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International Rice Research Notes

The *International Rice Research Notes* (IRRN)expedites communication among scientists concerned with the development of improved technology for rice and rice-based systems.

The IRRN is a mechanism to help scientists keep each other informed of current rice research findings. The concise scientific notes are meant to encourage rice scientists to communicate with one another to obtain details on the research reported.

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The IRRN is divided into three sections: notes, news about research collaboration, and announcements.

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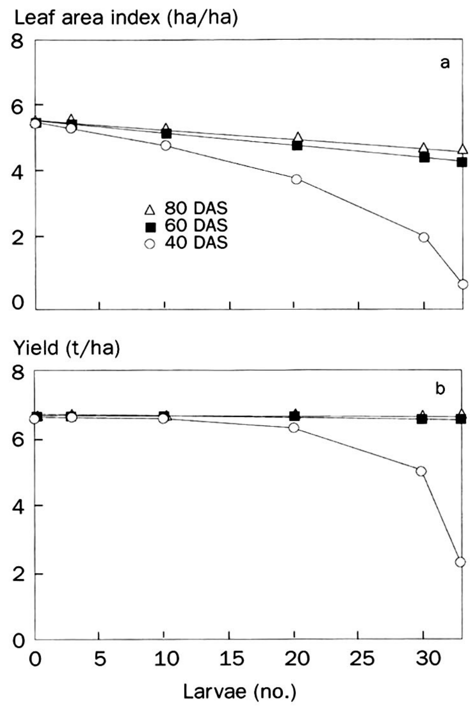

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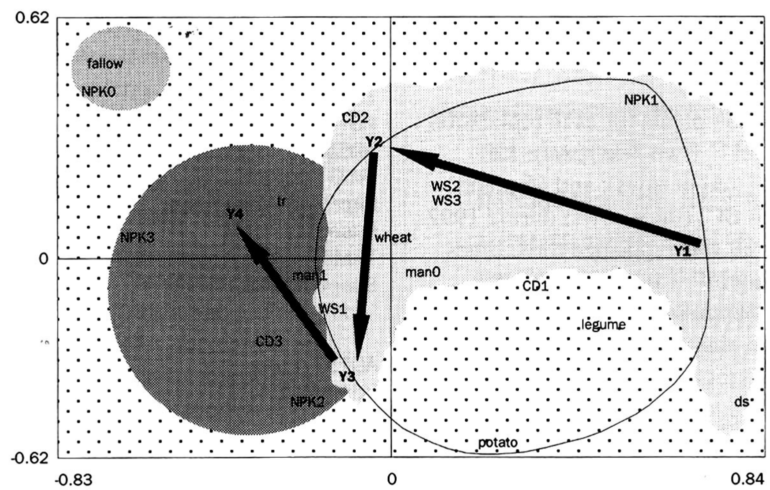

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Germplasm improvement

Genetics

Inheritance of aroma and breadthwise grain expansion in Basmati and non-Basmati rices

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Aroma is the most important criterion for distinguishing Basmati from non-Basmati rice. Minimum breadthwise grain expansion is a desirable Basmati rice quality. We studied the inheritance of aroma and breadthwise grain expansion in Basmati (Pusa Basmati 1) and non-Basmati rice varieties (TKM9, ADT37, ADT39, IR50, and Improved White Ponni).

The non-Basmatis were crossed with Pusa Basmati 1 during 1991 dry season (DS). F_1 and parents were sown during 1991 wet season (WS). F_1 plants were selfed and backcrossed (BC_1 - $F_1 \times P_1$; BC_2 - $F_1 \times P_2$). Non-Basmati varieties were again crossed with Pusa Basmati 1 to produce F_1 seed.

We grew 30 plants for each replication of P_1, P_2, and F_1 (two 3-m rows); 120 plants for F_2 (eight rows); and 45 plants for BC_1 and BC_2 (three rows) during 1992 DS. The trial was replicated three times. One seedling/hill was planted using a spacing of 30 cm between rows and 20 cm between plants. We evaluated 10 plants per replication in P_1, P_2, and F_1; 70 plants in F_2; and 30 plants in BC_1 and BC_2. To evaluate aroma, 2 g of chopped blade from the leaf below the flag leaf of each plant was soaked in 10 ml of 1.7% KOH solution in a test tube for 10 min at 30 °C. Samples were classified as aromatic or nonaromatic by smelling.

All F_1 plants were nonaromatic, indicating that aroma was recessive (Table 1). F_2 of two crosses, ADT37/Pusa Basmati 1 and IR50/Pusa Basmati 1, segregated into 3 nonaromatic: 1 aromatic, suggesting monogenic inheritance that was confirmed in BC_1 and BC_2 generations. Cross combinations TKM9/Pusa Basmati 1, ADT39/Pusa Basmati 1, and Improved White Ponni/Pusa Basmati 1 segregated into a 15-1 ratio for nonaromatic and aromatic in F_2, indicating digenic inheritance that was confirmed in BC_1 and BC_2 generations.

Segregation due to monogenic or digenic recessive genes suggests that genes responsible for aroma may differ with the breeding materials used in a study.

To evaluate for inheritance of breadthwise grain expansion, 4-mo-old rough rice was hulled using a McGill sheller and milled in a Kett rice polisher. Ten randomly selected whole milled kernels were measured (mm) before and after cooking using a graduated piece of cardboard. Milled kernels were cooked using the method of Juliano and Perez. The ratio of mean breadth of cooked rice to mean breadth of milled rice was computed as breadthwise grain expansion.

Bold-grained parents TKM9 and ADT37 recorded the least breadthwise expansion (Table 2). The mean value of F_1 toward minimum breadthwise expansion indicated its dominance over maximum breadthwise expansion. BC_1 with the better parent produced less breadthwise expansion than BC_2, with the other parent.

Additive, dominance, and dominance × dominance effects were significant (Table 2). The h and 1 effects had opposite signs, revealing the presence of duplicate gene action. Effective factors ranged from 1 to 18. Because additive

Table 1. Chi-square test for inheritance of aroma, TRRI, Aduthurai, India.

Designation	Generation	Plants (no.) Tested	Nonaromatic	Aromatic	Expected ratio of nonaromatic to aromatic	χ^2	Probability
TKM9		30	30	-	1:0		
ADT37		30	30	-	1:0		
ADT39		30	30	-	1:0		
IR50		30	30	-	1:0		
Improved White Ponni		30	30	-	1:0		
Pusa Basmati 1		30	-	30	0:1		
TKM9/Pusa	F_1	30	30	-	1:0		
Basmati 1	F_2	210	193	17	15:1	1.22	0.20-0.30
	BC_1	90	90	-	1:0		
	BC_2	90	63	27	3:1	1.20	0.20-0.30
ADT37/Pusa	F_1	30	30	-	1:0		
Basmati 1	F_2	210	164	46	3:1	1.07	0.30-0.50
	BC_1	90	90	-	1:0		
	BC_2	90	48	42	1:1	0.40	0.50-0.70
ADT39/Pusa	F_1	30	30	-	1:0		
Basmati 1	F_2	210	195	15	15:1	0.29	0.50-0.70
	BC_1	90	90	-	1:0		
	BC_2	90	65	25	3:1	0.37	0.50-0.70
IR50/Pusa	F_1	30	30	-	1:0		
Basmati 1	F_2	210	163	47	3:1	0.77	0.30-0.50
	BC_1	90	90	-	1:0		
	BC_2	90	50	40	1:1	1.12	0.20-0.30
Improved White	F_1	30	30	-	1:0		
Ponni/Pusa	F_2	210	194	16	15:1	0.67	0.30-0.50
Basmati 1	BC_1	90	90	-	1:0		
	BC_2	90	67	23	3:1	0.02	0.80-0.90

Table 2. Mean values of breadthwise grain expansion for six generations and estimates of gene effects.[a] TRRI, Aduthurai, India.

	TKM9/Pusa Basmati 1	ADT37/Pusa Basmati 1	ADT39/Pusa Basmati 1	IR50/Pusa Basmati 1	Improved White Ponni/Pusa Basmati 1
Generation					
P_1	1.34 ± 0.007	1.38 ± 0.001	1.50 ± 0.005	1.57 ± 0.009	1.53 ± 0.010
P_2	1.64 ± 0.012	1.69 ± 0.012	1.65 ± 0.013	1.64 ± 0.011	1.62 ± 0.012
P_1	1.47 ± 0.009	1.43 ± 0.012	1.51 ± 0.010	1.60 ± 0.012	1.61 ± 0.009
P_2	1.41 ± 0.007	1.48 ± 0.006	1.53 ± 0.007	1.59 ± 0.008	1.55 ± 0.007
BC_1	1.41 ± 0.012	1.43 ± 0.008	1.49 ± 0.010	1.55 ± 0.008	1.54 ± 0.011
BC_2	1.61 ± 0.013	1.61 ± 0.009	1.54 ± 0.010	1.63 ± 0.010	1.57 ± 0.009
Parameter					
m	1.08* ± 0.05	1.37 * ± 0.04	1.62* ± 0.04	1.63* ± 0.04	1.56* ± 0.04
d	–0.15* ± 0.01	–0.15* ± 0.01	–0.08* ± 0.01	–0.03* ± 0.01	–0.05* ± 0.01
h	0.92* ± 0.12	0.35* ± 0.09	–0.27* ± 0.10	–0.11 ± 0.10	–0.10 ± 0.10
i	0.41* ± 0.04	0.16* ± 0.03	–0.04 ± 0.02	–0.02 ± 0.04	0.01 ± 0.04
j	–0.10* ± 0.04	–0.05 ± 0.03	0.03 ± 0.03	–0.08* ± 0.03	–0.02 ± 0.03
l	–0.53* ± 0.08	–0.30* ± 0.06	0.15* ± 0.07	0.09 ± 0.07	0.14* ± 0.07
Effective factors					
$(d^2)/D$	–	3.8	0.9	0.1	0.3
$(h^2)/H$	14.8	17.5	4.6	–	0.6

[a] * = significant at the 5% level.

gene action is present, the pedigree breeding method is recommended. Dominance and epistatic interactions were also seen; selection in later generations with one or two cycles of intermating selected segregants will result in lessening breadthwise grain expansion. ■

Inheritance of aroma in two rice crosses

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Two nonscented varieties, ADT38 and ADT39, were crossed with a scented variety, Badshabhog, to study the inheritance of aroma in rice. The parents, F_1, and F_2 were grown in Nov 1992. For each cross, 2 g of leaf blades from 15 randomly selected parent and F_1 plants and 200 F_2 plants were soaked in 10 ml of 1.7% KOH solution in test tubes and evaluated for scent after 10 min by smelling the contents.

All F_1 plants were nonaromatic, indicating the recessive nature of the gene controlling aroma (see table). A 15 nonaromatic: 1 aromatic segregation occurred for F_2 plants in both crosses, suggesting that two recessive genes control aroma in Badshabhog. Pedigree breeding with a larger population for F_2 selection is suggested for introducing scent into nonscented varieties. ■

Behavior of F_1 and F_2 populations with regard to inheritance of aroma.

Cross	Plants (no.)			c^2	P
	Total	Nonaromatic	Aromatic		
F_1					
ADT38/Badshabhog	15	15	–	–	–
ADT39/Badshabhog	15	15	–	–	–
F_2					
ADT38/Badshabhog	200	189	11	0.19	0.50-0.75
ADT39/Badshabhog	200	190	10	0.53	0.25-0.50

Breeding methods

Evaluation of rice cytoplasmic male sterile lines for floral traits influencing outcrossing

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The success of hybrid rice technology depends as much on developing stable male sterility and restoration systems as on the amount of seed set on cytoplasmic male sterile (CMS) lines by natural outcrossing. Rice is an autogamous crop; high outcrossing does not generally occur. Considerable outcrossing, however, has been reported in some wild species as a function of floral structure and biology. Environmental variation may influence the expression of these traits.

We evaluated 15 CMS lines for nine floral traits influencing outcrossing under two irrigated environments: 1991 dry season (DS) and 1991 wet season (WS). Five spikelets were randomly selected from the main panicle in each CMS line to record anther and stigma traits using stage and ocular micrometers. Anthesis duration was recorded as the time

IRRN REMINDER

Routine research. Reports of screening trials of varieties, fertilizer, cropping methods, and other routine observations using standard methodologies to establish local recommendations are not ordinarily accepted. Examples are single-season, single-trial field experiments. 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 replications and an internationally known check or control treatment.

Floral characters of CMS lines under two environments. Bangalore, India. 1991 DS and WS.

CMS line	Anther length (mm)		Anther breadth (mm)		Anther size (mm^2)		Stigma length (mm)		Stigma breadth (mm)		Stigma size (mm^2)		Style length (mm)		Pollen sterility (%)		Anthesis duration (min)	
	1991 DS	1991 WS	1991 DS	1991 WS	1991 DS	1991 WS	1991 DS	1991 WS	1991 DS	1991 WS	1991 DS	1991 WS	1991 DS	1991 WS	1991 DS	1991 WS	1991 DS	1991 WS
V20 A	2.30	1.50	0.45	0.32	0.92	0.48	1.66	2.11	0.56	0.41	1.86	1.73	0.53	0.69	100.0	99.8	273	285
IR54752 A	2.21	1.83	0.65	0.40	1.46	0.73	1.52	1.69	0.60	0.43	1.82	1.45	0.84	0.86	98.8	100.0	238	250
IMA	2.19	1.63	0.64	0.33	1.40	0.54	1.33	1.62	0.43	0.37	1.14	1.20	0.83	0.65	2.8	37.0	250	205
Mangala A	1.97	2.13	0.42	0.41	0.83	0.87	1.25	1.46	0.42	0.33	1.05	0.96	0.55	0.79	4.5	13.8	205	195
Pushpa A	2.40	1.76	0.41	0.38	0.98	0.67	1.61	1.50	0.42	0.31	1.35	0.93	0.55	1.00	1.5	17.0	211	185
PMS1 A	1.90	1.78	0.39	0.35	0.74	0.62	1.36	1.46	0.43	0.31	1.17	0.91	0.63	0.63	100.0	69.0	256	260
PMS2 A	1.84	1.34	0.39	0.33	0.72	0.48	1.36	1.27	0.43	0.31	1.17	0.79	0.92	0.95	98.5	98.0	251	260
PMS3 A	1.98	1.74	0.37	0.30	0.74	0.52	1.50	1.33	0.55	0.33	1.65	0.88	0.69	0.66	100.0	100.0	284	290
PMS4 A	1.75	1.36	0.35	0.34	0.63	0.63	1.40	1.65	0.44	0.36	1.23	1.19	0.72	0.77	98.2	74.0	255	285
PMS5 A	2.02	1.73	0.34	0.38	0.69	0.66	1.36	1.45	0.44	0.33	1.20	0.96	0.76	0.71	96.5	100.0	251	260
PMS6 A	1.99	1.70	0.30	0.29	0.60	0.49	1.43	1.33	0.43	0.33	1.23	0.88	0.73	0.82	88.6	100.0	208	218
PMS7 A	2.37	1.91	0.43	0.33	1.01	0.63	1.55	1.45	0.54	0.33	1.67	0.96	0.72	0.90	98.0	99.2	256	260
PMS8 A	1.96	1.69	0.37	0.26	0.73	0.44	1.58	1.37	0.47	0.33	1.49	0.90	0.74	0.86	99.3	98.9	246	265
PMS9 A	2.23	1.89	0.45	0.33	1.00	0.62	1.58	1.35	0.53	0.37	1.67	0.97	0.80	0.61	99.0	100.0	285	290
PMS10 A	1.85	1.89	0.36	0.37	0.67	0.62	1.52	1.57	0.53	0.37	1.61	1.16	0.62	0.65	97.0	100.0	257	265
Mean	2.05	1.76	0.43	0.34	0.87	0.60	1.47	1.50	0.48	0.35	1.42	1.06	0.71	0.77	78.84	80.45	248.49	251.63
Range	0.64	0.79	0.35	0.15	0.86	0.43	0.41	0.84	0.18	0.12	0.81	0.94	0.39	0.39	98.5	86.2	80.0	105.0
CV (%)	9.39	10.52	23.68	12.12	29.94	18.78	8.20	13.82	13.00	10.43	19.17	23.81	16.26	16.18	49.96	39.68	9.88	13.76
SE (m)	0.05	0.05	0.025	0.011	0.067	0.03	0.03	0.054	0.028	0.009	0.07	0.07	0.03	0.03	10.17	8.22	6.34	8.93

between opening of the first spikelet in the main panicle in the morning and closing of all spikelets in that panicle.

Genotypes performed very differently under the two environments (see table). In general, the mean values for anther length, anther breadth, anther size, stigma breadth, and stigma size were greater in DS than in WS, while mean values for stigma length and pollen sterility were greater in WS than in DS. No difference was observed between the environments for anthesis duration. Anthesis, however, started earlier (0900 h) in DS than in WS (1100 h).

Variability (indicated by range and coefficient of variation) for anther breadth, anther size, stigma breadth. and pollen sterility was higher in DS than in WS; for anther length, stigma length, stigma size, style length, and anthesis duration, variability was higher in WS than in DS. Expression of floral traits influencing outcrossing was generally better in DS than in WS.

Results suggest that it is advantaged to produce hybrid rice seed during DS because more floral traits are better expressed than during WS. ■

Restorers and maintainers for MS 577 A and wild abortive cytoplasmic male sterility system

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Ninety-six rice genotypes were crossed with six cytoplasmic male sterile (CMS) lines possessing cytoplasmic male sterility system of MS 577 A and 24 genotypes with four wild abortive (WA)-type CMS lines, resulting in 252 F_1s with 577 A cytoplasm and 39 F_1s with WA cytoplasm. Based on spikelet fertility of these hybrids, genotypes were classified as restorers (>80%), partial restorers (10-80%), and maintainers (<10%).

None of the 96 genotypes completely restored the fertility of 577 A. IR36, IR13146-45, IET7191, Karna, Milyang 54. and Nucleoriza however, were found to be partial restorers.

Of the 18 IRRI genotypes evaluated, 10 were identified as restorers for WA CMS lines (IR8, IR36, IR60, IRI3146-45, IRl5324-13, lR20226-24, IR21543-2-1-22, IR27280, IR22810-60, and IR31916-9), 6 as partial restorers. and 1 as a maintainer (IR21916- 128). Among other genotypes, 3 were identified as restorers (Cornell culture, ARC11353, and RP101-3-129), 2 as partial restorers, and 1 as a maintainer (local variety CTH1). ■

Yield potential

Performance of anaerobically direct seeded rice plants in the Mekong Delta, Vietnam

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Most farmers in the Mekong Delta of Vietnam practice direct seeding. Improved rice cultivars are used, but they were selected for use in the transplanting system. Introducing cultivars suitable for direct seeding may benefit farmers. We conducted this study to identify desirable traits for high-yielding direct seeded rice

Table 1. Crop establishment, growth parameters, grain yield, and yield components of direct seeded rice in the Mekong Delta.[a] CLRRI, 1993 wet season.

Cultivar	Seedlings[b/] m^2 (no.)	TDM[b] at flowering (g/m^2)	TDM[b] at maturity (g/m^2)	LAI [b] at flowering	Harvest index[b] (%)	Spikelets/ m^2 (no. x 10^3)	Panicles[c/] m^2 (no.)	Spikelets[c/] panicle (no.)	Filled spikelets[c] (%)	1,000 grain weight[c] (g)	Yield[a] (t/ha)
IR41996-50-2-1-3	400 a	455 c	740 b	2.20 b	47.0 a	23.4 c	527 a	44 d	76.6 a	29.5 a	2.87 d
IR52341-60-1-2-1	406 a	561 c	953 ab	1.53 c	47.0 a	28.9 bc	446 a	65 c	73.9 a	27.5 b	3.77 bcd
IR31802-48-2-2-2	401 a	455 c	811 b	1.93 bc	41.0 b	37.1 b	527 a	70 c	63.4 b	24.0 c	3.40 cd
MTL 114 (check)	375 b	734 b	1134 a	3.47 a	44.0 ab	39.1 b	479 a	82 c	73.8 a	27.7 b	4.80 abc
MTL 103 (check)	379 b	713 b	1020 ab	3.50 a	47.0 a	36.5 b	471 a	77 c	80.2 a	28.1 b	5.13 ab
BR736-20-3-1	407 a	870 a	1110 a	3.87 a	42.0 ab	55.4 a	410 a	135 a	78.7 a	21.5 e	5.20 ab
BR1870-67-1-3	400 a	840 a	1114 a	4.00 a	45.0 ab	55.8 a	442 a	126 b	80.3 a	22.7 d	5.83 a

[a]Means in a column followed by a common letter are not significantly different at the 1% level by DMRT. [b]Sampled from 0.5 m^2 per plot. [c]Analyzed from 20 panicles per plot. [d]Harvested from 5 m^2 per plot.

Table 2. Coefficients of simple linear correlations between the characters associated with grain yield.[a]

Character	Two	Three	Four	Five	Six	Seven	Eight	Nine	Ten	Eleven
One	–0.17	–0.33	0.36	–0.21	0.19	0.12	–0.14	–0.48	–0.20	–0.28
Two		0.94**	0.91**	–0.84*	0.90**	0.86*	0.67*	–0.55	–0.15	0.95**
Three			0.79*	–0.80*	0.78*	0.75	0.51	–0.42	–0.14	0.92**
Four				–0.55	0.79*	0.80*	0.66	–0.45	–0.16	0.90**
Five					–0.79*	–0.69	–0.60	0.53	0.02	–0.75
Six						0.98**	0.42	–0.86*	–0.45	0.84*
Seven							0.33	–0.88**	–0.53	0.84*
Eight								0.02	0.55	0.62
Nine									0.73	–0.52
Ten										–0.10

[a]* = significant at the 5% level; ** = significant at the 1% level. 1 = seedlings (no./m^2). 2 = TDM accumulation at flowering. 3 = TDM accumulation at maturity, 4 = LAI at flowering, 5 = panicles (no./m^2), 6 = spikelets (no./ panicle), 7 = spikelets (no./m^2). 8 = filled spikelets (%), 9 = 1,000-grain weight, 10 = harvest index, 11 = yield.

