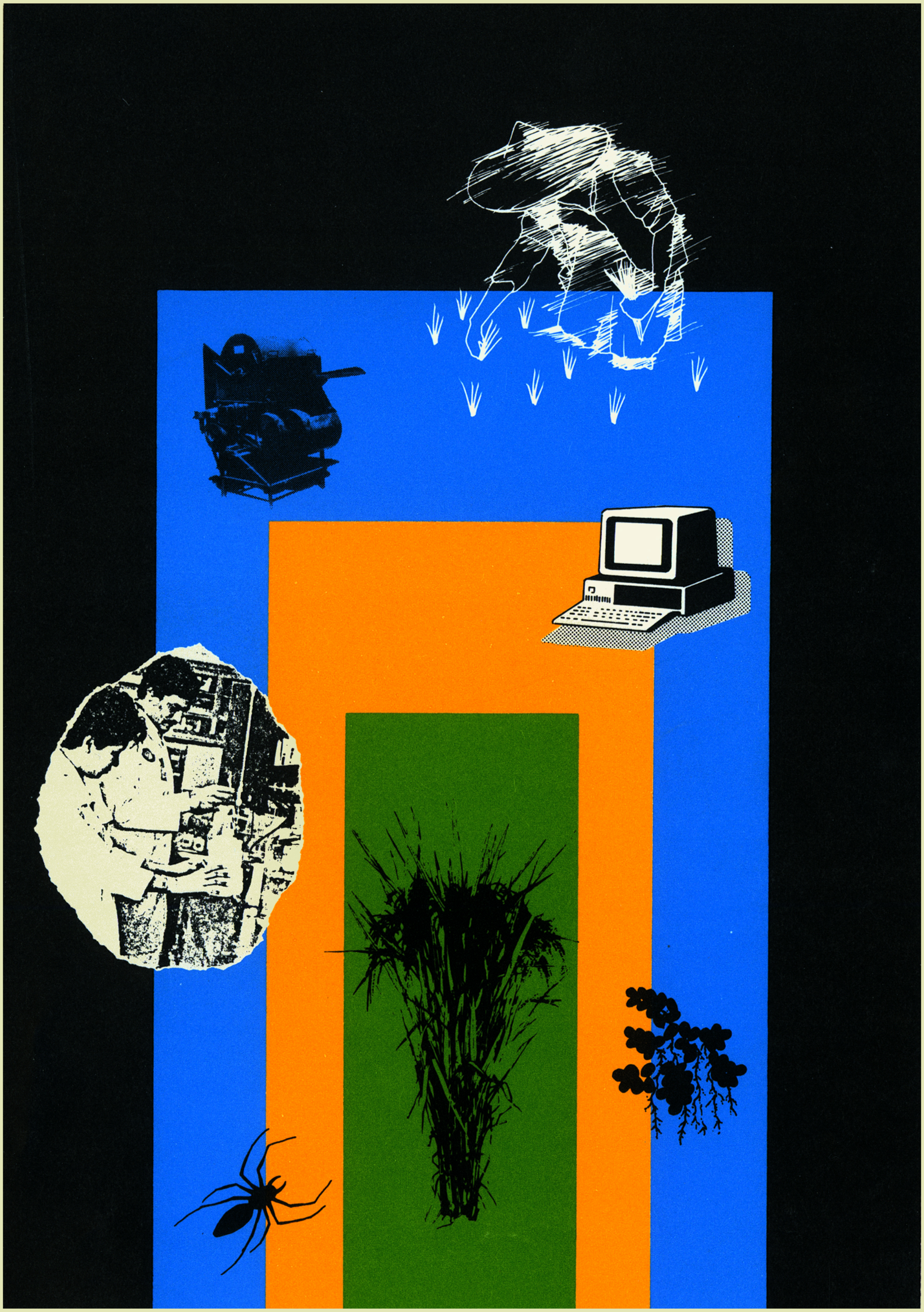
VOLUME 14 NUMBER 3

INTERNATIONAL RICE RESEARCH NEWSLETTER

JUNE 1989



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

IRRN GUIDELINES

The *International Rice Research Newsletter* objective is:

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

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

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

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

Criteria for IRRN research reports

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

Guidelines for contributors

'The *International Rice Research Newsletter* is a compilation of research briefs on topics of interest to rice scientists all over the world. Contributions to IRRN should be reports of recent work and work-in-progress that have broad interest and application. Please observe these guidelines in preparing submissions:

- The report should not exceed two pages of double-spaced typewritten text. No more than two figures (graphs, tables, or photos) may accompany the text. Do not cite references or include a bibliography. Items that exceed the specified length will be returned.
- Include a brief statement of research objectives and project design. The discussion should be brief, and should relate the results of the work to its objectives.
- Report appropriate statistical analysis.
- Provide genetic background for new varieties or breeding lines.
- Specify the environment (irrigated, rainfed lowland, upland, deep water, tidal wetlands). If you must use local terms to specify landforms or cropping systems. explain or define them in parentheses.
- Specify the type of rice culture (e.g., transplanted, wet seeded, dry seeded).
- Specify reasons by characteristic weather (wet, dry, monsoon) and by months. Do not use national or local terms for seasons or, if used, define them.
- When describing the rice plant and its cultivation, use standard, internationally recognized designators for plant parts and growth stages, environments, management practices, etc. Do not use local terms.
- When reporting soil nutrient studies, be sure to include 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.
- Survey data should be quantified (infection percentage, degree of severity, sampling base, etc.).
- When evaluating susceptibility, resistance, tolerance, etc., report the actual quantification of damage due to stress used to assess level or incidence. Specify the measurements used.
- 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 gram per pot (g/pot) or per row (g/row) for small-scale studies.
- Express all economic data in terms of the US$. Do not use national monetary units. Economic information should be presented at the exchange rate $:local currency at the time data were collected.
- Use generic names, not trade names, for all chemicals.
- When using acronyms or abbreviations, write the name in full on first mention, following it with the acronym or abbreviation in parentheses. Thereafter, use the abbreviation.
- Define in a footnote or legend any nonstandard abbreviations or symbols used in a table or figure.

Categories of research reported

GERMPLASM IMPROVEMENT
- genetic resources
- genetics
- breeding methods
- yield potential
- grain quality and nutritional value
- disease resistance
- insect resistance
- drought tolerance
- excess water tolerance
- adverse temperature tolerance
- adverse soils tolerance
- integrated germplasm improvement
- seed technology
- research techniques
- data management and computer modeling

CROP AND RESOURCE MANAGEMENT
- soils and soil characterization
- soil microbiology and biological N fertilizer
- physiology and plant nutrition
- crop management
- soil fertility and fertilizer management
- disease management
- insect management
- weed management
- managing other pests
- integrated pest management
- water management
- farm machinery
- environmental analysis
- postharvest technology
- farming systems
- research methodology
- data management and computer modeling

SOCIOECONOMIC AND ENVIRONMENTAL IMPACT
- environment
- production
- livelihood

EDUCATION AND COMMUNICATION
- training and technology transfer research
- communication research
- information storage and retrieval

CONTENTS

GERMPLASM IMPROVEMENT

Breeding methods
4 Improved medium for efficient anther culture of some indica rice hybrids
4 Optimum distance of isolation for hybrid rice seed production
5 CNA-IRAT 4, a new CMS indica rice population
6 Isolation of maintainers and restorers for three cytoplasmic male sterile lines
6 Androgenesis in rice treated with physical and chemical mutagens
7 Production of doubled-haploid rice plants through anther culture
7 Gamma ray-induced genetic male sterile mutation in rice variety Bala
8 CNA-IRAT 5 upland rice population
9 Some Indonesian restorers and maintainers of WA cytosterile lines
9 Yield of F_1 hybrids at Tamil Nadu Rice Research Institute (TRRI), Aduthurai, India
10 Evaluation of some CMS and maintainer lines in Tamil Nadu

Yield potential
10 Correlation between yield and its components in upland rice in Cuba
10 Analysis of rice panicle structure
12 Quality attributes of seed produced on different tillers of IR50
12 A basic plant ideotype for rice
13 A technique for screening herbicide tolerance in rice

Grain quality and nutritional value
14 Induced variation in aromatic rice cultivars
14 Hua-03—a high-protein indica rice
15 Sources of cooked rice grain elongation

Disease resistance
16 A natural inoculation-spread technique (NIST) for selecting bacterial blight (BB)resistant rice cultivars
17 Changes in ascorbic acid content of rice cultivars due to *Rhizoctonia solani* inoculation and carbendazim application
17 A new pathotype of *Xanthomonas campestris* pv. *oryzae*
17 Serotypes in *Xanthomonas campestris* pv. *oryzae*
18 TM4309: A blast (Bl)-resistant, short-duration rice
18 Reaction to sheath blight (ShB) disease of new rice cultivars in Andhra Pradesh (A.P.)
19 Field evaluation for resistance to rice grassy stunt virus (GSV)
19 Resistance of TKM6 and IR20 to rice tungro spherical virus (RTSV)
20 Bacterial blight (BB) resistance in some Nepal rice cultivars

Insect resistance
20 Screening rice varieties for damage caused by *Oebalus insularis* (Stal)
21 Reactions of gall midge (GM)-resistant rice accessions to yellow stem borer (YSB), leaffolder (LF), and rice blast (B1)
21 Difference of resistance to rice stem borer (SB) in indica and japonica rices
22 Resistance of rice germplasm to whitebacked planthopper (WBPH) in Changsha, China
22 Molecular distillation of rice plants resistant and susceptible to white-backed planthopper (WBPH)
23 Ptb 10—a promising donor of gall midge (GM) resistance

Excess water tolerance
23 Changes in shoot growth in response to partial submergence

Adverse soils tolerance
24 A rapid screening technique for salt tolerance in rice
25 Relationship of rice embryo weight and salinity tolerance at seedling stage
25 Ion transport in two rice varieties grown under saline conditions
25 Zinc:phosphorus ratio—a criterion for salt tolerance in rice

Integrated germplasm improvement
26 Two modern photoperiod-sensitive rice varieties for Bangladesh
26 RAU4045-2A—a very short-duration cultivar for harsh upland environments
27 Sachiminori—a fine quality rice cultivar
27 Stored grain infestation by Angoumois grain moth (AGM) in resistant and susceptible rice varieties

CROP AND RESOURCE MANAGEMENT

Soil microbiology and biological N fertilizer
28 Effect of nitrogen, phosphorus, and cropping method on azolla productivity

Physiology and plant nutrition
29 Effect of seedling age and leaf removal on rice grain and straw yields
29 Influence of potassium and kinetin on protein partitioning in rice
30 Effect of plant growth regulators on ripening, grain development, and rice quality

Crop management
31 Nursery management for rice grown in intermediate deep water

Soil fertility and fertilizer management
32 Effect of continuous application of ammonium sulfate and urea on irrigated rice
32 Reaction of IR20 rice to carbofuran and urea
33 Response of rice to potassium
33 Effect of urea supergranule depth of placement in irrigated transplanted rice
34 Effect of phosphorus with and without zinc on wetland rice
34 Response of spring rice to fertilizer practices in rice - rapeseed rotation

Disease management
35 Field evaluation of fungicides to control rice sheath blight (ShB)
35 Survival of rice root-knot nematode juveniles in moist soil
35 Recovery of rice tungro virus (RTV) from rice stubble
36 Effect of potassium level on bacterial blight (BB) incidence and rice yield
37 Influence of rice tungro virus (RTV) infection on severity of bacterial blight (BB) and bacterial leaf streak (BLS) in rice
37 Inducing resistance to rice bacterial blight (BB) by inoculating non-pathogenic isolate of *Xanthomonas campestris* pv. *oryzae*
37 Rice diseases in the Southern Guinea Savannah Zone of Niger State, Nigeria

Insect management
38 Incidence of rice stem borer (SB) in the Punjab
38 Whitefly (Hemiptera: Aleyrodidae) — a potential pest of rice in West Africa
39 A method for rearing armyworm *Spodoptera mauritia acronyctoides* Guenee (Lepidoptera: Noctuidae) on graminaceous hosts
39 Simulated yellow stem borer (YSB) population dynamics: sensitivity and application
40 Life cycle of *Micraspis* sp. on brown planthopper (BPH) and rice pollen
40 Simulated yellow stem borer (YSB) population dynamics: modeling and evaluation
41 Life history and hosts of *Sogatodes pusanus* (Distant) (Hemiptera: Delphacidae)

Water management
42 Evapotranspiration and deep percolation loss of water in summer rice on lateritic soil

Postharvest technology
42 Utilization of rice by-products

Farming systems
43 Economics of upland rice-based cropping patterns for midhills of Uttar Pradesh
43 Yield of rice - oilseed cropping system without irrigation in coastal saline soil

ANNOUNCEMENTS

44 Recent rice publications list
44 Rice literature search service
44 New IRRI publications

ERRATA

GERMPLASM IMPROVEMENT

Breeding methods

Improved medium for efficient anther culture of some indica rice hybrids

S. K. Raina, S. M. Balachandran, S. S. Virmani, and F. J. Zapata, Tissue Culture Laboratory, Plant Breeding Department, IRRI

Anther culture of high heterotic F_1 hybrid rices could be used to isolate doubled-haploid true breeding lines. Assuming that heterosis in rice is due primarily to dispersion of genes in parents that display directional dominance, some doubled-haploid lines derived from heterotic F_1s theoretically should equal F_1 hybrid performance. Such doubled-haploid lines could be used for commercial cultivation or as parents of second-cycle F_1 hybrids.

To test the validity of this assumption, we cultured anthers of four IRRI-bred heterotic F_1 hybrids.

An improved culture medium increased anther culture efficiency in the F_1 hybrids tested. Two media formulations differing in source of N were used (Table 1). Medium MSN is a blend of Murashige and Skoog's and Chinese N6. SK-1 contains N, mainly as nitrate, among other modifications. Vitamins, amino acids, sucrose, and hormones were similar for both media.

Response (% anthers producing visible calli) was better in MSN medium for all the hybrids (Table 2), in some cases more than twice that in SK-1. In the regeneration medium, however, calli induced in SK-1 averaged 200% higher regeneration of green plants. In IR54752 A/IR2797-125-3-3-2 R and IR54752 A/ IR64 R, the difference was 400%.

Among 859 anther calli induced in MSN, 96 green plant-regenerating calli were identified. As many as 144 green plant-regenerating calli were obtained from only 427 calli induced in SK-1.

Other media formulations also were tested. In all, more than 35,000 anthers were cultured, resulting in more than 300 green plant-regenerating anther calli. About 700 plants transferred to the field reached maturity.

The SK-1 culture medium appears promising for alleviating the poor anther culture efficiency of indica rices. □

Table 1. Media composition.[a]

Constituent	SK-1 (mg/liter)	MSN (mg/liter)
KNO_3	3150	2830
$(NH_4)_2SO_4$	–	463
KH_2PO_4	540	170
$CaCl_2 \cdot 2H_2O$	150	440
$MgSO_4 \cdot 7H_2O$	185	185
$MnSO_4 \cdot 7H_2O$	22.3	4.4
$ZnSO_4 \cdot 7H_2O$	10	1.5
H_3BO_3	6	6.2
KI	1	0.8
$Na_2MoO_4 \cdot 2H_2O$	0.25	0.25
$CuSO_4 \cdot 7H_2O$	0.025	0.025

[a]Constituents (mg/liter) in common: 27.85 $Na_2 \cdot EDTA$ + 37.25 $FeSO_4 \cdot 7H_2O$; 2 glycine; 100 inositol; 2.5 niacin; 2.5 thianine HCl; 2.5 pyridoxine; 500 casein hydrolysate; 0.75 2, 4-D; 2.5 NAA; 0.75 kinetin; 40,000 sucrose; 8,000 agar. The generation medium consisted of MS basal medium supplemented with 1 mg NAA, 1 mg BAP, 0.5 mg kinetin, 30,000 mg sucrose/ liter.

Table 2. Callus induction and green plant regeneration in anther calli of hybrid rices induced in SK-1 and MSN media.

Hybrid[a]	Anthers plated (no.)	Anther calli		Calli transferred (no.)	Calli regenerating			
					Green plants		Albino plants	
		no.	%		no.	%	no.	%
				SK-1				
H-1	2216	146	6.1	114	42	36.8	27	23.6
H-2	1698	82	4.8	52	23	44.2	20	38.4
H-4	2855	308	10.7	220	74	33.6	55	25.0
H-5	1572	69	4.3	41	5	12.2	4	9.7
Total	8401	605	7.2	427	144	33.7	106	24.8
				MSN				
H-1	2147	298	13.8	278	20	7.1	65	23.3
H-2	2495	275	11.0	228	15	6.5	45	19.1
H-4	2900	406	14.0	284	55	19.3	80	28.1
H-5	2176	125	5.7	69	6	8.6	12	17.3
Total	9718	1104	11.3	859	96	11.1	202	23.5

[a]H-1 = hybrid 1 (IR54752 A/IR2797-125-3-3-2 R), H-2 = hybrid 2 (IR54752 A/IR64 R), H-4 = hybrid 4 (IR54752 A/ARC11353 R), H-5 = hybrid 5 (IR46830 A/IR29723-143-3-2-1 R).

Optimum distance of isolation for hybrid rice seed production

M. N. Prasad and S. S. Virmani, Plant Breeding Department, IRRI

Maintaining purity of parental lines and F_1 hybrid seed is the most important factor in hybrid seed production. One way to maintain seed purity is to adequately isolate plots used for producing hybrid seed.

We laid out an experiment at IRRI 1987-88 to determine the isolation distance that would prevent contamination. A seed production plot of IR64 (1,250 m^2) was used as the pollen source. At 10 d before flowering, eight potted plants of the CMS line IR54752 A were placed at different distances (0, 25, 50, 75, 100, 125, 150, 175, 200, 225 m) in two directions (northeast and northwest) from the pollen source (per anticipated wind direction during flowering). Weather records for the experimental periods of both years are given in Table 1.

Pollen fertility was measured at flowering and four plants showing

Table 1. Weather record for rice flowering period at Los Baños (Agroclimatic Data Bank, IRRI).

Season	Flowering period (d)	Maximum temperature (°C)	Wind [a]		Relative humidity
			Speed (m/s)	Direction	
1987 WS					
(20-29 Nov)	1	23.9	2.1	ENE	55
	2	24.4	1.6	VRBL	78
	3	23.6	1.4	VRBL	81
	4	23.0	1.4	ESE	70
	5	24.0	1.3	NE	64
	6	24.2	1.7	NE	60
	7	22.9	5.2	WNW	62
	8	21.1	3.9	ENE	70
	9	23.0	1.7	SSE	57
	10	23.0	1.2	ESE	63
1988 DS					
(16-25 May)	1	36.2	1.2	NNW	42
	2	37.0	1.0	VRBL	34
	3	35.4	1.2	SE	42
	4	37.0	1.4	E	34
	5	36.5	1.1	S	42
	6	35.6	1.2	E	45
	7	35.0	0.9	VRBL	48
	8	36.5	1.2	SE	39
	9	33.4	1.1	NE	60
	10	34.5	1.2	NE	50

[a] Expected wind direction in November and May is NE.

Table 2. Effect of distance between restorer line (R) and CMS line on outcrossing rate. IRRI, 1987 WS and 1988 DS.

Direction of CMS line in relation to pollen source	Distance (m) of CMS line from pollen source	Seed set [a] (%)	
		1987 WS	1988 DS
NE	0 (control)	9.2	8.6
	25	7.2	7.0
	50	6.0	5.0
	75	5.6	2.0
	100	5.0	0.5
	125	4.1	0.0
	150	3.8	0.0
	175	3.1	0.0
	200	2.4	0.0
	225	2.0	0.0
NW	0 (control)	6.0	4.0
	25	5.3	3.1
	50	5.1	1.2
	75	4.0	0.3
	100	3.3	0.0
	125	2.1	0.0
	150	0.8	0.0
	175	0.0	0.0
	200	0.0	0.0
	225	0.0	0.0

[a] Av of 4 replications.

complete pollen sterility were retained per distance (each plant represented one replication). The potted plants were kept in the field for 10 d (20-29 Nov in 1987 wet season [WL] and 16-25 May in 1988 dry season [DS]) to synchronize with flowering of the pollen source. No other flowering rice crop was around the field for more than 500 m in any direction. Distance pollen traveled was determined by seed setting on open-pollinated panicles of the CMS line.

In 1987 WS, seed set on CMS plants up to 225 m distance in the northeast direction and up to 150 m in the northwest direction (Table 2). In 1988 DS, seed set on CMS plants up to 100 m in the northeast direction and up to 75 m in the northwest direction. Pollen traveled farther in WS than in DS, perhaps because of higher wind velocity (1.2-5.2 m/s in WS, 0.9-1.4 m/s in DS). Higher temperature, lower relative humidity, and unfavorable wind direction in DS may have cut the distance pollen could travel. Under Los Baños conditions, a safe isolation distance would be 125 m in DS and 250 m in WS. □

CNA-IRAT 4, a new CMS indica rice population

J. Taillebois and P. C. F. Neves, Coordenador arroz, EMBRAPA/Centra Nacional de Pesquisa-Arroz, Feijao (CNPAF), C.P. 179, 74000 Goiânia, Brazil

CNPAF and Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières (IRAT) have created an indica population that segregates for a monogenic recessive male sterile gene obtained by mutation on IR36 by R. J. Singh and H. Ikehashi.

Nine varieties were crossed and backcrossed to IR36 as the male parent to achieve sterile plants (see table). F_2 seeds of each backcross were bulked to form the initial population, CNA-IRAT 4/0/0.

Outcrossed seeds collected on male sterile plants of that population were bulked to form the next population, CNA-IRAT 4/0/1. The procedure was repeated four times to obtain the CNA-IRAT 4/0/4 population.

Seeds of the CNA-IRAT 4/0/4 population are available to rice breeders. □

CNA-IRAT 4 population composition.

Variety	Parentage	Outcrossing rate (%)
IR36 (ms ms)	IR1561-228-1-2/IR1737//CR94-13	25.00
BG90-2	IR262/Remadja	8.33
CNA7	T141/IR665-1-175-3	8.33
CNA3815	CICA4/BG90-2/SML 5617	8.33
CNA3848	5461//IR36/CICA7	8.33
CNA3887	4440//BG90-2/Tetep	8.33
Colombia 1	Napal/Takao Iku 18	8.33
Eloni	IR454/SML KAPURI//SML 66H10	8.33
Nanicao	Brazilian germplasm	8.33
UPR103-80-1-2	IR24/Cauvery	8.33

Isolation of maintainers and restorers for three cytoplasmic male sterile lines

J. S. Bijral, T. R. Sharma, B. Singh, B. B. Guptu, and K. S. Kanwal, SKUAST, Regional Agriculture Research Station, R.S. Pura 181102, India

We crossed 35 short-, medium-, and long-duration indica cultivars with cytoplasmic male sterile lines Zhen Shan 97 A, IR48483 A, and IR46830 A to identify maintainers and restorers. The F_1 hybrids were grown in the field.

The main panicles of five randomly selected plants of each cross were harvested and spikelet fertility calculated. Cultivars showing more than 75% spikelet fertility were classified as effective restorers, those between 1 and 75% fertility as partial restorers, and those of less than 1%, maintainers (see table).

IR31802-48-2-2-2 and RR8585 restored fertility of all three CMS lines; China 988, China 1007, and Sattari maintained their sterility. Recurrent backcrosses with China 988 and China 1007 are underway, to transfer cytoplasmic male sterility into their nuclear background. □

Restorers and maintainers for Zhen Shan 97 A, IR48483 A, and IR46830 A CMS lines at Regional Agriculture Research Station, R. S. Pura, India.[a]

Variety	Zhen Shan 97 A	IR48483 A	IR46830 A
IR8	–	–	PR
IR36	–	R	R
IR42	–	M	M
IR50	–	R	PR
IR21820-154-3-2-2	–	R	M
IR28150-84-3-3-2	–	R	–
IR28228-12-3-1-1-2	–	M	PR
IR31802-48-2-2-2	R	R	R
IR31851-63-1-2-3-2	R	R	–
IR31868-64-2-3-3-3	R	R	PR
IR32429-47-3-2-2	–	R	R
CR666-1	PR	R	R
CR666-7	R	PR	PR
CR666-49	M	M	–
CR666-36-4	M	M	M
Sattari	M	M	M
China 988	M	M	M
China 1007	M	M	M
RR8585	R	R	R
VL 15	R	R	PR
PC-19	–	R	–
Jaya	–	–	R
Sadri	PR	PR	–
IET1410	R	–	–
Musatareme	R	–	–
Mehr	PR	–	–
Domsiah	PR	–	–
Ranbir Basmati	–	–	R
Rasi	–	R	PR
Dular	–	R	–
ITA173	–	M	–
ITA183	–	PR	PR
B3016 B	–	M	M
Khuch	–	M	M
K85-2	–	–	M

[a]R = restorer (75% spikelet fertility), PR = partial restorer (1-75% spikelet fertility), M = maintainer (1% spikelet fertility), – = damaged seedlings.

Androgenesis in rice treated with physical and chemical mutagens

P. Boyadjiev, Pham Coung, M. Naidenova, D. Pouleva, and K. Perfanov, Institute of Introduction and Plant Genetic Resources, K. Malkov, Sadovo, Plovdiv, Bulgaria

We studied the effect of mutagens on androgenesis, using L_{44}, a dihaploid line obtained through anther culture of the F_1 hybrid Bellozem/ Plovdiv 22. Mutagenic treatments were 1) gamma rays ^{60}Co at 25 kR, 2) 0.004 M sodium azide (NaN_3), and 3) 25 kR + 0.003 M NaN_3. The NaN_3 treatment involved soaking seeds in the mutagenic solution for 18 h, then sowing them with a control for panicle collection. Callus induction and plant regeneration were

Table 1. Germination and efficiency of callus induction in anther culture of rice treated with mutagens.

Treatment	Germination rate (%)	Anthers inoculated (no.)	Callus induction[a] no.	Callus induction[a] %
Control	44.8	1000	364	36.4
25 kR treatment	31.6	995	134	13.5
0.004 M NaN_3	16.8	939	169	18.0
25 kR + 0.003 M NaN_3	20.4	983	47	4.8

[a] $\frac{\text{Calli induced (no.)}}{\text{Anthers inoculated (no.)}} \times 100.$

Table 2. Plant regeneration in anther culture of rice treated with mutagens.

Treatment	Calli inoculated (no.)	Non differentiated calli		Calli showing rhizogenesis		Green plants (no.)	
		no.	%	no.	%	Total	Av
Control	397	62	15.6	178	44.8	246	0.62
25 kR	119	56	47.1	33	27.7	42	0.3
0.004 M NaN_3	88	38	43.2	28	31.8	59	0.67
25 kR + 0.003 M NaN_3	54	23	42.6	13	24.1	41	0.76

achieved on N_6 and Murashige and Skoog media, respectively.

Germination rate and callus induction efficiency were inversely proportional to the mutagenic activity of the treatments (Table 1). The combined physical and chemical treatment drastically reduced callus induction efficiency.

