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Contents

Guidelines and Style for IRRN contributors

Articles for publication in the International Rice Research Newsletter (IRRN) should observe the following guidelines and style.

Guidelines

- Contributions should not exceed two pages of double-spaced typewritten text. Two figures (graphs, tables, or photos) may accompany each article. The editor will return articles that exceed space limitations.
- Contributions should be based on results of research on rice or on cropping patterns involving rice.
- Appropriate statistical analyses should be done.
- Announcements of the release of new rice varieties are encouraged.
- Pest survey data should be quantified. Give infection percentage, degree of severity, etc.

Style

- For measurements, use the International System. Avoid national units of measure (cavan, rai, etc.).
- Abbreviate names of standard units of measure when they follow a number. For example: 20 kg/ha, 2 h/d.
- Express yield data in tonnes per hectare (t/ha). With small-scale studies, use grams per pot (g/pot) or g/row.
- Express time, money, and common measures in number, even when the amount is less than 10. For example: 8 min, $2.3 kg/ha, 2-wk intervals.
- Write out numbers below 10 except in a series containing 10 or higher numbers. For example: six parts, seven tractors, four varieties. *But* There were 4 plots in India, 8 in Thailand, and 12 in Indonesia.
- Write out numbers that start sentences. For example: Sixty insects were put in each cage. Seventy-five percent of the yield increase is attributed to fertilizer.
- Place the name or denotation of chemicals or other measured materials near the unit of measure. For example: 60 kg N/ha, not 60 kg/ha N 200 kg seed/ha, not 200 kg/ ha seed.
- Use common names — not trade names — for chemicals.
- The US$ is the standard monetary unit in the IRRN. Data in other currencies should be converted to US$.
- When using acronyms, spell each out at first mention and put the specific acronym in parentheses. After that, use the acronym throughout the paper. For example: The brown planthopper (BPH) is a well-known insect pest of rice. Three BPH biotypes have been observed in Asia.
- Abbreviate names of months to three letters: Jun, Apr, Sep.
- Define in the footnote or legend any nonstandard abbreviations or symbols used in a table or figure.
- Do not cite references or include a bibliography.

Genetic Evaluation and Utilization

AGRONOMIC CHARACTERISTICS

Viviparous seed germination in rice varieties at Maruteru

P.S.S. Murthy, M. D. Bahu, and S.S.R. Prasad, Agricultural Research Station, Maruteru, Andhra Pradesh, India

In coastal Andhra Pradesh, Mahsuri, the most popularly grown variety, has almost gone out of cultivation because of viviparous seed germination during kharif when rains occur at harvest or when the plants lodge into standing water because of high winds.

To screen for viviparous germination, 25 rice varieties were grown during 1982 kharif under normal conditions at 20- × 15-cm spacing with a fertilizer schedule of 40-13-25 kg NPK/ha.

Mature panicles were collected and kept in trays filled with soil. Conditions for seed germination were created by maintaining water saturation level in the trays. Temperatures ranged from 23-25°C to 28-31°C. Varieties were classified into 3 germination capacity groups: strong (80-94% germination), moderate (more than 20% germination), and weak (0-5% germination).

Ten varieties exhibited weak viviparous germination and can be safely grown during kharif (see table). MTU8002, MTU8089, and MTU4870 already are widely grown. Among the moderate varieties, MTU7029 occupies 50% of the area in coastal A.P. All long-duration kharif varieties tested had lower viviparous germination than Mahsuri (80% germination at maturity). ■

Viviparous seed germination in Maruteru rices.

Strong	Moderate	Weak
MTU4392	MTU10, MTU19,	MTU6024, MTU11, MTU8089,
MTU5195	MTU4569, MTU3,	MTU8002, MTU23, MTU5194,
MTU2716	MTU3626, MTU7030,	MTU8, MTU13, MTU4870,
MTU6182	MTU7029, MTU7633,	MTU16
MTU5182	MTU5196, MTU5249	

Rice ratooning in West Bengal

B.K. Mandal and B. N. Chatterjee, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal 741235, India

In the low-lying marshy areas of West Bengal, two rice crops, kharif (Jul-Nov) and boro (Jan-May), are grown. During the rainy season, 50-100 cm stagnant water caused by impeded drainage cuts productivity and the high-yielding varieties do not show an advantage over local varieties.

Maintaining a continuous crop (through ratooning) was tested with two high-yielding varieties (IR36 and IR50) and two photoperiod-sensitive varieties (CR1014 and Kumragore) that can stand semideep water lodging. Seedlings were transplanted in Jan with 4 fertilizer treatments (100 kg N, 100-22 kg NP/ha, 100-42 kg NK/ha, and 100-22-42 kg NPK/ha) in a split-plot design with 4 replications. All ratoon plots received 20 kg N/ ha at main crop harvest and 10 kg N/ ha at 60 d.

IR50 and IR36 started putting forth ratoon panicles 30 d after main crop harvest. Mature panicles were picked at 15- to 20-d intervals. A number of hills died. The 2 photoperiod-sensitive varieties flowered 120 d after the main crop harvest. Fertilized ratoon crops of the tall varieties partially lodged.

The photoperiod-sensitive varieties yielded appreciably lower in the main crop than the two high-yielding varieties (see table) because the number of mature panicles was much lower. In the ratoon crop, IR30 and IR50 yields were appreciably lower than their main crop yields. CR1014 and Kumragore also had reduced ratoon yields, but not as much.

Panicles per unit area, grains per panicle, and grain test weight in IR50 and IR36 were lower in the ratoon crop than in the main crop. Except in test weight, reductions were not significant in the CR1014 and Kumragore ratoons. Residual P effect was not significant in the ratoon crops.

IR50 can be ratooned to produce a total yield of 7 t/ha.☐

Effect of fertilizer treatment on growth and productivity of main and ratoon crops in West Bengal.

Treatment	Grain yield (t/ha)	Panicles /m^2	Grains/ panicle	1000-grain wt (g)	Duration (d)
		Main crop			
N 100	3.2	251	74	19.90	
NP 100-22	3.8	313	85	20.6	
NK 100-42	3.3	244	76	20.0	
NPK 100-22-42	3.9	327	91	20.6	
CD at 5%	0.4	49	8	0.3	
IR50	5.3	417	89	21.7	153
IR36	5.1	399	83	20.9	153
CR1014	1.6	197	90	15.0	173
Kumragore	2.2	284	84	23.5	173
CD at 5%	0.2	38	6.2	0.5	
		Ratoon crop			
N 100	1.5	272	62	18.5	
NP 100-22	1.8	325	76	19.4	
NK 100-42	1.6	278	66	18.6	
NPK 100-22-42	1.8	319	74	19.0	
CD at 5%	0.1	ns	ns	ns	
IR50	1.7	312	51	18.6	90[a]
IR36	1.4	302	49	18.4	90[a]
CR1014	1.7	292	91	16.0	170
Kumragore	1.7	288	87	22.5	170
CD at 5%	0.1	ns	10	0.7	

[a]Started flowering 30 days after main crop harvest.

Effect of shallow submergence on agronomic characters

M.S. Rao, Agricultural Research Station (ARS), Pulla, West Godavari District; and P.S.S. Murthy, ARS, Maruteru, West Godavari District, Andhra Pradesh, India

We studied the effect of shallow submergence on four popular rices and two tall varieties. Entries received shallow submergence (60 cm) for 70 d starting from 40 d after transplanting. Water level in the control plots was 5-7.5 cm. Performance in shallow submergence was evaluated by grain yield and other agronomic characters.

Shallow submergence resulted in an increase in plant height (32%) and flowering duration (3%), and a decrease in panicle-bearing tillers (30%), total spikelets (12%), and filled grains (19%) (see table). This resulted in a 50% decrease in grain yield.

Under submergence, CN540 had the highest yield (3.1 t/ha), followed by PLA1100 (2.7 t/ha).☐

Grain yield and other agronomic characteristics of rice varieties in shallow submergence. Pulla, Andhra Pradesh, India, 1984 kharif.

Variety	Parentage	Plant ht (cm) at maturity		Flowering duration (d)		Panicle-bearing tillers/plant		Total spikelets/ panicle		Fertility (%)		Grain yield (t/ha)	
		Control	60 cm water	Control	60 cm water	Control	60 cm water	Control	60 cm water	Control	60 cm water	Control	60 cm water
MTU5182	MTU4569/ARC6650	108	146	131	134	11	7	202	198	98	96	5.4	2.4
MTU5293	MTU4569/ARC6650	104	145	141	144	11	7	178	146	60	68	5.3	2.4
MTU4870	MTU4569/ARC6650	109	155	135	142	9	6	165	153	99	80	5.1	1.4
PLA1100	Mahsuri/Vijaya	94	136	140	148	10	8	280	235	91	69	5.5	2.7
CN540	IR262/Khao Nahng Nuey 11	141	181	130	130	9	7	236	222	93	89	5.0	3.1
NC492	Pureline selection	178	203	140	140	8	7	183	135	78	81	4.8	2.6
Mean		122	161	136	140	10	7	207	182	86	80	5.2	2.4

Maturity behavior of Intan in main and ratoon crops

M. Mahadevappa, Nagaraju, and M. K. Narasimhareddy, Universiy of Agricultural Sciences, Bangalore, India

A wet season Intan main crop — seeded on 19 Jul, transplanted on 14 Aug, and harvested on 11 Jan — was ratooned. The main crop stubble was cut 8-10 cm high and topdressed with 25 kg N/ha. Water management on the ratoon crop was similar to that on the main crop. Because uneven maturity is reportedly a problem in ratoon crops, 46 hills were measured when the ratoon looked ready for harvest on 24 Mar. Of 742 tillers, only 360 were mature (48.5%), 315 were in flower (42.5%), and 67 were still in the boot leaf stage (9.0%). An average of 8 tillers/hill matured. The ratoon crop yield was 3.6 t/ha.

This means that ratoon crop yields could be substantially increased with uniform flowering. □

Genetic Evaluation and Utilization
DISEASE RESISTANCE

Blast-resistant upland variety developed in Mato Grosso State, Brazil

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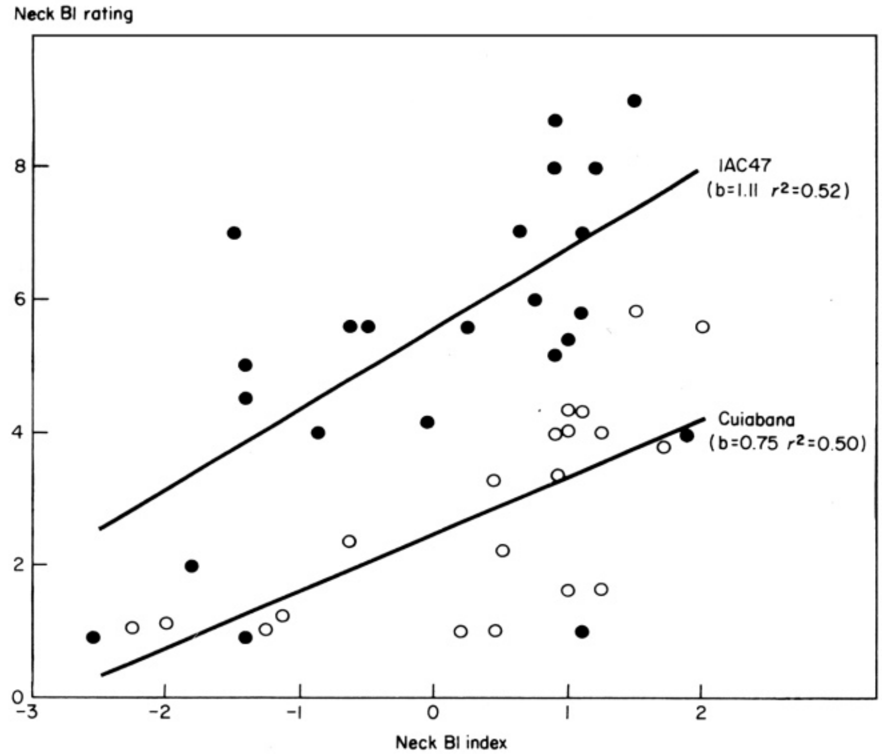
CNA104-B-2-Py43-2 (IAC47/SR2041-50-1), an upland rice developed at the National Center for Rice and Beans (CNPAF/EMBRAPA), has been released as Cuiabana variety by the Mato Grosso State Research Organization for Agriculture and Animal Husbandry (EMPA-MT).

The performance of Cuiabana was evaluated during 1982–83 and 1983–84 growing seasons in 39 advanced yield trials, using widely cultivated upland rice IAC47 as the local check.

In 6 locations, Cuiabana yield increases averaged 9.4% over the local check. Yields ranged from 1.6 to 4.8 t/ha in observations by extension service.

Cuiabana is moderately resistant to leaf and panicle blast (Bl). An average neck Bl incidence of 2.7% was registered, but leaf Bl was negligible.

Bl stability as a function of the integrated effect of environmental and biological factors was evaluated in 23 varietal trials in the states of Mato Grosso, Mato Grosso do Sul, Goiás, and Minas Gerais. The neck Bl rating of the test cultivar in each trial was regressed against the neck Bl index.



Regression of neck Bl rating for IAC47 and Cuiabana on neck Bl index. Mato Grosso, Brazil, 1983-84. Neck Bl was evaluated using the 1980 *Standard evaluation system* for rice scale of 1-9.

The index was calculated by subtracting the mean disease rating of all trials from the average disease rating of that particular experiment. Positive values indicated disease under favorable environmental conditions and negative values indicated disease under unfavorable environmental conditions. The stability of the cultivars' Bl resistance was compared by the slope (b) of the regression line. Results show that the disease resistance of Cuiabana is more stable across environments than that of IAC47 (see figure).

The average height of Cuiabana is 107 cm in the poor soils of Mato Grosso; in soils with high fertility, it may attain 150 cm and often lodges. The grains are long and slender with high milling and cooking quality. Growth duration is 120-125 d. □

Influence of seedling rate on tungro (RTV) incidence at Cuttack

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A trial under protected and unprotected conditions measured influence of number of seedlings per hill on RTV incidence. Protection was 0.01% decamethrin sprayed weekly up to heading. TN1 (susceptible) and Ratna (tolerant) were planted in 3- × 3-m plots in a randomized block design with 3 replications.

Ten days after transplanting (DT), infected Jaya tillers were transplanted around each plot to inoculate unprotected plots. Protected plots were not inoculated. Disease incidence was recorded 60 DT.

Disease incidence in TN1 was 100% in all unprotected plots; it varied in tolerant cultivar Ratna (see table). Disease incidence gradually decreased with seedling rate.

Effect of number of seedlings per hill on RTV incidence and grain yield in rice cultivars TN1 and Ratna.[a] Orissa, India.

Seedlings/ hill (no.)	Disease incidence (%) in unprotected plots		Grain yield (t/ha)			
			Unprotected		Protected	
	TN1	Ratna	TN1	Ratna	TN1	Ratna
1	100	62 d	0.5 a	1.8 c	1.5 b	2.8 b
2	100	42 c	0.5 a	2.3 bc	2.1 a	3.4 ab
3	100	28 b	0.5 a	2.5 b	2.1 a	3.4 ab
4	100	12 a	0.5 a	3.1 a	2.0 a	3.6 ab
6	100	13 a	0.6 a	3.1 a	2.2 a	3.6 ab
8	100	9 a	0.6 a	3.1 a	2.0 a	3.8 a

[a] In each column, values followed by the same letter do not differ significantly at P = 0.05 by DMRT.

Grain yield differed between protected and unprotected plots. Yields of TNI were higher under protected conditions. Under protected conditions, yields did not significantly differ at 2 to 5 seedlings/ hill, but were lower for 1 seedling/ hill. Yields of Ratna under unprotected conditions gradually increased with numbers of seedlings/ hill; there was no significant yield difference among 4, 6, and 8 seedlings/ hill.

Number of seedlings per hill had no effect on susceptible TN1, especially under unprotected conditions. Four seedlings per hill is optimum for Ratna. □

Growth and virulence of two isolates of *Sarocladium oryzae* causing sheath rot (ShR) in rice

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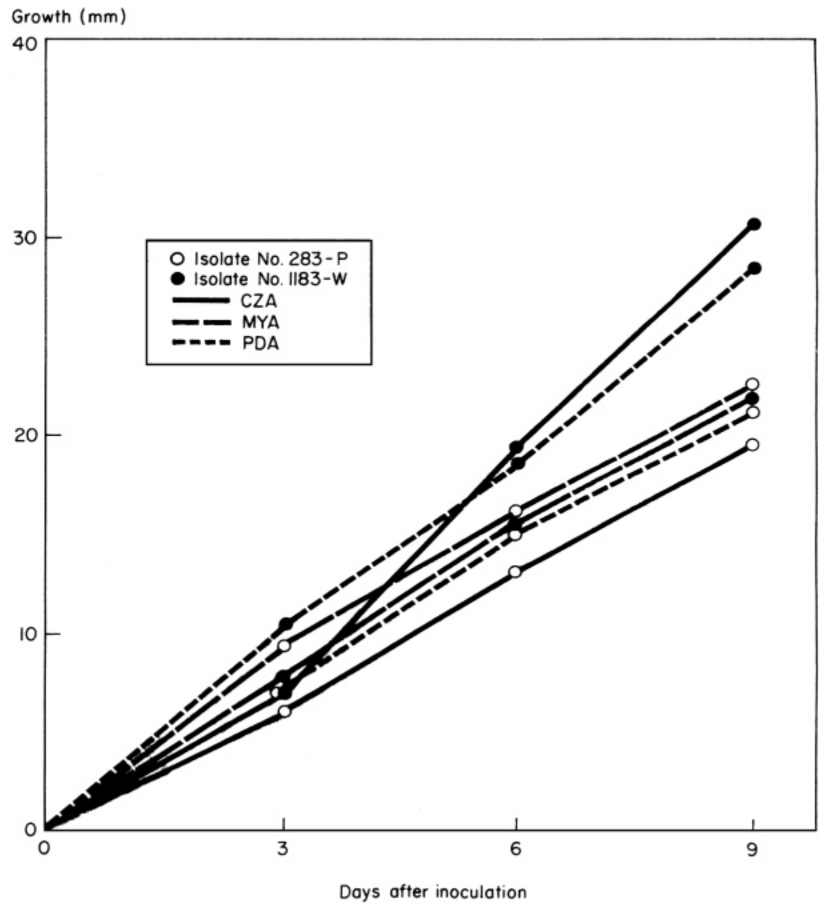
ShR is caused by *Sarocladium oryzae* and *S. artenuatum,* the former being more prevalent. To obtain information on the variation in growth and virulence of *S. oryzae,* two isolates that differed in colony color were used. The mycelium of isolate 283-P was slightly pinkish, isolate 1183-W appeared whitish on potato dextrose agar medium. Three areas were studied: morphology of the conidia and conidiophores, growth of the two isolates in three semisolid and liquid media, and virulence of the isolates in different rice genotypes.

