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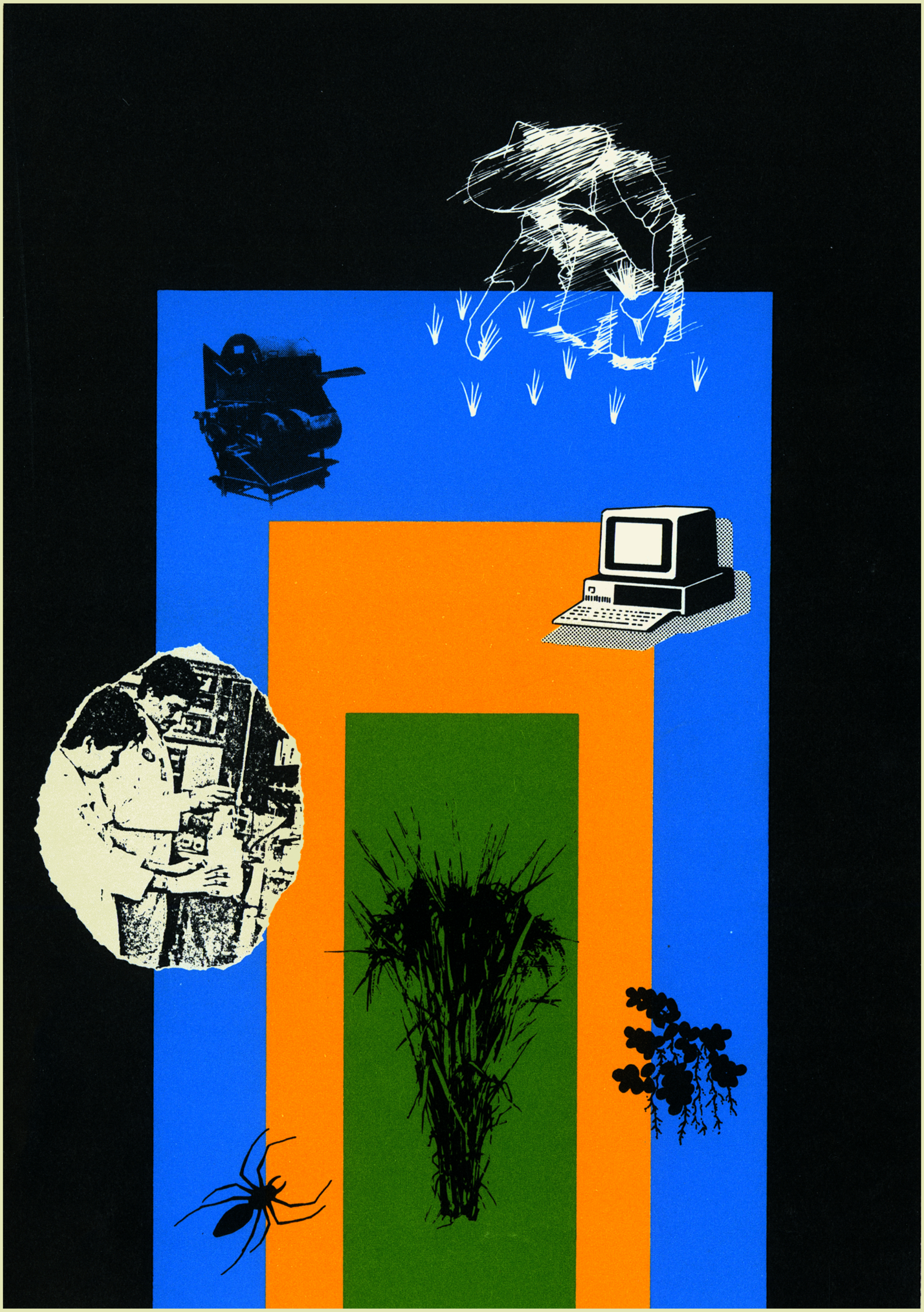

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IRRN GUIDELINES

The *International Rice Research Newsletter* objective is:

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

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

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

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

Criteria for IRRN research report

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

Guidelines for contributors

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

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

All work should have pan-national relevance.

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

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

Please observe the following guidelines in preparing submissions:

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

Categories of research published

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

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

ENVIRONMENT

SOCIOECONOMIC IMPACT

EDUCATION AND COMMUNICATION

RESEARCH METHODOLOGY

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ERRATA

GERMPLASM IMPROVEMENT

Genetic resources

Evaluation of rice germplasm in Bangkhen

Kanchana Klakhaeng, Songkran Chitrakon, and Hatairat Luangsodsai, Pathum Thani Rice Research Center, Rice Research Institute, Department of Agriculture, Thanyaburi, Pathum Thani 12110, Thailand

We evaluated 198 local rices from the National Rice Seed Storage Laboratory for Genetic Resources for 36 agronomic traits. Culm number, panicle length, culm length, blade color, and grain yield varied considerably.

At Bangkhen Rice Experiment Station, Bangkok, soil pH is around 4.7. Annual rainfall averages 109.58 mm; temperature averages 28 °C (33 °C maximum and 24 °C minimum).

The 1988-89 experiment was laid out in a completely randomized block design. Plants were spaced 25 × 33 cm with four 5-m-long rows/plot. RD7, KDML, 105, and KTH17 were the standard checks.

Most of the varieties screened did not differ in morphology such as blade pubescence. Ligule was white with two clefts. Stigma was yellow. Apiculus was white in most rices, but red at the apex in Sao Nueng (GS.5699) and Niaw Nak (GS.5701).

Range, mean, and coefficient of variation for different characters in rice germplasm collection in Thailand.

Character	Range	Mean	SD	CV (%)
Leaf length (cm)	41.4 - 84.2	65.52	7.87	12.01
Leaf width (cm)	0.5 - 2.1	1.35	0.22	16.41
Culm length (cm)	60.0 - 167.8	133.80	20.00	14.95
Ligule length (cm)	6.4 - 25.0	17.78	5.55	3 1.24
Culm number	2 - 19	10.25	2.98	29.04
Panicle length (cm)	21.5 - 32.8	27.46	16.16	58.86
100-grain weight (g)	2.2 - 3.6	2.96	0.25	8.52

Considerable variation in culm length and panicle length was observed among varieties (see table). Genotypes with desirable characters can be used as parents in breeding programs for specific locations.

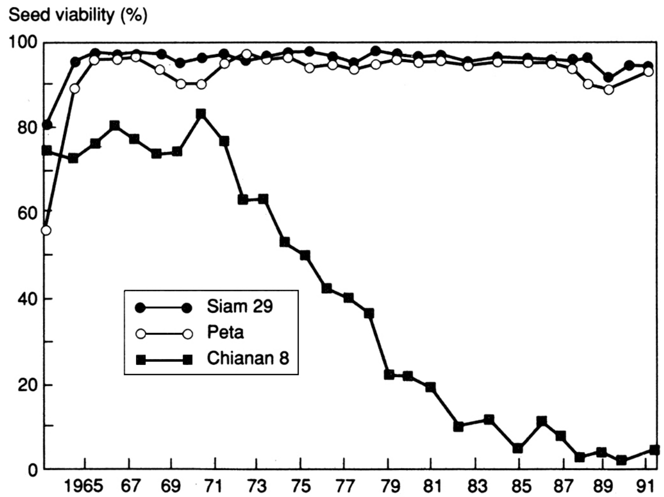
Low SD for leaf width, leaf length, culm number, and 100-grain weight indicates limited scope for selection of these characters. ■

Findings from a 28-yr seed viability experiment

T. T. Chang, International Rice Germplasm Center (IRGC), IRRI

In April 1963, Peter R. Jennings and I set up a germplasm bank seed storage experiment. Seed lots of varieties Siam 29, Peta, and Chianan 8 were dried at 50 °C in a convection oven to 13, 11, 7, 5, and 3.5% wet basis initial seed moisture content. After cooling, the seed lots were embedded in liberal amounts of silica gel inside airtight 1 1/2-gallon glass jars. The equilibrium seed moisture content was maintained at about 8.5%, and the jars kept at 2 °C.

Twice a year, 500 seeds of each variety were sprouted in petri dishes in 100-seed lots to measure viability. Seeds dried to 11% moisture content have shown the least drop in viability over 28 yr (see figure). This moisture content is the average of seeds kept in IRGC's short-term storage room.



Changes in seed viability over time of controlled varieties kept at 2 °C cold storeroom.

The viability reading shows

- two dormant varieties (Siam and Peta) began with moderately low germination (60-80%), which increased markedly after dormancy expired; viability remained around 96% to early 1991.
- viability of nondormant Chianan 8 deteriorated rapidly after 8 yr; by 1990, viability was less than 5%.

The longevity pattern between the indica varieties dominant in the tropics and the sinica varieties dominant in the subtropics is striking, and little known to rice workers and seed physiologists.

These findings led IRGC staff to set up a control set of 8-10 representative varieties from major rice-growing countries in the IRGC medium-term (2 °C, 40%

relative humidity [RH]) and long-term (-10 °C, 30% RH) storerooms for periodic monitoring of seed viability, and monitoring every 5 yr for the medium-term and every 10 yr for the long-term storage. These intervals follow the longevity patterns of the control varieties.

Subtropical and temperate zone varieties stored earlier were regenerated as a batch in 1973-74, before average viability dropped to 50%. Tropical varieties were rejuvenated at later intervals.

This is the longest, continuously monitored seed storage experiment on record, but the control seed lots are now running low. ■

Genetics

Combining ability of some rice cultivars with selected cytoplasmic male sterile (CMS) lines

S. B. Mishra, C. H. Mishra, and C. N. Chaubey, Plant Breeding Department, N. D. University of Agriculture and Technology, Faizabad, India

We studied the general combining ability (GCA) of 18 parents and the specific combining ability (SCA) of 45 crosses in a 15 (line) × 3 (tester) mating design: 12 varieties and 3 male fertility restorer lines used as pollen parents were crossed with 3 CMS lines.

The 63 treatments (15 lines, 3 testers, and 45 F_1s) were laid out in a completely randomized block design with three replications during 1985 wet season under irrigation. Experimental plots were three 3-m-long rows. Row and plant spacing was kept at 20 × 15 cm. Five competitive plants were randomly selected from each plot for analysis.

Male fertility restorer line IET5656 was the best general combiner for grain yield, followed by Narendra 80, IR54, Z97 A, and T26 (Table 1). Madhuri and Sattari exhibited good GCA effect for test weight. Narendra 80 and Pankaj were good general combiners for tiller number; IR54 and T26 were good for plant height. Sattari and Narendra 80 and female line IR46829 A were good general combiners for early heading.

Table 1. General combining ability for grain yield and other chracters of some parental linea.[a]

Parents	Plant height	Heading date	Tiller number	Test weight	Grain yield
CMS female lines					
V20 A	-1.54*	-0.49	0.64	-2.41**	0.28
IR46829 A	-14.48**	-2.32**	-3.78**	-2.33**	-3..75*
Z97 A	16.02**	2.82**	3.14**	-0.07	3.47**
Male lines					
Male fertility restorer lines					
IR50	3.16*	4.34**	-0.16	-2.41 *	2.22**
IR54	17.12**	15.25**	4.82**	0.69	9.32**
IET5656	8.35**	8.89**	5.11**	-0.30	20.77**
Non-fertility restorer varieties					
Sattari	-11.90**	-15.53**	-11.77**	2.95**	-17.83**
Narendra 80	-4.20*	-3.53*	10.75**	0.57	10.73**
Pankaj	1.86	7.27**	10.29**	-0.57	-10.05**
T26	20.13**	14.25**	-2.62**	-3.47**	3.25**
Madhuri	-8.32**	-2.24	-0.16	3.26**	-8.07**

[a]* and ** = significant at P.05 and P.01, respectively.

Table 2. Crosses showing specific combining ability effects for grain yield and other characters.[a]

Cross	Plant height	Heading date	Tiller number	Test weight	Grain yield
V20 A/IR54	26.73**	7.03*	-5.44**	1.59	-3.60*
V20 A/Sattari	-9.73**	18.08**	-3.44*	-2.45*	-2.20
IR46829 A/Pankaj	1.73	11.29**	0.11	3.96**	-3.88**
IR46829 A/Sattari	6.21	-7.62*	2.18	-0.05	8.46**
IR46829 A/T26	-15.49**	6.49	2.70	3.82**	-3.26*
Z97 A/IR50	2.95	4.59	13.64**	0.05	-5.40**
Z97 A/IET5656	4.94	-4.96	6.10**	-4.00**	23.83**

[a]* and ** = significant at P. 05 and P .01, respectively.

Only seven crosses showed high SCA effects for one or more characters (Table 2). V20 A/IR54 for tall and IR46829A/T26 for dwarf plant height; IR46829 A/Sattari for early heading; IR46829 A/Pankaj and IR46829 A/T26 for test weight; 297 A/IR50 for tiller number; and Z97 A/IET5656 for grain yield were the best specific combiners.

The parental lines 297 A and IET5656 had the highest GCA effects in their respective female and male groups for grain yield, and also produced the best SCA effect for grain yield. Crosses showing high SCA effects for plant height and tiller number involved parents of high and low GCA values; parents with high GCA values exhibited high SCA effect for earlier heading date in their crosses. Parents showing high SCA values in their crosses were low general combiners for test weight. The SCA effect was more common and pronounced in crosses involving male fertility restorer lines with CMS lines.

The cross combination showing high SCA effect for grain yield also showed high SCA effect for tiller number, indicating tiller number is an important yield component. ■

Relationship of genetic variances of quantitative characters in indica rice to nitrogen level

Peng Junhua and Li Youchun, Crop Institute, Sichuan Academy of Agricultural Sciences, Chengdu 610066, Sichuan Province, China

Genetic variance reflects the magnitude of the gene effect controlling certain characters. We studied the relationship of genetic variance of 12 characters to N level in a field experiment in Tsukuba, Japan, May-Oct 1989. Indica rice varieties IR8, IR24, Milyang 23, Stipepe, Saturn, 68-1, Ch-47, Belle Patna, Guichao 2, and IR2061-214-3 were used. N levels were 0, 35, 70, and 105 kg N as urea/ha. The experiment was laid out in a split-plot design with three replications, N in the main plots and variety in the subplots. Forty plants/variety were grown in each subplot, at 15- × 25-cm spacing. Quantitative characters were measured on the middle five plants in each subplot. Genetic variance of each character was estimated as

$$Vg = (MSg - MSe)/r$$

where MSg and MSe are the mean squares for genotype and error, and r the number of replications. The relationship of Vg and phenotypic mean for each character with N level was determined by correlation analysis (see table).

Correlation coefficients for genetic variance and phenotypic means of 12 characters with N levels.[a]

Item	PH	DH	MTN	PN	ETP	TSN
P	-0.982*	-0.788	-0.977*	0.973*	-0.955*	-0.040
G	0.900	-0.957*	0.986*	0.987*	0.649	-0.075
	FSN	FSP	GW	GY	BY	HI
P	-0.895	-0.774	-0.972*	0.961*	0.969*	-0.983*
G	-0.709	0.953*	-0.525	0.888	0.812	-0.378

[a]P = correlation coefficient between phenotypic mean and N level, G =correlation coefficient between genetic variance and N level, * = significant at 5% level. PH = plant height, DH = days to beading, MTN = maximum tiller no., PN = panicles/plant, ETP = effective tiller percentage. TSN = total spikelet no., FSN = filled spikelets/panicle, FSP = filled spikelet percentage, GW = 1,000-grain wt, GY = grain yield, BY = biological yield/plant, HI = harvest index.

Genetic responses to N did not always coincide with phenotypic response. The genetic variances of maximum tiller no. (MTN), panicles per plant (PN), and filled spikelets per panicle were positive and significantly correlated with N level. The genetic variance of days to heading (DH) was negative and significantly correlated with N level.

Genetic variation is the basis of rice breeding. It is easier to select for a certain character when its genetic variance is larger. In breeding indica rice, selecting for MTN, PN, and effective tiller percentage would be more efficient at higher N levels. But selecting for DH would be more efficient at lower N levels. ■

Contents of endogenous hormones GA, IAA, and ABA in semidwarf rice

Xu Jianlong, Agronomy Department, Zhejiang Agricultural University, Hangzhou (new address: Plant Institute, Zhejiang Academy of Agricultural Science, Hangzhou); and Zhang Jinyu, Genetic Institute, Jiangsu Academy of Agricultural Science, Nanjing, China

We measured the level of endogenous GA, IAA, and ABA in near-isogenic lines of indica rices.

Er-Jiu-Qing with Sd_1 gene, Er-Jiu-Qing with sd_1 gene, waxy Guang-Lu-Ai 4 with *Wx* gene, and nonwaxy Guang-Lu-Ai 4 with *wx* gene are near-isogenic lines with one gene difference. Four plant types are tall, dwarf a, dwarf b, and superdwarf, japonica type (derived from Jia 23/Xue-He-Ai-Zao (XHAZ) F_3) with $Sd_1Sd_1Sd_sSd_s$, $sd_1sd_1Sd_sSd_s$, $Sd_1Sd_1sd_ssd_s$, and $sd_1sd_1sd_ssd_s$ genotypes, respectively, by genetic test of plant height and GA, response. Jia 23 (sd_1 gene) and XHAZ (sd_s gene) were the check varieties. Suge's method of assay and of extraction were used to evaluate hormone level in aboveground plant parts.