Seven cultivars were used, five of which are tolerant of soil anaerobiosis during seedling establishment. The other two are local checks (Table 1). Pregerminated seeds (2 d old) were sown at 400 seeds/m^2 (about 100 kg/ha) immediately after puddling the soil (pH 5.2, 0.04% total P, 3.2% organic C, and 0.26% total N). Seeds were beneath the soil surface. A herbicide, Sofit, was sprayed 3 d after sowing (DAS). Fertilizer was applied at 60-17-25 kg NPK/ha at 10 DAS, 30 kg N/ha at 30 DAS, and 60 kg N/ha at 60 DAS. The experiment was laid out in a randomized complete block design with three replications. Plot size was 20 m^2.

Number of seedlings established was higher for anaerobic cultivars than for checks. Yields of BR1870-67-1-3 and BR736-20-3-1 were the same as those of the checks, and higher than those of IR52341-60-1-2-1, IR31802-48-2-2-2, and IR41996-50-2-1-3. Difference in yield was due to the difference in total dry matter (TDM) accumulation at maturity and not in harvest index (HI) (Table 1). BR1870-67-1-3 and BR736-20-3-1 had large panicle size, indicated by the high spikelet number/panicle. Although BR1870-67-1-3 and BR736-20-3-1 had more spikelets/m^2, they did not outyield checks significantly because their 1,000-grain weights were small.

Correlation analysis showed that the grain yield highly correlated with TDM accumulation at flowering and harvest, spikelets/panicle, spikelets/m^2, and leaf area index (LAI) at flowering (Table 2). The significant correlation between spikelets/m^2 and spikelets/panicle ($r = 0.98^{**}$) indicated that big panicles are important for obtaining a large number of spikelets per unit land area.

The yield recorded for BR1870-67-1-3 was higher than the mean (4.3 t/ha) for the past 7 yr at CLRRI during the wet season under transplanting (80-25-18 kg NPK/ha). The physiological and morphological traits required for high-yielding direct seeded rice in the Mekong Delta in the wet season seem to be high TDM accumulation at flowering and harvest, LAI at flowering of about 4, and large panicle size. These characters may be considered when breeding rice for direct seeding in the Mekong Delta.

Simulating rice leaffolder feeding effects on yield using MACROS

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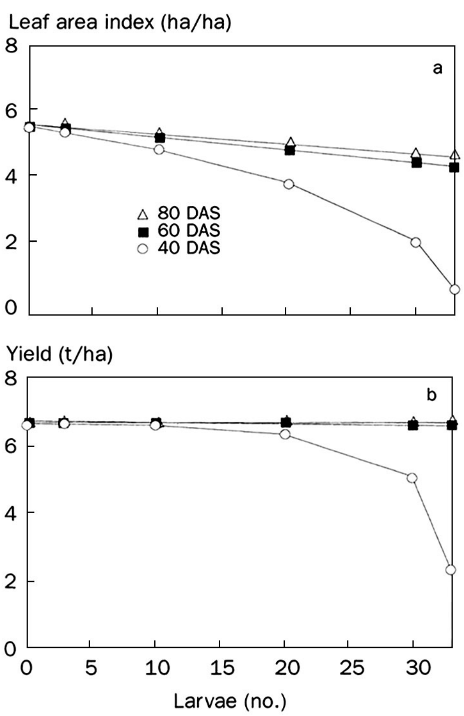
The rice leaffolder (LF), *Cnaphalocrocis medinalis,* can affect yield by reducing leaf area. Most previous attempts to relate yield to leaf area removed were probably too simplistic. Systems analysis and simulation approaches may improve our understanding of this relationship.

We conducted an experiment to quantify the reduction in leaf area due to LF feeding. We incorporated the actual leaf consumption into the MACROS rice model and predicted yield loss at different larval densities and crop ages,

Destructive weekly samplings were taken from five hills of IR36. A LICOR LI-3000 leaf area meter was used to measure total leaf area and leaf area damaged in 1- × 1 -m plots infested with 3 second-instar larvae per hill on plants at 40, 60, and 80 d after seeding (DAS). Infested plots were enclosed with open fiberglass cages to prevent larvae from dispersing.

The leaf area damaged by LF larvae was higher on plants at 40 DAS than on plants at 60 and 80 DAS (see table). Leaf consumption, based on actual leaf area damage, was incorporated into the model. Simulation runs were made for each larval density and crop age. (See figure for the simulated leaf area and simulated yield at different larval densities and crop ages.) The model predicted 9, 12, and 30% leaf area reduction on plants at 80, 60, and 40 DAS, respectively, when infested with 20 larvae. Crop response to insect damage seemed to decrease with crop age. The predicted yield reduction was only 3.4% on plants at 40 DAS infested with 20 larvae. The simulated yield reduction was £ 1% on plants at 80 and 60 DAS infested with up to 33 larvae. In most ricefields, LF larval populations are rarely more than two per hill.

The results suggest that leaf consumption of 20 larvae seems insufficient to significantly reduce crop yield. This may be attributed to the rice plant's ability to compensate for damage at early stages. In addition, photosynthesis rates in different leaf layers may increase as a result of damage. Although MACROS does not have these compensatory components, yield losses predicted were extremely low. Thus, it appears that LF can rarely cause significant yield losses in farmers' fields. ■



Simulated leaf area (a) and simulated yield (b) at different larval densities and crop ages.

Weekly mean leaf area damage on plants infested (± SE) by LF at different crop ages.

Sampling time (wk)	Damaged leaf area (cm^2)/hill		
	40 DAS[a]	60 DAS	80 DAS
1	4.52 ± 0.16	2.58 ± 0.09	1.99 ± 0.06
2	10.69 ± 0.28	6.08 ± 0.29	4.64 ± 0.12
3	9.12 ± 0.33	6.53 ± 0.22	4.41 ± 0.04

[a] DAS = days after seeding.

Pest resistance

Resistance of Guangxi wild rice to diseases and insect pests

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Oryza rufipogon and *O. officinalis* are the two kinds of wild rice in Guangxi Province, China. The Institute of Crop Germplasm Resources under the Guangxi Academy of Agricultural Sciences and the Institute of Plant Protection under the Guangxi Agricultural College have cooperated since 1981 to evaluate these wild rices for resistance to blast (Bl), bacterial blight (BB), brown planthopper (BPH), whitebacked planthopper (WBPH), and gall midge (GM) (Table 1).

Of the available accessions, the following are resistant to a particular pest: 23 *O. rufipogon* and 15 *O. officinalis* to Bl; 16 *O. rufipogon* and 11 *O. officinalis* to Chinese BB races I-V; 20 *O. rufipogon* to BPH biotypes 1 and 2 (86 *O. officinalis* are highly resistant to BPH); 117 *O. officinalis* to WPBH, with 47 possessing very high resistance; and 8 *O. rufipogon* and 1 *O. officinalis* to GM. These accessions have been recommended as donors of resistance in the national rice breeding program (Table 2). They are conserved in the Nanning Wild Rice Nursery. ■

Table 1. Wild rice resistance to diseases and insect pests.

Species	Disease/insect pest	Accessions evaluated (no.)	Resistant accessions no.	Resistant accessions %
O. rufipogon	Blast	1587	67	4.1
	Bacterial blight	1553	289	18.6
	Brown planthopper	1214	30	2.5
	Whitebacked planthopper	1236	27	2.2
	Gall midge	1203	8	1.4
O. officinalis	Blast	199	22	11.0
	Bacterial blight	199	194	97.5
	Brown planthopper	198	195	98.5
	Whitebacked planthopper	197	197	100.0
	Gall midge	184	1	0.5

Table 2. Accessions with resistance to diseases and insect pests. Nanning, Guangxi, China.

Resistance	Accession
Blast	*O. rufipogon:* YD.2-0417, 0418, 0435, 0452, 0453, 0528, 0538, 0555, 0578, 0583, 0587, 0590, 0591, 0593, 0618, 0797, 0854, 0971, 1010,1263,1314, 1360, 1372
	O. officinalis: YD.2-1618, 1624, 1626, 1627, 1628, 1629, 1635, 1645,1647,1674,1680,1698,1724,1737,1764
Bacterial blight	*O.* rufipogon: YD.2-0078, 0233, 0314, 0317, 0321, 0339, 0349, 0369, 0480, 0684, 0764, 0795, 0842, 1162,1470,1504
	O. officinalis: YD.2-1630, 1656, 1667, 1668, 1669, 1670, 1685, 1702, 1703,1719, 1721
Brown planthopper	*O. rufipogon:* N-0471, 0513, STS-543, 2167, 2172, 2173, 2182, 2184, 2190, 2205
	O. officinalis: YD.2-1665, 1694, 1738, 1594, 1597, 1608, 1609, 1611, 1612, 1613, 1616, 1617, 1618, 1623, 1624, 1630, 1632, 1633, 1646, 1649, 1650, 1651, 1652, 1654, 1655, 1656, 1658, 1659,1660, 1661
Whitebacked planthopper	*O.* officinalis: YD.2-1592, 1593, 1594, 1595, 1596, 1608, 1609, 1641, 1642, 1643, 1661, 1671, 1673, 1674, 1675, 1684, 1685, 1686, 1692, 1694, 1695, 1696, 1697, 1698, 1701, 1702, 1703, 1704,1712,1713
Gall midge	*O. rufipogon:* YD.2-0352, 0686, 0869, 0899, 1296, 1373, 1422, 1536
	O. officinalis: YD.2-1751

Pest resistance—disease

Resistance to rice blast in a line derived from *Oryza minuta*

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Oryza minuta, a wild species of rice, is highly resistant to rice blast (Bl). A line derived from a wide cross between 0. minuta and an elite *O. sativa* breeding line, IR31917-45-3-2, hereafter referred to as *Os*S, was found to possess B1 resistance. Genetic studies of this line have shown that a single gene confers resistance to isolate *PO6-6* of *Pyricularia oryzae.*

During initial screening, plants were artificially inoculated with isolate *PO6-6,* and disease reactions were scored on a 0-5 scale (Table 1). Although resistance was dominant over susceptibility, under highly favorable conditions for B1 development the homozygotes (RR) were significantly more resistant than the heterozygotes (Rr) using the t-test ($P<0.001$). The mean disease rating for RR plants was 1.8 ± 0.6 (mean ± SD, $n = 21$), while that of the Rr group was 2.8 ± 1.1 ($n = 34$). To characterize this resistance further, we evaluated a homozygous line, hereafter referred to as *NIL127,* in greenhouse and field studies under upland conditions. *NIL127* was shown to be nearly isogenic to *Os*S based on analysis using molecular markers (less than 1% introgression of markers from the wild species).

To assess the resistance in *NIL127* with respect to pathogen lineages, we inoculated it with 49 isolates of *P. oryzae* representing lineages 1, 4, 7, 9, 10, 11, and 14. (A lineage is a group of isolates inferred to be related by descent, based on DNA fingerprinting and phylogenetic analysis.) In this test, each treatment consisted of a pot of 12 seedlings per line. Seedlings were inoculated by spraying with a spore suspension (10^5 spores/ml) at 21 d after sowing (dry seeded). After inoculation, plants were incubated for 24 h at 24 °C and 100% relative humidity, then transferred to a mist room at 24 °C under natural light for 5 d. Disease reactions were scored (Table 1). Each treatment was replicated twice.

Of the 49 isolates tested, 32 (representing lineages 4, 7, and 14) were compatible on recurrent parent *Os*S (Table 1). *Os*S was not susceptible to any test isolates of lineages 1, 9, 10, or 11. *NIL127* was resistant to all test isolates of

Table 1. Characterization of NIL127 Bl resistance with respect to *P. oryzae* lineages 4, 7, and 14.

Lineage[a]	Isolate	Disease reaction[b]	
		OsS	*NIL127*
4	Ca1	4	0
4	Ca9	4	0
4	Ca13	3	0
4	Ca19	4	0
4	Ca27	4	0
4	Ca30	4	0
4	Ca33	4	0
4	Ca40	4	0
4	Ca42	4	0
4	Ca44	4	0
4	Ca48	4	0
4	Ca51	4	0
4	Ca52	4	4
4	Ca70	4	2
4	Ca72	4	0
4	Ca73	4	0
4	Ca74	4	0
4	Ca77	4	0
4	Ca78	4	0
4	Ca79	4	0
4	Ca80	4	4
4	Ca81	4	4
4	Ca83	4	2
4	Ca84	4	0
4	Ca87	4	0
4	Ca89	4	0
4	Ca90	4	0
4	Ca91	4	0
4	Ca93	4	0
7	BN105	4	0
7	BN117	4	0
14	BN113	4	0

[a] Lineage as determined by DNA fingerprinting using the probe MGR586. [b] Definition of disease reactions: 0 = immune, no evidence of infection; 1 = resistant, with brown specks, no sporulation: 2 =moderately resistant, 1 - to 2-mm long, irregularly shaped lesions wtth brown margins; 3 = intermediate, 5 or less, 3- to 7-mm long typical, spindle-shaped sporulating lesions per inoculated leaf; 4 = susceptible, 5 or more typical lesions per inoculated leaf, lesions often coalesce; 5 = highly susceptible, many coalesced lesions infecting 50% or more of inoculated leaf, leaf dies because of lesions.

Table 2. Evaluation of *NIL127* Bl resistance in upland screening sites.

Site	Line[a]	Predominant lesion type[b]	Final percentage diseased leaf area[c]			RADPC[d] Mean	
			1991	1992	1993	1992	1993
Bangladesh	*NIL104*	4	55	75	60	21.3	29.2
	NIL127	1	1.5	1.1	1.5	0.3	1.0
Colombia[e]	*Os*S	4	-	-	-	-	-
	NIL127	1	-	-	-	-	-
Indonesia	*Os*S	4	-	81.25	100	22.80	42.9
	NIL127	0	-	0.05	0.01	0.11	2.5
Philippines	*Os*S	4	-	Nd[f]	71.67	Nd	18.17
	NIL127	0	-	Nd	0.57	Nd	0.28

[a] In most cases, *NIL127* (RR) was compared with the recurrent parent, *Os*S (rr). Sometimes, however, a susceptible sibling of *NIL127,* identified above as *NIL104* (rr), was used. *NIL104* and *Os*S are identical for the purposes of this study. [b] See Table 1 for definition of lesion types. [c] Mean of four replications. [d] RADPC = relative area under the disease progress curve: mean of four replications. [e] Only predominant lesion type data were collected when *NIL127* and *Os*S werescreened in Colombia. Tests were conducted for three consecutive seasons in two consecutive years (1992A and E and 1993A). [f] Nd = no disease observed at the site in the 1992 wet season due to delay of rain. Susceptible and resistant lines alike failed to develop Bl symptoms.

lineages 7 and 14 and susceptible to only three isolates of lineage 4 (Table 1).

To determine the performance of *NIL127* under diverse field conditions, we evaluated this line for Bl resistance in upland sites at Joydebpur, Bangladesh; Santa Rosa, Colombia; Sitiung, West Sumatra, Indonesia; and Cavinti, Laguna, Philippines (Table 2). At least two 30-50 cm rows of each line were dry seeded parallel to the prevailing winds between one or two rows of a resistant cultivar. At the leeward end of the plot, two rows of a mixture of susceptible spreader varieties were planted perpendicular to the prevailing winds. Leaf Bl severity was evaluated twice a week for 3-4 wk by estimating diseased leaf area (%) on a plot basis. In addition, at least five plants were selected at random at the peak of disease development and were evaluated for lesion type using the 0-5 scale (Table 1). The experiments were replicated three or four times. Means were calculated from the replications.

We previously observed that *NIL127* remained Bl-free when planted in the IRRI blast nursery and in lowland field plots on the IRRI farm (data not shown). *NIL127* was also resistant to field populations of Bl in all upland screening sites where it was tested. At the Santa Rosa, Colombia site, for example, six lineages are known to be present, yet the line has remained resistant for three seasons. Hypersensitive lesions were observed (type 0 or 1), although it was not possible to obtain any viable Bl isolates from them. On the other hand, lesions on the recurrent parent, *Os*S, were usually type 4 (susceptible) (Table 2).

We conclude from these studies that *NIL127* performs well under Bl stress at a variety of sites. Although the resistance in *NIL127,* presumably contributed by a resistance gene from *O. minuta* in the IR31917-45-3-2 background, may not be(effective against artificial inoculation with some lineage 4 isolates, *NIL127* functions effectively in the field. The apparent susceptibility of *NIL127* to some isolates in greenhouse tests suggests that this wild species-derived resistance gene is not likely to condition durable resistance alone, although it may be a useful component in a gene pyramiding program.

For further evaluation or for use in breeding programs, *NIL127* seeds can be requested from the International Network for Genetic Evaluation in Rice under the line number WHD-IS-75-1-127. This line will be included in the International Rice Blast Nursery core collection in 1994. ■

Comparative transmission of two strains of rice tungro spherical virus in the Philippines

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A virulent strain of rice tungro spherical virus (RTSV), designated as strain Vt6, was found to be infecting rice plants in Midsayap, North Cotabato, Philippines. The strain could highly infect rice cultivar TKM6, which is highly resistant to the IRRI strain of RTSV, designated as strain A. We conducted comparative transmission tests to identify varieties with resistance to both strains.

We tested rice accessions from the International Rice Germplasm Center for their reaction to strain Vt6. Selected accessions had been previously identified as resistant to strain A but were susceptible to green leafhopper (GLH) according to the IRRI Entomology Unit's data base on GLH resistance. Virus-free adult GLH were given 4 d of access to rice cultivar Taichung Native 1 (TN1) infected with both rice tungro bacilliform virus and strain Vt6. Three GLH were confined for 24 h with a 6-d-old seedling in a test tube for inoculation access.

Forty seedlings (2 replications, 20 seedlings/replication) were inoculated for each variety. Inoculated seedlings were transplanted into pots and grown in screened cages until symptoms developed. An identical set of test varieties simultaneously inoculated with strain A in the same manner served as control. Rice tungro viruses were indexed by enzyme-linked immunosorbent assay 1 mo after inoculation.

Results showed that all of the varieties tested were resistant to strain A except for Utri Rajapan, which showed an intermediate reaction. Their reaction to strain Vt6, however, varied from highly resistant (0-10% infection ratio) to very susceptible. Twenty-nine varieties had an infection rate of more than 60%, comparable with susceptible check TN1 (see table). These results contradict our previous view that virus resistance is more durable than vector resistance.

Eleven leafhopper-susceptible accessions were highly resistant to both strains. These accessions may be used as source

Comparative transmission of two RTSV strains.

IRGC[a] Acc. no.	Variety name	RTSV infection (%) Strain A	Strain Vt6
177	Adday Sel.	0	0
180	Adday Local Sel.	0	0
237	TKM6	0	59
10262	G378	0	100
11751	Habiganj DW8	0	26
12274	ARC6561	7	100
12428	ARC10312	0	93
12437	ARC10343	0	78
12765	Kataribhog	5	74
14504	IR580 420-1-1-2	4	58
14527	Barah	0	41
16680	Utri Merah	0	3
16684	Utri Rajapan	38	79
19680	ARC10963	0	68
20600	ARC7321	0	18
21310	ARC11315	0	80
21474	ARC11555	0	14
21745	ARC11920	0	8
21958	ARC12170	3	94
22199	ARC12620	0	51
22215	ARC12636	0	15
22307	ARC12746	0	52
22331	ARC12778	0	28
26253	Nep Bap	0	8
26410	Pala Bhir	3	3
26495	Konek Chul	3	8
26527	Shuli 2	0	86
26582	Buchi 2	0	100
26791	Sham Rosh	0	3
26813	Gogoj	0	3
105	Taichung Native 1	98	95
27779	Bara Pashawari 390	0	97
27787	Basmati Nahan 381	13	53
27798	Basmati 1	10	100
27818	Basmati 242	0	29
27829	Basmati 377	3	82
27830	Basmati 388	11	94
27832	Basmati 405	0	97
27833	Basmati 406	0	13
27836	Basmati 433	0	98
27856	Begumi 302	10	18
27869	Chahora 144	3	100
27870	Chahora 148	0	83
27872	Chahora 292	0	97
27873	Chahora 382	0	100
27946	Hansraj 62	0	100
27947	Hansraj 189	0	100
27951	Hansraj 365A	0	92
28102	P590	0	92
28522	Gundrikbhog	0	50
28867	Aus 4	0	100
36731	Firro E(1)	0	16
37215	Matichakma	0	67
37337	Urman Sardar	0	51
37482	Konekchul	0	92
37761	Maliabhangor 1096	0	3
49996	Ovarkondoh	0	3
11355	IR20[b]	0	16
24153	IR26[b]	0	8
30413	IR30[b]	0	6
21473	ARC11554[b]	0	0

[a]IRGC = International Rice Germplasm Center. [b]Vector-resistant variety. Other varieties are susceptible to GLH after IRRI data base on GLH resistance.

of resistance genes to both strains of RTSV. Information on the occurrence of virus strains in different regions is needed for effective deployment of resistance genes. ■

Symptomatic strains of rice tungro bacilliform virus

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Several tungro virus strains have been reported previously. Most of these reports, however, were published long before the discovery that two viruses are involved in the disease. Hence, the reported strains could be interpreted as being due to either infection with one or both viruses. From an isolate maintained in a greenhouse, we isolated four rice tungro bacilliform virus (RTBV) strains by separating them from rice tungro spherical virus (RTSV). Differential cultivars, TN1 and FK135, were serially inoculated with the strains, using *Nephotettix virescens,* until consistent symptoms were obtained.

The RTBV strains (Ic, G1, and G2) were differentiated from the type strain (L) by the symptoms they cause on FK135 and TN1. On FK135, strain Ic induced distinct interveinal chlorosis, stunting, reduced tillering, and narrow leaves, whereas GI and G2 caused only mild stunting, with foliage remaining normal and green. Symptoms caused by these strains were milder than those caused by strain L, which induces very severe stunting and interveinal chlorosis (Fig. la). On TN1, Ic and G1 caused mild stunting and foliage remained green in contrast with G2, which caused severe stunting and discoloration similar to the type strain (Fig. 1b).

