
Ptb 1	Local check	137	7	140	55	1.5	–	2.7
LSD (0.05)						0.7		

CROP AND RESOURCE MANAGEMENT

Soil microbiology

Response of blue-green algae (BGA) in wetland rice culture in Himachal Pradesh, India

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We studied during wet season 1990 the effect on rice of BGA inoculation with different levels of applied N. Experimental soil was sandy loam, with pH 7.2, medium organic C (0.60%) and available N (110 kg/ha), and low available P (3.5 kg/ha).

The experiment was laid out in a randomized block design with three replications; plot size was 5 × 4.75 m. Thirty-day-old seedlings of IR579 were transplanted 7 Jul 1990. Dry soil-based BGA inoculum was broadcast 10 d after transplanting. The crop was harvested 10 Oct.

A mother culture of BGA procured from the National Facility for Blue-Green Algae Collections, Indian Agricultural Research Institute, at New Delhi was multiplied in the field during June. Ten kilograms of loamy soil mixed with 200 g single superphosphate was spread on a 15- × 7.5- × 22.5-cm galvanized iron tray flooded to 7.5 cm, and 250 g mother culture broadcast. A thick mat of BGA formed in about 10 d.

The water was allowed to evaporate and the dry BGA flakes with some soil were collected and ground for inoculum.

Inoculated plots produced a luxuriant growth of BGA, about 4 kg fresh weight/m^2. No microscopic observations were made because of the lack of facilities. The dominant algae biomass resembled *Anabaena* morphologically. A BGA bloom during maximum tillering continued up to panicle initiation, then gradually diminished.

Effect of inoculating BGA with and without applied N on irrigated rice yields. Himachal Pradesh, India, 1990 wet season.

Treatment (kg/ha)	Grain yield (t/ha)	Straw yield (t/ha)	Plant height (cm) at harvest	Panicle length (cm) at harvest	Grain number (no./panicle) at harvest
BGA_0N_0	2.1	5.2	80.0	18.3	131
BGA_0N_{30}	2.4	6.4	80.5	19.4	147
BGA_0N_{60}	2.6	7.7	82.9	20.0	150
BGA_0N_{90}	2.9	8.6	84.0	20.0	151
$BGA_{10}N_0$	2.5	6.2	81.0	20.4	159
$BGA_{10}N_{30}$	3.0	6.6	81.0	19.5	168
$BGA_{10}N_{60}$	3.1	8.1	81.5	21.0	174
$BGA_{10}N_{90}$	3.5	9.0	82.5	21.3	177
LSD (0.05)					
BGA	0.4				
N	0.1	0.4			
BGA×N	0.2	0.6			

Grain and straw yields were highest with 10 kg BGA + 90 kg N/ha (see table). Grain yields, but not straw yields, were influenced significantly by BGA. Nearly half a ton extra grain was obtained from BGA application. □

Integrated fertilizer management

Long-range effect of continuous cropping and fertilizer application on yield stability of Wet Season (ws) rice

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We began a long-range fertilizer experiment in 1977 (Apr-Sep) WS. Treatments included three N levels, three P levels, and two K levels, with a no-treatment control.

The experimental area was double-cropped wetland with sandy clay loam soil (riverine alluvium deposited over laterite soil), 71% sand, and 5% silt. Initial soil analysis on composite samples from the top 20 cm layer showed pH 5.2; EC 0.25 dS/m; 0.72% organic C; and 156, 31, 178 kg available N, P, K/ha. The experimental layout was a partially confounded randomized block design with four replications. Jaya was the test variety.

N level significantly affected yields for 9 yr (see table). P level significantly affected yields for the last 10 yr. The delayed response to P may be due to a residual effect. No response to potash occurred, perhaps because of the high soil K content. With no fertilizer, yields varied from 3.7 t/ha in 1977 to 2.7 t/ha in 1990. □

Grain yields averaged over 14 WSs in continuous WS cropping experiment. Kerala, India, 1977-91.

Fertilizer	Grain yield (t/ha)					
	No P	17.6 kg P/ha	35 kg P/ha	NoK	33 kg K/ha	Mean(N)
4o kg N/ha	3.4	3.9	3.9	3.8	3.7	3.8
80 kg N/ha	3.8	4.2	4.3	4.2	4.0	4.1
120 kg Nha	3.9	4.4	4.5	4.2	4.3	4.3
Mean (P & K)	3.7	4.2	4.2	4.1	4.0	
No K	3.8	4.2	4.3			
33 kg K/ha	3.7	4.1	4.2			
LSD N and P	0.2					

Crop management

Effect of tillage practices on deepwater rice (DWR) yield and return

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In DWR areas, land preparation is done when water recedes. We studied the effect of six different tillage practices in a randomized block design with four replications in 1988 and 1989 wet seasons (Apr-Dec).

Soil at the experimental site was clay loam (Aridisol) with pH 8.2, 0.52% organic C, 11 kg available P, 248 kg K/ha.

Rice variety Jalmagna was direct seeded in rows 25 cm apart on 20 Apr 1988 and 25 Apr 1989. Plot size was 90 m^2. Basal fertilizer was 40 kg N, 8.8 kg P/ha. Water started to rise in Jul, reaching a maximum 240 cm in Aug 1988 and 210 cm in Sep 1989.

Yields differed significantly both years (see table). Highest grain yield, net return, and benefit:cost ratio were with one moldboard plowing plus two plowings by country plow, with planking after each plowing. □

Effect of tillage practices on DWR grain yield, net income, and benefit:cost ratio.[a]

Treatment [b]	Grain yield (t/ha)		Total cost ($/ha)	Gross income ($/ha)	Net income ($/ha)	Benefit:cost ratio
	1988	1989				
Farmer's method, 4 plowings, with bullock-drawn country plow	2.8	3.1	158	338	180	2.1
1 moldboard plowing + 2 country plowings	3.4	4.0	149	423	214	2.8
1 moldboard plowing + 2 cultivations with bullock-drawn 3-tine cultivator	2.5	2.1	148	298	150	2.0
4 cultivations with tractor-drawn cultivator	2.3	2.2	161	259	98	1.6
2 cultivations with tractor-drawn cultivator + 2 country plowings	2.8	2.8	161	321	160	1.9
2 cultivations with tractor-drawn cultivator + 2 cultivations with bullock-drawn 3-tine cultivator	2.4	2.5	155	286	131	1.8
LSD (0.05)	0.1	0.3				

[a]US$1 = Rs. 16.32. [b]Planking after each plowing or cultivation.

Integrated pest management—diseases

Using single hills to determine an equation for estimating yield loss caused by rice blast

C. Q. Torres and P. S. Teng, IRRI

We used a modified single hill technique to estimate yield loss due to leaf blast (LB) and panicle blast (PB) caused by *Pyricularia grisea,* during 1988 wet season.

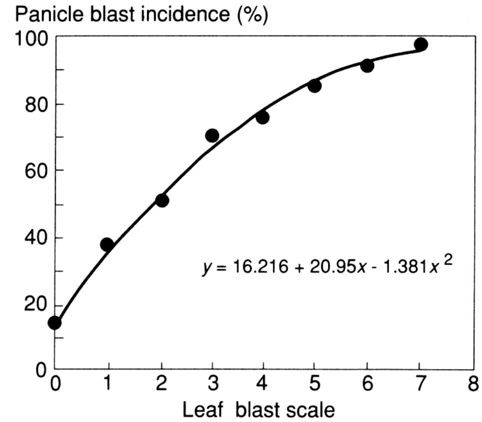
Different levels of blast severities were created by transplanting different densities of blast-infected seedlings and uninfected seedlings in a 2,500-m^2 irrigated lowland field.

At maximum tillering, when plants had the highest LB severity, 800 hills were randomly selected, tagged, and rated as 0 = no blast, 1 = 1-5 lesions/hill, 2 = 6-10 lesions/hill, 3 = 11-15 lesions/hill, 4 = about 10% diseased leaf area (DLA), 5 = about 25% DLA, 6 = about 50% DLA, and 7 = about 75% DLA.

The modified single hill technique requires that approximately 100 plants be tagged for each LB scale rating. In this experiment, only 509 hills out of the 800 tagged could be identified as having panicle blast incidence (PBI) and harvested to determine grain yield/hill. Because each rating on the LB scale represents a range of blast lesions, data from hills with the same LB ratings were grouped and average PBI percentage and yield for that rating calculated. Yield loss for diseased hills was calculated from the average yield of all hills with no LB or PB.

Relationships between LB and PBI, and between LB, PBI, and yield loss were estimated by regression analysis. To calculate the regression between yield loss and LB and PBI, loss was regressed against each group of hills with the same LB scale rating but different PBI, using the data from individual hills. Yield loss was used as the dependent variable.

LB severities ranged from 0 to 75% DLA, PBI from 0 to 100%. The relationship between LB and PBI was significant (Fig. 1). Regression analysis gave the following equations:



1. Relationship between leaf blast severity (LB, scale of 0-7) and panicle blast incidence (PBI, percent) measured on IR50.

Simple linear:

$$PBI = 25.8825 + 11.2836\ LB$$
$$r^2 = 0.94 \text{ (significant at P = 0.0001)}$$

Quadratic:

$$PBI = 16.216 + 20.95\ LB - 1.381\ LB^2$$
$$r^2 = 0.99 \text{ (significant at P = 0.0001).}$$

Plants without LB sustained some PB infection (average 14.15%), suggesting the possible involvement of external inoculum for PB infection. The data (not presented) also showed that variation in PBI was higher when LB was below 50% DLA. This may indicate that to assure uniform PB infection, LB severity earlier in the crop's growth would have to be at least 50% DLA.

Although a highly significant relationship between PBI at harvest and LB at maximum tillering is shown, our results do not provide any epidemiological explanation for the relationship. This points to the need for further experiments using whole plots.