Differentiation was much less in the mutagen treatments than in control (Table 2). In all mutagen treatments, differentiation was similar but the ratio of green plants to the number of calli plated was higher with NaN_3 alone and with NaN_3 + radiation. □

Production of doubled-haploid rice plants through anther culture

I. Reiffers, Commission of the European Community; and A. de Barros Freire, National Center of Rice and Beans Research, CNPAF/EMBRAPA, Caixa Postal 179, 74000 Goiânia, Brazil

We studied the androgenetic ability of 23 F_1 crosses. Cultivars used were 17 japonica type Brazilian upland cultivars, 3 indica cultivars (Metica 1, Tetep, TOMl-3), 2 cultivars from indica/japonica crosses (IRATl l8, Cuiabana), and 1 nonclassified Colombian upland cultivar (Colombia 1).

Cytological studies established a relationship between panicle morphology and optimal microspore stage (late uninucleate). Panicles pretreated for 8 d at 4 °C were dissected and the anthers inoculated for callus-induction [N6 basal medium with 1 mg naphthaleneacetic-acid (NAA)/liter, solidified with 8 g agar/liter]. Calli formed 4 to 8 wk later were transferred to a plant regeneration medium (MS basal medium with 3 mg kinetin/liter + 0.5 mg NAA/liter, solidified with 8 g agar/liter).

Genotypes differed in androgenetic potential (see table). Callus induction rates varied from 0.22 to 29% and plant regeneration rates from 0 to 144%.

The indica/japonica hybrids had good androgenetic yields. On average, 27% of the plants were albinos; 59% of the green plants underwent spontaneous doubling of chromosome number.

The haploid plants were treated with colchicine to achieve diploids. Diploid lines were multiplied and evaluated in the field. Individual lines appeared homogeneous in morphological characteristic, but several lines originating from the same callus demonstrated heterogeneity.

Very promising lines had excellent behavior in upland fields and good grain quality. Those lines have been introduced into the advanced observation tests of the CNPAF breeding program. □

Anther culture ability of 23 simple F_1 crosses.

Cross	Anthers cultured (no.)	Callus induction (%)	Green plant regeneration (no.)	Green plant regeneration[a] (%)
Dourado Precoce/CNA5175	2004	20.1	15	3.7
Dourado Precoce/Araguaia	2124	6.8	0	0.0
Dourado Precoce/IAC81-176	2246	5.6	0	0.0
Dourado Precoce/Colombia 1	2057	8.0	0	0.0
Dourado Precoce/L 13	2064	5.6	0	0.0
Dourado Precoce/Tetep	2040	3.5	19	26.8
Guarani/Dourado Precoce	2010	29.0	0	0.0
Guarani/Araguaia	2020	16.2	0	0.0
Guarani/L 13	2005	23.2	0	0.0
Guarani/Chorinho Alianca	2056	17.3	0	0.0
Guarani/CNAx 539-2-1-3	1854	0.9	3	18.8
Guarani/Jaguari	2166	1.4	0	0.0
Araguaia/IAC81-176	2012	0.7	0	0.0
IREM195/Araguaia	2088	14.8	0	0.0
IREM195/IAC81-176	2058	6.8	0	0.0
IREM257/IAC164	944	4.8	6	13.3
CNA5 180/Cuiabana	2780	0.5	3	20.0
CNA5180/IAC81-176	2086	2.9	0	0.0
CNA4157/TOM1-3	1522	2.3	22	62.9
L 8511/Cuiabana	9012	7.9	98	13.8
EEPG 369/Araguaia	4606	8.1	31	8.3
Catetão Precoce/Metica 1	4088	0.2	13	144.4
IRAT118/Cuiabana	2132	2.8	15	25.0

[a] $\frac{\text{Green plants (no.)}}{\text{Callus (no.)}} \times 100$.

Gamma ray-induced genetic male sterile mutation in rice variety Bala

M. R. K. Singh and P. K. Sinha, Plant Breeding and Genetics Department, Birsa Agricultural University, Ranchi 834006, Bihar, India (present address: Plant Breeding and Genetics Department, Manipur Agricultural College, Iroisemba, Imphal 795001, Manipur, India)

Upland rice variety Bala was irradiated with gamma rays at 10, 20, 30, 40, and 50 kR and 400 seeds/variety per treatment used to grow the M_1 population. At maturity, 50 M_1 panicles/treatment were selected on the basis of spikelet sterility and used to grow the M_2 (panicle progeny rows).

The panicle progeny rows were screened between flowering and maturity for segregation of male sterile mutations. Sterile mutations were identified by panicle erectness, spikelet chaffiness, and prolonged green plant color. The three first-formed panicles of all sterile mutations were evaluated for grain fertility (Table 1).

At the same time, two sterile plants from each segregating M_2 line (considered true male sterile) were crossed with the parent for segregation

Table 1. Segregation in M_2 and F_2 of gamma ray-induced male sterile mutants of Bala variety, Manipur, India.

Line	Generation	Plants (no.) at maturity	Segregating plants				Genetic ratio [a]	χ^2 value	*P* value
			Fertile (>75%)	Partly fertile (50-75%)	Semisterile (10-49%)	Sterile (<10%)			
Bala G 3-6	M_2	24	5	8	5	6	1:2:1	0.10	0.90-0.95
				13					
Bala G 3-6-4/Bala	F_2	178	41	52	46	49	1:2:1	1.86	0.30-0.50
				98					
Bala G 3-6-7/Bala	F_2	164	40	47	38	39	1:2:1	0.23	0.80-0.90
				85					

[a]Partly fertile and semisterile pooled.

studies in the F_2. The segregating line in the M_3 also was studied.

In the 30 kR gamma-irradiated population, genetic male sterile line Bala G 3-6 had completely aborted anthers (devoid of any pollen grain). No other male sterile mutation was identified in any treatment. The monogenic recessive gene for male sterility was confirmed in the F_2 segregating pattern of Bala G 3-6-4/ Bala and Bala G 3-6-7/Bala (Tab1e 1) and in the M_3 segregating lines of Bala G 3-6 (Table 2). □

Table 2. Segregation in the M_3 of gamma ray-induced male sterile mutants of Bala variety, Manipur, India.

Line	Generation	M_3 lines observed (no.)	Nonsegregating lines (no.)	Segregating lines (no.)	Genetic ratio	χ^2 value	*P* value
Bala G 3-6	M_3	18	6	12	1:2	0.06	0.70-0.80

For information on ordering IRRI publications, write Communication and Publications Dept., Div. R, IRRI, P.O. Box 933, Manila, Philippines.

CNA-IRAT 5 upland rice population

J. Taillebois and E. P. Guimaraes, Coordenador arroz, EMBRAPA/Centro Nacional de Pesquisa-Arroz, Feijao (CNPAF), C.P. 179, 74000 Goiânia, Brazil

To develop a segregating population for a recurrent selection program for drought and field blast resistance, CNPAF and Institut de Recherches Agronomiques et des Cultures Vivrières (IRAT) used 27 upland rice varieties and a monogenic recessive male sterile gene obtained by mutation on IR36 by R. J. Singh and H. Ikehashi.

We crossed and backcrossed 26 varieties to male-sterile F_2 plants of Palawan/ IR36 (MS +). The crosses were made to obtain a polycytoplasmic population. F_2 seeds of each backcross were bulked in different proportions to ensure a different rate of each component (see table). The bulked seeds were considered the initial population CNA-IRAT 5/0/0.

CNA-IRAT 5 initial population.

Variety	Parentage	Outcrossing rate (%)
IR36 (ms +)	Mutant of IR36	12.50
Palawan [a]	Asian germplasm	12.50
Cuiabana [a]	IAC47/SR2041-50-1	8.10
IRAT237 [a]	IAC25/RS25	6.73
Beira Campo	Brazilian germplasm	5.39
CNA4097	63-83/IAC25	5.39
CNA4145	IAC47/Kinandang Patong	5.39
Cabaçu (IRAT177)	Mutant of 63-83	5.39
IREM41-1-1-4	Mutant of Makouta	5.39
Palha Murcha	Brazilian germplasm	5.39
TOx 1011-4-2	IRAT13/DP689//TOx 490-1	5.39
CNA5171	IAC47/IRAT13	2.69
IAC165[a]	Dourado Precoce/IAC1246	2.69
IREM247 [a]	Mutant of IAC25	2.50
IAPAR9 [a]	Batatais/IACF 3-7	1.57
IRAT112 [a]	Dourado Precoce/IRAT13	1.47
CNA4135[a]	IAC47/63-83	1.36
IREM238 [a]	PJ110/IAC25	1.35
Arroz de Campo [a]	Brazilian germplasm	1.25
CA 435 [a]	African germplasm	0.84
Casca Branca	Brazilian germplasm	0.84
CNA5179	IAC47/IRAT13	0.84
CNA770187	Brazilian germplasm	0.84
Comum Crioulo	Brazilian germplasm	0.84
Jaguari	Brazilian germplasm	0.84
L-13		0.84
L-81-24	IAC2091/Jaguari//IRAT10	0.84
Santa America	Brazilian germplasm	0.84

[a] Cytoplasms used to form the population.

Outcrossed seeds collected on male sterile plants of the initial population were bulked to form the next population, CNA-IRAT 5/0/1. The procedure was repeated three times to obtain the CNA-IRAT 5/0/3 population.

Samples of bulk seeds harvested on self-pollinated plants of the CNA-IRAT 5/0/2 population are available to rice breeders. □

Some Indonesian restorers and maintainers of WA cytosterile lines

B. Sutaryo, Plant Breeding Division, Sukamandi Research Institute for Food Crops, Subang, Indonesia

We crossed Chinese CMS line V20 A as the female parent with 10 standard rice cultivars during 1987-88 wet season. Hybrids and the male parents grown in the test cross nursery in 1988 dry season were examined (12 plants each) for pollen and spikelet fertility. Male parents of the F_1 that showed 71-90% pollen fertility and higher than 80% spikelet fertility were designated restorers. Male parents showing 5-9% pollen fertility were designated prospective maintainers.

Bahbolon, Cimanuk, Batang Pane, Citanduy, Ciliwung, and Bogowonto were identified as restorers; Bahbutong, Adil, Cisokan, and S397b-40-2 as prospective maintainers (see table). The prospective maintainers need to be tested by recurrent backcrossing. □

Spikelet and pollen fertility percentages in F_1 hybrids and their male parents.

Cross and male parent	Pollen fertility (%)	Spikelet fertility (%)
V20 A/Bahbolon	79	83.2
Bahbolon	82	88.6
V20 A/Cimanuk	78	81.3
Cimanuk	83	82.5
V20 A/Batang Pane	79	83.0
Batang Pane	81	90.5
V20 A/Citanduy	77	80.0
Citanduy	80	82.9
V20 A/Ciliwung	83	84.2
Ciliwung	90	91.0
V20 A/Bogowonto	82	86.5
Bogowonto	90	92.5
V20 A/Bahbutong	6	10.5
Bahbutong	77	88.2
V20 A/Adil	5	11.5
Adil	76	86.1
V20 A/Cisokan	9	10.0
Cisokan	79	85.5
V20 A/S397b-40-2	7	12.8
S397b-40-2	75	83.0

Yield of F_1 hybrids at Tamil Nadu Rice Research Institute (TRRI), Aduthurai, India

V. Sivasubramanian, S. Ganapathy, A. P. M. K. Soundararaj, and N. Nadarajan, TRRI, Aduthurai 612101, India

We evaluated 22 F_1 hybrids developed at IRRI and 2 hybrids developed at TRRI 1986-88. Single seedlings were transplanted at 15- × 15-cm spacing in 3- × 2-m plots with 3 replications. Plots were fertilized with 100-50-50 kg NPK/ha.

Many hybrids yielded less than local check ADT36. Eleven hybrids had 12 to 78% standard heterosis. The most promising were IR54752 A/IR25912-81-2-1 R and V20 A/T1154 (see table). □

Duration, grain yield, and standard heterosis of F_1 hybrids at Aduthurai, India, 1986-88.

Hybrid or check	Duration (d)	Yield (t/ha)	Standard heterosis (%)
	1986		
ADT36 (check)	110	8.4	
IR46828 A/IR13524-21-2-3-3-2-2	120	9.4	12
ZS97 A/Milyang 54	135	7.3	–12
IR46830 A/IR13292-5-3	113	6.5	–22
IR54752 A/IR54 R	129	4.5	–46
IR54752 A/IR19392-211-1	130	4.2	–50
IR54752 A/IR4422-480-2-3-3	130	4.2	–50
IR54752 A/IR20933-68-21	131	3.4	–60
IR54752 A/IR14753-120-3	131	3.1	–63
LSD (P = 0.05)	–	0.9	
	1987		
ADT36 (check)	108	6.3	
IR54752 A/IR25912-81-2-1 R	117	11.3	78
IR54752 A/IR19392-211-1 R	119	8.9	41
IR54752 A/IR28178-70-2-3 R	121	8.8	38
IR54752 A/IR19058-107-1 R	107	7.5	19
IR54752 A/IR28912-63-2-2 R	118	7.4	17
IR54752 A/IR46 R	118	7.3	14
IR54752 A/IR64 R	124	7.2	14
IR54752 A/IR29723-143-3-2-1 R	113	7.2	14
IR54752 A/IR13419-113-1 R	131	5.3	–17
IR46830 A/IR9761-19-1 R	103	4.4	–30
IR54752 A/IR21916-128-2-2-3 R	125	4.2	–34
LSD (P = 0.05)	–	0.7	
	1988		
ADT36 (check)	107	4.8	
Co 43 (check)	127	6.5	
V20 A/T1154 (ADH2)	108	7.4	57
IR54752 A/IR46 R	123	6.7	3
V20 A/IR18349-22-1-2-1-1 (ADH1)	110	3.9	–18
IR54752 A/ARC11353 R	122	2.5	–61
IR54752 A/IR54 R	128	1.6	–15
LSD (P = 0.05)	–	1.4	

Evaluation of some CMS and maintainer lines in Tamil Nadu

V. Sivasubramanian, S. Ganapathy, A. P. M. K. Soundararaj, and N. Nadarajan, Tamil Nadu Rice Research Institute, Aduthurai, Tamil Nadu, India

Five new cytosterile lines from IRRI were evaluated with check variety V20 A during 1987. Five plants in each CMS line were selected randomly to assess pollen stainability, spikelet fertility, plant height, tiller number per plant, days to 50% flowering, and panicle exsertion.

Pollen stainability was lowest in IR54753 A (0.1%) and highest in IR54752 A (10%) (see table). Spikelet fertility in bagged panicles was zero in all lines. Tillering was relatively low in IR54753 A (13 tillers) and highest in IR54757 A (41 tillers). IR54756 A and IR54757 A flowered early, but later than V20 A. The other lines had medium duration. Heading difference between A and B lines was 2-3 d in all lines tested.

Mild incidence of leaf spot was observed in IR54753 and IR54754.

Panicle exsertion was poor in all A lines and normal in B lines. □

Evaluation of newly developed IRRI CMS and maintainer lines in Tamil Nadu, India, 1987.

CMS or maintainer	Pollen stainability (%)	Spikelet fertility[a] (%) On bagged panicles	Spikelet fertility[a] (%) on open pollinated panicles	Plant height (cm)	Tillers (no./hill)	Days (no.) to 50% flowering	Panicle exsertion (grade)[b]
IR54752 A/	10.0	0	0.3	106	23	101	7
IR54752 B				122	22	103	1
IR54753 A/	0.1	0	0.8	103	13	101	7
IR54753 B				115	19	105	1
IR54154 A/	5.0	0	0.3	99	22	99	7
IR54754 B				115	20	102	1
IR54756 A/	0.4	0	0.8	85	31	89	7
IR54756 B				97	27	92	1
IR54757 A/	1.2	0	0.4	74	41	87	7
IR54757 B				89	23	90	1
V20 A/	0.5	0	4.12	65	35	65	7
V20 B				70	28	67	1

[a]Value is zero on bagged panicles. [b]1 = normal.

Yield potential

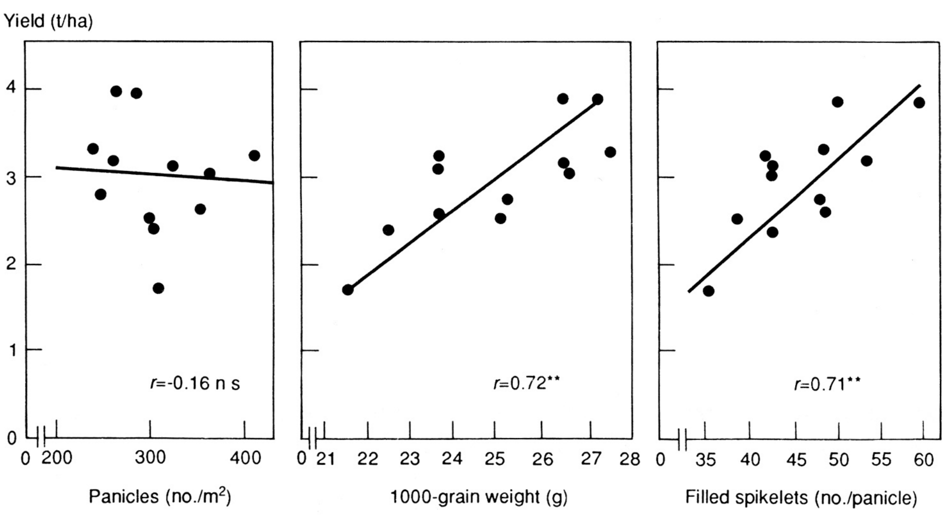
Correlation between yield and its components in upland rice in Cuba

E. Suarez, R. Alfonso, R. Perez, and J. Iglesias, Rice Research Institute, Autopista del Mediodia, Km 16 1/2 Bauta, Havana, Cuba

During 1984 wet season, we studied six varieties in rainfed fields in Sancti Spiritus and Havana Provinces, to establish the correlations between grain yield and its components. Plots were laid out in random block design with four replications. Total rainfall during the experiment was 637 mm in Havana and 694 mm in Sancti Spiritus.

Panicles/m^2 had no relation to grain yield; 1,000-grain weight and filled spikelets/panicle were highly related to grain yield (see figure).

These results are similar to those with the same varieties in irrigated fields. □



Correlation between upland rice yield and its components in Cuba.

Analysis of rice panicle structure

S. Mallik, A. M. Aguilar, and B. S. Vergara, Plant Physiology Department, IRRI

We studied the panicle structure from 10 primary tillers of 80 rice cultivars and lines for two seasons. Table 1 shows the panicle characters of some of the parents and their hybrids.

There were four distinct types of parents. The IR cultivars and Rewa type (PAU125-1-2/Lalco 14) have similar panicle structure. However, Rewa type has more spikelets on the secondary branches (SB) than do IR cultivars. Glaberrima type has more primary branches (PB) and spikelets on primary branches, with few SB and spikelets. The upland type derived from an anther-cultured Moroberekan/Palawan cross is intermediate. The upland type

Table 1. Panicle characteristics of different parents and their hybrids.

Type	Parents or crosses	PB	SB	PB:SB	SpPB	SpSB	SpPB:SpSB	TSp
Glaberrima type	Acc. 103995	12.3	7.3	1.7	98	16	6.1	114
	Acc. 103350	15.4	4.0	3.8	123	9	13.7	132
	Acc. 104003	16.3	18.7	0.9	126	56	2.2	182
IR cultivars or lies	IR30	9.1	22.2	0 4	46	69	0.7	115
	IR34615-75-1-1	12.1	32.2	0.4	67	113	0.6	180
	IR29725-135-2-2-3	10.3	19.8	0.5	65	59	1.1	123
	IR32307-75-1-3-1	8.3	23.8	0.3	45	79	0.6	124
	IR28211-43-1-1-2	10.4	26.1	0.4	68	92	0.7	160
	IR36 (check)	9.2	22.8	0 .4	50	72	0.7	122
Upland type	IR47705-AC1	13.0	30.0	0.4	80	92	0.9	173
	IR47705-AC3-2	14.0	35.5	0.4	82	109	0.7	190
	IR47705-AC4	12.4	39.0	0.3	77	131	0.6	208
	IR47705-AC4-1	12.5	36.5	0.3	78	116	0.7	193
	IR47705-AC5	14.0	17.7	0.8	81	54	1.5	135
	IR47705-AC5-1	14.7	30.7	0.5	91	97	0.9	189
Indica type	Rewa 353-2	10.1	35.2	0.3	61	131	0.5	192
	Rewa 353-3	10.0	34.4	0.3	61	129	0.5	191
	Rewa 353-4	10.5	36.4	0.3	64	137	0.5	202
	Rewa 353-7	10.3	3 1.0	0.3	63	114	0.5	177
	Ch IR87-3-1	12.3	24.4	0.5	80	72	1.1	152
	LSD (0.05)	1.2	3.9		14	15		12
F_1 hybrid	Rewa 353-3/IR47705-AC4	14.1	50.4	0.3	91	187	0.5	278
	Rewa 353-2/IR30	12.0	43.3	0.3	66	158	0.4	224
	Rewa 353-4/IR28211-43-1-1-2	10.9	32.0	0.3	68	116	0.6	184
	Rewa 353-7/IR32307-75-1-3-1	9.4	31.5	0.3	56	115	0.5	171
	Acc. 103995/IR47705-AC4	16.1	36.8	0.4	119	111	1.1	230
	Acc. 103350/IR47705-AC4	14.0	35.3	0.4	101	115	0.9	217
	Acc. 103350/IR47705-AC4-1	14.2	45.3	0.3	117	150	0.8	267
	Acc. 104003/IR47705-AC4-1	14.9	35.2	0.4	100	109	0.9	208
	IR47705-AC1/IR29725-135-2-2-3	13.6	35.2	0.4	91	119	0.8	210
	IR47705-AC3-2/IR34615-75-1-1	14.7	47.4	0.3	85	168	0.5	253
	IR47705-AC5/Ch IR87-3-1	17.3	40.3	0.4	113	130	0.9	244
	IR47705-AC5-1/IR28211-43-1-1-2	13.9	34.4	0.4	96	123	0.8	219
	LSD (0.05)	1.3	3.8		12	16		19

Table 2. Percentage of heterosis, heterobeltiosis, and standard heterosis for 5 panicle characters in 12 crosses. IRRI, 1988.

Cross	Percent														
	PB			SB			SpPB			SpSB			TSp		
	H	Hb	SH	H	Hb	SH	H	Hb	SH	H	Hb	SH	H	Hb	SH
Rewa 353-3/IR47705-AC4	25.9	13.7	53.3	37.3	29.2	121.0	32.0	18.2	84.0	44.1	43.4	160.3	45.4	44.4	127.9
Rewa 353-2/IR30	25.0	18.8	30.4	50.9	23.0	90.0	23.5	8.7	32.6	57.7	20.3	118.9	45.8	16.6	83.2
Rewa 353-4/IR2821143-1-1-2	4.3	3.8	18.5	2.4	–12.1	40.3	2.8	0	36.4	1.1	–15.6	61.1	1.7	–8.8	50.7
Rewa 353-7/IR32307-75-1-3-1	1.1	–8.7	2.2	15.0	1.6	38.2	3.3	–11.7	11.9	19.7	1.5	60.1	13.8	–3.2	40.1
Acc. 103995/IR47705-AC4	30.4	29.8	75.0	59.0	– 5.6	61.4	35.9	21.5	139.6	51.0	–15.1	54.2	43.0	10.6	88.5
Acc. 103350/IR47705-AC4	0.7	–9.1	52.2	64.2	– 9.5	54.8	1.1	–17.8	104.0	65.6	–11.7	60.3	27.5	4.2	77.7
Acc. 103350/IR47705-AC4-1	1.8	–9.1	54.3	123.7	24.1	98.7	16.1	– 5.4	134.6	140.6	29.3	108.3	64.1	38.1	118.5
Acc. 104003/IR47705-AC4-1	3.5	–8.6	62.0	27.5	– 3.6	54.4	–2.1	–20.8	100.2	26.4	– 6.3	50.0	11.0	7.9	70.7
IR47705-ACl/IR29725-135-2-2-3	16.7	4.6	47.8	41.4	17.3	54.4	26.0	14.0	83.5	57.4	28.6	65.3	42.0	21.8	72.3
IR47705-AC3-2/IR34615-75-1-1	12.6	5.0	59.8	40.0	33.5	107.9	14.5	4.4	71.2	51.1	48.2	133.2	36.6	33.2	107.4
IR47705-AC5/Ch IR87-3-1	31.6	23.6	88.0	91.4	65.2	76.7	48.8	39.4	128.2	106.7	80.8	80.8	69.9	60.6	99.6
IR47705-AC5-1/IR2821143-1-1-2	10.8	–5.4	51.1	21.1	12.0	50.9	20.4	4.9	92.8	30.0	26.4	70.8	23.3	15.8	79.3
LSD (0.05)	7.2	8.4	14.2	20.5	13.6	16.8	8.8	10.6	25.0	23.1	20.3	21.9	12.6	12.5	15.7

H = heterosis, Hb = heterobeltiosis, SH = standard heterosis.

has almost the same number of spikelets on PB (SpPB) and SB (SpSB). PB-SB and SpPB-SpSB ratios were high for the glaberrima type and low for the Rewa type.

Total spikelet number in Rewa 353-3/ IR47705-AC4 was 278, compared to about 150 spikelets in IR entries. Number of PB was 17.3 in IR47705-AC5/Ch IR87-3-1 and 16.1 in Acc. 103995/ IR47705-AC4; the IR varieties had about 10 PB. In crosses with glaberrima or upland type as the female parent, SpPB was 100 or more; the IR varieties had 45-68 SpPB.

Heterosis (over midparent), heterobeltiosis (over better parent), and standard heterosis (over IR36) were estimated for PB, SB, SpPB, SpSB, and total spikelets (TSp). Estimates of overall degree and direction of heterosis ($Fmac_1$–Pmac) were significant and positive for all characters, indicating dominance of higher values.

The values for individual F_1 families, however, differed from the overall estimates for heterosis in different characters (Table 2). The F_1 means deviated conspicuously from the respective parental and midparental values, indicating nonadditive gene action for most characters.

Substantial heterosis in the desirable direction showed in characters like number of PB, SpPB, and TSp, which are related to higher grain yield potential. Most crosses exhibited positive heterosis, heterobeltiosis, and standard heterosis for number of PB and SpPB; however, one Rewa cross, one upland cross, and three glaberrima crosses had negative heterobeltiosis, perhaps because of the already high number of PB and SpPB in the glaberrima parents.