No difference in morphology was found. Growth in Czapek's solution agar (CZA), malt yeast extract agar (MYA), and potato dextrose agar (PDA) were similar, but isolate



Linear growth of 2 isolates of *Sarocladium oryzae* in 3 media at 28 ± 2 ºC.

1183-W grew better than isolate 283-P in both semisolid and liquid media (see figure).

Thirty-seven varieties and lines at early booting were inoculated in the field with infected rice grain culture of the two isolates. The infected grain was pressed, with slight wounding, onto the sheath tissue of the flag leaf of a tiller and attached with scotch tape. Disease severity or lesion length was measured at hard-dough to maturity.

Disease severity in genotypes differed. A significant isolate × variety interaction indicates the possibility that the isolates are distinct strains or races. Except for Kalarharsall, the difference in disease severity was not great. The mean disease severity of the 37 entries was significantly higher for isolate 283-P (13.1 cm) than for isolate 1 183-W (11.4 cm), suggesting that 283-P is more virulent (see table). For these isolates, there was no relation between growth in culture media and virulence.

The mean disease severity based on lesion length shows that only one genotype, BR51-46-5-CI, may be considered moderately resistant (lesion length less than 6.5 cm); all others were moderately to highly susceptible (lesion length more than 6.5 cm). □

Reactions of 37 varieties and lines to 2 isolates of *Sarocladiurn oryzae* cawing sheath rot of rice.

Variety or line	Mean length of lesion[a] (cm)	
	Isolate 283-P	Isolate 1183-W
B2489B-PN-1-76-8	24.0	21.6
BR51-46-5-C1	6.3	3.0
BR51-49-6-HR50	14.4	5.3
BR425-48-1-4-1-2-1	9.7	3.3
BR425-53-2-1-1-4-3	11.0	6.6
BR425-87-1-1-2-3-1	11.5	11.5
BR425-93-3-1-2-3-4	9.3	15.0
BR425-110-2-1-1-2-3	18.5	14.0
BR425-110-2-1-1-6-1	11.3	6.0
BR425-177-1-3-1-4-4	10.3	9.8
BR425-177-1-3-1-5-3	16.9	10.6
BR1242-6-1-1	15.0	9.2
BR1356-10-1-6	9.0	6.2
BR1356-13-2-1	19.8	13.0
BR1356-40-3-1	14.7	2.5
BR1356-40-4-4	8.7	7.5
BR1412-5-1-1	10.1	20.6
IR54	8.2	15.8
IR34	10.3	9.3
IR10781-75-3-2	18.3	15.4
IR17983-45-3-2-3-1	7.2	12.3
IR18047-3-2-1-3	9.5	11.8
IR25166-14-1-1	18.5	7.3
IR25173-2-5-2	12.8	10.4
IR25173-5-1-2	16.0	9.3
IR25177-3-1-2	16.0	9.0
Kachamota	10.0	14.2
Kalarharsall	4.3	18.0
KAU 2084	13.2	19.3
M12C-34-3	9.0	7.6
M61B-1-1-2	15.3	13.5
M61B-11-2-1	15.0	6.6
M61B-18-2-1	9.0	9.3
M66B-30-1	14.8	13.5
Ptb-18	17.5	10.2
RNR74229	19.8	21.5
RP1125-104-2-1-1	20.5	19.8
Mean	13.1	11.4

[a]Means of 3 replications. LSD for comparing means: (a) Isolates within a variety = 15.9 at P .05, (b) Varieties within an isolate = 5.9 at P .05, (c) Isolates among all varieties = 1.0 at P .05.

Studies on ratoon performance of leaf blast-susceptible varieties at ARS, Ponnampet, Karnataka

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In the National Screening Nursery (NSN) of 1985-86 kharif, 50 rice cultures were screened for reaction to leaf blast (Bl). None of the cultures were resistant to leaf or neck B1; ratings varied from 7 to 9 cm on a 0-9 scale, with practically no yield.

The culms of the diseased entries were cut 10-15 cm from the base of the plant and allowed to ratoon. Only 3 of the 50 cultures gave rise to productive tillers. These cultures were free from B1 and yielded, an average 1.6 t/ha. In the ratoon, plant height was reduced 46.6% and days to flowering 42.6% (see table). □

Performance of main crop and ratoon crop of promising cultures in Mandya, India.

Variety	Main crop					Ratoon crop		
	Days to 50% flowering	Plant height (cm)	BI rating: Leaf B1	BI rating: Neck B1 (%)	Yield (t/ha)	Days to 50% flowering	Plant height (cm)	Yield (t/ha)
IET9667	86	133	2	90	0	36	99	1.7
IET9668	89	125	0	100	0	38	96	1.7
IET9670	94	114	1	90	0.1	41	91	1.6
Intan (check)	115	87	7	90	0	Ratoon crop destroyed by leaf B1		

[a]The test varieties had neither leaf nor neck Bl.

Balimau Putih, cultivar tolerant of rice tungro-associated viruses

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Rice cultivar Balimau Putih (IRRI Acc. no. 17204) consistently showed tungro resistance in greenhouse mass-screening tests. Its resistance to rice tungro bacilliform (RTBV) and spherical (RTSV) viruses was further evaluated by test tube inoculation and compared with resistance of susceptible TN1.

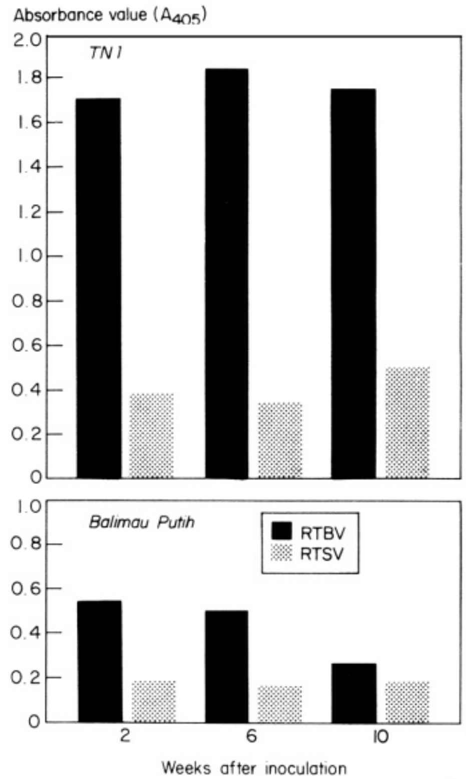
Seven-day-old seedlings, 120 for each variety, were infested with green leafhoppers *Nephotettix virescens* (5 insects/seedling) that had 4 d access to TN1 plants infected with both RTBV and RTSV. Presence of tungro-associated viruses was detected by enzyme-linked immunosorbent assay (ELISA) of each plant 1 mo after inoculation. The relative amount of virus was determined by ELISA (absorbance value at 405 nm) at 2,6, and 10 wk after inoculation. Height and yield were measured.

Balimau Putih was more susceptible to infection with tungro-associated viruses than TN1 (see table) but did not show symptoms typical of RTBV and RTBV+RTSV infection. Relative amounts of RTBV and RTSV were consistently lower in Balimau (see figure). Apparently, the multiplication of tungro-associated viruses was tolerable. Height reduction due to infection was lower in Balimau Putih than in TN1. Balimau Putih also had lower yield reductions. □

Reaction of Balimau Putih and TN1 in RTBV and RTSV by test tube inoculation of RTBV and RTSV at 5 insects [a] per seedling. IRRI, 1986.

Variety	Plants (no.) infected with [b]			Healthy plants (no.)	Infection (%)	Height reduction (%)		Yield reduction (%)	
	RTBV+ RTSV	RTBV	RTSV			RTBV	RTBV+ RTSV	RTBV	RTBV+ RTSV
TN1	87	31	0	8	93.6	41.6	21.3	90.0	50.0
Balimau Putih	46	68	3	5	95.9	11.4	5.0	18.4	1.6

[a]Green leafhopper *Nephotettix virescens* were given 4 d access to TN1 plants infected with both RTBV and RTSV. [b] Total of 4 trials. Detected by ELISA.



Relative amounts of RTBV and RTSV in doubly infected TN1 and Balimau Putih. IRRI, 1986.

Genetic Evaluation and Utilization
INSECT RESISTANCE

An approach to develop gall midge (GM)-resistant rice strains

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The GM *Orseolia oryzae* Wood-Mason (Diptera: Cecidomyiidae) is being successfully tackled through conventional breeding using major genes from known resistant donors. Some parents, like IR20 and Pelita 1/1, although susceptible, were known to possess both duplicate and complementary genes for GM resistance. The approach exploits these duplicate and complementary genes to develop GM-resistant, high yielding cultures.

Progeny from crosses involving IR20 and two other susceptible parents (Zenith, Malagkit Sungsong) were studied. During 1975–80, single plant progeny from F_3 to F_6 were selected under high insect pressure artificially created in the field. From 1981, single plants selected for high resistance, with semidwarf habit and other desirable agronomic traits, were bulked in F_7 and

Performance of promising GM-resistant cultures at Cuttack, India.

Designation	Cross combination [a]	Silvershoots (%)				Yield (t/ha)			Grain type [b]
		1981	1982	1983	1984	1982	1983	1984	
CR294-28-1	IR20/Zenith//MSS	1.5	0.1	1.3	0.7	3.9	4.1	3.9	LS
CR294-548	IR20/Zenith//MSS	2.6	nil	1.1	nil	4.4	4.3	4.1	LS
CR316-639	IR20/MSS	2.3	0.1	1.6	nil	4.2	4.1	4.2	LB
CR318-548-7	IR20/MSS//Zenith	1.2	nil	1.2	nil	4.0	4.2	3.6	LB
Jaya	Susceptible standard	51.1	16.6	26.6	25.8	3.1	3.1	3.0	LB
IR36	Resistant standard	1.8	0.6	1.3	nil	3.7	4.1	4.1	LS

[a] MSS = Malagkit sungsong. [b] LS = long slender, LB = long bold.

field evaluated for yield potential and GM resistance.

Field trials led to the identification of 4 cultures (2 from CR294, 1 from CR316, I from CR318) of 125 to 130 d duration with high resistance to GM (see table). All cultures also possess good levels of field resistance to bacterial leaf blight. They are being tested under the All India Coordinated multilocation testing in GM problem areas. Preliminary data of 1984 kharif showed that CR294-548 (IET9233) was resistant at the three sites of high GM incidence (Mangalore, Raipur, Sakoli). Average yield was outstanding in both the three high-incidence locations and in the nine test locations.

Tailoring GM resistance by exploiting the duplicate and complementary genes from IR20 might possibly counter the increasing spectrum and admixtures of GM biotypes.

Sources of resistance to whitebacked planthopper (WBPH) and green leafhopper (GLH)

R. Velusamy and P.C. Sundara Babu, Tamil Nadu Agricultural University (TNAU), Coimbatore 541003, India; and D. V. Seshu, IRTP, IRRI

We evaluated 100 rice accessions received through IRWBPHN 85 for resistance to WBPH *Sogatella furcifera.* The 15 accessions identified as resistant were further evaluated for resistance to GLH *Nephotettix virescens* by the standard seedbox screening.

Pregerminated seeds were sown in 60-× 40- × 10-cm seedboxes; Ptb 33 and TN1 served as resistant and susceptible checks. Separate seedboxes were used for each hopper species. Each accession was replicated five times for each insect species.

Each seedling was infested with 8 2d-instar nymphs of WBPH and 5 2d-instar nymphs of GLH 7 d after sowing. Damage was rated when 90-100% of TN1 plants died.

All 15 accessions were resistant to WBPH and to GLH (see table). □

Reaction of rice varieties, cultures, and mutants to yellow stem borer (YSB) in Kerala

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Activity of the YSB *Scirpophaga incertulas* (Walker) was studied on 24 rice varieties, cultures, and mutants in 1984 kharif and 26 in 1985 kharif.

Entries were grown in 20-m^2 plots replicated 3 times. Incidence of deadhearts 45 d after transplanting and incidence of whiteheads 10 d before harvest were recorded and damage percentage was calculated.

In 1984, deadheart incidence was highest in culture 1907 and lowest in culture 4. The highest number of whiteheads was in TKM9 and the lowest in culture 52-3-6.

In 1985, the incidence of deadhearts was highest in culture 4-4 and TKM9 and lowest in culture 126. The highest number of whiteheads was recorded in culture 4-4 and the lowest in Triveni (see table). □

Rice resistance to WBPH and GLH. TNAU, Coimbatore, India, 1985.

Designation	Damage rating[a]	
	WBPH	GLH
Chempan	1 a	1 a
Chemparan pandi	3 b	1 a
Horonamawee	1 a	1 a
IR9852-22-3	1 a	1 a
IR13427-40-2-3-3	1 a	1 a
IR13429-1961	1 a	1 a
IR13475-7-3-2	1 a	1 a
IR15429-268-1-2-1	3 b	1 a
IR15527-21-2-3	3 b	1 a
IR15529-256-1	3 b	1 a
IR15795-151-2-3-2-2	1 a	1 a
IR28154-101-3-2	1 a	1 a
Podiwi A8	3 b	1 a
Valsara Champara	1 a	1 a
Sufaida 172	1 a	1 a
Ptb 33 (resistant check)	1 a	1 a
TN1 (susceptible check)	9 c	9 b

[a]Mean of 5 replications. In a column, means followed by a common letter are not significantly different at the 5% level by Duncan's multiple range test.

YSB incidence in rice in Kerala, India, 1984 and 1985 kharif.[a]

	Deadhearts (%)		Whiteheads (%)	
	1984	1985	1984	1985
Variety				
Jyothi	1.0	0.2	7.3	5.6
	(1.2)	(0.8)	(2.7)	(2.3)
Jaya	0.7	0.4	3.9	14.1
	(1.1)	(1.0)	(1.9)	(3.8)
MO 5	0.2	0.1	6.0	10.0
	(0.8)	(0.8)	(2.2)	(3.1)
MO 6	0.4	0.1	12.2	7.4
	(1.0)	(0.8)	(3.5)	(2.6)
TKM 9	0.7	0.6	36.2	20.1
	(1.1)	(1.0)	(5.9)	(4.5)
IR36	0.2	0.5	7.3	13.0
	(0.8)	(1.0)	(2.6)	(3.6)
IR50	0.2	0.1	4.5	13.3
	(0.8)	(0.8)	(2.2)	(3.5)
Culture				
1907	1.3	0.3	9.5	9.1
	(1.3)	(0.9)	(3.1)	(3.0)
1954	0.3	0.2	4.5	10.5
	(0.9)	(0.8)	(1.9)	(3.2)
43-1-4	0.2	0.3	5.5	10.7
	(0.9)	(0.9)	(2.4)	(3.2)
52-3-6[b]	0.1	0.4	2.7	9.7
	(0.8)	(0.9)	(1.4)	(3.1)
25337	0.3	0.2	7.4	7.4
	(0.9)	(0.8)	(2.5)	(2.6)
169[b]	0.5	0.2	12.1	5.1
	(1.0)	(0.8)	(3.5)	(2.3)
25331	0.3	0.3	9.0	15.2
	(0.9)	(0.9)	(2.7)	(3.9)
4[b]	0.1	0.3	4.6	13.1
	(0.8)	(0.9)	(2.0)	(3.6)
1537/2	0.2	0.2	5.2	7.1
(Karthika)	(0.9)	(0.9)	(2.1)	(2.7)
126	0.2	0.0	10.3	6.3
	(0.8)	(0.7)	(2.8)	(2.5)
26-1-1	0.2	0.4	5.8	9.6
	(0.8)	(0.9)	(2.4)	(3.0)
4-4	0.2	0.4	5.7	20.4
	(0.8)	(0.9)	(2.3)	(4.5)
Mutant				
6	0.3	0.3	17.8	17.8
	(0.9)	(0.9)	(4.0)	(4.0)
210	0.2	0.1	11.5	12.4
	(0.8)	(0.8)	(3.3)	(3.5)
2	0.3	0.2	13.8	15.0
	(0.9)	(0.9)	(3.7)	(2.4)
102[b]	0.4	0.1	6.6	5.6
	(1.0)	(0.8)	(2.6)	(2.4)
109	0.2	0.3	9.5	13.7
	(0.8)	(0.9)	(3.1)	(3.3)
Cul. 23332-2	–	0.2	–	13.2
		(0.8)		(3.6)
Triveni[b]	–	0.3	–	5.0
		(0.8)		(2.2)
CD at 5% level	0.2	0.2	1.3	1.2

[a]Figures in parentheses are square root transformation values. [b]Less susceptible to stem borer incidence.

Sources of dual resistance to whitebacked planthopper (WBPH) and green leafhopper (GLH)

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We evaluated 100 rice accessions from the 1985 lnternational Rice Whitebacked Planthopper Nursery for resistance to WBPH *Sogatella furcifera* under greenhouse conditions; 15 accessions were identified as resistant. The WBPH-resistant varieties were further evaluated for resistance to GLH *Nephotettix virescens,* using the standard seedbox screening test.

Pregerminated seeds were sown in 60- × 40- × 10-cm seedboxes. Ptb 33 was the resistant check and TN1 the susceptible check. Each accession was replicated five times for each insect species. Seedlings were infested with 8 2d-instar nymphs of WBPH and 5 2d-instar nymphs of GLH/seedling 7 d after sowing. Damage was rated using the *Standard evaluation system for rice* when 90-100% of TN1 plants had died.

All 15 accessions were resistant to WBPH and to GLH (see table). ☐

Resistance of selected rice accessions to WBPH and GLH. Greenhouse, TNAU, Coimbatore, India, 1985.