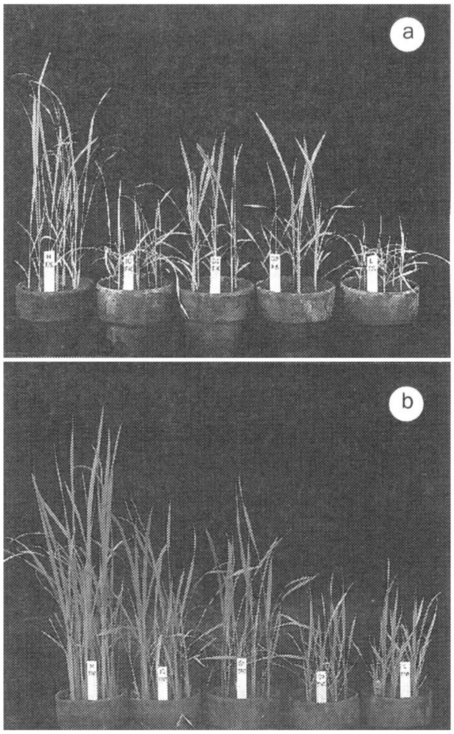
Cross-inoculation experiments showed that strains G1 and Ic were cross-protective. FK 135 plants infected with G1 did not show changes in symptom pattern when challenge-inoculated with Ic 1 or 2 wk after inoculation with G1, and vice versa. When virus-free green leafhoppers were allowed to access cross-inoculated plants for 24 h and used to inoculate FK135 seedlings, only the strain inoculated first was transmitted. Cross protection was incomplete when challenge inoculation was done at a 1-d interval. Most of the inoculated plants, however, showed the symptoms of the strain inoculated first. Both strains were recovered from these plants, but more of the strain inoculated first (see table).

These results indicate that RTBV is variable. The difference in symptom expression of the strains on TN1 and FK135 indicated that at least two viral

Cross-inoculation between RTBV strains G1 and Ic at different time intervals and virus recovery from cross-inoculated plants 1 mo after the second inoculation.

Interval between inoculations	Inoculation sequence[a] 1st	2d	Plants (no.) with symptoms[b] of 1st	2d	Strains recovered[c] (no.) 1st	2d
2 wk	G1	Ic	19	0	94	0
	Ic	GI	17	0	69	0
1 wk	G1	Ic	33	0	129	0
	Ic	GI	17	0	88	0
1 d	G1	Ic	46	5	120	38
	Ic	GI	39	4	111	14
Control	G1	None	17	0	30	0
	Ic	None	17	0	61	0

[a]Five viruliferous leafhoppers were confined with 2-wk-old FK135 plants for 24-h maculation access. [b]Based on presence or absence of interveinal chlorosis 1 mo after the second inoculation. [c]Virus-free leafhoppers were allowed 24 h access to cross-Inoculated plants showing symptoms of the 1st virus and used to incoulate 6-d-old FK135 seedlings. Plants were scored 1 mo after inoculation.



Symptoms exhibited by RTBV strains on rice cultivars FK135 (a) and TN1. (b) Left to right: healthy plants (check) and plants infected with strains Ic, G1, G2, and L.

genes (one for TN1 and another for FK135) are involved in RTBV symptom expression. RTBV strains could be used for comparative studies on the mechanisms of pathogenicity of the virus.■

Inheritance of resistance to rice blast disease in some japonicas

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Rice blast (Bl) disease (*Magnaporthe grisea* [Hebert] Barr) is a major constraint to rice production in China. Crosses of the susceptible variety, Nongfu 6 (NF6), and five resistant varieties, Xianghu 84 (XU84, derived from C81-45//Ce 21/ Xianghu 14), Xianghu 25 (XU25, derived from Aijing 23/Xianghu 14//Ce 21/Aijing 23), Xiushui 04 (XS04, derived from

Table 1. F_2 segregation of S/R[a] crosses with resistance to the 3 rice Bl races.[b]

Race	Cross	Reaction (no.) Parents		F_1		F_2			χ^2	
		R	S	R	S	R	M	S	3:1	15:1
ZB_{13}	NF6/XH84	9	0	9	0	296	1	19		0.0034
	NF6/XU25	26	0	10	0	305	4	16		0.7633
	NF6/XS04	13	0	11	0	528	2	33		0.0863
	NF6/XS11	9	0	11	0	213	0	76	0.1949	
	NF6/XS24	9	0	11	0	442	3	26		0.3127
	NF6	0	10							
ZC_{15}	NF6/XH84	9	0	9	0	261	2	16		0.0538
	NF6/XU25	21	0	10	0	279	3	16		0.2586
	NF6/XS04	18	0	11	0	415	0	26		0.0437
	NF6/XS11	8	0	11	0	204	4	68	0.0048	
	NF6/XS24	11	0	11	0	449	0	27		0.1815
	NF6	0	10							
ZE_3	NF6/XH84	9	0	9	0	284	2	17		0.1164
	NF6/XU25	17	0	10	0	275	0	18		0.0021
	NF6/XS04	18	0	11	0	453	6	26		0.5115
	NF6/XS11	9	0	11	0	242	7	67	2.3050	
	NF6/XS24	15	0	11	0	321	1	20		0.0382
	NF6	0	10							

[a]R = resistant, M = moderately resistant, and S = susceptible. [b]5% significance level, χ^2= 3.84.

Table 2. F_2 segregation of R/R crosses with resistance to the 3 rice Bl races.[a]

Race	Cross	Reaction (no.) F_1		F_2			χ^2	
		R	S	R	M	S	63:1	255:1
ZB_{13}	XU84/XU25	10	0	523	0	2		0.0988
	XU84/XS04	17	0	531	0	2		0.0842
	XU84/XS11	12	0	469	1	8	0.0001	
	XU84/XS24	18	0	612	0	3		0.0040
	XU25/XS04	16	0	735	0	2		0.0501
	XU25/XS11	18	0	927	0	0		
	XU25/XS24	15	0	461	0	0		
	XS04/XS11	11	0	461	0	7	0.0049	
	XS04/XS24	10	0	569	0	2		0.0328
	XS11/XS24	13	0	562	1	8	0.0203	
ZC_{15}	XU84/XU25	10	0	666	1	2		0.0049
	XU84/XS04	17	0	528	0	2		0.0895
	XU84/XS11	12	0	392	1	4	0.4750	
	XU84/XS24	18	0	563	0	0		
	XU25/XS04	16	0	756	0	0		
	XU25/XS11	18	0	684	0	0		
	XU25/XS24	15	0	507	0	0		
	XS04/XS11	11	0	512	0	0		
	XS04/XS24	10	0	518	0	0		
	XS11/XS24	13	0	489	0	0		
ZE_3	XU84/XU25	10	0	391	0	0		
	XU84/XS04	17	0	548	0	0		
	XU84/XS11	12	0	481	0	8	0.0026	
	XU84/XS24	18	0	518	0	2		0.1029
	XU25/XS04	16	0	848	0	0		
	XU25/XS11	18	0	907	0	13	0.0541	
	XU25/XS24	15	0	604	0	0		
	XS04/XS11	11	0	880	0	14	0.0161	
	XS04/XS24	10	0	584	1	1		0.2731
	XS11/XS24	13	0	518	0	0		

[a]5% significance level, χ^2 = 3.84.

Ce 21/Xianghu 14), Xiushui 24 (XS24 derived from (Ce 21/Xianghu 14)^2/ Xianghu 25), and Xiushui 11 (XS 11, derived from CE 21^2/Xianghu 25) were used to study the inheritance of resistance to three Bl races, ZB_{13}, ZC_{15}, and ZE_3, during 1991-93.

The seeds of parents, F_1, and F_2 were sown in 60- × 30- × 7-cm plastic trays, one cross/tray. Seedlings were inoculated at the 4-leaf stage by spraying an aqueous spore suspension of 5×10^4 conidia/ml. Disease reactions were scored about 10 d after inoculation.

The results indicated that two dominant genes controlled resistance to three Bl races in XU84, XU25, XS04, and XS24, and only one dominant gene controlled resistance in XS11 (Table 1). Testing allelism of resistant parents indicated that some resistance genes were allelic, depending on Bl races used (Table 2). ■

Pest resistance—insects

Resistance to rice mealybug in whitebacked planthopper-resistant rice varieties

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Resistance to rice mealybug (*Brevennia rehi*) was evaluated in rice varieties possessing diverse genes for resistance to whitebacked planthopper (WBPH) (*Sogatella furcifera*) using the seedbox screening test. Five replications were made. Pregerminated rice seeds were sown in rows in a 30- × 25- × 6-cm seedbox.

At 7 d after sowing, each seedling was infested with 5-6 first-instar nymphs (crawlers). When about 90% of the susceptible check, TN1, had died, plant damage was rated on a 0-9 scale as 0 = no damage, 1 = slight damage, 3 = first and second leaves of most plants partially browned, 5 = pronounced browning and stunting or about half of the plants wilted or dead, 7 = more than half of the plants wilted or dead and remaining plants severely stunted and covered with a mealy coating, and 9 = all plants dead.

Rice mealybug damage ratings on rice varieties resistant to WBPH.[a] Tamil Nadu, India.

Variety	Gene for resistance to WBPH	Origin	Damage rating[b]
Boegi Boera	*Wbph 1*	Indonesia	5.8 b
N22	*Wbph 1*	India	3.4 cd
Muskhan 41	*Wbph 1*	Pakistan	2.2 def
Siam Garden	*Wbph 1*	Peru	3.0 cde
Rening	*Wbph 1*	Indonesia	4.2 c
Senawee	*Wbph 1*	Sri Lanka	1.0 g
Oha	*Wbph 1*	Nepal	3.8 c
Sathra 265	*Wbph 1*	Pakistan	3.8 c
Sufaida 172	*Wbph 1*	Pakistan	1.0 g
ADR52	*Wbph 3*	India	1.0 fg
Podiwi A8	*Wbph 4*	Sri Lanka	1.4 fg
N'diang Marie	*Wbph 5*	Senegal	1.4 fg
WC1240	*Wbph 1* + 1 recessive	India	3.0 cde
Katuyhar Dhan	*Wbph 1* + *Wbph 2*	Nepal	3.4 cd
ARC5752	*Wbph 1* + *Wbph 2*	India	1.0 fg
Colombo	*Wbph 2* + 1 recessive	India	3.0 cde
Chaia Anaser	*Wbph 1* + *Wbph 3*	Nepal	1.8 efg
TN1 (susceptible check)			9.0 a

[a]Mean of five replications. [b]In a column, means followed by the same letter are not significantly different (P = 0.05) by DMRT.

Senawee, Sufaida 172, ADR52, and ARC5752 were highly resistant to mealybug. N22, Rening, Oha, Sathra 265, and Katuyhar Dhan were moderately resistant (see table). ■

Resistance to thrips in traditional rice varieties

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We evaluated 100 traditional rice varieties for resistance to *Stenchaetothrips biformis* (Bagnall) under field conditions at the Paddy Breeding Station, TNAU, Coimbatore, during Oct 1993.

Pregerminated seeds were direct seeded in three 1-m rows. The resistant check, Ptb 21, and the susceptible check, TN1, were sown between every 10 test varieties. Varieties were exposed to natural thrip infestation. Damage was scored 30 d after sowing (DAS) using the 1-9 scale of the *Standard evaluation system for rice.*

***S. biformis* population and plant damage ratings on traditional rice varieties under field conditions. Coimbatore, India, October 1993.[a]**

Variety	Population	Damage rating[b]
Co 2	9.0 cde	1.0 c
Co 4	8.2 def	1.0 c
Co 25	8.8 cde	1.4 c
Co 26	8.0 def	1.4 c
Co 27	7.8 def	1.0 c
Co 28	7.4 def	1.0 c
Co 30	7.4 def	1.0 c
ADT10	8.0 def	1.4 c
ADT25	9.8 cd	1.0 c
Ptb12	11.8 c	1.4 c
Ptb21 (resistant check)	6.0 f	1.0 c
PLR1	6.8 def	1.0 c
Thodavalan	9.0 cde	1.0 c
Kandagasalai	6.0 f	1.0 c
Valanchannel	8.8 cde	1.4 c
Chethuvali	7.8 def	1.4 c
Karuvali	6.6 ef	1.0 c
Kodagan	8.6 cdef	1.0 c
Vali	22.8 b	3.0 b
TN1 (susceptible check)	74.8 a	9.0 a

[a]Mean of five replications. In a column, means followed by the same letter are not significantly different (P = 0.05) by DMRT. [b]Scored using 1-9 scale in SES.

Eighteen traditional varieties had a damage rating of 1 in preliminary screening. They were retested to confirm resistance.

Treatments (varieties) were arranged in a randomized complete block design replicated five times. The resistant and susceptible checks were sown randomly among test entries. Water level was slightly increased at 7 DAS and maintained at the proper level. When susceptible check TN1 showed a rating of 7 at 20 DAS, 20 seedlings/replication were removed at random. Thrips were counted in each seedling under a binocular microscope and expressed as a mean population of thrips/seedling.

All of the selected traditional varieties had a low thrip population at 20 DAS, and all, except Vali, had a damage rating of 1, indicating a high level of resistance to thrips (see table). ■

Rice gall midge *Orseolia oryzae* (Wood-Mason) biotype in Karimnagar District, Andhra Pradesh, India

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The local gall midge (GM) Asian population at Agricultural Research Station, Warangal, AP, has biotype1 pattern and a resistant reaction to all three groups of differential donors (Eswarakora, Siam 29, and Veleuthacheera/ Banglei derivatives). Since 1988, however, widespread GM incidence has been reported in resistant varieties Surekha and Phalguna in the adjacent district of Karimnagar. An experiment to examine GM biotype under natural field infestation was conducted during 1992 and 1993 wet seasons (WS) at RARS.

Eleven differential donors, constituting three different resistance groups, were obtained from the Directorate of Rice Research, Hyderabad. Entries were transplanted in single rows at 15- × 15-cm spacing during the second week of Aug 1992 and third week of Aug 1993 to favor high GM infestation. TN1 was used as the susceptible check. GM incidence was recorded for each entry by counting damaged hills, total tillers, and silvershoots at 50 d after transplanting.

Table 1. Reaction of differentials to GM population at RARS, Jagtial, AP, India. 1992 and 1993 WS.

Group	Entry	Differential donor	Incidence at 50 d after transplanting			
			Silvershoots on a tiller basis (%)		Damaged plants on a hill basis (%)	
			1992	1993	1992	1993
I	1	W1263	0	0	0	0
	2	ARC6605	0	0	0	0
II	3	Phalguna	30	26	100	95
	4	ARC5984	20	18	100	100
	5	Surekha	12	20	100	100
III	6	CR-MR-1523	3	0	40	0
	7	Velluthacheera	0	0	0	0
	8	Aganni	0	0	0	0
	9	Ptb10	0	0	0	0
	10	T1477	0	0	0	0
IV	11	TN1 (susceptible check)	38	30	100	100

Table 2. Reaction of different rice varieties and cultures to GM population in multilocation trials. RARS, Jagtial, Karimnagar, AP, India, 1992 WS.

Variety/culture	Parentage	Source of resistance	Reaction
Kakatiya	IR8/W1263	Eswarakora	Resistant
Pothana	IR579/W12708	Eswarakora	Resistant
Kavya (WGL 48684)	WGL 27120/WGL 17672 /Mahsuri/Surekha	Eswarakora and Siam 29	Resistant
Divya (WGL 44645)	WGL 23022/Surekha	Eswarakora	Resistant
Erramallelu (WGL 20471)	BC5-W/W12708	Eswarakora	Resistant
Dhanyalaxmi (BPT1235)	BC5-W/W12708	Eswarakora	Resistant
WGL 18011-15	CR44/W12708	Eswarakora	Resistant
Surekha	IR8/Siam 29	Siam 29	Susceptible
Phalguna	IR8/Siam 29	Siam 29	Susceptible
WGL 3962	Phalguna/IR36	Siam 29	Susceptible
WGL 3943	Phalguna/IR50	Siam 29	Susceptible

GM incidence was heavy during I992 WS. The group II differentials, Phalguna, ARC5984, and Surekha, and TNI showed 100% damaged plants on a hill basis and 30, 20, 12, and 38% silvershoots, respectively, on a tiller basis. The group I differentials, W1263 and ARC6605, and group III differentials, CR-MR-1523, Velluthacheera. Aganni, and Ptb10, were free from GM attack, except for CR-MR- 1523, which had 40% damaged plants and 3% silvershoots.

A similar trend was noticed during 1993 WS. In group II differentials, Phalguna had 95% damaged plants with 2.6% silvershoots and ARC5984 and Surekha had 100% damaged plants with 18 and 20% silvershoots, respectively, compared with 100% damaged plants and 30% silvershoots in TN1. The other group I and II differentials were completely free from GM attack (Table 1).

In addition, previously GM-resistant varieties Phalguna and Surekha, derivatives of Siam 29, started showing susceptibility in 1988 at RARS, Jagtial, and surrounding villages.

High GM incidence was observed in multilocation varietal trials during 1992 WS in Siam 29 derivatives Phalguna, Surekha, WGL 3962, and WGL 3943. Eswarakora derivatives were resistant (Table 2).

Phalguna, Surekha, and ARC5984, differentials derived from Siam 29 and belonging to group II, were susceptible to the local GM population in Karimnagar District in 1992-93, indicating a change in the pattern of reaction from biotype 1 to one similar to that of biotype 3. ■

Field screening of rice cultivars for resistance to gall midge *Orseolia oryzae* in coastal Karnataka, India

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Gall midge (GM) is increasing in incidence in the coastal region of Dakshina Kannada, Karnataka State. We screened 50 promising cultures for resistance during 1992-93 wet seasons (WS).

Cultures were transplanted in 4-m rows spaced at 20 cm. We recorded the number of tillers and percentage showing silvershoots 50 d after transplanting for 10 randomly selected hills per row. Ten entries were resistant (see table). ■

Reaction of promising rice cultivars to GM infestation in the field, Karnataka, India, 1992-93 WS.

AV silvershoots (%)	Lines
0-5	IET9691, IET11475, IET12179, IET12351, IET12797, IET12811, IR36, Abhaya, Suraksha, Shakthi
5-10	IET9683, IET10851, IET10318, IET11151, IET11375, IET11467, IET12186, IET12187, IET12188, IET12191, IET12419, H4, Sasyasree, Kasturi, Pusa Basmati 1, Jaldi 2, Jaldi 3
10-20	IET9553, IET10265, IET10720, IET11466, IET12183, IET12190, Jaldi 1, Jaldi 4, PNR162, PNR166, PNR519, PNR546, PNR381, IR22 (R), Ratna, Vibhava, Vikas, Mangala, Rasi
20 or more	Sonasali, Avinash, IR20, Jaya (check)

Stress tolerance

Response of rice plants from different regions to ultraviolet-B radiation

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Increased ultraviolet-B (UV-B) radiation (280-320 nm), as a result of stratospheric ozone depletion, has damaging effects on several plant physiological processes including photosynthesis, carbohydrate status, ion uptake, and ultimately, dry matter production. Species and varietal differences, in terms of sensitivity to enhanced UV-B, have been reported. Varietal differences have been noted in rice. It is possible that land races and cultivars originating from high UV-B areas have greater tolerance.

We tested the hypothesis that rice cultivars originating from regions with higher ambient UV-B radiation are more tolerant of UV-B radiation by evaluating their growth response to elevated UV-B radiation.

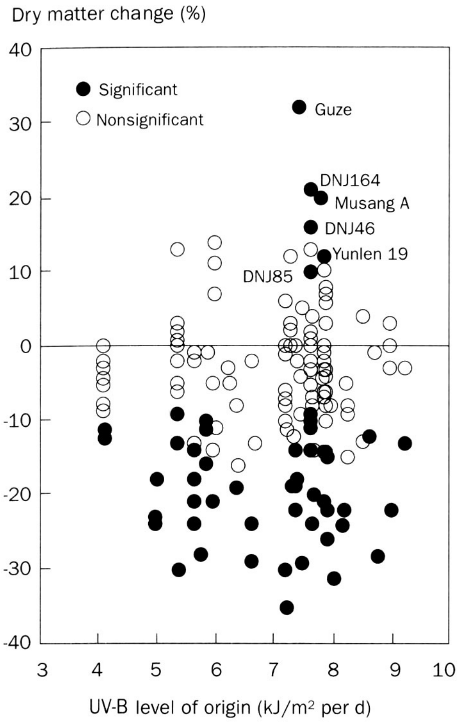
We screened 188 rice cultivars from various varietal groups and ecosystems, supplied by the International Rice Germplasm Center at IRRI, for their growth response to UV-B treatment from 1991 to 1992. Cultivars were screened in batches of 22. Seeds were pregerminated at 30 °C for 24 h and then sown in 1-liter plastic pots containing 1.7 kg of Maahas clay soil fertilized with 0.4 g N, 0.04 g P, and 0.25 g K/kg soil.

Plants were grown in the greenhouse for 10 d and then subjected to UV-B treatment for 3 wk in a temperature- and humidity-controlled glasshouse (day/night temperature = 27/21 °C; relative humidity = 70%). UV-emitting fluorescent lamps supplied the UV-B radiation. Plants were irradiated for 6 h/d (0900-1500 h). The average biologically effective UV-B radiation (UV-B_{BE}) was 13.0 kJ/m^2 per d. Six plants (2 pots) from each of the four replications were sampled after 3 wk of UV-B treatment. Plant height, tiller number, leaf area, leaf dry weight, and culm dry weight were determined. Plant dry weight was the sum of leaf and culm dry weight. The differences between the treated plant and corresponding control were analyzed using LSD test. The ambient UV-B radiation of origin was calculated based on latitude, longitude, and growing season according to the Björn and Murphy model.

Number of rice cultivars in a group showing a significant reduction ($P < 0.05$) in plant height, tiller number, leaf area, and dry weight when exposed to 3 wk of enhanced UV-B radiation.

Group	Number of cultivars	Plant height	Tiller number	Leaf area	Dry weight
Indica	117	87 (74)[a]	26 (22)	39 (33)	40 (34)
Japonica[b]	55	42 (76)	8 (15)	15 (27)	13 (24)
Javanica[b]	7	5 (71)	5 (71)	3 (43)	3 (43)
Hybrid	9	9 (100)	2 (25)	5 (73)	5 (73)
Total	188	143 (76)	41 (22)	62 (28)	61 (32)

[a] Values in parentheses represent the percentage of cultivars affected. [b]Japonica and javanica groups do not differ by isozyme analysis.