Contents of endogenous gibberellin-like substance were higher in tall plants and dwarf type with sd_s gene than in dwarf type with sd_1 gene (Table 1,2). The dwarfs had higher ABA content and significantly lower IAA content than tall plants. *Wx* was not related to endogenous GA, IAA, and ABA.

We suggest that dwarf plant height was not due to low GA. Low IAA content, however, was the critical factor. ■

Table 1. Content of endogenous hormones of near-isogenic lines.[a]

Variety	Genotype	Plant height (cm)	Hormone[a] (µg/kg fresh wt) GA	IAA	ABA
Tall Er-Jiu-Qing	Sd_1Sd_1	128.0	1.68 a	0.58 a	0.35 c
Dwarf Er-Jiu-Qing	sd_1sd_1	75.0	1.13 c	0.11 c	0.97 a
Waxy Guang-Lu-Ai 4	WxWx	80.0	1.18 b	0.13 b	0.81 b
Nonwaxy Guang-Lu-Ai 4	wxwx	80.0	1.18 b	0.13 b	0.81 b

[a]In a column, means followed by different letters are significantly different at the 5% level by DMRT.

Table 2. Content of endogenous hormones of near-isogenic plants with different dwarfing genes (µg/kg fresh wt).[a]

Plant type	Genotype	Plant height (cm)	Hormone[a] (µg/kg fresh wt) GA	IAA	ABA
Tall	$Sd_1 Sd_1 Sd_s Sd_s$	133.5	1.68 a	0.63 a	0.29 d
Dwarf a	$sd_1 sd_1 Sd_s Sd_s$	96.0	1.25 d	0.22 b	2.08 c
Dwarf b	$Sd_1 Sd_1 sd_s sd_s$	75.0	1.61 bc	0.14 e	2.29 a
Superdwarf	$sd_1 sd_1 sd_s sd_s$	45.0	1.57 c	0.09 f	2.32 a
Jia 23 (CK1)	$sd_1 sd_1 Sd_s Sd_s$	92.0	1.23 d	0.16 d	2.19 b
Xue-He-Ai-Zao (CK2)	$Sd_1 Sd_1 sd_s sd_s$	93.0	1.66 ab	0.19 c	2.16 b

[a] In a column, means followed by different letters are significantly different at the 5% level by DMRT.

Genetic nature of leaf epicuticular wax (EW) content in rice

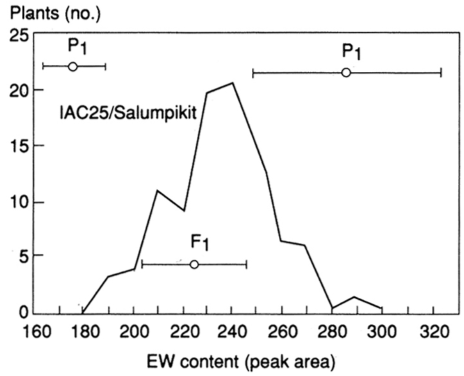
M. M. Hague, D. J. Mackill, and K. T. Ingram, IRRI

Leaf EW content has been related to drought resistance in sorghum, wheat, barley, soybean, and maize. EW content in rice leaves increases cuticular resistance to transpiration, which may confer dehydration tolerance. We studied the genetic nature of EW content in rice leaves in 1988-89.

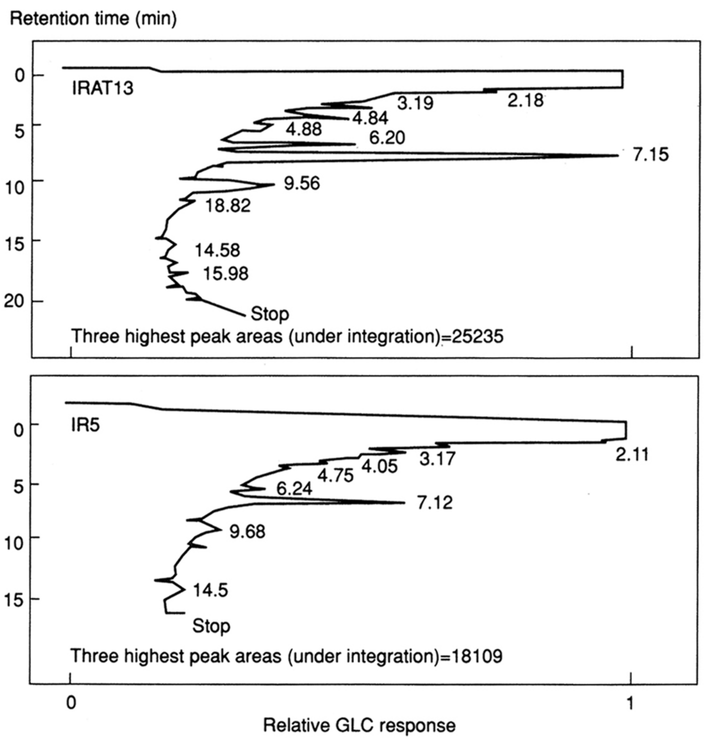
Leaf EW of phytotron-grown plants was extracted with chloroform, the chloroform evaporated off with N_2 gas, and EW reconstituted in 3 ml CCl_4. This solution was injected into a gas-liquid chromatograph (GLC). EW content in the solution of each sample was quantified by comparing total area under the three highest GLC peaks per unit leaf area extracted (Fig. 1). These three peaks, corresponding to C_{29}, C_{33}, and C_{35} hydrocarbons, consistently accounted for almost all the leaf EW.

Eight parents with high or low leaf EW were crossed in all possible ways except as reciprocals. The F_1 of the diallel set was analyzed by Griffing and Haymen's methods. Two F_2 populations were studied.

Upland parents IAC25, OS4, and IRATl3 had the highest EW levels. These cultivars belong to Glaszmann's isozyme group VI (japonica). General combining ability (GCA) effects were highly significant and specific combining ability (SCA) effects nonsignificant, indicating a predominance of additive genetic variation. Broad- ($h^2{}_b$) and narrow-sense ($h^2{}_n$) heritability were 0.77 and 0.62, respectively. IAC25 and OS4 had the highest positive GCA.



2. Distribution of leaf EW content in the F_2 population of IAC25/Salumpikit and the range, mean, and SE of the mean. Mean EW contents of P_1, P_2, and F_1 were 16.5, 5.9, and 10.5 mg/m^2, respectively.



1. Representative gas liquid chromatograms of high-wax IRAT13 and low-wax IR5. The numbers on top of each peak are retention time.

Monomodal distributions were observed in both F_2 populations. In IAC25/Salumpikit (Fig. 2), the number of recombinants matching the EW level of either parent was low, implying polygenic inheritance. Broad-sense heritability was 0.36.

Predominance of additive genetic variation for EW content implies that selection to increase leaf EW would be effective. Low heritability and the difficulty in measuring the trait, however, are obstacles to increasing the EW level in improved rainfed lowland cultivars. An additional constraint is that the sources of high EW are upland cultivars, which are difficult to use in rainfed lowland breeding programs. ■

Breeding methods

Evaluating S_1 family recurrent selection in a rice population

O. Watanesk and D. J. Mackill, IRRI

Recurrent selection has been used to improve particular traits in breeding populations of cross-pollinating crops. Difficulties in artificial crossing, however, make it difficult to use in self-pollinating crops such as rice.

Genetic male sterility can facilitate crossing during the intermating phase of recurrent selection. We evaluated S_1 family recurrent selection in the composite population CP103 (IR38499) segregating for genetic male sterility. As the S_1 generation segregated for male sterility, we selected S_1-derived S_3 and S_4 lines, which were homozygous for male fertility.

In 1989 wet season (WS), 79 S_1 lines and 46 S_3 lines were grown. In 1990 dry season (DS), 62 S_1 and 34 S_4 lines were grown. S_1 lines were replicated twice and S_3 and S_4 lines four times each season: Agronomic and grain quality traits were measured on 12 hills/plot. Only plots not affected by rats and tungro were included in the analysis. IR36 could not be included in the 1990 DS analysis because of damage.

Means and ranges for the S_1 lines are presented in Tables 1 and 2. Lines comparable with or better than the best check occurred in both seasons, although this population had not undergone previous selection for yield.

In 1989 WS, correlations between S_1 and the corresponding S_3 lines were significant for all traits except adjusted yield. Yield of IR68 was reduced by typhoon damage.

In 1990 DS, correlations were significant for all traits except days to 50% flowering and percentage unfilled grains.

As S_1 lines are segregating for male sterility, and the amount of seed is limited, it is difficult to evaluate yield directly. Our study indicates that yield components and grain quality traits can be measured on fertile S_1 plants in small plots. These measurements appear to reflect differences observed in fertile S_1-derived S_3 or S_4 lines. This indicates S_1 selection could be used in a recurrent selection program to improve these traits. ■

Table 1. Ranges, means, and LSD for grain quality and agronomic traits of 46 S_1 lines with check means and correlation coefficients (r) between the S_1 and the corresponding S_3 generations. IRRI, 1989 WS.

Character	S_1 lines		Checks		LSD (0.05)	r^a
	Range	Mean	IR36	IR68		
Plant height (cm)	91-170	120	96	128	10.9	0.92**
Days to 50% flowering	91-125	105	89	103	7.3	0.68**
Brown rice length (mm)	6.0-7.4	6.7	6.7	7.9	0.41	0.82**
Brown rice shape (L/W)	2.35-3.60	3.07	3.45	3.70	0.31	0.90**
Gelatinization temp score	3.71-7.00	5.74	4.46	6.50	1.13	0.70**
Panicles/hill	10-20	15	20	13	5.5	0.49*
Spikelet no./panicle	92-206	151	120	131	46.5	0.77**
% unfilled grains	19-55	36	23	45	16.3	0.58**
100-grain weight (g)	2.18-3.16	2.56	2.35	3.02	0.28	0.60**
Adjusted yield (g/2.25m^2)	537-1414	965	848	749	452	0.26 ns

[a] Correlation between 26 pairs of S_1 and their derived S_3 lines. *, ** = significant at the 5 and 1% level, respectively. ns = nonsignificant.

Table 2. Ranges, means, and LSD for grain quality and agronomic traits of 32 S_1 lines with check means and correlation coefficients (r) between the S_1 and the corresponding S_4 generations. IRRI, 1990 DS.

Character	S_1 lines		Check	LSD (0.05)	r^a
	Range	Mean	IR36		
Plant height (cm)	84-150	108	109	10.1	0.68**
Days to 50% flowering	83-102	93	95	4.7	0.36 ns
Brown rice length (mm)	6.0-7.6	6.8	8.1	0.43	0.80**
Brown rice shape (L/W)	2.30-3.45	2.93	3.60	0.29	0.81**
Gelatinization temp score	4.13-7.00	6.09	6.84	1.27	0.64**
Panicles/hill	12-23	16	14	4.3	0.58**
Spikelet no./panicle	105-229	164	197	39	0.69**
% unfilled grains	9-26	15	14	10.2	0.25 ns
100-grain weight (g)	2.07-2.84	2.41	2.63	0.28	0.61**
Adjusted yield (g/2.25 m^2)	955-1893	1331	1690	460	0.47*

[a] Correlation between 26 pairs of S_1 and their derived S_4 lines. *, ** = significant at the 5 and 1% level, respectively. ns = nonsignificant.

Estimates of combining ability of some rice varieties in diallel crossing systems

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We studied the nature of genetic control and amount of heterosis available for spikelets per panicle and identified suitable donors for this character.

The rice genotypes crossed in a complete diallel set were IR8 (IRRI), IR8423 (IRRI), 415 (INSA), IR19746-11-33 (IRRI), VX1-2 (USSR), X1 (INSA), CICA7 (IRRI), Tam den HP (INSA), VE19, and Te hat to.

The 90 F_1 cross combinations and their parents were grown in a randomized block design with three replications in winter-spring 1986-87. Ten competitive randomly selected plants from each replication were analyzed.

Highly significant F ratios for general combining ability (GCA), specific combining ability (SCA), and reciprocal effects (Table 1) indicate difference among these effects. The GCA effects of each parent given in Table 2 indicate that IR8423-132-6-22, IR19746-11-33, and Tam den HP are good general combiners for number of spikelets/panicle.

For spikelets per panicle, the variances due to GCA were higher than those due to SCA for IR8423-132-6-22, X1, VE19, and Te hat to. This indicates the role of additive gene action was predominant in inheritance of the trait. In all entries except X1, VE19, and Te hat to, nonadditive gene action was predominant in controlling this character. ■

Table 1. Analysis of variance of combining ability.

Source of variance[a]	Sum of squares	DF	Mean square	Value	F-table P = 0.05
GCA	18908.00	9	2100.89	2122.11	2.53
SCA	11646.34	35	332.75	336.12	1.83
RE	6137.50	45	136.39	137.77	1.56
Error	0.99	171			

[a] GCA = general combining ability, SCA = specific combining ability, RE = reciprocal effect.

Table 2. Estimate of GCA effects for spikelets/panicle. [a]

Parent	GCA effects (gi)	Parent	GCA effects (gj)
IR8	5.57	x1	6.18
IR8423-132-6-22	12.75	CICA7	-8.54
415	-16.01	Tam den HP	10.65
IR19746-11-33	9.34	VE19	-9.69
VX1-2	6.54	Te hat to	-16.81

[a] Standard error: gi - gj = 0.35 (i ≠ j).

Effect on grain yield of shoot removal at different stages of rice crop growth

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Damage to rice tillers by severe incidence of pests, diseases, rodents, etc. can occur at any stage of crop growth. Tiller number determines panicle number, and tiller damage can lead to reduced yield.

We laid out a 1989 wet season field trial in a split-plot design with two replications, with two varieties in the main plots, three crop stages in the subplots, and seven shoot removal treatments in the sub-subplots.

Single seedlings were transplanted at 20- × 15-cm spacing. Shoots were removed by cutting aerial shoots 2 cm above the soil surface. Standard cultural practices and plant protection measures were applied.

Grain yield was reduced by shoot removal (see table). This indicates that tiller losses at any stage of crop growth will lead to a yield reduction.

Shoot removal at flowering was most detrimental (25-100% reduction in yield), followed by shoot removal at panicle initiation (11.2-9 1.9%) and at active tillering (0.6-47.8%). At active tillering of Chaitanya, maintaining at least four tillers (including the main shoot) did not affect yield. This could indicate that not all the tillers produced were needed. ■

Effect of shoot removal on grain yield.[a]

Treatment	Grain yield (g/m^2)							
	Swarna				Chaitanya			
	AT	PI	Fl	Mean	AT	PI	F1	Mean
No shoots	408	122	0	177	394	59	0	151
Main shoot alone	459	193	68	240	396	116	91	201
Main shoot + 1 tiller	556	342	173	357	564	259	173	332
Main shoot + 3 tillers	664	463	363	497	601	418	316	445
Main shoot + 5 tillers	698	578	480	585	605	503	403	504
Main shoot + 7 tillers	699	733	494	642	614	608	535	586
Control (has main shoot + all tillers)	781	825	692	766	618	725	713	685
Mean	609	465	324		542	383	319	

Mean for stages	: AT = 576;	PI = 424;	Fl = 322
LSD (0.05)	:V = ns;	V in S.P = 33;	SSP in SP = 68
	SP = 18;	SP in V = 25;	SSP in V = ns
	SSP = 39;	SP in SP = 97;	V in SSP = ns
	V = varieties,	SP = stages.	SSP = treatments

[a] Shoots were removed at active tillering (AT), panicle initiation (PI), and flowering (F1).

Submergence tolerance and kneeing ability of some rainfed lowland rices

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In many monsoon areas, rainfed ricefields may be submerged 1-7 d or longer at a time. Submergence tolerance is needed for crop survival.

We conducted two separate trials during 1986, to evaluate submergence tolerance and kneeing ability of eight local deepwater lines, four derivatives of crosses between high-yielding varieties and a local deepwater rice, and one improved winter rice (Manoharsali). The experiments were laid out in randomized block designs with three replications.

To test submergence tolerance, 10-d-old seedlings were submerged in 30-cm water for 10 d and survival recorded 7 d after the water receded. For kneeing ability, plants were uprooted 100 d after sowing (but before flowering) and laid horizontally on a puddled bed with 2-cm-deep water. Kneeing was measured 8 d later.

Padmapani and Ranga Bao had the highest submergence tolerance (88.5%) (see table). All cultivars except Manoharsali and Itakhulig had >50% survival.

Padmapani had the highest kneeing angle (43.90°); Manoharsali, a winter rice, the lowest (15.900).

Six genotypes had both superior submergence tolerance (>58.5%) and kneeing ability (>35°). ■

Submergence tolerance and kneeing ability of rice genotypes. Assam, India, 1986.

Cultivar	Pedigree	Submergence tolerance (%)	Kneeing ability (°angle)
AR9	Local deepwater line	58.5	37.1
Padmapani	Local deepwater line	88.5	43.9
Herepi Bao	Local deepwater line	75.0	26.5
Rona Bao	Local deepwater line	66.5	35.8
Ranga Bao	Local deepwater line	88.5	30.0
Itakhulig	Local deepwater line	36.5	27.6
Dubraj	Local deepwater line	51.5	32.3
Sarsuri Bao	Local deepwater line	65.0	37.6
PJNB95-2	Pankaj/Jagannath//Negheri Bao	60.0	28.9
PJNB96-10	Pankaj/Jagannath//Negheri Bao	65.0	39.6
PN42	Pankajmegheri Bao	61.5	37.4
PN54	Pankajmegheri Bao	66.5	33.2
Manoharsali	Winter rice	41.5	15.9
LSD (0.05)		2.3	2.0
CV (%)		10.9	3.5

Yield differences among some deepwater rices (DWRs)

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Most deepwater areas in Thailand are planted to local cultivars. Farmers believe that some characteristics of their traditional DWRs—yielding capacity, internode elongation, growth duration, adaptability, and milling quality—make them most suitable.