Rice accession	Damage rating [a]	
	WBPH	GLH
Chempan	1 a	1 a
Chemparan pandi	3 b	1 a
Horonamawee	1 a	1 a
IR9852-22-3	1 a	1 a
IR13427-40-2-3-3	1 a	1 a
IR13429-196-1	1 a	1 a
IR13475-7-3-2	1 a	1 a
IR15429-268-1-2-1	3 b	1 a
IR15527-21-2-3	3 b	1 a
IR15529-256-1	3 b	1 a
IR15795-151-2-3-2-2	1 a	1 a
IR28154-101-3-2	1 a	1 a
Podiwi A8	3 b	1 a
Valsara Champara	1 a	1 a
Sufaida 172	1 a	1 a
Ptb 33 (resistant check)	1 a	1 a
TN1 (susceptible check)	9 c	9 b

[a]Mean of 5 replications. In a column, means followed by a ‘common letter are not significantly different at the 5% level by Duncan’s multiple range test.

Yield of gall midge (GM)-resistant rice varieties after early pulse crop at Hyderabad

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Yields of GM-resistant rices WGL 20506, WGL 23022, and WGL 16145 and cultivar Surekha following a green manure crop were examined. An early pulse crop was harvested in early Aug. The trial compared broadcasting sprouted seed and transplanting 30-d-old seedlings. Sowing was on 1 Aug and 16 Aug. Seed rate for broadcasting was 120 kg/ha, spacing for transplanting was 10 × 10 cm. Recommended fertilizer was 80-22 kg NP/ha. N was applied in three splits, all the P was applied basally.

Yield of promising GM-resistant rices following a green manure crop on 2 planting dates, Hyderabad, India. [a]

Cultivar	Yield (t/ha)			
	2 Aug planting		16 Aug planting	
	BC	TP	BC	TP
WGL 20506	3.5	3.5	3.6	3.3
WGL 23022	3.6	4.0	3.3	3.9
WGL 16145	3.3	5.0	2.4	4.4
Surekha	3.5	5.0	2.7	4.4
Mean yield	3.6	4.4	3.0	4.0

[a]BC = broadcast, TP = transplanted.

Transplanted crops yielded higher than broadcast crops (see table). Increases were 34.7% in WGL 16145 and 30.2% in Surekha in the first planting and 16.5% in WGL 23022, 40.5% in WGL 16145, and 38.8% in Surekha in the second planting. ☐

Resistance of selected *Oryza sativa* and *O. brachyantha* cultivars to the rice leaffolder (LF)

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Mass screening in the IRRI greenhouse has yielded cultivars with resistance or moderate resistance to the LF *Cnaphalocrocis medinalis* Guenée. Oviposition, larval survival, and host preference were studied on three resistant wild rices and five resistant cultivars.

One-month-old seedlings were planted in 5-cm-diam clay pots at 5 plants/pot per cultivar in a randomized complete block design with 5 replications. For the oviposition treatment, each replication was enclosed in a fiberglass net and 50 pairs of newly emerged adults were introduced. Eggs laid were counted after 3 d.

For larval survival measurement,

Table 1. Larval survival and oviposition preference of rice LF on *Oryza brachyantha* **and** *O. sativa* **cultivars.** [a] **IRRI, 1986.**

Oryza spp.	Accession no.	Larval survival (%)	Oviposition preference
O. brachyantha	101232	2 a	71 a
O. brachyantha	101233	14 a	63 a
O. brachyantha	101234	10 a	80 a
O. sativa			
Darukasail	45493	56 bc	128 b
Kamalbhog	49020	52 bc	176 c
Choorapundy	48529	38 b	131 b
TKM6	237	44 bc	172 c
TN1	105	64 c	227 d

[a]Av of 5 replications. n = 10. Means followed by a common letter are not significantly different (P = 0.05) by DMRT.

pots were infested with two 1st-instar larvae/tiller and enclosed in mylar film cages. Surviving larvae were determined 17 d after infestation.

To study host preference, 15-cm-diam petri dishes were divided into 6 areas. Three leaf pieces of each variety tested and 3 control leaf cuts were placed in alternate areas and 24 1st-instar larvae were placed in the center. Larvae settling on each leaf piece were counted at 24 h. Five replications were made.

O. brachyantha were more resistant than the *O. sativa* cultivars; fewer eggs were laid on them and fewer larvae survived (Table 1). Fewer larvae also settled on the wild rice leaves (Table 2).

Wild rices belonging to the *O. brachyantha* group have narrow, short leaves; *O. sativa* varieties have long, and broad leaves. Correlation of plant characters and LF infestation showed that cultivars with longer, broader leaves had more damage. These cultivars' leaves may have made folding easier, providing larger feeding areas. □

Table 2. Attraction of rice LF larvae to *Oryza brachyantha* and *O. sativa* cultivars.[a] IRRI, 1986.

Oryza spp.	Accession no.	Feeding preference (no. larvae/arena)[b]	Difference[c]
O. brachyantha	101232	8	56 **
TN1	–	64	
O. brachyantha	101233	15	32 **
TN1	–	47	
O. brachyantha	101234	16	42 **
TN1	–	58	
O. sativa	–		
Darukasail	45493	32	21 *
TN1	–	59	
Kamalbhog	49020	34	27 *
TN1	–	61	
Choorapundy	49529	34	17 *
TN1	–	51	
TKM6	237	39	19 *
TN1	–	58	

[a] Av of 5 replications. n = 24. [b] Reading taken at 24 h. [c] Level of significance: ** = 0.01, * = 0.05. TN1 is the susceptible check.

Green leafhopper (GLH) resistance in wild rices

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We evaluated 24 wild rices for resistance to GLH *Nephotettix virescens* under greenhouse conditions by the standard seedbox screening. Pregerminated seeds were sown in 60- × 40- × 10-cm seedboxes with resistant check Ptb 33 and susceptible check TN1. Each accession had five replications.

Seedlings were infested with 5 2d-instar nymphs/seedling 7 d after sowing. Damage was rated when 90-100% of susceptible TN1 seedlings died.

Sixteen wild rices were resistant, four were moderately resistant, and four were susceptible to *N. virescens* (see table). □

Reaction of wild rices to *Nephotettix virescens* in seedbox screening, TNAU, Coimbatore, India, 1985-86.

Species	Origin	IRRI acc. no.	Damage rating[a]
Oryza latifolia	Panama	100966	1 a
O. punctata	Ghana	101409	1 a
O. nivara	India	101510	1 a
O. australiensis	Australia	103318	1 a
O. nivara	Sri Lanka	103419	1 a
O. glaberrima	Senegal	103438	1 a
O. rufipogon	Venezuela	103810	1 a
O. sativalo/O. spontanea	Bangladesh	103826	1 a
O. nivara	Bangladesh	103835	1 a
O. rufipogon	Bangladesh	103844	1 a
O. perennis	India	103846	1 a
O. perennis	India	103848	1 a
O. glaberrima	Senegal	103439	3 b
O. glaberrima	Senegal	103443	3 b
O. sativalo/O. spontanea	Bangladesh	103831	3 b
O. perennis	India	103845	3 b
O. nivara	Australia	101466	5 c
O. glaberrima	Senegal	103437	5 c
O. glaberrima	Senegal	103488	5 c
O. rufipogon/O. nivara	Burma	103796	5 c
O. minuta	Philippines	101132	7 d
O. eichingeri	Tanzania	101171	7 d
O. nivara/O. sativa	Sri Lanka	103791	7 d
O. nivara	Bangladesh	103836	9 e
Ptb 33 (resistant check)			1 a
TN1 (susceptible check)			9 e

[a] Mean of 5 replications. Damage rating based on 0-9 scale. Means followed by a common letter are not significantly different at the 5% level by Duncan's multiple range test.

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Resistance of IR varieties to leafhoppers and planthoppers

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We evaluated varieties IR5 to IR64 for resistance to rice green leafhopper (GLH) *Nephotettix virescens,* brown planthopper (BPH) *Nilaparvata lugens,* and whitebacked planthopper (WBPH) *Sogatella furcifera,* in seedbox screening tests, Separate seedboxes were used for each insect species, with five replications per variety. Pregerminated rice seeds were sown in rows in 60- × 40- × 10-cm seedboxes. Ptb 33 and TN1 were the resistant and susceptible checks. At 7 d after sowing, seedlings were thinned to 20/variety and infested with 7-8 2d-instar nymphs of BPH or WBPH and 5 2d-instar GLH nymphs/ seedling. When the susceptible check died, damage was rated by the *Standard evaluation system for rice.*

Resistance to GLH, BPH, and WBPH differed significantly (see table). IR62 and IR64 were highly resistant to all three insect species. IR28, IR52, IR54, IR56, IR58, IR62, and IR64 were highly resistant to GLH; IR5, IR36, IR42, IR46, and IR60 were moderately resistant to GLH, BPH, and WBPH. □

Resistance of IR varieties to GLH, BPH, and WBPH.

Variety	Damage rating[a] GLH	BPH	WBPH
IR5	6.6 e	5.4 d	5.4 d
IR8	9.0 f	9.0 f	9.0 f
IR20	9.0 f	9.0 f	9.0 f
IR22	9.0 f	9.0 f	9.0 f
IR24	5.4 d	9.0 f	9.0 f
IR26	9.0 f	9.0 f	9.0 f
IR28	1.0 a	5.4 d	5.4 d
IR29	6.2 e	9.0 f	9.0 f
IR30	5.4 d	9.0 f	6.2 cd
IR32	3.4 c	9.0 f	5.4 d
IR34	3.0 bc	9.0 f	5.4 c
IR36	2.6 b	6.6 e	5.0 c
IR38	5.4 d	9.0 f	6.6 e
IR40	6.6 e	6.6 e	6.6 e
IR42	2.6 b	5.2 de	5.0 c
IR46	6.6 e	4.6 c	5.4 d
IR48	2.6 b	3.4 b	3.0 b
IR50	3.4 c	9.0 f	9.0 f
IR52	1.0 a	2.6 b	1.4 a
IR54	1.0 a	6.6 e	2.6 b
IR56	1.4 a	3.4 b	2.6 b
IR58	1.0 a	5.4 d	3.4 b
IR60	3.4 c	5.4 d	5.4 d
IR62	1.0 a	1.4 a	1.4 a
IR64	1.0 a	1.0 a	1.0 a
Ptb 33 (resistant check)	1.0 a	1.0 a	1.0 a
TN1 (susceptible check)	9.0 f	9.0 f	9.0 f

[a] Mean of 5 replications. In a column, means followed by a common letter are not significantly different at the 5% level by Duncan's multiple range test. Damage is rated on the 0-9 scale.

Genetic Evaluation and Utilization
COLD TOLERANCE

Screening rice cultivars at seedling stage and anthesis for low-temperature tolerance in Madagascar

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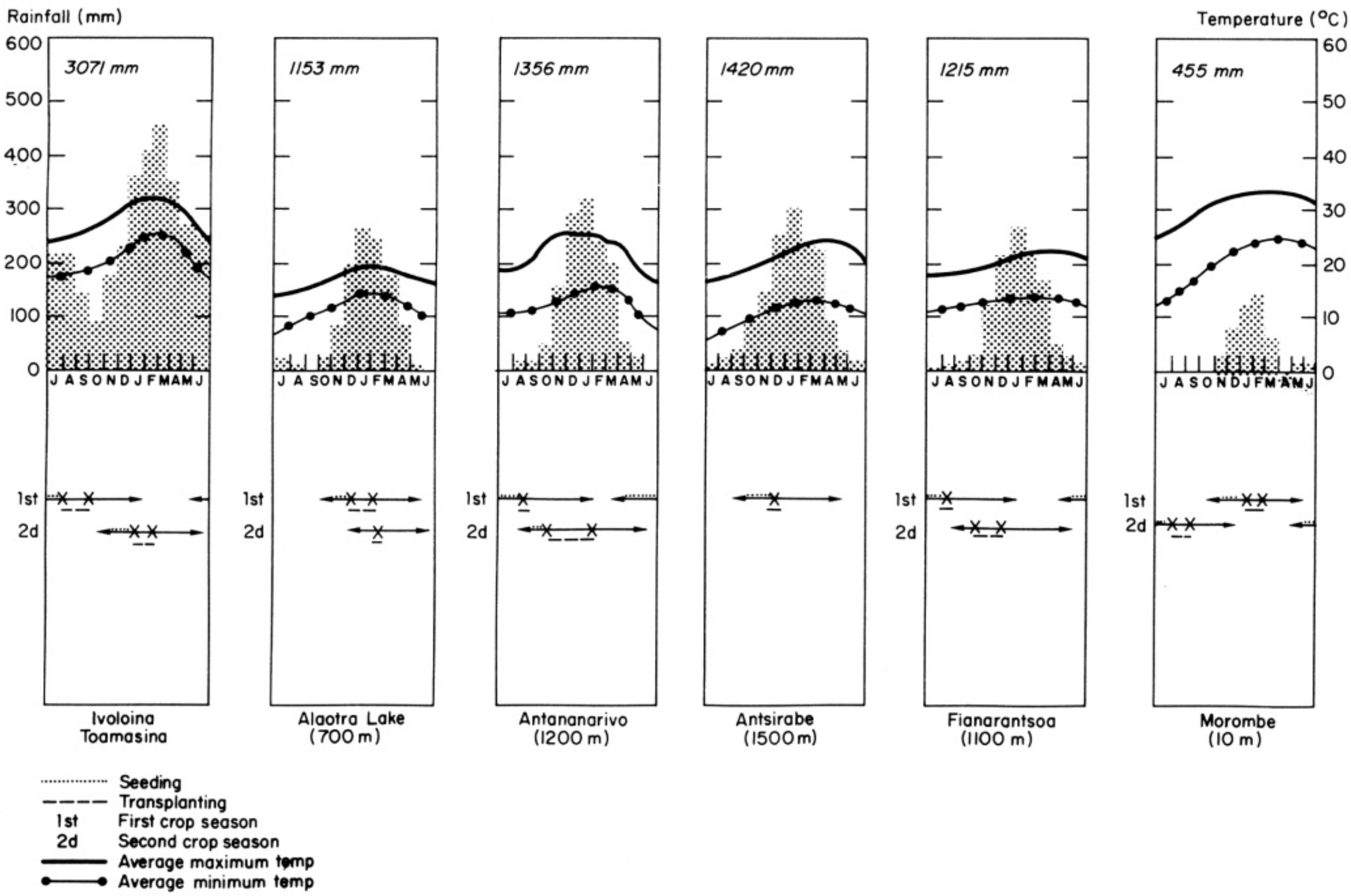
Half the 1.2 million ha of rice in Madagascar is in the High Plateau, above 1,000 m altitude.

Two crops of rice can be grown a year, although growing seasons differ by region. In Antananarivo (1,200 m), the first crop is sown Apr-May, transplanted Sep, and harvested Dec-Jan (see figure). Because low temperatures (min 9-11 °C) occur at the seedling stage, growth is very slow; farmers seldom transplant seedlings younger than 120 d. Second crop seeding is Oct-Nov, with harvest in Apr-May. Temperatures start decreasing in March but, depending on the altitude (800-1,300 m), may remain high enough (mean temp 22°C) for flowering and maturing.

In Antsirabe (1,500-2,000 m) only 1 crop is possible. Low temperature affects both seedling and ripening stages. Rice in Vinaninony-Fenomanana (1,900 m) has a more than 250-d duration.

To identify donor and outstanding cold-tolerant varieties, we studied the effects of low temperature at seedling and anthesis on 178 Malagasy accessions from the International Rice Germplasm Center (IRGC) and three from FOFIFA in the greenhouse and the IRRI phytotron.

Ten-day-old seedlings were



Temperatures and rainfall during the rice-growing season in Madagascar. Altitude at the sites is in the parentheses.

subjected to 12°C water for 10 d and scored for leaf discoloration using the *Standard evaluation system for rice.* At anthesis, newly emerged panicles were tagged and the plants were put in a constant 21°C temperature growth chamber for 10 d, then allowed to mature in the greenhouse. Cold tolerance was based on percent sterility of treated panicles.

Of the 181 accessions tested, 19 remained green after 10 d in the 12°C cold water tank (1-3 score), 39 other cultivars showed good recovery (5-7 score). Only Latsibavy scored 1 — this cultivar belongs to the series of Latsika varieties commonly cultivated in the Ankaratra mountain region (1,700-2,000 m) within the High Plateau region.

Fourteen cultivars showed low temperature tolerance at anthesis (less than 30% spikelet sterility). Lava 1418, IRAT129, and 617A had the highest fertility. Maintimolotsy 1226, 617A, IRAT118, IRAT119, and Latsibavy showed tolerance at both stages. □

Genetic Evaluation and Utilization

FLOOD TOLERANCE

Effect of complete submergence on plant height, flowering duration, and percentage recovery in five rice varieties

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The effect of complete submergence at different growth stages was studied in a pot culture at Pulla during kharif 1984.

Potted plants were completely submerged in tanks at active tillering, maximum tillering, panicle initiation, and booting for 7 and 10 d. Control plants were grown under normal conditions.

None of the plants completely recovered. In general, 10 d submergence had a more drastic effect than 7 d submergence (see table).

Effect of submergence for 7 and 10 d on plant height, flowering duration, and varietal recovery. Pulla, Andhra Pradesh, India, 1984 kharif.

Growth stage	MTU4870 (MTU4569/ARC6650)		MTU5 182 (MTU4569/ARC6650)		MTU5293 (MTU4569/ARC6650)		NC92 (pureline selection)		FPAR7360 (Patnai 23/IR8)	
	7d	10 d	7d	10 d	7d	10 d	7d	10d	7d	10d
					Plant ht (cm) at maturity					
Active tillering	102	93	95	85	93	85	137	126	90	82
Maximum tillering	77	–	86	95	–	–	117	94	80	81
Panicle initiation	–	–	64	–	–	–	88	–	–	–
Booting	45	–	50	–	–	–	66	57	54	–
Control	112		109		106		156		101	
					Flowering duration (d)					
Active tillering	139	146	139	143	151	152	141	141	141	146
Maximum tillering	151	–	151	153	–	–	142	144	147	152
Panicle initiation	–	–	154	–	–	–	150	–	–	–
Booting	157	–	157	–	–	–	155	160	155	–
Control	157		157		–		155		155	
					Recovery (%)					
Active tillering	100	100	80	40	80	20	100	20	80	20
Maximum tillering	80	0	40	20	0	0	100	60	80	40
Panicle initiation	80	0	20	0	0	0	40	0	0	0
Booting	60	0	60	0	0	0	100	60	60	0

Plant height was reduced (12-54%) and flowering duration increased (5-19%) with submergence. These effects were more severe under 10 d submergence.