Two Rewa crosses (Rewa 353-3/IR47705-AC4 and Rewa 353-2/IR30) and three upland crosses (all but IR47705-AC5-1/IR2821143-1-1-2) manifest positive heterosis, heterobeltiosis, and standard heterosis for all characters. The cross Acc. 103995/ IR47705-AC4 showed negative heterobeltiosis for SB and SpSB but positive heterobeltiosis for other characters. That is desirable to increase high-density grains (sp gr > 1.20) and grain yield potential. Most poor grains or low-density grains originated from secondary branches. ☐

Quality attributes of seed produced on different tillers of IR50

J. A. Selvaraj and P. Subramanian, Seed Technology Department, Tamil Nadu Agricultural University, Coimbatore 641003, India

A bulk seed crop of IR50 was raised during 1987 dry-season (rabi). At the boot leaf stage, 20 plants were marked at random. As panicles emerged, they were numbered sequentially. At harvest, panicles were measured individually for panicle length, number of filled spikelets/ tiller, seed weight/ tiller, 1 ,000-grain weight, and germination and vigor before and after 8 d accelerated aging (see table). The vigor index is derived from length of seedling × germination percentage.

Panicle length and seed attributes among tillers in IR50.

Tiller	Panicle length (cm)	Spikelets/tiller (no.)		Seed weight/ tiller (g)	1000-seed weight (g)	Before aging		After aging	
		Filled	Ill-filled			Germination (%)	Vigor index	Germination (%)	Vigor index
First	20.6	86	12	1.3	20.5	97	3780	39	820
Second	20.5	77	13	1.2	20.4	92	2910	36	730
Third	20.1	76	13	1.1	20.4	90	2650	33	620
Fourth	20.0	71	15	1.1	20.4	88	2380	30	540
Fifth	19.7	68	17	1.0	20.2	80	2100	28	480
Sixth	19.4	63	18	0.9	20.1	77	1920	26	430
Seventh	19.4	60	19	0.9	19.7	75	1820	19	290
Eighth	19.2	56	20	0.8	19.4	68	1500	17	240
Ninth	18.6	51	22	0.7	19.2	60	1230	14	160
Tenth	18.6	49	22	0.7	18.9	52	1050	11	99
Mean	19.6	66	17	0.9	19.9	78	2134	24	440
LSD (P=0.05)	1.1	4	3	0.01	0.1	7.0	192	1	41

Tillers that headed early had higher values for seed quality attributes.

The superior germination and vigor of large, early flowering tillers was evident in the accelerated aging test. We suggest that only large, early flowering tillers/panicles be used for breeder seed increase. ☐

A basic plant ideotype for rice

M. P. Janoria, J. N. Agricultural University, Jabalpur 482004, India

Plants grow within the confines of horizontal (HS) and vertical (VS) space. HS provides anchorage, VS furnishes solar energy, CO_2, O, water, and mineral nutrients. Crop productivity depends primarily on the plants' ability to utilize HS and VS.

An efficient plant would be one which occupies the minimum HS, but the maximum VS.

Efficient use of HS by a rice cultivar implies maximum panicles per unit of HS without reduction in mean panicle yield. This requires maximum tillers per unit of HS, with no ineffective tillers, limited tiller mortality, least inter- and intraplant competition, heavy panicles, and minimum intraplant panicle yield variation. Fewer tillers per plant would minimize ineffective tillers and promote intraplant synchrony of flowering, maturity, and panicle yield. Upright growth, erect leaves, and deep roots would minimize intraplant competition.

Taller plants intercept higher amounts of solar radiation and trap more CO_2. Thus, taller plants promote better gas exchange between the crop and environment by creating greater humidity within the stand. Greater movement of taller culms in air currents also can improve CO_2 fixation by reducing air-layering. Longer and thicker culms can store more assimilates, up to 40% of which may be transported to the grain. Height should be the optimum to ensure lodging resistance at intended fertility levels and to provide good penetration of sunlight and air movement through the crop stand.

Upright growth with fewer, well-spaced, thick, not-too-short, and stiff leaves should improve penetration of solar radiation as well as free movement of air through the stand. At a constant leaf area index, leaves of taller plants would be spaced farther apart than those of dwarf plants, which should considerably neutralize negative effects of tall stature on sunlight penetration through the canopy. Tall erect rice cultivars are likely to also have deeper roots, to better absorb water and nutrients.

Identification of these morphological traits allows construction of a basic ideotype with characteristic features of taller stature; lodging resistance; upright growth; fewer, all effective tillers; fewer, well-spaced, thick, not-too-short, stiff leaves; heavy panicles; limited intraplant variation in panicle yield; and deep, extensively branched roots. Cultivars of this type would have to be grown at closer spacing.

Rewa 353 (PAU125-1-2/Lalco 14) is our first prototype. It is 130 cm tall, with an average of six very upright, stiff tillers (all effective)/ plant. Highly synchronous panicles yield an average 4 g of long, slender grains. It has <10% sterility and a harvest index of 0.50.

In 1982, Rewa 353 averaged a yield of 4.3 t/ ha over 19 locations, compared with 3.85 t/ ha for semidwarf check Rasi. In 1983, average yields over 23 locations were 3.5 for Rewa 353 and 2.8 t/ha for Rasi. Both cultivars flower in about 85 d. Although Rewa 353 is an inadequate approximation of the new ideotype, its performance in wider spacings than ideal shows merit. □

A technique for screening herbicide tolerance in rice

Shi Chunhai and Shen Zongtan, Agronomy Department, Zhejiang Agricultural University, Hangzhou, China

We developed a technique to evaluate indica rices for herbicide tolerance at the seedling stage. To speed up screening for herbicide tolerance, we used the treatment method commonly applied in the field on seedlings in the incubator.

Seedlings were grown in 50- × 20- × 15-cm plastic trays with 7-cm-deep soil. At the 2-leaf stage, different trays were flooded with 50, 100, and 500 ppm butachlor, and 250, 500, and 1,000 ppm thiobencarb up to the pulvinus of the second leaf, with water treatment as a check. Seedlings were kept in the incubator (30/25 °C day/night, 12 h light and 3000 lx/d) for 11 d.

Treatment with 100 ppm butachlor or 500 ppm thiobencarb was best for discriminating herbicide tolerance among varieties. In most varieties, tolerance for both herbicides was similar (correlation coefficient 0.67**).

Tolerance of 100 indica rice varieties for 2 herbicides. Hangzhou, China.

Reaction [a]	Butachlor	Thiobencarb
Highly tolerant	Long-jiang-dao Radiation 8-1	Long-jiang-dao Wu-jie-gu
Tolerant	B-8 Pioneer 1, Zhen-long 13, Ai-jiao-nan-te, Radiation 85-65, Wu-jie-gu, Xiao-hong-gu, Min-shang 1	B-8 Er-jiu-nan 1, 82-469
Medium tolerant	Er-jiu-lu 1, Ai-nan-zao 1, Ai-nan-zao 39, Lu-hong-zao 1, Tie-lu 17, Xiang-zhu 443	Er-jiu-lu 1, Ai-nan-zao 1, Ai-nan-zao 39, Lu-hong-zao 1, Tie-lu 17, Xiang-zhu 443
	Zhong 834, Zuo 5, Zao-xian 141, 3168-3, Wen 189, Er-jiu-nan 1,82-469, Qing-lian 16, Wen-ge, IR58, Zhe-fu 802, E-zao 6, Long-fei 313, Er-jiu-ai 7, 60-ri-zao, 70-ri-huo-dao, Qing-gu-ai, Conggui 3, Yin-bu-ai	Radiation 8-1, Pioneer 1, Zhen-long 13, Radiation 85-65, Min-shang 1, IR1710
Susceptible	Zhen-shan 97, Si-mei 2, Guang-lu-ai 4, Er-jiu-qing, Zao-jian 1, Jia-xian 785, Zhong 86-151, Gui-lu-ai 8, Wen-guang-qing, Qing-gan-huang, Zhu-xi 26, Nong 8506, Ai-chang 25, PL 15, 15-4, Zhu-yun-nuo, Zao-xian 503, Lian-tang-zao, Zao-lian 31, Xiang-zao-xian 3, Radiation 83-29, BG 367-7, IR54, Dong-hai 109, Tetep, Cong-gui 314, Guang-liu-zao	Zhen-shan 97, Si-mei 2, Guang-lu-ai 4, Er-jiu-qing, Zao-jian 1, Jia-xian 785, Zhong 86-151, Gui-lu-ai 8, Wen-guang-qing, Qing-gan-huang, Zhu-xi 26, Nong 8506, Ai-chang 25, PL 15, 15-4, Zhu-yun-nuo, Zao-xian 503, Lian-tang-zao, Zao-lian 31, Xiang-zao-xian 3, Radiation 83-29, BG 367-7, IR54, Dong-hai 109, Tetep, Cong-gui 314, Guang-liu-zao
	Bao-nan-zao, IR29, Qing-xiao-jin-zao, Zhong 84-86, Zhen-gui 51, Yuan-feng-zao, Er-jiu-feng, Zao-er-liu 14, Chuan 84-508, Shu-feng 1, Zhen-lu-xi 1, Cong-xie 39, Guang-er-ai 105, Guang-hong 40, IR22, IR22107, IR1710	Ai-jiao-nan-te, Zhong 83-4, Zuo 5, 3168-3, Wen 189, Qing-lian 16, E-zao 6, Long-fei 313, Er-jiu-ai 7, 70-ri-huo-dao, Qing-gu-ai, Cong-gui 3, Yin-bu-ai, Zao-feng-shou, Yin-zao 41 1, Zhu-ke 2, Hong 410, IR26
Highly susceptible	Fu-yu 1, Zhe 85-2, Wen-xuan-qing, L201, L202, IR24, IR30, 5010, Zhu-lian-ai, B3, IR50, Yuan-wu, Chun-feng 1, Zhai-ye-qing 8, IR9129, Hua-ai 837	Fu-yu 1, Zhe 85-2, Wen-xuan-qing, L201, L202, IR24, IR30, 5010, Zhu-lian-ai, B3, IR50, Yuan-wu, Chun-feng 1, Zhai-ye qing 8, IR9129, Hua-ai 837
	Zao-feng-shou, Yin-zao 411, Zhu-ke 2, Hong 410, IR26	Xiao-hong-gu, Zao-xian 141, Wen-ge, IR58, Zhe-fu 802, 60-ri-zao, Bao-nan-zao, IR29, Qing-xiao-jin-zao, Zhong 84-86, Zhen-gui 51, Yuan-feng-zao, Er-jiu-feng, Zao-er-liu 14, Chuan 84-508, Shu-feng 1, Zhen-lu-xi 1, Cong-xie 39, Guanger-ai 105, Guang-hong 40, IR22, IR22107

[a] Highly tolerant: 2d and 3d leaves normal; tolerant: 2d leaf partially with water-soaked light brown spots, 3d normal; medium tolerant: 2d leaf with many large light brown spots, 3d with some; susceptible: spots linked with each other, leaves partially necrotic; highly susceptible: seedlings nearly dead or dead.

The 100 varieties screened could be divided into five response groups (see table). Long-jiang-ao, Radiation 8-1, B-8, and Pioneer 1 were tolerant of butachlor; Long-jiang-dao, B-8, Wu-jie gu, and Er-jiu-nan 1 were tolerant of thiobencarb. IR30, IR54, and Fu-yu 1 were susceptible to both herbicides. □

Grain quality and nutritional value

Induced variation in aromatic rice cultivars

V. P. Singh, Plant Breeding Department, IRRI; E. A. Siddiq, D.R.R., Rajendranagar, Hyderabad 500030; and F. U. Zaman and A. R. Sadananda, Indian Agricultural Research Institute, New Delhi 110012, India

Traditional aromatic varieties Karnal Local and Bindli were irradiated with 30 kR gamma rays to obtain semidwarf, nonlodging mutants that retain parental cooking quality characteristics. Only morphological mutants were selected and grown to the M_5 generation.

Important agronomic traits were recorded on five randomly selected plants per mutant. Bulk milled rice samples were used for grain quality analysis.

All short-statured mutants selected from Karnal Local tend to lodge and are near or inferior to the parent in yield per plant (see table). Mutants KLM-14 and KLM-24 possess longer and finer grains with desirable alkali spreading value and amylose content. Except for Karnal Local Mutant-8 (nonaromatic), all mutants have strong aroma.

All mutants selected from Bindli are strongly aromatic. Mutants below 100 cm height have thick, sturdy stems and relatively upright, dark green leaves. Bindli Mutants (BM) 34, 65, and 68 have desirable alkali spreading value and amylose content. BM64 is taller than its parent.

Early-maturing aromatic strains, whether land races or developed through recombination breeding/ mutation, that flower and mature at higher temperature and relatively high humidity do not develop aroma or develop only mild aroma. BM21 and BM24, despite having very short durations, maintained strong aroma and parental level of amylose content and alkali spreading value when they flowered and matured in Sep in North India. □

Range and mean for induced variations.

Character	Karnal Local	24 mutants of Karnal Local			Bindli	23 mutants of Bindli		
		Range	Mean[a]	SD		Range	Mean[a]	SD
Plant height (cm)	135.60	76.00-134.40	104.53	15.35	146.40	86.80-172.10	101.04	21.65
Tillers (no./plant)	15.00	10.00- 22.00	15.00	3.18	13.00	6.00- 17.00	12.12	2.60
Yield (g/plant)	29.30	4.50- 29.30	20.17	5.85	20.84	5.62- 37.14	21.19	7.85
Test grain weight[b] (g)	23.00	17.00- 25.80	21.10	2.31	18.00	10.50- 20.00	18.07	2.24
Filled grains (no./panicle)	85.00	20.00-103.00	65.72	20.33	80.00	57.00-140.00	94.58	20.36
Duration (d)	150.00	132.00-164.00	152.64	10.88	161.00	110.00-166.00	156.60	15.00
Length (L) of milled rice (mm)	7.55	6.95- 8.88	7.62	0.47	4.77	3.22- 4.80	4.56	0.36
Breadth (B) of milled rice (mm)	1.78	1.40- 2.23	1.82	0.18	2.58	2.20- 2.68	2.52	0.12
L/B ratio	4.24	3.37- 5.80	4.22	0.64	1.85	1.74- 1.92	1.80	0.09
Alkali spreading value	3.00	3.00- 4.00	3.56	0.50	4.00	3.00- 4.00	3.78	0.41
Amylose content (%)	25.5	17.00- 29.50	24.02	4.02	27.00	23.00- 29.00	25.16	1.28

[a]Includes parent. [b]One thousand randomly selected grains used to compute test grain weight.

Hua-03 — a high-protein indica rice

Yang Xuerong and Fu Huihua, Biology Department, Huazhong Normal University, Wuhan, China

Hua-03 is a newly released high-protein, early indica variety with wide

Table 1. Some agronomic characteristics and protein content of Hua-03.[a] Wuhan, China, 1983-88.

Variety	Duration (d)	Plant ht (cm)	Panicles (no./m^2)	Grains (no./panicle)	1000-grain wt (g)	Yield (t/ha)	Protein content (% dry wt brown rice)
Hua-03	113	76.96	568.13	54.20	25.20	7.0	13.72
Guang-Lu-Ai 4	117	63.31	511.21	53.16	25.18	6.2	10.50

[a]Mean of 5 sites.

adaptability in Hubei, Hunan, Kiangsi, and Kwangsi Provinces (23.0-32.0° N, 107-120° E). It was derived by anther culture from IR8/Er-Jiu-Qing F_2 during 1978-88. The new variety usually ripens 3-5 d earlier than popular local variety Guang-Lu-Ai 4.

In regional large-scale plantation trials in Hubei and Kiangsi 1986-88, average yield was 7 t/ha, nearly 10% higher than that of Guang-Lu-Ai 4 (Table I). Hua-03 has better nutritional quality and' palatability and higher milling rate.

An outstanding characteristic of Hua-03 is its high-protein content, especially of the eight essential amino acids (Table 2). Brown amino acid score (based on lysine) was 67% in preschool children and 89% in school children. □

Table 2. Amino acid analysis of Hua-03 brown rice.[a]

Essential amino acid	Content (mg/g protein) Hua-03 (mean of 5 analyses)	FAO/WHO standard Preschool child	FAO/WHO standard School child
Isoleucine	56	28	28
Leucine	87	66	44
Lysine	39	58	44
Methionine + cysteine	37	25	22
Tyrosine + phenylalanine	107	63	22
Threonine	32	34	28
Tryptophan	12	11	9
Valine	64	35	25

[a]Compared with FAO/WHO suggested requirement patterns for preschool and school children.

Sources of cooked rice grain elongation

N. S. Rani and T. E. Srinivasan, Directorate of Rice Research, Rajendranagar, Hyderabad 500030, Andhra Pradesh, India

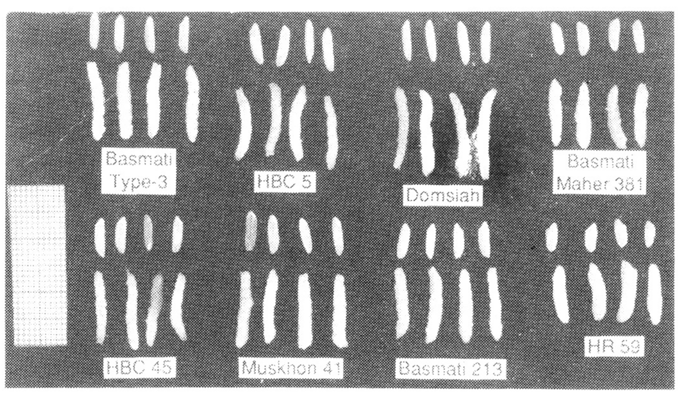
Elongation of rice grains during cooking is one of the unique features of Basmati rices. Some of the key Basmati traits-slenderness, translucency, and aroma-R simply inherited and easy to transfer into other genotypes. But linear grain elongation follows a complex pattern of inheritance. We studied the relationship between physicochemical components and grain elongation in 121 quality rices, including many aromatic types, during 1987 wet season.

The experiment used a simple lattice design with two replications. Each variety was transplanted in four rows of 17 plants each at 15- × 20-cm spacing. Normal irrigated rice cultural practices were followed. Quality characters were measured 3 mo after harvest.

Twenty varieties showed more than double grain elongation during cooking (see table). Domsiah (Iran), HR59, Basmati Maher 381, Muskhon 41, Basmati 213, Basmati type-3 (Dehradun), HBC5, and HBC45 (Haryana Basmati collection) showed excellent grain elongation, with the typical beaded appearance of cooked grains (see figure). Basmati Kamon, Basmati 370, Basmati 397, Basmati 43A, HBC30, and HBC34 also are promising as donors of linear grain elongation. □

Linear grain elongation during cooking of rice varieties in Hyderabad, India, 1987 wet season.

Variety	Raw grain length (mm)	L/B ratio	Cooked grain length (mm)	Elongation ratio
With very high elongation				
Domsiah	6.84	4.12	18.0	2.63
HR59	5.21	3.32	12.75	2.44
Basmati Maher 381	6.74	4.0	15.25	2.26
Muskhon 41	6.64	4.0	14.75	2.22
Basmati 213	6.76	4.17	14.92	2.21
Basmati type-3 (Dehradun)	6.61	4.15	14.5	2.19
HBC5	7.79	4.72	17.0	2.18
HBC45	7.12	4.44	15.42	2.16
With high elongation				
Basmati Kamon	6.89	4.26	14.83	2.15
Basmati 370	6.73	4.28	14.5	2.15
Basmati 397	6.74	4.34	14.42	2.14
Basmati 43A	6.37	4 .0	13.5	2.12
HBC30	7.79	4.72	16.47	2.11
HBC34	7.08	4.53	14.91	2.10
Basmati 410	7.24	4.24	15.08	2.08
Basmati 405	6.62	4.0	13.67	2.06
Basmati 242	6.49	3.93	13.32	2.05
Pakistan basmati	6.78	4.14	13.75	2.03
HBC4O	6.96	4.3	14.08	2.02
Dehradun basmati	6.99	4.29	14.08	2.01
Mean	6.82	4.20	14.76	2.16
LSD (0.05)	0.83	0.56	1.38	ns
CV (%)	5.8	6.4	4.5	8.1



Cooked grain of rice varieties showing high linear elongation. Hyderabad, India

Disease resistance

A natural inoculation-spread technique (NIST) for selecting bacterial blight (BB)-resistant rice cultivars

R. N. Singh and B. N. Mahto, N. D. University of Agriculture and Technology, P. O. Dabha Semar, District Faizabad 224133, Uttar Pradesh (U.P.), India

Eastern U.P., with favorable environmental conditions and endemic inoculum, is a hot spot for BB incidence. Evaluation of rice genotypes for resistance to the foliar phase of the disease, using clip inoculation technique (CIT), is routine.

But comparatively more extensive physical injury and higher inoculum load with CIT than with natural inoculation (insect feeding, bruising, and rain splattering) overload the physical and biochemical defense mechanisms of the rice plant, resulting in rejection of otherwise field-resistant genotypes. We compared the reaction of rice genotypes infected by NIST and by CIT.

Test entries were planted in two 2-m-long rows at 20- × 15-cm spacing, fertilized with 180-60-60 kg NPK/ha, and irrigated to maintain a humid plant microenvironment. Half of the rows were clip-inoculated alternately from opposite directions, and whole rows were sprayed with a suspension of a local isolate of *Xanthomonas campestris* pv. *oryzae* (Ishiyama) Dye at maximum tillering. Entries were rated for disease 15 and 35 d after inoculation (DAI) in clipped plants and at 35 d in unclipped ones. Unclipped plants were open to natural inoculation from the spray and as spread from flanking clip-inoculated rows.

Of 164 genotypes, 50 showed lower disease rating under NIST than under CIT at 15 DAI; 83 had lower ratings at 35 DAI (Table 1). But 44 NIST-inoculated genotypes had disease ratings higher than were recorded 15 DAI under CIT. Similar disease ratings under both systems were found in 71 and 74 genotypes at 15 and 35 DAI, respectively. NIST adequately identified true resistance or susceptibility of the test genotypes, considering a whole range of morphological resistance factors that become to a large extent redundant because of severe wounding in CIT.

Disease responses under NIST and CIT were compared (Table 2). Seven genotypes that scored 1 under CIT

Table 1. Comparative reaction of rice genotypes to *Xanthomonas campestris* pv. *oryzae* infection under CIT and NIST. Faizabad, U.P., India.

Genotypic reaction under NIST	Genotypes (no.)	Representative genotypes
Similar to reaction under CIT at 15 DAI	71	Amgandh, Anand, Anjana, Badshah Posawali, Bhagalpuri, Bindi Bali, Chameli, Chinidardi, Gajgaur, Gallor, Gajraj, Ghee Bhat, Jaisuria, Juhi Bengal
Similar to reaction under CIT at 35 DAI	74	Amgandh, Anand, Anjana, Badshah Posawali, Bhagalpuri, Bindi Bali, Chameli, Chinidardi, Gajgaur, Gajraj, Juhi Bengal, Kalamdan, Kala Namak
Lower than reaction under CIT at 15 DAI	50	Adamchini, Anjani III, Badshahpasand, Bakki, Bindi Kali, Bishunbhog, Damodar, Getu, Hansraj, Karhan, Katri, Kota Banmati, Loungchoor, Latisail
Lower than reaction under CIT at 35 DAI	83	Adamchini, Anjani III, Badshahpasand, Bakki, Bindi Kali, Bishunbhog, Damodar, Getu, Hansraj, Karhan, Katri, Kota Basmati, Loungchoor, Latisail, Madan chand
Higher than reaction under CIT at 15 DAI	44	Agwar, Beni Deoria, Dhurigabha, Dudaha, Gallor, Gajraj, Kalamdan, Kala Namak, Ramkajara, Rohan, Saren, Shyamzeera, Sorahi
Higher than reaction under CIT at 35 DAI	4	Beni Deoria, Dhurigabha, Dudaha, Saren

Table 2. Reaction of rice genotypes to infection with a local isolate of *Xanthomonas campestris* pv. *oryzae* under CIT and NIST. Faizabad, U.P., India.

Disease evaluation[a]		Representative genotypes showing reaction		Genotypes (%)	
Score	Reaction	CIT	NIST	CIT	NIST
0	HR	None	Anjani III, Bishunbhog, Damodar, Getu, IR20, Randhuri, Zeerabatti	0.0	4.3
1	R	Anjani III, Bishunbhog, Damodar, Getu, IR20, Randhuri, Zeerabatti	Chinidardi, Katri, Loungchoor, Latisail, Modak, Rambhog, Saraya, Sita	4.3	7.3
3	MR	Chinidardi, Katri, Loungchoor, Latisail, Modak, Rambhog, Saraya, Sita	Adamchini, Badshahpasand, Beni, Gallor, Gaurea, Gajraj, Hansraj, Kala Namak	12.8	26.8
5	MS	Adamchini, Badshahpasand, Beni, Gaurea, Hansraj, Juhi Bengal, Kana Bakera, Kataribhog	Agwar, Amgandh, Ashahaniya, Bakki, Bhagalpuri, Chameli, Dhurigabha, Jaisuria	32.9	26.8
7	S	Agwar, Ashahaniya, Bakki, Jaisuria, Karahan, Kota Basmati, Mirchbooti, Moti Badam	Beni Deoria, Bindi Kali, Ghee Bhat, Kalakand, Madanchand, Moti Badam, Sonachoor, Sukhawan	19.5	11.0
9	HS	Anand, Anjana, Bindi Kali, Gajgaur, Ghee Bhat, Kalakand, Madanchand, Sukhawan	Anand, Anjana, Bindi Bali, Gajgaur, Pasarahi, Rajbhog, Ramkajara	30.5	23.8

[a]*Standard evaluation system for rice* (1980). HR = highly resistant, R = resistant, MR = moderate1y resistant, MS = moderately susceptible, S = susceptible, HS = highly susceptible.

remained BB-free under NIST; of 21 genotypes that scored 3 under CIT, only could be scored under NIST. Scores 0-5 were found in 50% of the CIT cases and 65.2% of the NIST; those 15.2% of the genotypes saved under NIST could include potentially superior cultivars that would have been rejected under CIT.

Repeated testing of genotypes scoring 0-5 for two more seasons will eliminate chances of escape. □

Changes in ascorbic acid content of rice cultivars due to *Rhizoctonia solani* inoculation and carbendazim application

A. Karthikeyan, S. Thirumurthi, and R. Narayanaswamy, Agricultural Research Station, Bhavanisagar 638451, India

During 1985 samba season (Aug-Jan), rice varieties ADT3 1, CR 1009, AU42/ 1, IR20, and White Ponni were inoculated with *R. solani* at maximum tillering (80 d old) by single sclerotium method. Fungicide (0.1% carbendazim) was sprayed 3 d after inoculation. Sheath portions of the plants sampled at 3, 5, and 7 d after inoculation and 3, 5, and 7 d after fungicide application were analyzed for changes in ascorbic acid content.

Changes in ascorbic acid content after *R. solani* inoculation and carbendazim treatment. Bhavanisagar, India, 1985.