We compared the performance of local and improved DWRs under natural field conditions in 1988 and 1989 wet seasons. The experiment was laid out in a randomized complete block design with three replications.

The cultivars were dry seeded onto plowed soil at 120 kg seeds/ha. Seedlings experienced drought stress in late Jul. In late Aug, the water level gradually increased to about 1 m in early Nov. No fertilizer was applied, but routine crop protection was done as needed.

Table 1. Grain yield of 20 deepwater rice cultivars. Huntra Rice Experiment Station, Ayutthaya, Thailand, 1988 and 1989 wet seasons.

Cultivar	Grain yield (t/ha)	
	1988	1989
RD19 [a]	2.7	2.8
Khao Mali	2.7	2.7
Huntra 60 [a]	2.6	3.1
Khao Puang Nak	2.6	2.3
Plai Ngahm	2.5	2.4
Sai Bua	2.4	2.2
SPR7233-32-1-6-1	2.3	
Luang Pratharn		2.6
Mali Tawng	2.3	2.5
Khao Kaset	2.3	2.2
Leb Mue Nahng 111	2.3	2.2
Khao Rachinee	2.2	2.7
Sam Ruang	2.2	2.6
Nahng Khiew	2.2	2.5
Pan Tawng	2.2	2.5
Pin Gaew 56 [a]	2.2	2.0
Khao Hoi	2.1	2.0
Khao Lod Chong	2.1	2.4
Ban Daeng	2.1	2.2
Khao Tah Haeng 17	2.0	
Khao Raguad		2.4
Tapow Gaew 161 [a]	1.9	1.8
LSD (0.05)	ns	0.5

[a] Recommended deepwater rice variety.

Yield differences are shown in Table 1. Improved plant type cultivars Huntra 60 and RD19 yielded the highest. Recommended traditional plant type varieties Pin Gaew 56 and Tapow Gaew 161 yielded the lowest. Local cultivar Khao Mali gave relatively high yields.

Table 2. Relationship between grain yield and agronomic characteristics of deepwater rice.

Characteristic	1988	1989
Panicles (no./m²)	+0.65**	+0.83**
Panicle wt (g)	+0.45*	-0.40 ns
Tillers at maturity (no./m²)	+0.64**	+0.82**
Productive tillers (%)	–0.05 ns	+0.39 ns
Dry matter production (t/ha)	+0.29 ns	–0.10 ns
Harvest index	+0.54*	+0.81**
Height (cm)	-0.10 ns	-0.50*
Growth duration (d)	+0.12 ns	+0.15 ns

In simple linear correlation analysis, grain yields were positively correlated with panicle number and tiller number per unit area and with harvest index, but negatively correlated with plant height (Table 2). Correlations of grain yield with dry matter production, days to maturity, and productive tillers were low. Panicle number, not panicle weight, was the critical factor in higher yields. ■

Genetic studies in the F_2 of crosses for high grain quality

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We evaluated five genetic variables in the F_2 of three crosses (see table). OM576 is from Vietnam, Basmati 370 from India, and IR68 and IR31868-64-2-3-3-3 from IRRI (named OM87-9 in Vietnam). The parents all have good grain quality.

The 1990 wet season experiment was laid out in a randomized block design with three replications. Selection intensity was about 2% from each population.

Phenotypic and genotypic coefficient of variability (PCV and GCV) showed high values for panicles/hill, grain numbers/panicle, and single plant yield; low value for 1,000-grain weight; and moderate value for plant height. PCV was higher than GCV for all traits.

Genetic parameters of F_2 of 3 crosses for grain quality.[a]

Character	Cross	Mean	SD	GCV (%)	PCV (%)	h^2 (%)	GA (%of mean)
Plant height (cm)	OM576/Basmati 370	121.3	16.3	6.8	9.3	54.0	12.2
	IR68/Basmati 370	109.7	5.5	2.8	7.5	14.1	2.6
	OM87-9/IR68	107.0	4.4	3.4	7.9	18.2	3.5
Panicles/hill	OM576/Basmati 370	20.3	10.2	26.9	33.0	67.0	53.5
	IR68/Basmati 370	17.3	5.5	13.1	26.0	25.0	26.0
	OM87-9/IR68	13.7	1.2	25.7	38.3	45.2	41.7
Grains/panicle	OM576/Basmati 370	85.1	36.9	22.1	30.1	54.2	39.3
	IR68/Basmati 370	88.7	7.9	10.1	22.0	21.0	11.2
	OM87-9/IR68	91.5	5.1	10.5	21.7	23.4	7.2
1000-grain weight (g)	OM576/Basmati 370	24.7	1.1	1.4	4.8	8.1	0.0
	IR68/Basmati 370	25.4	1.3	0.4	4.9	1.5	0.0
	OM87-9/IR68	25.7	1.8	2.9	5.7	26.0	3.6
Single plant yield (g)	OM576/Basmati 370	15.2	1.5	37.2	44.4	70.0	75.1
	IR68/Basmati 370	12.5	3.0	9.8	31.2	10.0	7.5
	OM87-9/IR68	10.6	1.3	18.9	39.7	23.3	22.1

[a] h^2 = broad-sense heritability, GA = genetic advance.

Grain weight had low broad-sense heritability and low genetic advance, indicating nonadditive gene action.

Very high values of heritability and genetic advance were obtained, especially in OM576/Basmati 370. This indicates that additive gene action had more influence than environment did on yield. This trait also had high values for heterosis (111.7%) and heterobeltiosis (60.3%) in the F_1. ■

Yield of wet season ratoon rice in Konkan region, Maharashtra, India

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About 9,000 ha of the rice area in Konkan are double-cropped, under irrigation Dec-May and rainfed Jun-Oct. The May harvest is just before the start of monsoon rains in June. This leaves little time for land preparation for the wet season (WS) rice crop.

A WS ratoon crop would eliminate labor and seed costs and free the farmer from conventional puddling and transplanting.

In 1990, we compared yields of a ratoon crop and a WS crop in 100-m^2 plots.

Promising, medium-long duration Palghar 103-1-2 (a derivative of IR5/ Zinya 63) was transplanted in Dec and ratooned the third week of May by cutting 8-10 cm above the ground. The field was cleaned, immediately weeded, and irrigated. Fertilizer (50 kg N, 20 kg P, and 42 kg K/ha) was basally placed between rows. Another 25 kg N/ha was topdressed 30 d later, coinciding with the emergence of ratoon sprouts.

The regular WS crop of Palghar 103-1-2 was transplanted in an adjacent plot the first week of Jul 1990, using 30-d-old seedlings.

The rains started the first week of June. At 4 wk after main crop harvest, percent regenerated hills was 70.

Identical yield of the ratoon crop and the main WS crop can be attributed to the high number of basal tillers in the ratoon crop (see table). The ratio of basal tillers to ratoon tillers was 2: 1. Favorable wet season conditions (high temperature and humidity) as well as physiologically active stubble may have contributed to the emergence of basal tillers. This is also a characteristic of Palghar 103-1-2. The basal tillers were superior to ratoon tillers in growth and yield attributes. ■

Growth, yield attributes, and yield of ratoon rice and wet season rice.

Trait	Summer rice (Dee-May)	Ratoon rice[a] (Jun-Oct)	Wet season rice (Jun-Oct)
Plant height (cm)	103	133 55	135
Days to maturity	135	135 60	133
Panicle length (cm)	19	25 8	22
Number of spikelets/panicle	180	240 82	152
Productive tillers/hill	18	15 6	12
Grain yield (t/ha)	5.0	3.1	3.7

[a] Upper figure is basal tillers, lower figure is ratoon sprouts.

Pest resistance–diseases

Pathogenic races of *Xanthomonas oryzae* pv. *oryzae*

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Bacterial blight (BB) caused by *Xanthomonas oryzae* pv. *oryzae* (Xoo) is a major disease in India. We tested the pathogenicity of 12 of 37 isolates on 17 cultivars.

Rice seeds were treated with Dithane M 45 and germinated. Twenty-day-old seedlings were transplanted in earthen pots at 5 seedlings/pot and fertilized.

At 35 d after transplanting, plants were inoculated with Xoo (0.2 O.D. concentration) by spraying the top 5 leaves. Disease symptoms were recorded beginning 8 d after inoculation as phase I = lesion desiccated and/or pale green, 0.3-3.0 cm long; phase II = lesion desiccated and/or pale green, 3.1-9.0 cm long; phase III = lesion pale green with yellow boundary along the margin, 9.1-25 cm long; phase IV = lesion with brown central zone surrounded by a pale green region and yellow boundary along the margin, 25.1-40 cm long; and phase V = lesion with central necrotic zone surrounded by a pale green region and yellow boundary along the margin, 40.1 cm long, or total leaf blight.

Lesions coalesce at different stages. Infection on any given day after inoculation was calculated:

$$\%\ \text{infection} = \frac{\text{no. of lesions on all 5 leaves}}{5} \times 100$$

Most individual lesions had developed by phase II (see table). Later lesions coalesced, giving apparently less infection even though infection was severe.

All 12 isolates of Xoo were virulent on all 17 cultivars. Resistant varieties

Infection of 17 rice cultivars with 12 Xoo isolates.[a]

Isolate[b]	Infection (%) 10-12 d after inoculation (phase II)																
	Rasi	LG (I)	LG (F)	MS	IR58	RE	Lorai	TN1	XM	WA	Jaya	HK	BJ (I)	BJ (T)	DV86	K	DV85
Xoo-2	72	64	68	64	56	64	60	64	60	44	56	40	56	60	52	56	64
Xoo-3	60	64	64	60	48	64	60	60	64	64	64	64	60	64	56	60	60
Xoo-12	64	60	64	60	60	60	64	64	64	60	60	56	56	60	64	60	56
Xoo-13	64	60	56	64	60	60	56	56	56	60	60	64	64	60	44	60	56
Xoo-16	60	60	56	60	64	56	64	60	56	54	64	60	56	64	50	64	60
Xoo-17	64	56	60	60	60	60	64	48	60	60	44	60	60	60	60	60	56
Xoo-21	72	60	60	60	52	64	64	60	60	64	60	60	56	60	68	40	60
Xoo-22	76	60	60	60	60	60	48	60	60	60	64	60	56	56	60	64	56
Xoo-26	76	60	60	60	60	68	60	60	56	64	44	60	60	60	60	60	64
Xoo-27	72	60	56	64	60	60	60	56	56	64	60	56	56	56	56	40	60
Xoo-36	72	52	60	60	56	68	64	60	60	64	64	52	52	60	60	60	56
Xoo-37	72	60	60	60	48	56	60	60	56	64	60	60	56	56	56	60	60

[a] LG = Long pin, MS = Malagkit Sungsong, RE = Rantai Emas, RM = Rantai Mas, WA = Wase Aikoku 3, HK = Hashikalmi, I = India, F = Fiji, K = Kogyoku, T = Thailand. [b] All isolates were derived from an Andhra isolate except 2 (Xoo-36 and Xoo-37) from Tamil Nadu.

DV85 and Kogyoku were only relatively less susceptible than the rest.

Isolates 2, 26, and 36 were relatively highly virulent on all cultivars. Rasi seemed most susceptible; Kogyoku and DV85 were relatively less susceptible under our experimental conditions.

Pathogen groups IA, IB, II, IIIA, IIIB, IV, and V were differentiated in Japan on Kinmaze, Kogyoku, Rantai Emas, Wase Aikoku 3, Java 14, and IR8. Kogyoku was resistant to IA, IB, and V; Wase Aikoku 3 was resistant to IA, IB, II, IIIA, and IIIB; Java 14 was resistant to V.

Sayaphal has been reported resistant to Ia, Ib, and III; BJ and DV85 to Ia and Ib. DV85 is said to carry resistance genes *xa-5, Xa-7* and *xa-13.*

These results indicate that all 17 rices are highly susceptible to BB. The pathogen shows variable virulence on different cultivars. An isolate is not stable; on reisolation from different inoculated cultivars, it gives rise to variants, as indicated by isolates Xoo-1 to 35 derived from one isolate. The isolates we have probably represent a new virulent group. This indicates the need to look for resistance to the Indian pathogen in other sources. ■

Reaction of rice cultures and varieties to rice tungro disease

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We screened 62 rice cultures and varieties for their reaction to tungro by exposing them to viruliferous green leafhoppers (GLH) *Nephotettix virescens.* Ten-day-old seedlings (100/cultivar) were exposed to different numbers of GLH/seedling.

IR72, IR33043-46-1-3, IR50404-57-2-2-3, IR52431-60-1-2-1, IR34686-56-2-2-2, CRM25, TNAU LFR 842718, and AS33773 showed 20-30% infection with one viruliferous GLW seedling (see table). With two GLH/seedling, only IR72 and IR33043-46-1-3 had <30% infection. For the same cultivars, infection was 35-50% with five GLH/ seedling. ■

Tungro disease infection symptoms of rice varieties/cultures exposed to 1, 2, and 5 viruliferous GLH/ seedling.

Variety or culture	Tungro infection[a]					
	1 GLH		2 GLH		5 GLH	
	%	Score	%	Score	%	Score
IR72	20	3	25	3	35	5
IR33043-46-1-3	22	3	28	3	40	5
IR50404-57-2-2-3	25	3	30	3	40	5
IR52431-60-1-2-1	25	3	30	3	42	5
IR34686-56-2-2-2	25	3	35	5	45	5
CRM25	27	3	35	5	45	5
TNAU LFR 84271	27	3	35	5	40	5
AS33773	30	3	40	5	50	5
IR44761-27-1-3-6	35	5	45	5	58	7
IR45131-45-2-2-1-3	35	5	42	5	57	7
IR45912-9-1-2-2	38	5	45	5	63	7
IR50363-8-1-1-3	40	5	43	5	62	7
IR44538-131-3-1-3	40	5	45	5	68	7
CH404-14-1	40	5	57	7	73	9
IR50363-27-3-2-3	42	5	57	5	65	5
IR39485-151-2-1-3	42	5	50	5	65	7
CR491-1553	42	5	55	7	73	9
CR30-26-1	43	5	58	7	75	9
CR544-1-7	43	5	58	7	75	9
TNAU801793	43	5	55	7	68	7
TNAU (AC) 88115	45	5	55	7	70	7
AS34011	47	5	55	7	72	9
IR44530-41-12-1	48	5	53	7	75	9
TNAU BPHR 831293	48	5	58	7	70	7
IR35346-28-3-3-1	50	5	62	7	77	9
CR544-1-6	50	5	68	7	82	9
IR50363-61-1-2-2	52	7	63	7	78	9
IR32809-314-2-3-1	52	7	62	7	75	9
IR32822-94-3-3-2-2	52	7	62	7	78	9
IR34686-179-1-2-1	52	7	63	7	80	9
AS25370	52	7	63	7	78	9
IR34583-22-1-2	53	7	68	7	83	9
IR47903-151-3-2-3-2	53	7	65	7	78	9
IR44482-9-3-1-3	55	7	65	7	80	9
IR52289	55	7	65	7	80	9
AS24717	55	7	65	7	75	9
TNAU BPMR831305	55	7	65	7	78	9
IR42029-38-1-3-3-2	55	7	65	7	80	9
IR49517-23-2-2-3-3	58	7	63	7	83	9
IR39323-182-2-3-3-2	58	7	63	7	80	9
ET9762	58	7	65	7	80	9
IR37721-16-3-1-3-2	62	7	68	7	83	9
IR45131-59-2-3-2-3	63	7	70	7	85	9
CR544-1-2	63	7	75	9	83	9
IET9757	63	7	73	9	80	9
CR380-26-39	65	7	78	9	85	9
IET98 19	65	7	70	7	87	9
BR153-2B-10-1-3	65	7	72	9	80	9
AS37800	68	7	80	9	88	9
TNAU85 1979	70	7	83	9	90	9
IR32809-26-3-9	72	9	85	9	90	9
BG380-2	72	9	83	9	90	9
AD85358	73	9	80	9	88	9
TM4309	73	9	83	9	90	9
AD85361	75	9	82	9	92	9
IR44482-49-2-2-2	78	9	83	9	90	9
AD85469	78	9	83	9	90	9
IET8059	78	9	88	9	93	9
IET9286 (TNAU BFHRB 71390)	78	9	83	9	90	9
AD86465	80	9	85	9	93	9
AD86749	83	9	90	9	93	9
TN1 (susceptible check)	90	9	100	9	100	9

[a] Mean of 3 replications. Score is by the *Standard evaluation system for rice* scale of 0-9.

Disease resistance of some promising rice cultivars

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Bacterial blight (BB) caused by *Xanthomonas oryzae* pv. *oryzae* and stem rot (SR) caused by *Sclerotium oryzae* are major diseases in nontraditional rice-growing areas of Haryana. We evaluated 30 promising rice cultivars for resistance during 1988 wet season.