Dry matter change of 188 rice cultivars under enhanced UV-B radiation in the glasshouse compared with the UV-B level of their origin.

Rice cultivars used in this study showed a range of morphological changes and dry matter production to enhanced UV-B irradiation, although response varied among cultivars and groups (Table 1). About 28 of the test materials significantly reduced their leaf area, 32% significantly reduced their plant dry weight, and 76% significantly reduced their plant height. Indica and japonica groups did not differ much in plant height reduction. More reduction in tiller number (22%), leaf area (33%), and plant dry weight (34%), however, were observed in indicas than in japonicas under the UV-B treatment. Although the number of cultivars tested was small, the javanica rices now classified as tropical japonicas are more sensitive than temperate japonicas.

Because the ambient UV-B radiation level at lower latitudes is greater than that at higher latitudes, it is generally assumed that rice cultivars originating near the equator are more tolerant of UV-B radiation. The results of this study indicate that this hypothesis is not true. The correlation (r^2 = 0.01) between dry matter changes under enhanced UV-B and ambient UV-B level at the site of origin was not significant (see figure). Even after removing the nine hybrid rice cultivars from the plot, the r^2 value was still nonsignificant.

Six rice cultivars with significantly increased biomass production under elevated UV-B did, however, originate from high UV-B areas (7-8 kJ/m^2 per d). DNJl64, DNJ46, and DNJ85 (aus rice) are grown in Bangladesh during summer, when UV-B levels are highest. Yunlen 19, Guze, and Musang A are indigenous to high elevation areas where prevailing UV-B irradiance is most likely high (see figure). The UV-B-tolerant cultivars evaluated in this study might be used as possible donors in a breeding program, but the genetic bases and makeup for their response differences must be further examined. ■

Stress tolerance—drought

Changes in water content of rice grain during water deficit

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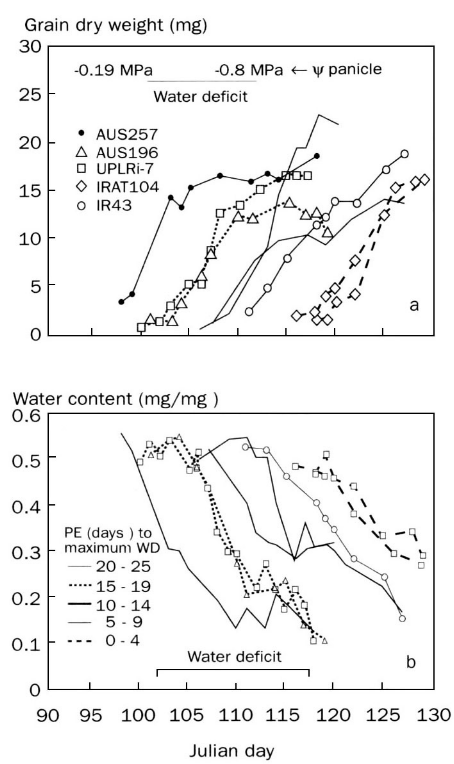
Water content of cereal grains decreases during maturity. Environmental stresses such as extreme temperature or water deficit, however, may cause abrupt changes in grain water content and result in seed shriveling and discoloration, delayed ripening, and poor grain quality. Similarly, rapid reduction in water content of grains can result in poor seed germination and seed deterioration.

Five rice cultivars (AUS257, AUS196, UPLRi-7, IR43, and IRAT104) were seeded on several dates during the dry season under upland conditions with sprinkler irrigation. Plots were at different growth stages when a 12-d water deficit was imposed. Maximum water deficit was observed at the end of the 12-d water deficit when $\psi_{panicle}$ was -0.8 MPa.

Panicle water potential was measured at dawn (0400-0600 h) using a pressure chamber. Developing grains were collected at 2- to 3-d intervals starting at 4-7 d after panicle emergence, and their water content and dry weights were determined gravimetrically. Rates of change were determined on the linear portion of dry weight and water content by least square method.

Grain dry weight, which generally followed a sigmoidal pattern, increased after panicle emergence regardless of water deficit; only slight differences in rates, however, were observed among most of the cultivars. During the panicle



Changes in grain dry weight (a) and water content (b) during water deficit.

Changes in grain dry weight and water content of rice stressed at different stages after panicle emergence.[a]

PE[b] before maximum WD[c] (d)	Cultivar	Change in dry weight (mg/d)	r	Change in water content (%/d)	r	Water loss and dry weight relationship slope	r
20-25	AUS257	1.8	0.97**	3.8	0.98**	–0.33	0.97**
15-19	AUS196	1.4	0.98**	5.5	0.99**	–0.27	0.92**
15-19	UPLRi-7	1.7	0.96**	2.5	0.99**	–0.43	0.95**
10-14	AUS257	0.8	0.88*	3.3	0.99**	–0.41	0.98**
10-14	IRAT104	2.4	0.98**	4.2	0.91**	–0.82	0.92**
5-9	IR43	1.1	0.98**	2.4	0.99**	–0.42	0.96**
0-4	UPLRi-7	1.7	0.99**	1.9	0.98**	–0.68	0.99**
0-4	UPLRi-7	1.7	0.98**	1.8	0.99**	–0.80	0.96**
SD		0.45		1.2		0.20	

[a]*, ** = Significant and highly significant, respectively, at the 5% level, [b]PE = panicle emergence. [c]WD = water deficit.

emergence period of 10-14 d before maximum water deficit, AUS257, a small-seeded cultivar, increased grain dry weight by 0.8 mg/d while IRAT104, a large-seeded cultivar, increased its grain dry weight by 2.4 mg/d (see table).

Except for AUS257, water content was almost constant until 5-6 d after panicle emergence, after which it decreased almost linearly. At harvest, grain water content ranged from 10 to 30% (see figure). Rice grain lost less water when panicle emergence was close to maximum water deficit (UPLRI-7 grain lost 1.8% water/d) than when panicles emerged between 15 and 19 d before maximum water deficit (grain lost 2.5% water/d). IRAT104 lost 4.2% water/d compared with AUS257, which lost only 3.3% water/d, even though their panicles emerged within the same period.

Grain water content and grain dry weight were negatively correlated (see table). The leveling off in dry weight was not accompanied by leveling off in water content because water loss continued for a few more days. These findings suggest that even if grain is fully mature, it continues to lose water even under water deficit. Results also suggest that a decrease in water loss in the grain was due to low water status during water deficit and not mainly to maturation. ■

Integrated germplasm improvement—irrigated

Kairala (Ptb49), a high-yielding rice variety with multiple resistance from Kerala, India

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Popular high-yielding rice varieties of Kerala—Jyothi, Pavizham, and Annapoorna—werecrossed with highly adaptable IR36 in a breeding program to develop varieties with multiple resistance to pests. Single plants with desired attributes were selected from the segregating population.

KAU8754, a promising culture isolated from the cross IR36/Jyothi, showed high yield potential and moderate to high levels of resistance to leaf blast, neck blast, sheath blight, gall midge biotypes 1 and 4, and whitebacked planthopper. This elite line was released as Kairali (Ptb49) in 1993.

The variety was highly promising in station trials from 1987 to 1991, with a mean yield of 4.1 t/ha. In the 1991-92 kharif (dry) season, the variety yielded a mean of 5.2 t/ha across 23 locations in the All India Coordinated Trials, indicating high adaptability to different soil and environmental conditions (see table). The mean yield of Kairali was 500 kg/ha higher than Ratna, the check variety.

Grain is long bold with red kernels. Milling and cooking qualities are excellent.

Performance of Kairali at different sites in India.

Location	Mean grain yield (t/ha) Kairali	Ratna
Kerala	4.7	4.1
Tamil Nadu	5.4	5.5
Karnataka	4.7	4.1
Andhra Pradesh	4.6	4.0
Maharashtra	3.2	2.8
Haryana	6.8	6.3
Rajasthan	5.4	5.4
Punjab	5.0	4.3
Jammu and Kashmir	5.5	4.0
Mean[a]	5.2	4.7

[a]Mean of two seasons at 23 locations.

With a duration of 110-115 d, the variety is recommended for all three rice-growing seasons of Kerala (kharif, rabi [wet], and summer). ■

Zhefu No. 9, a new indica rice variety in central and eastern China

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Zhefu No.9, derived from cross 44-1086/ IR50, was released in Apr 1993 for use as an early season (April to July) indica variety in the double-cropped area of central and eastern China.

Zhefu No. 9 is a short-duration, semidwarf indica rice. It is 80-85 cm tall and has 105-110 d growth duration. Average yield is about 6.6 t/ha under normal cultivation and maximum yield is 8.8 t/ha under high fertilization and good management, which was 8.1-18.7% and 4.3-20.1% more than the checks,

Table 1. Yield potential of Zhefu No. 9 in regional tests in eastern and central China, 1991.

Site	Average		Maximum	
	Yield (t/ha)	Increase over check (%)	Yield (t/ha)	Increase over check (%)
Hangzhou, Zhejiang	6.3	8.1 [a]	8.8	15.2 [a]
Ninbo, Zhejiang	6.9	10.4 [a]	8.1	4.3 [a]
Linhai, Zhejiang	5.8	7.7 [a]	7.7	10.2 [a]
Wuzhou, Jiangxi	6.8	10.5 [a]	7.7	12.6 [a]
Shangrao, Jiangxi	6.5	6.2 [a]	7.8	11.5 [a]
Changsha, Hunan	7.0	18.7 [b]	8.0	20.1 [b]
Yuyang, Hunan	7.1	10.2 [b]	8.6	18.3 [b]
Wuhan, Hubei	6.5	14.7 [b]	7.5	18.9 [b]

[a] Erjiufong. [b] Zhefu No. 802.

Table 2. Morphoagronomic characters of Zhefu No. 9 at different sites in central and eastern China, 1992.

Character	Hangzhou, Zhejiang	Wuzhou, Jiangxi	Xiangtan, Hunan	Wuhan, Hubei
Plant height (cm)	81.0	74.5	85.0	88.0
Panicle length (cm)	18.3	18.1	19.4	21.0
Grains (no./panicle)	100.5	102.4	124.0	129.0
Fertility (%)	78.0	83.6	86.5	78.6
1,000 grain wt (g)	22.6	22.9	22.0	22.8

respectively (Table 1). It is highly resistant to rice blast under field conditions. (See Table 2 for morpho-agronomic characters.)

It has medium grain and good cooking quality, with an amylose content of 23.1%. ■

Xin Guang S, a promising photoperiod/temperature-sensitive genic male sterile (P/TGMS) line for two-line system of hybrid rice breeding

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Seed set of bagged panicles of Xin Guang S grown in the phytotron, CNRRI, Fuyang, China. 1992.

Temperature [a] (°C)	Daylength [b] (h/d)	Plants observed (no.)	Seed set of bagged panicle (%)
30.1	15.0	15	0 ± 0
	14.0	15	0 ± 0
	12.5	15	0 ± 0
24.1	15.0	15	0.67 ± 1.44
	14.0	15	0.22 ± 0.58
	12.5	15	57.33 ± 10.75
23.1	15.0	15	1.30 ± 2.76
	14.0	15	9.43 ± 9.49
	12.5	15	23.15 ± 13.54

[a] Temperature was weighted mean of 1 d. [b] Illumination time: 12.5 h, 0600-1830 h; 14.0 h. 0530-1930 h: 15.0 h, 0500-2000 h.

We developed a P/TGMS rice from a spontaneous male sterile segregant found in the F_2 population of cross 2490(indica)/Geng 3 (japonica)//MR365(indica).

To observe agronomic traits, outcrossing habits, and fertility alteration, Xin Guang S was sown every 10 d from 9 Apr to 4 Jul 1993 at Hangzhou and transplanted 30 d later at one plant/hill at 15 × 16.6 cm. Fertility was estimated by the seed set of bagged panicles. To identify photoperiod/temperature response, transplanted seedlings with five fully extended leaves were transferred into the phytotron at the China National Rice Research Institute (CNRRI) in 1992 and grown to ripening phase under different photoperiod/temperature settings. Panicles of 15 plants were bagged at anthesis, and seed set was evaluated for each photoperiod/temperature treatment.

Growth duration of Xin Guang S from sowing to 20% heading varied from 80 to 102 d, depending on sowing date. Xin Guang S was about 85 cm tall with about 10 tillers/plant, white stigmas, and a 74.8% exsertion rate.

Xin Guang S had complete and stable sterility with the typical abortion of pollen grains and no seed set before 25 Aug. After this time it exhibited high to partial sterility and then partial fertility from 15 to 25 Sep, during which time very few pollen grains were aborted, although seed set of bagged panicles was 16.1-25.1%.

In the phytotron, Xin Guang S showed complete sterility at high temperatures (30.1° C) regardless of daylength. At low temperatures (23.1-24.1° C), it showed high sterility under long daylength (14-15 h/d) and partial fertility under short daylength (12.5 h/d). Xin Guang S is therefore photoperiod-sensitive (see table).

Extensive testcrossing showed that hybrids had normal fertility when Xin Guang S was crossed with indica and japonica rice, suggesting that it is a potentially promising P/TGMS line for the two-line system of hybrid rice breeding. ■

Gautam, an improved rice variety for winter (boro) season in Bihar, India

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Rice yield during wet season is poor in Bihar, while it is very high in winter (boro) season from Oct-Nov to Apr-May. The area cultivated in northeastern Bihar during winter season is about 0.1 million ha, mostly in low-lying tracts where the water table is high.

Available early- and medium-duration modern varieties and traditional tall boro rice are cultivated. To avoid cold injury, the nursery is raised in Oct-Nov and seedlings are transplanted in Jan-Feb. Seedlings are damaged severely by the cold. Cold tolerance at the seedling stage is required to ensure seedling survival, shorten the growing period, and expand the cropping area.

We screened available local and improved germplasm at Pusa, where temperatures drop to as low as 4 °C. A varietal trial was conducted at different sites to develop a suitable cold-tolerant variety. An EMS-induced mutant from Rasi, PSRM1-16-4B-11, was found superior in yield and cold tolerance over checks at all locations (Table 1). Yield averaged 7.9 t/ha in farmers' fields (Table 2). This culture was recently released as Gautam.

Gautam is semidwarf, with a high degree of cold tolerance at the seedling stage. It tillers profusely during winter. Its grains are short and fine. ■

Table 1. Performance of PSRM1-16-46-11 in multilocation varietal trials. Bihar, India, 1989-93.

Year	Center	Yield (t/ha)			CV (%)	LSD
		PSRM1-16-4B-11	Boro	Pusa 2-1		
1989-90	Pusa	7.3	5.1	Damaged	12.0	5.6
1990-91	Pusa	7.7	4.2	Damaged	10.7	4.3
	Biraul[a]	3.8	3.0	Damaged	16.4	5.1
	Katihar	5.7	-	5.4	13.4	3.5
1991-92	Pusa	5.3	4.6	Damaged	16.5	6.1
	Biraul	5.5	4.4	Damaged	13.8	4.3
	Katihar[a]	3.4	3.2	2.5	6.8	1.6
	Agwanpur	5.1	4.1	3.2	9.2	2.5
1992-93	Pusa[b]	4.2	3.6	Damaged	-	-
	Biraul[a]	2.5	2.3	Damaged	15.0	2.0
	Agwanpur	4.8	4.0	24.0	11.1	0.3

[a] Irrigation water unavailable at critical stage. [b] Av yield only.

Table 2. Performance of PSRM1-16-46-11 in farmers' field. Bihar, India.

Site	Area (m^2)	Yield (t/ha)
1	90	8.8
2	360	8.3
3	2000	8.1
4	2000	8.6
5	1000	8.1
6	1500	8.3
7	1000	7.2
8	1600	6.6
9	1000	6.5
10 (check)	1000	5.0
11 (check)	1000	5.5
AV	PSRM1-16-4B-11	7.9
	Check	5.2

Bengawan Solo, a short-duration aromatic rice in Indonesia

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B7136e-Mr-22-1-5 has been released as Bengawan Solo, a short-duration aromatic rice for cultivation under irrigation in Indonesia. This variety is derived from the cross IR56^2/IR841. Its plant height, maturity, and yield potential are about the same as those of IR64 (Table 1). Bengawan Solo is resistant to BPH biotype 1. (See Table 2 for important characteristics of Bengawan Solo compared with the local aromatic rice, Pandanwangi.)

Table 1. Plant height, maturity, and yield potential of Bengawan Solo and IR64 in eight provinces in Indonesia.

Province	Location (no.)	Bengawan Solo			IR64		
		Height (cm)	Maturity (d)	Yield (t/ha)	Height (cm)	Maturity (d)	Yield (t/ha)
South Sumatera	4	92	117	4.3	96	119	4.2
Lampung	4	103	109	4.9	97	112	5.1
West Java	5	103	110	5.1	105	113	4.7
Central Java	5	89	122	6.3	82	116	5.7
East Java	5	98	115	6.6	91	117	7.0
Bali	3	115	117	4.4	106	117	4.4
West Nusatenggara	2	99	117	4.4	99	111	4.7
South Sulawesi	5	99	118	4.0	94	118	3.8
Av		99.8	116	5.0	96	115	5.0

Bengawan Solo has good grain quality and strong aroma. Its aromatic trait is maintained across regions, unlike Pandanwangi, the aromatic trait of which is highly affected by environment. It is therefore grown only in limited areas in

Table 2. Important characteristics of Bengawan Solo and Pandanwangi.

Character	Bengawan Solo	Pandanwangi
Yield (t/ha)	4.0-6.5	3.0-5.0
Plant height (cm)	100	150
Days to maturity	116	160
1,000-grain weight (g)	20	28
Head rice recovery (%)	80	80
Grain length (mm)	5.9	6.5
Gram length-breadth ratio	2.7	2.2
Amylose content (%)	17	23
Cooking quality	soft	Tender
Aroma	Strong	Medium

Cianjur, West Java. The area of aromatic rice is expected to increase as cultivation of Bengawan Solo spreads in the major rice-producing areas in Indonesia. ■

Performance of experimental hybrids in Andhra Pradesh, India

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Eleven hybrids, MTU2000 through MTU2010, and two check varieties, Prabhat and Rasi, of different growth durations were evaluated for yield. The experiment was laid out in a randomized block design with three replications during 1992 kharif (monsoon) season. One seedling was planted per hill at 20- × 10- cm spacing. Plots were 9 m^2.

Data on quantitative traits (see table) were recorded. Standard heterosis (%) for yield over the checks was also estimated.

Most of the hybrids outyielded the check variety of similar duration. MTU2008 had the highest yield (5.9 t/ha) with 38.3% standard heterosis over Prabhat followed by MTU2003 (5.8 t/ha) with 35.9% heterosis and MTU2002 (5.4 t/ha) with 26.3% heterosis. MTU2004 yielded 3.4 t/ha with 28.5% heterosis over Rasi.

These hybrids have performed well around Andhra Pradesh. The highest yielding hybrids had long slender grains. The checks had medium bold and short bold grains. ■

Performance of experimental hybrids at Rice Research Unit, Bapatla, Andhra Pradesh, India. 1992 kharif.

Hybrid/ check	Parentage	Days to 50% flowering	Plant height (cm)	Ear-bearing tillers/m^2 (no.)	Panicle length (cm)	Spikelet fertility (%)	1,000-grain weight (g)	Grain yield (t/ha)	Grain type [a]	Standard heterosis (%) at 5% over	
										Prabhat	Rasi
MTU2000	IR62829 A/MTU SN 26	114	86	330	24.5	71.5	20.3	5.2	MS	22.8*	95.9*
MTU2001	IR62829 A/MTU SN 27	111	92	298	25.4	64.5	21.3	5.2	MS	21.6*	72.7*
MTU2002	IR58025 A/MTU SN 26	115	86	306	24.1	55.3	20.5	5.4	MS	26.3*	101.5*
MTU2003	IR58025 A/MTU SN 27	116	95	300	24.6	67.8	21.1	5.8	LS	35.9*	116.8*
MTU2004	IR58025 A/MTU SN 4	97	75	258	22.0	59.2	22.3	3.4	LS	(–) 19.5*	28.5*
MTU2005	IR62829 A/MTU SN 3	94	74	262	25.5	76.9	19.3	3.1	MS	(–) 27.7*	15.3 ns
MTU2006	IR62829 A/MTU SN 4	100	71	297	22.2	67.4	21.4	3.4	LS	(–) 20.6*	26.6*
MTU2007	IR62829 A/MTU SN 15	89	63	271	18.3	41.7	20.9	2.6	MS	(–) 38.7*	(–) 2.2 ns
MTU2008	IR62829 A/MTU SN 22	111	82	317	23.4	84.4	22.5	5.9	LS	38.3*	120.6*
MTU2009	IR62829 A/MTU SN 36	105	85	287	26.6	71.8	21.2	4.8	MS	11.9 ns	78.6*
MTU2010	IR62829 A/MTU SN 40	93	71	323	19.4	40.2	21.0	2.4	MS	(–) 43.5*	(–) 9.7 ns
Prabhat	Check	111	78	253	20.2	86.9	27.1	4.3	MB		
Rasi	Check	90	75	231	20.1	81.7	20.0	2.7	SB		
GM	4.10										
CD (0.05)	0.63										
CV (%)	9.20										

[a] MS = medium slender, LS = long slender, MB = medium bold, SB = short bold. [b] * = Heterosis is statistically significant at the 5% level using LSD test, ns = not significant.

Integrated germplasm improvement—flood-prone

IR4630-derived lines are stable high yielders under saline conditions in Kerala, India

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IR4630-22-2-17 was used in a rice breeding program to develop high-yielding, saline-tolerant varieties for pokkali cultivation. Three medium-duration, tall lines were evaluated with popular pokkali varieties, Vyttila 1 and Vyttila 3, for grain yield and other agronomic attributes.

The experiment was laid out in 50-m^2 plots in a randomized block design with four replications during 1988-91 dry season. Sowing dates and field salinity differed across years, depending on rainfall availability. Grain yield was recorded at 14% moisture level. Genotype stability over four environments was analyzed.