Recovery was highest in MTU4870 at active tillering stage; NC492 exhibited good recovery at all stages. □

Genetic Evaluation and Utilization
ADVERSE SOILS TOLERANCE

Varieties screened for acid-saline soils

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Soil salinity is also associated with soil acidity in the coastal area of West Bengal. A pot culture experiment screened eight rice varieties on an acid soil. Seedlings were transplanted in pots containing 8 kg of soil (pH 3.5, ECe 4.5 dSjm). N was added at 60 kg/ ha. Each variety was replicated three times.

Khao Dawk Mali and RD19 from Thailand and Mahsuri seem promising (see table). Sterility in Khao Dawk Mali was minimal. Length of panicle and grain weight were higher in Khao Dawk Mali. From those agronomic characteristics, Khao Dawk Mali and RD19 may be considered for coastal acid-saline soils. □

Variety performance in acid saline soils in West Bengal, India.

Variety	Av ht (cm)	Tillers with panicles (no./pot)	Grain (g/pot)	Straw (g/pot)	Sterility (%)	Length of panicle (cm)	Duration (d)
Khao Dawk Mali	112.3	6.0	12.6	38.9	28.6	24.0	130
Lemo	109.3	15.3	2.3	62.1	81.1	21.6	162
Mahsuri	131.0	10.0	9.0	52.4	38.0	19.7	130
IR26	76.7	10.7	6.5	19.0	79.5	18.5	111
Kajalsali	99.0	7.0	0.3	18.6	83.9	16.0	125
RD19	75.7	7.3	15.1	28.7	49.6	17.0	152
SR26B	107.7	3.0	3.6	14.7	62.4	20.3	152
Pokkali	79.7	10.3	3.7	12.0	50.8	15.5	111
CD (5%)	13.9	5.9	3.7	18.7	3.0	1.1	

Pest Control and Management

DISEASES

Effect of synthetic pyrethroids on tungro (RTV) incidence and vector control

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Two formulations of synthetic pyrethroid cypermethrin (Ripcord and Cymbush), two other synthetic pyrethroids, decamethrin and FMC 54800, and carboiuran were evaluated against RTV and its vector.

Cypermethrin, decamethrin, and FMC 54800 were sprayed every 10 d beginning 15 d after transplanting (DT) to 45 DT. Carbofuran was broadcast at 15-d intervals. Test cultivars were TN I (susceptible) and Ratna (tolerant). Plot size was 3 × 3 m in a randomized block design with 3 replications for each cultivar. RTV epidemic conditions were created by planting three infected tillers of Jaya in the middle of each plot. Disease incidence, grain yield, and leafhopper population were measured.

Cypermethrin and decamethrin were equally effective in reducing RTV incidence and leafhopper population in both varieties (see table). Carbofuran and fenvalerate were also effective in Ratna. FMC 54800 was not as effective as the other synthetic pyrethroids. ☐

Effect of synthetic pyrethroids on RTV and its vector on TN1 and Ratna cultivars. Cuttack, India.[a]

Insecticide	Concentration (%)	Disease incidence (%)		Grain yield (t/ha)		Leafhoppers/20 hills at 33 DT			
						TN1		Ratna	
		TN1	Ratna	TN1	Ratna	Adult	Nymph	Adult	Nymph
Cypermethrin (Cymbush)	0.01	7 c	1 a	3.9 ab	4.5 ab	0 a	0 a	0 a	0 a
	0.05	5 b	1 a	4.1 a	4.5 ab	0 a	0 a	0 a	0 a
Cypermethrin (Ripcord)	0.01	6 bc	1 a	3.9 ab	4.4 ab	0 a	0 a	0 a	0 a
	0.05	3 a	1 a	4.0 a	4.5 a	0 a	0 a	0 a	0 a
Decamethrin	0.005	11 d	1 a	3.6 bc	4.3 abc	0 a	1 a	0 a	0 a
	0.01	5 b	1 a	4.0 a	4.6 ab	0 a	0 a	0 a	0 a
FMC 54800	0.01	100 h	39 e	1.0 f	2.9 d	6 c	27 d	4 b	10 c
	0.05	79 g	18 d	1.6 e	3.1 abcd	3 b	3b	1 bc	1 a
Fenvalerate	0.01	17 e	14 c	3.0 d	3.3 bcd	0 a	0 a	1 bc	0 a
	0.05	10 d	5 b	3.5 c	3.8 abcd	0 a	0 a	0 a	0 a
Carbofuran	2 kg	26 f	4 b	2.9 d	4.3 abc	3b	11 c	2 c	3 b
Control	–	100 h	51 f	0.3 g	2.5 d	13 d	40 e	7 e	37 d

[a] In a column, values followed by the same letter do not differ significantly by DMRT (P = 0.05).

Association of Humicola sp. with stem rot (SR) complex in Haryana

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Plants infected with a disease similar to SR have been observed at Kaul since 1980. Patches of wilted rice plants (Jaya variety) were observed at postflowering during Oct 1984. Culms were water-soaked with reddish brown lesions without distinct margins. Cavities of the lower 3-4 internodes revealed off-white to dirty black hyphal masses concentrated near the nodes. At maturity, the sheaths of affected plants blackened up to 15-20 cm above soil level. Plants broke off at the crown and could be easily pulled, leaving most of the roots in the soil. Grains were partially filled and discolored.

Microscopic examination of mycelial mats revealed septate hyphae hyaline when young and brown when older. The fungus was easily isolated on PDA. Colonies were white at first, turning grey to black with production of numerous black conidia. The causal agent, identified as *Humicola* sp., proved pathogenic only when inserted inside the culm.

In a survey during 1984 kharif, wet crown rot was noticed at other sites. The pathogen occurred alone and in association with three sclerotial fungi: *Sclerotium oryzae, S, oryzae* var. *irregulare,* and *S. hydrophilum.* Affected hills could be classed into three categories (see table). *Humicola* sp. was associated more with category 1, but only where the stool was pulled out after breaking at the crown.

In varietal screening trials against SR fungi, *Humicola* sp. was recorded on 54 entries. Nineteen varieties were most susceptible: Tadukan, M. sung song, Jhona 349, HKR207, HAU53-4618-2-1, HAU118-358, HAU120-326, HAU98-8, C-1321-9, C-1158-7, HAU10-194-1, HAU6-11-1-1-1-1, HAUS-145-1, HKR111, Pusa 33, IR29692-65-2-3, IR25861-35-3-3, IR25890-82-5-3, and IR13538-48-2-3-2. ☐

Association of SR fungi with wet culm crown rot at RRS, Kaul, India.

Category	Description	SR association (% tillers)			
		S. oryzae	S. oryzae var. irregulare	S. hydrophilum	Humicola sp.
1	Whole stool easily pulled out, breaking at crown, roots left inside soil	30	25	100	100
2	Partial stool pulled out	10	–	50	50
3	Stool pulled out with difficulty, roots intact	20	20	100	–

Acquired resistance of rice leaves to *Rhizoctonia solani*

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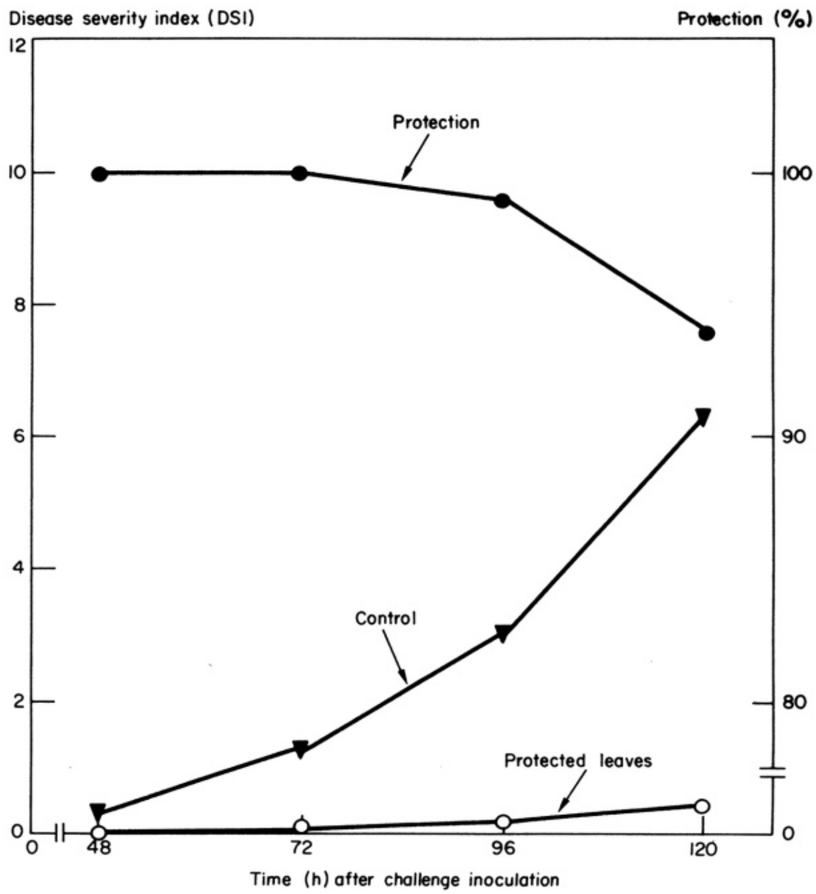
Sheath blight (ShB) incited by *Rhizoctonia solani* is a major fungal disease of rice. Acquisition of ShB resistance in excised rice leaves has been worked out through prior interaction with an avirulent *R. solani* isolate.

Several isolates from rice and other field crops were screened on TKM9 and Ponni for relative virulence. Avirulence on rice of isolate R7 from potato was further confirmed on CO 43 and IR50.

Leaves excised from 60-d-old field-grown rice plants were floated on 5 ppm kinetin to delay senescence and inoculated with a rice grain culture of R7. The leaves were challenged with sclerotia of virulent isolate R1 / R5 at 12 h. Disease spread was scored every 24 h from 48 h after challenge inoculation to 120 h.

In leaves preinoculated with R7, sclerotia of the virulent isolate did not spread until 72 h and formed only a few lesions, for 90% protection (see figure).



Effect of incompatible interaction on ShB severity. DSI = av no. of lesions/leaf × av lesion length (cm).

The generally slow-growing avirulent isolate R7 showed neither antibiosis nor parasitism and was overgrown by R5 in dual culture. Histopathological studies revealed sparse growth of R7 at the site of inoculation, with inability to produce infection cushions on rice leaves. Direct penetration of the mycelium through either stomata or cuticle was not observed.

The fact that 60-65% protection against ShB could be obtained even when leaves were challenge-inoculated where R7 had not spread (2-3 cm away) rules out direct antagonism between the 2 RS isolates and any competition for entry, colonization, and leaf exudates. Activation of host defense mechanisms might be responsible for acquired resistance. Preinoculation of rice leaves (prior-interaction) with R7 successfully induced protection. ☐

A new scale for rice sheath blight (ShB) disease assessment

S. W. Ahn, R.C. dela Peña, B.L. Candole, and T.W. Mew, Plant Pathology Department, IRRI

Using varietal resistance to minimize ShB damage is the least explored ShB management component. The level of resistance in most commercial cultivars is not high enough to protect rice plants from severe damage in highly conducive environments. However, combined with other disease control measures, such as chemical application or cultural practices, it could play a significant role in an integrated program. Improved resistance in modern rice cultivars is important in sustaining rice productivity in ShB-prone areas.

An efficient and reliable ShB screening method requires a quantitative scale that differentiates varietal reactions. Conventional grading of disease levels is arbitrary, without considering estimated yield losses. To improve this system, a scale was developed based on the relationship between ShB severity and yield loss (see table).

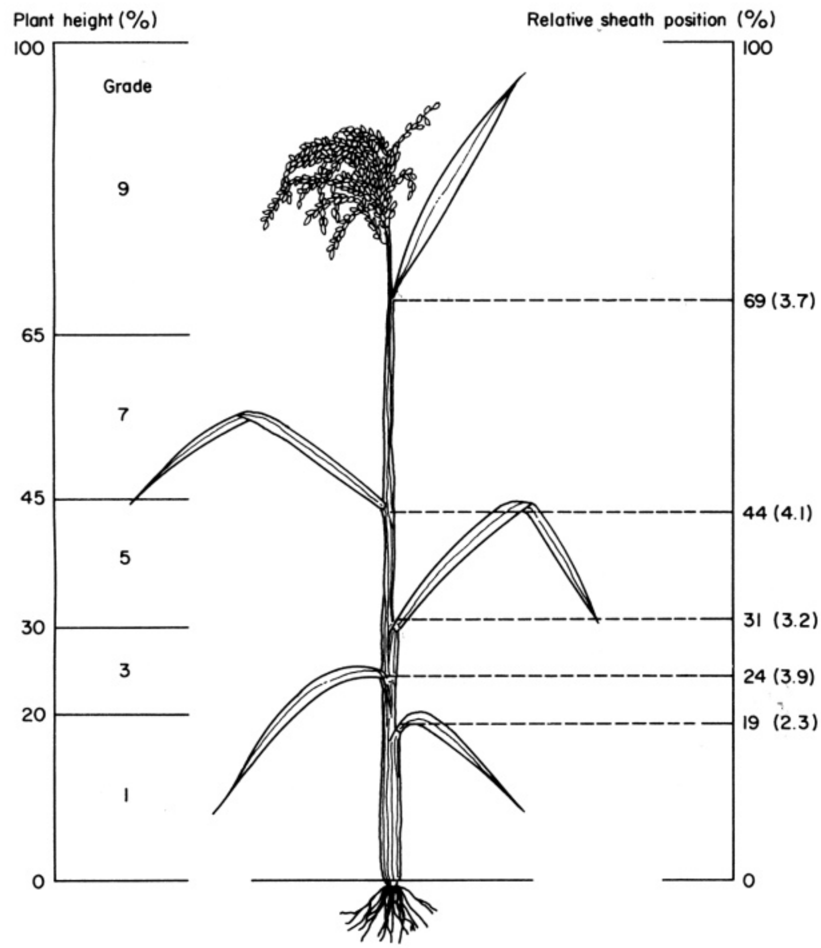
Rating on relative lesion height (RLH) is easier and faster to use in a uniformly inoculated mass-screening nursery, but rating on sheath position also can be used. The relative position and length of sheaths at different positions in different cultivars are uniform, except in extremely tall cultivars (see figure). Actual measurement of plant and lesion height is recommended, since visual estimation of RLH is often biased. Staggered planting of groups of entries with similar maturity and height would allow a better comparison.

Under favorable environments, highly susceptible cultivars would be rated more than grade 7, and descriptive classification can be directly applied. Otherwise, standardizing or adjusting the descriptive classification to the infection level of locally known susceptible cultivars is needed.

Scale for rice ShB evaluation. IRRI, 1986.

Grade	RLH[a] (%)	Sheath position[b]	Relative disease intensity	Yield reduction[c] (%)	Classification[d]
0	0	0	0	0	HR
1	< 20	<4	1	1	R
3	20-30	3-4	5	1-5	MR
5	31-45	2	20	6-15	MS
7	46-65	1	50	16-30	S
9	>65	>1	100	>30	HS

[a]Relative lesion height (%) = $\frac{\text{lesion height}}{\text{plant height}} \times 100$. [b]1 = uppermost sheath with flag leaf. [c]Estimated yield reduction in milled rice under pressure. [d]HR = highly resistant, R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, HS = highly susceptible.



Rating scheme of a new scale for ShB mass screening. IRRI, 1986. Relative sheath positions were based on 30 cultivars grown under upland conditions. Values in parentheses show standard error of mean.

For rapid disease assessment in field plots or screening nursery, ShB severity (average disease intensity of a plant population) can be computed:

$$\text{Severity (25 DAF)} = \frac{0(N_0) + 1(N_1) + 5(N_3) + 20(N_5) + 50(N_7) + 100(N_9)}{\text{Total number of tillers or hills observed}}$$

where DAF = days after flowering,
$N_0 - N_9$ = no. of tillers/ hill classified by grade.

Relative disease intensity was calculated using midvalues of the estimated ranges of yield losses in each grade. A detailed disease assessment should consider leaf or sheath area in each position. □

Effect of form and level of N fertilizers on sheath rot (ShR) incidence and yield

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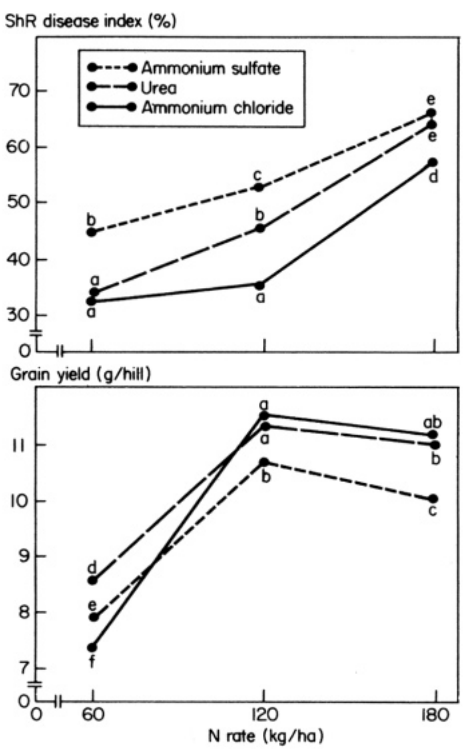
The effect of three forms of N fertilizer at 60, 120, and 180 kg N/ha on ShR incidence and yield of IR20 was studied in a pot culture experiment. Ammonium sulfate, ammonium chloride, and urea were applied 50% at transplanting, 25% at tillering, and 25% at panicle initiation. Plants were artificially inoculated with ShR by inserting a single infected rice grain between the leaf sheath enclosing the panicle and the culm of a tiller 65 d after planting. Disease incidence on 5 randomly selected tillers from each hill was recorded 30 d after inoculation.

ShR incidence was significantly lower with ammonium chloride at all the 3 N levels (see figure). At 120 kg N/ ha, ammonium chloride recorded the maximum yield (11.5 g/hill) with a disease index of 35.8%.☐



Effect of forms and levels of N fertilizers on ShR incidence and yield. TNAU, Coimbatore, India. Mean separation for N rate by DMRT at the 5% level.