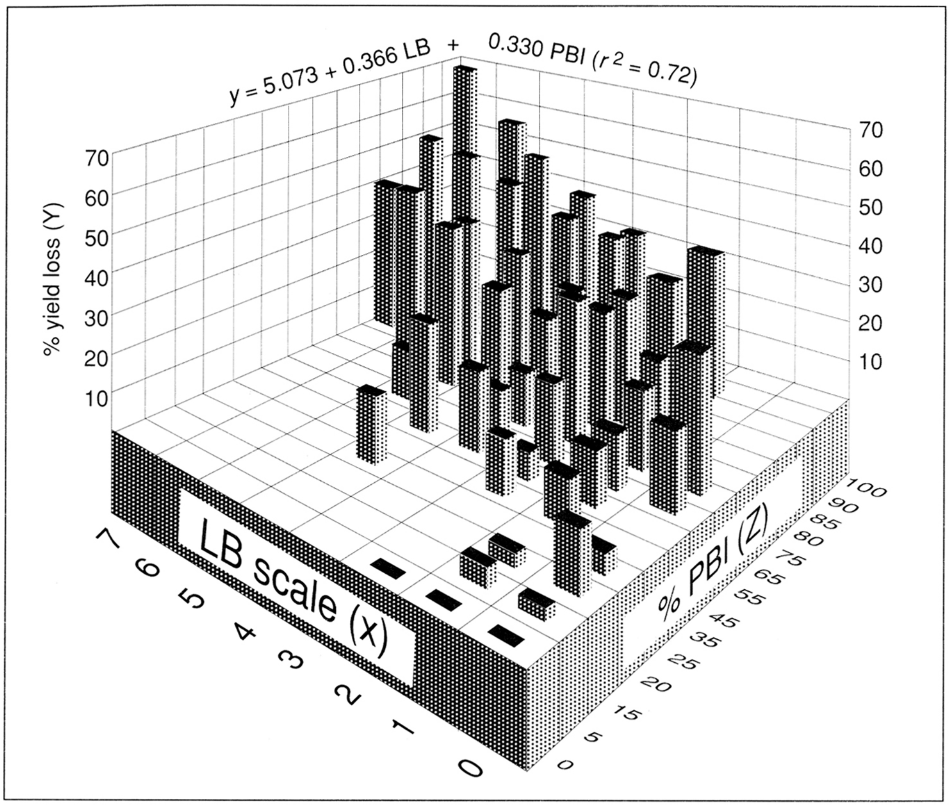
The data gave a response surface (Fig. 2) described by the following equation for estimating yield loss (Y):

$$Y = 5.0725 + 0.3664\ LB + 0.3301\ PBI$$
$$r^2 = 0.72, \text{ (significant at P = 0.01)}$$

The equation suggests that, in the absence of PB, one point on the LB scale at maximum tillering causes approximately 0.4% yield loss; in the absence of

LB, 1 % PB incidence at harvest results in approximately 0.3% yield loss.

The magnitude of losses caused by PB is close to losses reported for other cultivars in field plot experiments in Thailand and India. The modified single hill technique allows a preliminary estimate of yield loss in situations where it may be difficult to experiment with many blast severities. □



2. Response surface showing the relationship between yield loss (%), leaf blast (scale of 0-7), and panicle blast (% incidence, PBI) on IR50.

A new sheath rot (ShR) disease of rice identified in Tamil Nadu

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At the end of dry season 1990 (Apr-May), an unidentified ShR disease was observed on rice cultivars IR20 and TKM9 growing on experimental plots in Killikulam. Nearly 7% of rice plants at the boot leaf stage showed disease symptoms, mostly on the sheath enclosing the young panicle. Irregular, dark brown lesions covered much of the sheath. Panicles emerging from diseased plants were mostly black.

The pathogen was identified as *Curvularia lunata* (Walker) Boedijn (IMI NO. 343370). To test pathogenicity on IR20, a single-grain 15-d-old culture was inserted between the flag leaf sheath and unemerged panicle at the boot leaf stage. The fungus produced characteristic ShR symptoms within 15 d. Symptoms on inoculated plants were similar to those on naturally infected plants.

Infectivity of the fungus was tested on other rice cultivars. A single-grain culture was inserted at the boot leaf stage. Test cultivars were transplanted at 2 seedlings/earthenware pot in insect-proof cages. Five replications of 10 seedlings each were use. Disease severity was scored 15 d after inoculation using a 0-9 scale: 0 = no disease, 1 = less than 1% sheath area affected, 3 = 1-5%, 5 = 6-25%, 7 = 26-50%, and 9 = 51-100% sheath area affected. ADT36, ADT38, IR50, ASD7, ASD8, and ASD17 were completely free of disease (see table).

Infectivity of *Curvularia lunata* on Tamil Nadu rice cultivars.

Cultivar	Damage score (0-9)
ADT36	0.0
ADT38	0.0
IR50	0.0
Co 37	5.6
MDU2	3.8
MDU3	5.7
ASD1	7.8
ASD2	9.0
ASD3	1.9
ASD4	2.8
ASD5	2.5
ASD6	4.8
ASD7	0.0
ASD8	0.0
ASD9	3.5
ASD10	5.4
ASD11	3.8
ASD12	7.5
ASD13	8.6
ASD14	3.0
ASD15	7.0
ASD16	5.5
ASD17	0.0
IR20 (check)	9.0
TKM6 (check)	9.0
LSD (P = 0.05)	0.7

The result was confirmed by a repeated experiment.

Several species of *Curvularia* are known to infect the rice grain, and may even cause leaf spots and seedling blight under certain conditions. But ShR due to *Curvularia lunata* had not been reported previously. □

Effect of asynchronized rice planting on vector abundance and tungro (RTD) infection

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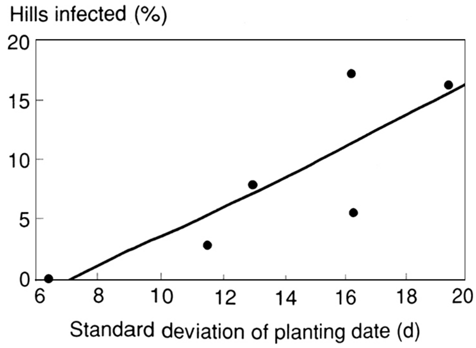
Variation across fields in time of planting the rice crop lengthens the period for an increase in insect pests and diseases and shortens the fallow period during which the numbers of many pest species decline. Insect-transmitted diseases such as RTD are expected to be more prevalent in asynchronously planted areas, because their vectors are more abundant and because the likelihood is greater that an insect will become a carrier when infected plants are present longer.

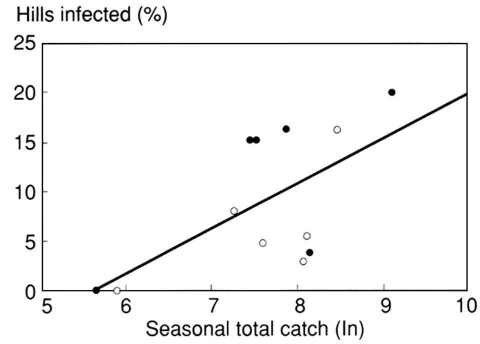
In the 1981 wet season, RTD broke out in an irrigated, double-cropped area of Nueva Ecija, Philippines, where we were studying the relationship between insect pest distribution and asynchronized planting. We selected 14 sites at regular intervals along two transects paralleling irrigation flows.

Using maps and data provided by the irrigation authority, we calculated the planting asynchrony around each site as the standard deviation of planting date (transformed to a cardinal value) in all fields within defined radii (0.2-2.0 km). Insect abundance was measured as total catch over the season in two simple kerosene light traps installed at each site.

We estimated the prevalence of RTD at six sites as the mean infection rate in five fields (150 hills/field) randomly selected within the rotational area (30-ha irrigation management unit) containing the light traps. Diagnosis was based on visual symptoms and confirmed by starch-iodine test.



1. RTD infection at 6 sites in relation to the asynchrony of planting within 0.6 km, Nueva Ecija, Philippines, 1981 wet season. The best-fitting equation is $Y = -9.12 + 1.28\ X$, where Y is arcsin-transformed.



2. RTD infection at 6 sites in relation to the seasonal abundance of GLH. ○ = 1981 wet season; ● = 1982 dry season. The best-fitting equation is $Y = -24.26 + 4.44\ X$, where Y is arcsin-transformed.

RTD prevalence increased with asynchrony of planting within 0.6 km of the sites (maximum correlation $r = 0.83$, $P<0.05$) (Fig. 1). The abundances of green leafhopper (GLH) *Nephotettix* spp. and of the most efficient vector *N. virescens* were also maximally correlated ($P<0.05$) with asynchrony within 0.6 km (Fig. 2). This suggests that the mean net displacement of these species over a season is limited.

Other parameters (mean varietal maturity, area devoted to rice, intensity of insecticide use) failed to account for significant additional variation in either disease prevalence or insect abundance.

RTD recurred the following dry season, but estimates of asynchronized planting were not available. However, taking both seasons together, disease prevalence was significantly correlated with the abundance of both GLH ($r = 0.69$, $P<0.02$; Fig. 2) and *N. virescens* ($r = 0.61$, $P<0.05$). □

Field evaluation to control "red stripe," a new rice disease in Vietnam

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"Red stripe" was recorded for the first time in the Mekong Delta in 1988 dry season. The disease developed rapidly in the summer and autumn of 1990. Severe attack caused up to 50% yield loss, due to premature senescence and high ratios of unfilled grain.

We tested the effects of some pesticides on red stripe at disease CLRRI experimental fields. The rice cultivar used was OM59-7. Plot size was 5 × 4 m, 20- × 10-cm plant spacing, in a randomized complete block design with three replications. Fertilizer was applied at 100-60-00 kg NPK/ha. All fungicides except one were applied twice, 7 d before heading (DBH) and 7 d after heading, using a knapsack sprayer (vol 500 liters/ha). Oryzemate 8% G was applied once at 20 DBH.

Disease severity was measured 7 and 14 d after the second spraying. When disease levels were low, leaves with symptoms were counted in 50-leaf samples. When disease levels were high, the percentage leaf area covered by disease lesions was measured. Fifty samples were taken in each plot.

Carbendazim, benlate, copper-benlate mixture, and triphenyltin acetate were effective against red stripe disease (Table 1). Kasuran and Oryzemate had no effect (Table 2). □

Table 1. Fungicides effective against rice red stripe disease.[a] CLRRI, Omon, Haugiang, summer-autumn 1990.