Regression of genotypes for average yield on the environmental index resulted in regression coefficients (*b*) from 0.805 to 1.191. The variance due to deviations from regression (s^2d) ranged from -0.805 to -0.296 (Table 1). These stability parameters were not significant, indicating all lines tested were stable yielders across the environments.

Table 1. Mean grain yield (t/ha) and estimates of stability parameters for 5 rice genotypes over 4 environments. Kerala, India. 1988-91.

Genotype	$\bar{x}$	*b*	s^2d
KAU904	3.3	1.028	–0.805
KAU905	3.7	0.805	–0.612
KAU906	3.7	0.990	–0.296
Vyttila 1	2.8	0.991	–0.585
Vyttila 3	3.0	0.191	–0.689
Av	3.3		

Rice culture KAU906 had b value close to unity (0.990), indicating its highly stable performance across the environments tested. This culture yielded the most (3.7 t/ha) and was released recently in Kerala as Vyttila 4 for cultivation in pokkali areas. (See Table 2 for morphoagronomic attributes.)

The three genotypes derived from the IR4630 cross were stable yielders over time. They are recommended for use in breeding programs aimed at developing saline-tolerant cultivars with high yield potential and adaptability. ■

Table 2. Morphoagronomic attributes of saline-tolerant rice genotypes from Vyttila, India.

Genotype	Parentage	Duration (d)	Plant height (cm)	Productive tillers (no.)	Grains/ panicle (no.)	Fertile grains/ panicle (no.)	Sterility (%)
KAU904	Chettivirippu/ IR4630-22-2-17	120	164	14	151	125	17.2
KAU905	Chettivirippu/ IR4630-22-2-17	120	162	13	125	108	14.0
KAU906	Chettivirippu/ IR4630-22-2-17	120	161	14	140	129	7.9
Vytilla 1	Choottupokkali (sel)	115	158	13	128	112	12.5
Vyttila 3	Vyttila 1/TN1	115	161	15	134	125	6.7

Crop and resource management

Fertilizer management—inorganic

Increasing efficiency of nitrogen in rice through split application

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We investigated the effect of applying 124 kg N/ha on Basmati 385 in two, three, and four splits during 1990-92 dry seasons in farmers' fields in Punjab, Pakistan. Phosphorus, K, and Zn were applied to all treatments at 35, 67, and 5 kg/ha, respectively. The soils were clay loam with pH of 8.1-8.4, EC of 1.7-3.4 dS/m, Olsen's P of 4-8 mg/kg, 0.48-0.76% organic matter, and 160-212 mg/kg ammonium acetate extractable K. Thirty-day-old rice seedlings were transplanted

Table 1. Schedule of application of N (kg/ha) in farmers' fields, Punjab, Pakistan. 1990-92 dry seasons.

Treatment (no.)	Last puddling	20-25 DAT[a]	40-45 DAT	60-65 DAT
1	0	0	0	0
2	62	0	62	0
3	41	41	41	0
4	31	31	31	31

[a] DAT = days after transplanting.

at 25- × 25-cm spacing. All P, K, and Zn were applied at last puddling. Nitrogen was applied according to a schedule to single plots on each farm (Table 1).

Rice yield (t/ha) from each treatment was recorded at 14% moisture. Results from experiments conducted during each year and pooled data were subjected to statistical analysis using randomized complete block design (Table 2). Each farm was considered to be a block.

Rice yield increased significantly due to fertilizer application. Although fertilizer treatments were statistically at par, three splits appeared to be more efficient for rice production. Farmers can realize more benefits from money spent on N fertilizer if they can afford the additional laborer to apply the N in splits. ■

Table 2. Average yield (t/ha) of Basmati 385 as affected by split application of N in farmers' fields, Punjab, Pakistan, 1990-92.[a]

Treatment (no.)	1990 (5[b])	1991 (3[b])	1992 (4[b])	Pooled (12[b])	Increase over control (%)	Range of variation
1	2.4 b	2.6 b	2.5 b	2.5 b		2.0 - 3.1
2	4.1 a	3.9 a	3.9 a	4.0 a	59	2.9 - 4.6
3	4.3 a	4.0 a	4.0 a	4.1 a	66	3.1 - 4.8
4	4.2 a	4.0 a	3.9 a	4.1 a	65	3.1 - 4.6
The block effect is significant.						

[a]Figures followed by a common letter are nonsignificant at 0.05 LSD. [b]No. of farms.

Grain yield and ^{15}N uptake of drill-seeded rice as affected by coated calcium carbide

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In drill-seeded rice (*Oryza sativa* L.) production systems in the United States, permanent flooding is usually imposed about 4 wk after drilling of rice seeds. Fertilizer N is usually applied just prior to flooding, and topdressings are later applied from an airplane. Losses of fertilizer N through nitrification and denitrification reactions in these systems have not been well-characterized. If these losses are significant, then use of a nitrification inhibitor to reduce nitrification-denitrification may have potential as an N management tool. Coated calcium carbide (CCC) is a slow-release source of acetylene, a potent nitrification inhibitor, that is formed when calcium carbide (CaC_2) is wetted.

In a 2-yr field study, the effect of CCC on uptake of ^{15}N-labeled urea, dry matter production (first year only), and grain yield (both years) of drill-seeded flooded rice was tested. The long-grained semidwarf rice variety, Lemont, was drill-seeded in late April 1990 and 1991 at 112 kg/ha. Approximately 29.5 kg P/ha and 55.6 kg K/ha were banded 5 cm deep at seeding. The experiment was laid out as a two-way factorial (urea treatment and N rate) in four randomized complete blocks. Immediately before the experimental site was permanently flooded 4 wk after seeding, urea N fertilizer treatments at 60 and 120 kg N/ha were surface-applied as urea alone and as urea + CCC at 20 kg CaC_2/ha. In the first year, 5 atom% ^{15}N urea was applied at the 120 kg N/ha rate in microplots established beside the large plots. A control was untreated.

Grain yield responded positively ($P<0.05$) to N rate in both years (see table). An increase in grain yield with urea + CCC vs urea alone was only observed in 1990 at the highest N rate ($P< 0.05$). Addition of CCC to urea in 1990 resulted in small but significant ($P<0.05$) increases in fertilizer-derived N (^{15}N) uptake and dry matter production between 3 and 6 wk after fertilization compared with urea alone. This might suggest that nitrification-denitrification losses were a factor in the first year.

A lack of response to CCC in the second year might have been related to a change in the coatings of the experimental CCC used. The coating material used in CCC is a mixture of waxes and shellac, applied in several layers. In preparing the CCC for the second year, more coatings were applied with the expectation that the release of acetylene would last longer. At the end of the season, however, much of the CCC applied was found on the soil, unreacted, indicating that the coatings were too thick. Improvement of the coatings is needed to give a more consistent release of acetylene so that CCC can be further tested in flooded rice. ■

Effect of coated calcium carbide (CCC) and N rate on grain yield (t/ha) of dry seeded rice.[a] Crowley, Louisiana, USA, 1990-91.

	1990			1991		
Urea treatment	0	60 (kg N/W	120	0	60 (kg N/W	120
Urea	5.6	6.8 a	6.6 b	3.5 a	5.1 a	6.6 a
Urea + CCC	-	7.2 a	7.6 a	3.5 a	4.9 a	6.3 a

[a]Means in a column followed by the same letter are not significantly different at the 5% probability level by F-test.

Fertilizer management—organic

Effect of farmyard manure application on yield and soil fertility in rice - wheat rotation

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We studied the effect of applying four graded levels of farmyard manure (FYM) (0, 10, 20, and 40 t/ha) on yield and soil fertility in a rice - wheat rotation. FYM was applied in a single dose in Jun 1989 or in four equal splits each June for 4 yr prior to transplanting rice (PR 108) followed by wheat (HD2329). The experiment was laid out in a randomized block design. Soil samples (0-15 cm depth) analyzed before starting the experiment showed that the Typic Ustochrept was sandy loam in texture, had pH of 8.3, and was nonsaline (EC 0.3 dS/m). Inorganic carbon content was low (6050 kg/ha) and bulk density was 1.52 Mg/m^3.

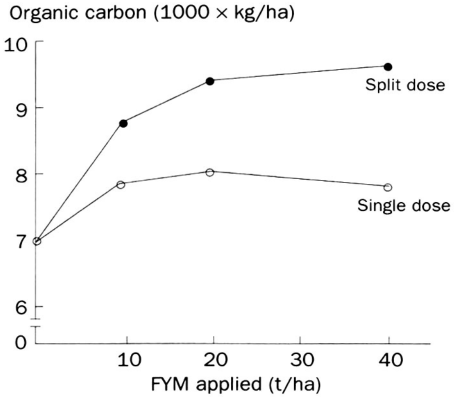
Grain yield of both rice and wheat increased significantly with graded levels of FYM. The highest yield (6.7 t/ha) was obtained using 40 t FYM/ha over 4 yr in four equal splits (see table). The residual effect of lower levels of FYM (10-20 t/ha) on wheat yield was not significant. Average yield of rice and wheat was significantly more when FYM was applied in four equal splits than as a single application. The effect was more pronounced in rice; the residual effect on wheat yield was also conspicuous.

Effect of FYM application on rice and wheat yields.[a]

FYM applied[b] (t/ha)	Rice (t/ha)	Wheat (t/ha)
0	4.1	1.4
10*	4.2	1.6
10**	5.9	1.9
20*	4.5	1.9
20**	6.1	2.0
40*	5.0	1.7
40**	6.7	2.5
CD (P = 0.05)	0.7	0.4

[a] Av of 4 yr. [b] * = applied in a single dose during Jun 1989. ** = applied in four equal splits to rice each year.

Soil organic carbon content improved with graded levels of FYM application from the initial value of 6050 kg/ha in Jun 1989 to 9600 kg/ha in May 1993 (see figure). Soil organic carbon content was highest where FYM was applied at 40 t/ha. It was significantly higher where split doses of FYM were applied each year than where a single large application of FYM was made.



Organic carbon content of soil in May 1993 after 4 yr of experimentation, Ludhiana, India.

To maintain soil fertility at higher levels and to obtain higher rice and wheat yields, FYM should be applied to rice each year in splits rather than as a single large dose. ■

Crop management

Relationships between soil properties, crop and pest management practices, pest intensity, and crop performance in rainfed lowland rice

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Holistic field surveys with integrated production level- and crop protection treatments were conducted at four rainfed lowland sites in northeast Thailand and in the Mekong Delta, Vietnam, in 1992. At each site, 4-5 farmers' fields were subdivided into plots receiving either no pest control, pest control according to farmers' practices, or fungicide and insecticide applications 4-5 times during the growing season. Fields were visited repeatedly during the growing season to collect data on crop development, yield, dynamics of disease and pest severities, water conditions, physicochemical soil properties, and crop and pest management practices. Descriptive analyses of the data were done.

Improved traditional varieties with superior grain quality prevailed in Thailand, while high-yielding IRRI varieties prevailed in Vietnam. Actual yields, final panicle numbers, and areas under the leaf area index progress curve were generally higher, while growth duration and plant height were shorter in Vietnam than in Thailand (Table 1). The data indicated more favorable physico-chemical soil properties and much higher crop and pest management inputs in Vietnam than in Thailand. High incidence of drought was observed during the

Table 1. Mean values of parameters of crop performance, soil properties, water problems, crop and pest management, and pest intensity in farmers' fields at rainfed lowland sites in northeast Thailand and Vietnam. Data are from plots that received pest control according to farmers' practice. 1992.

	Variable[b]	Site[a]							
		Thailand				Vietnam			
		KKN	PMI	SKN	UBN	BL	CM	LA	ST
Crop performance	YIELD	2.9	2.8	3.0	3.3	3.4	5.3	5.3	2.5
	GDURAT	147.0	163.4	166.6	158.4	106.5	139.3	98.5	117.7
	LAID	167.1	137.5	167.2	243.0	276.5	444.1	459.6	200.9
	PAN	138.6	138.3	141.6	150.5	354.2	452.1	522.9	408.3
	PHGHT	130.4	136.3	136.4	146.6	90.8	109.9	92.8	83.1
Soil properties	SAND	43.9	42.4	67.3	67.9	2.5	5.8	5.8	4.7
	SILT	21.4	20.4	20.7	25.1	42.2	41.0	44.4	42.3
	CLAY	35.1	37.4	12.1	7.3	55.2	53.2	49.8	53.0
	CARBON	.8	.8	.4	.6	1.3	1.9	2.1	1.1
	TLAYER	9.6	11.8	11.2	12.6	15.5	16.0	16.5	15.0
	PH	5.0	5.2	4.9	4.4	5.3	4.6	4.5	4.9
	CEC	4.4	11.4	4.1	4.6	8.9	11.9	12.8	10.8
	P	.3	2.0	1.1	2.0	2.0	4.3	4.8	1.5
	K	.4	.7	.2	.2	.3	.4	.2	.2
Water problems	SDROUGHT	.0	.4	.0	.0	1.0	.8	.3	1.0
	VDROUGHT	.0	.2	.0	.0	.8	.3	.0	1.0
	VFLOOD	.0	.0	.0	.0	.0	.0	.0	.3
	GDROUGHT	.2	.2	.0	.0	.0	.0	.3	.0
Crop and pest management	NAPP	20.2	31.2	11.6	22.0	170.4	124.2	103.0	76.0
	NOHAPP	.0	.0	.0	.0	1.8	1.5	1.3	.0
	NOPEST	.2	.0	.6	.8	6.0	5.0	3.5	.0
	NOHWEED	.6	.6	1.2	.6	.3	.3	1.8	1.0
		RD6	LPT123 KDML 105	RD6	KDML 105	IR13240	IR42	IR50404 IR9729	IR64
Pest intensity	BS	.0	.2	.0	.0	3.9	3.4	2.5	4.9
	DF	.0	.2	.0	.1	2.9	2.0	.1	1.3
	DH	.1	.0	.0	.0	2.9	1.3	1.3	.6
	DP	2.4	10.4	1.5	.8	26.5	15.0	23.6	38.7
	LF	.0	.0	.1	.0	.8	11.0	1.2	.8
	LS	.0	.0	.0	.0	8.6	4.5	.4	1.8
	MC_SBED	.0	.0	.0	.0	.0	.0	5.5	.0
	OTD	.4	.0	.0	.0	4.1	7.2	4.8	12.4
	PB	.0	.0	.0	.0	.1	.1	2.0	2.9
	R	.0	.6	.0	.0	.4	3.9	1.5	1.0
	RR	.0	.0	.0	.0	14.0	70.0	4.4	.0
	RS	.0	.0	.0	.0	1.3	.2	8.2	.3
	SHB	.3	.0	.0	1.4	.5	5.5	1.8	.0
	SHR	.0	.0	.1	.0	2.9	2.3	1.9	2.0
	SIDL	.0	.0	.0	.0	.5	.6	3.5	.2
	SIDS	.0	.0	.0	.0	4.2	.1	.0	.0
	SIDP	.0	.0	.0	.0	68.3	76.7	71.3	31.9
	TH_SBED	.0	.0	.0	.0	40.8	3.3	2.5	.0
	WCOVER	3.4	4.1	11.6	4.8	19.6	20.0	9.0	5.0
	WH	3.2	.0	.0	1.5	5.2	.5	2.7	1.5

[a] Site names: KKN = Khon Kaen, PMI = Phi Mai, SKN = Sakhon Nakhon, UBN = Ubon; BL = Bac Lieu, CM = Ca Mau, LA = Long An, ST = Soc Trang; soil properties: SAND, SILT, CLAY CARBON = % sand, silt, clay, soil C respectively, TLAYER = depth of top layer in cm, PH = soil pH (in H_2O), CEC = cation exchange capacity (meq/100 g soil), P = ppm P, K = meq K/100 g soil; water problems: S/V/GDROUGHT (FLOOD) = seedling-/vegetative-/generative phase drought stress (or submergence), respectively, 0 = none, 1 = observed in all cases crop and pest management: NAPP = kg N applied/ha, NOHAPP, NOPEST = no. herbicide- any kind of pesticide applications, NOHWEED = no. hand weedings, VARIETY = prevailing varieties; crop performance: YIELD = measured plot yield in t/ha), GDURAT = growth duration in days; LAID = area under the leaf area index curve (m^2/m^2*d), PAN = final no. panicles/ m^2, PHGHT = maximum plant height in cm; pest intensity: mean % severity/day: BS = brown spot, DF= other defoliation. DH = stem borer deadhearts, DP = dirty panicle, LF= leaffolder damage, LS = leaf scald, MC_SBED = mole cricket damage in seed bed, OTD = other tiller damage, PB = panicle blast, R = rat damage, RR = root rot at maximum leaf area stage RS = red stripe disease, SHB = sheath blight, SHR = sheath rot, SIDL = sucking insect damage on leaves, SIDS = sucking insect damage on sheaths, SIDP = sucking insect damage on panicles, TH_SBED = thrips damage in seed bed, WCOVER = weed cover (%/d); maximum % severity: FSm = false smut, WH = stem borer whiteheads; only pest problems exceeding 2.5% intensity at one site at least are presented; no. fields/site: 4-5.

Table 2. Correlation coefficients of relationships among parameters of crop performance, soil properties, crop and pest management, and pest intensity measured in farmers' fields at rainfed lowland sites in Vietnam and northeast Thailand. Data are pooled across plots that received different intensities of pest control.[a] 1992.

	YIELD	NAPP	NOWEED[b]	NOPEST	VDIS	VDISINS	GDISINS	VGDISINS	WCOVER
CLAY	.35	.59**	.12	.47*	.72**	.73**	.57**	.69**	.27
SILT	.51**	.65**	.25	.64**	.67**	.72**	.68**	.66**	.35
SAND	–.45*	–.67**	–.19	–.59**	–.77**	–.79**	–.66**	–.74**	–.33
TLAYER	.58**	.59**	.13	.57**	.70**	.71**	.44*	.58**	.22
CARBON	.75**	.60**	.29	.61**	.72**	.75**	.61**	.71**	.35
PH	–.37**	.15	–.24*	–.04	–.10	–.14	.08	.03	–.01
CEC	.48**	.41**	.10	.17	.62**	.63**	.52**	.64**	.20
P	.56**	.40**	.39**	.28*	.49**	.54**	.18	.34**	.23
K	–.00	.02	–.14	–.08	–.18	–.17	–.09	–.01	–.02
NAPP	.45*		.32	.74**	.61**	.68**	.63**	.66**	.56**
NOWEED	.32	.32		.44*	.36	.41*	.29	.36	.49*
NOPEST	.63**	.74**	.44*		.62**	.66**	.51**	.56**	.48*
AYIELD	.67**	.76**	.33	.81**	.77**	.81**	.67**	.76**	.56**
VDIS	.51**	.61**	.36	.62**		.98**	.59**	.82**	.42*
VDISINS	.53**	.68**	.41*	.66**	.98**		.60**	.83**	.52**
GDISINS	.31	.63**	.29	.51**	.59**	.60**		.90**	.27
VGDISINS	.40*	.66**	.36	.56**	.82**	.83**	.90**		.39*
WCOVER	.30	.56**	.49*	.48*	.42*	.52**	.27	.39*	

[a]WDIS = % total disease on vegetative plant parts; VDISINS = % total disease and Insect damage on vegetative plant parts; GDISINS = % total disease and insect damage on generative plant parts and on whole tillers; VGDISINS = VDISINS + GDISINS; for definition of other parameters. see Table 1; one-tailed test, n = 93; * = significant at p = 0.01; ** = significant at p = 0.001; correlation coefficients were truncated; pest control treatments: a) no control, b) control accordingto farmers' practices, c) pest control 4-5 times during growing season. [b]NOWEED = number of weed control measures (hand weeding and/or herbicide application).

vegetative phase at some sites in Vietnam.

A wide spectrum of disease and insect damage was observed. Severity ratings of biotic constraints were generally higher at sites in Vietnam than at those in Thailand. High severity ratings of dirty panicles and weed infestation were observed in both countries. Noticeable levels of leaf scald, brown spot, red stripe, root rot, sheath blight, leaffolder damage, whitehead damage, and discoloration due to sucking insects (especially on panicles), tiller damage caused by rats and other pests, and seedbed damage due to thrips and/or mole crickets were observed, mainly in Vietnam.

Correlation analyses showed a complex structure of intercorrelations among parameters of crop performance, soil fertility and water-holding capacity, crop and pest management intensity, and pest intensity (Table 2). High actual yields of sites, high physiological potential production levels as determined by parameters of soil fertility and water-holding capacity, high fertilizer and pest control inputs, and high pest intensities were closely associated.

Pest intensity may primarily depend on the physiological potential production level and not on the intensity of pest control while the willingness of farmers to invest in pest control may mainly depend on a site's yield potential. In this light, cause-effect relationships between site-specific conditions and pest problems and the profitability of pest control need to be critically examined. The data can be useful for characterizing patterns of and interrelations among cropping and pest control practices, factors determining productivity level, and pest problems in rainfed lowland rice areas. ■

Integrated pest management—diseases

Efficacy of three fungicides for controlling growth of five seedborne fungi associated with rice grain spotting

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Many fungi may cause rice grain spotting. The presence of fungi and discoloration reduce rice seed quality. Fungi may appear externally on the lemma and palea and/or internally in the grain. Grains with black dots, pigmentation, chalkiness, and stains from the Province of Corrientes, Argentina, were studied. We isolated 10 fungi from field-infected panicles using the blotter test method, following the rules of the International Seed Testing Association. The following were selected for an in vitro control test due to their importance and frequency: *Bipolaris oryzae, Curvularia lunata,* an unidentified species, and *Fusarium semitectum.* *Fusarium moniliforme* was included as an ordinary pathogenic control species.