Foliar spray to control sheath blight (ShB)

I. F. Telan and D. B. Lapis, Plant Pathology Department, university of the Philippines at Los Baños (UPLB)

Fungicides were evaluated singly and in combination under upland and lowland conditions during the 1983 wet season. Varieties used were UPLRi4 for upland and UPLRi5 for lowland. There were eight treatments in upland and seven treatments in lowland with three replications in a randomized complete block design. Plots measured 2 × 3 m in upland and 2 × 2 m in lowland. Plant spacing was 20 cm between rows for upland and 20 × 20 cm between hills for lowland. The first spraying was at early booting (70 d after seeding); the second 2 wk later. Inoculation was with a 3- to 4-wk-old rice grain-hull culture of *Rhizoctonia solani* inserted between tillers and between plants 2 d after the first spraying. Disease was rated by the *Standard evaluation system for rice* and severity was computed:

$$\text{Disease severity} = \frac{\text{Sum of disease rating}}{\text{Total ratings} \times \text{max disease rating}} \times 100$$

Under upland conditions, all treatments except PCNB had significantly lower disease ratings than control (Table 1). Under lowland conditions, only iprodione and benomyl gave lower disease ratings (Table 2). PCNB had the highest disease rating and disease severity in both situations. Applying either iprodione or benomyl alone seems to be as good as applying them in combination.☐

Table 1. Foliar spray control of ShB on UPLRi5 under upland conditions.[a] UPLB, 1986.

Fungicide	Rate (kg/ha)	Disease rating[b]	Disease severity (%)
Iprodione 50% WP	1.5	3.7 a	41.0
Benomyl 50% WP	1.5	3.8 ab	42.2
Benomyl-EMDOC[c]	1.5-1.5	4.4 b	49.6
Benomyl – iprodione	1.5-1.5	4.0 ab	45.1
Triphenyltin acetate 60% WP – triphenyltin hydroxide 50% WP	1.5-1.5	4.7 cd	52.5
Triphenyltin acetate 60% – iprodione	1.5-1.5	4.2 ab	46.6
PCNB	1.5	5.2 de	57.7
Control	–	5.4 e	60.5
CV (%)		6.8	

[a] Means of 10 marked plants/treatment with 3 replications. [b] Means followed by the same letter are not significantly different by Duncan's multiple range test at the 1% level. [c] Ethyl 3-(3-5 dichloro-phenyl)-5-methyl-2-4 deoxo-5-oxazoldine carboxylate (Serinal 50% WP).

Table 2. Foliar spray control of ShB on UPLRW under lowland conditions.[a] UPLB, 1986.

Fungicide	Rate (kg/ha)	Disease rating[b]	Disease severity (%)
Iprodione 50% WP	1.5	4.4 abc	49.6
Benomyl 50% WP	1.5	4.0 a	44.4
Benomyl – iprodione	1.5-1.5	5.6 abcde	62.2
Triphenyltin acetate 60% WP – triphenyltin hydroxide 50% WP	1.5-1.5	6.0 bcde	67.3
Triphenyltin acetate – iprodione	1.5-1.5	6.2 bcde	69.5
PCNB 75% WP	1.5	6.5 cde	72.5
Control	–	8.0 e	84.4
CV (%)		18.4	

[a] Mean of 10 random hills/treatment with 3 replications. [b]Means followed by the same letter are not significantly different by Duncan's multiple range test at the 5% level.

Evaluation of new fungicides in controlling blast (Bl)

H. D. Lewin, V. Mariappan, and S. Chelliah, Tamil Nadu Rice Research Institute, Aduthurai 612101, India

We evaluated recently introduced emulsifiable concentrates and wettable powders in Oct-Jan 1984-85 for Bl control in a field trial laid out in a randomized block design. The 12 treatments were replicated 4 times; test variety was highly B1-susceptible IR50. The fungicides were applied as foliar spray during tillering after disease symptoms appeared, at panicle initiation, and at flowering.

Intensity of leaf B1 was scored by the *Standard evaluation system for rice* on 25 randomly selected plants from each plot 10 d after the final fungicide application. Neck infection percentage was assessed on five randomly selected hills from each plot.

Edifenphos, pyroquilon, and isoprothiolane significantly controlled leaf B1 (see table). Plots treated with edifenphos or pyroquilon yielded 80% higher than the check. □

Effectiveness of selected fungicides in controlling B1. Aduthurai, India.

Treatment	Dosage per liter	Leaf Bl intensity (grade)	Neck Bl (%)	Yield (t/ha)
Edifenphos 50EC	1 ml	2.6	24	4.0
Pyroquilon 50WP	1 g	3.0	28	4.0
Copper oxychloride 50WP	2.5 g	4.5	34	2.8
Isoprothiohne 40EC	1 ml	3.2	22	2.7
Propiconazole 25EC	1 ml	4.6	33	2.7
Dithiocarbamate 75WP	2.5 g	4.7	26	2.6
Carbendazim 50WP	1 g	4.0	29	2.3
Thiophanate methyl 70WP	1 g	4.6	29	2.2
IBP 48EC	1 ml	5.0	24	2.1
Natural plant product	1 ml	4.9	32	1.9
Captafol 80WP	1.25 g	5.2	33	1.8
Untreated check	–	6.2	31	2.2
CD		1.4	ns	1.0

Identifying tungro viruses by the transmission method

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Tungro spherical virus (RTSV) and tungro bacilliform virus (RTBV) can be identified by electron microscopic studies and by serological methods. It has been reported that the viruses can also be identified by symptomatology and transmission. We tested identification by transmission method.

Twenty 15-d-old Taichung Native 1 (TN1) seedlings in cages were exposed to viruliferous leafhoppers at 1, 2, 3, and 5 leafhoppers/seedling for 24 h. The insects had been confined for 48 h on 45-d-old RTV-infected TNl plants. Symptoms were observed 30 d after inoculation.

On plants with symptoms, back inoculation tests were conducted, using virus-free insects. For plants without symptoms, back inoculation tests used insects that had been fed on RTBV-infected plants (identified by serological methods) for 24 h. Those insects were tested for infectivity on 10-d-old TN1 seedlings.

RTV viruses were identified as follows:

1. plants showing severe symptoms back transmissible by non-viruliferous leafhoppers: infected with RTSV + RTBV.
2. plants showing moderate symptoms not back transmissible by nonviruliferous leafhoppers: infected with RTBV.
3. plants not showing clear symptoms, back transmissible when leafhoppers were given sequential acquisition feeding on the plants and then on RTBV-infected plants: infected with RTSV.
4. plants not showing clear symptoms, not back transmissible when leafhoppers were given sequential acquisition feeding on the plants and then on RTBV-infected plants: uninfected.

Control of rice blast (Bl) by fungicide-treated seed

H.D. Lewin and P. Vidhyasekaran, Tamil Nadu Rice Research Institute, Aduthurai 612101, India

Foliar fungicides are usually recommended for B1 control. Systemic fungicides also known to control B1 were tested through seed treatment. One kilogram seed of highly susceptible IR50 was soaked in 1 liter 0.2% fungicide solution for 12 h. The treated seeds were sown in raised beds and disease intensity was assessed on the *Standard evaluation system for rice* (SES) scale 40 d after sowing. Leaf area affected (%) also was calculated.

Pyroquilon 50 WP, carbendazim 50 WP, carbendazim 25 SD, and carbendazim 25 SD + thiram 50 WP were equally effective in reducing B1 intensity in the nursery (see table). □

Controlling rice Bl in the nursery by treating seed with fungicides. Tamil Nadu Rice Research Institute, Aduthurai, India.[a]

Treatment	Disease intensity	
	SES	Leaf area affected (%)
Carbendazim 25 SD	5.8 a	22 a
Carbendazim 50 WP	5.2 a	13 a
Carbendazim 25 SD + thiram 50 WP	5.2 a	13 a
Pyroquilon 50 WP	5.0 a	10 a
Control	7.1 b	53 b

[a]In a column, means followed by a common letter are not significantly different from each other.

Of 80 inoculated plants, 68 showed symptoms. Numbers of plants showing visible symptoms increased with an increase in leafhopper population (see table). Plants containing RTBV + RTSV increased with insect load. There were no clear trends in number of plants containing RTBV or RTSV. All 80 inoculated plants were also serologically tested; serological and transmission identification of RTV virus particles agreed. □

Identifying tungro viruses (RTBV and RTSV) by the transmission method with different levels of leafhoppers. Cuttack, India.

Leafhoppers used for inoculation (no.)	Plants inoculated (no.)	Plants infected (no.)				Healthy plants (no.)
		Visual observation	Transmission method			
			RTBV+RTSV	RTBV	RTSV	
1	20	13	12	3	2	3
2	20	16	14	3	2	1
3	20	19	16	3	0	1
5	20	20	18	2	0	0

Effect of coal tar-coated urea on brown spot (BS)

P. Vidhyasekaran, B. Rajamanickam, and H.D. Lewin, Tamil Nadu Rice Research Institute, Aduthurai 612101, India

Nitrogen level can be used to manage BS *Helminthosporium oryzae* Breda de Haan incidence. Its effect varies with level and fertilizer type.

Coal tar-coated and commercial urea at 100 kg N/ha were compared. Urea was mixed with coal tar melted over a low flame and dissolved in kerosene at 1 kg of coal tar and 1.5 liters kerosene/100 kg urea. All the coal tar-coated urea was applied basally at transplanting; commercial urea was applied in three splits.

Coal tar-coated urea uniformly decreased BS incidence and increased yields of IR20 and ADT36 (see table). □

Effect of coal tar-coated urea on BS incidence, Tamil Nadu, India.

Treatment	Disease intensity[a]			Yield[b] (t/ha)	
	IR20	ADT36	TKM9	IR20	ADT36
Commercial urea	4.8	3.3	4.5	2.6	2.2
Coal tar-coated urea	1.9	2.7	2.2	2.8	2.5
No N	4.3	3.3	3.3	1.3	1.5
CD	0.4	0.5	0.7	0.1	0.2

[a] Assessed using the *Standard evaluation system* for rice 0-9 scale. [b] No yield data could be recorded for TKM9 because of heavy rat damage.

Effect of density on sheath blight (ShB) incidence

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We studied the relation between sowing density (seed rate) and incidence of ShB *Rhizoctonia solani* Kuhn.

The experiment had 3 replications in a randomized complete block design. Plot size was 6 × 3 m. Rice varieties BWl00 (samba-type grains) and BG400-1 (long grains) were broadcast at different seeding rates: recommended by the Department of Agriculture (DR), 0.5 × DR, 1.5 × DR, and 2 × DR).

Seven-day-old *R. solani* culture on rice grains were inoculated by evenly spreading the grains on the water surface at panicle initiation. Recommended fertilization was applied and standard plant protection measures were taken.

Disease incidence was assessed at harvest. The number of tillers with infected flag leaf and total number of tillers within a 1-m^2 quadrat from each plot were recorded and the disease incidence percentage was computed:

$$\text{\% of flag leaf infection} = \frac{\text{no. of tillers with infected flag leaf/m}^2}{\text{total no. of tillers/m}^2} \times 100$$

ShB incidence and yield at different seeding rates. Bombuwela, Sri Lanka.

Variety	Seeding rate (kg/ha)	Disease incidence[a] (%)		Yield (t/ha)	
		1982-83	198 3-84	1982-83	1983-84
BG400-1	100 (DR)	54.1	54.1	3.9	3.0
(long grain)	50	40.2	40.3	4.4	3.1
	150	57.3	58.0	3.8	3.3
	200	66.3	65.6	4.0	2.7
BW100	15 (DR)	55.1	57.1	4.1	3.0
(samba-type grain)	31.5	44.8	42.8	3.6	3.1
	112.5	61.9	67.9	3.4	2.7
	150	11.1	69.4	3.5	2.6

[a] LSD (P = 0.05) = 12.5 for 1982-83 and 5.1 for 1983-84. The correlation between disease incidence and seeding rate was positive and linear in both seasons: *r* = 0.913** for BW100 and 0.719** for BG400-1 in 1982-83, and 0.88** for BW100 and 0.75** for BG400-1 in 1983-84.

Grains were air-dried and weighed, and yield calculated, leaving a 30-cm border around each plot.

Disease incidence and yield at different seed rates are given in the table. The expected yield increase with higher plant densities was not found. Higher disease incidence affected yield. □

Pest Control and Management

INSECTS

Persistent toxicity of three modified formulations of carbofuran to brown planthopper (BPH) in India

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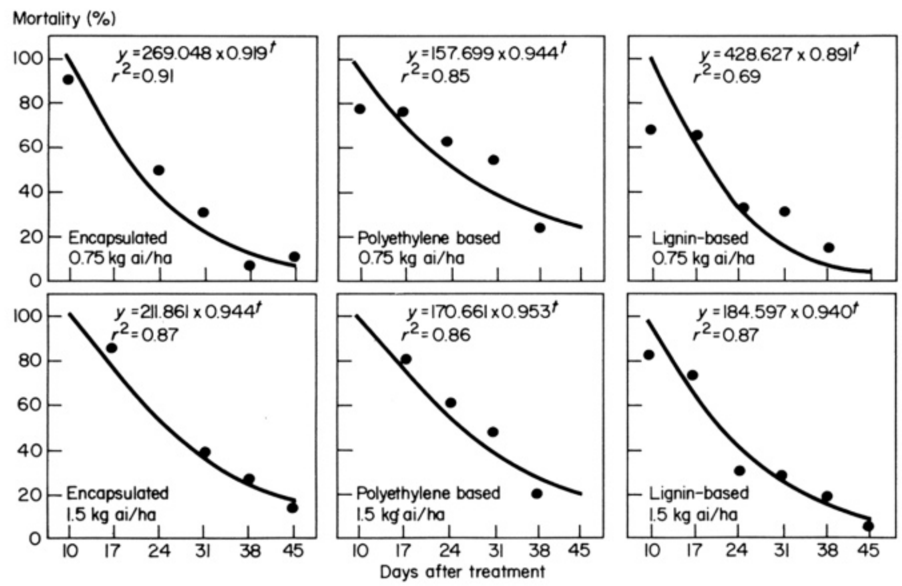
The Regional Research Laboratory (Hyderabad, India) supplied polyethylene-based and lignin-based formulations of carbofuran reported to be slow releasing in nature. We studied their persistent toxicity to BPH compared to that of commercially available encapsulated granules of carbofuran in a confined cage experiment Jun-Jul 1985.

The treatments were in a factorial combination of 3 formulations of carbofuran (polyethylene-based, lignin-based, and encapsulated) and 2 application rates (0.75 and 1.50 kg ai/ha).

The formulations were broadcast into the floodwater at 0.75 and 1.5 kg ai/ha 5 d after transplanting (DT). Starting 3 d after treatment, toxicity was monitored weekly using the BPH bioassay technique.

Toxicity of polyethylene-based and encapsulated preparations persisted at a higher level and longer than did toxicity of the lignin-based granule (see figure). Mortality remained consistently higher with 1.5 kg ai/ha to 50 DT.



Mortality of BPH adults, at various days after treatment, on rice plants in fields that received modified formulations of carbofuran at 2 rates. Trivandrum, India, 1985.

The persistent toxicity differed with rate of application, with a significant interaction between formulation and rate of application.

Mortality decline (4.7% /d) was lowest with the polyethylene-based formulation at 1.5 kg ai/ha, closely followed by polyethylene-based formulation at 0.75 kg ai/ha and encapsulated formulation at 1.5 kg ai/ ha. Mortality declined at a faster rate in the lignin-based formulation. Release of the active ingredient appeared to differ with formulation. □

Epidemiology of rice tungro virus (RTV) in 1984-85 kharif, Chingleput District, Tamil Nadu

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During 1984-85 kharif (May-Aug) the rice crop in Chingleput District was completely devastated by an unprecedented outbreak of RTV. Crops planted early the next season (samba, Sep-Jan) were also severely affected.

We studied the epidemiology of the disease in a field experiment, laid out in a randomized block design with three replications. Nine plantings of 25-d-old CO 43 seedlings were staggered at 10-d intervals starting 10 Aug 1984. Seedlings were transplanted in 3- × 3-m plots at 20- × 10-cm spacing. Recommended agronomic practices were followed and 100-50-50 kg NPK/ha applied. All the P_2O_5 and K_2O were applied basally along with 50% N. The remaining N was topdressed in 2 equal splits at 15 and 30 d after transplanting (DT).

RTV incidence was assessed at 45 DT. The number of green leafhoppers collected in light traps Aug-Nov was recorded by month.

RTV incidence in the field correlated positively with the field population of the vector *Nephotettix* *virescens* (see table). The early-planted crops were significantly more severely infected with RTV, resulting in lower grain yield, than late planting. Severe RTV infection in the early samba crop was due to overlapping of younger plants with the sornavari season (May planting) older crop that had high RTV incidence and vector population. When the vector population declined later, RTV incidence also was reduced. We concluded that the spread of RTV was mainly influenced by the vector population. □

Effect of planting time and field population of green leafhopper on RTV incidence.[a] Tirur, India, 1984.

Planting date	RTV incidence[b] (%)	Grain yield (t/ha)	GLH in light trap (no./mo)
10 Aug	68.6 g	0.97 e	Jul : 181,196
20 Aug	60.6 f	1.77 d	Aug : 30,343
30 Aug	19.6 e	2.60 c	Sep : 2,407
10 Sep	8.1 d	2.43 c	Oct : 906
20 Sep	1.9 c	4.27 a	Nov : 1,278
30 Sep	2.1 c	3.60 b	
10 Oct	1.0 b	2.57 c	
20 Oct	1.2 bc	2.57 c	
30 Oct	0.2 a	2.47 c	
CD (P = 0.05)	1.95	0.36	

[a] Means in a column followed by a common letter are not statistically significant at the 5% level. [b] Mean of 3 replications.

A new annelidan pest of rice in Nepal

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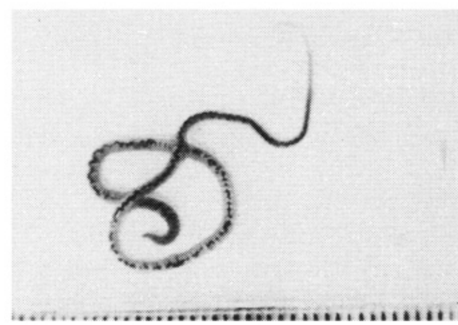
A new pest of rice, tentatively named "Sano Gadeula" (small earthworm), was recorded in farmers' fields during the 1980 crop in the plains and hills of Nepal (see figure). The pest was identified in Japan as *Limnodrilus* sp., phylum Annelida and class Oligochaeta.

Fields infested with this pest resemble Zn-deficient plots. Leaves of infested plants turn yellow or brown and the plant is stunted. Severely infested plants die.

Closer observation revealed newly hatched worms in the basal part of the plant tissue. Mature worms usually were found in clusters in the roots and the underground basal parts of the plant.