Chemical	Dosage (parts/thousand)	Time of application	Disease severity		Unfilled grains/ panicle (no.)	Grain yield (t/ha)
			% leaves with disease at 7 DAS	% leaf area covered by disease at 14 DAS		
Copper-benlate mixture	2	7 DBH	28.66	12.05	34.9	2.7
Benlate 50 % WP	3	7 DBH	19.86	2.44	36.6	2.4
Triphenyltin-acetate 60 % WP	3	7 DBH	35.84	13.69	36.1	2.4
Oryzernate 8 % G + carbendazim 6 % WP	4 kg ai/ha 2	20 DBH-7 DBH	18.75	0.01	38.5	2.2
Control (unsprayed)	-	-	46.95	52.99	45.1	2.0
LSD (0.01)			15.21	10.86		
(0.05)					6.4	ns

[a]DAS = days after spraying, DBH = days before heading.

Table 2. Fungicides not effective against rice red stripe disease.[a] CLRRI, Omon, Haugiang, summer-autumn 1990.

Chemical	Dosage (parts/thousand)	Time of application	Disease severity: % leaves with disease at 7 DAS	Disease severity: % leaf area covered by disease at 14 DAS	Unfilled grains/ panicle (no.)	Grain yield (t/ha)
Kitazin 50 % EC	2	7 DAH	23.23	23.85	38.1	4.4
Hinosan 40 % EC	2.0	7 DAH	22.77	50.07	38.5	4.9
Kasuran 20 % WP	1.5	7 DAH	26.68	51.47	48.4	4.1
Oryzemate 8 % G	4 kg ai/ha	20 DBH	25.78	52.13	33.3	4.6
Control (unsprayed)	-	-	23.36	61.17	41.3	4.4
LSD (0.05)			ns	19.52	ns	ns

[a] DAH = days after heading, DAS = days after spraying, DBH = days before heading.

Integrated pest management–insects

A parasitoid of stalk-eyed fly eggs in West Africa

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During ecological investigations on the stalk-eyed fly (SEF) *Diopsis longicornis* Macquart, in 1989 wet season at IITA in southwestern Nigeria, we introduced SEF eggs into an experimental field to explore indigenous parasitoids.

Potted plants of rice cultivar Suakoko 8 carrying 1-d-old eggs from a screenhouse culture of SEF were exposed for 1 d in ricefields each week for 2 mo. Exposed eggs were incubated in the laboratory in glass vials with a wet wad of cotton.

Three to four trichogrammatid wasps developed from each SEF egg. Upon dissection, each SEF egg showed as many as 8-9 larval/pupal stages of the parasitoids. Superparasitism was 12-15%. The developmental period of the parasitoid was 7-9 d.

The parasitoid was identified as *Trichogramma* sp. near *kalkae* Schulten & Feijen. This species has the distinctive genitalia characteristic of *T. kalkae,* a species found in SEF eggs in Malawi. However, the antennae of *T.* sp. near *kalkae* resemble those of *T. mandelai* Pintureau & Babault, found in eggs of Noctuidae (Lepidoptera) from Chad.

It may be that *T.* sp. near *kalkae* has not yet been described, or that the degree of intraspecific variation in genitalia characters or antennae is great. □

A population of brown planthopper (BPH) biotypes 1 and 2 mixture in Guangdong, China

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Guangdong in South China is the primary area of BPH immigration from Southeast Asia. BPH biotypes 2 and 3 are already present in the Philippines, Indonesia, Vietnam, and the Solomon Islands. In June 1990, we collected a BPH colony in Gaozhou county, Guangdong, and isolated BPH biotypes 2 and 3.

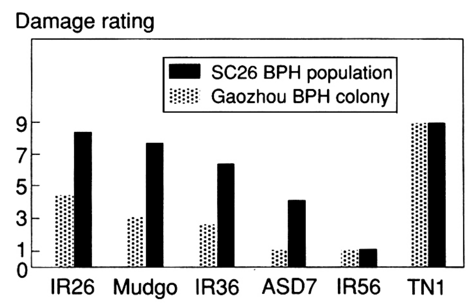
For biotype evaluation, progenies of these BPH were evaluated using seedling bulk and survival rate tests. IR26 and Mudgo with the *Bph I* resistance gene, IR36 and ASD7 with *bph* 2, IR56 with *Bph 3,* and TN1 with no resistance gene were used as identifying varieties.

Gravid BPH females were caged on 35-d-old plants of IR26, Mudgo, and ASD7, with 20 replications. First-generation nymphs were evaluated on IR26, Mudgo, ASD7, and TN1 in the seedling bulk test. If some of the progenies damaged IR26, Mudgo, or ASD7 seedlings, the insects were mass-reared on TN1 for seedling bulk and survival rate tests.

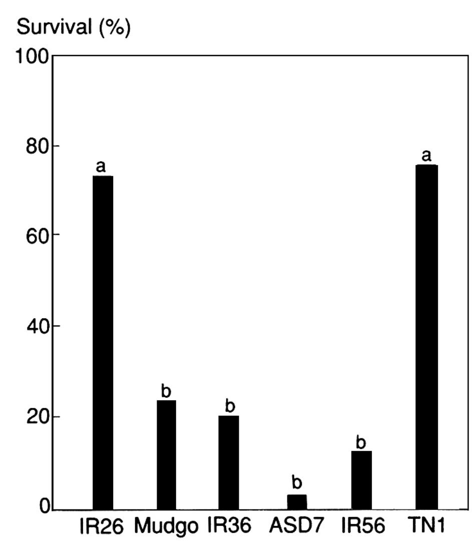
In the seedling bulk tests, each 7-d-old rice seedling in the mass seedbox was infested with 10 newly hatched nymphs. When TN1 seedlings died, responses of all varieties were rated by the *Standard evaluation system for rice* scale. In survival rate tests, 10 third- to fourth-instar nymphs were caged on 35-d-old potted rice plants, with five replications per variety. BPH were counted 10 d after infestation.

Two and one replications of nymphs isolated with IR26 and Mudgo damaged IR26 and Mudgo seedlings, respectively. However, nymphs isolated with ASD7 did not damage IR26, Mudgo, or ASD7.

A progeny from a female isolated on



1. Damage rating to rice varieties infested with Gaozhou BPH colony and SC26 BPH population.



2. Survival rate of SC26 BPH population. Bars with a common letter are not significantly different by Duncan's multiple range test (P 0.05).

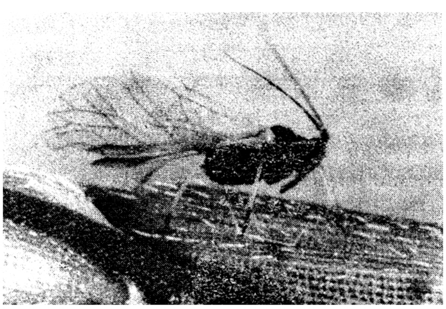
IR26 (SC26), which damaged IR26 and Mudgo, was evaluated in seedling bulk and survival rate tests, with the original Gaozhou BPH colony as control. The varieties responded differently to the populations in the seedling bulk test (Fig. 1). TN1 showed susceptibility to the original Gaozhou BPH, IR26 was moderately resistant, and Mudgo, ASD7, IR36, and IR56 were resistant. TN1, IR26, and Mudgo were susceptible to the newly isolated SC26 population, IR36 was moderately resistant, and ASD7 and IR56 were resistant. The survival of the SC26 population on varieties differed: survival on IR26 and TN1 was significantly higher than on Mudgo, IR36, ASD7, and IR56 (Fig. 2).

Although BPH biotype 1 was dominant in the Gaozhou colony, some BPH biotype 2 insects were found. IR26 could be damaged by BPH biotype 2; mature Mudgo plants could not. □

Wild rice: a new host for *Hysteroneura setariae* (Thomas) [Hemiptera: Aphididae] in the Philippines

A. T. Barrion and J. A. Litsinger, IRRI

The rusty plum aphid *H. setariae,* a vector of sugarcane and soybean mosaic virus, is a polyphagous pest that occurs yearround in coconut, coffee, and grasses [particularly *Echinochloa* spp., *Leptochloa chinensis* (L.) Nees, and *Eleusine indica* (L.) Gaertn.] and occasionally in wheat and rice.



1. Winged form of the female *H. setariae.*

The wingless female is dark brown, shiny, and relatively small (1.70 mm long, 1.00 mm wide), with black antennal segments 1 and 2 and apices of segments 5 and 6, black siphunculi long and cylindrical, cauda white and parallel-sided. The frontal tubercles in the head are absent. The winged form is 1.50 mm long and 0.70 mm wide with a dark brown head and thorax. The forewing has a twice-forked median vein and the hindwing has a cubitus (Fig. 1).

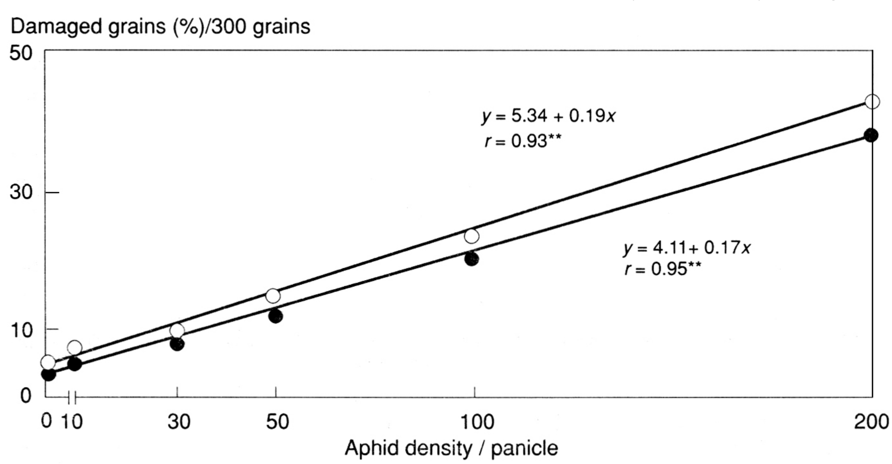
For the last 5 yr, *H. setariae* has invaded wild rices *Oryza minuta* Presley and *O. officinalis* Wall in an IRRI greenhouse. Aphid density was high (>50 aphids or 2-6 colonies/panicle) during the Jan-Apr dry season, but no yield loss has been reported.