We used fungicides thiabendazole, carbendazim, and mancozeb. Solutions were prepared using 50, 100, 500, and

Effect of chemical treatments on some fungi that cause rice grain spotting.[a]

Treatment	Concentration (ppm)	Fungus species growth[b] (ϕ cm): *Bipolaris oryzae*	*Curvularia lunata*	Unidentified	*Fusarium moniliforme*	*Fusarium semitectum*
Thiabendazole	0	2.74 de	3.80 d	2.01 c	4.83 c	4.85 a
	50	2.95 cd	3.20 e	0.60 g	0.60 g	0.60 f
	100	2.92 cde	2.53 e	0.60 g	0.60 g	0.60 f
	500	3.12 bcd	2.07 h	0.60 g	0.60 g	0.60 f
	1000	2.84 cde	2.14 gh	0.60 g	0.60 g	0.60 f
Carbendazim	0	2.91 cde	5.77 ab	3.71 a	5.78 a	4.50 b
	50	3.57 a	5.89 a	0.97 ef	0.60 g	0.60 f
	100	3.60 a	5.72 b	0.73 fg	0.60 g	0.60 f
	500	3.50 ab	5.78 ab	0.60 g	0.60 g	0.60 f
	1000	3.20 abc	5.85 ab	0.60 g	0.60 g	0.60 f
Mancozeb	0	2.49 e	4.69 c	2.85 b	5.65 b	4.49 b
	50	3.15 bcd	2.24 g	2.64 b	4.88 c	4.20 c
	100	2.78 cde	2.15 gh	2.81 b	4.68 d	4.52 b
	500	1.59 f	1.33 i	1.47 d	4.42 e	3.60 d
	1000	1.00 g	0.60 j	1.24 de	3.95 f	3.42 e

[a]Mean of 4 replications. [b]In a column, means followed by common letters are not significantly different at 5% by DMRT.

1,000 ppm sterile distilled water. For each, 1 ml of the fungicide solution was mixed with glucose potato agar (GPA), melted at 50 °C, and poured in petri dishes. Agar slugs (6-mm-diam disks) of each species were then centered in the dishes containing the agar and fungicide concentrations.

Each concentration was replicated four times as was the control sample (0 ppm) in which 1 ml distilled water was added to the melted agar. Petri dishes were kept in an incubator at 25 °C. We measured colony diameters on days 2, 4, 6, 8, and 10.

A totally random design was used and a factor analysis of data was performed. Duncan's multiple range test was applied to evaluate the differences between mean values.

Of the three products, mancozeb had the greatest efficacy on *B. oryzae* and *C. lunata,* with the greatest effect at 500 ppm. Carbendazim and thiabendazole had good efficacy at 50 ppm in controlling the growth of *F. semitectum, F. moniliforme,* and the unidentified species. ■

Leafhopper transmission of the Philippine isolate of rice dwarf virus

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Rice dwarf virus (RDV) is a new viral disease of rice in the Philippines. It is presently found only in Midsayap, North Cotabato. Several leafhopper species are known vectors of the disease in countries where it occurs. We determined which leafhopper species transmit RDV in the Philippines.

Second-instar nymphs of *Nephotettix nigropictus, N. virescens,* and *Recilia dorsalis* were allowed 4 d of access to RDV-infected Taichung Native 1 (TN1) plants. They were transferred to healthy TN1 seedlings for 4 d, and then, individually used to inoculate a 6-d-old TN1 seedling in a test tube. Until they died, insects were transferred daily to fresh seedlings. Inoculated seedlings were transplanted in pots and scored 1 mo after inoculation.

To test for transovarial passage of the virus, 2d- to 3d-instar nymphs of *N. nigropictus* were given access to a diseased plant for 4 d and then reared on healthy TN1 seedlings until they became adults. All female adults were selected and confined on healthy TN1 seedlings to lay eggs for 3 d. Nymphs that hatched were immediately tested for RDV transmission as above.

Among the three leafhopper species tested, only *N. nigropictus* transmitted RDV (see table). About 10% of those tested were active transmitters. The virus is persistent in the vector and has an incubation period of 8-23 d (av of 15 d). RDV was also passed through transovarial passage to the progenies of viruliferous insects. About 10% of the insects were congenitally infective. Eight percent of them transmitted RDV immediately after hatching.

RDV had an incubation period of about 9 d in the rice plant. The first sign of RDV infection was minute white specks on emerging leaves. Leaf symptoms became more conspicuous 3-4 wk after inoculation. Stunting on TN1 was very mild. Infected plants looked normal except for the white specks or streaks on leaf blades. Plants grown from seeds of infected plants did not show RDV symptoms.

Our results showed that *N. nigropictus* is the main vector of RDV in the Philippines and was not transmitted, as in other countries, by *N. virescens* and *R. dorsalis.* This difference in vector transmission may be due to either a difference in the colony of insects used or a difference in RDV strain. ■

Transmission of rice dwarf virus (RDV) by 3 species of leafhoppers.

Species	Insects tested (no.)	Insects that transmitted (no.)	Incubation period in vector (d)
N. nigropictus	400	40	8-23
N. virescens	400	0	
R. dorsalis	400	0	
Transovarial passage[a]			
N. nigropictus	579	60	0-2

[a]Insects hatching from eggs of all female adults with access to RDV-infected plants.

Bakanae and foot rot disease incidence in Basmati 385 nursery in Punjab, Pakistan

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Bakanae and foot rot disease has become a serious disease of Basmati varieties, particularly Basmati 385, in Punjab, Pakistan. The disease can attack the rice plant from preemergence to flowering.

Disease incidence data have been recorded only from the transplanted crop in Pakistan. We conducted a survey to determine the bakanae and foot rot disease incidence in nurseries in traditional rice-growing areas of Sheikhupura, Gujranwala, and Sialkot districts during 1992.

Disease symptoms observed in the nurseries were discolored (whitish) seedlings, which were prevalent in nurseries up to 15-18 d after seeding, and elongated (thin and pale) seedlings, which were found at later stages. The data were recorded in a nursery from four randomly selected spots of 0.09 m^2 each. Seed source, seed treatment, and water source were also recorded.

Bakanae and foot rot disease incidence on Basmati 385 in the traditional rice-growing areas of Punjab, India. 1992.

Item	Sheikhupura	Gujranwala	Sialkot	Total
Nurseries checked (no.)	89	36	55	180
Diseased nurseries (%)	92.0	97.2	98.1	93.9
Treated seed nursery (%)	3.4	5.5	9.1	5.5
Untreated seed nursery (%)	96.6	94.5	90.9	94.5
Seed source (%)				
Farmers' own	89.8	86.1	94.5	90.5
Punjab Seed Corporation	5.6		1.9	3.3
Rice Research Institute, Kala Shah Kaku	2.2	2.8	1.9	2.2
Others	2.2	11.1	1.9	3.9
Disease incidence (%)				
Untreated seed				
0-12 d	10.5	6.5	5.6	
13-24 d	5.4	3.6	3.8	
25 d and more	1.2	1.7	2.5	
Av	7.2	3.6	4.5	
Treated seed	3.3	2.4	2.7	
Reduction in disease incidence (%)	54.9	33.5	40.7	

Seeds of 94.5% of the 180 nurseries surveyed were not treated with fungicide. Farmers used their own seed, produced from the previous year's crop, in most (90.5%) of the nurseries (see table). The high number of diseased nurseries (93.9%) might be due to infected seed, indicating the disease's seedborne nature.

Disease incidence was greater in younger nurseries and decreased with age. The highest average incidence (7.2%) was observed in Sheikhupura. Treating seed with a fungicide reduced the incidence 33.5-54.9%. ■

Using gypsum to manage sheath rot in rice

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Foliar application of salts (calcium sulfate, magnesium sulfate, and ammonium molybdate) reduced sheath rot (ShR) incidence, caused by *Sarocladium oryzae* (Sawada) Grams and Hawksw, in an earlier greenhouse experiment. We conducted field trials to compare these treatments with soil application of calcium sulfate as gypsum during 1991-92 wet season (WS) (Sep-Feb) in two locations using variety Co 43. Plot size was 5 x 4 m^2; treatments were laid out in a randomized block design. Gypsum, at 500 kg/ha, was applied basally and as a topdressing, singly and in combination. Salts and a fungicide, carbendazim, were

Effect of various salts on rice ShR incidence and grain yield.[a] Aduthurai, India, 1991-92 WS.

Treatment	Time of application	Mean ShR Incidence (%)		Mean grain yield (t/ha)	
		Trial 1	Trial 2	Trial 1	Trial 2
Gypsum 500 kg/ha	50% basal + 50% at 35 d after transplanting (DAT)	21.8 ab	22.8 a	3.6 a	4.0 a
Gypsum 500 kg/ha	50% at 20 DAT + 50% at 35 DAT	20.1 a	21.9 a	3.6 ab	3.6 ab
Gypsum 500 kg/ha	Basal only		27.7 ab		3.4 ab
Gypsum 500 kg/ha	Topdress only at 25 DAT		30.6 b		3.7 c
Calcium sulfate 0.2%	Booting and 10 d later	26.5 abc		3.2 bcd	
Magnesium sulfate 0.2%	Booting and 10 d later	28.1 bc		3.3 bcd	
Ammonium molybdate 0.005%	Booting and 10 d later	26.3 abc		3.4 abc	
Carbendazim 0.1%	Booting and 10 d later	20.7 ab	23.0 ab	3.4 ab	3.9 a
Untreated check		31.2 c	40.9 c	3.1 d	2.6 d

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

applied as a foliar application at booting and 10 d later. We measured ShR incidence as a percentage of tillers affected on 25 randomly selected hills/plot, 20 d after the last spray.

In the first trial, applying gypsum to the soil in two equal splits at different times was comparable with carbendazim in reducing ShR and increasing grain yield significantly (see table). Foliar application of the salts was inferior to the gypsum application.

In the second trial, all gypsum treatments significantly reduced ShR, although only basal applications increased the yield considerably.

Gypsum is a promising treatment for reducing ShR incidence in rice and for increasing grain yield when applied as two equal splits. ■

Integrated pest management-insects

Effects of botanical treatments on brown planthopper *Nilaparvata lugens* (Stål)

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We tested several extracts from plant species for use in controlling brown planthopper (BPH).

Field-collected BPH populations were cultured in screenhouse insect cages. Sap was extracted from test botanicals using a mortar and pestle and then mixed with water (1:1). Three-week-old TN1 seedlings/pot (7.6-cm-diam) were kept in a screened enclosure. Leaves were pruned at 30 cm above soil level.

Each extract (4 ml/pot) was applied to rice seedlings using a hand sprayer. Immediately after treatment, about 900 nymphs (4th-5th stages) and adults (3:1) were released and prorated in the enclosure. We counted BPH on the plants after 12 h.

The free-choice experiment was laid out in a completely randomized design replanted twice for each treatment, and replicated five times. Endosulfan-treated and untreated rice plants served as controls.

Some of the botanical treatments were significantly more effective than others, but none were nearly as effective as endosulfan (see table). Untreated plants had the most insects (8.6/plant). Nymphs and adults responded in the same way to treatments. *Azadirachta indica, Anonas reticulata,* and *Tinosphora rumphii* appear to have repellant effects on BPH. ■

Effects of botanical treatments on BPH.

Plant species/ chemical	Plant part used	BPH/ plant[a] (no.)	
Endosulfan[b]	-	0.5	a
Anonas reticulata	Leaf	3.6	b
Azadirachta indica	Leaf	4.0	bc
Tinosphora rumphii	Vine	4.6	bcd
Capsicum frutescens	Fruit rind	6.0	bcde
Pithosporum resiniferum	Leaf	6.3	bcde
Carica papaya	Leaf	6.5	bcde
Dieffenbachia picta	Leaf, stalk	6.5	bcde
Momordica charantia	Leaf, stem	6.5	bcde
Anonas muricata	Leaf	6.8	bcde
Curcuma zedoaria	Rhizome	7.1	bcde
Citrus sp.	Leaf	7.6	de
Ageratum conyzoides	Leaf	7.8	de
Anonas squamosa	Leaf	8.1	de
Catharanthus roseus	Leaf	8.6	e
Musa sapientum	Stalk	8.6	e
Control		8.6	e

[a]Means followed by a common letter are not significantly different at the 5% level by DMRT. [b]Three tablespoons/16 liters of water.

Research methodology

Illustrating the recommendation domain concept in integrated pest management: an Indian case study

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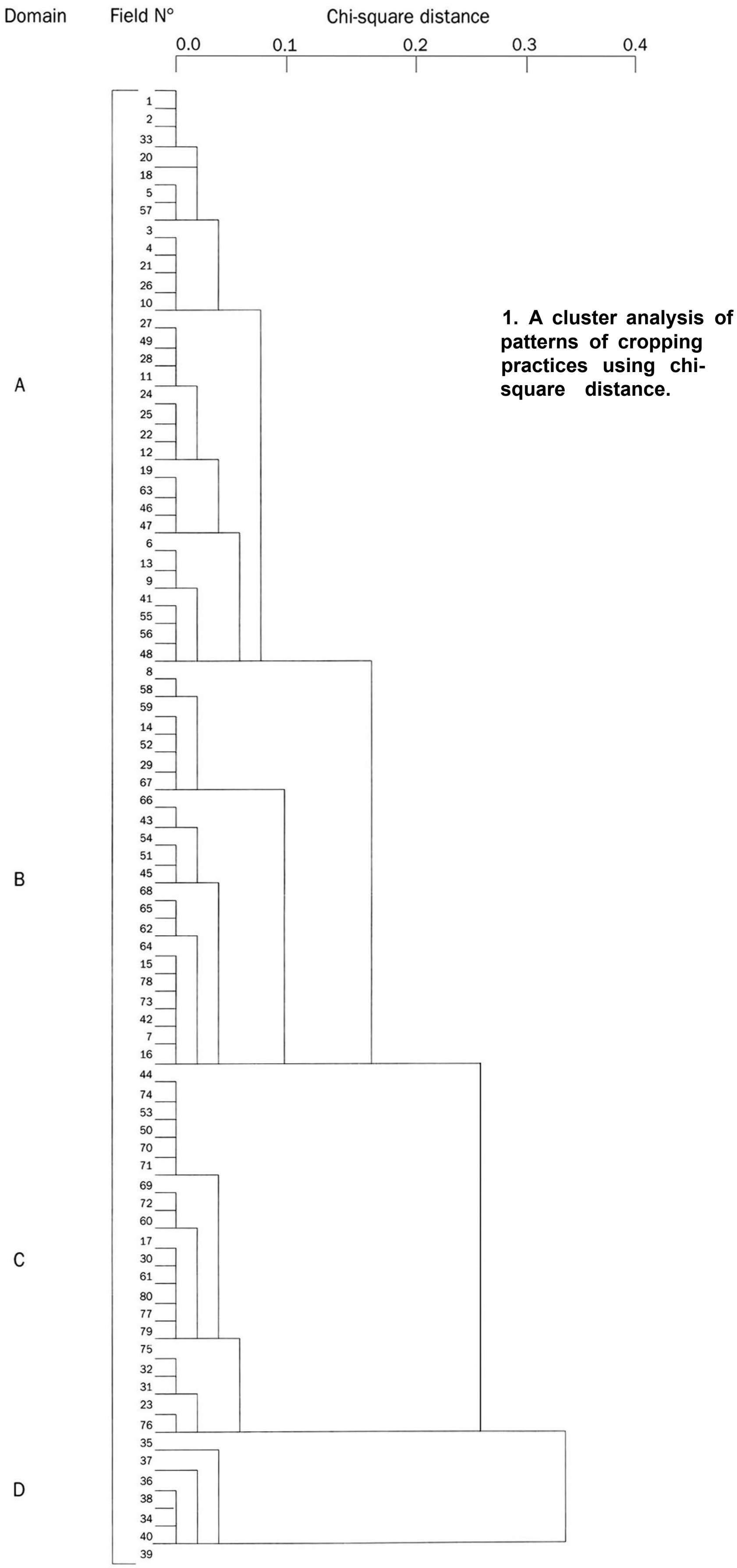
Integrated pest management (IPM) strategies are site-dependent. Among the many reasons for this is that the particular combination of pests and diseases (the injury profile) that affects a given crop is, to a significant extent, driven by location-specific crop management practices. Another reason is that the amount of yield reduction (damage) that can be attributed to a given injury profile depends on the (attainable) yield the crop would have achieved had these pests been absent. The attainable yield reflects a given production situation and is site-dependent. It is therefore necessary to identify the domains where rice pests and diseases may become constraints to productivity and where differing IPM strategies are to be considered.

Surveys have been jointly initiated by NDUAT, IRRI, and ORSTOM since 1991 to characterize the injury profile associated with differing production situations in Uttar Pradesh, India. The surveys address monsoon season crops in three typical rainfed landforms of two villages. The procedure to analyze this information is exemplified using 1992 data, represent-



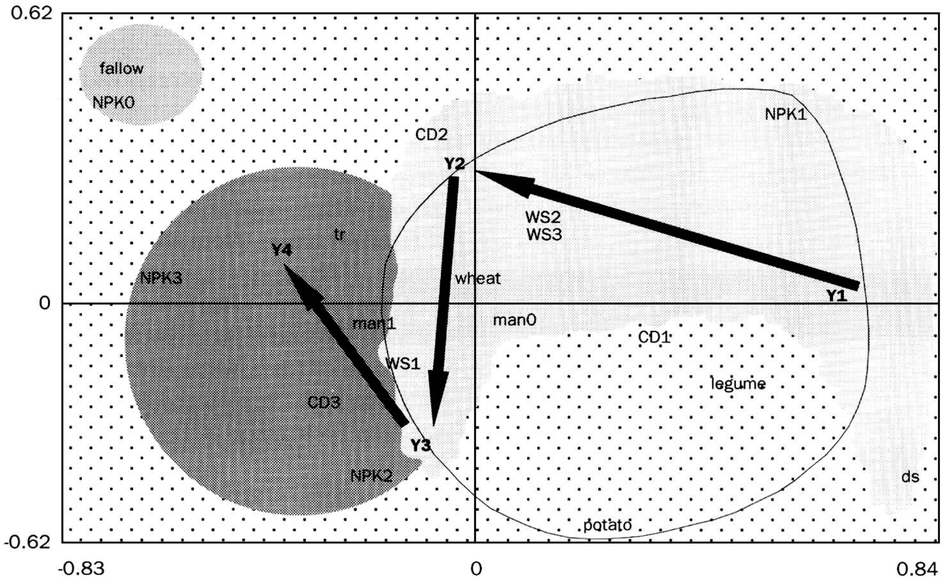
1. A cluster analysis of patterns of cropping practices using chi-square distance.

ing 80 fields. The data collected cover several categorical (qualitative) or categorized (quantitative) attributes of the agroecosystem as

- components of the cropping practices, such as previous crop in a given field (fallow, wheat, legume, or potato), level of fertilizer inputs (from absent [NPK0] to high [NPK3]), application of manure (yes [man0] or no [man1]), crop establishment method (transplanted [tr] or direct seeded [ds]), water stress (low [WS1] to high [WS3]), and duration of rice crop cycle (short [CD1] to long [CD3]);
- components of the injury profiles, represented by the intensities of disease and pest injuries assessed at three crop development stages, such as maximum proportion of tillers with deadhearts or sheath blight; maximum proportion of panicles with whiteheads, sheath rot, or neck blast; maximum observed number of armyworms/hill; area under the number of observed rice bugs/hill; and area under brown spot intensity or leaffolder injury progress curves; and
- rice yield, estimated from three 1-m^2 sampling areas in each field (very low, < 2.4 t/ha [Y1] to high, > 3.4 and < 5.2 t/ha [Y4]).

The methodology to analyze these data strongly relies upon nonparametric, multivariate methods that enable the handling of qualitative and quantitative information simultaneously. The analysis proceeds in two steps: (i) patterns of cropping practices are characterized using cluster analysis (Fig. 1), and (ii) these patterns are linked to predominant pests using chi-square tests and correspondence analysis (Fig. 2).

As the crop management practices are described by qualitative attributes, such as variety name, previous crop, crop establishment method, a qualitative metric, such as chi-square distance, is appropriate to aggregate fields into clusters (Fig. 1). Correspondence analysis allows the visualization of relationships among variables. Graphs that can be read as maps are generated. They show the locations of various attributes of the agroecosystem. (See Figure 2 for a path of increasing yield levels corresponding to the changes in



Domain	Cropping practices	Pest constraints
A	High fertilizer input Some manure Previous crop: wheat predominant Transplanted rice Medium-high yield	Deadhearts Whiteheads Armyworms Rice bugs Sheath blight Sheath rot Neck blast
B	Low fertilizer input Some manure Diverse previous crops Water stress often high Transplanted rice predominant Short cycle Low yield	Glume discoloration (Leaf blast)
C	Low fertilizer input No manure Previous crop:wheat only Medium-low water stress Transplanted or direct seeded rice Long -cycle varieties	Weeds above the rice canopy Glume discoloration
D	No fertilizer Fallow	Deadhearts Whiteheads Sheath rot

2. A correspondence analysis of patterns of cropping practices, yield levels, and pest profiles.

crop management practices.) It indicates that recommendation domains associated with the corresponding injury profiles can actually be delineated.

A recommendation domain should be seen in terms of the combination of crop management practices, rather than in terms of spatial proximity, and need not be continuous at the farm level (Fig. 2). For example, two neighboring fields may belong to different recommendation domains.

This approach provides a framework for the current hypothesis-testing process, where the actual damage due to pest combinations is being measured in farmers' field experiments in Uttar Pradesh and in crop loss data base experiments at IRRI. ■

Empirical estimates of yield and pest potentials of farmers' rainfed lowland ricefields

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Data on crop performance. including disease, insect, weed, and other pest severities; yield; soil conditions; and crop and pest management practices, were collected in field surveys and holistic experiments with integrated crop protection treatments at four rainfed lowland sites in the Mekong Delta, Vietnam, and northeast Thailand in 1992. At each site, 4-5 farmers' fields were selected and subdivided into plots receiving either no pest control, pest control according to farmers' practices, or fungicide and insecticide applications 4-5 times during the growing season. Fields were visited repeatedly during the growing season for data collection. Data were used to develop simple methods for estimating yield potentials of sites, pest-yield effects, and pest proneness.