To evaluate yield and yield-contributing characters, cultivars were transplanted in 6.2- × 2.0-m plots at 20- × 15-cm spacing in a randomized block design with three replications. The crop was fertilized with 120 kg N, 26 kg P, and 5.75 kg Zn/ha. All the P and Zn were applied at puddling; N was applied in three equal splits: at transplanting, 21 d after transplanting (DT), and 42 DT.

To evaluate BB and SR resistance, cultivars were transplanted in two fields, in two 5-m-long rows/entry and an alternate row of susceptible check TN1 for BB and Jhona 349 for SR.

For BB screening, plants were clip-inoculated 45 DT by cutting 5 cm from the tip of the upper leaves with a sickle dipped in bacterial suspension (prepared by soaking small pieces of infected leaves 20 min). SR screening was done in an infected field.

Only six cultivars showed resistance to BB (see table). Seven entries showed resistance to SR.

Susceptibility of promising rice cultivars to BB and SR in Kaul, India, 1988 wet season.

Cultivar	Parentage	Yield (t/ha)	Grain type [a]	Reaction [b] to: Bacterial blight	Reaction [b] to: Stem rot
IET8562	IET5122DR9168-13-2	4.9	MS	7	5
IET8950	RP270-36-1-2/Bankura 32	5.0	LS	7	5
IET9247	RPW6-17/ARC6650	5.0	LB	7	5
IET9552	RPW6-17Ptb 2	4.1	LB	7	7
IET9553	RPW6-17Ptb 2	4.1	LB	7	7
IET9557	RPW6-17Ptb 2	4.4	LB	9	9
IET9686	RPW6-17/ARC6650	5.2	LS	7	7
IET9688	RPW6-17/ARC6650	5.1	LB	7	5
IET9700	RPW6-17/ARC6650	4.1	LB	7	1
IET9701	RPW6-17/ARC6650	4.6	LB	7	1
IET9910	ET4141/CR98-7216	5.1	LB	3	7
IET9912	IET4141/CR98-7216	5.4	SB	3	9
IET9924	IRS/Surekha	5.0	SB	7	9
IET9941	Sona/K118	4.4	LB	9	7
IET10294	IR20/CR95-1128	3.5	LS	5	3
IET10301	Phalguna/ARC6650	2.4	LB	7	5
IET10413	CR114/CR115	4.2	MS	3	1
IET10417	CR114/CR115	4.3	LS	5	1
IET10418	CR114/CR115	5 .0	LS	3	3
IET10419	CR114/CR115	5.6	MS	7	5
IET10428	IR4219-35-3/IR4570	5.2	LS	7	3
IET10411	CR94/Ratna	5.0	MS	7	7
IET10312	CBII/Ratna	5.9	LS	3	5
IET10313	IR 162/Parmel	5.9	LS	3	7
IET10318	Nam Sagui 19/IR4215-301-2-2-6// IR5853-162-1-2-3	6.8	LS	7	5
IET10319	Nam Sagui 19/JR4215-301-2-2-6// IR5853-162-1-2-3	4.8	LS	7	9
IET10320	Nam Sagui 19/IR4215-301-2-2-6// IR5853-162-1-2-3	4.6	LS	7	9
IET10321	RP6-516-31-6Pusa 33	6.7	LB	5	7
Jaya (check)	RP6-516-31-6Pusa 33	5.5	LB	7	9
PR106 (check)	RP6-516-31-6Pusa 33	5.2	LS	7	7
LSD (0.05)		0.4			
CV (%)		4.9			

[a] MS = medium slender, LS = long slender, LB = long bold, SB = short bold. [b] Resistant = with score of 3 or below, moderately resistant = score 5, susceptible = score 7 or above.

IET10413 and IET10418 showed resistance to both diseases, but their yields were less than those of the check varieties. IET10318 gave the highest yield, but it is susceptible to BB and only moderately resistant to SR. IET10321 also gave good grain yield, was moderately resistant to BB, and susceptible to SR. Entries IET10321 and IET10313 had good yields and showed resistance to BB. ■

Pest resistance - insects

Reaction of rice cultivars to rice hispa

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Hispa *Dicladispa armigera* (Oliv.) (Coleoptera: Chrysomelidae) recently became a serious pest of rice, occurring in endemic form throughout Assam. Adult bugs scrape parenchymatous tissues off the rice leaves by making parallel streaks; grubs mine between the two epidermal layers inside the leaves. Damaged leaves dry up. Damaged rice plants look like straw. Heavy infestations can extensively damage winter, summer, and autumn rice.

We screened for resistance to hispa, 96 local cultivars suitable for postflood situations for resistance to hispa in early Sep 1987, 1988, and 1989 at Sensowapathar, an endemic area of Sibsagar.

The hispa population peaked (25-38 adults/hill) late Sep to early Oct. Borsali, the local susceptible check, had 100% infestation.

Reaction of rice cultivars to hispa in the field. Sibsagar, Assam, India, 1987-89.

Cultivar	Germplasm reference number	Leaf damage [a] (%)
Malbhog	NS 27	15
Pokikoli	NS 30	17
Silguti	S 307	17
Gajep sali-1	S 100	18
Sarusokua	S 248	20

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

Local varieties Malbhog, Pokikoli, Silguti, Gajep sali 1, and Sarusokua suffered 15-20% leaf damage (see table). Nonpreference for feeding may be the resistance mechanism in these varieties. This study confirmed that glutinous rice varieties are less preferred by hispa. ■

Resistance of selected rice varieties to brown planthopper (BPH) and whitebacked planthopper (WBPH)

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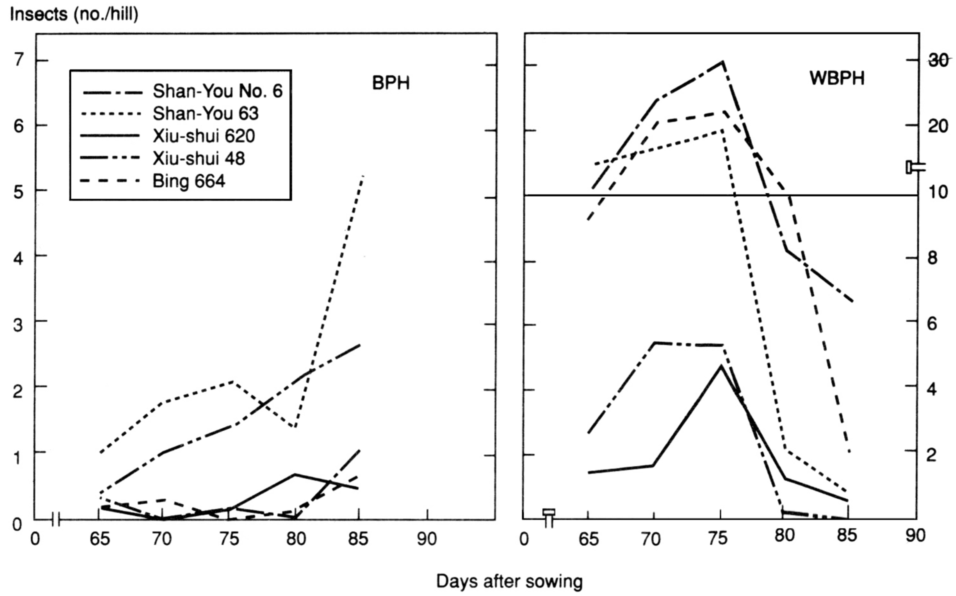

Population dynamics of the brown planthopper (BPH) and the whitebacked planthopper (WBPH) on select on rice varieties in ricefields, Hangzhou, China, 1990.

The important rice pests in China—BPH *Nilaparvata lugens* Stål and WBPH *Sogatellafurcifera* Horvfáth—usually occur together. Many varieties resistant to planthoppers have been released, and the threat of BPH and WBPH outbreaks significantly reduced. We evaluated damage, fecundity, and population dynamics of BPH and WBPH on some widely cultivated rice varieties, using the seedling screening technique in the glasshouse.

Xu-Shui 620 and Bing 664 were resistant to BPH but moderately resistant and moderately susceptible, respectively, to WBPH. Shan-You No. 6 was resistant to BPH but susceptible to WBPH. Both Shan-You 63 and Xiu-Shui 48 were susceptible to both BPH and WBPH.

In the ovipositing test, a pair of newly emerged BPH or WBPH adults were introduced into test tubes containing one plant of a variety. Plants were replaced every 2 d and the number of eggs laid counted.

At tillering and booting, the BPH female laid significantly more eggs on Shan-You 63 and Xiu-Shui 48 than on other varieties, but BPH fecundity at booting was higher than at tillering (see table). Shan-You No. 6, Shan-You 63, and Xiu-Shui 48 received more WBPH eggs than Bing 664 and Xiu-Shui 620 at tillering, but at booting, significantly fewer WBPH eggs were laid on all varieties.

In a field survey, Xiu-Shui 620, Shan-You No. 6, and Bing 664 had lower BPH populations than Shan-You 63, and Xiu-Shui 48. The number of BPH increased gradually with plant age, but the number of WBPH decreased rapidly with plant age after 73 d old. This seems to be due to the decline in fecundity of WBPH after booting (see figure).

Japonica variety Xiu-Shui 620 appears to be most valuable as a BPH and WBPH resistance donor. ■

Damage and fecundity of BPH and WBPH on selected rice varieties.[a] Hangzhou, China, 1989.

Variety	Damage rating[b]		Fecundity of BPH[c] (eggs/female in 8 d)		Fecundity of WBPH[c] (eggs/female in 8 d)	
	BPH	WBPH	Tillering	Booting	Tillering	Booting
Shan-You No. 6	1.3	9.0	51.2 bc	79.2 b	112.7 ab	92.8 a
Shan-You 63	8.7	9.0	74.5 b	139.9 a	138.6 a	86.0 a
Xiu-Shui 620	1.0	3.7	56.0 bc	78.5 b	77.4 b	69.9 a
Bing 664	2.3	5.7	34.9 c	62.9 b	82.7 b	74.6 a
XU-Shui 48	9.0	8.0	128.9 a	132.0 a	126.5 a	93.0 a
Rathu Heenati (resistant check)	1.0	1.3	22.4 c	28.6 c	12.4 c	10.1 b
TN1 (susceptible check)	9.0	9.0	113.2 ab	125.6 a	104.8 ab	88.4 a

[a]Separation of means in a column by Duncan's multiple range test at the 5% level. [b]By the Standard evaluation system for rice. [c]Av of 2 replications.

Stress tolerance—adverse soils

Rice genotypes with tolerance for low available phosphorus in Sierra Leone soils

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Soils in Sierra Leone are low activity clay type and low in available P. Inadequate P retards growth and development of rice. Identification of genotypes tolerant of low available P will assist breeders and farmers in minimizing adverse effects of P deficiency.

In 1989-90, we screened 294 local rices collected in 1988 for tolerance for low available P. In the uplands, 72 accessions of *O. glaberrima* and 72 of *O. sativa* were tested with and without P; in the inland valley swamp, 70 accessions of *O. glaberrima* and 80 of *O. sativa* were evaluated.

Upland soil was sandy loam (Oxisol) with pH H_2O (1:1) 4.9, 4.3 kg Bray I's P/ha, 67 kg Bray I's K/ha, 105 kg total P/ha; 0.78% organic C, and CEC 10.2 meq/100 g. Inland valley swamp soil was clay loam (Typic Tropaquept) with pH H_2O (1:l) 4.2, 5.3 kg Bray I's P/ha, 74 kg Bray I's K/ha, 110 kg total P/ha, 2.4% organic C, and CEC 18.3 meq/100 g.

At the upland site, rice seeds were drilled 0.2 m apart in three 5-m-long rows/variety. At the inland valley swamp site, 21-d-old seedlings were transplanted at 2-3 seedlings/hill, 0.15- × 0.20-m spacing, in three 5-m-long rows/variety. Fertilizer was 60 kg N as urea, 32 kg K as muriate of potash at the upland site, and 40 kg N and 32 kg K/ha on the inland valley swamp. P was applied at 25 kg/ha, as appropriate.

In the uplands, 30 *O. glaberrima* and 10 *O. sativa* varieties showed tolerance for low P; in the inland valley swamps, 20 *O. glaberrima* and 11 *O. sativa* accessions showed tolerance (Table 1). These results indicate *O. glaberrima* varieties have greater tolerance for low available P than *O. sativa* varieties. These accessions will be used in breeding for tolerance for low available P.

Tolerance for low available P correlated significantly with tiller production, panicles/m^2, panicle weight, and days to 50% flowering (Table 2). ■

Table 1. Rice germplasm materials tolerant of low available P in Sierra Leone.[a]

Rice accessions	Upland				Inland valley swamp			
	T	MT	S	Total	T	MT	S	Total
O. glaberrima	30	20	20	72	20	20	30	70
O. sativa	10	15	47	72	11	18	51	80
Total	40	35	69	144	31	38	81	150

[a]T = tolerant (90-100%), MT = moderately tolerant (80.90%), S = susceptible (less than 80%).

Table 2. Correlations between tolerance for low available P and some plant characters.[a]

	Upland		Inland valley swamp	
	O. gla.[b]	*O. sat.*[b]	*O. gla.*[c]	*O. sat.*[d]
Tolerance vs				
a. tiller no. at maximum tillering	0.80**	0.75**	0.68**	0.62**
b. panicles/m^2	0.58**	0.49**	0.45**	0.40**
c. plant height	0.21 ns	0.23 ns	0.17 ns	0.22 ns
d. duration	-0.62**	-0.59**	-0.63**	-0.59**
e. panicle weight	0.66**	0.71**	0.59**	0.75**
f. phosphorus content in grains	0.72**	0.64**	0.48**	0.46**

[a]Significant at the 1% (**) level. ns = not significant. [b]n = 72. [c]n = 70. [d]n = 80.

Integrated germplasm improvement—irrigated

VX-83, a promising very short-duration rice variety in Vietnam

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Very short-duration rice varieties are important for intensifying farming systems in Vietnam and expanding the areas of winter crops such as maize, sweet potato, soybean, potato, and vegetables.

In 1985 we used diallel crossing method to estimate the combining ability of some rice varieties and selected the promising cross-combination line 64-8-3. It matures in 95-100 d, has semidwarf stature, and is tolerant of lodging, drought, and submergence. It is a high-tillering plant type, with yields of 6-8 t/ha, 1,000-grain weight 27-28 g, resistance to major diseases and pests, and high grain quality. Line 64-8-3 was named as rice variety VX-83 and recommended for production.

VX-83 was selected from the cross IR8/IR22-XL//IR19746-11-33 (or CN2).

Performance of VX-83 in replicated yield trials at nine locations in 1988-89 is given in Table 1. VX-83 has the same duration as IR19746-11-33 and CN2 (check 2), and is about 18-22 d earlier than IR8423 (check 1). VX-83 yields were higher than those of other entries. It has better resistance to major diseases and pests (Table 2).

VX-83 is recommended for late spring, early summer, and summer-autumn rice crops. ■

Table 1. Yields of VX-83 and other rices at 9 locations in 1988-89.

Entry	Yield (t/ha)								
	I	II	III	IV	V	VI	VII	VIII	IX
IR8423 (check 1)	4.6	4.6	4.6	4.3	4.3	4.4	4.6	4.6	4.6
VX-83	4.6	4.6	4.6	4.4	4.3	4.5	4.6	4.6	4.6
C662083	4.4	4.4	4.4	4.1	4.0	4.0	4.4	4.4	4.4
IR19746-11-33 (check 2)	3.9	3.9	3.9	3.7	3.7	3.6	3.9	3.9	3.9

Table 2. Resistance of VX-83 to diseases and pests.

Entry	Reaction[a] to			
	Brown planthopper biotypes 1 and 2	Bacterial blight	Sheath blight	Blast
IR8423 (check 1)	1	2	7	5
VX-83	1	1	3	3
C662083	3	1	3	3
IR19746-11-33 (check 2)	1	2	7	5

[a]1 = resistant, 3 = moderately susceptible, 7 = susceptible.

Performance of IR64 in Karnataka, India

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We tested IR64 (selected from the cross IR5657-33-2-1/IR2061-465-1-5-5, designated IR18348-36-3-3) in trials of the All India Network of the Directorate of Rice Research, under IET no. 9671. It yielded 4.0-8.7 t/ha in different states and is already popular with farmers in Andhra Pradesh and parts of Orissa and Karnataka.

In Karnataka, yield trials were conducted in both the wet (WS) and dry seasons (DS).

Under Bangalore and Mysore conditions in the rainy season, duration was 125-135 d, but a week earlier under Shimoga and Chitradurga conditions. Duration was 4-5 d longer in DS. In experimental farm trials 1988-90, mean grain yields ranged from 6.8 t/ha in DS to 6.2 t/ha in WS. Even when transplanted the third week of Aug in WS, it produced 4 t/ha, compared to 3.0-3.5 t/ha of other short-duration varieties. It failed to perform well when it was planted as late as Sep and Oct. No serious pest or disease incidence was observed when it was planted in Jun-Jul in WS and Jan-Feb in DS. In late WS at Bangalore, blast disease attacked many varieties, but was not found on IR64. It scored 2 against 7 for susceptible check S317 for leaf blast. It had no neck blast.

In irrigated farmers' fields in Mysore, Hassan, Chitradurga, and Shimoga districts, grain yields ranged from 6.2 to 7.5 t/ha against 6.0-6.5 t/ha for emergency Sona, Rasi, Madhu, Telhamsa, and Jyothi.