We studied the effect of aphid feeding at different densities on grain development. Each booting tiller was enclosed in a 2.5- × 11-in cylindrical mylar cage with a nylon mesh vent on top and a sleeve on the side. Aphids were released into cages at six densities, and the sleeve was taped to prevent escape. *H. setariae* were allowed to feed on the panicle for 96 h and then were killed by a pyrethroid insecticide. Percent of damaged grain was determined using the formula

$$\text{\% damage (adjusted)} = \frac{U(\%) - u(\%)}{100 - u(\%)} \times 100$$

where U is percent unfilled grains in each test and u the percent unfilled grains in the control.

Aphid feeding produced 4-43% empty grains, proportional to pest density (Fig. 2). The relatively low fertility of wild rices, particularly *O. officinalis,* was further reduced by aphid feeding. *O. minuta* and *O. officinalis* appear to have little or moderate resistance to aphids. □



2. Correlation of different aphid densities per panicle with damaged grain in wild rices *O. minuta* (●—●) and *O. officinalis* (○—○).

Comparing parasitoid-host responses in laboratory experiments

K. L. Heong, Guo Yujie, and A. A. Lazaro, IRRI

Parasitoid-host responses are determined in the laboratory by recording host parasitization at different parasitoid densities. Two components of the functional response are estimated: instantaneous attack rate *a* and a satiation factor, or handling time T_h.

One way to obtain these estimates is with nonlinear curve-fitting procedures found in statistical packages such as SAS, BMDP, and MINITAB. While these methods often provide standard errors of the parameter estimates from which comparisons can be made, they generally do not permit comparisons of the curve of total responses.

In a statistical test for significance between two or more functional response curves, two assumptions are inherent: 1) a null hypothesis that the curves represent samples from a common population, and 2) that the best possible sets of parameters describing the model's function can be estimated.

The parasitoid-host functional

responses are well described by the Random Parasitoid Equation and are characterized by the parameters a and T_h. Thus, the respective curves may be compared to the curve obtained using pooled data.

We used two simple statistical methods to compare the response curves of the parasitoid *Cardiochiles philippinensis* attacking larvae of *Cnaphalocrocis medinalis.* In the F-test, the residual sums of squares (RSS) of each separate curve were totaled and compared with the RSS of the pooled curve (see table).

In the nonparametric rank-sums test, a single functional response curve was fitted to the pooled data, and residuals computed. The residuals for each sample were arranged in a single array, largest negative to largest positive, using PROC NPARIWAY available in SAS.

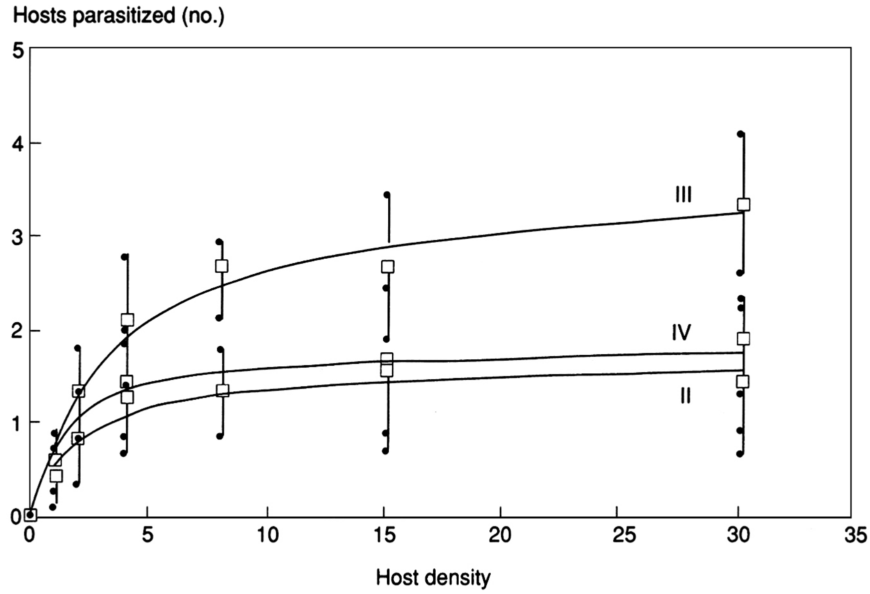
The figure shows the functional responses. The rank-sums test was highly significant (P_{RS} = 0.0001); the F-test was more conservative ($0.05 < P_F > 0.01$). The curve differences were primarily due to different handling times. T_h for the third instar was 0.28, significantly lower than for the second and fourth instars (see table).

The rank-sums test does not assume normal distribution of the data and is thus a more appropriate test. □

Parameter estimates (± asymptotic SEs) of the Random Parasitoid Equation of *Cardiochiles philippinensis* attack at different larval stages of *Cnaphalocrocis medinalis.*

Larval instar	a	T_h	RSS[a]	CV (%)
Second	1.53 ± 1.29	0.60 ± 0.09	46.56	76.8
Third	2.81 ± 1.75	0.28 ± 0.03	50.83	43.9
Fourth	7.11 ± 15.85	0.55 ± 0.06	37.98	57.9
Pooled	2.32 ± 1.16	0.43 ± 0.03	178.36	64.0

[a]RSS = residual sum of squares.



Functional responses of the larval parasitoid *Cardiochiles philippinensis* attacking second-, third-, and fourth-larval instars of *Cnaphalocrocis medinalis.* Means (□) are presented with SEs at 95% confidence level. The curves are generated using a and T_h estimates from the table.

Co-variation between insects in a ricefield and important spider species

P. S. Reddy, Andhra Pradesh Agricultural University, Hyderabad, India; and K. L. Heong, IRRI

Spiders are among the first arthropods to colonize wetland rice. Most common are *Pardosa (= Lycosa) pseudoannulata, Atypena (= Callitrichia) formosana,* and *Tetragnatha maxillosa.* These spiders are polyphagous predators that feed on the adults and nymphs of many insect species. The presence of spiders might influence the establishment and increase of pest populations.

We collected arthropods from an IRRI plot at weekly intervals using an insect suction machine (FARMCOP). All species were identified and counted. The data on rice hoppers and dipterans collected during the cropping period were linearly regressed with number of important spider species.

T. maxillosa populations appeared to be directly related to number of dipterans, suggesting a positive numerical response (see table). Similar relationships were found between *A. formosana* and BPH. WBPH, dipterans, and all hoppers.

P. pseudoannulata populations, however, were not related to BPH and WBPH.

The differences in the relationships of the three spider species to rice arthropods may be a result of different predatory habits. *T. maxillosa* is a horizontal orb-web building spider that tends to catch more flying insects. □

Regression analysis of linear relationships between insects and spiders in ricefields.[a] IRRI 1989.

Insects	*T. maxillosa*			*A. formosana*			*P. pseudoannulata*		
	a	b	*F* value	a	b	*F* value	a	b	*F* value
BPH	0.345	0.001	0.003 ns	1.152	0.174	10.970**	4.662	0.038	0.114 ns
WBPH	0.331	0.012	0.103 ns	1.221	0.143	4.041 *	4.082	-0.091	0.368 ns
GLH	0.261	0.019	2.373 ns	1.263	0.033	2.083 ns	3.997	0.153	10.218 **
Dipterans	0.146	0.268	16.348 **	1.604	-0.255	4.028 *	4.083	0.311	9.055 **
Total hoppers	0.192	0.021	3.152 ns	0.856	0.076	12.356 **	3.678	0.137	8.872 **
Totalinsects	0.019	0.011	3.047 ns	0.933	0.060	8.754 **	3.520	0.144	11.722 **

[a]a = intercept, b = slope, ns = not significant, * = significant at P < 0.05, ** = significant at P < 0.01.

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.

Distribution of *Tetragnatha maxillosa* webs in ricefields

P. S. Reddy, Andhra Pradesh Agricultural University, Hyderabad, India; and K. L. Heong, IRRI

Among the spider species that inhabit the rice canopy, orb-weaving spiders (families Araneidae and Tetragnathidae) are often abundant in unsprayed ricefields. *T. maxillosa* is most common.

To learn more about its role in the rice ecosystem, we studied its web distribution and the prey captured in the webs.

T. maxillosa spider webs in an IRRI ricefield transplanted with IR1917 were recorded weekly from 15 d after transplanting (DT), at nine sampling points during the 1988 dry season (DS) and 12 sampling points during the 1989 wet season (WS). Vertical web distribution was measured from the hub of the web to the ground.