Period (d) after inoculation and fungicide application	Treatment	Ascorbic acid content (mg/g of oven-dry tissue)					
		ADT31	CR1009	AU42/1	IR20	White Ponni	Mean
3	Healthy	0.812	0.983	0.881	0.904	0.872	0.890
	Inoculated	0.873	1.053	0.985	1.057	0.993	0.992
	Fungicide treated	0.942	1.167	1.098	1.113	1.054	1.075
5	Healthy	0.803	0.884	0.824	0.860	0.853	0.845
	Inoculated	0.856	0.907	0.859	0.874	0.872	0.874
	Fungicide treated	0.884	0.921	0.896	0.904	0.884	0.898
7	Healthy	0.762	0.838	0.801	0.788	0.797	0.797
	Inoculated	0.796	0.865	0.822	0.823	0.821	0.825
	Fungicide treated	0.837	0.884	0.864	0.873	0.854	0.862

Highly susceptible ADT31 contained less ascorbic acid than susceptible CR1009, AU42/ 1, IR20, and White Ponni (see table). Ascorbic acid content increased with *R. solani* inoculation in all varieties and with fungicide application. It decreased with plant age. □

A new pathotype of *Xanthomonas campestris* pv. *oryzae*

M. T. S. Reddy, APAU, Rajendranagar; and A. P. K. Reddy, Directorate of Rice Research, Rajendranagar, Hyderabad, Andhra Pradesh, India

We tested in the glasshouse the virulence of 150 isolates of *X. c.* pv. *oryzae,* representing 25 endemic locations in India, using clip inoculation on a selected set of rice differential varieties.

The population first divided into two distinct groups: pathotypes I and II. Pathotype 1 did not behave as a homogeneous population. But IR20, with the *Xa-4* gene, responded differentially on repeated tests to isolates of pathotype I.

lsolates from eastern Uttar Pradesh (U.P.), Maharashtra, and Punjab belonged to pathotype Ia, to which IR20 was resistant. Isolates from Andhra Pradesh, Bihar, Gujarat, Haryana, Kerala, Orissa, Tamil Nadu, and western U.P., belonged to pathotype Ib, to which IR20 was susceptible (see table). □

Pathogenicity patterns of *X. c.* pv. *oryzae* on differential rice varieties. Andhra Pradesh, India.

Group	Pathogenicity pattern on differential varieties					
	IR8	IR20	BJ1	DV85	Cempo Selak	Java 14
Pathotype Ia	S	R	R	R	S	S
Pathotype Ib	S	S	R	R	S	S
Pathotype II	S	S	S	S	R	R

Serotypes in Xanthomonas *campestris* pv. *oryzae*

M. T. S. Reddy, APAU, Rajendranagar; and A. P. K. Reddy, Directorate of Rice Research, Rajendranagar, Hyderabad, Andhra Pradesh, India

Studies on serological relationships among pathotypes of *X. c.* pv. *oryzae* show they can also be differentiated by gel-diffusion and agglutination tests. In India, pathotypes I and II are classified on the basis of differential reactions on rice varieties DV85 and Cempo Selak. We tested antisera prepared in New Zealand white rabbits.

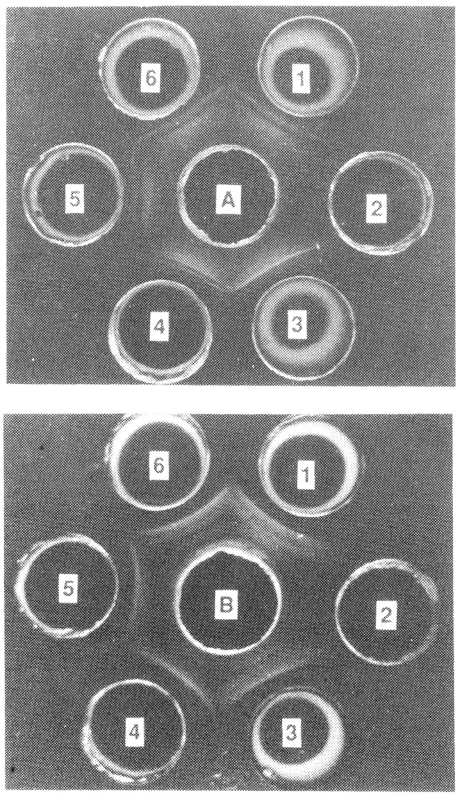
In the agglutination dilution series with their respective homologous antigens, the highest titers (5120 and 2560) were obtained in pathotype I and II. In the cross agglutination test, no titer value could be detected in any dilution series between the antiserum of pathotype I and the antigen of pathotype II, and vice versa (see table). These results were confirmed by gel-diffusion tests.

In the gel-diffusion test with the antiserum of pathotype I, one to four precipitin bands were formed with nonheated antigenic preparations of pathotype I isolates collected at different sites; no band was formed against pathotype II antigen. With heated antigenic preparations, a thick precipitin band was formed near the antigenic well and two fast-moving precipitin lines formed near the antiserum well, except with the antigen of pathotype II (see figure).

These results indicate that pathotypes I and II are serologically distinct in their antigenic components. ☐

Agglutination titers of antisera of pathotype I and II isolates. Andhra Pradesh, India.

Group	Antiserum	Antigens	
		H.561	H.501
Pathotype I	H.561	1:5120	–
Pathotype II	H.501	–	1:2560



Serological reactions of heated (B) and nonheated (A) antigens of *X. c.* pv. *oryzae* isolates tested against pathotype I antiserum. The central well contained pathotype I antiserum. The outer well had non-heated (top) or heated (bottom) isolates of Punjab (1), West Bengal (2), Orissa (3), and Bihar (4, 5, and 6).

TM4309: A blast (Bl)-resistant, short-duration rice

A. Thyagarajan, K. Nilakantapillai, and T. B. Ranganathan, Rice Research Station, Tirur 602025, India

TM4309, a short-duration, high-yielding, Bl-resistant, fine rice selection from the pedigree of BAM3/ IR50, was selected to replace Bl-susceptible IR50 in rabi season (Jan seeding). In dry (rabi) and early wet (kharif) seasons 1986-88, TM4309 had a yield average of 5.0 t/ ha (see table). The lower yield of IR50 (3.9 t/ ha) was due to severe damage by Bl. ☐

TM4309 performance under Bl stress at Tirur, India, 1986-89.

Season	Duration (d)	IR50			TM4309		
		Yield (t/ha)	Bl rating		Yield (t/ha)	Bl rating	
			Score[a]	Reaction[b]		Score[a]	Reaction[b]
Kharif 1986-87	105	2.9	9	S	4.1	1	R
Rabi 1986-87	105	3.6	9	S	4.9	2	R
Kharif 1987-88	110	5.6	5	MS	6.5	1	R
Rabi 1987-88	115	3.0	7	S	4.7	1	R
Kharif 1988-89	105	4.2	–	–	4.8	–	–
Mean	108	3.9	7.5	S	5.0	1.3	R

[a] Standard evaluation system for rice. [b] R = resistant, S = susceptible, MS = moderately susceptible.

Reaction to sheath blight (ShB) disease of new rice cultivars in Andhra Pradesh (A.P.)

H. S. N. Rao, M. T. S. Reddy, and N. Kulkarni, Agricultural Research Institute, Rajendranagar, Hyderabad 500030, A. P., India

We screened 38 rice cultivars developed at Agricultural Research Institute, Rajendranagar, Hyderabad — 18 short, 13 medium, and 7 long duration— against ShB caused by *Rhizoctonia solani* Kuhn. The cultivars and TN1 as susceptible check were grown in 1986 and 1987 monsoon seasons in a randomized complete block design with two replications.

Each entry was planted in 6-m^2 plots, at 15- × 15-cm spacing. At booting, individual hills were artificially inoculated by inserting pathogen grown on typha bits between the tillers, just above the water. Disease intensity was evaluated 30 d after inoculation.

Differences between years were significant (Table 1), indicating the importance of measuring resistance across years. Varietal differences and their interaction with year were also significant. The highest incidence was on susceptible TN1 both years (Table 2). RNR6250, RNR74802, and RNR1535 had the lowest ShB incidence.

Table 1. ANOVA for ShB incidence in new rice cultivars. 1986 and 1987 wet seasons, Andhra Pradesh, India.

Source	df.	MSS
Replications within location	1	0.268
Years	1	135.148**
Varieties	38	2.655**
Varieties × years	38	2.953**
Error	76	0.287

** = significant at 1% level.

RNR74802 (Sona/ Manoharsali) has long slender grains and RNR1535 (Tella Hamsa/ARC14302) has medium bold grains. They are now in minikit trials in A.P. □

Table 2. Average ShB scores, 1986 and 1987.

Cultivar	Disease score
RNR6250	4.3
RNR74802	4.5
RNR1535	4.8
RNR1-138-8-1	5.0
RNRl806	5.1
RNR18953	5.1
RNR98357	5.4
RNR9075	5.4
RNR133-87	5.4
RNR10244	5.5
RNR89128	5.6
RNR286	5.6
RNR3070	5.7
RNR9062	5.8
RNR99372	5.9
RNR1-111-63	5.9
RNR82096	6.0
RNR5 204	6.0
RNR15-97-36	6.0
RNR52147	6.1
RNR32341	6.1
RNR6827	6.2
RNR16210	6.5
RNR99514	6.6
RNR17085	6.7
RNR9139	6.8
RNR15-84-11	6.8
RNR769	6.8
RNR18586	6.8
RNR99378	6.8
RNR10212	6.9
RNR10208	6.9
RNR99180	7.1
RNR18545	7.1
RNR17-1864	7.1
RNR18864	7.1
RNR527	7.1
RNR16050	7.2
TN1 (check)	7.2
SE (m) ±	0.4

Field evaluation for resistance to rice grassy stunt virus (GSV)

R. Devika, S. Leenakumary, N. R. Bai, and C. A. Joseph, Rice Research Station, Kerala Agricultural University, Moncompu, India

Severe yellowing and stunting affected rice in the Kuttanad area of Kerala, India, during 1988 kharif (Aug-Sep to Oct-Nov). Serological tests at the Directorate of Rice Research, Hyderabad, confirmed the presence of GSV strain 2 (GSV-2).

We screened 7 varieties, 8 prerelease cultivars from 3 crosses, and 70 promising cultivars from 16 crosses for resistance to GSV-2 in the field.

None of the seven varieties showed resistance (see table). Of the eight prerelease cultivars, only KAU168 (ARC6650/ Jaya) showed moderate resistance.

Twelve cultivars from the crosses MO 5/ Improved Sona, MO 4/ Culture 25331, Culture 1954/Jyothi, Jyothi/Culture 2533 1, Vykatharyan/MO 6, Thonnooran/IR8, and Thonnooran/MO 6 showed moderate resistance. □

Varietal resistance to GSV strain 2. Kerala, India, 1988 kharif.

Variety or culture	Parentage	GSV-2 damage[a] (0-9)	Grain yield (t/ha)
MO 4 (Bhadra)		5	0.2
MO 5 (Asha (R))		5	1.0
MO 6 (Pavizham)		4	2.3
MO 7 (Karthika)		4	1.3
Jyothi		4	1.4
Mahaveera		4	0.9
Jaya		4	0.8
KAU93	Jaya/Ptb 33	4	1.1
KAU126	Jaya/Ptb 33	4	1.8
KAU129	Jaya/Ptb 33	4	1.6
KAU153-1	IR1561/Ptb 33	4	1.4
KAU168	ARC6650/Jaya	2	4.4
KAU170	ARC6650/Jaya	4	1.8
KAU200	IR1561/Ptb 33	4	2.0
KAU204	IR1561/Ptb 33	4	1.3
M28-1-1	MO 5/lmproved Sona	3	1.4
M38-2-1-1	MO 4/Culture 25331	3	2.1
M38-2-1-2	MO 4/Culture 25331	3	1.3
M38-4-1	MO 4/Culture 25331	3	1.9
M38-8-2	MO 4/Culture 25331	3	3.1
M39-3-1	Culture 1954/Jyothi	3	1.7
M40-5-2	Jyothi/Culture 25331	3	1.5
M41-16-2	Vykatharyan/MO 6	3	2.1
M48-11-1	Thonnooran/IR8	3	1.4
M48-11-2	Thonnooran/IR8	3	1.9
M48-11-3	Thonnooran/IR8	3	2.9
M49-2-3	Thonnooran/MO 6	3	1.6

[a]*Standard evaluation system for rice.*

Resistance of TKM6 and IR20 to rice tungro spherical virus (RTSV)

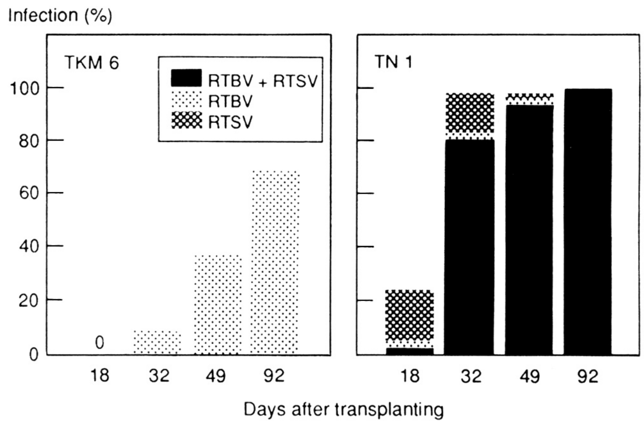
R. C. Cabunagan, E. R. Tiongco, Z. M. Flores, and H. Hibino, IRRI

In the greenhouse, TKM6 and IR lines with TKM6 in their parentage show high levels of resistance to RTSV infection, but are susceptible to rice tungro bacilliform virus (RTBV) infection. Field trials at the IRRI farm confirm the resistance of TKM6 and IR20 to RTSV.

In 1987 wet season (WS), TKM6 and TN1 planted in 25- × 50-m plots at 20- × 20-cm spacing were subjected to natural infection. Leaf samples were collected at 18, 32, 49, and 92 d after transplanting (DT) from a sample of 36 hills. Each plot had 10 sampling units arranged in a W-pattern.

In 1988 WS, IR20 (IR262-24-3/TKM6) was planted in 21- × 21-m plots at 20- × 20-cm spacing. Leaf samples were collected from a sample of 9 hills at 14, 28, 42, and 55 DT. The 46 sampling units/plot were arranged in a quincuncial pattern. Leaf samples were

RTBV and RTSV incidence on TKM6 and TN1 at different days after transplanting. IRRI, 1987 WS.



Infectivity on TN1 seedlings of GLH collected 44 DT from field plots planted to IR20 and TN1. IRRI, 1988 WS.

Source of GLH	GLH tested (no.)	GLH transmitted (%)		
		RTBV+RTSV	RTBV	RTSV
IR20	129	0.01	0.01	0
TN1	132	42	13	2

indexed by ELISA for the presence of RTBV and RTSV.

In 1987, at 92 DT (when TN1 had 100% infection with both RTBV and RTSV), TKM6 had 69% infection with RTBV only (see figure). In the 1988 trial, when tungro incidence was relatively lower, RTBV incidence on IR20 was 0.6% at 14 DT and increased to 2.6% at 55 DT. Very low infection with both RTBV and RTSV and no infection with RTSV alone were recorded.

Infectivity test of green leafhopper (GLH) collected at 44 DT from IR20 plots yielded a low percentage of infective leafhoppers; GLH collected from an adjacent field planted to TN1 with 30% tungro incidence had high infectivity (see table).

Because transmission of RTBV by GLH depends on the presence of RTSV, RTBV incidence will not increase remarkably nor become RTBV + RTSV if the population of RTSV-infected or RTBV + RTSV-infected plants is very low. □

Bacterial blight (BB) resistance in some Nepal rice cultivars

T. B. Adhikari and T. W. Mew, Plant Pathology Department, IRRI

We evaluated nine traditional and two improved rices reported resistant to BB in Nepal in the greenhouse at IRRI against Philippine races of *Xanthomonas campestris* pv. *oryzae.* Plants were clip-inoculated at maximum tillering with inoculum (10^8 CFU/ ml) from each race group. Lesion development was measured on 10 randomly inoculated leaves of each cultivar 14 d after inoculation.

Reaction to the races varied significantly among cultivars (see table). Rato anadi was highly resistant to races 2 and 5, Saeto anadi was resistant only to race 5. Laxmi was moderately resistant to races 1, 4, and 5. In general, the Nepalese rices had low levels of resistance to the Philippine races of *X. c* pv. *oryzae.* □

Reaction of some Nepalese rice cultivars to 6 Philippine races of *X. campestris* pv. *oryzae.* IRRI, 1989.

Cultivar	Lesion length[a] (cm)						
	1 (PXO61)	2 (PXO86)	3 (PXO79)	4 (PXO71)	5 (PXO112)	6 (PXO99)	Mean
Ghaiya	5.14 c	10.40 bc	7.21 c	19.41 b	6.42 c	35.65 a	14.04 bc
Saeto anadi	27.48 a	26.54 ab	16.70 b	23.57 ab	1.35 c	25.21 ab	20.14 a
Rato anadi	18.06 bc	1.24 d	12.61 c	23.03 ab	1.08 d	28.87 a	14.15 bc
Choto marshi	21.89 a-c	11.87 c	12.91 bc	22.93 ab	17.56 bc	30.15 a	19.55 a
Ramdulari	18.68 b	20.88 ab	12.99 b	18.90 b	14.11 b	30.45 a	19.34 a
Malbhog	12.27 b	9.04 b	8.89 b	10.79 b	12.70 b	28.68 a	13.73 bc
Gadar	12.69 bc	22.42 a	8.74 c	8.48 c	21.67 b	32.93 a	17.82 ab
Sataraj	14.63 ab	11.67 ab	7.40 b	18.17 a	14.77 ab	18.55 a	14.20 bc
Jaswa	16.31 bc	25.18 ab	16.51 bc	13.67 c	13.25 c	28.95 a	18.98 a
Janaki[b]	10.07 b	20.72 a	8.66 b	8.76 b	5.53 b	11.84 ab	10.93 c
Laxmi[b]	4.86 b	18.13 a	9.94 ab	6.62 b	4.10 b	17.62 a	10.21 c
TN1	22.56 b	21.24 b	17.02 b	23.91 ab	7.04 c	32.89 a	20.78 a
Mean	15.39 bc	16.61 b	11.63 cd	16.52 b	9.96 d	26.81 a	16.15

[a]Disease was assessed by lesion length: 0.0-3.0 cm = resistant, 3.1-7 cm = moderately resistant, 7.1-10.0 cm = moderately susceptible, 10.1 cm or longer = susceptible. In a row, means having a common letter are not significantly different at the 5% level by DMRT. [b]Improved cultivar.

Insect resistance

Screening rice varieties for damage caused by *Oebalus insularis* (Stål)

A. G. Yanis and E. A. Ruiz, Entomology Department, Rice Research Institute, Havana, Cuba

In 1985, insect pests and diseases affected about 50% of the rice area in Cuba. The pests that caused the greatest damage were water weevil and stink bug. *O. insularis* is the most plentiful and widespread bug species. Use of resistant varieties plays an important role in widely accepted integrated control.

During spring 1987, we evaluated commercial varieties IR880, J104, Amistad 82, and Blue Belle for *O. insularis* incidence. (Blue Belle is tolerant of rice stink bug *Oebulus pugnax* in the U.S.)

Five 1-m^2 plots were sown per variety. The agronomic practices were common to all treatments. Complete insect control was used from seeding to the milk stage. In the milk stage, varieties were infested at two levels, 0 (check) and 0.3 insect/panicle in 0.16-m^2 cages. Population levels were determined at 3-d intervals and additional releases were made to maintain the insect levels to 12 d after infestation. When the milk stage ended, insects were eliminated with insecticide.

Table 1 shows the results from evaluating stylet sheath identified with acid fuschin solution on randomly selected panicles. IR880 showed the highest insect incidence and Blue Belle the lowest. There was no significant difference in average punctures/panicle and average punctures/grain.

We found a trend in number of stylet sheath, in ascending order from Blue Belle, Amistad 82, J104, and IR880: apparently a certain tolerance exists.

We also compared yields in cages with and without insects (Table 2). Percentage of infestation did not differ significantly between varieties. □

Table 1. Feeding rate of *Oebalus insularis* (Stal) on 4 rice varieties. Havana, Cuba, 1985.

Variety	Stylet sheaths	
	no./panicle	no./grain
J104	27.98	0.30
Amistad 82	28.28	0.31
IR880	40.84	0.44
Blue Belle	24.14	0.29

Table 2. Effect on rice yield of four varieties of damage caused by *Oebalus insularis.*

Variety	Yield (t/ha)		Infestation (%)
	0 insect /panicle (check)	0.3 insect/ panicle	
J104	6.5	5.2	20.4
Amistad 82	7.4	5.9	20.1
IR880	5.1	3.9	24.2
Blue Belle	5.6	4.7	16.0

Reactions of gall midge (GM)-resistant rice accessions to yellow stem borer (YSB), leaffolder (LF), and rice blast (Bl)

M. Muthuswami and K. Gunathilagaraj, Agricultural Entomology Department, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai 625104, India

We evaluated 794 rice accessions for resistance to GM *Orseolia oryzae* (Wood-Mason) in two field trials and identified 205 new sources of resistance. Of these, 24 were tested against YSB *Scirpophaga incertulas* (Walker), LF *Cnaphalocrocis medinalis* (Guenée), and leaf Bl caused by *Pyricularia oryzae* Cav. CO 37 and IR50 were the susceptible checks.

Almost all GM-resistant accessions were either resistant or moderately resistant to YSB. IET9576 exhibited high resistance (see table). IET10251 and ARC10847 were resistant to LF. RP2238-112-38-57 was free of B1 and RP160741-3, RP2311-225-229, IET10251, RP2362-16-5-1, RP2432-102-11-6, and IET9552 were resistant (see table). Only IET10251 was resistant to both insects and Bl. □

Reaction[a] of GM-resistant rice accessions to YSB, LF, and Bl. Madurai, India.

Accession	YSB		LF		Blast damage rating
	Deadheart (%)	Damage score	Leaf damage (%)	Damage score	
RP1607-401-3	9.1	1	45.2	7	1
RP2199-16-2-2-1	2.8	1	30.3	5	5
RP2199-102-14-19-10	8.0	1	49.6	7	5
RP2235-136-65-10	3.5	1	69.9	9	6
RP2238-62-38-72	7.1	1	70.5	9	5
RP2238-112-38-57	8.4	1	47.7	7	0
RP2311-225-229	8.5	1	44.9	7	1
RP2311-35748	12.8	1	77.0	9	3
RP2362-16-5-1	12.2	1	79.6	9	2
RP2432-102-11-6	11.3	1	67.5	9	2
RP2432-111-1-3	8.3	1	48.6	7	3
IET9552	6.7	1	71.5	9	2
IET9576	0.0	0	54.4	9	5
IET9698	5.3	1	62.7	9	5
IET10251	4.7	1	8.3	1	1
Nagrasal	9.0	1	12.9	3	3
W1263	3.8	1	17.7	3	4
ARC595 1	2.3	1	26.3	5	5
Phalguna	12.5	1	71.9	9	5
ARC10847	13.6	1	9.2	1	4
S2204	11.1	1	30.7	5	3
ARC5823	18.6	1	36.7	7	4
Balam	10.2	1	19.4	3	3
Banglei	13.7	1	13.4	3	3
CO 37	21.3	3	80.0	9	4
IR50	22.2	3	77.0	9	9

[a]*Standard evaluation system for rice.*

Difference of resistance to rice stem borer (SB) in indica and japonica rices

Gu Zhen-yuan, Xiao Ying-fang, and Wang Yi-min, Institute of Plant Protection, Jiangsu Academy of Agricultural Sciences, Nanjing, China

We evaluated 47 commercial rice varieties (9 conventional indica varieties, 25 conventional japonica varieties, 7 hybrid indica varieties, and 6 hybrid japonica varieties) for resistance to rice SB *Chilo suppressalis* Walker in 1986 and 1987. IR40 and Shanyou 63 were the resistant and susceptible checks.

Entries were sown on 10 Apr and transplanted on 10 May, at 13- × 13-cm spacing, 10 hills/row, 2 rows/variety, with three replications.

In late May, all plots were infested with 50 first-instar larvae/ replication. Deadhearts were observed 1 mo after infestation.

Resistance to SB significantly differed between indica and japonica varieties. Indica varieties were more susceptible than japonicas. Of 31 japonica varieties, 79122 and Wu Fan-keng were moderately resistant, 21 varieties were tolerant, and 8 were moderately susceptible. All 16 indica varieties were moderately susceptible or susceptible. Differences in resistance between conventional varieties and hybrids were not significant.

At 40 d after infestation, average larvae survival, body length, and head width were 21%, 11.62 mm, and 0.94 mm, respectively, in japonicas and 45.34%, 13.52 mm, and 1.3 mm, respectively, in indicas. Lower larvae survival and shorter bodies are common characteristics on resistant varieties.

The diameter of the air cavity in the leaf sheath in moderately resistant 79122 (0.78 mm) was significantly smaller than that in susceptible Shanyou 63 (1.607 mm). The larger air cavity possibly favored larvae survival.

Amount of soluble sugar in the plant was 2.2-2.9% in moderately resistant varieties, and 3.83-4.83% in susceptible varieties. □

Resistance of rice germplasm to whitebacked planthopper (WBPH) in Changsha, China

Jiang Jian-yun, Peng Zhao-pu, Lei Hui-zhi, and Liu Gui-qiu, Plant Protection Institute, Hunan Academy of Agricultural Sciences, Changsha 410125, China

The WBPH *Sogatella furcifera* population on hybrid rice plants is usually higher than it is on conventional varieties. To find a source of WBPH resistance for hybrid rice breeding, we conducted seedbox screening tests of 1,777 rice accessions in the screenhouse 1986-88.

Pregerminated seeds were sown in 12-cm rows in 50- × 30- × 10-cm seedboxes. TN1 and N22 were the susceptible and resistant checks. At the 3- to 4-leaf stage, each seedling was infested with seven second- to third-instar nymphs by distributing insects uniformly on the seedbox. Plant damage was scored when susceptible check seedlings were about 90% dead.

Of 218 accessions showing resistance, 41 were resistant to both WBPH and BPH (see table). These lines and varieties can be used in breeding. The IR varieties that have also been identified as restorer lines for hybrid rice breeding will be used in that program. □

Lines and varieties resistant to WBPH and BPH in Changsha, China.