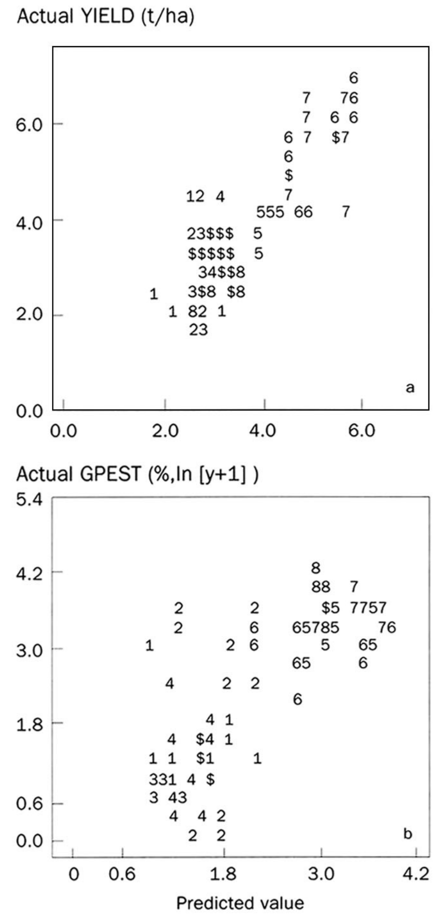
Target yields (Y_t) were computed based on a model developed and parameterized by Neue in 1985: $Y_t = 0.05\ FN_e - 0.000225\ FN_e^2 + 0.05\ FN_eN_t + (2.4152\ N_t - 6.0882\ N_t^2)d_r$, where N_t = % soil N, d_r = effective rooting depth in cm, and FN_e = effective uptake of N fertilizer in kg/ha: $FN_e = 1.193\ FN^{0.9}$, where FN = fertilizer N in kg/ha. N_t was estimated based on total soil C content, assuming a C-N ratio of 10.

Because a portion of the total C and N in soils is effectively inert due to chemical nature and organomineral interactions, the model was modified by a relationship independently found by Gaunt that accounts for protection of soil C and N by clay: $N_t = (C - 0.016L)/10$, where C = % soil carbon and L = % clay content of soil. A variable (GPEST) representing the combined maximum severity levels of pest intensity on

Results of regression analyses to explain yield and pest intensity in farmers' fields at rainfed lowland sites in Vietnam and northeast Thailand.[a]

Dependent variable	Variable in equation	Slope	Standard error of slope	Beta value
YIELD	Y_t	.616	.044	1.033
	GPEST	–.332	.073	–.333
	constant	2.763	.146	
	R^2 = .72; n = 93			
GPEST	SAND	–.021	.004	–.507
	Y_t	.342	.071	.571
	Y_t*P*K	–.127	.036	–.355
	constant	2.402	.263	
	R^2 = .62; n = 93			

[a]YIELD = yield in t/ha: Y_t = target yield: GPEST = pest intensity on generative plant organs and/or whole tillers: SAND = % soil sand content: P = ppm available soil P; K = meq K/100 g soil. All variables in the equations are significant at P = 0.001 according to *T* test. Both regression models are significant at p = 0.0001 according to *F*- test.



a) Observed yield (YIELD) and b) pest intensity during the generative phase (GPEST) vs values estimated by MRA for farmers' fields at rainfed lowland site [a] in northeast Thailand and Vietnam [b].

[a]Sites: Thailand 1 = Khon Kaen, 2 = Phai Mai, 3 = Sakhon Nakhon, 4 = Ubon ; Vietnam 5 = Bac Lieu, 6 = Ca Mau, 7 = Long An, 8 = Soc Trang. $ = multiple occurrence of data points. [b]See Table 1 for regression equations and definition of variables.

generative plant organs and/or whole tillers was computed: GPEST = 1n { [1-(1-x_1/100)(1 - x_2/100)...(1-x_n1/100)]100+ 1}, where x_1 ... x_n = % maximum severity level of the respective disease or pest damage type. Pest damage types and diseases considered for computing GPEST were panicle blast, dirty panicle, stem rot, foot rot, tungro virus, false smut, other panicle damage, stem borer deadhearts and whiteheads, and cut tillers due to other pests.

In multivariate regression analyses, yield variation was explained by Y_t (target yield) and GPEST with R_2 = 0.72. Y_t had a much greater relative value for predicting yield than did GPEST (see table). Variability of GPEST could be explained by parameters of soil fertility and water-holding capacity such as soil sand content (SAND), Y_t, and a term describing interaction among Y_t, soil phosphorus (P), and soil potassium content (K) with R^2 = 0.62. When predicted values are plotted vs actual values, data points for the different sites blend fairly well into a homogeneous data cloud along the 1:1 line (see figure).

The results indicate that it is possible to quantify rice yield expectations for rainfed lowland areas based on parameters that characterize soil fertility corresponding to physiological potential yield, although parameterization of Y_t might need further adjustment and the role of water problems needs investigation and appropriate consideration. Yield expectations can be further adjusted for pest damage effects through relatively simple single equation-type models. Pest damage expectations might be quantifiable based on parameters of soil fertility and water-holding capacity, because high soil N (and in some cases drought stress) increases the susceptibility of the rice crop to pest attacks.

Further analyses will aim to identify key biotic constraints for higher yields, develop simple yet robust rules for predicting the proneness of sites for specific pest-loss problems, and define agroecological domains for extrapolation of knowledge and technology for disease management in rainfed lowland rice. ■

Genetic manipulation of *Xanthomonas oryzae* pv. *oryzae*

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Introduction of plasmid DNA into *Xanthomonas oryzae* pv. *oryzae* (Xoo), the rice bacterial blight pathogen, can be routinely and efficiently achieved by electrotransformation or by conjugation using a biparental mating system. Mobilizable plasmids with broad-host range, such as pUFR027, pUFR047, pHM1 (cosmid), pUFR034 (cosmid), pUFR043 (cosmid), and pLAFR3 (cosmid) are convenient vectors that are compatible with Xoo. Electrotransformation requires a costly instrument, the electro- porator, but is fast, easy, and good for small-scale cloning experiments. Bipa- rental matings between Xoo and *E. coli* strain S17-1, which has a mobilization gene in the chromosome, do not require expensive equipment and are excellent for large-scale experiments, such as screening a genomic library. With this system, a helper plasmid is not needed to mobilize the vector, which simplifies manipulation. Generally, the transconjugation frequencies obtained after biparental mating are 10^2- to 10^5-fold higher than those observed after both electro transformation (Table 1) and triparental matings.

The presence of restriction-modification (R-M) systems in Xoo strains influences transformation and conjugation frequencies (Table l). Xoo contains at least two R-M systems (*Xor*I and *Xor*II). Genomic DNA from Xoo that contains the *Xor*I R-M system is not digested by the endonuclease *Pst*I (*Xor*I isoschizomer). Genomic DNA from Xoo that contains the *Xor*II R-M system is not digested by either *Xor*II or *Pvu*I (isoschizomer of *Xor*II). The Xoo strains with neither R-M system (*Xor*I$^-$/*Xor*II$^-$ phenotype) are better recipients than strains having one or both of the R-M systems. Strains with *Xor*I$^-$/*Xor*II$^+$ phenotype are better recipients than those with *Xor*I$^+$/*Xor*II$^-$ phenotype.

We have so far been unable to introduce DNA into PX061, which has both *Xor*I and *Xor*II R-M systems, by either of the two methods (Table 1). Transformation and conjugation frequencies of 5-azacytidine-resistant mutants of PXO99 (designated as PXO99A) are markedly higher when compared with those of the wild-type strain PX099 (Table 1). 5-azacytidine has been reported to affect R-M systems, and it is possible that a third, unidentified R-M system has been affected in PXO99A. We have not yet characterized the mutation in strain PXO99A. Factors such as the growth stage of the recipient cell or culture medium and culture conditions affected transformation frequency, but the effects were not as dramatic as those imposed by the R-M systems of the recipient Xoo strain.

Both electrotransformation (Table 2) and biparental mating methods (Table 1, footnote) are sufficient to introduce plasmids into Xoo cells, which is a prerequisite for genetic studies of this agronomically important pathogen. Using these techniques, we have identified and characterized several genes controlling host-pathogen interactions (avirulence genes and hypersensitive and pathogenicity response genes), an *Xor*II methylase gene, and a phosphate-binding protein gene from an Xoo genomic library. Genetic manipulation is no longer a serious obstacle for genetic analysis of Xoo. ■

Table 1. Introduction of plasmid pUFR027 into Xoo strains with different R-M systems by means of electrotransformation or biparental mating.

Strain[a]	R-M system[b] XorI	R-M system[b] XorII	Growth stages[c] of recipient	Transformation frequency[d]	Conjugation frequency[e]
PX061	+	+	ML	< 10^{-9}	< 10^{-8}
			LL	< 10^{-9}	< 10^{-7}
8820	+	–	ML	5.4×10^{-8}	6.8×10^{-3}
			LL	4.6×10^{-8}	2.9×10^{-3}
PX086	–	+	ML	1.6×10^{-7}	2.0×10^{-1}
			LL	2.4×10^{-8}	4.7×10^{-1}
PX099	–	–	ML	1.6×10^{-6}	7.6×10^{-4}
			LL	1.0×10^{-6}	1.4×10^{-1}
PX099A	–	–	ML	6.5×10^{-3}	7.6×10^{-1}

[a]The prefix PXO indicates Philippine strains; 8820, Korean strain; PX099A, 5-azacytidine-resistant mutant of PX099 that was selected for growth on 200 µM 5-azacytidine. [b]+/–, presence/absence of R-M systems based on resistance/susceptibility, respectively, of genomic DNA to digestion with endonuclease PstI (isoschizomer of *Xor*I) or XorII. [c]ML/LL, mid-/late-logarithmic growth stage. Cells were grown in nutrient broth at 28 °C with shaking at 200 rpm. [d]Number of transformants per total number of cells recovered. Av of two experiments. [e]Conjugation frequencies are the number of transconjugants per total number of cells recovered after introduction of plasmid DNA by biparental mating. Recipient Xoo cells were grown in nutrient broth overnight with shaking. Cells were harvested by low-speed centrifugation and the cell number was adjusted to 10^{11} cfu/ml in sterile, distilled water. An aliquot (20 µl) was pipetted onto a nutrient agar plate. air-dried, then incubated 1-2 h at 28 °C. *E. coli* strain S17-1 cells were cultured for 1 d on Luria Bertani agar containing appropriate antibiotics. For mating, *E. coli* cells were collected with a toothpick and mixed with the pre-incubated Xoo cells. After incubation at 28 °C for 2 d, cells were harvested, resuspended in 200 µl of sterile water, and serially diluted (10-fold). The cells (100 µl) were spread on agar peptone sucrose medium plates supplemented with cephalexin (20 µg/ml) and appropriate antibiotics. Av frequency obtained from two experiments is reported.

Table 2. Basic protocol for electrotransformation of Xoo with DNA.

Step	Procedure and technical comments
1.	Select, if possible, *Xor*I$^-$II$^-$ Xoo strains as recipients. *Xor*I$^+$II$^-$ and XorI$^-$II$^+$ strains also are useful, but expect a much lower transformation frequency.
2.	Grow Xoo in 500 ml nutrient broth at 28 °C with shaking at 200 rpm until mid- to late-logarithmic growth stage (about 12-24 h).
3.	Harvest cells by low-speed centrifugation at 2 °C.
4.	Wash cells by centrifugation in 500 ml of cold sterile distilled water three times.
5.	Wash the cells in 30 ml of cold, sterile 10% glycerol.
6.	Harvest cells and resuspend in 2-3 ml of cold, sterile 10% glycerol.
7.	Dispense 70 µl of the cells into a microcentrifuge tube that was cooled on ice; store at –80 °C until use. For immediate use, do not freeze and omit step 8.
8.	Thaw the cells on ice.
9.	Add DNA (less than 10 µl volume) into each tube containing cells and mix well by repeated pipetting. Plasmid DNA prepared by mini-scale alkaline lysis method is pure enough to be used directly. Make sure to wash DNA with 70% ethanol before use. DNA should be resuspended in sterile distilled water and not in buffer.
10.	Transfer the cell-DNA mixture into the precooled electroporation chamber. Electroporation chambers can be reused several times by washing well with distilled water, 95% alcohol, and then 70% alcohol. The chamber should be completely dry before use. Keep the chambers at –20 °C until use.
11.	Expose cells to 600 V (amplitude) for 5 milliseconds (pulse length). These conditions are for T-100™ electroporator system (Biotechnical and Experimental Research Inc., BTX, San Diego, CA) and an electroporation chamber with 0.56-mm gap.
12.	After electroporation, recover the cells from the electroporation chamber by pipetting with 600 µl of peptone sucrose broth.
13.	Incubate at 28 °C with shaking at 200 rpm for 4 h.
14.	Dilute and spread cells on suitable agar medium (such as peptone sucrose agar) containing appropriate antibiotics.

A new approach for estimating egg parasitism of whitebacked planthopper

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Anagrus spp. are important egg parasitoids of whitebacked planthopper (WBPH) in ricefields in China. Egg parasitism, which ranges from 10 to 70%, is commonly estimated by dissecting rice tissue and recording numbers of healthy and parasitized host eggs. It is difficult, however, to detect parasitized eggs after wasps have emerged. Therefore, a simpler, more accurate method is needed.

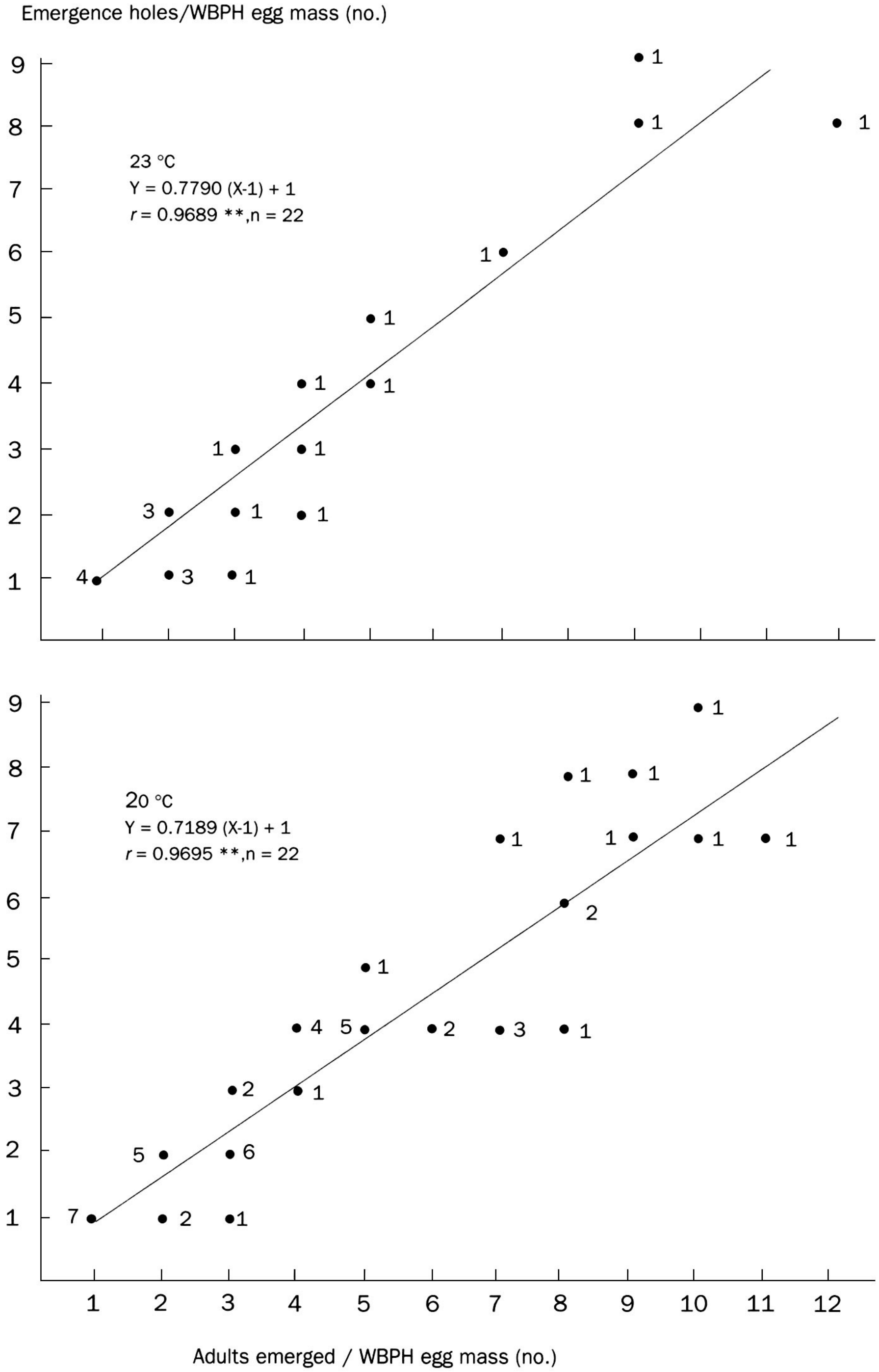
Previous studies showed that when *Anagrus* spp. have completed their development in WPBH eggs, they gnaw through the eggshells and rice plant tissues and escape through the resulting emergence holes. The relationship between number of emergence holes on tillering Guangluai 4 rice plants (about 5-10 mm in diam and 20 cm tall) and number of emerging adults of the egg parasitoid *Anagrus nilaparvata* Pang et Wang was measured in laboratory.

Female parasitoids were confined for 24 h in tubes enclosing hills of rice infested with WBPH eggs and then removed. Plants were kept in culture cabinets under suitable light (141: 10 d) and constant temperatures of 20° and 23° C. After offspring parasitoids emerged, the number of emergence holes on the rice plant surface and percentage of parasitism of WBPH eggs were determined using a stereomicroscope.

A linear regression function was obtained for each temperature (see figure). Slope values of *b* (0.7189, 0.7790) are less than 1, which indicates the parasitoids can emerge through emergence holes made by previously emerged parasitoids. Because the two slopes are not significantly different, the data sets from 20° and 23° C were pooled to obtain a common function:

$Y = 0.7267\ (X-1) + 1$, ($r = 0.9699$, $n = 71$, $P<0.01$)

Number of parasitized WBPH eggs can be estimated using the function



Relationship of number of emergence holes to number of emerged adults of *A. nilaparvata*/ egg mass of whitebacked planthopper (WBPH).[a] Figures near dots indicate number of observations at same values.

$X = 1.3761(Y-1) + 1$.

Mean number of WBPH eggs/egg mass laid within tillering Guangluai 4 plants under different constant temperatures was measured in other independent experiments: 17 °C: 7.94 ± 0.68(17); 23 °C: 9.40 ± 1.00(35); 26 °C: 7.93 ± 0.60(341); 30 °C: 6.04 ± 0.61(25). The parabolic relationship of number of WBPH eggs/egg mass against temperature is

$M = -13.9722 + 2.1149T - 0.0484T^2$, ($r = 0.9764$, $P<0.01$).

A practical way to estimate egg parasitism is to collect WBPH-infested hills of rice on day t, and observe them in the laboratory for about 1 wk for parasitoid emergence. Number of WBPH egg masses and parasitoid emergence holes can be counted under a stereomicroscope or magnifying glass. Parasitism then can be calculated as

$$P(\%) = ([1.3761\ (A/n-1) + 1]/M) \times 100$$

in which A = number of emergence holes, n = number of WBPH egg masses, M = mean number of WBPH eggs/egg mass under average daily mean temperature (T) from day t-10 to day t. ■

Applying rapid immunofilter paper assay to detect rice viruses

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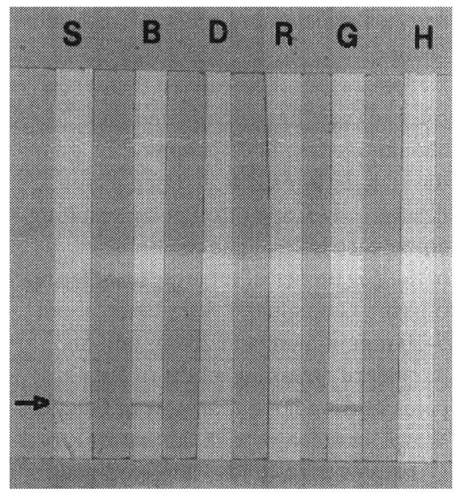
Rapid immunofilter paper assay (RIPA) was applied to detect nine rice viruses in extracts of plants infected with rice tungro bacilliform virus (RTBV), rice tungro spherical virus (RTSV), rice grassy stunt virus (RGSV), rice stripe virus (RStV), rice gall dwarf virus (RGDV), rice black-streaked dwarf virus (RBSDV), rice ragged stunt virus (RRSV), rice dwarf virus (RDV), or rice transitory yellowing virus (RTYV).

Two kinds of latex beads (Japan Synthetic Rubber Co. Ltd., Tsukuba) were used in RIPA: white latex as the solid phase and pink latex as the tracer. The white and pink latices were separately sensitized with specific antiserum. A thin coat of sensitized white latex was applied on Whatman glass filter paper strips (Whatman GF/A; 0.5 × 9 cm) about 1.5 cm from the lower end. Latex-coated filter paper strips were stored in a desiccator at room temperature until use, while the sensitized pink latex suspension was kept at 4 °C.

For virus assay, 0.1 g each of healthy and infected rice leaves were separately ground in 900 µl of extraction buffer (TBS = 0.02 M Tris-HCl, 0.15 M NaCl, pH 7.2 with 0.01 M Na_2SO_3) using mortar and pestle. The extracts were clarified by centrifugation at 15,000 rpm for 10 min. Clarified sap was serially diluted twofold with extraction buffer. One hundred microliters of clarified extract was placed in flat-bottomed Eppendorf tubes in which the lower end of the latex-coated filter paper strip was dipped until the extract was fully absorbed. Then, 100 µl of IgG-coated pink latex (diluted to 0.025% [vol/vol] with TBS) was added to the same tube. The pink latex suspension moved upward by capillary action and a pink band appeared on the spot where the white latex was applied, indicating a positive reaction (see figure).