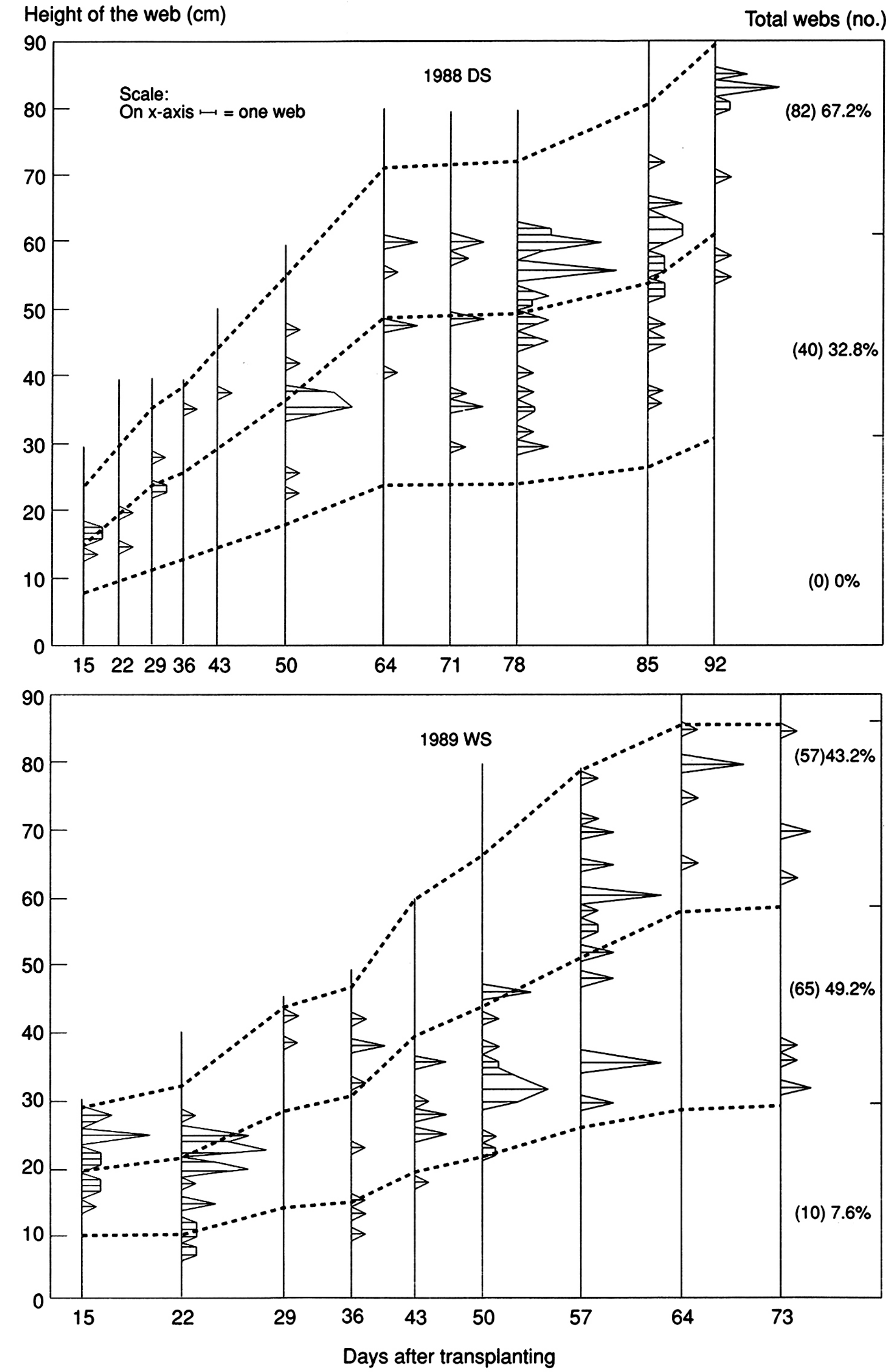
Evidence of predation by *T. maxillosa* was obtained by removing all prey carcasses in each web, then counting new prey caught. All arthropods found dead in a web were considered prey. Prey were collected and preserved in 70% ethyl alcohol for laboratory examination.

The crop canopy was divided equally into top, middle, and bottom portions. Ninety-six percent of the webs found were built in the top and middle portions (see figure). Prey caught were primarily insects (98.9%) (see table). Dipterans, mostly scavengers, made up 56%; 34.9% were other rice pests.

Although *T. maxillosa* is often abundant in the rice ecosystem, its role as a rice pest predator appears negligible. With relatively weak webs constructed in the top and middle portions of the canopy, its main prey seems to be weak fliers. □

Prey spectrum caught by *T. maxillosa* in ricefields. IRRI, 1988 DS and 1989 WS.

Prey	Prey caught no.	Prey caught %	Total prey from an order (%)
DIPTERA			
Tipulidae	4	2.2	
Anthomyidae	1	0.5	
Muscidae	62	33.3	
Culicidae	24	12.9	
Criptochironomus sp.	2	1.1	55.9
Nillobezzra sp.	1	0.5	
Drosophilidae	6	3.2	
Megaselia scalaris	1	0.5	
Chironomus sp.	3	1.6	
HEMIPTERA			
Cyrtorhinus lividipennis	2	1.1	
HOMOPTERA			
Nephotettix sp.	18	9.1	
R. dorsalis	3	1.6	21.0
N. lugens	11	5.9	
S. furcifera	5	2.7	
EPHEMEROPTERA	15	8.1	8.1
LEPIDOPTERA			
S. incertulas	6	3.2	
C. medinalis	16	8.6	14.0
N. aenescens	2	1.1	
R. atimeta	2	1.1	
ARANEAE			
Tetragnatha sp.	2	1.1	1.1
Total	186		



Vertical distribution of *T. maxillosa* webs in IR1917 canopies at IRRI.

Integrated pest management—weeds

Effect of nitrogen uptake by weeds on rice yield

J. C. Biswas and S. A. Sattar, Agronomy Division, Bangladesh Rice Research Institute, Gazipur 1701, Bangladesh

Nitrogen use efficiency in rice is low when weeds compete; that reduces rice yield. Farmers need an economic threshold, when weed control practices would be profitable. We experimented with different weed populations in rice in Joydebpur in 1988 and 1990.

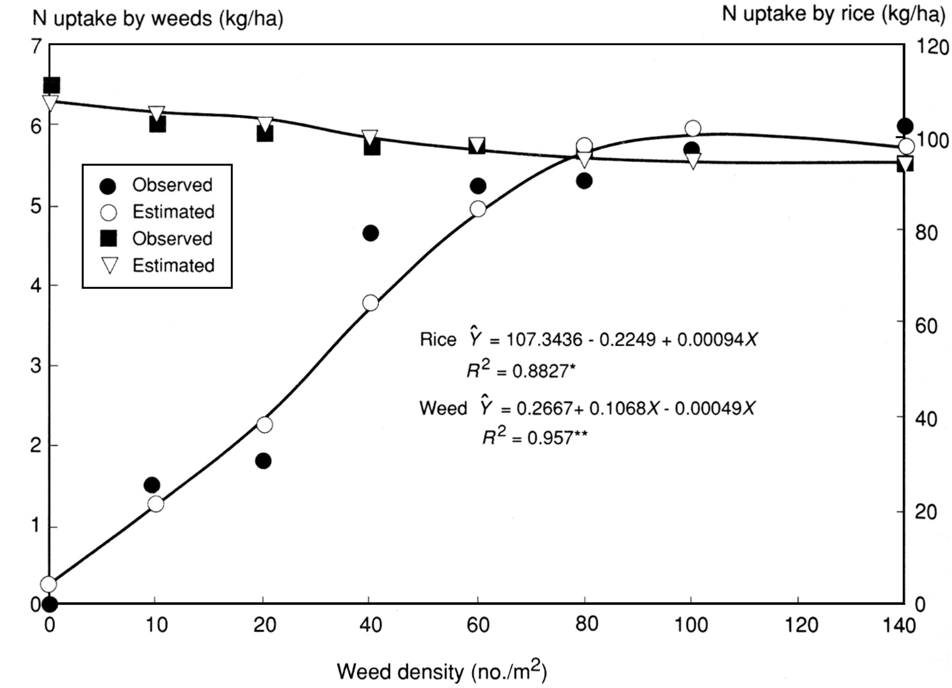
The experiment was laid out in a randomized complete block design with three replications. Plot size was 1 m^2. Thirty-day-old BR23 seedlings were transplanted at 20- × 20-cm spacing. Weeds were allowed to grow with rice from the 2- to 3-leaf stage at eight weed densities (unwanted weeds were removed). Recommended fertilizer for transplanted aman (wet season second crop) rice was applied.

At maturity, weeds were removed, cleaned, and identified. Weed dry weights and N uptake were determined. Rice grain yield was adjusted to 14% moisture content.

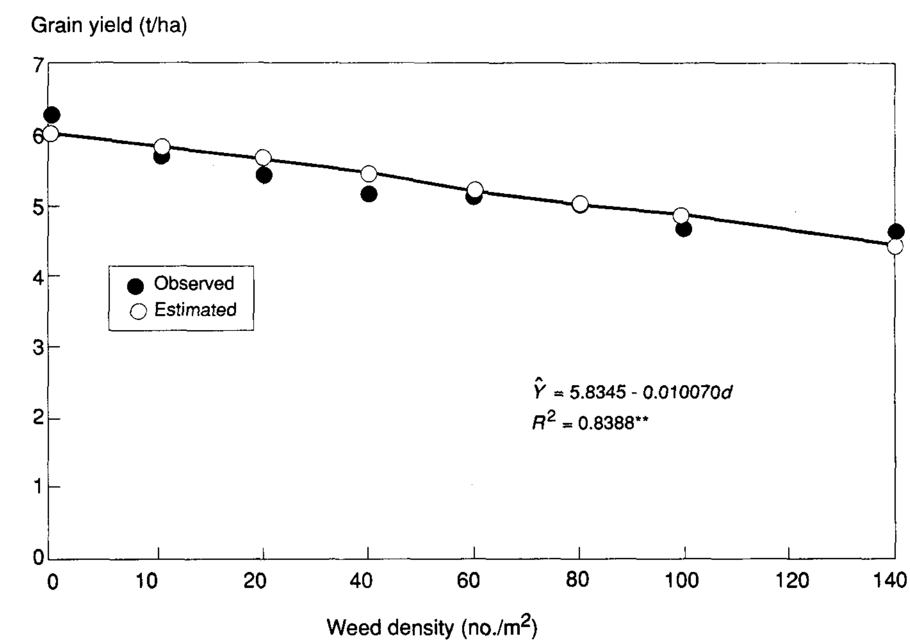
Fimbristylis miliacea was the dominant weed species, followed by *Sphenoclea zeylanica, Cynodon dactylon, Monochoria vaginalis, Scirpus mucronatus,* and *Heteranthera limosa.*

Best fit regression models based on average data were used to determine N uptake and yield loss of rice at different weed densities.