Line or variety	Scale [a]	
	WBPH	BPH
IR27280-39-2-2-3-2	0	1
IR29692-131-2-1-3	0	3
IR19661-3-2-2-3-1	0	3
IR21231-117-2-2	1	3
IR32420-130-1-3	1	3
IR28210-68-4-1-3-1	1	3
IR28251-85-1-2-3	1	3
IR25891-19-1-2	1	3
IR14497-15-2	1	3
IR19126-42-1	1	3
IR27208-102-3	1	3
IR28138-43-3-1-3-2	1	3
IR19672-195-2-2	1	3
IR21931-78-2-2	1	3
IR21817-50-2	1	3
IR18348-36-3-3	3	1
IR27300-124-2	3	1
IR24609-4-2-3-1	3	1
IR13525-118-3-2-2-2	3	1
IR19661-150-1-2-3-2	3	3
IR10781-75-3-2-2	3	1
IR13149-19-1	3	1
IR31802-56-4-3-3	3	3
IR31805-20-1-3-3	3	3
IR17494-32-1-1-3-2	3	3
Wnachyukuo	3	3
Bhusarisali Paddy	3	3
Fu 26-23	1	3
Pei hua Xuan-4	3	1

[a] *Standard evaluation system for rice.*

Molecular distillation of rice plants resistant and susceptible to whitebacked planthopper (WBPH)

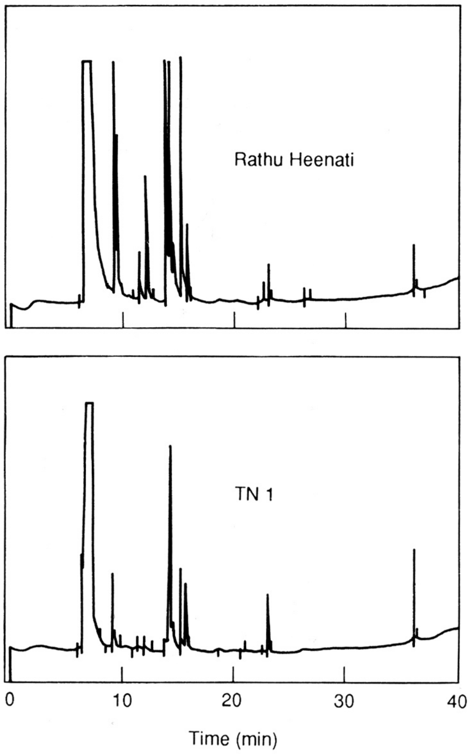
G. Liu, Agricultural and Environmental Department (AED), University of Newcastle upon Tyne; P. Caballero, Cereal Chemistry Department, IRRI; R. C. Saxena, Entomology Department, IRRI; B. O. Juliano, Cereal Chemistry Department, IRRI; and R. M. Wilkins, AED, University of Newcastle upon Tyne, Newcastle upon Tyne NE1 7RU, UK

Attractants in susceptible rice plants and repellents in resistant plants play an important role in an insect's selection of host and establishment. We evaluated volatiles in molecular distillate extracts from WBPH-resistant Rathu Heenati and susceptible TN1 rice plants, using gas chromatography (GC).

Leaves and leaf sheaths of 7-wk-old plants were cut into 5-cm-long pieces and 100 g placed in a 500-ml glass container, with 3 replications/variety. The container was connected to one end of a 10-cm-long U tube. The other end was connected to a glass thimble, to collect distillate. A high vacuum valve was connected 5 cm above the thimble.

The sample container was immersed into a Dewar flask containing dry ice (acetone) for 20 min. The system was connected to a high vacuum line and air evacuated until the pressure inside the container reached 10^{-3} mm Hg. Then the high vacuum valve was closed, the Dewar flask transferred to the extract collector, and the apparatus left to equilibrate at room temperature for 24 h.

GC analysis was performed on a Varian 3700 GC equipped with a wide bore 60 m × 0.75 mm SPB-1 column. N was the carrier gas, at a flow rate of 3 ml/min. Injector and detector temperatures were set at 170 °C and heated to 250 °C, respectively. Oven temperature was programmed to increase from 50 °C for 2 min to



Gas chromatograms of molecular extracts from WBPH-resistant Rathu Heenati and susceptible TN1 rice plants. IRRI, 1988.

250 °C, at 5 °C per min. One μl of the extracts was used for analysis on the splitless mode.

The figure shows qualitative and quantitative differences between molecular distillate extracts of resistant Rathu Heenati and susceptible TN1. This may reflect different volatile composition of the odors produced by rice plants that influence the insect in-locating its host plant. □

Ptb 10 — a promising donor of gall midge (GM) resistance

P. S. Reddy, M. A. Khader, I. N. Rao, and R. Radhakrishna, Andhra Pradesh (A. P.) Agricultural University, Agricultural College and Research Station, Ragolu 532484, Srikakulam District, A. P., India

During the 1986 rainy season a severe epidemic of GM in Srikakulam District destroyed resistant varieties Phalguna and Surekha (derivatives of Siam 29). Grain yield losses were estimated at 50-90%. We evaluated certain potential new donors of resistance to the GM population of the district during 1988 rainy season at Panukuvalasa, a hot spot location.

Seven proven donors and two derivatives of Siam 29 were planted in six rows of 16 hills each at 15- × 15-cm spacing. GM incidence was recorded at 30 and 50 d after transplanting (DT) on hills and tillers from 20 preselected hills/entry.

Among the Ptb series, only Ptb 10 had no silvershoots (SS) (see table). The three other donors had 20-40% SS/hill at 50 DT.

Phalguna and Surekha, the predominant varieties of the north coastal district of A.P., had 95-100% SS/hill and 41-49%/ tiller at 50 DT. Susceptible check Jaya had 90 and 33%, respectively. Proven donors Siam 29 and Leuang 152 had 100% GM/hill and 24-30%/ tiller.

These results show the need to reorient the breeding programs for GM resistance, using Ptb 10 as one of the donors. □

Reaction of donors and derivatives to GM. A.P., India, 1988.

Designation	Parentage	GM incidence[a] (% SS)			
		30 DT		50 DT	
		HB	TB	HB	TB
Ptb 10	Donor	Nil	Nil	Nil	Nil
Ptb 18	Donor	20	1.45	20	2.07
Ptb 21	Donor	40	4.26	40	4.36
Ptb 33	Donor	20	2.18	20	3.67
Siam 29	Donor	45	4.93	100	24.52
Leuang 152	Donor	45	6.51	100	29.56
OB677	Donor	30	2.97	30	3.20
Phalguna	IR8/Siam 29	90	22.25	95	40.99
Surekha	IR8/Siam 29	65	7.31	100	49.07
Jaya (susceptible check)	TN1/IR8	70	9.16	90	32.69

[a]HB = hill basis, TB = tiller basis.

Excess water tolerance

Changes in shoot growth in response to partial submergence

S. Singh and D. P. Bhattacharjee, Central Rice Research Institute, Cuttack 753006, India

We tested tall and semitall rice varieties for growth and yield under normal and semideep water (55-60 cm) in a tank experiment during 1980 wet season (kharif). Seedlings (30-d-old) were transplanted in two tanks, with three replications. At 25 d after transplanting, one tank was flooded to 55-60 cm water depth, the other was kept at 5-10 cm. Plants were sampled at 20 and 45 d after submergence, flowering, and maturity.

At 20 d after submergence, 55-60 cm water reduced dry weight 23% and leaf area per tiller 58%. At flowering, they increased 41 and 26%, respectively (see table). Excess water significantly increased dry weight/ tiller at maturity. In almost all varieties, specific leaf weight (SLW) increased significantly at 20 d after submergence. Crop growth rate under 55-60 cm water was reduced by 50% 20-45 d after submergence, but increased during pre-anthesis (45 d after submergence to flowering) and post-anthesis (flowering to maturity).

Semitall Jagannath showed drastic reduction in shoot growth under 55-60 cm water, Janaki and CR1030 (tall) had maximum stability. □

Morphological changes in rice shoot due to excess water.[a] Cuttack, India, 1980 wet season.

Variety	Treatment	Dry weight/tiller (g)			Leaf area/tiller (cm^2)		Specific leaf wt (mg/cm^2)		Crop growth rate (g/m^2 per d)		
		20 DAS	Flowering	Maturity	20 DAS	Flowering	20 DAS	Flowering	20-45 DAS	45 DAS to flowering	Flowering to maturity
Janaki	Normal	0.76	2	4.30	75.3	41	2.70	7	5.6	11.6	4.0
	Submerged	0.72	3	4.43	52.8	101	5.43	6	5.8	12.8	4.2
CR1030	Normal	0.76	3	4.96	91.8	73	3.25	7	10.1	12.1	4.5
	Submerged	0.79	4	5.96	57.6	90	5.23	7	8.4	14.4	3.2
FR13-A	Normal	0.78	2	4.47	84.6	60	4.35	7	7.2	11.6	3.6
	Submerged	0.80	3	6.43	52.6	65	5.03	7	4.6	16.6	2.9
CN643	Normal	0.46	2	3.57	78.0	61	2.54	6	4.5	3.3	1.1
	Submerged	3.35	3	6.14	18.6	68	4.53	6	3.8	6.0	6.5
IET6205	Normal	0.73	2	5.67	96.3	56	2.93	7	8.8	6.9	3.6
	Submerged	0.53	4	7.20	45.8	94	4.56	8	7.7	12.5	5.8
IET6207	Normal	0.74	3	4.60	100.0	72	2.98	7	7.0	8.8	5.3
	Submerged	0.42	4	4.74	31.5	78	4.83	8	6.3	6.8	6.4
CR260-131	Normal	0.68	3	5.32	103.3	101	2.68	7	9.2	12.3	1.8
	Submerged	0.36	4	6.56	24.8	94	4.20	7	0.8	15.3	1.1
Mahsuri	Normal	0.59	1	3.33	81.4	40	2.60	6	10.6	1.4	9.9
	Submerged	0.64	4	3.73	52.2	90	4.90	7	1.1	11.0	8.1
IET6271	Normal	0.59	3	3.80	91.2	68	2.68	6	8.2	9.2	1.2
	Submerged	0.33	3	4.30	24.4	64	4.46	6	2.3	6.0	2.7
Jagannath	Normal	0.60	2	2.90	85.3	55	2.90	6	8.2	9.7	2.4
	Submerged	0.25	2	3.75	15.1	44	3.70	6	0.3	4.8	3.0
Mean	Normal	0.67	2	4.15	88.7	63	2.87	7	8.0	8.7	3.7
	Submerged	0.51	4	5.42	37.6	79	4.70	7	4.1	10.6	5.0
LSD (0.05)	Treatment	0.05	0.1	0.50	5.0	6	0.29	ns	1.2	1.4	1.0
	Variety	0.11	1.0	1.03	11.2	12	ns	1	2.7	3.2	1.5
	T×V	0.16	1.8	1.45	15.9	18	ns	ns	ns	4.5	ns

[a]DAS = days after submergence.

Adverse soils tolerance

A rapid screening technique for salt tolerance in rice

M. Aslam and R. H. Qureshi, Soil science Department, University of Agriculture, Faisalabad, Pakistan

We screened 34 rice varieties for salt tolerance at germination and at the seedling stage. The effects of level of salinity and stage of salinization on rice growth were studied separately.

For seedling stage screening, 14-d-old seedlings were transplanted to Yoshida nutrient solution salinized incrementally with NaCl to concentrations of 0, 50, 100, 150, and 200 mol for 2 wk. Fresh and dry weight and percentage mortality were the criteria for assessing tolerance. The experiment was repeated with 16 varieties and with 7 varieties selected out of the 16.

Results of the solution culture studies were compared with those of soil culture in pots (nine varieties). The solution culture technique was fairly reliable; the patterns of salt tolerance in various varieties, especially for the most tolerant and most sensitive, were the same in pot culture and in the field (see table).

Fresh and dry shoot weights were compared after 2 wk in solution. The

Salt tolerance of rice varieties at different growth stages.[a] Faisalabad, Pakistan.

Variety or line	Salt-tolerance rating						
	Germination	Seedling stage[b] experiment			Maturity[c]		Final
		I	II	III	Pot trial	Field trial	
Basmati 370	MS	S	S	S	S	S	S
Basmati 198	MS	MS	MS	MS	MT	S	MS
NIAB6	T	T	T	T	T	T	T
IR6	T	MT	MT	T	MT	T	T
KS282	T	MT	MS	MT	MT	T	T
BG402-4	MT	T	T	MT	S	S	MS
IR1561	S	S	S	S	S	S	S

[a]Tolerance class: S = sensitive, MS = moderately sensitive, MT = moderately tolerant, T = tolerant
[b]Fresh and dry shoot weight and % maturity. [c]Yield basis.

solution technique had a significant correlation among the three experiments, showing high consistency and reproducibility of the technique.

Similarity with the results with pot culture and close association with field results (where absolute yields were the indices of salt tolerance) show the practical validity of this technique.

The technique is simple, quick, and reliable for screening a large number of genotypes. □

Relationship of rice embryo weight and salinity tolerance at seedling stage

M. Akbar, B. Mishra, and M. P. Pandey, IRRI

We screened 19 indica and 6 japonica cultivars with varying embryo weights for salt tolerance, using water culture in the IRRI phytotron glasshouse (29/21 °C (day/ night) temperature, 70% relative humidity, natural daylight). Salinity stress of 6800 ppm (EC 12 dS/m) was introduced by adding 1:1 mixture of NaCl and $CaCl_2$ to the nutrient solution. Seedling survival after 2 wk salinization was taken as the criterion for salt tolerance.

Embryo weight/50 seeds ranged from 0.0140 g (Intan Gawri and Palman 46) to 0.0467 g (Rikuto Norin 15). Seedling survival under salinity stress ranged from 2 (Palman 46) to 90 (IR51491-AC4-6).

Among the cultivars studied, the association between embryo weight and salt tolerance was not significant (r = 0.2151) (see table). This finding does not support earlier reports of such an association. □

Correlation ($r = 0.2151^{ns}$) between embryo weight and seedling survival after 14 d salinization (EC = 12 dS/m). IRRI, 1989.

Cultivar	Embryo weight (g)	Survival (%)
Rikuto Norin 15	0.0467	7
Bombilla	0.0454	36
Chang You Zae Rae	0.0450	10
Thatnosubnet	0.0440	12
Jinbu 4	0.0393	45
Pokkali	0.0386	85
Nona Bokra	0.0358	89
IR51491-AC4-6	0.0309	90
IR31779-19-3-3-2-2	0.0302	10
RNR1429	0.0299	18
IR51491-AC4-7	0.0297	82
IR51500-AC9-8	0.0272	32
TNAU (AD) 103	0.0263	8
MI-48	0.0245	2
Khao youth	0.0237	22
IR25924-92-1-3	0.0236	5
Laxmi	0.0227	8
IR28	0.0226	20
Suweon 341	0.0219	70
IR36	0.0209	42
NIAB6	0.0208	25
Duansan	0.0202	18
Basmati 370	0.0195	20
Intan Gawri	0.0140	8
Palman 46	0.0140	2

Ion transport in two rice varieties grown under saline conditions

M. Aslam and R. H. Qureshi, Soil Science Department, University of Agriculture, Faisalabad, Pakistan

Resistance to salt entry into the shoot is often related to survival and growth of plant species. We studied the transport of Na^+, K^+, and Cl^- from root to shoot in two rice varieties with different salt tolerances.

NIAB6 (salt tolerant) and IR1561 (salt sensitive) were transplanted at 14 d after seeding into Yoshida nutrient solution. Two salinity levels (0 and 100 mol NaCl) were used. Samples were taken at 7, 14, and 28 d after salinization. Cell sap of whole shoot and root was analyzed and rate of ion transport calculated as

$$J = (M_2 - M_1) / (\overline{WR} \times \Delta T)$$

where M_1 and M_2 are amounts of ion in samples 1 and 2, respectively; $\overline{WR}$ is the log mean root fresh weight (g); and T is difference between harvests, in days.

Rate of Na^+ transport from root to shoot increased with salinity during both growth periods, but was higher 14 d after salinization (see table). IR1561 had four times higher Na^+ transport rate (J_{Na^+}) than NIAB6.

J_{K^+} decreased considerably from 14 to 28 d under no salinity and under 100 mol salinity. At 100 mol salinity, the drop in K^+ transport (J_{K^+}) in salt-sensitive IR1561 was spectacular.

Rate of ion transport from root to shoot in 2 rice varieties under 2 salinity levels (0 [control] and 100 mol NaCl). Faisalabad, Pakistan.

Variety	7-14 d		14-28 d	
	0 (control)	100	0 (control)	100
Rate of Na^+ transport (µmol/g dry wt per d)				
NIAB6	6.0	26.1	2.2	23.7
IR1561	9.2	106.1	1.7	17.9
Rate of K^+ transport (µmol/g dry wt per d)				
NIAB6	235.4	98.7	80.2	45.3
IR1561	325.4	193.2	78.1	5.9
Rate of Cl^- transport (µmol/g dry wt per d)				
NIAB6	30.1	76.6	15.3	26.8
IR1561	37.1	170.2	16.4	33.9

IR1561 had higher J_{K^+} during early stress, but could not maintain the rate of K^+ transport.

J_{cl^-} was also much lower for NIAB6 than for IR1561, particularly during the first growth period. It decreased substantially during the second growth period, although it was still higher for IR1561 than for NIAB6. Lower J_{cl^-} for NIAB6 at high salinity at 14 and 28 d after treatment indicates it has a better Cl^- exclusion mechanism.

Zinc:phosphorus ratio — a criterion for salt tolerance in rice

M. Aslam and R. H. Qureshi, Soil Science Department, University of Agriculture, Faisalabad, Pakistan

Different physiological parameters (potassium selectivity [K:Na ratio], exclusion/ inclusion of Na^+ and Cl^- in

Effect of salinity levels (0 [control] and 100 mol NaCl) (3 wk stress) on Zn and P concentrations in shoot and root of 4 rice varieties and lines.[a] Faisalabad, Pakistan.

Variety or line	Fresh wt (g/plant)		Zn^{2+} (mg/kg dry wt)		P (%)		Zn^{2+}:P	
	0	100	0	100	0	100	0	100
				Shoot				
Basmati 370	19.25 a	3.99 c (21)	32.7 d	43.3 b-d	0.224 e	0.281 b	1.46×10^{-2}	1.54×10^{-2}
NIAB6	19.91 a	7.81 b (39)	41.0 cd	71.3 a	0.163 g	0.231 d	2.51×10^{-2}	3.09×10^{-2}
BG402-4	16.52 a	5.94 bc (36)	37.7 d	50.7 b	0.216 f	0.267 c	1.75×10^{-2}	1.90×10^{-2}
IR1561	19.50 a	2.96 d (15)	43.3 b-d	51.3 bc	0.231 d	0.287 a	1.87×10^{-2}	1.79×10^{-2}
Mean	18.80 A	5.18 B	38.7 B	54.7 A	0.208 B	0.266 A	1.64×10^{-2}	2.68×10^{-2}
				Root				
Basmati 370	21.12 ab	5.98 d (28)	43.3 b	43.3 b	0.131 d	0.157 b	3.30×10^{-2}	2.76×10^{-2}
NIAB6	19.69 ab	9.46 c (48)	58.7 a	62.3 a	0.127 d	0.157 b	4.62×10^{-2}	3.97×10^{-2}
BG402-4	18.82 b	10.13 c (54)	56.0 a	56.7 a	0.131 c	0.152 a	4.27×10^{-2}	3.73×10^{-2}
IR1561	23.12 a	4.10 d (18)	59.7 a	55.0 a	0.141 c	0.195 a	4.23×10^{-2}	2.82×10^{-2}
Mean	20.55 A	7.42 B	54.4 A	53.3 A	0.132 B	0.165 A	4.10×10^{-2}	3.32×10^{-2}

[a]Means with different letters differ significantly by DMRT (P = 0.05). The Zn^{2+}: P ratio is calculated when the concentration of Zn and P is in percent. Values in the parentheses represent percentages of respective controls.

various plant tissues, ionic balance, osmotic adjustment, etc.) are related to a plant's salt tolerance. Many workers have used these physiological traits to screen rice genotypes for salt tolerance. We determined the effect of external salinity on Zn and P concentrations in shoot and root. Seedlings of four rice varieties were transferred at 14 d to foam-plugged holes (1 cm diam) in thermopal sheets floating on Yoshida nutrient solution at two salinity levels: 0 and 100 mol NaCl in plastic tubs. Plants were harvested after 3 wk, separated into shoot and root, dried, and Zn and P contents determined.

Zn^{2+} concentration in the shoot increased significantly with external salinity of 100 mol NaCl; in the root, it was not affected by salt stress (see table). Zn concentration in the shoot of salt-tolerant NIAB6 was significantly higher than in the other varieties. Zn concentration in roots of NIAB6 was significantly higher than that of Basmati 370 (which had the lowest Zn^{2+} concentration in shoot and root).

Salt-sensitive IR1561 had significantly higher P concentration in shoot and root than all other varieties; salt-tolerant NIAB6 had significantly lower shoot P concentration than all other varieties.

Zn:P ratios in shoot and root were highest in NIAB6 and lowest in Basma 370 with and without salt stress. These ratios were also low in IR1561. □

Integrated germplasm improvement

Two modern photoperiod-sensitive rice varieties for Bangladesh

M. A. Kabir and N. M. Miah, Plant Breeding Division, Bangladesh Rice Research Institute (BRRI), Gazipur 1701, Bangladesh

BRRI recently released modern photoperiod-sensitive varieties BR22 and BR23 for T. aman season in Bangladesh.

BR22 was developed from Nizersail/BR51-46-5; BR23 was derived from DA29/ BR4. Both varieties are suitable for late planting in T. aman. Yield potential and disease reactions are comparable to those of existing modern varieties, but the new varieties yield more than 1 t higher in late plantings (see table).

Grain yield and plant height of 2 new varieties for Bangladesh.

Variety	Plant height (cm)	Yield[a] (t/ha)	
		1st planting	2d planting
BR22	115	4.4	3.4
BR23	120	4.6	3.7
BR11 (check)	110	3.8	1.3
Nizersail (local check)	132	3.1	2.6

[a]Average of 3 yr at 4 regional stations.
1st planting: 4-15 Aug with 30-d-old seedlings, 2d planting: 15-22 Sep with 40-d-old seedlings.

BR22 has medium bold grain with intermediate amylose content and moderate resistance to tungro (RTV), bacterial leaf blight, sheath rot, sheath blight (ShB), and blast.

BR23 has long slender grain with intermediate amylose content and moderate resistance to RTV, stem rot, ShB, and submergence tolerance. □

RAU4045-2A — a very short duration cultivar for harsh upland environments

S. C. Prasad, Plant Breeding and Genetics Department, Birsa Agricultural University, Kanke, Ranchi; and J. B. Tomar, NBPGR Regional Station, Ranchi, India

RAU4045-2A (IET9790), a semidwarf variety derived from Fine Gora/ IET2832, has resistance to brown spot and grain discoloration and

Table 1. Yield of RAU4045-2A (IET9790) in the All India Coordinated Rice Improvement Project during 1985 and 1986.

Variety	1985 yield (t/ha)							1986 yield (t/ha)					
	Titabar	Hazaribagh	Kanke	Faizabad	Coimbatore	Pondi-cherry	Mean	Chiplima	Arudha-tinagar	Kanke	Faizabad	Mean	Mean days to 50% flowering
RAU4045-2A	1.6	3.7	3.5	3.5	5.0	4.4	3.6	1.7	2.5	4.3	3.6	3.0	59
Akashi (national check)	1.2	2.2	2.7	3.2	5.0	4.0	3.0	1.2	2.4	3.2	3.5	2.6	68
Cauvery	1.3	1.8	1.7	2.6	4.8	3.9	2.7	0.6	2.4	1.5	1.9	1.6	70
Local check	–	1.3 (Brown Gora)	1.9 (Brown Gora)	2.7	5.0	4.2	2.5	1.3	2.0	1.9	3.2	2.1	71
LSD (0.05)								0.7	0.7	0.7	0.5		

moderate resistance to bacterial blight and blast. It has a very short duration (80-85 d) and early vegetative vigor. It can survive a drought at the vegetative stage and is highly suited to drought-prone upland areas.

It has up to 125 grains/panicle and 1,000-grain weight is 23 g. Grain is short bold with high hulling (76%), milling (72%), and head rice recovery (63%). It has intermediate gelatinization temperature and gel consistency.

Mean yields of RAU4045-2A in regional experiments 1983-86 were 3.5 t/ha compared to Akashi, 2.4 t/ha, and Brown Gora, 2.1 t/ha.

In 1983-85 dryland testing, it yielded an average 2.5 t/ha against checks Bala (2.3 t/ha), Brown Gora (2.3 t/ha), and Kiran (1.9 t/ha). In All India Coordinated Rice Improvement Project experiments 1985, it yielded 3.6 t/ha over six locations, better than three other varieties; in 1986, it outyielded three other varieties, with a mean yield of 3.0 t/ha over four locations (Table 1).

Table 2. Average yields of RAU4045-2A in minikit testing in plateau region of Bihar, 1985-86.

District	Minikits (no.)	Average yield (t/ha)		Increase over Local Gora (%)
		RAU4045-2A	Local Gora	
Ranchi	61	1.6	1.3	23
Hazaribagh	45	2.1	1.7	24
Giridih	17	1.2	1.0	20
Palamau	28	1.5	1.2	25
Dhanbad	18	2.4	1.5	60
Total	169	1.8	1.3	31

In 1985-86 tests (169) RAU4045-2A, mean yield was 1.8 t/ha, compared to 1.34 t/ha for local Gora (Table 2). Mean yield in the International Rice Testing Program trials was 3.4 t/ha over 34 locations in 1982 and 3.5 t/ha over 56 locations in 1983. □

Sachiminori — a fine quality rice cultivar

Sheng Jinshan, Institute of Crop Germplasm Resources, Chinese Academy of Agricultural Sciences, China

Sachiminori, a japonica introduced from Japan in 1982, has very high tillering ability, panicles/plant, and spikelet fertility, 1,000-grain weight of 26 g, and yields 6-7 t/ha. Grain quality is fine, with acceptable flavor. Percentage of brown rice is 82 and milled rice, 72-76. Sachiminori is highly resistant to blast and tolerant of drought, and has wide adaptability. When grown under the same conditions, inputs for Sachiminori are lower, yield higher and more stable, and profit higher than those of most other cultivars.

In 1988, in the region that includes Beijing, Tianjing, and Hebei Provinces, more than 7,000 ha were planted to Sachiminori (renamed Xing Shi). In recent years, eight other provinces have introduced Xing Shi, changing the early season cultivar choice from the original hsien (indica) rices to keng (japonica) rices. □

Stored grain infestation by Angoumois grain moth (AGM) in resistant and susceptible rice varieties

K. N. Ragumoorthi and K. Gunathilagaraj, Agricultural Entomology Department, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai 625104, Tamil Nadu, lndia

We studied infestation by AGM *Sitotrogu cerealella* (Olivier) in the resistant CO 32 and susceptible CO 44 rice varieties in the insectary. Mylar film sheet cylinders (30 cm × 6 cm) were divided into 10 cross-sections, each 1 cm deep. Separate cylinders (in three replications) were filled with grains of CO 32 and CO 44 (number of grains in a section average 1,011). AGM eggs in a strip of cloth were placed in the center of the top layer of each cylinder. Infestation was sustained for 10 wk, during which two generations of AGM developed.

AGM larvae bored through the entire depth (10 cm) of susceptible CO 44; infestation depth was 7 cm in resistant CO 32 (see table). Infestation was higher in the first three sections, with maximum infestation in the top layer, for both varieties. Infestation at 10 cm of susceptible CO 44 was higher than that at 7 cm of resistant CO 32. □

Depth of infestation and percentage of grains damaged by AGM in resistant and susceptible rice varieties. Tamil Nadu, India.