Height is 70 to 90 cm, depending on the season. Tillering ability is moderate, but grains/panicle, grain-filling percentage, and grain weight are on the high side, implying that they are the characteristics contributing to yield.

Grain is slender with straw-colored husk, and has been found to be very good for puffing, which earns a premium in the market. Grains do not have any pigmentation or abdominal white, making the variety attractive to consumers. Brown rice recovery is 77-78% and head rice recovery 60-67%. Cooking quality was judged good by a taste panel that included farmers. ■

Ptb 46 (KAU1727), a high-yielding, widely adaptable rice variety from Kerala, India

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KAU1727, a short-duration, semidwarf rice culture from the cross Triveni/IR2061, was identified as high-yielding with multiple resistances and wide adaptability. It has been released as Ptb 46 in Kerala.

The 120-d variety has white slender grains and is suitable for all three seasons in Kerala.

In 1983, KAU1727 was evaluated in the International Rice Yield Nursery (IRYN) early group at 37 sites in 18 countries (see table). It ranked first among 25 elite breeding lines with an average yield of 5.3 t/ha. In 1984, the culture ranked second with a mean yield of 5.1 t/ha. Average yield of check variety IR36 was 4.8 and 4 t/ha, respectively.

In screening trials at IRRI, KAU1727 exhibited resistance to all three brown planthopper biotypes. In multilocation trials, it exhibited resistance to green leafhopper, blast, bacterial leaf streak, and leaffolder. In trials at Pattambi, ratooning ability was highly promising. ■

Performance of KAU1727 in 1983 and 1984 International Rice Yield Nursery.

Location	1983		1984	
	Days to 50% flowering	Grain yield (t/ha)	Days to 50% flowering	Grain yield (t/ha)
Southeast Asia	87	4.8	87	4.1
South Asia	97	5.0	101	5.2
East Asia	110	7.2		
West Asia and North Africa	104	8.4	112	10.3
Latin America			86	4.9
Overall	94	5.3	94	5.1

Contribution of IR36 to new varieties in Hunan, China

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Xiang-Zhong Xian No. 2, a derivative of the cross Ai-Bao//IR36/Shuang-Gui 36, released in Dec 1989, is a high-yielding indica rice variety. It performed well in 1987-89 regional trials in monocropped midseason rice areas.

Average grain yield was 8.3 t/ha, 2.4% higher than that of high-yielding hybrid rice Shan-You 63. Average growth duration was 133 d in Hunan, 5 d earlier than Shan-You 63. It is resistant to whitebacked planthopper and brown planthopper and moderately resistant to rice blast and sheath blight. Xiang-Zhong Xian No. 2 also has resistance to lodging and good response to high levels of fertilizer.

In 1990, Xiang-Zhong Xian No. 2 was grown in 16,667 ha in Hunan. In midseason cropping, it yielded an average 7.5-7.9 t/ha, with the record 10.5 t/ha. In late rice cropping, it yielded 6.6-8.2 t/ha, with the highest 9.8 t/ha.

One reason Xiang-Zhong Xian No. 2 has such high yield potential and multiple resistance is the contribution of IR36's excellent resistance and agronomic characters. ■

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

Integrated germplasm improvement–upland

Makiling, an improved variety for acid upland areas in the Philippines

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The Philippine Seed Board recently approved the release of breeding line IR10147-113-5-1-1-5 as PSBRC-1, popular name Makiling, for planting in acid upland areas. This cultivar was derived from KN-1B-361-1-8-6//E425/IR22///BPI-76*9/Dawn, using parents from Indonesia, West Africa, Philippines, and the U.S.

KN-1B-361-1-8-6 and E425 are sources of drought resistance and tolerance for acid soils. E425 is also resistant to blast and has a deep and thick root system. Recovery ability after moisture stress is contributed by the BPI-76*9/Dawn parent. Good eating quality is contributed by parents from Indonesia and the Philippines.

Makiling has a green basal leaf sheath. The flag leaf angle is intermediate. Under favorable conditions, panicle length is about 25 cm. The flag leaf is about 35 cm long. The lemma and palea have gold furrows on a straw background and short hairs at the upper portion. The gold color is more intense in the upper portion of the panicles, fading toward the base. Apiculus color is straw and the grains have no awns. Grain shape is intermediately slender.

Data from the National Rice Cooperative Testing Project (NRCT) of the Rice Varietal Improvement Group of the Philippine Seed Board showed that Makiling varies in plant height, from 94 to 130 cm, and matures in 114-130 d, depending on location and environmental conditions.

It is resistant to deadhearts and moderately resistant to whiteheads caused by the striped stem borer. It is moderately susceptible to the yellow stem borer and three races of brown planthopper. It is resistant to blast, and has intermediate resistance to bacterial blight, ragged stunt, and grassy stunt virus.

Amylose content is about 20% and gel consistency is 48%. Head rice recovery is 48%; milling recovery averages 64%, with 4.5% chalky grains.

In field tests at IRRI, Makiling showed moderate resistance to field drought and good recovery ability.

In six regional trials in the Philippines, Makiling yielded an average 2.4 t/ha over four seasons (Table l), 4% higher than the check. In farmer-managed NRCT trials over three seasons, the yield advantage was 6% (Table 2). In regional trials, Makiling performed best in Tupi, South Cotabato, and Musuan, Bukidnon, where the soil is acid. In on-farm trials, it performed best in Calaca, Batangas, and Janiuay, Iloilo. ■

Table 1. Yield over locations[a] and seasons of promising upland rice selection IR10147-113-5-1-1-5 and check UPLRi-5, National Rice Cooperative Testing Project, Philippine Seed Board, 1985-88.[b]

Year, season	Yield (t/ha)						Season mean (t/ha)
	CMU	IES	LGES	MRRTC	UPLB	TSF	
			UPLRi-5 (check)				
1985 WS	4.0	3.4			2.5	2.4	3.1
1986 WS	1.9	2.2		2.3		3.4	2.5
1987 WS	3.0		1.2			2.8	2.3
1988 WS	3.6	2.1	1.5	1.0	2.4		“1
			IR10147-113-5-1-1-5				
1985	3.7	2.8			2.2	3.4	3.0
1986	3.9	1.8	-2.0	0	2.5	2.5	
1987	3.5		1.3			3.1	2.6
1988	2.3	1.1	1.5	1.2	2.1		1.6
	GMTE = 2.4	GMC = 2.5	YA = –3.9%	No.* = 3/16	No. # = 3/16		

[a] CMU = Central Mindanao University, Musuan, Bukidnon, IES = Ilagan Experimental Station, Isabela, LGES = La Granja Experimental Station, Negros Occidental, MRRTC = Maligaya Rice Research and Training Center, Nueva Ecija, UPLB = University of the Philippines at Los Baños, College, Laguna, TSF = Tupi Seed Farm, South Cotabato. [b] GMTE = grand mean of test entry; GMC = grand mean of check YA = yield advantage of a given test entry over the check [(GMTE - GMC) + GMC] × 100, No. * =number of time a test entry has significantly higher yield than the check. No. # = lower than the check.

Table 2. Grain yield of promising upland rice selections in on-farm trials, National Rice Cooperative Testing Project, Philippine Seed Board, 1987-89 wet season.

Site	Grain yield (t/ha)					
	UPLRi-5 (Check)			IR10147-113-5-1-1-5 (PSBRi 3)		
	1987	1988	1989	1987	1988	1989
Trece Martires, Cavite		1.0	4.8		1.1	4.2
Calaca, Batangas	4.3	2.2	3.3	4.3	2.6	4.0
Padre Garcia, Batangas	4.7			4.5		
Janiuay, Iloilo #1		3.5			3.7	
Maasin, South Leyte	2.7			2.9		
Janiuay, Iloilo #2	-	3.6			4.7	
Victorias, Negros		2.2	1.7		1.9	2.1
Mean	3.9	2.5	3.2	3.9	2.8	3.4

Integrated germplasm improvement–rainfed

TP-AS42673, a high-yielding, short-duration rice for semidry and wet conditions

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In Agasteeswaram and Thovalai Taluks of Kanyakumari district, 7,000 ha of rice is direct seeded in semidry conditions during May when the summer rains start. It grows 40-50 d with available soil moisture, then is converted to wet conditions when canal water is received for irrigation. In 7,000 ha of transplanted rice, nurseries are raised Jun-Jul after receipt of canal water.

We evaluated eight improved short-duration cultures under both conditions 1989-91, with popular varieties TPS1 and TKM9 as checks. Test plots were 5 × 4 m, laid out in a randomized block design with three replications. Three seeds/hill were dibbled in May at 15- × 10-cm row spacing for semidry conditions and three seedling/hill were transplanted in July at 15- × 10-cm spacing for wet conditions. Fertilizer was applied at 75-37.5-37.5 kg NPK/ha.

TP-AS42673 (ASD/IR36) gave the highest mean grain yield under both conditions (see table). Its higher yield potential may be ascribed to more productive tillers and more grains/panicle.

TP-AS42673 is a semidwarf variety with high tillering ability and light green foliage. The panicle is compact with good spikelet fertility. Grain is short bold, with a white pericarp. It shows tolerance for drought and blast. ■

Performance of TP-AS42673 under semidry and wet conditions at Agricultural Research Station, Thirupathisaram, Tamil Nadu, India.

Entry	Parentage	Grain yield (t/ha)							Productive tillers/hill (no.)	Grains/ panicle (no.)
		Semidry			Wet			Overall mean		
		1989	1990	Mean	1989	1990	Mean			
TP-AS42673	ASD8/IR36	4.6	4.7	4.6	5.0	4.6	4.8	4.7	10	202
TP-AS26556	IET5233/IR2153	5.3	4.5	4.9	2.9	3.8	3.3	4.1	10	179
TP-AS22954	IRON309/ADT31	4.9	4.2	4.5	3.8	3.9	3.8	4.1	10	188
TP-AS42700	ASD8/IR50	4.2	4.1	4.1	4.2	4.0	4.1	4.1	8	178
TP-AS25370	ASD1/IRON297	2.8	3.9	3.3	4.6	4.5	4.5	4.0	7	174
TP-AS42698	ASD8/IR36	4.4	3.5	3.9	3.8	4.2	4.0	4.0	8	152
TP-AS42692	ASD8/IR36	4.3	3.2	3.7	3.8	4.2	4.0	4.0	9	149
TP-AS37419	IET1444/IR20	3.8	3.3	3.5	4.0	3.1	3.5	3.6	7	128
TPS1 (check)	IR8/Kattisamba	5.1	4.1	4.6	3.6	3.9	3.7	4.1	8	178
TKM9 (check)	TKM7/IR8	4.2	3.5	3.8	3.3	4.2	3.7	3.6	8	162
LSD (0.05)		1.1	0.2	07	0.3	0.4	0.4	0.5		

Integrated germplasm improvement—deepwater

Newly released deepwater rice varieties in West Bengal

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Four new rice varieties developed for deep water (50-100 cm) at the Chinsurah RRS were released in 1989.

NC490 (IET8987), released as Nalini, is a pureline selection from farmers' cultivar Sindurmukhi. It is photoperiod-sensitive and flowers 26-28 Oct in West Bengal. Well-exserted panicles are 22 cm long with about 200 medium slender grains (5.6 mm long, 2.5 L/B ratio); 1,000-grain weight is 20 g. Highest yield was 5.8 t/ha at Central Rice Research Institute (CRRI), Cuttack, in 1983 preliminary yield trials. Average yield was 3.4 t/ha (see table). Nalini is resistant to blast (Bl) and moderately resistant to stem borer (SB), sheath blight (ShB), and bacterial blight (BB).

NC491 (IET8988), released as Matangini, was selected from Kajallata. It flowers in late Oct. Its compact panicle has about 200 short bold grains (6 mm long, 2.0 L/B ratio); 1,000-grain weight is 27.2 g. It had the highest yield at CRRI, 6.6 t/ha in 1983. Matangini is

Yields of new deepwater rice varieties in state and national trials in India, 1983-88.

Year	Trial[a]	Sites (no.)	Water depth (cm)	Yield[b] (t/ha) New variety	Check
	NC490 (IET8987), Nalini				
1983	National (PVT-5)	7	42 - 75	3.6*	2.9 (Tilakkachari)
1984	National (UVT-5)	7	36 - 66	3.1	2.8 (Local variety)
1985	National (UVT-5)	10	22 - 90	3.0**	1.9 (Janki)
1985	Physiological screening	3		3.5*	2.8 (Local variety)
1986-88	State adaptive	4	50 - 85	3.1*	2.5 (Tilakkachari)
1988	On-farm (minikit) (3 districts)	8		3.9	
	Total or av	36		3.4	
	NC49I (IET8988), Matangini				
1983	National (PVT-5)	3	42 - 65	3.8**	2.3 (Local variety)
1985	National (UVT-5)	9	22 - 90	3.0	2.7 (Local variety)
1985	Physiological screening	1		2.5	2.2 (Local variety)
1986	National (UVT-5)	3	62 - 110	2.5	2.1 (Local variety)
1986	Physiological screening	2		3.3*	2.8 (Local variety)
1986-88	State adaptive	5	65-100	3.4*	2.6 (NC487)
	Total or ave	23		3.1	
	NC493 (IET8989), Amulya				
1983	National (PVT-5)	4	42 - 75	3.3	2.9 (Tilakkachari)
1984	National (UVT-5)	8	36 - 66	3.1*	2.5 (Local variety)
1985	National (UVT-5)	9	22 - 90	3.2**	2.0 (Janki)
1985	Physiological screening	4		3.6	3.2 (Local variety)
1987-88	State adaptive	2	55 - 95	3.0*	2.2 (NC488)
1988	On-farm (minikit) (3 districts)	8		3.1	
	Total or av	35		3.2	
	CN570-652-39-2 (IET10001), Dinesh				
1985	National (PVT-5)	3	40 - 55	3.3*	2.7 (Tilakkachari)
1986	National (UVT-5)	4			1.9 (Local variety)
1986	Physiological screening	2	62 - 113	2.7*	1.9 (Janki)
1987	National (UVT-5)	5	50 - 108	4.5**	2.8 (Local variety)
				3.0*	2.2 (Local variety)
1987-88	National (UVT-6)	3	95 - 116	3.5**	2.4 (Local variety)
1987	Physiological screening	1		3.5	3.0 (NC492)
1987-88	State adaptive	2	75 - 105	3.3**	2.1 (Jaladhi 2)
	Total or av	20		3.4	

[a]PVT-5 = preliminary variety trial-5, UVT-5 = uniform variety trial-5, UVT-6 = uniform variety trial-6. [b]*,** = significant at 5 and 1% level.

moderately resistant to B1 and ShB, and moderately susceptible to BB.

NC493 (IET8989), released as Amulya, is a selection from the land race Najani. It is photoperiod-sensitive and flowers 26-28 Oct. Panicles are long, compact, and well-exserted, with more than 200 long slender grains (6.4 mm long, 3.1 L/B ratio); 1,000-grain weight is 24 g. Highest yield was 7.4 t/ha in uniform variety trials at Arundhutinagar, Tripura, in 1985. Amulya is resistant to ShB and moderately resistant to BB and SB.

CN570-652-39-2 (IET10001), released as Dinesh, is from a cross between Jaladhi 2 and Pankaj. It flowers 30 Oct-3 Nov. It has good kneeing ability. Panicles are 22 cm long with 185 short bold grains (5.9 mm long, 2.0 L/B ratio). It had the highest yield (4.8 t/ha) at Chinsurah in 1987. It is moderately resistant to ShB and Bl and moderately susceptible to BB. ■

Seed technology

Hand-operated vacuum packing system for rice seed storage

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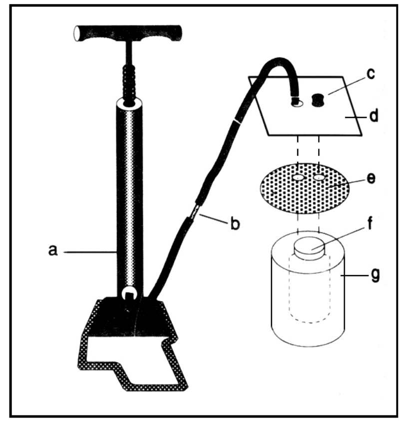
We developed a hand-operated vacuum packing system to facilitate dry seed storage. Reducing the oxygen content in sealed containers prevents seed rehydration and suffocates, adult insects. Components of the vacuum packing system are

- a bicycle tire pump, with pump plunger seal or cup in reverse, to use as the vacuum pump;
- a tire inner tube stem valve, to use as a check valve to prevent backflow of air into the vacuum chamber;
- a large food can, irrigation pipe, or pressure cooker to use as the vacuum chamber;
- a lid for the vacuum chamber, used with a rubber gasket made from a tire inner tube and sheet metal or wood;
- a glass jar with a screw cap and gasket or a lid with a plastic inner liner, to use as the storage container.

Seeds are placed in the glass jar and its lid is twisted on snugly, but not so tight that air cannot escape during evacuation. The jar is placed in the vacuum chamber, the chamber evacuated, and the vacuum released rapidly. The rapid intake of air into the vacuum chamber will slam the jar lid down and seal it. Tightening the screw cap will help secure the seal.