As weed density increased, the weeds took up more N and rice less (Fig. 1). This was reflected in grain yield (Fig. 2). Yield losses were 13% with 20 weeds/m^2 and 17% with 40 weeds/m^2. □



1. Effect of weed density on N uptake (kg/ha) by weeds and rice.



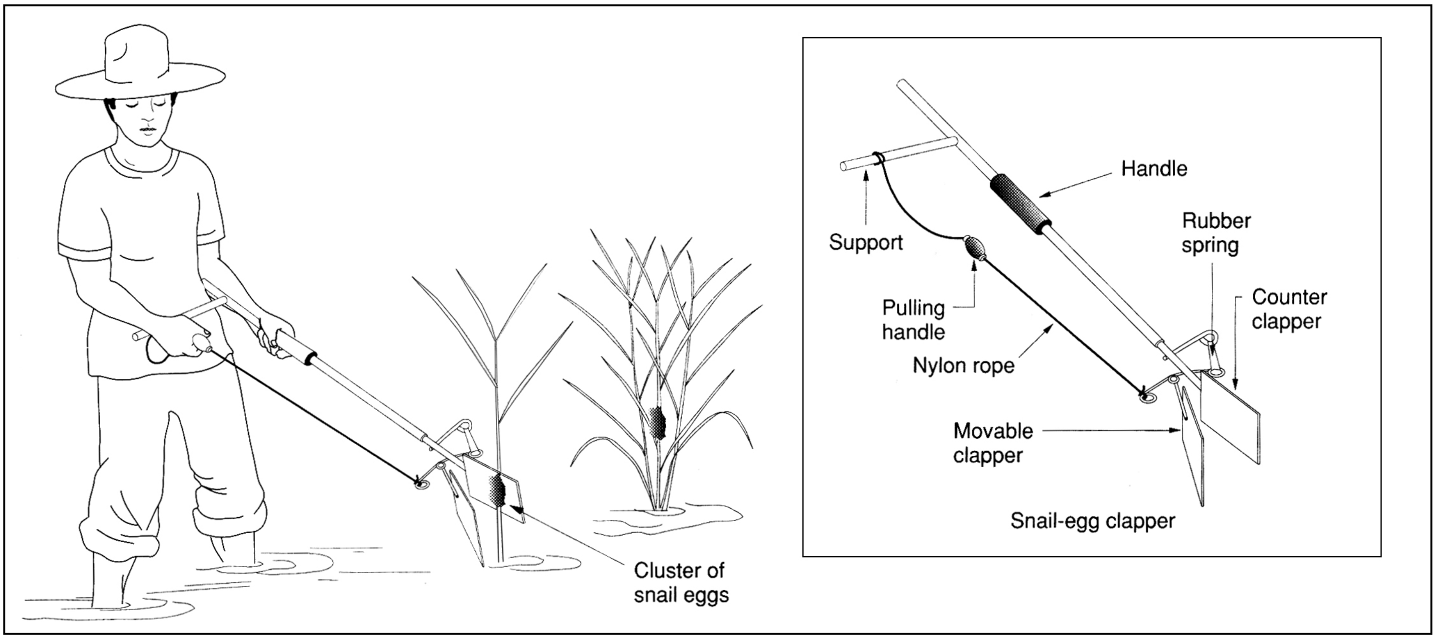
2. Effect of weed density on rice grain yield.

Integrated pest management—other pests

Crushing snail eggs with a "snail egg clapper"

N. K. Awadhwal and G. R. Quick, IRRI

The golden apple snail *Pomacea lineata* Spix. is a major rice pest in the Philippines. It can cause total destruction of germinating rice seedlings and more than 20% damage in young seedlings. It can be controlled with organotin molluscicides, but these chemicals are toxic to human beings, livestock, and aquatic life.



Use of a snail-egg clapper.

Other control measures include installing screens on water inlets, releasing snail-feeding ducks in field, and manually collecting and crushing snails and egg masses. Using a snail collector or *salaan* speeds collection of snails and eggs.

Snails lay eggs in clusters on objects above the water surface, including the vegetation of standing crops. Each cluster may contain 25-500 of the delicate eggs. Picking up snail eggs regularly is an effective control measure, but is tiring because it requires stooping.

The snail egg clapper was developed at IRRI to allow egg clusters on rice plants and vegetation to be mashed without stooping. The simple device weighs about 800 g (see figure). When the rope is pulled, the clappers move apart; when it is released suddenly, the clappers snap back together. The strength of clapper impact can be adjusted by tightening the rubber spring.

To operate the device, open the clappers by pulling the rope and align them on the rice plant or vegetation until the egg mass is between them. Then release the rope. The clapper will destroy the egg mass.

We compared the effectiveness of the clapper, collector, and hand picking. Area covered and work rate (egg masses removed/min) were recorded.

Area covered by the clapper varied from 1.6 to 9 m^2/min, 35-70% higher than that of the egg collector and 5-10% higher than hand picking.

The work rate of the clapper (mean 20.3/min) was about 1.8 times higher than with the egg collector (mean 11.2/min). With the egg collector, more than 32% of the egg masses dropped off the plant or bounced off the tool. The clapper missed fewer than 4% of the egg masses. We also found that while using salaan egg collector, the tillers would bend under the collector and sometimes needed support as the eggs were scraped off.

Effects of clapper impact on rice plant growth was measured at two growth stages, 3 wk after seeding and at panicle initiation, in collaboration with physiologists. The rice plants used were not infested with snail eggs.

The clapper was set at two levels of impact: high (47.5 g) and low (25.6g). There was no significant difference in plant height, weight of plant, root and shoot weight and their ratio, number of panicles, and grain weight between plants on which clappers were used and untreated plants.

The snail egg clapper is simple and inexpensive (costs less than US$ 2 to construct), and can be made with locally available materials. Blueprints are available free from IRRI Agricultural Engineering Division. □

Farmingsystems

Hybrid rice ratoon exploited in Sichuon China

Zhang Jing-guo, Crop Breeding and Cultivation Institute, Sichuan Academy of Agricultural Sciences, Chengdu, Sichuan 610066, China

About 0.7 million ha of rice is grown at 29-31°N latitude, below 400 m elevation, in southeast Sichuan Province, China. Annual temperature is 17.5-18.5°C and annual rainfall about 1,000 mm. Most rice areas are rainfed lowland fields planted to a single crop of medium- to long-duration hybrid rice. The growing season is not long enough to grow two crops of rice.

Field duration of the rice crop is only 120 d from mid-Apr to mid-Aug. During the rest of the year, the fields are fallow under submergence, or more than 60 d elapse from the harvest of rice to the sowing of wheat in a rice - wheat cropping pattern.

Since 1986, about 80% of the farmers who ratoon rice follow the system rice -

ratoon rice - submerged fallow. The remaining farmers grow rice - ratoon rice - wheat.

In 1989, ratoon rice was on 0.45 million ha. Average yield of the main crop was about 7 t/ha, average yield of the ratoon crop was 1.6 t/ha (Table 1). Maximum ratoon yield was 4 t/ha. The ratoon crop has a short growth duration (about 60 d) and costs less than a second transplanted crop because it eliminates three major crop establishment operations: raising seedlings in the seedbed, field plowing, and transplanting.

Hybrid rices are planted in 85% of the total rice area in Sichuan. Some hybrids not only are high grain yielding but also have high ratooning ability. Hybrid rice ratoon crops yield 17% higher than conventional rice ratoon crops (Table 2). At present, the leading hybrid rice combinations Shanyou 63 and D-you 63 are most suitable for ratooning.

To make rice ratooning productive and economical, a package of main and ratoon crop management practices is recommended. The main crop nursery is sown in early Mar. Seedlings are raised under a plastic film or in a greenhouse, then transplanted at 33- × 13.3-cm spacing to reduce sheath blight. Rice is grown on ridges and fish in the ditches. Applying urea at 45-68 kg N/ha 2 wk before harvesting the main crop delays main crop senescence to produce more ratoon tillers and panicles. In fields with P deficiency, applying P fertilizer to the main crop significantly increases ratoon yield.

The main crop is harvested when nearly mature and when ratoon shoots have just begun to grow (3-5 cm). Optimum cutting height is 30-40 cm aboveground.

Inadequate fertilizer and low temperature injury at ratoon rice heading are the major factors associated with low ratoon crop yields. Breeders are selecting hybrid rices for intermediate to early maturity, high yield in the main crop, and strong ratooning ability. □

Table 1. Area and yield of ratoon rice in Sichuan Province, China, 1986-90.

Year	Area (10^4 ha)	Yield (t/ha)
1986	4.6	1.1
1987	19.3	1.5
1988	28.3	1.3
1989	45.0	1.6
1990	34.5	1.3

Table 2. Grain yield of main and ratoon crops of some rice varieties in Jiangjin, Sichuan, China, 1986. [a]

Type	Variety	Grain yield (t/ha)		
		Main crop	Ratoon crop	Total
Hybrid	Shanyou 63	8.6 a	2.0 a	10.6 a
Hybrid	D-you 63	8.5 a	2.0 a	10.5 a
Hybrid	V-you 63	8.5 a	1.7 a	10.2 ab
Hybrid	Gangai 63	7.6 b	2.1 a	9.7 bc
Hybrid	Zaishengyou	7.8 b	1.6 a	9.4 c
Conventional	40-1	6.9 c	2.1 a	9.0 d
Conventional	Daonan 18	6.6 c	1.7 a	8.3 e

[a] Av of 3 replications. In a column, means followed by the same letter are not significantly different at the 5% level.

Farm machinery

Ideal seed drill for direct sowing rice in semidry fields

R. Kailappan, SP. Ramanathan, C. Ramaswami, and A. A. Kareem, Tamil Nadu Rice Research Institute, Aduthurai 612101, India

Rice crops that are broadcast seeded by hand in semidry fields have poor stands and low productivity. We compared two seeding techniques during 1990 wet season (WS). The trial was laid out in a randomized block design with 14 replications.

Soil was clay loam (fine Udic Chromusterts) with pH 6.8, 0.78% organic C; 300, 35, and 127 kg available NPK/ha. Rice cultivar CR1009 was seeded in dry soil in Aug, at 80 kg/ha. Fertilizer (150-60-60 kg NPK/ha) was applied at different stages of crop growth. The crop was flooded 30 d after seed germination.

The crop sown in lines with a three-tined, cupfeed type, bullock-drawn seed drill had the best yield attributes, resulting in a significantly higher yield (12.4% more than with conventional broadcasting) (see table). Gross income, net return, and benefit:cost ratio were also higher. □

Effect of rice seeding technique on yield and net income at Aduthurai, Tamil Nadu, India, 1990 WS.

Seeding method	Plant height (cm)	Tillers (no.)	Panicles/hill	Grain yield (t/ha)	Net return ($/ha)	Benefit:cost ratio
Line drill-sown	95.7	9.9	8.3	5.8	425	1.27
Broadcast	94.2	8.6	6.1	5.2	333	1.10
LSD (0.05)	ns	1.1	0.7	0.2		

Efficiency of a compartment-type rice separator

R. K. Gupta (present address: Central Institute of Agricultural Engineering, Post Harvest Technology Scheme, Nabi Bagh, Berasia Road, Bhopal 462018, Madhya Pradesh), and N. G. Bhole, Post Harvest Technology Centre, Indian Institute of Technology, Kharagpur (W.B.), India

Separating rough rice from brown rice is an important operation of modern rice mills: it avoids damage to polisher parts from the abrasive action of rice husks. Unhusked rice that goes through a polisher may also affect overall mill capacity.