Depth (cm)	Grain damage [a] (%) CO 32 (resistant)	CO 44 (susceptible)
1	32.7 (34.92) f	37.7 (37.91) e
2	2.9 (9.17) e	4.2 (11.92) d
3	1.7 (7.70) d	2.6 (9.01) c
4	0.9 (5.87) c	0.8 (5.32) b
5	0.4 (3.91) b	0.7 (5.07) b
6	0.2 (2.95) ab	0.3 (3.38) a
7	0.1 (2.56) ab	0.2 (3.09) a
8	0.0 (1.81) a	0.2 (2.89) a
9	0.0 (1.81) a	0.1 (2.70) a
10	0.0 (1.81) a	0.2 (2.89) a

[a] Mean of 3 replications. Figures in parentheses are arcsin percentage transformed values. In a column, values followed by a common letter do not differ significantly (P=0.05) by DMRT.

CROP AND RESOURCE MANAGEMENT

Soil microbiology and biological N fertilizer

Effect of nitrogen, phosphorus, and cropping method on azolla productivity

P. P. Joy, Regional Agricultural Research Station, Pattambi, Kerala; and G. V. Havanagi, University of Agricultural Sciences, Bangalore, India

We studied the effect of N, P, and method of azolla culture on azolla productivity in irrigated lowlands during 1983 wet season (Jun-Oct). Soil was sandy clay with pH 6.7; 286, 27, 341 kg available NPK/ ha.

The experiment was in a split-plot design with three replications. Main plots were combinations of 0, 50, and 100 kg N/ha and 0, 11, and 22 kg P/ha; subplots were three methods of growing azolla with transplanted rice: monocropping, intercropping, and dual cropping.

Jaya rice was transplanted at 20- × 10-cm spacing 18 Jul. Fresh *Azolla pinnata* R. Br. at 3 t/ ha was inoculated to monocrop and dual-crop plots 20 d before transplanting rice and to intercrop plots 1 d after transplanting.

Azolla was manually incorporated 2 times before transplanting in monocrop plots, 2 times after transplanting in intercrop plots, and 2 times each before and after transplanting in dual-crop plots. N as urea was applied in two equal splits, at transplanting and 30 d after transplanting; P as single superphosphate was applied basally; K as muriate of potash was applied basally at 42 kg K/ha to all plots.

Application of 50 kg N/ ha had no adverse effect on yield of fresh azolla, but application of 100 kg N/ha significantly reduced azolla yield in the dual-crop plots (Table 1, 2).

In dual cropping, remnant azolla that

Table 1. Effect of N, P, and method of cultivation on azolla.[a] Bangalore, India, 1983 wet season.

Treatment	Dry matter (%)	Nutrient content in dry matter (%) N	P	K	Yield (t/ha) Total	Per day	N contribution (kg N/ha) Total	Per day
N (kg/ha)								
0	6.8	2.2	0.2	1.2	24.9	0.8	36.1	1.1
50	6.8	2.2	0.2	1.1	24.1	0.8	34.6	1.1
100	6.8	2.2	0.2	1.1	21.8	0.7	33.1	1.1
LSD (P 0.05)	ns	ns	ns	ns	2.2	0.1	ns	ns
P (kg/ha)								
0	6.1	2.2	0.1	1.1	23.6	0.7	34.6	1.1
11	6.8	2.2	0.2	1.1	22.4	0.7	33.7	1.1
22	6.9	2.1	0.2	1.2	24.9	0.8	35.5	1.1
LSD (P 0.05)	0.10	ns	ns	ns	ns	ns	ns	ns
Monocropping	6.9	2.2	0.2	1.3	19.8	1.0	30.0	1.5
Intercropping	6.8	2.2	0.2	1.1	15.6	0.5	22.4	0.8
Dual cropping	6.8	2.1	0.2	1.0	35.4	0.7	51.4	1.0
LSD (P 0.05)	0.1	ns	0.0	0.1	1.4	0.0	3.4	0.1
LSD (P 0.01)	0.1	ns	ns	0.1	1.8	0.1	4.5	0.1
General mean	6.8	2.2	0.2	1.1	23.6	0.7	34.6	1.1

[a] ns = not significant.

had been mixed with fertilizer N during soil incorporation was retained as seed for further multiplication. In monocrop and intercrop plots, fresh azolla was inoculated. Adverse effects of more than 50 kg N/ ha would be reduced by minimizing mixing of fertilizer N and azolla or by seeding fresh azolla for further multiplication.

The poor response of azolla to applied P may be due to the high available P in the soil and its increased availability under flooded conditions.

Monocropping for 20 d and dual cropping for 50 d resulted in higher yields of fresh azolla, contributing more N/day, dry matter content, and K content of dry matter. Monocrop azolla did not experience any competition with rice. Intercrop azolla suffered considerable competition with rice for all growth factors, in particular light and nutrients. □

Table 2. Effect of N and cultivation method interaction on yield of fresh azolla, Bangalore, India, 1983 wet season.

N (kg/ha)	Total yield of fresh azolla (t/ha)			
	Monocropping	Intercropping	Dual cropping	Mean
0	21.0	16.0	37.8	24.9
50	19.8	15.4	37.1	24.1
100	18.5	15.6	31.5	21.8
Mean	19.8	15.6	35.4	23.6
LSD (P=0.05)	2.4[a]	3.0[b]		

[a]Between 2 methods of cultivation at same level of N. [b]Between 2 N levels in same cultivation method.

Physiology and plant nutrition

Effect of seedling age and leaf removal on rice grain and straw yields

N. R. Das and N. Mukherjee, Agronomy Department, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Kalyani 741235, Nadia, West Bengal, India

We studied the effect of age of seedling and removal of leaf on rice grain and straw yields during kharif 1988, at the Seed Farm (23.5° N, 89.0° E, and 9.75 mean sea level). Treatments were three seedling ages and four leaf removal levels, in a split-plot design with four replications.

Soil was clayey loam (0.61% organic C, 0.59% total N, 14 kg available P/ha, 208 kg available K/ha, and pH 6.8). Fertilizer was 40-50-50 kg NPK/ ha applied at plowing and 50 kg N/ ha applied 30 d after transplanting (DT). IR8 seedlings at 21, 28, and 35 d after seeding were transplanted 20 Jul at 25-× 15-cm spacing, four seedlings/ hill. Leaves were removed (0, 25, 50, and 100%) 1 mo after transplanting in 7.5-× 2.0-m subplots.

Seedling age did not significantly affect grain and straw yields. Grain and straw yields decreased with increased leaf removal (see table). □

Effect of seedling age and leaf removal on rice grain and straw yields of IR8. West Bengal, India, 1988.

Seedling age (d)	Yield (t/ha) No leaves removed		25% of leaves removed		50% of leaves removed		100% of leaves removed		Mean	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
21	4.8	5.0	3.6	4.0	3.6	4.0	2.8	3.6	3.7	4.1
28	4.4	4.7	4.4	5.0	4.0	4.5	3.8	4.7	4.2	4.7
35	4.5	4.9	3.7	4.2	3.2	3.5	3.1	3.3	3.6	4.0
Mean	4.6	4.8	3.9	4.4	3.6	4.0	3.2	3.9	–	–

LSD (0.05)
Leaf removal 0.7 grain
0.7 straw

Influence of potassium and kinetin on protein partitioning in rice

I. Sakeena and M. A. Salam, Kerala Agricultural University (KAU), Cropping Systems Research Centre (CSRC), Karamana 695002, Trivandrum, India

We examined protein partitioning in rice, using short-duration Triveni in a summer 1987 field experiment at Karamana (8.5° N, 77.9° E, and 29 m above sea level). Soil of the experimental field was sandy loam, pH 4.5, with 84.3, 13.6, 63.8 ppm available NPK.

Treatments, a factorial combination of four potassium levels (0, 14.5, 29.1, 58.1) and four kinetin spray treatments, are given in Table 1. The experiment was laid out in a randomized block design with three replications.

K as KCl was applied 50% basal and 50% at panicle initiation; 70 kg N and

15.4 kg P/ha were applied uniformly. The crop was raised following the KAU package of recommended practices.

Protein contents of leaf, sheath, culm, and panicle were analyzed by the improved Kjeldahl method (N × 6.25). Protein yield was worked out by multiplying protein content of a sample by sample dry weight, expressed in kg/ha. Protein content in source and sink was also worked out as percentage of total protein produced (Table 1, 2).

Protein content in leaf, sheath, and culm decreased with increased K up to 29.1 kg K/ha (Table 1). Protein yield increased with K level, a 106% increase in plants treated with 58 kg K/ha. Plants treated with 58 kg K/ha contained 71.6% of the total protein in the sink.

In general, protein content of source (leaf, sheath, or culm) decreased with kinetin spray, with a corresponding increase in grain protein content. Two sprays of kinetin resulted in accumulation of the highest amount of protein in the grain (9.37%). Protein yield also increased with kinetin spray. The sink of plants treated with two sprays of kinetin contained 507 kg protein/ha, 71% of total protein.

There was a significant negative correlation between grain yield and protein content of leaf (-0.72**), sheath (-0.81**), and culm (-0.39**); there was a significant positive correlation between grain yield and protein content of panicle (0.91**).

The K-kinetin interaction was significant on protein content of leaf, sheath, and panicle, and synergistic on grain protein and total protein yield (Table 2). Application of 29.1 kg K/ha with two sprays of kinetin resulted in the highest accumulation of protein in the sink (73.6%). These results indicate a synergistic K × kinetin interaction to mobilize protein from source to sink. □

Table 1. Influence of K and kinetin on protein content and protein yield of different plant parts. Trivandrum, India, 1987 summer.

Treatment	Protein content at harvest (%)				Protein yield at harvest (kg/ha)		Percentage of total protein in	
	Leaf	Sheath	Culm	Panicle	Panicle	Total	Source	Sink
No K	3.62	3.73	4.06	6.65	250.6	418.9	40.2	59.8
14.5 kg K/ha	3.47	3.60	4.01	8.40	405.5	596.0	32.0	68.0
29.1 kg K/ha	3.22	3.53	3.95	8.96	469.7	667.5	29.6	70.4
58.1 kg K/ha	3.23	3.54	3.91	9.55	517.8	723.0	28.4	71.6
Water spray	3.49	3.64	3.97	7.52	318.1	489.2	35.0	65.0
10 ppm kinetin at flowering	3.41	3.61	4.02	8.02	372.1	554.3	32.9	67.1
10 ppm kinetin at 10 d after flowering (DF)	3.33	3.59	3.99	8.65	445.9	647.8	31.2	68.8
10 ppm kinetin at flowering and at 10 DF	3.32	3.54	3.95	9.37	507.4	714.2	29.0	71.0
LSD (0.05)	0.11	0.04	ns	0.24	27.9	39.2	–	–

Table 2. Potassium × kinetin interaction on protein content and protein yield of different plant parts. Trivandrum, India, 1987 summer.

Treatment combination	Protein content at harvest (%)				Protein yield at harvest (kg/ha)		Percentage of total protein in	
	Leaf	Sheath	Culm	Panicle	Panicle	Total	Source	Sink
No K + water spray	3.69	3.78	4.08	5.73	166.9	307.4	45.7	54.3
+ 10 ppm kinetin at flowering	3.55	3.78	4.07	6.07	186.3	330.7	43.7	56.3
+ 10 ppm kinetin at 10 d after flowering (DF)	3.56	3.75	4.04	6.54	262.6	451.1	41.8	56.2
+ 10 ppm kinetin at flowering and at 10 DF	3.66	3.59	4.05	8.26	386.5	586.3	34.1	65.9
14.5 kg K/ha + water spray	3.56	3.63	4.08	7.14	290.1	473.4	38.7	61.3
+ 10 ppm kinetin at flowering	3.59	3.68	4.04	8.13	360.1	540.5	33.4	66.6
+ 10 ppm kinetin at 10 DF	3.43	3.57	4.01	8.56	419.8	612.2	31.4	68.6
+ 10 ppm kinetin at flowering and at 10 DF	3.31	3.53	3.92	9.76	552.1	757.9	27.1	72.9
29.1 kg K/ha + water spray	3.44	3.61	4.04	7.89	358.3	538.6	33.5	66.5
+ 10 ppm kinetin at flowering	3.34	3.49	4.03	8.12	390.1	581.0	32.9	67.1
+ 10 ppm kinetin at 10 DF	3.15	3.55	3.93	9.80	544.8	754.9	27.8	72.2
+ 10 ppm kinetin at flowering and at 10 DF	2.96	3.45	3.80	10.02	585.4	795.6	26.4	73.6
58.1 kg K/ha + water spray	3.26	3.55	3.69	9.33	456.8	637.5	28.3	71.7
+ 10 ppm kinetin at flowering	3.16	3.48	3.95	9.76	552.1	764.8	27.8	72.2
+ 10 ppm kinetin at 10 DF	3.16	3.52	3.98	9.68	556.5	772.9	28.0	72.0
+ 10 ppm kinetin at flowering and at 10 DF	3.35	3.61	4.01	9.44	505.7	716.9	29.5	70.5
LSD (0.05)	0.21	0.08	ns	0.48	55.7	78.4		

Effect of plant growth regulators on ripening, grain development, and rice quality

I. Awan and H. K. Alizai, Faculty of Agriculture, Gomal University, Dikhan (NWFP); and F. M. Chaudhry, Agronomy Department, University of Agriculture, Faisalabad, Pakistan

We studied the effect of plant growth regulators in a pot experiment laid out in a completely randomized block design with four replications.

IR6 seedlings were transplanted at 30 d after seeding, 3 seedlings/240-mm-diameter, 300-mm-deep pot. An aqueous solution of 100 ppm gibberellic acid (GA_3) and 100 ppm indoleacetic acid (IAA) were sprayed at 3 ml/plant at panicle initiation.

Application of growth regulators at panicle initiation significantly affected plant height, tillers/plant, grains/panicle, 1,000-grain weight, sterility, abortive kernels, grain yield, and protein content (see table). Higher, better quality yield with GA_3 and IAA may be the result of more efficient, vigorous leaves and other plant parts for a longer period because of delayed senescence in treated plants. □

Effect of plant growth regulators on yield components and rice quality. Dera Ismail Khan, NWFP, Pakistan, 1986 summer.

Treatment [a]	Plant height (cm)	Tillers (no./plant)	Grains (no./panicle)	1000-grain weight (g)	Sterility (%)	Abortive kernels (%)	Grain yield (g/pot)	Protein content (%)
Control	81 c	12 b	103 c	21 b	10 c	3 b	23 c	7 b
Gibberellic acid (GA_3) 100 ppm at panicle emergence	92 a	16 a	114 b	22 a	8 b	2 a	38 b	8 a
Indoleacetic acid (IAA) 100 ppm at panicle emergence	89 b	16 a	117 a	22 a	7 a	3 b	40 a	8 a

[a] In a column, numbers followed by the same letter do not differ significantly at 5% level of probability by DMRT.

Crop management

Nursery management for rice grown in intermediate deep water

C. V. Raghavaiah, B. C. Ghosh, and M. K. Jana, Agricultural Engineering Department, Indian Institute of Technology, Kharagpur 721302, India

Experiments on seedbed management were conducted in a farmer's field during 1985 and 1986 wet seasons. Soil was an alluvial, sandy loam type with pH 6.0, CEC 12 meq/ 100 g soil, 0.74% organic C, and 4 ppm available P.

Seedlings of Tilakkachari (an improved selection) and CR1018 (high-yielding variety) were grown by sowing seeds at low (200 kg seeds/ ha) and high density (400 kg seeds/ ha) with three levels of fertilizer (Table 1).

Seedlings were transplanted at 40 and 60 d after seeding. The submergence water level in the main field varied from 15 to 60 cm during most of crop growth.

Rice plants grown from seedlings raised in the low seed density nursery performed better (productive tillers, grains/panicle, and yield) than plants grown from seedlings raised in the high density nursery (Table 1). Plants grown from seedlings that received $N_{30}P_{15}$ in the nursery bed also produced significantly higher yield than treatment $N_{30}P_0$ or no NP.

Applying $N_{30}P_{15}$ in the nursery followed by topdressed N_{30} as urea supergranule further ameliorated

Table 1. Effects of seed rate and fertilizer in nursery on growth and yield of transplanted rice varieties under intermediate submergence (15-60 cm). Kharagpur, India, 1985 and 1986 wet seasons.

Treatment	1985 Productive tillers (no./m^2)	1985 Grains (no./panicle)	1985 Grain yield (t/ha)	1986 Productive tillers (no./m^2)	1986 Grains (no./panicle)	1986 Grain yield (t/ha)
Variety						
Tilakkachari	213	101	3.7	271	99	4.7
CR1018	323	119	5.2	270	134	4.8
LSD (0.05)	72	2	0.4	ns	6	ns
Seed rate (kg/ha)						
200	284	116	4.5	272	123	4.8
400	252	104	4.3	269	110	4.7
LSD (0.05)	14	3	0.1	ns	2	ns
Fertilizer (kg/ha)						
N_0P_0	235	104	4.0	258	108	4.0
$N_{30}P_0$	277	108	4.5	268	117	4.9
$N_{30}P_{15}$	292	118	4.7	288	124	5.3
LSD (0.05)	17	4	0.2	9	2	0.3

Table 2. Effects of seedling age and fertilizer in nursery on growth and yield of transplanted rice varieties under intermediate submergence (15-60 cm). Kharagpur, India, 1985 and 1986 wet seasons.

Treatment	1985 Productive tillers (no./m^2)	1985 Grains (no./panicle)	1985 Grain yield (t/ha)	1986 Productive tillers (no./m^2)	1986 Grains (no./panicle)	1986 Grain yield (t/ha)
Variety						
Tilakkachari	252	117	3.9	238	106	4.9
CR1018	294	149	5.7	267	133	5.4
LSD (0.05)	ns	15	0.1	ns	11	0.4
Seedling age (d)						
40	256	132	4.4	244	114	5.1
60	290	134	5.2	261	124	5.2
LSD (0.05)	24	ns	0.2	15	6	ns
Fertilizers (kg/ha) in nursery						
N_0P_0	246	120	4.2	223	109	4.6
$N_{30}P_0$	272	128	4.8	239	118	5.1
$N_{30}P_{15}$	279	138	5.0	251	124	5.2
Fertilizers (kg/ha) in nursery and in field						
$N_{30}P_{15}$ and $N_{30}P_0$ (top-dressing)	295	146	5.3	298	127	5.8
LSD (0.05)	10	4	0.2	8	3	0.2

submergence stress (increased growth and significantly higher grain yield) (Table 2). Older seedlings tolerated intermediate submergence better than did younger seedlings.

Semidwarf variety CR1018 performed better than improved tall variety Tilakkachari, which grows locally under submergence. □

Soil fertility and fertilizer management

Effect of continuous application of ammonium sulfate and urea on irrigated rice

A. Buntan and I. T. Corpuz, Agronomy Department, Maros Research Institute for Food Crops, P.O. Box 173, Ujung Pandang, Indonesia

We studied the effect of continuous application of ammonium sulfate on rice yield and on some physicochemical properties of wetland soil.

The clayey soil had pH 6.2 (slightly acidic); 0.12% total N (low); 150 ppm available P (fairly high); 19.8, 7.9, 0.8 meq Ca, Mg, K/100 g soil (high); and 8 ppm SO_4-S content (low). N was deficient and S was below the critical 9 ppm level.

The experiment was established in 1984 wet season (WS) after a simple trial to identify the problem of plant yellowing despite the application of urea. The rice crop was observed to respond to the application of ammonium sulfate.

Twelve treatments were arranged in a randomized complete block design with 4 replications (see table). P as TSP and K as KCl were applied (60 kg each) in treatments 2 to 12.

Grain yield was higher when S was applied, at any level. The significant increase in yield was due to N.

Effect of S on grain yield (14% moisture) of IR54. Ujung Pandang, Indonesia, 1984 wet season.

Treatment	Grain yield (t/ha)
Control	2.7
20 kg S/ha as ammonium sulfate	3.9
0 S, 20 kg N/ha as urea	3.7
40 kg S/ha	4.4
0 S, 40 kg N/ha	4.3
60 kg S/ha	4.8
0 S, 60 kg N/ha	4.4
80 kg S/ha	4.4
0 S, 80 kg N/ha	4.2
100 kg S/ha	4.6
0 S, 100 kg N/ha	4.3
0 S, 0 N, 26.4 kg P, 49.8 kg K/ha	3.0
LSD (0.05)	0.6
(0.01)	0.8
CV (%)	11.8

Application of P and K without S or N did not have any significant effect on yield. □

Reaction of IR20 rice to carbofuran and urea

M. A. Salam, Kerala Agricultural University, Cropping System Research Centre, Karamana, Trivandrum 695002, Kerala, India

The reaction of IR20 rice to combinations of carbofuran and urea was studied at Tamil Nadu Agricultural University (TNAU) in summer (Feb-Jun) 1983. The objective was to examine the phytotonic effects of carbofuran and its interaction with N.

The experiment was laid out in a factorial combination of three levels of N (0, 60, and 90 kg N/ ha as urea) and four levels of carbofuran (0, 1.0, 2.0, and 3.0 kg ai/ha) in a randomized block design with four replications.

Soil at TNAU (11° N, 77° E, and 427 m above mean sea level) was a Vertisol (clay loam) containing 1.0% organic C, 99-8.0-254 ppm available NPK, 0.7 ppm DTPA-extractable Zn, with pH 8.2 and EC 0.3 dS/m. The crop was uniformly fertilized and kept insect free by spraying all plots with phosphamidon on a need basis, including plots treated with insecticide.

Carbofuran was incorporated at planting to ensure minimum loss. N as urea was applied in three splits: 50% basal, 25% at tillering, and 25% at panicle initiation.

Tiller production, leaf area index, root production, and grain yield increased with urea application up to 90 kg N/ha and with carbofuran application up to 1.0 kg ai/ha (see table).

Based on costs, the combination 90 kg N/ha and 1.0 kg ai carbofuran/ha was optimum. Costs were \$2.5/kg carbofuran 3% granule, \$0.5/kg N, \$0.2/kg rough rice, and \$2.91 person (for labor). □

Influence of carbofuran (0, 1, 2, 3 kg ai/ha) and N on grain yield of IR20. TNAU, Coimbatore, India, 1983.

N (kg/ha)	Grain yield (t/ha)				
	No carbofuran	1 kg	2 kg	3 kg	Mean
0	1.9	2.7	2.9	2.9	2.7
60	3.3	3.8	3.1	2.7	3.3
90	4.2	5.0	3.8	4.1	4.2
Mean	3.2	3.8	3.3	3.2	

	LSD (0.05)
Nitrogen (N)	0.5
Carbofuran (C)	0.9
N×C	1.4

Response of rice to potassium

J. S. Kolar and H. S. Grewal, Agronomy Department, Punjab Agricultural University, Ludhiana 141004, Punjab, India

We studied the response of irrigated rice to K applied at different crop stages for two consecutive cropping seasons (1987-88). Treatments (see table) were in a randomized complete block design with four replications.

Soil was sandy loam (Typic Ustochrept) with 135 kg available K, 0.23% organic C, and 13.0 kg Olsen's P/ha. All plots received 120 kg N and 13 kg P/ha. All P and 1/3 N were applied just before transplanting; the remaining N was applied at 21 and 42 d after transplanting. Sources of N, P, K were urea, single superphosphate, muriate of potash, respectively.

Yield responded significantly to split application of 50 kg K/ ha (1/2 at transplanting + 1/2 at active tillering) (see table). Split application of K at transplanting and panicle initiation and at active tillering and panicle initiation also significantly increased yield in 1988. Applying 100 kg K at transplanting was as efficient as split application. K helped increase panicle-bearing tillers and grain weight. ☐

Effect of K application on grain yield and some yield components. Punjab, India, 1987-88.

K (kg/ha)	Grain yield (t/ha)		Effective shoots (no./hill)		Grains (no./panicle)		1000-grain wt (g)	
	1987	1988	1987	1988	1987	1988	1987	1988
0 (control)	6.8	6.2	11.0	9.8	170	155	24.5	23.8
50 (all at transplanting)	7.1	6.6	11.5	10.6	174	160	25.1	24.5
50 (½ at transplanting + ½ at active tillering)	7.3	6.9	12.3	11.5	169	159	25.4	24.9
50 (½ at transplanting + ½ at panicle initiation)	7.2	6.9	11.7	11.6	176	158	25.3	25.1
50 (½ at active tillering + ½ at panicle initiation)	7.2	6.8	11.5	11.4	178	156	25.4	25.3
100 (all at transplanting)	7.4	7.1	12.5	11.6	177	154	25.7	25.3
100 (½ at transplanting + ½ at active tillering)	7.3	7.0	12.4	11.5	176	159	25.6	25.2
100 (½ at transplanting + ½ at panicle initiation)	7.5	7.0	12.6	11.8	171	158	25.4	25.4
100 (½ at active tillering + ½ at panicle initiation)	7.3	7.1	12.3	11.7	174	160	25.7	25.3
LSD (0.05)	0.5	0.6	1.2	1.6	ns	ns	0.82	1.01

Effect of urea supergranule depth of placement in irrigated transplanted rice

K. Singh, A. N. Singh, and K. N. Singh, Agronomy Department, Institute of Agricultural Sciences, Banaras Hindu University (BHU), Varanasi 221005, India

We conducted field trials at the BHU Research Farm during 1984 and 1985 rainy seasons. Urea supergranule (USG) and neem cake USG were placed at three depths (5, 10, and 15 cm) at three N levels (60, 120, and 180 kg N/ha). Soil was sandy loam with pH 7.4, 205.2 kg available N/ha, 13.8 kg available P/ha, and 171.7 kg available K/ha. The crop was irrigated as needed to maintain soil moisture between saturation and field capacity. All the N through USG was applied 1 wk after transplanting of rice variety Jaya, when soil moisture content was between field capacity and soil saturation. USG was applied at specified depths in the center of hills, with the help of a peg.

Effect of USG amount and depth of placement on transplanted irrigated rice.[a] Varanasi, India.

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Protein content (kg/ha)		N uptake (kg/ha)		
			Grain	Straw	Grain	Straw	Total
Placement depth (cm)							
5	3.9	4.9	360	120	60	20	80
10	4.3	5.9	430	170	70	30	100
15	4.0	5.6	370	130	60	30	90
LSD (0.05)	0.2	0.1	na	na	ns	ns	na
N source							
USG	3.9	5.6	380	140	60	20	80
Neem cake/USG	4.2	6.0	420	170	70	30	100
LSD (0.05)	0.2	0.2	na	na	ns	ns	na
N applied (kg/ha)							
60	3.4	5.6	310	140	50	20	70
120	4.2	6.0	430	170	60	40	100
180	4.7	6.6	520	230	80	40	120
LSD (0.05)	0.3	0.6	na	na	ns	ns	na

[a]Av of 2 yr, 1984-85. ns = not significant, na = not analyzed.