Feeding habits of the worm and plant injury are under study, The worm can survive in fresh water for several days, even without soil, but when exposed without water or soil, dies within a minute because of dehydration. □



Limnodrilus sp., a new pest of rice found in Nepal.

Caseworrn (CW) preference for vegetative stage rice

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CW *Nymphula depunctalis* moths oviposit on the undersides of leaves floating in water. In a no-choice test, most eggs were laid on floating leaves, a few on erect leaves, and some on leaves bent in water (Table 1).

In 13 plots exhibiting all plant growth stages, we randomly sampled 20 hills per growth stage and recorded the number of leaves touching the water. Only vegetative stage rice had significant numbers of leaves in contact with water.

A free-choice test measured oviposition by seedling age. Potted plants of different ages were immersed in a drum filled with water set so that leaves of each age were at the same distance above the water surface. The number of eggs laid on seedlings 1, 2, 3, 4, and 5 wk after sowing did not differ.

A preference to oviposit on leaves 2, 4, 6, and 8 mm wide was tested. Excised 4-wk-old floating leaves were randomly pinned to submerged stakes

Table 1. Ovipositional preference of *N. depunctalis* on IR36 rice at different plant ages.[a] IRRI greenhouse, 1983–84.

Plant age[b] (WT)	Oviposition site[c] (no. eggs/10 females per 3 d)		
	Excised floating leaves	Leaves bent in water	Erect leaves
2	123 b	157 a	85 a
4	378 a	189 a	157 a
6	278 ab	153 a	37 b
8	201 ab	179 a	35 b
10	109 b	90 a	31 b
Mean	218	153	69

[a] Av of 6 replications, 10 females and males per replication. Potted plants and excised leaves were placed in mesh-covered 44-gallon gasoline drum cages 3/4 full of water. Floating and bent leaves were pinned to submerged stakes. [b] Transplanted 3 wk after germination. WT = wk after transplanting. [c] In a column, means followed by a common letter are not significantly different by DMRT at the 5% level.

and 5 pairs of moths released. After 3 d, the number of eggs laid on leaves of different widths did not differ.

CW reared on potted 2- to 6-wk-old rice had shorter larval development period and higher larval weight, and growth index, survivorship, and fertility (Table 2).

We conclude that suitable oviposition sites occur only during the vegetative stage. CW on older rice have low survival and slow development. ☐

Table 2. Effect of rice plant age on growth and development of *N. depunctalis.*[a] IRRI greenhouse, 1983-84.

Plant age[b] (WT)	Larval wt (mg)	Larval developmental period (d)	Growth index[c]	Survivorship from larva to adulthood (d)	Fertility (no. of eggs/female)
2	5.76 b	18 ab	4.7 ab	65 a	111 a
4	7.07 a	15 a	5.6 a	69 a	117 a
6	8.24 a	17 a	4.3 b	63 a	108 a
8	4.47 c	21 c	2.7 c	37 b	67 b
10	3.89 d	20 bc	2.1 c	36 b	74 b

[a] Av of 6 replications of 25 insects each replication. In a column, means followed by a common letter are not significantly different by DMRT at the 5% level. [b] Transplanted 3 wk after germination. [c] Growth index = pupation (%)/larval developmental period (d).

Bioefficacy of seven insecticides against leaffolder *Cnaphalocrocis medinalis* Guenée in India

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A replicated trial was laid out in a randomized complete block design in 1984 kharif at the HPAU Rice Research Station to evaluate seven insecticides: quinalphos, carbofuran, monocrotophos, benfuracarb, bromophos-ethyl, ethoprop, and UC54229. Insecticides were applied as needed at 26 and 38 d after transplanting (DT). Damage was assessed at 50 DT.

All insecticides were superior to the untreated control (see table).

UC54229, quinalphos, and monocrotophos are promising for checking leaffolder damage. ☐

Effect of 7 insecticides on leaffolder damage and yield of cultivar Himalaya 1 at Malan, H. P., India, 1984.[a]

Insecticide	Rate (kg ai/ha)	Leaffolder damage (%)	Damage decrease (%)	Grain yield (t/ha)[a]	Yield increase (%)
Quinalphos 3G	1.5	1.5 d	89.3	3.9 a	61.6
Carbofuran 3G	1.0	2.3 cd	83.6	3.4 b	40.6
Monocrotophos 40EC	0.5	1.9 cd	86.5	3.1 bc	29.0
Benfuracarb 3G	1.5	2.7 c	80.8	3.0 cd	25.5
Bromophos-ethyl 5G	1.5	2.4 c	82.9	2.9 cd	23.2
Ethoprop 10G	1.5	3.7 b	73.7	2.7 de	13.9
UC 54229 99SP	0.75	1.3 d	90.7	2.7 de	11.6
Untreated control	–	14.1 a	–	2.4 e	–

[a] In a column, figures followed by the same letter are not significantly different from each other.

Nuclear polyhedrosis virus for controlling the ear-cutting caterpillar

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The ear-cutting caterpillar *Mythimna separata* (Walker) damages rice in the Solomon Islands. The mature caterpillar cuts the panicles of ripening rice. Early infestations are minor but a late infestation with old larvae causes serious damage and heavy yield loss. The immature stage consists of six larval stadia; larvae of the last two instars are ravenous feeders. In the field, a viral disease occasionally caused high mortality of young larvae.

M. separata's nuclear polyhedrosis virus *(Ms* NPV) was first studied in the early 1970s in India, but the virus has not been formulated and used commercially. *Authographa californica's* NPV *(A.cal* NPV) was first isolated in the early 1960s from a diseased larva in a California alfalfa field. *A.cal* NPV has a large host spectrum including 9 families (Lepidopterans), 29 genera, and 35 species of insect pests. This has aroused worldwide interest in its potential as a broad-spectrum microbial control agent.

We used MsNPV and *A.cal* NPV from the Institute of Virology (IOV), Oxford, U.K., to test insects collected from the Solomons. The bioassay was conducted at the IOV in Oct 1985.

Larvae of *M. separata* were reared on an artificial diet with basic elements from brewer yeast and red kidney bean extracts. Thirty 2d-instar larvae were used for each of three replications per treatment. With a vacuum suction device, 10 mg of the diet was put in a compartment of a transparent multicompartment plate. One larva was placed in each of the other compartments. Then the viral suspension was released onto the diet at 1 µl/larva. Untreated control insects were fed with the same diet and water. At 3 d after treatment (DAT), all insects were transferred into 4-cm-diam butter cups filled to 1.5 cm depth with the diet, at 1 larva/cup.

Mortality was recorded at 7 and 14 DAT. The midgut of dead larvae was smeared on slides and stained with naphthalene black for diagnosis under a microscope (1000X). Mortality of larvae in the untreated control was 0.3% at 7 DAT and 0.7% at 14 DAT. Mortality of the treated insects was adjusted using Abbott's formula (see table).

The results indicate that *A.cal* NPV is pathogenic to *M. separata.* Differences in insect mortality were greater at 14 DAT. Treated insects that died without being affected by the virus were those that failed to eat during the first few days.

Mortality of *Mythimna separata* (Walk.) treated with nuclear polyhedrosis virus.[a]

Treatment		Mortality[c] (%)	
Virus	Dosage[b] (PIB/ml)	7 DAT	14 DAT
*A. cal*NPV	6.675×10^4	3.2 b	6.7 d
	6.675×10^5	10.0 ab	23.3 c
	6.675×10^6	16.3 ab	31.7 bc
	6.675×10^7	15.7 ab	36.7 b
	6.675×10^8	34.7 a	83.3 a
Ms NPV	3.540×10^4	3.0 c	3.3 d
	3.540×10^5	23.7 b	36.7 b
	3.540×10^6	35.7 b	53.3 ab
	3.540×10^7	41.0 ab	83.3 a
	3.540×10^8	62.0 a	96.7 a

[a]Thirty 2d-instar larvae replication, 3 replications/treatment. [b]PIB = polyhedral inclusion bodies. [c]Means in a column followed by common letter are not significantly different by Duncan's multiple range test at 5% level.

Effects of the viruses in the field would depend on application method and formulation to give proper distribution-deposition and protection from ultraviolet and other adverse factors. The virus is projected to be used at Solrice farm next year, together with the parasite *Apanteles ruficrus* Haliday (Braconidae - Hymenoptera), to control *M. separata.* □

Rice leaffolder (LF) complex in Madurai, Tamil Nadu, India

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During 1985–86 rabi (winter Nov planting), recommended chemicals did not give adequate control of LF in the Madurai Agricultural College Farm. The larvae were collected periodically and reared to adults.

We found that LF is a complex of three species: *Cnaphalocrocis medinalis, Marasmia patnalis,* and *Marasmia ruralis.* The first two were abundant on all sampling dates (see table). Insecticides need to be screened against all three LF species. □

Survey of rice LF in Madurai, India, 1985.

Date collected	LF adults that emerged (no.)		
	C medinalis	*M. patnalis*	*M ruralis*
26 Sep	107	115	1
27 Sep	25	17	–
28 Sep	43	46	–
29 Sep	30	30	1
30 Sep	13	3	–
1 Oct	29	25	1
2 Oct	45	38	–
10 Oct	4	16	–
14 Oct	2	7	–
Total	298	297	3

Effect of 3 granular insecticides on brown planthopper (BPH) *Nilaparvata lugens* (Stal) in the Easternghat Highland Zone, Koraput, India

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In the Easternghat Highland Zone, Koraput district, India, serious BPH outbreaks were observed on irrigated

Effect of granular insecticides on BPH population and rice yield at Semiliguda, Koraput, India, 1981.[a]

Insecticide	Adults/hill (treatment at 15 DT)		Nymphs/hill (treatment at 35 DT)		Yield (t/ha)
	10 DAT	20 DAT	10 DAT	20 DAT	
Untreated	13.7 d	59.0 e	27.0 d	0.0	0.0
BPMC	4.7 a	51.7 de	7.3 b	27.7 b	1.5 a
Carbofuran	5.7 ab	35.7 a	6.3 b	34.7 b	1.8 a
Isoprocarb	7.0 bc	42.3 abc	4.3 a	21.0 a	1.7 a
Phorate	8.0 bc	43.3 bc	19.0 cd	0.0	0.0
Disulfoton	8.7 c	41.3 ab	13.0 c	0.0	0.0
Quinalphos	9.3 c	49.3 cd	18.3 cd	0.0	0.0

[a]In a column, means followed by a common letter are not significantly different at the 1% level after logarithmic transformation. DT = days after transplanting.

summer rice (Feb–May) in 1980 and 1981. No rice varieties grown was found to be resistant. A trial to evaluate six granular insecticides was conducted during 198 1 summer.

The trial was laid out in a randomized block design with three replications. Pest-susceptible cultivar Suphala (TNl/Tl41) was transplanted on 21 Feb 1981. Insecticide granules at 1.5 kg ai/ha were broadcast at 15 and 35 d after transplanting, when heavy migratory hopper populations appeared. BPH adult and nymph populations were recorded at 10 and 20 d after treatment (DAT) on a random sample of 10 hills after each application.

Heavy adult population was recorded at 10 DAT, increasing up to 20 DAT with a continuous influx of emigrant hoppers. Hopperburn was noticed with phorate, quinalphos, and disulfoton treatments, resulting in a total yield loss (see table).

The superiority of isoprocarb, carbofuran, and BPMC was evident 10 d after the second treatment, with a significant reduction in nymph population. ☐

Insect pests of wet season rice in Jabalpur, India

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Wet season rice grown after wheat in Jabalpur is attacked by several insect pests. In a 1984 survey, whitebacked planthopper was a major pest at the vegetative stage, 8-107 hoppers/hill (see table). Rice hispa, although sporadic, was 0.3-12/hill and caused 17-28% damaged leaves.

Insect pests of rice at Jabalpur, India, 1984.

Pest	Economic status[a]	Damage or population[b]
Whitebacked planthopper *Sogatella furcifera* (Horvath)	Major (R)	107 hoppers/hill Jul planting
Rice hispa *Dicladispa armigera* (Olivier)	Major (S)	12 hispas/hill and 28.3% leaf damage in Jul planting
Rice whorl maggot *Hydrellia philippina* Ferino	Minor	16% leaf damage in Jul planting
Rice armyworm *Mythimna separata* (Walker)	Major (R)	1.8 larvae/hill in Jul-Aug planting
Rice green leafhoppers *Nephotettix* spp.	Minor (R)	1-3 hoppers/hill
Yellow stem borer *Scirpophaga incertulas* (Walk.)	Minor (R)	1.4% deadhearts
Rice satyrid butterfly *Melanitis leda ismene* (Cramer)	Minor (S)	Traces
Rice gundhi bug *Leptocorisa acuta* (Thunberg)	Minor (S)	1-2 bugs/hill

[a]R = regular, S = sporadic, [b]Peak population or damage during season.

Rice whorl maggot damage was recorded in this region for the first time during that survey with 5% damaged leaves in early August, increasing to 16%. Populations of rice armyworm started at 0.2 larva/ hill and reached 2 larvae/hill. The 1.3 larvae/ hill during the first week of Oct coincided with booting and panicle development. That population was higher than the economic threshold level of 1 larva/hill.

Trace numbers of yellow stem borer, rice skipper *Pelopidus* sp., rice satyrid butterfly, and rice gundhi bug *Leptocorisa acuta* (Thunberg) [=varicornis (Fab)] were found. ☐

Biogas to control rice storage pests

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Effect of biogas on rice storage pests.

Insect	Biogas dose	Time to 10% mortality	
		Without grain	With grain
S. cerealella	20 liters/min	30 s	4 h
S. oryzae	20 liters/min	35 s	4 h 50 min
R. dominica	20 literslmin	50 s	6 h

The major insect pests of stored rice are the Angoumois grain moth *Sitotroga cerealella,* the lesser grain borer *Rhizopertha dominica,* and the rice weevil *Sitophilus oryzae.* We tested controlling these pests with biogas from cow dung, consisting of 60% methane, 30-35% carbon dioxide, and traces of other gases.

Twenty-five adults of each pest were placed in 1-kg-capacity closed glass containers and subjected to biogas at 20 liters/min, at 28°C room temperature and 80% relative humidity. Within 30-50 s, all test insects died. No insects died in the untreated check.

Test insects were subjected to 20 liters biogas/min in the presence of 1 kg rough rice. The time to 100% death was 4-6 h (see table). *S. cerealella* was easily killed, followed by *S. oryzae* and finally *R. dominica.* The same treatment also was highly effective in controlling rats. ☐

Pest Control and Management
WEEDS

Schoenoplectus corymbosus (Roth ex Roem. and Schult.) J. Raynal, a new weed in ricefields in India

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Large numbers of *Schoenoplectus corymbosus* (80.8/m^2) in standing water of ricefields around Mudigere, Karnataka, India, affect crop growth and productivity.

The stout rhizomatous perennial grows to 70-110 cm ht (see figure). Stems are tubular and bear inflorescences about 15 cm from the tip. The inflorescence has 4-8 rays bearing clustered, often proliferous spike1ets. Bracts are about 3 cm long, erect and rigid. Spikelets are ellipsoid, about 8 × 4 mm. Glumes are oblong, acute, with a narrow, minutely excurrent midrib. It has no bristles. The nut is obovoid, about 2 mm long, unequally triquetrous, black and shiny. Average dry weight of a single clump is 9.72 g and there are around 39.2 stems in each clump.


Schoenoplectus corymbosus, a new weed in ricefields in the hill region of Karnataka, India.

In a rice plot with large numbers of *S. corymbosus,* yield was 30.7% less than in a *S. corymbosus*-free plot.

This weed of rice is new for the hill region of Karnataka. □

Integrated weed management in transplanted rice

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The effect of manual (hand weeding), chemical (preemergence or postemergence herbicides), and cultural (azolla dual cropping) methods of weed control alone or in combination was studied in transplanted IR50 during 1985 kharif. The treatments were in a randomized block design replicated 3 times.

Weed flora at the experimental site

Effect of weed control treatments on transplanted rice. Madurai, India.

Treatment[a]	Weed dry weight at harvest (g/m^2)	Grain yield (t/ha)	Net return ($/ha)
Butachlor 1.25 kg ai/ha + HW 25 DT	12.94	6.4	687.4
Thiobencarb 1.50 kg ai/ha + HW 25 DT	14.20	6.3	659.4
Oxadiazon 0.75 kg ai/ha + HW 25 DT	15.06	6.2	641.5
2,4-D sodium salt 1.0 kg ai/ha + HW 40 DT	15.80	6.2	658.4
Azolla 1 t/ha 10 DT	34.20	5.1	508.0
Azolla 1 t/ha + HW 25 DT	17.20	5.6	565.5
Azolla 1 t/ha + HW 40 DT	16.60	5.7	586.8
Butachlor 1.25 kg ai/ha + azolla 1 t/ha	17.66	5.8	606.2
Thiobencarb 1.5 kg ai/ha + azolla 1 t/ha	17.34	5.8	594.2
Oxadiazon 0.75 kg ai/ha + azolla 1 t/ha	17.86	5.7	581.6
HW 25 and 40 DT	13.20	6.3	664.2
Unweeded check	45.20	5.0	496.0
CD 5%	2.32	0.3	–

[a] DT = days after transplanting, HW = hand weeding.

(clay loam) comprised *Echinochloa colona, Echinochloa crus-galli, Cyperus rotundus, Cyperus difformis, Marsilea quadrifolia, Ludwigia perennis, Sphaeranthus indicus,* and *Eelipta prostrata.*

Preemergence herbicides (butachlor, thiobencarb, and oxadiazon) were applied 3 d after transplanting (DT); postemergence herbicide 2,4-D was applied 25 DT. Azolla was inoculated 10 DT.

Preemergence butachlor (1.25 kg ai/ ha), thiobencarb (1.5 kg ai/ha), or oxadiazon (0.75 kg ai/ ha) followed by 1 hand weeding (HW) 25 DT; or postemergence 2,4-D sodium salt (1.0 kg ai/ ha) with H W at 40 DT controlled weeds as effectively as 2 HW (25 and 40 DT) (see table). Weed dry weights in weeded plots were 12.94-15.80 g/m^2, compared to 45.2 g/m^2 in the unweeded.