A vacuum system using a 16-cm-diameter × 17-cm-high food can requires 8-15 strokes with the modified (4-cm-diameter × 62-cm-high) bicycle pump to attain a vacuum adequate for sealing. We have easily achieved 50-80 kPa (15-25 inches mercury) suction. Larger vacuum chambers need more strokes to achieve the desired air evacuation.

Including dehydrating agents, such as silica gel, in the storage jar facilitates moisture control. ■



Vacuum packing system: a) bicycle pump with reversed cup, b) tire stem valve, c) rubber stopper, d) sheet metal or plywood, e) rubber gasket, f) jar, and g) food can.

CROP AND RESOURCE MANAGEMENT

Physiology and plant nutrition

Rice mitochondria surface membrane contains concanavalin A receptors

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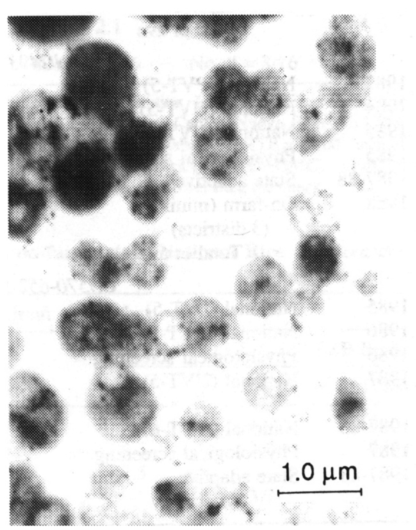
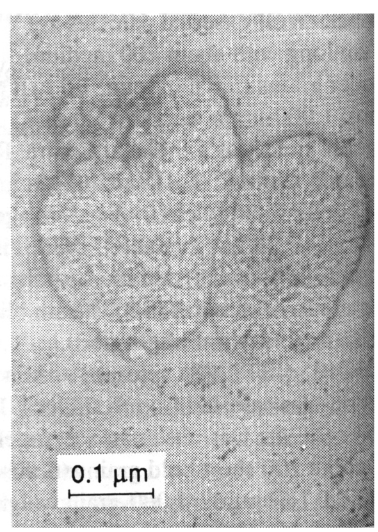
Cell organoids membranes contain the residues of different sugars. The residues in surface membranes provide informational cooperation with other organoids, transport molecules, etc. The presence of sugar residue in the surface membrane of



1. Rice mitochondria stained with Con A gold conjugate suspension.



2. Rice mitochondria stained with Con A gold conjugate.

rice mitochondria and their nature can be shown with the help of the lectins.

We used the concanavalin A (Con A) gold conjugates. This lectin has sugar specificity: D-mannose > D-glucose > N-acetyl D-glucosamine. Rice mitochondria were isolated, fixed, incubated in 20% Con A gold conjugate solution in phosphate buffered saline (PBS), and studied under an electron microscope.

The rice mitochondrion surface membrane binds the Con A gold conjugate (i.e., contains Con A receptors, probably D-mannose) (Fig. 1, 2). When stained with Os, the rice mitochondrion surface looks as if it consists of global grains. This is probably the result of protein structure distribution.

The golden deposits structure looks like a ramified tree. Evidently this is connected with the fact that the lectin carbohydrate receptors are parts of the polymer chains. ■

Fertilizer management—organic sources

Performance of *Sesbania rostrata* in calcareous soils

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We compared the performance of stem- and root-nodulating *S. rostrata,* a newly introduced green manure (GM) crop, and *S. aculeata,* the GM crop commonly grown in Bihar, with different levels of inorganic fertilizer in an irrigated ricefield during 1987-89 wet season (May-Dec).

Soils were silt-loam with pH 8.5, 0.60% organic C, and 272-16-119 kg available NPK/ha.

The experiment was laid out in a randomized black design with four replications. GM crops were broadcast the third week of May at 30 kg seed/ha. When needed, 17.6 kg P/ha was basal applied. To ensure germination, one irrigation was applied 5 d before sowing.

The GM crops were incorporated 45 d after sowing; on the same day, 35- to 40-d-old seedlings of 150-d-duration rice variety Radha were transplanted. K was basal applied at 16.6 kg/ha in all plots. P and N were applied per treatment (see table).

GM plant stands were uniform in all plots. Dry matter production and N yield were estimated at incorporation.

S. rostrata added more dry matter and N than *S. aculeata* in all treatments. P applied at sowing of GM crops was superior to P applied at puddling.

Highest grain yields (3.1-3.3 ma) were with recommended fertilizers; with *S. rostrata* plus P and 40 kg N/ha in two equal splits; and with *S. aculeata* plus P and 40 kg N/ha in two equal splits. Straw yields with these treatments followed the same trend. Net returns were higher with *S. rostrata* plus P and N. ■

Effect of GM crops on rice yield and net return per rupee of investment on pooled (1987, 1988, and 1989) basis, Bihar, India.

Treatment[a]	Dry matter from GM (t/ha)	N accumulated (kg/ha)	Rice yield (t/ha) Grain	Rice yield (t/ha) Straw	Net return
Sesbania aculeata + P + 40 kg N/ha in 2 equal splits: MT + PI	4.2	76.2	3.1	5.1	1.10
S. aculeata + no P + 40 kg N/ha in 2 equal splits: MT + PI	4.0	72.4	2.8	4.7	1.08
S. rostrata + P + 40 kg N/ha in 2 equal splits: MT + PI	4.3	81.5	3.3	5.5	1.24
S. rostrata + no P + 40 kg N/ha in 2 equal splits: MT + PI	4.0	75.0	2.9	4.8	1.15
40 kg N/ha in 2 equal splits: MT + PI	-	-	2.4	3.9	0.71
80-40-20 kg NPk/ha	-	-	3.3	5.4	1.20
S. aculeata + recommended 40-20 kg PK/ha	4.0	12.3	2.4	4.0	0.85
S. rostrata + recommended 40-20 kg PK/ha	4.1	16.4	2.5	4.2	0.93
Control (no GM, no NPK)	-	-	1.8	2.8	0.51
LSD (0.05)	-	-	0.3	0.4	0.12

[a]MT = maximum tillering, PI =panicle initiation, GM = green manure.

Integrated pest management—diseases

Kresek in mature rice plants

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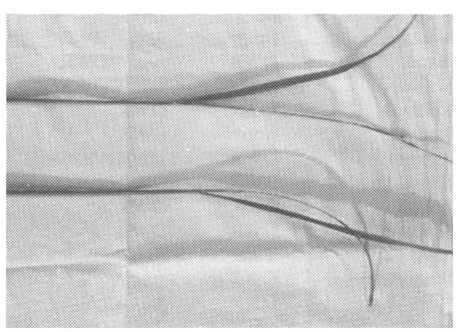
We found kresek in mature rice plants during 1990 in rainfed lowland fields at the BRRI Regional Station experimental farm and in farmers' fields in Barisal. This is the first report of this disease in Bangladesh.



Infested tiller showing normal older leaves and leaf sheaths.

The first symptom appears in the youngest leaf as dense whitish stripes or lesions at the base of the leaf blade. This whitish lesion moves upward through the midrib, which turns brown. Gradually, the leaf turns yellow and rolls along the midrib. It looks like deadheart caused by stem borer, but the dead leaf cannot be pulled up easily. Older leaves and leaf sheaths remain normal and green (see figure).

When a diseased tiller is split, the entire leaf base enclosed by the older leaf sheath appears soft and rotten and has a very strong, unpleasant odor. Leaves developing later seldom pass through the damaged leaf base, but are malformed. In some cases, the entire tiller becomes damaged, turns dark brown, looks rotten, and has an unpleasant odor.

Disease symptoms were confined mostly to plants between tillering to boot. Seedlings that show kresek symptoms die within a week or two; infected mature tillers do not die. In farmers' fields, almost all varieties or lines were infected, with less intensity in local varieties and higher in BR11 (see table). ■

Rice entries severely infected with kresek at the mature plant stage in rainfed lowland fields at BRRI Regional Station, Barisal, 1990.

Designation	Infected hills (%)	Infected tillers (%)	Designation	Infected hills (%)	Infected tillers (%)
Affakilombero-1-96	90	33	BRB468-33-2-2	100	24
B5986-MR-B-1-10	100	46	BRB468-33-3-1	100	31
BR11	100	49	BRB468-33-3-2	100	24
BR23	70	36	BRB489-22-2-2	100	26
BR850-9-1-1	90	36	BRB489-51-3-2	100	27
BR1244-9-1-2-1-1	80	30	BRB489-53-1-4	100	23
BR1711-27-3-2-2	80	32	BRB489-58-2-6	90	28
BR1728-26-1-1-5	90	30	BRB489-60-1-9	90	29
BRB398-26-1-3	90	31	BRB498-6-B	100	23

Integrated pest management–insects

Influence of changing cropping pattern on insect pests of deepwater rice

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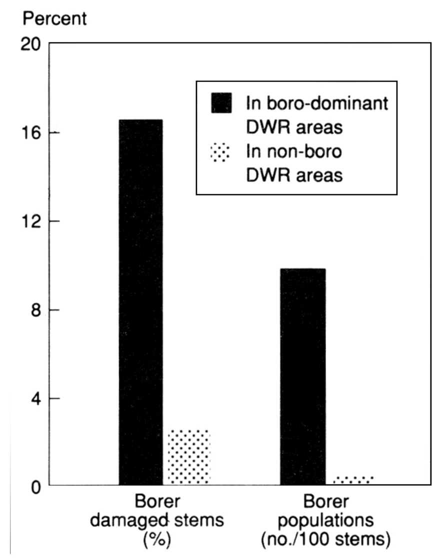
The traditional cropping pattern in deepwater rice (DWR) areas of Bangladesh is single DWR or mixed DWR + aus (summer rice) followed by nonrice rabi (winter) crops or fallow. During the last two decades, irrigated modern variety (MV) boro (winter rice) rice has been grown in about 0.8 million ha of the 2.0 million ha DWR area. In many DWR areas, boro - fallow or boro - rabi crops has become the dominant cropping pattern.

We compared the incidence in DWR of insect pests, particularly yellow stem borer (YSB) *Scirpophaga incertulas,* in boro rice-dominant and DWR-dominant sites in central Bangladesh in early Jul 1988, when DWR was at the early elongation stage and aus rice was either at the ripening stage or harvested. YSB incidence was estimated by dissecting about 100 DWR stems from each site. Incidence of other pests was recorded.

YSB, hispa beetle *Dicladispa armigera,* and long-horned cricket *Euscyrtus concinnus* were moderate to severe at some sites (see table). In boro rice sites, stem borer (SB) damage to DWR was about six times greater than at the DWR or nonboro rice sites (see figure; p<0.01, t-test on square root transformed data).

Of the 60 borer larvae and pupae found during stem dissections, 97% were YSB and the rest (3%) dark-headed borer *Chilo polychrysa.* Larvae and pupae populations were significantly higher at the boro rice sites (9.88/100 stems) than at the nonboro rice sites (0.56/100 stems, p <0.01, t-test on square root transformed data). Correlation was positive between the presence of a boro crop in DWR areas and SB damage levels (r = 0.618, p <0.05, df = 14).

Hispa activity was also higher in boro crop areas. Hispa incidence appeared higher in single-crop DWR fields than in mixed aus + DWR fields; the opposite was true of long-horned cricket incidence. Correlation was negative between aus +



Population densities of yellow stem borer *Scirpophaga incertulas* Walker in DWR and levels of damaged stems in boro-dominant and non-boro deepwater rice locations, July 1988, Bangladesh. Boro =

Incidence of 3 insect pests in deepwater rice in selected areas in Bangladesh, 1988.[a]

Location	Dominant rice crop in the area	Present rice crop	Stem borer: Damaged stems (%)	Stem borer: Population (no./100 stems)	Hispa beetle[b]	Long-horned cricket[b]
Lowhajang	DWR	DWR	0	0	M-S	Minor
Sherajdikhan	Boro	DWR	14.3	7	M-S	Minor
Mirzapur	Boro	Aus + DWR	21.9	7	Minor	M-S
Basail	DWR	Aus + DWR	1.7	0	Minor	M-S
Kalihati	DWR	Aus+DWR	1.2	0	Minor	Minor
Kalihati	Boro	DWR	2.4	1	M-S	Minor
Rupganj	Boro	DWR	2.8	2	M-S	Minor
Rupganj	DWR	DWR	0	0	Minor	Minor
Narshingdi	DWR	DWR	1.3	1	Minor	Minor
Polash	Boro	DWR	21.5	13	Minor	Minor
Arihazar	DWR	DWR	2.7	0	Minor	Minor
Dhamrai	Boro	Aus + DWR	12.5	3	Minor	M-S
Dhamrai	DWR	Aus+DWR	1.5	0	Minor	M-S
Shibalaya	DWR	Aus + DWR	11.7	3	Minor	M-S
Manikganj	DWR	Aus+DWR	3.3	1	Minor	Minor
Joydebpur	Boro	DWR	34.3	36	Minor	Minor

[a]DWR = deepwater rice, aus = summer rice, boro = winter rice. [b]M-S = moderate-severe.

DWR mixed crops and hispa incidence (r = -0.509, p <0.05, df = 14), but positive in the case of the long-horned cricket (r = 0.76, p <0.01, df = 14).

The change in cropping pattern (increased MV boro rice cropping in DWR areas) positively influenced YSB and probably also favored hispa. Boro cropping favored the establishment of first generation YSB moths (following diapause in winter) in boro rice during Feb and Mar. Irrigated boro cropping also reduced or eliminated high temperature stress (>33 °C) coupled with low relative humidity (<70%) on the YSB during Apr-Jun, which favored population buildup.

YSB seems to concentrate in DWR following boro rice harvest. Hispa prefers young rice plants. That explains its concentration in fields with only DWR. Ripening aus rice probably influenced the high incidence of long-horned crickets in aus rice + DWR fields. ■

Toxicology of insecticides to rice leaffolder (LF) larvae

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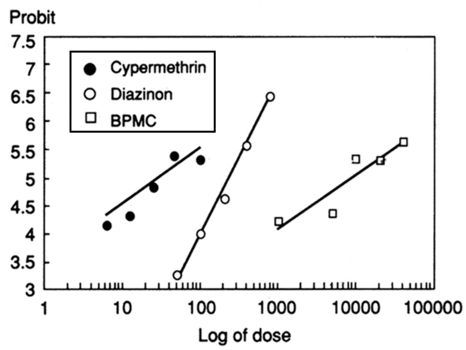
We evaluated the toxicology of three commonly used insecticides: an organophosphate, a carbamate, and a synthetic pyrethroid. Fourth-instar LF *Cnaphalocrocis medinalis* larvae from cultures reared from moths collected in Laguna, Philippines, were topically treated at 15 d old with 0.5 µl of each insecticide solution, using an Arnold Microapplicator. Control larvae were treated with acetone.

Results are given in the table. The probit lines fitted the data well, and the insects used were found to be homogeneous.

In the test for parallelism, probit lines for BPMC and cypermethrin were found to be parallel; diazinon significantly deviated from these two lines (see figure). The parallel lines satisfy the condition of similarity and are thus comparable.

Cypermethrin was about 250 times more toxic than BPMC. This implies that a much smaller dose of cypermethrin is required to cause LF mortality.

These results can be used as baseline data for insecticide resistance studies. ■



Probit lies of insecticides topically applied on the fourth-instar leaffolder *Cnaphalocrocis medinalis* larvae.

Probit analysis of diazinon, BPMC, and cypermethrin on 4th-instar larvae of rice leaffolder *Cnaphalocrocis medinalis.*

Insecticide	LC_{50} (ppm)	Fiducial limits (ppm)	LD_{50} (µg/larva)	Regression equation
Diazinon	259.8	215.5 - 310.1	0.13	$y = 5.07 + 2.70\ (x-12.44)$
BPMC	9896.6	6519.1 -15264.4	4.95	$y = 4.91 + 0.95\ (x-13.97)$
Cypermethrin	40.6	23.0 - 141.1	0.02	$y = 4.83 + 1.11\ (x-11.46)$

Rice whorl maggot (RWM) incidence in Assam

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In May 1990, RWM *Hydrellia philippina* Ferino was observed to attack traditional rice variety Maibi sown 20 Mar 1990 as summer rainfed rice on a 15-20% slope in the hill district of Karbi Anglong, Assam. This is the first report of RWM attacking rice in upland fields. The insect has been recorded earlier on rice crops in the plains and low-lying areas. ■

Dispersal range of rice insect pests under natural conditions in the Phillppines

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We estimated the dispersal range of rice insect pests in the Philippines using a low-cost method that measures rather than manipulates natural movement. Conventional approaches (such as mark-recapture) often require handling the insects in ways that could significantly affect behavior.

During the fallow period between wet and dry season crops in early 1982, we located an isolated 1.5-ha field in Nueva Ecija where IR52 had been grown under irrigation from a shallow well pump. Except for a similar field one km west, this field had the only standing rice within several kilometers.

As the crop approached maturity, we established two parallel transects of kerosene light traps running eastward, 200 m apart. The traps were positioned within the field and at 5, 20, 50, 95, 170, 290, and 485 m into the fallow area, a geometric progression that provided greatest resolution near the field. The lamps were lit every night for more than a month, until harvest in late February.