RIPA efficiently detected the virus antigen at different dilutions on infected sap but not on healthy sap (see table). The sap dilution end points depended on concentration of the virus in the plant and the titer of the antiserum. For RStV and RGSV, which have high reactivity to their antibodies, a negative reaction was observed at low dilutions of the extract from infected plants. A higher dilution (640-1280 x) is, therefore, recommended for their detection in RIPA. Optimum sap dilutions for virus detection were determined for each virus. Dilution range that gave the brightest pink band in at least three trials was considered optimum for a given virus. Optimum sap dilutions for other viruses were 40-80 x for RTBV and RTSV, 640 x for RDV and RTYV, and 80-160 x for RGDV, RRSV, and RBSDV. The sensitivity of RIPA is comparable with enzyme-linked immunosorbent assay (ELISA) when tested on RTBV, RTSV, RGSV, and RDV.

RIPA is simpler, less time-consuming, and less expensive than ELISA and does not require sophisticated equipment. RIPA is as simple as using pH test paper strips. Coated filter paper strips can be prepared in advance and stored in a desiccator for about 6 mo. ■



Detection of rice viruses by RIPA: S = RTSV, B = RTBV, D = RDV, R = RPSV, G = RGSV, H = healthy check. Visible bands (arrow) indicate a positive reaction.

Detection of RTBV, RTSV, RGDV, RDV, RStV, RGSV, RRSV, RTYV, and RBSDV in rapid immunofilter paper assay.[a]

Virus	Reciprocal of dilution										
	10	20	40	80	160	320	640	1280	2560	5020	10240
RTBV	+	+	+	+	+	+	+	+	–	–	–
RTSV	+	+	+	+	+	+	+	–	–	–	–
RGDV	W	W	+	+	+	+	+	+	+	+	–
RDV	+	+	+	+	+	+	+	+	+	+	–
RStV	–	–	–	W	+	+	+	+	+	+	–
RGSV	–	–	–	–	W	+	+	+	+	+	–
RRSV	+	+	+	+	+	+	+	–	–	–	–
RTYV	+	+	+	+	+	+	+	+	+	–	–
RBSDV	+	+	+	+	+	+	+	+	+	–	–
Healthy sap	–	–	–	–	–	–	–	–	–	–	–

[a] + = strong positive reaction, – = negative reaction. W = weak reaction.

News about research collaboration

Insecticides may favor ricefield pests

Insecticide sprays destroy rice pests, but they also kill other insects which feed on the pests. As a result, ricefields become more favorable environments for the development of certain pest species, according to the results of an intensive ecological study in Nueva Ecija, Philippines, and at IRRI.

The study was made by Dr. K. L. Heong, coordinator of IRRI's Integrated Pest Management (IPM) project, and Drs. Joel Cohen and Kenneth Schoenly of Rockefeller University, New York, United States. The researchers estimated that at the end of the 1992 dry season crop, ricefields sprayed with insecticides had four times more pests than the unsprayed fields.

Insecticide sprays destroy the delicate food web which links the insect pests of rice and the insect predators that feed on them, explains Heong. A natural balance exists with the food web that keeps pest infestations below damaging levels.

"Insecticides reduce not only the number of pests but also the number of predators that eat the pests," says Heong. "Some pest species, such as the brown planthopper, embed their eggs in the plant tissues beyond the reach of sprays. When the nymphs emerge from the eggs, they are free to carry out their destruction if the predators have already been eliminated."

Predators, such as spiders that prey on brown planthoppers but do not attack the rice plant itself, are often more adversely affected than are the pests. As a result, pests such as the brown planthoppers survive.

The study showed that the sprayed area had 56 million pests per hectare more than in the unsprayed area. Most of these pests were brown planthoppers. In a large rice-growing area such as Central Luzon, Philippines, the extra brown planthopper population triggered by insecticide sprays can be in the billions, Heong says.

"In addition to the direct costs and health costs of insecticide use, ecological costs in the form of increased pest populations must also be considered," says Heong■

The Netherlands supports rainfed lowland rice research

The Government of The Netherlands will contribute DFL500,000 (US$259,000) to IRRI's core programs in 1994. A complementary contribution of DFL250,000 (US$129,500) will be made available to the Rainfed Lowland Rice Research Consortium for Asia. These contributions reflect The Netherlands' policy of strengthening international, development-oriented, agricultural research.

The complementary contribution will support increased research on rainfed lowland rice which makes up about one-fourth of the world's total riceland. There are more than 35 million hectares of rainfed lowland rice in Asia, located primarily in eastern India, Bangladesh, and Southeast Asia.

Rainfed lowlands are characterized by low rice production (less than 2 tons per hectare), floods, and drought. Farmers in these areas are among the region's poorest and have little access to improved technology.

The research consortium on rainfed lowland rice, set up in 1991, is composed of IRRI and the national agricultural research systems of Bangladesh, India, Indonesia, Philippines, and Thailand. The consortium member scientists are studying the extent and distribution of acid and infertile soils, drought and flooding, blast, bacterial blight, and weeds. At the same time, they are collecting and studying rice germplasm that confers resistance to and tolerance for these stresses.■

Rice-wheat atlases: information at your fingertips

Atlases of the rice-wheat production systems of Bangladesh, China, India, Nepal, and Pakistan have been published by IRRI in cooperation with the International Maize and Wheat Improvement Center (CIMMYT) and the research councils and rice and wheat institutes of these countries.

The atlases are produced under the International Collaboration in Rice-Wheat Research sponsored by the Asian Development Bank.

The atlases—one for each country—contain maps and text that illustrate and interpret the various spatial changes that have occurred in each country's rice and wheat production systems during the past two to three decades.

Each atlas represents up-to-date, district-by-district estimates of the area under rice-wheat sequential cropping. In these areas, the monsoon season rice that is usually grown on irrigated puddled soil is followed by wheat that is grown under irrigation during the cooler, drier months.

The atlases examine the production trends of rice-plus-wheat per capita and assess past and current per capita production in relation to nutritional needs for the two crops. The trends indicate where and to what extent rice and wheat production has matched increases in population.

Free copies of the atlases are available from IRRI. ■

Switzerland: small country, great vision

The Government of Switzerland has approved two grants to IRRI which are, according to IRRI Director General Klaus Lampe, "the equivalent of every Swiss citizen giving a dollar each" for research to enhance the genetic protection of rice and improve rice production in the Lao People's Democratic Republic. The two grants total US$6.826 million. Switzerland's population in 1992 was 6.87 million.

His Excellency, Dr. Hanspeter Strauch, Ambassador of Switzerland to the Philippines, and Dr. Lampe signed the two agreements to safeguard and preserve genetic diversity in rice and to improve rice research in Lao PDR, a country where rice production is among the lowest in Asia.

Under the agreements, the Swiss Development Cooperation (SDC) will provide IRRI with a grant of US$3.286 million for the 5-year rice genetic diversity project which will be implemented together with nongovernment organizations and farmers' organizations. SDC will also provide IRRI with US$3.54 million over 3 years for the Lao PDR project. "Switzerland may be a tiny country," noted Dr. Lampe, "but it has great vision." ■

Rainfed Lowland Rice Research Consortium holds thematic conference

The Rainfed Lowland Rice Research Consortium (RLRRC) sponsored a thematic conference last 28 Feb-5 Mar 1994 in Lucknow, Uttar Pradesh, India. It consisted of four events: the Stress Physiology Workshop, a field visit to the Faizabad site, the Third Annual Technical Meeting, and the Steering Committee Meeting. This year's meeting was chaired by Dr. R. K. Singh, Director for Research of Narendra Deva University of Agriculture and Technology. There were 82 participants from 11 countries.

In the Stress Physiology Workshop, 13 papers dealing with research on the physiology of drought and submergence were presented by Consortium scientists and invited speakers from Australia, USA, and UK. During the technical meeting, Phase I research achievements in the RLRRC key sites were presented.

The Steering Committee discussed the future research directions for the next phase. The next RLRRC meeting will be in IRRI in conjunction with the International Rice Research Conference in February 1995. Dr. Santiago R. Obien, Phil Rice director, was elected chairman of the Steering Committee. Proceedings of the Stress Physiology Workshop will be published in late 1994. ■

Announcements

Postdoctoral research fellowship at IRRI

The International Rice Research Institute invites applicants for a 2-year postdoctoral research fellowship in agricultural engineering to work on an experiment to test the impact of global climate change on rice physiology and production. We are currently field testing 20 open-top chambers designed to simulate future environments by controlling the atmospheric CO_2 concentration and temperature.

The successful candidate will be responsible for proper upkeep and utilization of the physical structure of the field chambers including injection and exhaust blowers, heaters, CO_2 sampling and injecting systems, and all other electronics needed to maintain proper control.

The successful candidate must have a good background in structural engineering and electronics and understand basic programming. Experience with the Campbell CR-10 dataloggers is a plus. Candidate must have the ability to troubleshoot effectively and to take appropriate measures. He or she will supervise two research assistants.

To apply, send curriculum vitae, university transcripts, and three letters of recommendation to L. Ziska, Project coordinator, Agronomy, Plant Physiology, and Agroecology Division, IRRI. E-mail: IN%"L.Ziska@CGNET.COM" ■

New IRRI publication

Manual for hybrid rice seed production. 1993. 57 pages. US$12.00 in highly developed countries (HDC), US$3.00 in less developed countries (LDC) plus US$3.50 airmail or US$1.50 surface postage.

Research at IRRI and elsewhere indicates that hybrid rice technology offers opportunities for increasing rice varietal yields by 15-20% beyond those achievable with improved, semidwarf, inbred varieties.

This manual describes and illustrates the many steps involved in hybrid rice seed production for both beginning and experienced seed growers. It is based on experiments at IRRI and hybrid rice seed production experience in China. The authors, Dr. S.S. Virmani and the late Dr. H.L. Sharma (who was a research fellow during 1990-92 on leave from Punjab Agricultural University), have presented a complex topic in systematic, easy-to-understand terms that should appeal to trainers and growers alike.

As with many such IRRI books, this manual was designed for easy translation and inexpensive copublication in less industrialized, agriculture-dominated countries. ■

New publications

Prospects of rice farming for 2000. Edited by Xiong Zhenmin and Min Shaokai. In Chinese and English. Order from the China National Rice Research Institute (CNRRI), 171 Tiyuchang Rd, 310006 Hangzhou, Zhejiang, P.R. China.

Rice germplasm resources in China. Edited by Ying Cunshan. In Chinese with an English synopsis and table of contents. Order from CNRRI.

Rice varieties and their genealogy in China. Edited by Lin Shicheng and Min Shaokai. In Chinese with an English synopsis. Order from CNRRI.

Selected papers of the Ho Chi Minh City symposium on acid sulphate soils. Edited by D. L. Dent and M. E. F. van Mensvoort.
Order from International Institute for Land Reclamation and Improvement, P.O. Box 45, 6700 AA Wageningen, The Netherlands. ■

Tropical agriculture conference

The Faculty of Agriculture of the University of the West Indies is sponsoring a conference on Advances in Tropical Agriculture in the 20th Century and Prospects for the 21 st Century: TA 2000. The conference will be held from 4 to 9 September in Port-of-Spain, Trinidad.

The conference program will record advances in tropical agricultural development in the 20th century, trace their genesis in applied policy, management and technology, and evaluate prospects and strategies for further advances in the 21 st century. Specific objectives include reviewing tropical agriculture from around the world, examining advances made in the 20th century in crop and livestock production, soil and land management, economic and social issues in agricultural development, and providing for the scholarly exchange on advances, successes, and prospects for tropical agriculture in the 21st century.

Send requests for details to the Secretariat, TA 2000, Office of the University Dean, Faculty of Agriculture, University of the West Indies, St. Augustine, Trinidad, West Indies. Tel: (809) 662-2686. Fax: (809) 662-1182. ■

Rice dateline

15-17 Aug	IRRI-FAO Workshop on Small Enterprise Development: Farm Equipment Manufacturing at IRRI	*G.R. Quick, IRRI*
4-9 Sep	Advances in Tropical Agriculture in the 20th Century and Prospects for the 21st Century: TA 2000 Port-of-Spain, Trinidad	*Secretariat, TA 2000* Office of the University Dean Faculty of Agriculture University of the West Indies St. Augustine, Trinidad, WI
3-7 Oct	Annual Workshop of IRRI-EPA and IRRI-UNDP (GEF Methane Projects), Indonesia	*H.U. Neue, IRRI*
10-25 Oct	Rainfed Lowland Monitoring Workshop, India, Bangladesh, Thailand	*R. C. Chaudhary, IRRI*
12-14 Oct	Postharvest Technology for the Humid Tropics, IRRI	*G.R. Quick, IRRI*
17-21 Oct	Planning Workshop on Biological Control of Rice Diseases, IRRI	*T. W. Mew, IRRI*
1-2 Nov	IRRI-UK Day, United Kingdom	*R. D. Huggan, IRRI*
21-26 Nov	IRRI-Japan Day, Japan	*G.S. Khush, IRRI*
28 NOV-2 Dec	International Workshop on Flood-Prone Rice, Thailand	*D. W. Puckridge, IRRI*

Rice literature update reprint service

Photocopies of items listed in the *Rice literature update* are available from the IRRI Library and Documentation Service. Reprints of original documents (not to exceed 40 pages) are supplied free to rice scientists of developing countries. Rice scientists elsewhere are charged US$0.20 for each page or part of a page copied, plus postage. Make checks or money orders payable to Library and Documentation Service, IRRI.
Address requests to Library and Documentation Service, IRRI. E-mail: IN%"C.AUSTRIA@CGNET.COM" ■

Call for news

Individuals, institutions, and organizations are invited to tell readers about upcoming events in rice research or related fields in the Rice Dateline. Send announcements to the Editor, International Rice Research Notes, IRRI. ■

IRRI group training courses for 1994

IRRI provides a limited number of scholarships for participation in its short-term group training courses for 1994. To be considered for an IRRI-funded scholarship, a scientist must be affiliated with a national institution that has an official collaborative agreement with IRRI in rice-related research and training projects. A scientist interested in an IRRI-funded scholarship should apply directly to his or her institution and not to IRRI.

IRRI also accepts scientists from other institutions and agencies for the courses if they are working in rice or rice-related areas. Their applications to participate in courses must be endorsed to IRRI by their employer and specify funding sources to cover costs. IRRI's group course training fee is approximately US$1,200/month; this does not include participants' roundtrip international airfare, enroute expenses, or shipping allowance upon return home.

The courses are conducted at IRRI headquarters unless otherwise indicated. For additional information, contact the Head, Training Center, IRRI. ■

Date	Course
18 Jul-9 Sep	Integrated Pest Management (University of the Philippines Los Baños/National Crop Protection Center)
25 Jul-16 Sep	Integrated Nutrient Management
3 Oct-4 Nov	Rice Seed Health
10 Oct-2 Dec	Rice Production Research (Pathum Thani Rice Research Center, Thailand)
17 Oct-4 Nov	Upland Rice Breeding
31 Oct-11 Nov	Scientific Programming
4-25 Nov	Research Management
14-25 Nov	Gender Analysis

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SOS for SES

Standard evaluation system far rice (SES) was first printed in 1975 by IRRI. The booklet contains a standard coding system for morphoagronomic characters, grain quality characters, and damage score due to rice pests, diseases, and other stresses. The booklet will shortly reprinted. We plan to revise and expand this fourth edition and seek help in making it more useful. You are invited to suggest modifications, revisions, deletions, or additions in the existing codes and characters. Please send your suggestions to Dr. R.C.Chaudhary, INGER global coordinator, IRRI, P.O. Box 933, Manila, Philippines. ■

Call for papers

INTERNATIONAL RICE RESEARCH CONFERENCE 1995

Fragile lives in fragile ecosystems

Feeding the world's poor from neglected rice ecosystems

13-17 February 1995
International Rice Research Institute
Los Baños, Laguna, Philippines

Purpose

- To assess research progress and identify new research approaches and issues for reducing constraints and improving the productivity and sustainability of fragile rice-producing ecosystems.
- To convene and support international partnerships for addressing research challenges.

Papers

- Papers should focus on issues relevant to rainfed lowland, upland, and flood-prone rice ecosystems. Papers are being solicited on the following topics:

Fragile lives: rural and urban poor in rainfed rice environments

SESSIONS

1. Food and hunger in the next century.
2. Risk, gain, and sustainability: constraints to farmer adoption of technology.
3. Crop intensification and diversification: options for risk and drudgery reduction and increased flexibility in rice-based systems.

Fragile environments: sustaining productivity for the future

SESSIONS

4. Understanding variable environments and modeling crop response to stress.
5. Nutrient, soil, and water management in rainfed rice systems.
6. Managing present and future impact of pests and diseases in rainfed rice systems.

Opportunities for fragile environments: expanding the resource base

SESSIONS

7. Rice breeding strategies and concepts for rainfed systems.
8. Applying biotechnology to solve problems in rainfed rice.
9. Managing and utilizing biodiversity in largely traditional rainfed rice systems.

Submission procedures

Authors should submit an abstract of about 200 words on research in one of the above topics. Clearly specify the session number and topic for which the abstract is intended. Abstracts must be in English and summarize original, current research. References should not be cited in the abstract.

Abstracts must be received by 12 August 1994. Abstracts received after that date may no be considered. A committee of international referees will review the abstracts for each subject. Selection will be based on relevance of scientific contribution to the session topics, complementarity with other selected papers, and regional and ecosystem balance.

Authors will be notified of acceptance by mid-September, with papers due 1 December 1994.

Other information

Participants are responsible for obtaining government clearances if needed. IRRI will provide supporting invitations as requested for first authors of accepted papers. A limited number of travel grants are available for scientists presenting selected papers.

Proceedings of the scientific sessions will be published. Sessions may be combined or subdivided based on the number of submissions.

Send abstracts and requests for details to

R.S. Zeigler
International Rice Research Institute
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Philippines

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Telex: (ITT) 40890 RICE PM
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IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE

Instructions for contributors

NOTES

General criteria. Scientific notes submitted to the IRRN for possible publication should
- be original work,
- have international or pan-national relevance,
- be conducted during the Immediate past three years or be work in progress,
- have rice environment relevance,
- advance rice knowledge,
- use appropriate research design and data collection methodology,
- report pertinent, adequate data,
- apply appropriate statistical analysis, and
- reach supportable conclusions.

Routine research. Reports of screening trials of varieties, fertilizer, cropping methods, and other routine observations using standard methodologies to establish local recommendations are not ordinarily accepted. Examples are single-season, single-trial field experiments. 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 replications and an internationally known check or control treatment.

Multiple submissions. Normally, only one report for a single experiment will be accepted. Two or more items about the same work submitted at the same time will be returned for merging. Submitting at different times multiple notes from the same experiment is highly inappropriate. Detection will result in the rejection of all submissions on that research.

IRRN categories. Specify the category in which the note being submitted should appear. Write the category in the upper right-hand corner of the first page of the note.

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
  other stresses
Integrated germplasm improvement
  irrigated
  rainfed lowland
  upland
  flood-prone (deepwater and tidal wetlands)
seed technology

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

ENVIRONMENT
SOCIOECONOMIC IMPACT
EDUCATION AND COMMUNICATION
RESEARCH METHODOLOGY

Manuscript preparation. Arrange the note as a brief statement of research objectives, a short description of project design, and a succinct discussion of results. Relate results to the objectives. Do not include abstracts. Do not cite references or include a bibliography. Restrain acknowledgments.

Manuscripts must be in English. Limit each note to no more than two pages of double-spaced typewritten text. Submit the original manuscript and a duplicate, each with a clear copy of all tables and figures. Authors should retain a copy of the note and of all tables and figures.

Apply these rules, as appropriate, in the note:
- Specify the rice production ecosystems as irrigated, rainfed lowland, upland, deepwater, and tidal wetlands.
- Indicate the type of rice culture (transplanted, wet seeded, dry seeded).
- If local terms for seasons are used, define them by characteristic weather (wet season, dry season, monsoon) and by months.
- Use standard, internationally recognized terms to describe rice plant parts, growth stages, and management practices. Do not use local names.
- Provide genetic background for new varieties or breeding lines.
- For soil nutrient studies, 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, such as Infection percentage, degree of severity, and sampling base.
- When evaluating susceptibility, resistance, and tolerance, report the actual quantification of damage due to stress, which 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) 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. Use the abbreviation thereafter.
- Define any nonstandard abbreviations or symbols used in tables or figures in a footnote, caption, or legend.

Tables and figures. Each note can have no more than two tables and/or figures (graphs, illustrations, or photos). All tables and figures must be referred to in the text; they should be grouped at the end of the note, each on a separate page. Tables and figures must have clear titles that adequately explain the contents.

Review of notes. The IRRN editor will send an acknowledgment card when a note is received. An IRRI scientist, selected by the editor, reviews each note. Reviewer names are not disclosed Depending on the reviewer's report, a note will be accepted for publication, rejected, or returned to the author(s) for revision.

(continued on back cover)

Instructions for contributors (continued from inside back cover)

NEWS ABOUT RESEARCH COLLABORATION

General. The section facilitates the timely communication to rice scientists about collaborative activities from consortia, networks, collaborating groups, national agricultural research systems, institutions, countries, and other groups.

Items accepted: general news and current update items about consortia, networks, country and regional projects, conference and workshop recommendations, and other information of interest to IRRN readers, such as new projects, work plans, memorandums of understanding, and highlights of collaborative projects in progress.

Items not accepted: routine housekeeping information for collaborative groups, research notes, new variety releases, work and trip reports, and personal items.

Length. Limit submissions to one page of double-spaced typewritten text.

Submission. Send contributions to the editor at any time. To be printed in a specific issue, items must be received two and a half months in advance of cover date. Items for the March issue, for example, should be received by 15 Dec.

ANNOUNCEMENTS

General. The section includes announcements of upcoming conferences, symposia, workshops, training courses, meetings, and other activities; new rice-related publications, series, and videos; and a calendar of events.

Format and submission. Same as for news items. Announcements of workshops, meetings, and conferences need to be received at least 6 months before the date of the event.

OTHERS

Comments. If you have comments or suggestions about the IRRN, please write to the editor. We look forward to your continuing interest in IRRN.

Mailing address. Send all notes, news, announcements, and other correspondence to the Editor, IRRN, IRRI, P.O. Box 933, Manila 1099, Philippines. Fax: (63-2) 818-2087.

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