Azolla with HW or in combination with preemergence herbicides had higher yields than the unweeded check, but lower than those with chemical treatments. The highest net returns were with butachlor + HW ($687.4) and with 2 HW ($664.2). □

Pest Control and Management
OTHER PESTS

Rat damage to rice seedlings in the hilly region of Karnataka, India

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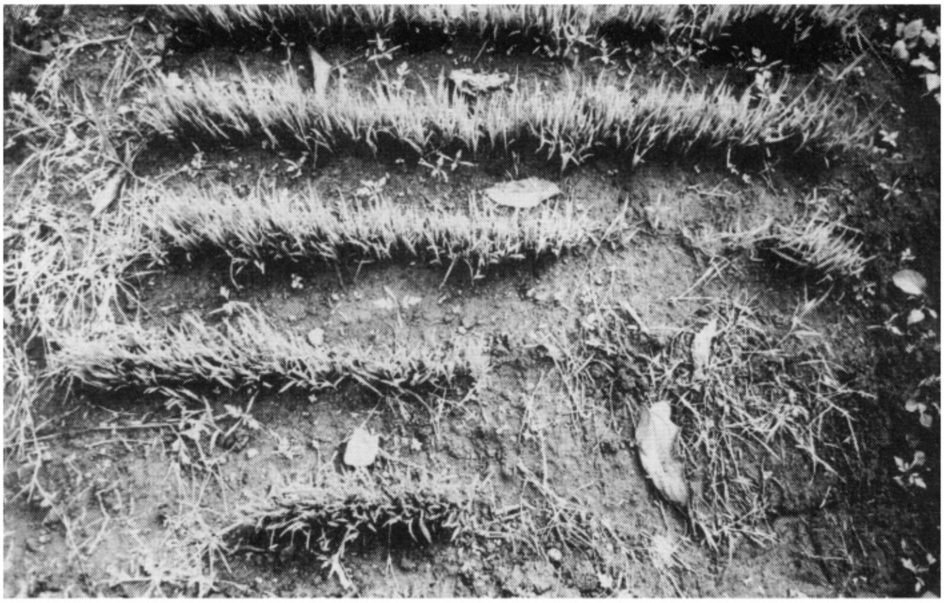
Little is known about rice yield losses to rodents. To estimate loss of seedlings to rats *Bandicota bengalensis,* the number of rows per bed and percent of rows damaged in a bed were recorded. For analysis, partially damaged rows were averaged (two 50% damaged rows = one 100% damaged row). Rice seedlings in 10 randomly selected rows with no rat damage were counted to set the average number of seedlings per row for a rice nursery. For each sowing date, a control, rat-free nursery was maintained by repeated application of aluminum phosphide, a rodent burrow fumigant.

Soil was sandy loam; seeds were hand-sown in rows, 0.1 m apart.

Rats scooped out lumps of mud to feed on germinating rice seeds (see figure), damaging seedlings in the process. They caused significant losses to rice seedlings sown on 23 Jan and 31 Jul (see table). □



Rows of IR20 seedlings damaged by *Bandicota bengalensis* in Mudigere, India.

Losses of rice seedlings to *Bandicota bengalensis* **in Mudigere, India, 1984-86.**

Sowing date	Nursery bed size (m)	Rows/ bed (no.)	Beds/ nursery (no.)	Rows damaged (%)	Seedlings damaged/ nursery %[a]	F value[b]
23 Jan 1984	5 × 1 × 0.3	42	18	18.51	25.12 a (0.08)	P < 0.05
18 Jun	10 × 4 × 0.4	44	8	5.42	7.10 c (0.01)	P > 0.05
8 Jul	5 × 1 × 0.2	45	5	8.90	14.00 b (0.00)	P > 0.05
31 Jul	5 × 1 × 0.3	45	8	37.50	43.50 a (0.05)	P < 0.05
2 Jun 1986	5 × 2 × 0.3	45	8	2.10	3.15 c (0.00)	P > 0.05
22 May	5 × 2 × 0.3	45	5	3.80	4.60 c (0.00)	P >0.05

[a] Figures in parentheses correspond to control. Letters followed by the same letter are not statistically different by Duncan's multiple range test. [b] F values compared to control.

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Control of spiral nematode on rice

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Six nematicides against spiral nematode *Helicotylenchus abunaamai* were evaluated. Clay pots filled with sterilized soil (500 g/pot) were infested with 1,000 nematodes each. One week later, the granular nematicides aldicarb, phorate, fensulfothion, carbofuran, and diazinon at 2 and 4 kg ai/ha and the fumigant dibromochloropropane (DBCP) at 6 and 12 liters/ha were applied. Each treatment was replicated four times. Annapurna seedlings were transplanted after 15 d at 1 plant/ pot. Nematode populations and plant growth were evaluated 90 d after transplanting.

DBCP at 12 liters/ha was most effective in reducing nematode populations, followed by phorate at 4 kg ai/ha (see table). Carbofuran (4 kg ai/ ha), DBCP (6 liters/ ha), and phorate (2 kg ai/ha) brought nematode populations below the inoculum level.

Dry plant weight was highest with 12 liters DBCP/ha. It was also significantly higher than that of the control with carbofuran and phorate (both rates), DBCP (6 liters/ ha), and aldicarb (4 kg ai/ha). □

Effect of 6 nematicides on spiral nematode populations and plant growth. Bhubaneswar, India.

Nematicide	Dosage (ai/ha)	Nematode recovery/ 500 g soil[a]	Plant mean dry wt (g)
Aldicarb	2 kg	1878	15.6
	4 kg	1330	16.4
Phorate	2 kg	875	16.4
	4 kg	556	16.4
Fensulfothion	2 kg	1993	1.53
	4 kg	1456	15.7
Carbofuran	2 kg	1205	16.6
	4 kg	819	16.8
Diazinon	2 kg	2141	15.2
	4 kg	1699	15.4
DBCP	6 liters	871	16.6
	12 liters	280	17.2
Control		3854	15.2
CD (0.01)			0.4

[a]Mean of 4 replications, Initial population = 1000/500 g soil.

Soil and Crop Management

Insecticide-zinc interactions in lowland rice

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We studied the effects on yield of soil-applied granular insecticides, Zn, and their interactions during the southwest monsoon season Jul-Oct 1982. The experiment was laid out in a factorial combination of 3 levels of insecticides (no insecticide, carbofuran at 0.75 kg ai/ha, phorate at 1.0 kg ai/ ha) and 2 levels of Zn (no $ZnSO_4$ and 25 kg $ZnSO_4$/ha).

Carbofuran (2,3-Dihydro- 2,2-dimethyl-7-benzofuranyl-methyl-carbamate), available in 3% granules commercially, is a broad-spectrum insecticide recommended at 0.5 to 0.75 kg ai/ha for rice. Phorate (0.0-Diethyl S [(ethylthio) methyl] phosphoro-dithioate), available in 10% granules commercially, is recommended at 1 kg ai/ ha. The experiment in wetland rice at Tamil Nadu Agricultural University, India (11°N, 77°E, and 427 m above mean sea level) used standard management practices. The soil contained 1.1% organic C, 196-9.5-200 ppm available NPK, 598 ppm total soil N, and 0.4 ppm DTPA extractable Zn. Test variety was IR20.

Application of either insecticide or Zn increased yields significantly (see table). However, the increases depended on the level of the other factor. The effect of Zn was highest when phorate was applied, 20% increase against 10% for carbofuran and 15% without insecticide. The effect of insecticide was also slightly higher when Zn was applied. □

Effects of insecticide and Zn application on IR20 yield. Coimbatore, India, Jul-Oct 1982.

Insecticide	Yield (t/ha)		Difference	
	No Zn	25 kg $ZnSO_4$ /ha	t/ha	%
No insecticide	2.81	3.23	0.42	15
Carbofuran 3% G 0.75	3.45	3.78	0.33	10
Phorate 10% G 1.0	3.37	4.06	0.69	20
AV	3.21	3.69	0.48	15
CD .01 = 0.20 t/ha				

Response of rainfed wetland rice to level, method, and timing of azolla application

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We conducted two azolla experiments under rainfed conditions during the 1983 crop year. The first involved two application methods (Table 1) in split-plot design with three replications. Fresh azolla was incorporated and surface-applied at 0, 10, 20, and 30 t/ha. IR36 was grown on 2- × 3-m plots at 25- × 25-cm spacing with practices suitable for rainfed culture. Partially sun-dried azolla was applied 3 d before transplanting.

The second experiment involved seven timings of azolla application (Table 2) in a randomized complete block design with four replications. Azolla was incorporated at 20 t/ ha, IR36 was spaced 25 × 25 cm with 3 seedlings/ hill.

Method of application did not affect plant height, tiller count, fresh straw yield, 1000-seed weight, or the grain yield (Table 1). Taller plants occurred in all azolla-treated plots. Highest grain yield (7.0 t/ha) was with 20 t azolla/ ha.

Time of treatment did not influence height and fresh straw yield (Table 2). Azolla applied 2 WBT had the most tillers (17/ hill). Applying azolla 3 WBT, 2 WBT, 1 WBT, or ATT was evidently best for grain yield; means ranged from 6.6 to 7.8 t/ ha. Grain yields decreased significantly when application was after transplanting. □

Table 1. Effect of 2 application methods and 4 rates of fresh azolla on growth and yield of IR36. PSPC, Mambusao, Capiz, Philippines.

Application method	Application rate (t/ha)	Plant ht (cm)	Tillers/ hill (av no.)	Fresh straw wt (t/ha)	1000-seed wt (g)	Grain yield [a] (t/ha)
Surface applied	0	77.5	13	17.8	25.8	5.9
	10	87.1	15	15.2	26.4	6.7
	20	85.1	15	12.9	25.3	6.7
	30	87.0	15	14.0	27.5	6.5
Incorporated	0	81.4	13	13.7	25.8	6.5
	10	85.7	15	14.4	27.5	6.9
	20	84.4	15	15.4	26.9	7.2
	30	84.2	14	13.0	28.1	6.5
Means (rate)	0	79.4	13	15.7	25.8	6.2
	10	86.4	15	14.8	26.9	6.8
	20	84.7	15	14.2	26.1	7.0
	30	85.6	15	13.5	21.8	6.5
Means (method)						
Surface applied		84.2	15	15.0	26.2	6.5
Incorporated		83.9	14	14.1	27.1	6.8
Test of significance	Method	ns	ns	ns	ns	ns
	Level	1%	ns	5%	ns	5%
	Interaction	ns	ns	ns	ns	ns
LSD (for level)	5%	4.5	–	1.7	–	0.7
	1%	6.4	–	2.4	–	1.0
CV (%)	Main plot	3.6	6.6	12.8	10.0	1.3
	Sub-plot	3.0	8.5	7.2	5.6	6.1

[a] Sun-dried weight.

Table 2. Time of azolla application and growth and yield components of IR36.[a] PSPC, Mambusao, Capiz, Philippines.

Time of application [b]	Plant ht (cm)	Tillers (no./hill)	Fresh straw yield (t/ha)	Grain yield [c] (t/ha)
3 WBT	71.0	14 b	15.0	7.6 a
2 WBT	75.5	17 a	15.7	7.8 a
1 WBT	71.3	14 b	15.1	6.8 ab
ATT	70.0	13 b	14.9	6.6 abc
1 WT	70.7	12 b	14.7	5.6 bcd
2 WT	70.9	11 b	14.3	5.3 cd
3 WT	69.2	11 b	13.9	4.7 d
Test of significance	–	1%	–	1%
cv (%)	6.8	9.1	4.8	13.6

[a] Means of 4 replications. In a column, means with a common letter are not significantly different by DMRT at the 5% level. [b] WBT = weeks before transplanting, ATT = at transplanting, WT = weeks after transplanting. [c] Sun-dried weight.

Effect of Zn on yield and quality of rice in Turkey

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The effect of Zn applied with N and P on grain yield and quality of rice grown in the main production areas of Turkey was studied. Field experiments in Central Anatolia, Çorum Province, Ankara, and at Trachia, Edirne Province, lasted 2 yr. Soil analyses of the experimental fields are shown in Table I. Seven different treatments were tested with rice variety Ribe in a randomized block design replicated four times. Treatments are in Table 2.

Urea and superphosphate were applied at 150 kg N/ ha and 35 kg P/ ha to all treatments.

$ZnSO_4 \cdot 7H_2O$ at 60 kg should be applied to the soil before seeding in Çorum; in the other states, foliar application of $ZnSO_4$ gave better results.

One rice quality factor is protein content. Zn had no effect on protein

Table 1. Physical and chemical properties of ricefield soils in Turkey.

State	Soil depth (cm)	Texture[a]	pH	Organic matter (%)	$CaCO_3$ (%)	Total N (%)	Available Olsen P (ppm)	Exchangeable cations (meq/100 g) Na^+	K^+	Ca^{++}	Mg^{++}	CEC (meq/100 g)	DTPA extractable Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
Corum	0-20	C	7.4	1.41	9.45	1.36	6.94	1.88	0.42	22.00	9.88	34.18	2.03	41.10	12.72	7.05
	20-40	C	7.5	1.54	10.12	1.06	6.24	1.40	0.46	20.16	8.00	30.02	1.09	42.20	12.27	11.43
	40-60	C	7.3	1.61	9.88	0.94	3.18	0.96	0.31	18.40	11.13	30.80	0.48	40.13	12.00	9.00
Ankara	0-20	C	7.6	2.65	22.23	1.49	7.28	0.34	1.39	26.16	9.13	37.02	2.96	45.00	13.88	5.45
	20-40	C	7.7	1.13	22.37	1.47	3.04	0.20	1.46	24.24	10.37	36.27	3.02	41.00	8.74	8.00
	40-60	C	7.7	2.46	22.00	1.45	4.32	0.12	1.63	13.90	10.00	25.65	2.88	32.86	11.62	5.20
Edirne	0-20	Sil	6.6	1.14	1.52	1.71	7.62	1.32	0.63	10.38	7.10	19.43	1.08	56.25	14.64	2.58
	20-40	Sil	7.0	0.40	11.66	1.43	7.62	0.88	0.36	12.24	6.40	19.88	0.39	40.14	11.12	1.74
	40-60	Sil	7.2	0.34	1.08	1.06	5.30	0.97	0.30	8.20	4.16	13.63	0.45	42.00	12.88	1.11

[a] C = clayey, Sil = silty.

Table 2. Effect of Zn on grain yield in Turkey.

Treatment	1981 crop season Corum Yield[a] (t/ha)	Increase (%)	1981 Ankara Yield[a] (t/ha)	Increase (%)	1982 crop season Corum Yield (t/ha)	Increase (%)	1982 Edirne Yield (t/ha)	Increase (%)	Mean yield (t/ha)	Mean increase (%)
No Zn	4.6 cd	–	3.4 b	–	3.5	–	6.7	–	4.5	–
30 kg $ZnSO_4$ basal	5.6 ab	20.9	4.4 ab	30.1	3.8	7.3	7.2	7.2	5.2	15.0
60 kg $ZnSO_4$ basal	5.7 a	23.5	4.4 ab	31.0	4.3	21.1	7.1	5.8	5.4	17.9
1% $ZnSO_4$ foliar	4.8 bcd	4.0	5.1 a	49.0	3.9	11.9	7.5	11.9	5.3	16.8
1% Zn-EDDHA foliar	5.4 abc	16.6	3.7 b	7.6	3.6	1.5	6.5	–2.7	5.8	4.9
1% $ZnSO_4$ seed soak	5.0 abcd	8.3	3.6 b	5.1	3.6	2.6	6.9	2.5	4.8	4.5
ZnO seed coat	4.4 d	–5.1	4.3 ab	25.3	4.0	12.9	6.8	1.8	4.8	6.6
SD	47.3		72.8		47.1		62.4			
CV (%)	9.0		17.7		12.4		9.0			
F	**		*		ns		ns			

[a] Means followed by the same letter are not significantly different at the 1% level.

content. Milling recovery increased 67-70% in Corum, 61-66% in Ankara, and 58-62% in Edirne, regardless of Zn applications; the variation was not significant. The 1000-kernel wt also showed no difference.

A common Zn deficiency exists in the rice production area of Corum. Farmers have recognized the problem, but thought it a disease, not a nutritional problem. Application of Zn will solve it. □

Effect of Calcutta City waste compost on rice yield

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Disposal of city garbage is a continuing problem in Calcutta. Dumping lands are gradually being filled up by city garbage and further dumping is almost impossible. Newly developed, expensive land is being used as garbage dumps, wasting material wealth and posing health hazards.

Wastes could be converted to compost and used for agricultural purposes. Investigations at the Agricultural Experimental Farm during 1984 and 1985 kharif examined the possibility of using such compost alone or in combination with urea in rice production.

Characteristics of soil and Calcutta city waste compost, mechanically prepared, are presented in Table 1. N at 120 kg/ha was supplied by urea,

Table 1. Chemical characteristics of soil and compost. Calcutta, India.

	pH	Organic C (%)	Available nutrients (ppm) N	P	K	Zn	Mn	Fe	Cu
Soil	6.2	0.92	94.0	20.3	520.8	0.82	0.55	4.22	0.15
Calcutta City waste compost	8.1	7.50	343.3	374.0	2185.0	147.05	35.00	89.25	29.25

compost, and a urea-compost mixture. Rice varieties Ratna, Subarna, and IET1444 were used. A uniform 50 kg K/ ha was applied basally during land preparation. N as urea was applied in three equal splits; the entire amount of compost was added basally. A separate field experiment was conducted for each variety with three replications in a randomized block design.

Compost was effective in increasing yield (Table 2). Ratna gave the best response. Yields with urea were highest in all treatments; yields with compost alone and in combination with urea were similar. The effect of compost on yield may be due to its appreciable amounts of N, P, K, Zn, Fe, Mn, and Cu, along with organic matter. In addition, increased available macro- and micronutrients in the soil ultimately help increase yield. □

Table 2. Response of rice to compost and urea. Calcutta. India.

Treatment	Yield [a] (t/ha)		
	Ratna	Subarna	IET1444
Control (no N)	3.1	3.5	3.7
Compost at 120 kg N/ha	5.2	4.7	5.4
Urea at 120 kg N/ha	5.3	5.1	5.6
Compost at 60 kg N/ha + urea at 60 kg N/ha	5.2	4.9	5.4
CD at 5%	0.2	0.2	0.2

[a] Means of 2 yr.

Influence of herbicides on biomass production and relative growth rate of *Azolla pinnata*

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Field and pot culture experiments were used to study the effect of some promising preemergence herbicides on biomass production and relative growth rate (RGR) of azolla. Azolla was inoculated at 200 g/m^2 and fresh biomass was estimated 15 d later in the field. RGR was calculated from fresh weight in pot cultures at 3-d intervals.