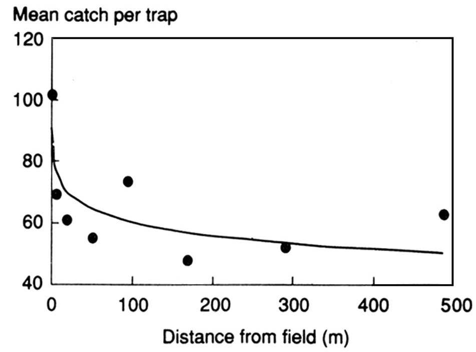
We analyzed catches of *Scirpophaga incertulas, Parapoynx fluctuosalis,* and *Naranga aenescens* from 19 Jan until they began to rise after the fallow area was planted (see table). Catches of other species were too low to analyze.

The best-fitting first- or second-degree nonlinear equations are given in the table and illustrated for yellow stem borer (YSB) males in the figure. Catches declined with distance from the field. Dispersal distances were calculated from regressions corrected for background density (i.e.. insects emerging from rice stubble, other host plants, and distant, scattered sources). We estimated background density from catches in four light traps at two sites 4.5 km to the east and the south. Corrected equations were integrated and rotated about the origin (in other words, assuming that movement was similar in all directions).

Equations[a] relating light trap catches of rice-feeding insects to distance from an isolated field, and estimated dispersal distances. Nueva Ecija, Philippines, Jan-Feb 1982.

	YSB males	YSB females	*P. fluctuosalis*	*N. aenescens*
Period	19/1 - 16/2	19/1 - 16/2	19/1 - 12/2	1911 -8/2
Best-fitting equation	$Y = 87.0 - 5.74 \ln (X + 0.5)$	$Y = 48.1 + 33.0 \ln (X + 0.5) - 2.72 \ln (X + 0.5)^2$	$Y = 11.0 \exp (-0.002 X)$	$Y = 6.83 \exp (-0.003 X)$
F	9.45*	11.7*	4.77*	5.08*
$R^2$0.53		0.59	0.27	0.39
Equation corrected for background density	$Y = 40.0 - 5.74 \ln (X + 0.5)$	$Y = 43.6 + 33.0 \ln (X + 0.5) - 2.72 \ln (X + 0.5)^2$	$Y = 8.59 \exp (-0.003 X)$	$Y = 6.35 \exp (-0.006 X)$
$R^2$0.53	0.59		0.29	0.39
Estimated dispersal distances (km):				
50% of population	0.46	0.76	0.64	0.27
80% of population	0.70	1.10	1.10	0.47

[a] Y = total catch during the indicated period, X =distance from the field edge. * = $P < 0.05$. YSB = yellow stem borer.



Catch of YSB in kerosene light traps 19 Jan-I6 Feb 1982, in relation to distance from the edge of an isolated field planted out of season. The curve is the uncorrected equation given in the table.

Dispersal may have been underestimated because the transects were oriented to the prevailing wind. On the other hand, dispersal from a field planted in synchrony with surrounding areas probably would have been lower, because insects would fly over potential habitat rather than over barren ground. Dispersal estimates are sensitive to the assumed background density, but catches at the traps used to calculate background density were low and uniform for all but YSB males.

The median dispersal distances we found are similar to indices of dispersal derived from the correlation of seasonal abundance as measured in light traps, and the duration of the rice crop in the vicinity (described elsewhere). ■

Rice yellow stem borer (YSB) egg deposition preferences

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We studied preference of YSB *Scirpophaga incertulas* (Walker) moths for egg deposition on deepwater rice (DWR) during the first week of Jul 1988. YSB moth populations were very high in Rajbari, Gazipur (a DWR research site). We counted the egg masses on four randomly selected lines out of 12, each 5 m long, in a regional yield trial.

BR4112-2B-6 and DWC-B-184 had significantly fewer egg masses (Table 1). Plant height, leaf blade width, and foliage color did not correlate with number of egg masses.

Table 1. Yellow stem borer egg masses deposited on deepwater rice[a] entries at early elongation stage. Rajbari, Gazipur, Bangladesh, July 1988.

Line	Replications (no.)	Foliage color	Plant height (cm)	Leaf blade width (mm)	Egg mass density[b] (no./4 rows)
BR4112-2B-6	3	Pale green	128.9	7.8	1.0 e
DWC-B-184	3	Deep green	139.8	8.7	1.3 e
Habiganj Aman II	3	Pale green	118.3	6.5	2.7 de
BR311-B-5-4	4	Pale green	108.7	6.5	3.0 cde
Sadapankaich	4	Pale green	115.2	6.8	3.2 cde
BR516-48-3	3	Green	131.4	7.2	3.3 bcde
BR308-B-2-4	4	Green	115.5	6.1	3.5 bcde
Kartiksail	4	Green	109.0	7.9	3.5 bcde
BR683-65-4-1-1 (c)	3	Pale green	108.8	6.6	3.7 bcde
DWC-B-14-1-x-6	4	Green	107.7	6.3	3.7 bcde
Habiganj Aman I	4	Pale green	110.9	6.2	3.7 bcde
BR683-65-4-1-1 (M)	3	Deep green	99.4	8.1	4.0 bcde
BR4112-2B-9	3	Green	130.4	6.7	4.0 bcde
Habiganj Aman IV	4	Green	105.9	6.4	4.7 bcd
Kartiksail-HR8	4	Green	105.4	6.4	5.0 bcd
BR306-B-3-2-HR46	3	Green	136.4	6.8	5.0 bcd
IR11185-0-0-0-88-2	3	Green	133.4	7.1	5.0 bcd
BR224-2B-2-5	4	Green	115.9	6.2	5.2 bcd
BR4112-2B-2	3	Green	126.8	6.7	5.7 bcd
BR4112-2B-7	3	Green	126.6	8.0	6.0 abc
IR33708-2B-1	3	Green	119.4	6.7	6.3 ab
Sadapankaich-HR40	3	Green	122.5	6.6	6.3 ab
BR4112-2B-5	3	Pale green	125.5	7.4	9.0 a

[a] Water depth varied from 35 to 55 cm on different plots. [b]Counted on 4 of 12 rows each 5 m long, in 3- × 5-m plots. Means followed by the same letter are not significantly different at the 5% level.

In 1989, we tested apparent nonpreference for egg deposition on these DWR entries in a pot experiment in the nethouse, in a completely randomized design with eight replications. Three of the less preferred and two of the highly preferred entries were exposed for 2 d at maximum tillering to about 300 female moths. Egg masses deposited and tiller density were counted and average plant height measured.

BR4112-2B-6 and Habiganj Aman II, two of the less preferred entries in the field, had significantly fewer egg masses than did highly preferred Sadapankaich-HR40 (Table 2). DWC-B-184, which was less preferred in the field, had about the same number of egg masses as the highly preferred entries. ■

Correlations between egg masses and plant height and tiller density were positive and significant. Taller and denser canopies were more preferred for egg deposition. BR4112-2B-6 was least preferred, probably because it had the shortest plants and produced fewer tillers (Table 2).

Leaf blade width and foliage color had no apparent influence on egg deposition. ■

Table 2. Yellow stem borer egg masses deposited on deepwater rice entries in a nethouse. Pot study, BRRI, Gazipur, Bangladesh, 1989.

Entry	Reaction[a] in 1988	Plant height (cm)	Tiller density (no./pot)	Egg mass density (no./pot)[b]
Sadapankaich-HR40	HP	73.5	31.3	6.5 a
DWC-B-184	LP	67.0	26.4	5.1 ab
BR4112-2B-5	HP	62.5	21.2	4.0 ab
Habiganj Aman II	LP	54.6	27.2	2.9 b
BR4112-2B-6	LP	46.4	17.4	2.1 b

[a] LP = less preferred, HP = highly preferred in the field. [b] Means followed by the same letter are not significantly different at the 5% level.

Red stripe, a newly reported disease of rice in Vietnam

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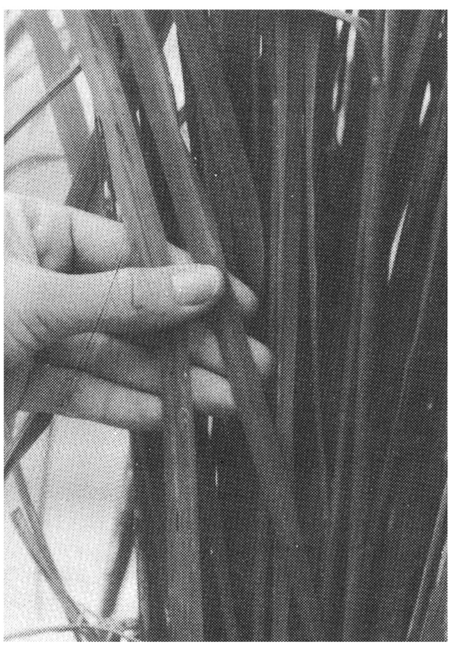
A new disease on rice in the Mekong Delta has the typical symptom of an orange stripe extending from both ends of an oval lesion (Fig. 1).

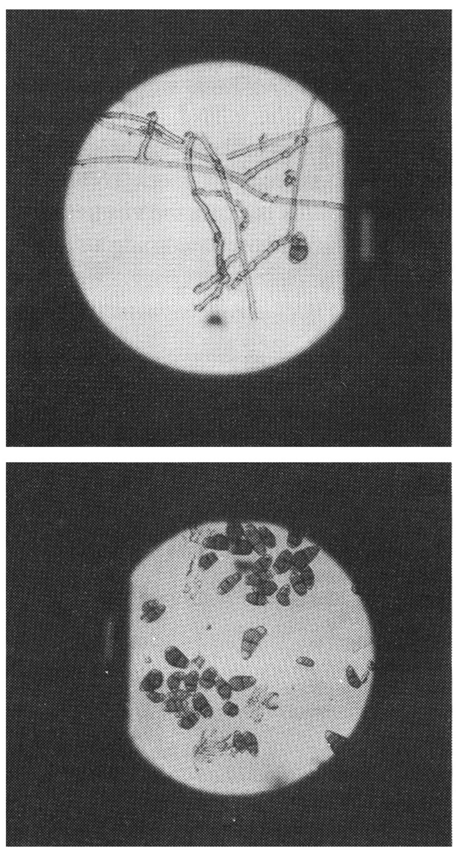
The lesion usually begins as a small water-soaked yellow spot 0.1-0.3 cm in size. It gradually turns orange-red within 2-3 d. The stripe develops from both ends of the spot, enlarging rapidly under moist, hot conditions, and may extend the entire length of the leaf. Numerous stripes may occur on the same leaf. An infected leaf may die and dry out. Red stripe was also observed on the leaf sheath. In severe cases, the entire plant may be killed 10-15 d before harvest.



1. Typical red stripe lesions on inoculated plants.

Although the disease has been found on 20-d-old seedlings, it normally is most severe after heading, and can cause 50% yield reduction.

Red stripe was first observed in 1988, when thousands of hectares of rice were affected in Tien Giang Province. Since then, it has been readily found. In the 1990 summer and autumn season, thousands of hectares were affected by the disease. Most promising short-duration varieties, such as IR64, IR66, IR19660, IR42, MTL 61, and MTL 58, were severely affected.



2. a) Conidia, conidiophores, mycelia of *C. lunata* PDA culture. b) Spores of *C. lunata* on PDA culture.

We isolated *Curvularia lunata* on PDA by culturing 0.1-0.3 cm leaf pieces cut from new spots. We obtained 65-75% fungus 3 to 5 d after culturing.

Inoculum was prepared from cultures grown in the same medium. We inoculated 35- to 45-d-old seedlings by spraying. Inoculated plants were placed in a moist chamber for incubation. Typical lesions appeared 7 d after incubation at 30-32°C, and 15 d after incubation at 26-28°C. Lesions developed on both 35- and 45-d-old seedlings.

When we sectioned diseased tissues, we observed abundant species and mycelium of *C. lunata* in the vascular systems (Fig. 2a,b). ■

Correlations between light trap catches, field populations of yellow stem borer (YSB), and lunar phase

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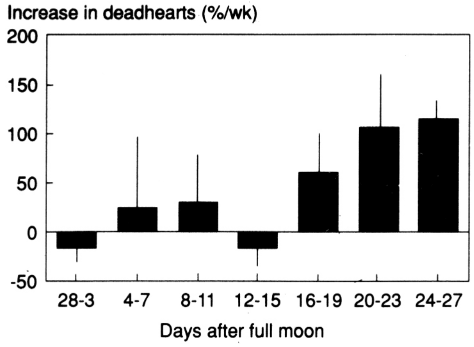
As part of a larger study on the regional dynamics of rice insect pests, we examined the relationship between YSB *Scirpophaga incertulas* catches in small kerosene light traps and populations in adjacent fields.

Nine traps were within a 17,000-ha area of uniform double cropping in Nueva Ecija Province, Philippines, during 1981 wet season. Near the median planting date of surrounding fields, exprimental plots of IR52 were planted within 150 m of the light traps. Egg masses counted on 200 plants at 4, 6, and 8 wk after transplanting (WT) were correlated significantly (r = 0.69, P <0.05) with total number of female moths caught during the 3 mo the crop was standing. Percentage deadhearts (DH) at 4, 6, and 8 WT was correlated with total number of YSB males and females during the 3-mo period (r = 0.75, P <0.05).

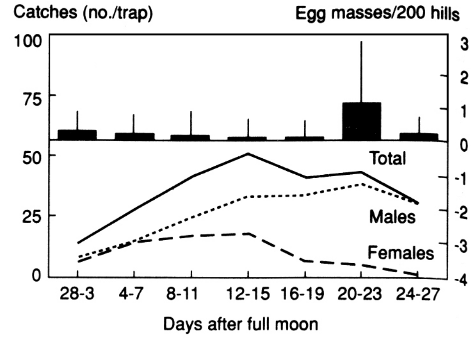
At seven of the sites, we monitored DH-weekly from 3 to 9 WT. The rate of change differed significantly among seven periods based on the lunar month (F6, 32 = 6.53, P <0.01), with the peak occurring 24-27 d after the full moon (Fig. 1). The number of egg masses and male and female moths caught in light traps also differed among the 7 periods (F6, 70 = 2.66, P <0.02; F6, 30 = 11.5, P <0.01; F6, 30 = 6.51, P <0.01, respectively).

The concentration of egg masses is particularly striking: the average in the 20-23 d period was greater than the total in other periods combined (Fig. 2).

Although the delay between maximum number of female moths and maximum egg masses is longer than indicated by published descriptions of the YSB life cycle, the order of the peaks in number of females and eggs, and change in DH is as expected. The YSB generation length is substantially longer than that of a moth (45-55 d in the area studied), and it is unlikely that these peaks are due to synchronization of the insect's development with some external cue other than lunar phase.



1. Rate of change per week of deadhearts in experimental fields in relation to lunar phase. Bars represent 1 standard error. Nueva Ecija, Philippines, 1981 wet season.



2. YSB egg masses at 3 sampling occasions and catches in light traps over 3 mo in relation to lunar phase. Nueva Ecija, Philippines, 1981 wet season.

Similar trends were observed in the 1982 wet season. While wider confirmation is needed, these results suggest that scouting for damage caused by YSB should be done primarily in the 2 wk after the full moon. They also indicate that catches in small kerosene light traps do reflect patterns in the development of nearby field populations, lending support to the use of these traps in wide area monitoring of rice insect pests. ■

Virulence of brown planthopper (BPH) populations collected in China

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We monitored the virulence of BPH populations collected from Hainan, Guangdong, Guangxi, and Zhejiang Provinces in Apr-Jun 1987-90. Collected insects were mass-reared on susceptible variety TN1 and tested on resistant varieties IR26 (containing resistance gene *Bph 1*) and IR36 (*Bph 1 + bph 2*). IR26 and IR36 plants were transplanted at 1 plant/pot 30 d after sowing, and each pot caged with 10 5th-instar nymphs 15-30 d after transplanting. Surviving BPHs were counted 10 d after infestation.

BPH populations collected in 1987-88 had significantly lower survival on IR26 and IR36 than on TN1 (see table). The Zhejiang population had the lowest survival on variety IR26. Survival on variety IR26 of BPH populations collected in 1989-90 was similar to that on susceptible check TN1. Survival on variety IR36 was still obviously lower than that on susceptible check TN1.

These results indicate the virulence of BPH populations was becoming strong enough to damage varieties containing *Bph 1*. They also show that the BPH population was shifting from biotype 1 to biotype 2. Establishment of BPH populations on resistant varieties widely cultivated in China and field damage need further surveillance. ■

Survival of BPH *Nilaparvata lugens* Stål of different geographical populations on rice varieties. Hangzhou, China, 1987-90.

Locality	Date	Temperature (°C)	Survival (%) of 5th-instar nymphs		
			IR26	IR36	TN1
Hainan Lingshui	5-14 Sep 1987	24.9	45.0	19.0	66.0
Zhejiang Longyou			14.0	13.0	65.0
Guangdong Xinhui[a]	8-17 Sep 1987	28.8	44.0	12.0	82.0
Hainan Lingshui	5-14 Sep 1988	26.5	18.0	12.0	75.0
Zhejiang Longyou			9.0	3.0	88.0
Guangdong Xinhui[a]	26 Sep-5 Oct 1988	25.7	30.0	14.0	54.0
Hainan Lingshui	3-12 Sep 1989	24.4	54.0	18.8	67.0
Zhejiang Longyou			53.0	3.0	75.0
Zhejiang Hangzhou			55.0	10.0	62.0
Guangdong Xinhui[a]			46.0	4.2	64.0
Hainan Lingyou	30 Jun-10 Jul 1990	28.8	72.2	12.2	73.3
Guangxi Nanning	7-16 Jul 1990	30.2	65.6	7.8	64.4
Guangxi Longzhou			63.3	20.0	66.7
Zhejiang Longyou			71.1	12.2	73.3
Zhejiang Hangzhou			72.6	12.0	74.2

[a]Tested in Guangdong Academy of Agricultural Sciences, Guangzhou, China.