A compartment separator (Schule-type) is more commonly used in modern rice mills than tray and screen type separators. We evaluated the effect of stroke length and slope of deck on separation, capacity, and energy consumption of a compartment-type paddy separator manufactured in India.

The separator has two outlets; three compartments with a single deck; and adjustments for feed control, slope, and stroke length. Variables considered were 0.5, 1.0, 1.5, 2.0, and 2.5 degree table slopes and 140, 150, 160, and 170 mm stroke lengths. A mixture of brown rice to rough rice of 9:1 was taken at a feed rate of 220 kg/h. The separator was run with a particular set of adjustments. Samples (100 g) were collected from both outlets at three different times.

Effectiveness of separation was highest at a 1-2 degree slope, with stroke length 150-165 mm. In general, processing capacity increased with table slope and stroke length. Energy consumption decreased with an increase in table slope and increased with an increase in stroke length.

When the separator is set up with a 1-2 degree table slope and 150-165 mm stroke length, a feed rate of 220 kg/h gave the best performance. □

SOCIOECONOMIC IMPACT

Environmental impacts

Impact of agrochemicals on mosquito larvae populations in ricefields

I. Simpson, NRI, England, and P. A. Roger, Soil Microbiology Division, IRRI (present address: ORSTOM, France)

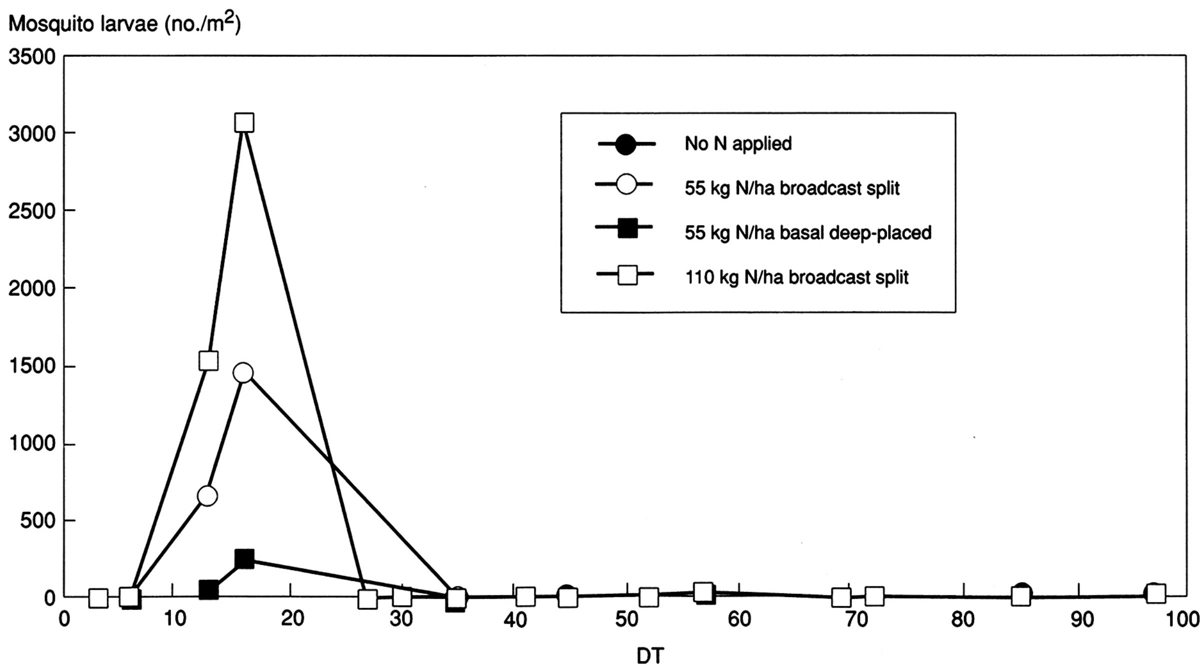
As part of an experiment to study the impacts of agrochemical use on floodwater and soil ecology in wetland ricefields, we investigated the combined effects of N fertilizer and two widely used pesticides—carbofuran and butachlor—n mosquito larvae in irrigated fields at the IRRI farm during 1990 dry season. The experiment involved 65 16-m^2-plots, with five replications. Treatments were

- one unplanted unfertilized control.
- ten combinations of five N treatments (no N, 55 and 110 kg N/ha broadcast split, 55 kg N/ha-deep placed, and azolla incorporated before transplanting) and two levels of carbofuran (one at 0.1 kg active ingredient [ai]/ha and two at 0.3 kg/ha each).
- two additional treatments with 110 kg N/ha broadcast split combined with two applications of 0.5 kg carbofuran/ha each and five applications of 0.5 kg/ha each. Treatments with two and five applications of carbofuran also received one application of 0.375 kg ai butachlor/ha 3 d after transplanting (DT).

Pesticide rates represent low, medium, and high levels as commonly used by farmers in the Philippines.

Population density of mosquito larvae was determined by counting individuals in five samples collected by inserting 7-cm-diameter clear perspex cylinders into the soil and removing the enclosed floodwater and surface soil with a vacuum pump.

Mosquito larvae, tentatively identified as *Aedes davidi,* developed populations larger than 100/m^2 only during the first third of the crop cycle, peaking at about 16 DT. Largest populations—2000-3500 larvae/m^2—were in plots where inorganic N fertilizer was broadcast (Fig. 1). Population density remained lower than 300/m^2 in plots where N fertilizer was deep-placed, azolla was incorporated, and



1. Dynamics of mosquito larvae populations during a crop cycle under different N fertilizer inputs. Variance analysis at 12 and 16 DT shows no significant differences between no N and55 kg N deep-placed. N broadcast at 55 kg showed significantly higher numbers than no N and 55 kg N deep-placed. N broadcast at 110 kg gave significantly higher numbers than 55 kg N broadcast. Each value is the average of 8 (N0, 55 kg N broadcast, 55 kg N deep-placed) or 16 (1 10 kg N broadcast) plots.

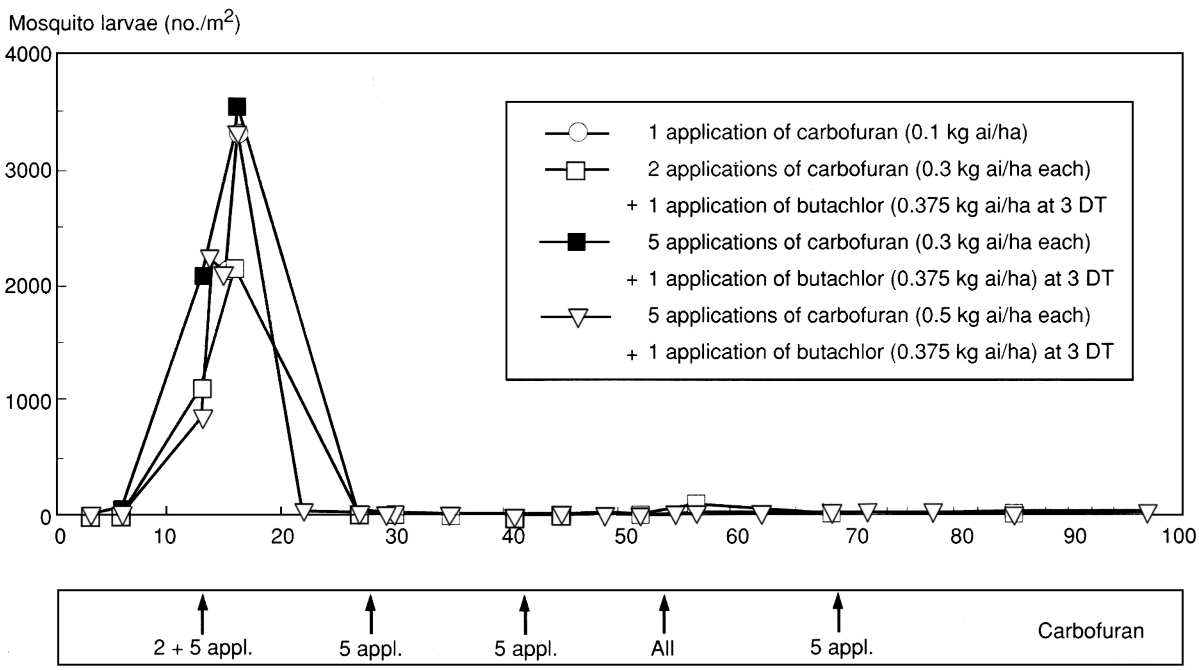
no fertilizer was applied (planted and unplanted). No significant increase in population density was observed after the second fertilizer application 55 DT.

During the first 4 wk, mosquito larvae peaked in three of the four treatments receiving 110 kg N as broadcast urea where carbofuran (0.3 and 0.5 kg ai/ha) and butachlor had been applied once. Populations at various levels of pesticides (Fig. 2) did not differ significantly.

Populations of mosquito larvae were higher in plots where N fertilizer had been broadcast than in plots with N deep-placement and no N. They were not affected by carbofuran and butachlor.

Broadcasting N fertilizer is known to favor blooming of unicellular eukaryotic algae. This was the case in our experiment, as indicated by dissolved oxygen measurements (data not shown) and microscopic observations. Such blooms increase floodwater pH, favor N loss by ammonia volatilization, and inhibit the growth of N_2-fixing blue-green algae. We found that broadcasting fertilizer encouraged the growth of unicellular eukaryotic algae and enhanced populations of mosquito larvae and other algal grazers, especially Ostracods (data not shown).

Deep placement of N fertilizer shows a further advantage: a significant reduction in the population of mosquito larvae. The adults of some mosquito species are vectors of human diseases associated with rice culture, such as malaria and Japanese encephalitis. □



2. Dynamics of mosquito larvae populations at 4 levels of pesticide application in plots with 110 kg N surface split-applied as prilled urea. Variance analysis at 12 and 16 DT shows no significant difference between treatments. Each value is the average of 4 plots.

ANNOUNCEMENTS

A new handbook for identifying rice leafhoppers and planthoppers published

Sap-sucking leafhoppers and planthoppers (Homoptera: Auchenomyncha) reduce rice yields by direct feeding or by transmitting virus and virus-like pathogens. Effective rice pest management requires the accurate identification of any pest species.