Grain and straw yields were significantly higher with deep point placement of USG; placement 10 cm deep resulted in the highest yields, followed by that at 15 cm and 5 cm (see table). Protein harvest and N uptake were also highest under 10-cm-deep placement.

USG treated with neem cake proved somewhat better than USG. Application of 180 kg N/ha gave significantly higher grain and straw yields as well as protein yield and N uptake. None of the interaction effects were significant. ☐

Effect of phosphorus with and without zinc on wetland rice

A. Buntan, L. Gunarto, M. Rauf, and I. T. Corpuz, Agronomy Department, Maros Research Institute for Food Crops, P.O. Box 173, Ujung Pandang, Indonesia

Data from the 1981 and 1982 dry season (DS), Long-Term Soil Fertility Trials at Lanrang Substation showed that application of Zn significantly decreased rice grain yields. Responses to phosphorus also were observed. We designed an experiment in the 1984-85 DS (Nov-Feb) to determine yield response of rice to different P rates, with and without Zn.

The clay loam soil had pH 5.9 (slightly acidic); 2.6% organic matter content (low); 9 ppm available P (medium); 13.8, 8.8, 0.8 meq exchangeable Ca, Mg, K/100 g soil (adequate).

P, N, and K were applied in the form of TSP, urea, and KCl, respectively; 100 kg N/ ha and 50 kg P/ha were applied as basal. Treatments were arranged in a randomized complete block design with four replications (see table).

ZnO at 5 kg/ha with P rates ranging from 13 kg P to 66 kg P/ ha in 13-kg P increments did not significantly affect grain and straw yields of IR54. There were no significant differences between P with and without Zn. And there was no response to phosphorus. ☐

Response of IR54 to P with and without Zn. Lanrang, Indonesia, 1984-85 DS.

Treatment	Grain yield[a] (t/ha) at 14% moisture	Straw yield (t/ha) (sun-dried)
Control	4.7	4.7
13 kg P	6.0	5.3
13 kg P + 5 kg ZnO	5.8	5.4
26 kg P	6.0	5.4
26 kg P + 5 kg ZnO	6.0	5.5
40 kg P	5.9	5.8
40 kg P + 5 kg ZnO	5.8	5.6
53 kg P	6.0	5.2
53 kg P + 5 kg ZnO	5.8	5.4
66 kg P	5.2	5.5
66 kg P + 5 kg ZnO	5.9	5.5
0 P + 100 kg N + 50 kg K + 5 kg ZnO	5.7	5.6
LSD (0.05)	0.7	0.8
(0.01)	0.8	0.9
CV (%)	9.5	8.4

[a]Based on 25 hills free of rat damage (harvestable area = 4 m^2).

Response of spring rice to fertilizer practices in rice - rapeseed rotation

V. Prakash, V. K. Bhatnagar, and P. Singh, Vivekananda Parvatiya Krishi Anusandhan Shala, Almora 263601, Uttar Pradesh (U.P.), India

Spring rice, the principal crop in the midhills of U.P., is sown under rainfed conditions in Mar and harvested in Sep. A short-duration (Oct-Feb) rapeseed (*Brassica campestris* L. var. *toria*) was found to fit the intervening period best. But yields are low because farmers use very low amounts of chemical fertilizers (4-5 kg/ha). Farmyard manure (FYM) is the principal source of plant nutrients.

We studied the response of spring rice to N and FYM and the residual effect on a succeeding rapeseed crop at Hawalbagh, Almora (1,250 m above mean sea level, average annual rainfall 1,027.3 mm) for 3 yr (1983-86).

The soil was sandy loam (pH 6.2, 0.43% organic C, CEC 22 meq/100 g, 22.7 kg available P (Bray's)/ ha, 229.6 kg available K/ha). Two levels of N (0 and 20 kg N/ha) and three levels of FYM (0, 10, and 20 t/ha) were applied only to spring rice, in a factorial randomized block design with three replications. FYM applied the first yr had 0.65% N, 0.23% P, 0.60% K, and 18.8% moisture content; in the second yr, it had 0.61% N, 0.27% P, 0.58% K, and 16.7% moisture content; and in the third year it had 0.56% N, 0.21% P, 0.65% K, and 15.5% moisture content. Rice variety VL 206 was seeded the second half of Mar and harvested the middle of Sep. Rapeseed variety T9 was planted the beginning of Oct and harvested in the second half of Feb.

Rice yield increased by 0.14 t/ ha with 20 kg N/ ha (see table). Yield increases

Effect of N and FYM applied to spring rice on grain yield of spring rice and rapeseed. Almora, India, 1983-86.

Manurial treatment N rate (kg/ha)	Manurial treatment FYM (t/ha)	Yield (t/ha) 1983-84 Rice	1983-84 Rapeseed	1984-85 Rice	1984-85 Rapeseed	1985-86 Rice	1985-86 Rapeseed	Mean Rice	Mean Rapeseed
0	0	1.43	0.22	1.41	0.22	0.79	0.30	1.21	0.24
0	10	1.72	0.31	1.81	0.32	1.66	0.51	1.73	0.38
0	20	1.91	0.37	2.07	0.43	1.93	0.61	1.97	0.47
20	0	1.50	0.19	1.60	0.22	0.95	0.32	1.35	0.24
20	10	1.81	0.38	1.91	0.33	1.77	0.53	1.83	0.41
20	20	2.02	0.37	2.26	0.44	2.28	0.62	2.19	0.48
LSD (0.05)	N	0.10	ns	0.15	ns	0.15	ns		
	FYM	0.16	0.06	0.13	0.08	0.15	0.03		
	N×FYM	ns	ns	ns	ns	ns	ns		

with 10 and 20 t FYM/ha were 0.52 and 0.76 t/ha, respectively. Highest yield was with 20 t FYM and 20 kg N/ha.

The residual effect of FYM on the following rapeseed crop was significant. Rapeseed yields were 0.17 and 0.24 t/ha higher with 10 and 20 t FYM/ha, respectively. The residual effect of fertilizer N on rapeseed yield was not significant.

Applying 20 kg N with 20 t FYM/ha to spring rice not only increased rice yield, but also doubled yield of the succeeding rapeseed crop. ☐

Disease management

Field evaluation of fungicides to control rice sheath blight (ShB)

Y. Suryadi and T. S. Kadir, Sukamandi Research Institute for Food Crops, West Java, Indonesia

We tested eight fungicides against *Rhizoctonia solani* in the field.

Pelita I-2 was planted in a randomized block design with three replications in 4- × 5-m plots at 20- × 20-cm spacing. Plants were artificially inoculated 55 d after transplanting (DT) by placing small amounts of ShB inoculum on rice husk at the center of each hill. Fungicides were sprayed at 60, 67, and 74 DT, and disease incidence (lesion length and relative lesion height) measured 25 d after flowering.

Triazole was most effective in inhibiting enlargement of ShB lesions. Significant lesion reduction also occurred with chlorothalonil, mancozeb, and maneb + zineb treatments (see table). No phytotoxicity occurred in any treatment. ☐

Control of rice ShB by fungicides. Sukamandi, Indonesia, 1986-87.[a]

Treatment	Application rate (formulation/ha)	Plant height (cm)	Lesion length (cm)	RLN[b] (%)	Severity[c] (%)
Benomyl	0.25 kg	124.16 a	58.26 cde	46.94 bc	39.14 cd
Mancozeb	2.0 kg	125.16 a	49.08 abcd	39.21 ab	26.37 abc
PCNB	1.0 kg	123.59 a	52.89 bcd	42.72 abc	35.60 bcd
Chlorothalonil	1.7 kg	125.34 a	46.06 ab	36.77 ab	22.12 ab
Carbendazim	0.8 kg	125.91 a	56.07 bcde	44.52 abc	33.53 bcd
Triazole	0.5 liter	116.77 b	40.13 a	34.16 a	19.5 a
Captafol	1.5 liter	123.51 ab	59.23 c	46.14 bc	39.74 cd
Maneb + zineb	1.0 kg	121.6 ab	47.69 abc	39.15 ab	26.30 abc
Control (unsprayed)	–	126.69 a	65.78 e	51.92 c	48.8 d
CV (%)		3.01	11.29	11.07	14.41

[a]Mean of 3 replications. Means followed by the same letter are not significantly different at the 5% level by DMRT. [b] $\text{RLH} = \frac{\text{lesion length}}{\text{plant height}} \times 100$

[c] $\text{Severity} = \frac{0\,(n0) + 1\,(n1) + 5\,(n3) + 20\,(n5) + 50\,(n7) + 100\,(n9)}{\text{number of tillers observed}} \times 100$

n0 - n9 = number of tillers with 0-9 scale.

Survival of rice root-knot nematode juveniles in moist soil

M. H. Soomro, Agriculture Department, University of Reading, Reading, United Kingdom (present address: Crop Diseases Research Institute, National Agricultural Research Centre, Park Road, Islamabad, Pakistan)

Severe infestations of the soil by *Meloidogyne graminicola* can cause up to 50% yield losses. To develop an efficient control method for this nematode we need to know its survival capacity in the absence of a host plant.

To measure rice root-knot nematode survival, eight plastic pots were filled with sterilized soil and inoculated with 4,000 freshly hatched *M. graminicola* juveniles/pot. The soil was kept moist. Pots were incubated at two temperatures: four pots at 26 ± 4 °C, and four pots at 20 ± 1 °C.

Survival and viability of the nematodes were measured by a bioassay method at 2, 3, 4, and 5 mo after inoculation. After assay, a 2-wk-old seedling of *Echinochloa colona* was planted in one pot from each incubation temperature and kept at 26 ± 4 °C.

Seedlings were uprooted 2 mo after transplanting. Roots washed free from soil were weighed and fixed in FA 4:1. Fixed roots were stained in acid fuchsin in lacto-glycerol and cleared for 24 h. Number of nematodes in the roots was estimated by counting nematodes in three 0.5-g subsamples (see table).

Second stage juvenile of rice root-knot nematodes can survive in soil without any host plant for up to 5 mo at temperatures up to 26°C and remain viable to invade host roots and reproduce. ☐

Nematodes surviving soil incubation and infesting host plant roots. Reading, UK.

Soil incubation period (mo)	Survival (no./g roots)	
	26±4°C	20±1°C
2	442	812
3	133	693
4	96	451
5	536	707

Recovery of rice tungro virus (RTV) from rice stubble

Z. M. Flores, E. R. Tiongco, R. C. Cabunagan, and H. Hibino, IRRI

Rice stubble can serve as a RTV source. In a greenhouse study, stubble of IR22 and IR36 naturally infected with both

Table 1. Infectivity of GLH on TN1 seedlings exposed for 1 d to caged or uncaged RTV-infected stubble of IR64 and TN1 2 wk after harvest. IRRI, 1987.

Cultivar	Caged stubble [a]					Uncaged stubble [b]				
	GLH introduced (no.)	GLH recovered and tested (no .)	Disease transmission (%)			GLH introduced (no.)	GLH recovered and tested (no.)	Disease transmission (%)		
			RTBV+RTSV	RTBV	RTSV			RTBV+RTSV	RTBV	RTSV
IR64	1600	389	25	22	4	800	12	17	33	0
TN1	800	395	28	33	2	400	31	45	23	0

[a] IR64 (80 stubbles) and TN1 (40) exposed to 20 GLH/stubble. [b] IR64 (40) and TN1 (20) exposed to 20 GLH/stubble.

RTBV and RTSV, IR26 infected with RTBV alone, and IR54 infected with RTSV alone were used. (Infection was confirmed by ELISA.)

The stubbles were potted individually and covered with mylar cages. Virus-free green leafhopper (GLH) *Nephotettix virescens* were introduced for a 4-d acquisition feeding, then released individually on TNl seedlings for a 24-h inoculation feeding.

Three weeks later, inoculated seedlings were indexed by latex test. GLH that had fed on doubly infected IR22 stubble transmitted 60% RTBV + RTSV, 17% RTBV, and 14% RTSV. GLH fed on doubly infected IR36 stubble transmitted 25% RTBV + RTSV, 28% RTBV, and 7% RTSV. GLH fed on RTSV-infected IR54 stubble transmitted 8% RTSV. No transmission was obtained on RTBV-infected IR26 stubble.

In a field study, caged and uncaged stubbles of IR64 and TN1 naturally infected with both RTBV and RTSV were used as virus sources 2 wk after harvest. Virus-free male GLH were introduced onto the stubbles, recovered the following day, and tested for infectivity. Field GLH populations collected by sweep net on 1- and 4-wk-old stubbles also were tested for infectivity.

Although GLH mortality was higher on IR64 stubble than on TNl stubble, infectivity of the vectors did not differ significantly (Table 1). Field population collected on 1- and 4-wk-old TN1 stubbles had low levels of infectivity; those collected on IR64 stubbles were not infective (Table 2). □

Table 2. Infectivity of GLH field population collected on 1- and 4-wk-old IR64 and TN1 stubbles. IRRI, 1987.

Cultivar	From 1-wk-old stubble					From 4-wk-old stubble				
	GLH density (no./10 sweeps)	Total GLH tested (no.)	TN1 infected (%)			GLH density (no./10 sweeps)	Total GLH tested (no.)	TN1 infected (%)		
			B+S	B	S			B+S	B	S
IR64	4	11	0	0	0	9	45	0	0	0
TN1	31	31	0	7	0	14	41	1	3	0

Effect of potassium level on bacterial blight (BB) incidence and rice yield

R. Sudhakar, K. Ramanujam, and R. Ramabadran, Plant Pathology Department, Faculty of Agriculture, Annamalai University, Annamalainagar 608002, Tamil Nadu, India

IR20 seedlings were raised in concrete pots during navarai (Feb-May) 1988. K was applied at different levels (0, 21, 42, 62, and 83 kg/ ha). N and P were applied uniformly, at 100 and 50 kg/ha, respectively.

At 60 d, seedlings were clip-inoculated with BB *Xanthomonas campestris* pv. *oryzae* suspension at 10^6 cells/ml. Distilled water was used for control.

Effect of K application and *X. c.* pv. *oryzae* inoculation on BB incidence and grain and straw yields of IR20. Tamil Nadu, India, 1988.

K (kg/ha)	Disease incidence [a] (%)	Decrease (%) from control	Grain yield			Straw yield		
			Healthy (g/pot)	Inoculated (g/pot)	Decrease (%) due to infection	Healthy (g/pot)	Inoculated (g/pot)	Decrease (%) due to infection
0	36.7 (36.6)	–	23.7	21.4	10.6	51.3	43.9	16.9
21	27.0 (31.2)	24.2	26.4	24.6	7.1	55.4	49.1	12.8
42	25.8 (30.5)	27.6	30.1	28.9	4.3	58.2	53.1	9.4
62	23.5 (28.9)	34.2	32.3	31.6	2.2	63.6	60.2	5.6
83	21.2 (27.4)	40.6	33.2	32.7	1.5	65.2	62.9	3.7
			LSD (P = 0.05) 1.8			LSD (P = 0.05) 1.8		

[a] Mean of 3 replications. Angular transformed values are in parentheses.

Plants were scored for disease incidence 14 d after inoculation. Disease incidence decreased with increasing K (see table).

Grain and straw yields of both healthy and inoculated plants increased with K application, but BB inoculation caused a significant yield difference. That difference lessened with increased K. □

Influence of rice tungro virus (RTV) infection on severity of bacterial blight (BB) and bacterial leaf streak (BLS) in rice

R. K. Jain, Plant Pathology Division, Central Rice Research Institute, Cuttack 753006, India (present address: Indian Agricultural Research Institute (IARI), New Delhi 110012, India)

Ricefields often are subjected to multiple infection, with the intensity of one disease influenced by other diseases. We studied the influence of RTV infection on severity of BB and BLS diseases in the glasshouse. Susceptible rice cultivar TN1 plants (30-d-old, 3- to 4-leaf stage) were artificially inoculated with each incitant alone or in combination.

Disease reaction 7 d after inoculation indicated that BB severity was less in plants also inoculated with RTV, regardless of inoculation sequence (see table). BLS severity was higher in plants also inoculated with RTV, regardless of inoculation sequence. □

Disease severity of BB and BLS on TN1 rice plants inoculated with RTV, Cuttack, India.

Inoculation type	Inoculation schedule[a]			Disease severity[b] (%)	
	1st inoculation	Time lapse	2d inoculation	BB	BLS
Same time	RTV	0	XCO/XCOZ	–15	+70
Sequentially	RTV	24	XCO/XCOZ	–25	+115
Sequentially	XCO/XCOZ	24	RTV	–5	+115

[a] RTV = rice tungro virus, XCO = *Xanthomonas campestris* pv. *oryzae,* XCOZ = *Xanthomonas campestris* pv. *oryzicola* [b] Estimates based on lesion length of 3 different leaves each from 20 plants. + = increased, – = decreased disease severity on doubly inoculated plants.

Inducing resistance to rice bacterial blight (BB) by inoculating nonpathogenic isolate of *Xanthomonas campestris* pv. *oryzae*

Chandrasekaran and P. Vidhyasekaran, Tamil Nadu Rice Research Institute, Aduthurai 612101, India

We obtained an isolate of *X. campestris* pv. *oryzae,* the incitant of rice BB, which became nonpathogenic across repeated subculturing. We tested the ability of this nonpathogenic isolate to induce resistance to a virulent isolate in the greenhouse, using rice cultivar IR20 (Table 1).

The nonpathogenic isolate was clip-inoculated (10^8 CFU/ ml) at the boot leaf stage. The virulent isolate was clip-inoculated (10^8 CFU/ml) 1, 2, and 3 d later. The nonpathogenic and virulent isolates (10^8 CFU/ ml each) were mixed and inoculated in one treatment.

In a second experiment, the virulent isolate was inoculated first, followed 1, 2, and 3 d later by inoculation with the nonpathogenic isolate. Disease intensity was assessed 20 d after inoculation.

The experiments were repeated twice with three replications each.

The nonpathogenic isolate induced resistance to the virulent isolate only when it was inoculated before or simultaneously with the virulent isolate (Table 2). □

Table 1. Effect of differing concentrations of avirulent bacteria on control of rice BB. Aduthurai, India.

Avirulent bacteria (CFU/ml)	Disease intensity[a]
10^8	1.3
10^6	2.3
10^4	3.7
10^2	4.5
0	7.6
LSD (P = 0.05)	0.9

[a]*Standard evaluation system for rice.*

Table 2. Efficacy of an avirulent isolate in controlling rice BB. Aduthurai, India.

Sequence of inoculation with virulent and avirulent isolates	Leaf area affected (%)		Disease intensity	
	Trial I	Trial II	Trial I	Trial II
Avirulent + 3 d virulent	2.8	5.0	1.7	3.0
Avirulent + 2 d virulent	5.0	8.0	3.0	3.3
Avirulent + 1 d virulent	4.8	12.0	2.9	3.7
Avirulent – virulent	1.8	2.5	1.3	1.6
Virulent + 1 d avirulent	50.0	70.0	7.0	7.8
Virulent + 2 d avirulent	82.5	75.0	8.3	8.0
Virulent + 3 d avirulent	95.0	80.0	8.8	8.2
Virulent isolate alone (check)	95.0	95.0	8.8	8.8
LSD (P = 0.05)	–	–	0.5	0.6

Rice diseases in the Southern Guinea Savannah Zone of Niger State, Nigeria

E. D. Imolehin, National Cereals Research Institute (NCRI), PMB 8, Bida, Nigeria

Wetland rice in the Southern Guinea Savannah Zone of Niger State of Nigeria is grown in the floodplains (locally called Fadama). Diseases and pests have become a great menace. We have little information on rice pathogens other than blast (Bl) caused by *Pyricularia oryzae* Cav. Shifts in the status of existing diseases and/ or occurrence of new ones are possible.

Experimental rice plots at NCRI, Badeggi, and in farmers' fields at Badeggi, Wuya, Edozhigii, Doko, Agaie, Lapai, Kasha, Mokwa, and Pateggi were surveyed (523 fields). Ricefields were examined at 9 spots (the four corners, midway along each edge, and at the center).

During 1985-87 cropping seasons, Bl occurred most frequently. It affected rice at all stages of development and was most severe on late-planted seedlings.

Other fungi diseases observed, in order of prevalence, were brown spot [caused by *Helminthosporium oryzae* Breda de Haan]; leaf scald [*Gerlachia oryzae* Has. and Yokogi]; glume discoloration (many pathogens); sheath blight [*Rhizoctonia solani* Kuhn]; stem rot [*Sclerotium oryzae* Catt]; sheath rot [*Sarocladium oryzae*]; bakanae [*Gibberella fujikuroi* (Sawada), Ito]; false smut [*Ustilaginoidea virens* (Cke) Tak]; and narrow brown leaf spot [*Cercospora oryzae* Miyake].

Rice yellow mottle virus and unconfirmed bacterial blight symptoms were found occasionally. □

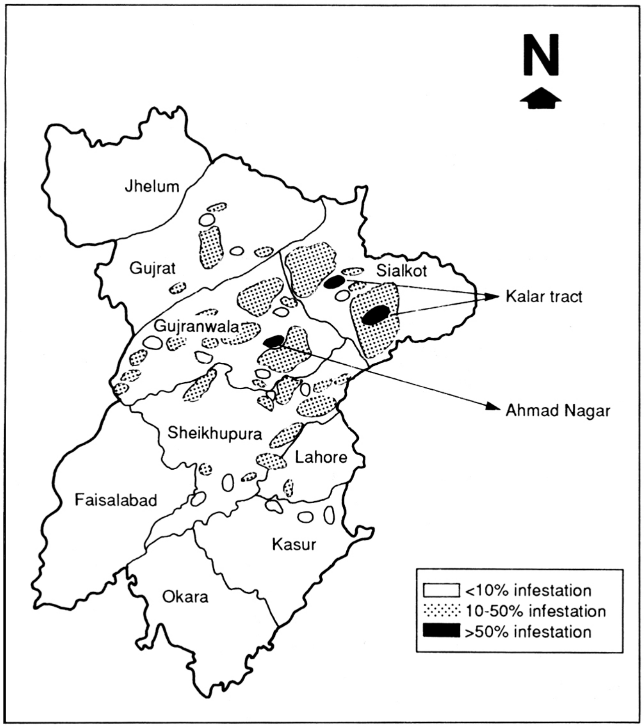
Insect management

Incidence of rice stem borer (SB) in the Punjab

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

We surveyed incidence of rice SB *Scirpophaga* spp. and *Sesamia* spp. in the Punjab. Samples of rice stubble were collected at harvest from 98 locations in 1986 and from 60 locations in 1987 and dissected to determine tiller infestation and larvae/hill.

Overall tiller infestation was 25% in 1986 and 18% in 1987 (see figure). Traditional rice-growing Kalar tract and Ahmad Nagar were badly infested; Gujarat, Mandi Bahauddin, and Sheikhupura were comparatively less infested.



Incidence of rice SB in the Punjab, 1986-87.

SBs found were yellow rice SB *Scirpophaga incertulas* (Wlk.), white SB *S. innotata* (Wlk.), and the pink graminaceous SBs *Sesamia inferens* (Wlk.) and *S. uniformis* (Dudg.).

Scirpophaga spp. made up 357 of 362 larvae collected in 1986, and 1,291 of 1,296 larvae collected in 1987. □

Whitefly (Hemiptera: Aleyrodidae) - a potential pest of rice in West Africa

M. S. Alam, International Institute of Tropical Agriculture (IITA), Oyo Road, P.M.B. 5320, Ibadan, Nigeria

Whiteflies are pests of many crops and also vectors of several plant virus diseases. Whiteflies on rice were first reported in 1966, when *Aleurocybotus indicus* D. and S. was identified in Satara, India. In 1970, *Bemisia tabaci* M. and H. was found on rice in Madras, India.

A. indicus was reported to be restricted to India, with its preferred hosts graminaceous grasses *Chloris barbata* and *Dactyloctenium aegyptium.* But *A. indicus* was reported in Africa in April 1977, on irrigated rice at Richard Toll, Senegal. In recent years, it has spread to Mauritania, Senegal, Burkina Faso, Nigeria, and Niger.

The insect attacks rice plants from seedling to flowering stages. During the hot, dry season, especially in Feb, Mar, and Apr, the insect is seen in irrigated rice at the IITA experimental farm at Ibadan. It has become a serious problem in screenhouses and insect rearing cages. When infestation is high, black sooty mold that develops on rice leaves can cause withering and plant death.

In the course of screening for *Diopsis longicornis* in the screenhouse, we found no *Oryza sativa* or *O. glaberrima* varieties that were tolerant of whitefly (500 entries tested).

A calcid larval parasite, *Encarsia* sp. found at Ibadan is definitely not

Encarsia formosa, a larval parasite of other whiteflies.

Identification of the whitefly collected at Ibadan was verified by L. M. Russell, U.S. Department of Agriculture at Beltsville, Maryland, and D. J. Williams, Commonwealth Institute of Entomology (CIE). The parasite was identified by A. Polaozek of CIE. □

A method for rearing armyworm *Spodoptera mauritia acronyctoides* Guenée (Lepidoptera: Noctuidae) on graminaceous hosts

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

Armyworms often are reared in petri dishes with moistened paper towel and cut rice leaves to track development of individuals. But this method entails changing of plants and removing fecal material daily and is unreliable. Also larval survival is low because of high levels of fungal or bacterial infections.

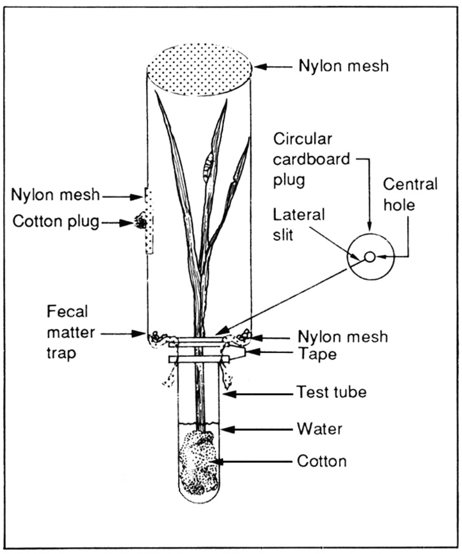
We have designed a setup to minimize these disadvantages (see figure).

One-mo-old host plants are uprooted. Individual tillers are separated, wrapped with moistened cotton, and placed in 10.5- × 2.5-cm test tubes. A cardboard plug prevents larvae from drowning.

Each test tube with plant is enclosed in a 19- × 4-cm cylindrical mylar cage with nylon mesh vents on the side and top. Nylon mesh attached to the base of the cylinder traps fecal material and aerates it to prevent fungal or bacterial infection.

One first-instar larva is placed on each host plant, using a moist camel hair brush. Caged plants with larvae are held upright in a wooden rack. (We use a compartmentalized 47- × 85-cm seedbox to accommodate 60 setups.) Plants are replaced every 3 d.

Average pupation of *S. m. acronyctoides* larvae was higher with this method than with using petri dishes (see table). □



Improved method for rearing armyworm. IRRI, 1988.