Brown planthoppew (BPH) dispersal range under natural conditions in the Philippines

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Methods for measuring the movement of insect pests frequently require manipulating the insects in ways that may bias results. A fortuitous natural experiment in 1981-83 permitted a quantitative estimate of the dispersal range of BPH *Nilaparvata lugens* that avoided this difficulty.

As part of a larger study of the regional dynamics of rice-feeding insects, small kerosene light traps were established across a 17,000-ha area of irrigated, double-cropped rice in Nueva Ecija Province, Philippines. In early Feb 1982, large catches of BPH were noticed in the traps. The numbers caught declined from west to east.

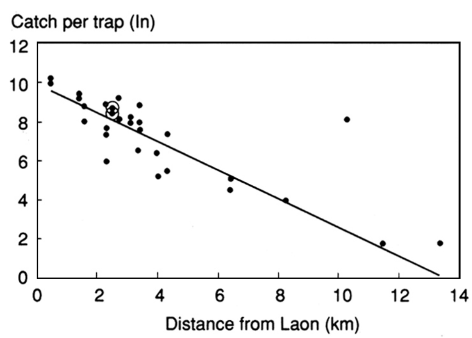
At that time of year, many fields were still being prepared for the dry season crop or had been planted no more than 2 wk earlier. The only possible source of insects was an area of abandoned ricefields along the Chico River, dominated by volunteer rice and *Leersia hexandra.* (Farmers had cultivated the poorly drained area during a time when irrigation had been cut off for canal maintenance.)

Figure 1 illustrates the relationship between catches 6-25 Feb and distance from the old ricefields for the 16 sites in the northern half of the study area. An exponential decay fits the data well (r = -0.92, P <0.001).

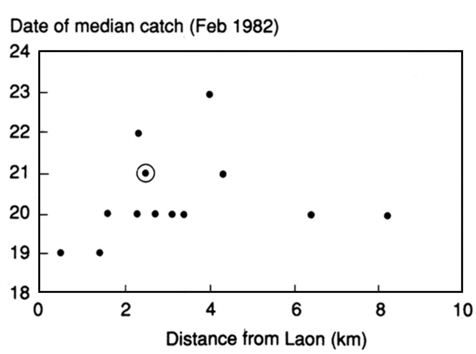
After correcting for the possible immigration from other sources of the 2.5 BPH/trap (estimated from the catch over the 20 d prior to 6 Feb) in the two traps farthest from the old fields, and after integrating and rotating the curve about the origin, I calculated that 50% of dispersing BPH would move less than 2.3 km, 80% less than 4.1 km, and 95% less than 6.5 km.

These estimates assume that dispersal is similar in all directions, which at first seems unlikely. Fifteen of the 16 light trap sites lay between north-northeast and east of the old fields. To reach them, BPH would have had to fly directly into the prevailing winds (at that time, northeast to east between dusk and dawn). Catches at the one site that lay downwind of the old fields (circled points in Fig. 1). however, were not notably higher than expected on the basis of the overall regression.

Could BPH have flown such considerable distances upwind? One possibility is that insects were avoiding take-off in strong winds, and that they made repeated flights, particularly near dawn when winds were lighter. These behaviors are known from the literature. Figure 2 supports this interpretation: the median catch in the 6-25 Feb period is seen to occur later in the sites farthest from the old ricefields (r_s = 0.47, P <0.05). Note that at the downwind site, the median is reached 2 d later than the closer sites, suggesting that BPH may take more than one night to reach points only a few km away, whether upwind or downwind. ■



1. BPH catches in light traps over the period 6-25 Feb 1982 in relation to distance from Laon, an old-field area. Ln Y = 9.939 – 0.7340 x. n = 32 traps. Circled data = downwind locations.



2. Date of median catch in the 6-25 Feb period in relation to distance from Laon, an old-field area. n = 14 sites.

Integrated pest management-weeds

Ricefield weeds in Chitwan Valley, Nepal

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Rice is the main crop in Chitwan Valley in the central inner Terai of Nepal, about 145 km south of Kathmandu. We surveyed the weeds in transplanted ricefields and determined their dominance Aug-Sep 1987-88.

Fifty weeds were identified (see table). On the basis of Sculthope's life-form categories, the weed flora was composed of 49 emergent weeds and one floating-

Scientific name and summed dominance ratio (SDR) of weeds [a] in transplanted ricefields, Chitwan Valley, Nepal.

Scientific name	SDR value [b]
Eleocharis atropurpurea (Retz.) Presl	12.577
Monochoria vaginalis (Burm. f.) Presl	10.534
Echinochloa colona (L.) Link	7.958
Ludwigia perennis L.	7.207
Cynodon dactylon (L.) Pers.	6.802
Fimbristylis miliacea (L.) Vahl	5.934
Rotala indica (Willd.) Koehne	4.770
Sagittaria guayanensis Kunth[a]	3.398
Alternanthera sessilis (L.) R. Br. ex Roem & Schult.	3.220
Sphenoclea zeylanica Gaertn.	3.098
Scirpus lateriflorus Gmel.	2.705
Caesulia axillaris Roxb.	2.668
Eriocaulon cinereum R. Br.	2.697
Cyperus difformis L.	2.482
Commelina paludosa B1.	1.718
Cyanotis cristata D. Don	1.705
Ageratum houstonianum Mill.	1.618
Hedyotis diffusa L.	1.528
Ceratopteris thalictroides (L.) Brogn.	1.337
Tenagocharis latifolia (D. Don) Buch.	1.280
Cyperus iria L.	1.242
Phyllanthus urinaria L.	1.072
Paspalum scrobiculatum L.	0.968
Cyperus squarrosus L.	0.795
Cyperus compressus L.	0.750
Lindernia procumbens (Krock.) Philcox	0.735
Lindernia anagallis (Burm. f.) Pennell	0.724
Eragrostis tenella (L.) Beauv. ex Roem. & Schult.	0.662
Murdannia nudiflora (L.) Brenan	0.631
Lindernia ciliata (Colsm.) Pennell	0.571
Amischophacelus axillaris Rolla Rao & Kamathy	0.534
Phyllanthus fraternus Webster	0.467
Scirpus juncoides Roxb.	0.448
Melochia concatenata L.	0.434

continued on next page

Table continued.

Scientific name	SDR value[b]	Scientific name	SDR value[b]
Cyperus haspan L.	0.422	*Paspalum conjugatum* Berg.	0.185
Hemarthria compressa (L. f.) R. Br.	0.398	*Fimbristylis dichotoma* (L.) Vahl	0.151
Phyllanthus virgatus Forst. f.	0.378	*Eclipta prostrata* (L.) L.	0.132
Euphorbia hirta L.	0.336	*Mollugo pentaphylla* L.	0.112
Phyla nodiflora (L.) Greene	0.314	*Cyperus brevifolius* (Rottb.) Hassk.	0.112
Marsilea quadrifolia L.	0.228	*Scoparia dulcis* L.	0.1 12
Eragrostis unioloides (Retz.) Nees ex Steud.	0.218	*Brachiaria murica* (Forsk.) Stapf.	0.092
Digitaria ciliaris (Retz.) Koel	0.197	*Euphorbia hypericifolia* L.	0.069

[a]Floating leaf species. [b]Mean ratio of relative density and relative frequency.

leaf weed. *Eriocaulon cinereum* showed a submerged life form in early rice growth stages.

For each species, we determined the summed dominance ratio (SDR)—the average of relative density plus relative frequency. Seven locations were selected randomly and 10 quadrats in each location were temporarily positioned. Species were counted in 70 one-m^2 quadrats. On the basis of higher SDR value, *Eleocharis atropurpurea, Monochoria vaginalis, Echinochloa colona, Ludwigia perennis, Cynodon dactylon, Fimbristylis miliacea, Rotala indica, Sagittaria guayanensis, Alternanthera sessilis,* and *Sphenoclea zeylanica* were the most commonly occurring weeds. ■

Water management

Irrigation methods for rice in tropical Australia

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Water is the largest single cost for irrigated dry seeded rice production in north Queensland, Australia. It accounts for about 40% of all variable costs. We evaluated increasing water-use efficiency by

- reducing water use while maintaining grain yield,
- increasing grain yield, while maintaining water use.

The experiment was conducted at Millaroo Research Station (19° 30' S, 147° 30' E) in 1989 dry season (winter). Traditional, intermittent irrigation to the 3-leaf stage, followed by permanent flood (PF-3L), flooding at sowing (PF-S), flooding at panicle initiation (PF-PI), saturated soil culture (SSC), and intermittent irrigation (II) were compared. SSC is a technique recently developed for soybean: plants are grown on 1.5-m raised beds with water maintained in the furrows between beds, some 10-15 cm below the bed surface. II plots were irrigated by raising the water table to the surface at 7-d intervals. Irrigation treatments were in 288-m^2 plots replicated three times. Rice cultivar Lemont was used.

Rice yields were 8-9 t/ha in all treatments except II, which yielded 5.4 t/ha (see table). PF-PI and SSC did not reduce grain yield significantly. However, water use of PF-PI (12.1 million liters/ha and SSC (9.4 million liters/ha) was significantly less ($P < 0.01$) than that of PF-3L (13.7 million liters/ha). Most importantly, water-use efficiency (grain yield per unit consumption of water) of SSC (0.84 t/million liters) was significantly higher than that of PF-3L (0.65 t/million liters).

Grain yield and water use of rice cultivar Lemont grown under 5 irrigation methods at Millaroo Research Station, North Queensland, 1989 dry season.[a]

Irrigation treatment	Grain yield (t/ha)	Water use[b] (million litersha)	Water-use efficiency (t/million liters)	% water[c] saved
Flooding at sowing	9.3 a	14.0 a	0.66 b	0
Intermittent irrigation followed by permanent flood	8.8 ab	13.7 a	0.65 b	
Flooding at panicle initiation	8.4 ab	12.1 b	0.69 ab	12
Saturated soil culture	7.9 b	9.4 c	0.84 a	31
Intermittent irrigation	5.4 c	7.9 d	0.68 ab	42

[a]In a column, means followed by a common letter are not significantly different at 5% level. [b]Includes all irrigation plus rainfall. [c]Savings calculated in relation to PF - 3L.

SSC used up to 1/3 less water than the flooded treatments because evaporation from the saturated soil surface was significantly less than that from a free water surface throughout crop growth. It should be noted that the cultivar used was developed for flooded rice production. The possibility exists that cultivars with improved yield under saturated soil can be developed. ■

Evaluation of drain performance based on head loss fraction in rice-growing acid-saline tract of Kuttanad

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Irrigated rice is the main crop in the acid-saline tract (Kari soils) of Kuttanad in Kerala. Because field elevation (0.5 to 1.5 m below sea level) is much lower than that of the surrounding water bodies, field preparation involves forming a ring bund and draining from inside. Pregerminated seeds are sown into puddled soils both wet and dry seasons.

Soils are extremely acidic and contain toxic concentrations of Fe, Al, and organic products. Yields are very low (1.0-1.5 t/ha), even with 100% adoption of high-yielding varieties. The hydraulic gradient created by the higher elevation water bodies brings toxic salts up to the root zone.

To limit that upward movement of salts and other toxic products, we experimented

Table 1. Head loss fraction for PVC and clay drainage pipes in add-saline, low-elevation tract.

Hours after set of drainage	h_e/h_{tot}	
	Slotted PVC pipe	Baked clay pipe
1	0.87	0.25
6	0.80	0.27
12	0.83	0.27
24	0.83	0.28
48	0.88	0.35
72	0.94	0.41

with subsurface drains. PVC pipes with slots 5 cm long and 0.1 cm wide, and baked clay pipes with an effective bell mouth diameter of 15 cm and tail diameter of 12.5 cm were tested. Effective areas of water entry were 162 cm^2/m. Performance was measured through head loss fraction: the ratio of entrance head loss (h) to total head (h_{tot}).

Head loss fraction for the clay pipe drain was low and its performance moderate (Table 1). PVC slotted pipes give very poor performance, possibly because of inadequate slot size and/or clogging of the slots by iron oxides.

We also measured irrigation water quality for five hydrological years, 1983-88. Water samples were collected from all irrigation sources at weekly intervals and analyzed for pH and EC. The optimum 5.0-6.0 pH for rice occurred in all months except Jun; the optimum EC of 0.8-1.4 dS/m occurred Jul-Mar (Table 2).

These favorable soil chemical properties are attained primarily during the southwest monsoon. ■

Table 2. Monthly variation of pH and EC of irrigation water in the acid-saline soils of Kuttanad (pooled over 1983-88).

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
pH	5.4	5.6	4.4	5.2	5.2	5.3	5.4	5.2	5.3	5.2	5.4	6.1
EC	2.7	2.5	2.2	1.2	0.8	1.0	1.0	0.9	1.3	1.0	0.8	0.9

Farming systems

Integrated nutrient management in rice - mustard cropping sequence

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We studied the effect of green manure (GM) *Sesbania aculeata,* blue-green algae (BGA), paper mill sludge (PMS), and Udaipur rock phosphate (URP) with urea, single superphosphate (SSP), and muriate of potash (MP) on wet season rice and succeeding dry season mustard in 1988-89.

Soil was sandy loam, acidic, pH 5.5, 0.3% organic C, 0.03% total N, CEC 7.15 cmol/kg, 24 kg available P/ha, and 155 kg available K/ha.

S. aculeata was sown the first week of Jun and fertilized at 13.2 and 22.0 kg P/ha through SSP, and URP, respectively (see table). At 45 d after sowing (DAS), fresh biomass weighing about 10 t/ha (0.68% N fresh weight basis) was incorporated. Rice variety Parijat was transplanted at 15- × 15-cm spacing 5 d after GM incorporation.

PMS (75% $CaCO_3$) at one-half the lime requirement of 4.5 t $CaCO_3$ was added 7 d before transplanting rice. P and R were applied as basal. N was applied to rice in three splits.

BGA algal crust at 10 kg/ha was inoculated 7 d after transplanting. N added through BGA at 30 d after inoculation was estimated at 10.9 kg/ha.

Mustard cultivar M27 was sown at 30- × 10-cm spacing in residual soil moisture immediately after rice harvest the first week of Nov. P and K were applied as basal and N was applied in two splits.

Treatments were laid out in a randomized block design with three replications.

Yields with application of PMS + 60-13-25 and 40-9-17 kg NPK/ha (with and without S) to rice and mustard, respectively, were the highest and comparable to that with GM + 13 kg P/ha + 20-0-25 and 40-9- 17 kg NPK/ha (see table). The GM treatment saved 40 kg fertilizer N/ha in rice.

Direct and residual effect of BGA on grain yield of both crops were not pronounced. This might be due to low N from BGA in the acidic soil environment with intermittent dry-wet conditions.

Highest net return and cost:benefit ratio were with PMS + 60-13-25 and 40-9-17 kg NPK/ha (without S) and GM + 13 kg P/ha + 20-0-25 and 40-9-17 kg NPK/ha. ■

Effect of biochemical and chemical fertilizers and paper mill sludge on grain yield and economics of rice + mustard. Orissa, India.

Treatment[a] (kg NPK/ha)		Grain yield (t/ha)		Gross return ($/ha)	Total cost ($/ha)	Net return ($/ha)	Benefit: cost ratio
Wet season	Dry season	Rice	Mustard				
60-13-25	40-9-17	2.0	0.7	622.3	355.7	266.6	1.75
60-22[b]-25	40-0-16	1.9	0.7	626.8	347.0	279.8	1.81
BGA+40-13-25	40-9-17	1.8	0.7	611.1	352.9	258.2	1.73
GM[c]+20-0-25	40-9-17	2.2	0.8	703.8	349.6	354.2	2.01
GM[c]+BFA+0-0-25	40-9-17	1.8	0.8	629.3	347.0	282.3	1.81
GM[d]+20-0-25	40-0-17	2.1	0.8	670.6	340.2	330.4	1.97
PMS+60-13-25	40-9-17	2.3	0.8	714.9	364.5	350.4	1.96
PMS+60-13-25 (-S)	40-9-17 (3) + gypsum	2.2	0.9	768.7	366.5	402.2	2.10
LSD (0.05)		0.2	0.1			50.3	-

[a]BGA =blue-green algae. GM = green manuring with *S. aculeata.* Gypsum applied at 250 kg/ha. PMS =paper mill sludge. [b]50% as a single superphosphate and 50% through Udaipur rock phosphate. [c]13 kg P/ha as single superphosphate was applied to S. aculeata. [d]22.0 kg P/ha was applied to *S. aculeata* as Udaipur rock phosphate.

ERRATA

New IRRI publications, 16 (2) (Apr 1991), 25. Line 1 should read: *Editing and publication-a training manual,* by I. Montagnes.

C.V. Singh et al. Rice-based intercropping systems by rainfed upland conditions of Chotanagpur plateau. 15 (3) (Jun 1990), 36.

In column 1, the spacings should read “20-, 45-,45-, 45, and 75-cm.”

In column 3 of the text and in the last column of the table, “equivalency” should be “equivalent.”

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