Handbook for the identification of leafhoppers and planthoppers of rice by M R Wilson, International Institute of Entomology, London, and M F Claridge, School of Pure and Applied Biology, University of Wales, Cardiff, provides keys for the identification of more than 70 leafhopper and planthopper species recorded in major rice-growing regions of the world. The handbook gives data on all the major pest species, as well as others frequently found, but not yet considered important.

Orders should be addressed to CAB International: Wallingford, Oxon OX10 8DE, UK; 845 North Park Avenue, Tucson, Arizona 857 19, USA; PO Box 11872,50760 Kuala Lumpur, Malaysia; or Gordon Street, Curepe, Trinidad and Tobago. □

The IRRI blue-green algae (BGA) collection: strains available for distribution

The IRRI collection of N_2-fixing BGA was initiated in 1979 as part of a collaborative research program of ORSTOM (France) and IRRI to study the ecology of BGA and their possible use as biofertilizer in wetland rice culture. The collection now comprises 204 strains (about 45% from Africa and 40% from Asia) originating from 21 countries.

Classification is limited to the genus level and uses morphological criteria directly observed on material growing on petri dishes, as recommended by Rippka et al. in 1979. Dominant genera are *Nostoc, Anabaena,* and *Calothrix,* reflecting the ricefield origin of the strains.

Strains are maintained by subculturing in liquid medium and on agar slants. Some strains are also maintained in dry state as powdered culture and soil-based inoculum. Information on the strains is compiled in a computer program involving six interconnected Hypercard stacks.

"Collection" provides the following information (when available) on each strain:

- name of the strain, IRRI code, other codes when applicable;
- country and location of origin, and from which environment the strain was isolated;
- year of isolation, year of acquisition at IRRI collection;
- information on strain conservation;
- information on soil properties of the environment from which the strain was isolated;
- description of the visual appearance of the culture in liquid and on solid medium;
- standardized microscopic description of the strain; and
- additional notes, including bibliographic references on the strain or its environment.

"Describe" is an on-screen tool to describe cultures of strains growing on solid and liquid media (aspect and color), and their morphological features under the microscope. Terminology is connected to definitions in the "Glossary" for on-screen help.

"Keys" provides on-screen taxonomic keys for genera of BGA encountered in ricefields.

"Glossary" provides definitions of specific terms or concepts, including terms used in "Describe." When needed, definitions are illustrated with schematic drawings.

"Methods" provides general information on methods for maintenance. mailing, and revival of the strains, and estimating BGA abundance and activiries in ricefields.

"Sites" provides information on the environments from which the strains were isolated.

The descriptions of the strains and the methods for isolation, culture, and conservation are also available in a booklet entitled "The Blue-green Algae Culture Collection at IRRI."

Strains of the collection are provided free, together with a copy of the booklet. Cultures are sent as dried material on paper strips: these remain viable for several months and are easy to mail and revive in liquid medium. A copy of the Hypercard stacks is provided free upon receipt of two 3-1/2 inch double-sided diskettes. Their use requires a Macintosh computer, a hard disk, and a Hypercard 2 program. The stacks are not protected and can be modified.

Requests should be addressed to Soil Microbiology Division, IRRI, P.O. Box 933, Manila 1099, Philippines, Attention: Susan Ardales/P. A. Roger. □

Rodents and rice

An expert panel on rice rodent control met at IRRI 10-14 Sep 1990. The 23 participants discussed the problems rodents cause in rice research and production, assessed needs, identified gaps, outlined researchable areas of concern, and recommended action.

Seventeen papers were presented. A summary of the observations follows.

- In many parts of the rice world, field data show that rats are still the rice farmer's worst pest. There tends to be a steady attrition with crop damage, chronic losses, and periodic outbreaks. In many areas, impacts on community health and on the environment are attributable to rodents.
- Agencies and even rice researchers often tend to overlook the rodent problem, unless there is an outbreak or losses are high. By that time, remedial action is far more expensive and may be ineffective.
- IPM programs often fail to include a rodent control component—with a resulting loss of their credibility and with the farmer clientele having to deal with his worst pest.

Rodents impact society through crop and storage losses, structural damage, and hardships caused by the transmission of diseases. The management practices to control rodents may endanger nontarget animals, including humans, or change the environment. While deleterious impacts may be lessened by applying IPM principles in rodent control, the impact on the community and the environment must always be considered and weighed when strategies and rodent control programs are developed.

The proceedings are being reproduced by Agricultural Engineering Division, IRRI. □

New IRRI publications

IRRI 1990- 1991 A continuing adventure in rice research

Direct seeded flooded rice in the tropics

Rice blast modeling and forecasting

Rice grain marketing and quality issues

Handbook for weed control in rice

World bibliography of rice stem borers 1794-1990

World rice statistics 1990

A primer on organic-based rice farming

A farmer's primer on growing upland rice (Bicol)

A farmer's primer on growing cowpea on riceland (Bicol, French)

A farmer's primer on growing soybean on riceland (French)

□

ISBN 971-22-0012-4

GRAIN QUALITY

Rice Grain Marketing and Quality Issues

1991. 66 pages. Size 15.24 x 22.86 cm. Paperback. HDC US$6.75, LDC US$1.75 plus airmail (US$2.00) or surface mail (US$1.00) postage

International Rice Research Institute

As rice supplies increase to meet demand, and as incomes rise in many developing countries, rice consumers become increasingly concerned with the chemical and physical characteristics of the rice that they buy. Those grain quality preferences affect the prices they are willing to pay.

Selective breeding for preferred qualities in particular market areas could result in the return of more of the benefits of improved quality rice (with the higher market price it commands) to the farmer. This is particularly true for irrigated rice, the source of most rice in the market.

One session of the 1990 International Rice Research Conference cosponsored by IRRI and the Rural Development Administration, Republic of Korea, focused specifically on grain quality and consumer preferencesfor particular characteristics of rice in different markets. This book contains the research papers presented in that session

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STATISTICAL TECHNIQUES

World Rice Statistics 1990

1991.320 pages. Size 15.24 x 22.86cm. Paperback. HDC US$16.50, LDC US$4.50 plus airmail (US$4.00) or surface mail (US$1.00) postage.

International Rice Research Institute

World Rice Statistics draws together data on rice production, trade, consumption, inputs, prices, and related information from various international and national sources. This edition includes revisions, updates, new tables, and an additional section on rice costs and returns. FAO publications are used as sources of data on production, area, yield, and trade of rice. Tables on rice trade include origin and destination, tariff and nontariff measureson rice, and carry-over stocks of rice.

Aside from expanding geographical and subject matter coverage, a computerized World Rice Statistics Database System (RICESTAT) is being developed to provide researchers and policy makers more efficient access to global information on rice.

The developmentof the RICESTAT and the publication of *World Rice Statistics* is being undertaken by the staff of the IRRI Social Sciences Division under the overall direction of Cristina C. David and Jikun Huang.

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COMMUNICATION OF INFORMATION

Training and Technology Transfer Course Performance Objectives Manual (TT1-01)

1991.287 pages. Size 21.59 x 27 94 cm. Smythe-sewn. HDC US$15.50, LDC US$4.00 plus airmail (US$8.00) or surface mail (US$2.00) postage.

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Direct Seeded Flooded Rice in the Tropics

1991. 117 pages. Size 15.24x22.86cm. HDC US$6.75, LDC US$1.75 plus airmail (US$2.00) or surface mail (US$1.00) postage

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CONSEQUENCES OF RICE TECHNOLOGY

Basic Procedures for Agroeconomic Research: Revised Edition

International Rice Research Institute

1991. 230 pages. 15.24 x 22.86 cm. Paperback. HDC US$17.00, LDC US$5.00 plus airmail (US$3.00) or surface mail (US$1.00) postage.

This is the revised edition of the 1984 *Basic Procedures for Agroeconomic Research,* a reference manual on basic mathematical, statistical, and economic procedures for cropping systems and agricultural researchers. The book gives new perspectives on economic analysis by field-level researchers. The procedures presented range in sophistication from those appropriate at the farm level, to those required at the institutional level.

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OTHERS

World Bibliography of Rice Stem Borers 1794-1990

Z. R. Khan, J. A. Litsinger, A. T. Barrion,
F.F.D. Villanueva, N.J. Fernandez, and L.D. Taylo

1991. 415 pages. 21.59 x 27.94 cm Smythsewn HDC US$26.75, LDC US$7.00 plus airmail (US$11.00) or surface mail (US$3.00) postage.

This comprehensive bibliography is the first of its kind on stem borers, an important pest of rice and a major cause of yield losses and lower production.

The authors have accomplished a monumental task. The stem borers that infest rice all over the world belong to a complex comprising at least twenty lepidopterous and two dipterous species. Until now, nocompilation of literature on any of them was availale. Also, the voluminous literature on stem borers is scattered.

This volume lists all references to stem borers that could be found in the world rice literature. It also provides descriptions and an identification key of the different species, explains the life history of stem borers, and discusses pest occurrence, crop damage, host plant resistance, and methods of control.

An important section is the key word index. That will enable users of the bibliography to locate background on specific topics quickly. All of the nearly 3,700 references listed are available at IRRI, through the Library and Documentation unit of the Information Center.

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MAP

Human Geography of Rice in Southeast Asia

R.E. Huke and E.H. Huke

1990. 21.7 x 27.9cm. HDCUS$15.00. LDGUS$4.00 plus airmail (US$5.00) or surface mail (US$1.00) postage

The geography of rice production in Southeast Asia is characterized by a great diversity of production systems and strongly contrasting human pressures on the landscape. Population density is lower and rice farms are somewhat larger than in either South Asia to the west or China to the north. Even so, Southeast Asia is heavily populated in contrast to the rest of the world. Here, 8% of the world's population lives on 3% of its land area.

In 1982, IRRI published a data set and three maps to illustrate the extent and the spatial distribution of six major physical environments in which rice is produced in Asia. *Human Geography of Rice in Southeast Asia* updates the earlier data. It includes a map of farm size and land ownership, and one of labor utilization in rice farming.

Dr. Robert E. Huke, visiting scientist from the Department of Geography, Dartmouth College, Hanover, New Hampshire, USA, together with Ms. Eleanor H. Huke, cartographic technician, Cold Regions Research and Engineering Laboratory, Hanover, collected and standardized the data, supervised the computerization, and designed and executed the maps.

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