Pupation of *Spodoptera mauritia* acronyctoides reared on graminaceous host plants. IRRI laboratory and greenhouse, Jun-Jul 1988.

Plant	Pupation [a] (%) Petri dish method	Pupation [a] (%) Whole plant method
Oryza sativa L.	0	100 ± 0
Echinochloa glabrescens Munro ex Hook f.	20 ± 0.45	100 ± 0
E. colona (L.) Link	40 ± 0.55	100 ± 0
Brachiaria distachya (L.) Stapf.	20 ± 0.45	80 ± 0.45
Echinochloa crus-galli (L.) Beauv. ssp. *hispidula* (Retz.) Honda	40 ± 0.55	80 ± 0.45
Paspalum conjugatum Berg.	40 ± 0.55	80 ± 0.45
Leptochloa chinensis (L.) Nees	20 ± 0.45	60 ± 0.55
$\overline{X}$	26 ± 0.15	86 ± 0.15

[a] Av of 5 replications.

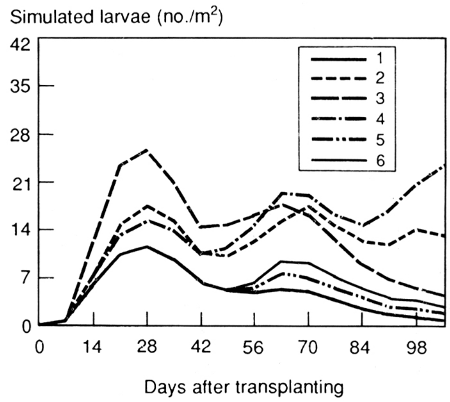
Simulated yellow stem borer (YSB) population dynamics: sensitivity and application

J. Y. Xia, F. W. T. Penning de Vries, and J. A. Litsinger, IRRI

We analyzed the sensitivity of a simulation model of YSB *Scirpophaga incertulas* population dynamics (SIMYSB) to changes in structure and parameter values.

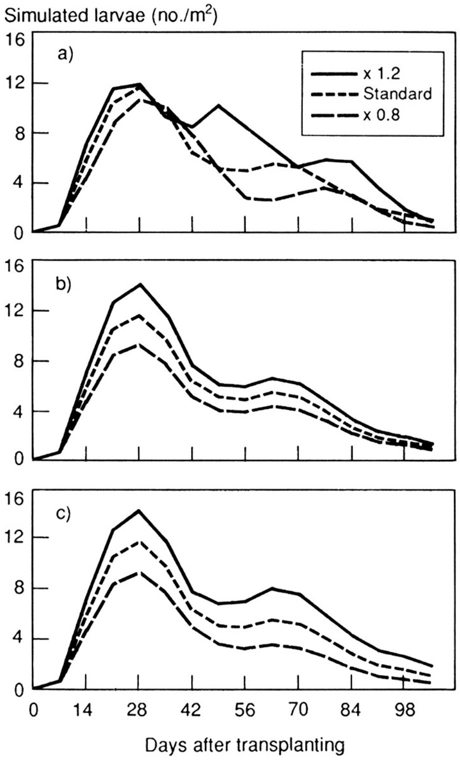
For coarse sensitivity analysis, five mortality factors—egg predation; plant age; and parasitization of eggs, larvae, and pupae—were sequentially omitted from the model, to determine their significance for YSB larval population dynamics. Fine sensitivity analysis involved increasing and decreasing development, immigration, and oviposition rates by 20% to determine their relative importance in the system.

Without the effects of egg predation, egg parasitization, or plant age, larval population fluctuated at a relatively high level in both generations (Fig. 1). Without larval or pupal parasitization, the fluctuating level was relatively low, particularly in the first generation. On the whole, egg predators, egg parasites, and plant age are the most important factors regulating YSB populations.



1. Effect of omitting different mortality factors on simulated YSB larval populations in 1987 WS. 1 = with all effects (reference model), 2 = without egg predation, 3 = without egg parasitization, 4 = without effect of plant ages on larval survival, 5 = without larval parasitization, 6 = without pupal parasitization.

Response of larval populations to changes in egg, larval, and pupal development rates was highly proportional and asymmetrical (Fig. 1). This implies that rates are important variables, because they have large, complex effects on the system. Changes in immigration rate brought about an exactly proportional (20%) and symmetrical (±20%) effect on insect population across the season (Fig. 2b). Response to changes in oviposition rate was highly proportional but



2. Effect on YSB larval populations in 1987 WS of small changes in development rate (a), immigration rate (b), and oviposition rate (c).

semisymmetrical (Fig. 2c); a 20% alteration brought about the same amount of absolute changes in the first peak density but resulted in a higher increase (45.7%) in the second.

SIMYSB has been designed for application in YSB management. The user or researcher may choose to investigate single or combined common pest control tactics. Novel control strategies examined using the computer may lead to the design of useful field experiments. □

Life cycle of *Micraspis* sp. on brown planthopper (BPH) and rice pollen

B. M. Shepard and H. R. Rapusas, Entomology Department, IRRI

The coccinellid *Micraspis crocea* (Mulsant) feeds on plants and on leafhoppers and other small insect pests of rice. It also has been observed feeding on rice flower pollen. Beetles are abundant in ricefields and could help suppress populations of several insect pests.

But because they feed on pollen, many farmers consider them a pest and often spray insecticides to control them.

We studied *M. crocea* in the greenhouse, using the BPH *Nilaparvata* lugens (Stål) and flowering rice panicles. Adult beetles collected from fields were caged on TN1 rice plants with BPH nymphs. Beetle eggs collected daily were placed in petri dishes lined with moist filter paper to determine incubation time. Individual larvae were placed in 2- × 20-cm glass vials with rice stems and second- and third-instar BPH. We reared 75 larvae using this procedure.

Another set of 75 larvae were reared in vials containing flowering rice panicles. Panicles and BPH were changed daily. Ladybeetle larvae were observed to determine time between stages, pupation period, and emergence of adults. Newly emerged adults were reared on both rice panicles and BPH to determine longevity.

Biology of *Micraspis* sp. on BPH nymphs and flowering panicles. IRRI greenhouse, 1988.

Stage	Developmental period on[a] (d)	
	BPH nymphs	Flowering panicles
Incubation period	4.0 ± 0	4.0 ± 0
1st instar	3.2 ± 0.07	3.35 ± 0.08
2d instar	3.4 ± 0.11	3.3 ± 0.15
3d instar	4.2 ± 0.17	4.4 ± 0.18
4th instar	4.4 ± 0.14	7.1 ± 0.24
Pupal stage	4.0 ± 0	4.0 ± 0
Egg to adult	23.1 ± 0.33	26.1 ± 0.38
Adult longevity	94.4 ± 4.41	74.47 ± 3.57

[a]Mean of 75 insects ± standard error.

In general, *Micraspis* sp. survived and developed successfully on both pollen and BPH (see table). This could explain why this beetle is so abundant during rice flowering and during BPH outbreaks. More detailed studies are underway to determine the effects of rice pollen feeding.

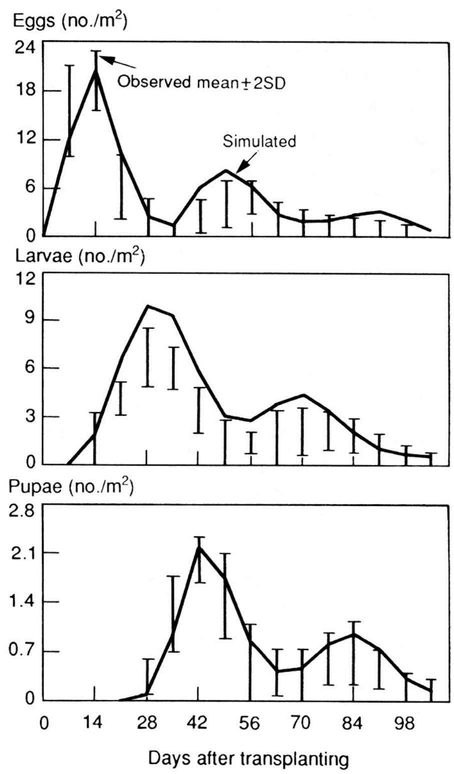
Simulated yellow stem borer (YSB) population dynamics: modeling and evaluation

J. Y. Xia, F. W. T. Penning de Vries, and J. A. Litsinger, IRRI

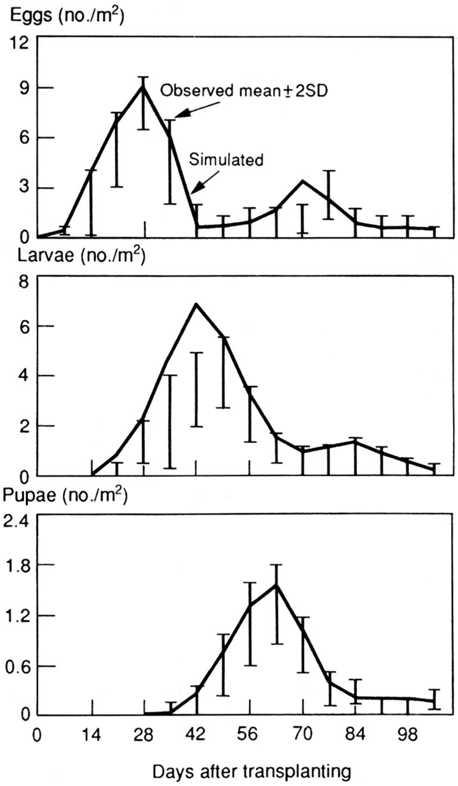
A simulation model of YSB *Scirpophaga incertulas* population dynamics (SIMYSB) was constructed using the state variable approach and boxcar train technique.

YSB population dynamics in a farmer's field were compared to model output for 1987 wet season (WS) and 1988 dry season (DS). A 2,500-m^2 field in Calauan, Laguna, Philippines, was transplanted with C168 (local long-duration variety susceptible to YSB) and not treated with insecticides. The field was subdivided into 50 plots.

Weekly pest sampling started shortly after transplanting. Each week, all plants in three plots selected at random were examined for adult moths and egg masses; 25% of the plants were sampled for dissection.



1. Simulated and farmer's field YSB egg, larval, and pupal populations, Calauan, Philippines, 1987 WS. First-instar larvae were excluded.



2. Simulated and farmer's field YSB egg, larval, and pupal populations. Calauan, Philippines, 1988 DS. First-instar larvae were excluded.

Over a period of 105 d, the model satisfactorily simulated the time of all population density peaks, except one in 1987 WS (Fig. 1) and two in 1988 DS (Fig. 2). The failure to predict by 1 wk the second egg density peak for 1987 WS (Fig. 1) is attributed to sampling error. The failure to predict by 1 wk the second egg and first larval density peaks for 1988 DS (Fig. 2) is probably because low relative humidity in DS slowed insect development. The 1987 WS had two distinct generations in the field; population sizes in the first were much larger than in the second. The 1988 DS had one large, complete first and one small, incomplete second generation.

On the whole, the model simulated YSB field population dynamics well. The acceptable agreement between simulated and observed patterns of YSB population fluctuations allows use of the model for sensitivity analysis, research planning, and evaluation of pest control measures.

Source code with full documentation is available from IRRI. □

Life history and hosts of *Sogatodes pusanus* (Distant) (Hemiptera: Delphacidae)

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

In ricefields, *S. pusanus* is often confused with whitebacked planthopper *Sogatella furcifera* (Horváth). *S. pusanus* is not a rice pest but an *Echinochioa* -feeding planthopper. A colony of 100 adults can hopperburn a plant with 10 tillers in 5-7 d.

The planthoppers differ in color of body, apical cells of the fore wings, and shape of parameres. The two species can be identified by the following key:

- yellow medially and dark brown laterally; apical cells of fore wing crescently dark brown; male parameres straight with two divergent processes apically .... *Sogatodes pusanus* (Distant)
- Pronotum uniformly whitish-yellow except dark brown or pale yellow area underneath eyes; mesonotum whitish-yellow medially with dark brown outer sides of lateral carinae; fore wings with black pterostigma; male parameres broad basally and apically bifurcated without large spine .... *Sogatella furcifera* (Horvath)

We studied the development of *S. pusanus* on 15 common ricefield plant species in three families—Poaceae (9), Cyperaceae (5), and Sphenocleaceae (1). Individual host plants were caged in 10- × 72-cm mylar cylinders (10 cm diam, 72 cm high) with side and top vents. Five pairs of newly emerged adults were released per cage for oviposition. Host suitability was determined by measuring biological parameters: survival, growth index, fecundity, and life cycle duration.

S. pusanus completed development on only two plant species, *Echinochloa colona* and *E. crus-galli* (see table).

On *E. colona,* development from egg to adult took 19.7 ± 0.6 d with an incubation period of 7.5 ± 0.5 d;

Hosts of *Sogatodes pusanus.*[a] **IRRI greenhouse, Feb 1988.**

Plant species	Eggs laid (no./5 females)	Egg hatchability[b] (%)	Nymphl survival[c]	Growth index[d]
Poaceae				
Echinochloa colona (L.) Link	245.7 ± 86.6 a	80.1 ± 9.9 a	87.5 ± 4.9 a	5.7 ± 0.8 a
E. crus-galli (L.) Beauv. ssp. *hispidula* (Retz.) Honda	138.2 ± 61.9 b	76.2 ± 9.1 b	83.7 ± 3.6 a	5.1 ± 0.6 a
Paspalum conjugatum Berg.	44.7 ± 36.4 c	0	0	0
Leptochloa chinensis (L.) Nees	26.2 ± 17.7 d	0	0	0
Oryza sativa L.	25.5 ± 23.3 d	0	0	0
Panicum repens L.	23.5 ± 9.7 d	0	0	0
Chloris barbata Sw.	23.0 ± 2.1 d	0	0	0
Brachiaria mutica (Forsk.) Stapf	11.7 ± 7.9 d	0	0	0
Eleusine indica (L.) Gaertn.	11.2 ± 9.2 d	0	0	0
Cyperaceae				
Cyperus brevifolius (Rottb.) Hassk.	9.0 ± 3.6 d	0	0	0
Fimbristylis miliacea (L.) Vahl	7.4 ± 3.0 d	0	0	0
Cyperus iria L.	4.0 ± 1.6 d	0	0	0
C. kyllingia Endl.	3.2 ± 2.7 d	0	0	0
C. rotundus L.	2.8 ± 1.5 d	0	0	0
Sphenocleaceae				
Sphenoclea zeylanica Gaertn.	16.3 ± 13.6 d	0	0	0

[a]Means (X ± SD) followed by a common letter are not significantly different at the 5% level by DMRT.

[b]Egg hatchability (%) = $\frac{\text{eggs hatched (no.)}}{\text{eggs laid (no.)}} \times 100$

[c]Nymphal survival (%) = $\frac{\text{nymphs becoming adults (no.)}}{\text{eggs hatched (no.)}} \times 100$

[d]Growth index = $\frac{\text{\% nymphs becoming adults}}{\text{mean development period (d)}}$

stadium I, 3.0 ± 0.7 d; stadium II, 3.3 ± 0.4 d; stadium III, 2.6 ± 0.8 d; and stadium IV, 3.3 ± 0.5 d. Survival was 88%.

On *E. crus-galli* ssp. *hispidula,* development took 20.1 ± 1.6 d with a similar incubation period; stadium I, 3.3 ± 0.6 d; stadium II, 3.3 ± 0.5 d; stadium III, 2.6 ± 0.4 d; and stadium IV, 3.3 ± 0.5 d. Survival was 84%. Adult longevity in both host plants was 5.6 ± 1.6 d. All the host plants tested, including rice (TN1), served as ovipositional hosts. □

Water management

Evapotranspiration and deep percolation loss of water in summer rice on lateritic soil

E. P. Patil, A. S. Bal, and S. S. Prabhudesai, Irrigation Research Scheme, Central Experiment Station, Konkan Krishi Vidyapeeth, Wakawili 415711, Dapoli, Ratnagiri District, M.S., India

We studied evapotranspiration and deep percolation in irrigated rice culture during summer 1987-88.

Permanently installed lysimeters (3 × 3 × 1.5 m) were filled with layers of lateritic soil (37% sand, 17.3% silt, and 45.7% clay having bulk density 1.45 g/cm^2 and infiltration rate of 4.42 cm/h). Two lysimeters with closed taps were used for continuous submergence and two with open taps for irrigation scheduled at 25 mm CPE (Cumulative Pan Evaporation).

Rice (Ratna) seedlings were planted in the field and in the lysimeters at the same densities. Fertilizer, weeding, and other cultural operations were similar.

Water use was measured daily from transplanting to harvest in the continuous submergence treatment and after each irrigation in the scheduled irrigation treatment. In the continuous submergence treatment, loss of water was measured as the decline in water level. Soil was submerged to 5 cm after each observation. Loss of water through percolation was measured by the water collected in the irrigation treatment lysimeters. Loss of water from the scheduled irrigation treatment represented evapotranspiration + deep percolation, that from the continuous submergence treatment represented evapotranspiration only.

Combined loss of water due to deep percolation + evapotranspiration amounted to 1,650 mm, of which 1,012 mm (61%) was attributed to percolation and 638 mm (39%) to evapotranspiration (see table). Evapotranspiration under continuous submergence was 12% higher than under scheduled irrigation.

Evapotranspiration was highest from transplanting to maximum tillering, and decreased thereafter. Percolation/day was highest during early crop growth stages. □

Water use in irrigated rice.[a] **Ratnagiri district, M. S., India.**

Growth stage	Continuous submergence		Scheduled irrigation at 25 mm CPE				
	ET (mm)	ET/d (mm)	Water use (mm)	ET (mm)	ET/d (mm)	Percolation (mm)	Percolation/d (mm)
Transplanting to tillering	285.15 (40)	13.58	672.21 (41)	169.83 (27)	8.09	502.39 (50)	23.92
Maximum tillering to panicle initiation	232.78 (32)	8.03	366.66 (22)	170.78 (27)	5.89	195.89 (19)	6.75
Panicle initiation to harvesting	197.67 (28)	5.99	611.10 (37)	297.61 (47)	5.72	313.50 (31)	6.03
Total or av	715.17 (100)	8.62	1650.00 (100)	638.22 (39)[b]	6.26	1011.78 (61)[b]	9.92

[a] Figures in parentheses represent the percentage of the corresponding total of the column. [b] Percent of total water use (row). ET = evapotranspiration. CPE = cumulative pan evaporation.

Postharvest technology

Utilization of rice by-products

M. K. Srivastava and P. N. Tripathi, N. D. University of Agriculture and Technology, Crop Research Station, Masodha, P. O. Dabhasemar, Faizabad 224001, Uttar Pradesh, India

Rice bran, a high volume by-product of rice milling, is a source of protein, oil, nutrients, and calories. Its use varies from fuel to food, including fertilizers, pharmaceuticals, soap, and animal feed. We evaluated the rice bran of short-, medium-, and long-duration varieties for their edible oil content.

Five grams raw rice bran were collected after brown rice was milled in a Kett laboratory model polisher. The bran was air-dried for 6 h and its oil content extracted with refluxing boiling point 40-60°C petroleum ether in a Soxhlet extractor.

Saket 3 bran had the highest oil content, N22 the least (see table). The correlation between growth duration of the varieties and oil content of the bran was not significant. □

Bran oil content of some short-, medium-, and long-duration rice varieties, Uttar Pradesh, India.

Variety	Duration (d)	Oil (%)
Saket 3	95	21.7
N22	100	15.5
Saket 4	105	18.3
T3	125	19.6
IR24	125	17.8
T9	150	18.8
T100	150	19.4
Jalmagna	200	19.0
LSD (0.05)		1.2
Correlation between duration and oil content = 0.02		

Farming systems

Economics of upland rice-based cropping patterns for midhills of Uttar Pradesh

V. Prakash, K. D. Koranne, and J. P. Tandon, Vivekananda Parvatiya Krishi Anusandhan Shala, Almora, U.P., India

We compared three rainfed spring rice-based and one June-seeded rice-based cropping patterns (200% cropping intensity) with traditional pattern (150% cropping intensity) in 1981-83 at Hawalbagh experimental farm (29°36' N, 70°40' E, elevation 1,250 m). The experiment used a randomized block design with six replications.

Soil was sandy loam with medium fertility. NPK were applied at 40-13-9 kg/ ha to June-seeded rice and rapeseed *Brassica campestris* L. var Toria, 40-9-0 kg/ ha to wheat and finger millet, 20-26-17 kg/ ha to pea. Spring rice received 9-7 kg PK and 10 t farmyard manure/ha.

Grain yield, costs, and returns in 1981-83 for rainfed (upland), rice-based cropping systems in mid-hills of Uttar Pradesh, India.

Cropping pattern no.[a]	Components	Yield (t/ha)	Variable cost ($/ha)	Total variable cost ($/ha)	Net return[b] ($/ha)	Total net return ($/ha)	Benefit: cost ratio
1	Jun-seeded rice (experimental strain) -	1.9	199.6	373.0	22.1	226.9	1.6
	wheat (VL 421)	2.8	173.4		204.8		
2	Spring rice (VL 206) -	2.4	197.8	320.9	83.6	187.9	1.6
	pea for green fodder (VL 1)	20.3	123.1		104.3		
3	Spring rice (VL 206) -	2.2	197.8	338.9	63.0	184.5	1.5
	rapeseed (T9)	0.8	141.1		121.5		
4	Finger millet (VL 101) -	1.9	175.9		4.9		
	fallow -	–	–	263.1[c]	–	92.1[c]	1.4
	spring rice (VL 206) -	2.1	197.8		49.6		
	wheat (VL 421)	2.4	173.4		150.9		
5	Spring rice (VL 206) -	1.9	197.8		30.3		
	wheat (VL 421) -	2.9	173.4	335.2[c]	209.4	197.3[c]	1.6
	finger millet (VL 204) -	2.3	175.9		31.9		
	rapeseed (T9)	0.8	141.1		132.6		

[a]Cropping patterns 4 and 5 are 2-year rotations. [b]Gross benefits — variable costs. [c]After discounted B:C; US $1 = Rs 13.4.

Minimum turnaround between crops was 2 wk.

Highest rice yield was with spring rice (170 d duration) following fodder legume (see table). June-seeded rice (110 d duration) yielded almost as well, and the succeeding wheat crop yielded 2.8 t/ha.

Net returns were almost twice as high in the improved crop sequences as in the traditional cropping system. Highest average annual net return was with June-seeded rice - wheat. All intensive cropping sequences had higher benefit:cost ratios than the traditional 2-yr sequence. ☐

Yield of rice - oilseed cropping system without irrigation in coastal saline soil

B. Mazumdar, G. Prasad, and P. N. Jagdev, National Agricultural Research Project, Motto, Balasore 756132, Orissa, India

We studied rice varieties of different durations in the wet season (WS) followed by different oilseed crops in the dry season (DS) 1987-88 under nonirrigated condition in a coastal saline area where soil salinity increases in DS (EC of experimental plot 4.50-5.27 dS/m). Experimental plots were 28 m^2, with four replications.

Thirty-day-old seedlings of medium-duration IR56 and long-duration CR1009 were transplanted the third wk of Jul at 20- × 15-cm spacing. IR56 was harvested in Oct and CR1009 in Dec. Three oilseed crops—mustard (RJ3), linseed (local variety), and safflower (local variety) — were sown the first week of Dec in IR56 plots and the fourth week of Dec in CR1009 plots. All crops were grown without irrigation.

Soil had pH 6.60 with EC 0.35 dS/m in WS but pH 6.8 and EC 4.50 dS/m in Jan and pH 7.0 and EC 5.27 dS/m in Mar.

Rice yield was 3.2 t/ha for IR56 and 3.6 t/ha for CR1009 (see table).

Yields of rice (1987) and oilseeds (1987-88) and rice - oilseed cropping system profitability.[a] Motto, Orissa, India, 1987-88.

Cropping system	Yield (t/ha) Rice	Yield (t/ha) Oil crop	Net return[b] ($/ha)	Net return per $ investment
IR56 - mustard	3.2	0.3	350.18	1.23
IR56 - linseed	3.2	0.3	325.84	1.15
IR56 - safflower	3.2	0.5	417.60	1.47
CR1009 - mustard	3.6	0.3	427.84	1.50
CR1009 - linseed	3.6	0.3	400.75	1.41
CR1009 - safflower	3.6	0.5	478.74	1.68
Mean	3.4	0.4	400.16	1.40
LSD (P 0.05)	ns	0.1	43.11	–

[a]Cost of cultivation= $284.64/ha. [b]$1 = Rs 13.35.

Safflower had the significantly highest yield (0.5 t/ha) among the oilseed crops.

Net returns were significantly highest with CR1009 - safflower ($478.74/ha). ☐

Individuals, organizations, and media are invited to quote or reprint articles or excerpts from articles in the IRRN.

ANNOUNCEMENTS

Recent rice publications list
A new service is added to the IRRN mailing with this issue: the list of the latest acquisitions of the IRRI Library and Documentation Center. It will take the place of selective routing of tables of contents to outlying IRRI cooperators and network collaborators. It will also make the same service available to all rice scientists receiving IRRN. We hope it assists you in your research.

Rice literature search service
The IRRI Library and Documentation Center supports national efforts in rice research through literature retrieval services utilizing the following computerized databases:

- IRRI rice database—125,000 rice literature titles dating from 1961 to 1988, representing both worldwide conventional and nonconventional literature on rice. The original documents are in the IRRI library, and photocopies are available to rice researchers throughout the world.
- AGRICOLA (AGRICultural On-Line Access)—a computerized bibliographic data file from 1981 to August 1988 on CD-ROM laser disk distributed by the U.S. National Agricultural Library. It includes literature related to agriculture from worldwide sources.

A literature search, in the form of computer printouts, will be supplied free to rice researchers. Address requests, specifying the parameters to be searched, to

Library and Documentation Center
International Rice Research Institute
P.O. Box 933
Manila, Philippines

New IRRI publications
Rice farming systems: new directions
Vector-borne disease control in humans through rice agroecosystem management
IRRN subject index and index of varieties, cultivars, and lines for 1988
Helpful insects, spiders, and pathogens — friends of the rice farmer (in Hiligaynon)
A farmer's primer on growing cowpea on riceland (in Tagalog)

ERRATA

Salt tolerance of anther culture-derived rice lines, by F. J. Zapata, M. Akbar, D. Senadhira, and D. V. Seshu. 14 (1) (Feb 1989), 6-7. In the last column on page 7, line 3, should read: ". . . variety, had the highest Na content." □

Leafhopper and planthopper populations and rice tungro virus (RTV) incidence at the tail end of an irrigation system. 12 (1) (Feb 1987), 22.

Authors of the article are A. L. Alviola III, M. E. Loevinsohn, and J. A. Litsinger. □

INTERNATIONAL RICE RESEARCH INSTITUTE
P.O. BOX 933, 1099 MANILA, PHILIPPINES

Printed Matter

Air Mail

ISSN 0115-0944