Among the herbicides tried, biomass production was highest with EPTC alone (see table). Butachlor recorded the least biomass production. Thiobencarb, molinate, and combinations with 2,4-D EE were similar. Biomass production was significantly less than for EPTC and its combinations with 2,4-D esters.

Azolla inoculation 3 d after herbicide application recorded the highest biomass; that on the day of herbicide application drastically reduced biomass production.

Applying EPTC either alone or in combination with 2,4-D esters and inoculating azolla 3-6 d after application produced the highest azolla biomass and higher RGR. □

Effect of some herbicides on azolla biomass production. Coimbatore, India.

Herbicide	Biomass (t/ha) in field	RGR (g/g per d) in pot culture
EPTC	6.69	0.1818
EPTC + 2,4-D ethyl ester (EE)	6.51	0.1994
EPTC + 2,4-D butyl ester (BE)	6.47	0.1810
Molinate + 2,4-D (EE)	5.20	–
Molinate	4.86	–
Thiobencarb	4.05	–
Butachlor	2.96	–
No herbicide (control)	–	0.1974

Preparation method for carbon dioxide-bicarbonate medium used to culture rice plant in water

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The pH value of media used in water culture of rice plants declines rapidly because of nutrient absorption by rice roots. The pH must be adjusted almost every day, a time-consuming process. A more practical, carbon dioxide-bicarbonate medium, containing large quantities of CO_2 has been developed. Similar conditions exist in field soil solutions.

In the new medium ammonium bicarbonate and potassium bicarbonate are used to lower the proportion of sulfate and chloride salts.

Stock solution A: Dissolve 113 g of ammonium bicarbonate (NH_4HCO_3) and 3 1.9 g of potassium bicarbonate ($KHCO_3$) in 1 liter of distilled or CO_2-saturated water. Stir carefully and slowly to dissolve the chemicals and to prevent formation of heavy foam. Preserve this stock solution in polyethylene or glass bottles.

Stock solution B: Dissolve 40.0 g of Na_2HPO_4 in 1 liter of distilled water.

Stock solution C: Dissolve 36.7 g of $MgSO_4 \cdot 7H_2O$ in 1 liter of distilled water.

Stock solution D: Dissolve 15.1 g of Fe-EDTA and 10.5 g of CaC12.2H20 in 1 liter of distilled water.

Mix 11 ml of stock solution A and 5.5 ml of stock solutions B, C, and D, and dilute with water to total 5.5 liters of medium. The final concentrations are shown in Table 1. Because the pH value of this solution is higher than 7.0, adjust pH by blowing CO_2 gas directly from a CO_2 cylinder into the bicarbonate solution. The pH declines to 5.2 within 3-4 min. The pH value adjusted by CO_2 bubbling depends on the salt composition of the diluting water, but generally varies from pH 5.2 to 5.5.

The pH of this carbon dioxide-bicarbonate medium rises no more than 0.2-0.3 unit/d, even at the vegetative growth stage of rice plants, and adjustment by CO_2 gas bubbling is necessary only every 3-4 d during cultivation. Plant growth in this new medium was identical to that in the standard Kasugai medium (Table 2). □

Table 1. Composition of salts and concentration of elements in bicarbonate solution.

Element	Concentration		Salt
	ppm	mM	
N	40	2.85	NH_4HCO_3
P	8.72	0.28	Na_2HPO_4
K	24.9	0.64	$KHCO_3$
Ca	2.86	0.071	$CaCl_2 \bullet 2H_2O$
Mg	3.61	0.149	$MgSO_4 \bullet 7H_2O$
Fe	2	0.036	Fe-EDTA

Table 2. Dry mass of rice shoots cultivated in carbon dioxide-bicarbonate medium for 2 mo.

Treatment		Dry mass (g)
Kasugai medium[a]	pH 6.6	133 ±14
Carbon dioxide-bicarbonate medium	pH 6.6	140 ± 8
Carbon dioxide-bicarbonate medium	pH 5.5	132 ± 7

[a]Sources of N and K in Kasugai medium are ammonium sulfate and potassium chloride.

Azolla growth relative to soil moisture

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Growth of azolla *A. pinnata,* Bangkok strain, was measured at different soil moisture levels. Five experimental treatments — 3-cm-deep water (control), saturated garden soil (with water film on the surface), moist garden soil, moist compost, and moist paddy soil — were used in a randomized complete block design with four replications.

Polyethylene plastic sheets were laid beneath the soil in 1-m^2 plots to maintain the water level required in the 3-cm-deep and saturated treatments. Other plots were sprinkled as necessary. The experiment was kept in partial shade. Harvest was 20 d after stocking the azolla plants. The azolla crop was harvested by hand with most of the roots intact, washed to remove soil and other foreign matter, and drained before the weight was recorded.

Fresh and sun-dried weights of 100 azolla plants from different growing media did not differ from each other (see table). Of the total biomass production, however, azolla grown on saturated garden soil, moist compost, and 3-cm-deep water had the highest fresh weight; plants grown on saturated garden soil recorded the highest sun-dried weight. Azolla grown on saturated garden soil covered 98% of the experimental plot; that grown with 3-cm-deep water covered 95%. Dry weight percentage of harvested material did not vary among the treatments.

These results strongly suggest that azolla can be grown on saturated or moist media as productively as on water. □

Means [a] of some growth components of azolla plants grown on different media, PSPC, Mambusao, Capiz, Philippines.

Growing medium	100-plant weight (g)		Computed plant weight (t/ha)		Dry weight (%)	Matting[b] (%)
	Fresh	Sun-dried	Fresh	Sun-dried		
3-cm-deep water (control)	11	0.6	8.9 ab	0.62 b	6.8	95
Saturated garden soil	9	0.8	11.6 a	0.96 a	8.3	98
Moist garden soil	12	0.8	4.9 c	0.33 c	6.1	50
Moist compost	12	0.8	8.3 abc	0.62 b	7.5	80
Moist paddy soil	13	0.8	5.4 bc	0.26 c	4.8	75
Test of significance	ns	ns	1%	1%	ns	–
CV (%)	18	21.2	30.1	30.26	10.1	–

[a]Av of 4 replications. Means having a common letter are not significantly different from each other at the 5% level. [b]Visual observation.

Management of Zn deficiency in lowland rice

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We sought a practical and efficient method of curing Zn deficiency in the field.

IR6 was transplanted on high pH (8.2) clay loam soil with low organic matter (0.55%) and a cation exchange capacity of 28 meq/ 100 g soil. Available DTPA-extractable Zn in the soil was 0.75 ppm. Fertilizer was 120-26-0 kg NPK/ ha. The lowest Zn deficiency symptoms and the highest yields were recorded in the treatments

Efficiency of source and method of Zn application for IR6.[a] Tamboli (Sheikhupura), Pakistan.

Zn application method	Zn deficiency symptoms[b] 25 DT	Plant height (cm)	Productive tillers/plant (no.)	Yield (t/ha)	Efficiency of Zn application
Control (no Zn)	7	113.3 a	11.1 bc	5.63 c	–
Soaking the seed in 1% $ZnSO_4$ solution for 24 h before seeding (0.25 kg $ZnSO_4$/ha)	4	113.6 a	12.5 ab	6.20 ab	2300.0
Dipping the sprouted seed in 1% ZnO suspension (0.25 kg ZnO/ha)	3	114.5 a	12.4 ab	6.28 ab	2628.0
Broadcasting $ZnSO_4$ at 10 kg/ha on nursery bed before seeding (0.25 kg $ZnSO_4$/ha)	5	113.6 a	11.6 abc	5.89 abc	1056.0
Broadcasting Zn frit before transplanting at last puddling (0.25 kg/ha)	5	113.2 a	10.9 bc	5.81 bc	748.0
Broadcasting Zn frit mixture before transplanting at last puddling (0.25 kg/ha)	7	113.4 a	10.5 c	5.52 c	–
Dipping the nursery roots in 1% ZnO suspension	1	116.4 a	13.1 a	6.75 a	1119.0
Dipping the nursery roots in 1% $ZnSO_4$ solution	1	116.4 a	13.1 a	6.74 a	1117.0
Broadcasting $ZnSO_4$ at 10 DT (10 kg/ha)	2	115.0 a	12.7 ab	6.34 a	73.2

[a]In a column, means followed by the same letter are not significantly different from each other (DMRT). DT = days after transplanting. [b]Symptoms were recorded visually in a scale of 0-10: 0 = no deficiency, 10 = severe deficiency.

where nursery roots were dipped in ZnO suspension and $ZnSO_4$ (see table). Treatments affected productive tillers and yield significantly, but not plant height.

Dipping sprouted seed and nursery roots in 1% ZnO suspension before seeding or transplanting was the most efficient method of curing Zn deficiency, followed by dipping sprouted seed and nursery roots in 1% $ZnSO_4$ solution and broadcasting 10 kg $ZnSO_4$/ha on the nursery bed before seeding. Broadcasting 10 kg $ZnSO_4$/ha 10 d after transplanting was least efficient. □

Biofertilizers for rice and their residual effect on rabi crops in Madhya Pradesh, India

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A field experiment was conducted to measure the response of rice to applications of fresh biofertilizers blue-green algae (BGA), *Azospirillum,* and *Azotobacter* and their residual effect on rabi crops. Soil was clay loam with 180-16-450 kg available N, P, and K/ha. Plot size was 8 m × 5 m in kharif, divided into 4 subplots of 5 m × 2 m for rabi crops.

Rice was transplanted on 16 Jul and harvested on 19 Oct 1984. Rabi crops were sown on 20 Nov and harvested 14 Mar–10 May 1985. Rice received 18 kg P and 10 kg K/ha. The table shows the treatments.

BGA was applied in 5-7 cm standing water 7 d after transplanting; growth was sufficient to fix atmospheric N. Seedling roots were soaked 6 h in a solution of *Azospirillum* and *Azotobacter* before transplanting.

Rice yield was significantly higher with 10 kg BGA and the 2 N levels than in the control, but not with 15 and 20 kg BGA, showing erratic response to inoculation (see table). Only chickpea responded significantly to residual fertility of biofertilizers.

However, all the treatment yields were significantly greater than that of the control. Residual effects of biofertilizers can be obtained in succeeding crops such as chickpea. □

Effect of BGA, *Azospirillum, Azotobacter,* and N on rice yield and residual effects on rabi crop yields. Madhya Pradesh, India, 1984-85.

Treatment	Yield[a] (t/ha)				
	1984 kharif rice (Ratna)	1984-85 rabi			
		Wheat (Lok-1)	Chickpea (JG62-404)	Linseed (R552)	Mustard (Varuna)
Control (no fertilizer)	3.2	1.0	1.5	0.3	1.0
10 kg BGA/ha	3.9	1.1	2.1	0.3	1.2
15 kg BGA/ha	3.2	1.0	1.9	0.4	1.0
20 kg BGA/ha	3.6	1.0	1.8	0.3	0.9
40 kg N/ha	4.1	1.0	1.9	0.3	1.0
60 kg N/ha	4.1	1.1	1.9	0.3	1.0
Azospirillum	3.5	0.9	1.9	0.4	1.0
Azotobacter	3.4	0.9	2.1	0.3	1.0
CD (0.05%)	0.5	ns	0.4	ns	ns

[a]Varieties used are in parentheses.

Effect of green manure (GM) and Fe application on the Fe held by organic matter in redried submerged soils

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We investigated the effect of GM and Fe application on the Fe held by the organic matter in redried soils that varied in $CaCO_3$ content. The pot culture experiment was conducted on highly calcareous (pH 8.7, 0.56% organic C, 4.7% $CaCO_3$, and Fe held by organic matter at 25.3 mg/ kg) and slightly calcareous (pH 8.5, 0.17% organic C, 0.25% $CaCO_3$, and Fe held by organic matter at 62.2 mg/ kg) soils (Aeric Fluvaquent). pH was measured in a 1:2 soi1:water suspension.

Two levels of dry green manure (0 and 1%) from *Sesbania aculeata* (total Fe content 307 mg/ kg) and 4 Fe levels (0, 15, 30, and 60 mg/kg) from $FeSO_4$-$7H_2O$ were used. Soils were submerged 85 and 145 d, then dried 30 d.

To determine Fe held by organic matter, dried soil was allowed to react overnight with 30% H_2O_2 (1:1 soil H_2O_2 ratio). The soil tubes were immersed in a beaker containing water maintained at 75°C + 2°C for completion of the reaction. Fe was extracted with DTPA (1:4 soil DTPA ratio). To calculate Fe held by organic matter, a blank reading (without H_2O_2) was abstracted.

Submerging soil for 85 d increased the Fe held by organic matter from 25.3 to 28.9 mg/kg for highly calcareous soil and from 62.2 to 79.8 mg/kg for slightly calcareous soils (see table). Fe content further increased to 30.2 and 90.0 mg/kg after 145 d of submergence. The effect of submergence was more pronounced on slightly calcareous soil.

GM increased organic bound Fe significantly in both soils in both submergence periods. The effect was higher at 85 d in slightly calcareous soil; in highly calcareous soil, the effect was almost the same for both submergence intervals.

Adding Fe increased organic bound Fe significantly in both soils at both submergence intervals.

The interaction between GM and added Fe was significant only at 85 d of submergence in both the soils. ☐

Effect of GM and Fe application on Fe held by organic matter in soils redried after being submerged. Ludhiana, Punjab, India.

Fe applied (mg/kg)	Fe held by organic matter (mg/kg)					
	Submerged 85 d			Submerged 145 d		
	No GM	GM	Mean	No GM	GM	Mean
			Highly calcareous soil			
0	28.9	35.1	32.0	30.2	36.3	33.2
15	30.9	37.0	33.9	31.8	37.3	34.5
30	33.3	37.9	35.6	33.4	39.1	36.3
60	35.8	39.7	37.7	34.2	41.7	37.9
Mean	32.2	37.4		32.4	38.6	
			Slightly calcareous soil			
0	79.8	91.7	85.8	90.0	91.8	90.9
15	83.0	97.0	90.0	92.9	94.2	93.5
30	85.2	101.8	93.5	94.5	96.8	97.7
60	88.6	103.6	96.1	97.1	98.8	97.9
Mean	84.2	98.5		93.6	95.4	
CD (0.05)	Fe	GM	Fe × GM	Fe	GM	Fe × GM
Calcareous	0.5	0.4	0.7	1.0	0.7	ns
Noncalcareous	0.6	0.5	0.9	0.8	0.5	ns

Estimating azolla cover

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Quantitative estimates of azolla cover during multiplication are important in assessing its agronomic applications and weed-suppressing properties. The faster covering occurs, the greater its weed suppression efficiency. When studying large areas in farmers' fields, it is useful to have a simple but precise method that is faster than the usual fresh and dry weight measurement.

A new scoring method, based on the Braun Blanquet Cover-Abundance Scale, is proposed. The Braun Blanquet method is used by ecologists all over the world. In the table, the new scale is compared to the IRRI scale used in azolla INSFFER trials.

The new scale is more precise: it gives, within the significant range of cover, lower and upper limits. Errors

Two scoring methods for estimating azolla cover.

IRRI method	Modified Braun Blanquet method
0 = no azolla	r = rare with small cover
2 = 25% azolla cover	+ = few, with small cover
4 = 50% azolla cover	1 = numerous but less than 1/20 cover (<5%)
6 = 75% azolla cover	2 = cover between 1/20 and 1/4 (6-25%)
8 = 100% azolla cover	3 = cover between 1/4 and 1/2 (26-50%)
10 = 100% azolla cover with overlapping growth	4 = cover between 1/2 and 3/4 (51-75%)
	5 = cover more than 3/4 (>75%)
	6 = cover more than 3/4 (>75%) with overlapping growth of azolla

can only occur in borderline cases. It should eventually improve data processing and interpretation.

To apply this method, estimate the exact area of the plot and then the area of azolla cover. First ask: "Does azolla cover more or less than 50% of the area?" Continue to estimate according to the scale. The same scale (except for level 6) can be used to estimate area covered by rice and by different weed species. □

Urea timing and application method in direct-seeded lowland rice

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A trial tested time and method of applying urea N on waterlogged (up to 50 cm submergence) direct-seeded rice during the 1984 and 1985 wet seasons under rainfed conditions. OR117-8 (160 d) seed was broadcast on sandy clay loam (pH 5. 1, 0.045% total N, 7 kg Olsen P/ ha, and 50 kg K/ ha). At sowing, 11 kg P/ ha and 21 kg K/ ha were applied uniformly. N as urea was applied at 50 kg/ ha (see table).

Cured urea was prepared by mixing prilled urea 1:5 with moist soil and incubating 48 h in the shade. The rate of cured urea N was based on N added to the moist soil. When sufficient rainwater became available, the seedbed was plowed down by a wooden country plow followed by planking (a common practice in Orissa) at 30 d after sowing (DAS). Weeding and gapfilling were done at 40 DAS.

Effect of urea and cured urea on grain yield of rice, Bhubaneswar, India.

Treatment [a]	Yield (t/ha)		
	1984	1985	Mean
Control (no N)	3.3	2.6	2.9
100% N at seeding as PU	4.0	4.1	4.0
100% N at seeding as CU	4.3	3.7	4.0
50% N as PU at seeding + 50% N as PU through spray	4.0	3.6	3.8
50% N as CU at seeding + 50% N as PU through spray	3.9	3.2	3.5
50% N as PU at seeding + 25% at 30 DAS + 25% at panicle initiation (PI)	4.4	3.7	4.0
50% N as CU at seeding + 25% at 30 DAS + 25% at PI	4.1	3.6	3.8
50% N as PU at 40 DAS + 25% at 61 DAS + 25% at PI	5.0	4.5	4.1
50% N at CU at 40 DAS + 25% at 6 1 DAS + 25% at PI	4.4	3.1	4.0
CD (0.05)	0.6	0.7	–

[a] PU = prilled urea, CU = cured urea.

Application of 50% N at 40 DAS plus 25% at 61 DAS and 25% at panicle initiation gave the highest grain yield in both years. Applying 100% N as urea at seeding gave consistently good yields. Cured urea proved to be inferior to prilled urea. □

An improved method of representative sampling from aerobic soil solutions

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Analysis of a soil solution collected in situ from aerobic soil can be used for soil chemical environment analyses. However, it is difficult to obtain a sample from aerobic soils with moisture contents near field capacity (FC). The displacement method for well-packed FC moist soil columns has not been tested for validity under normal pot culture conditions. We evaluated samples collected by the conventional displacement method from three FC potted soils with different densities.

Twelve kilograms each of air-dried (>2 mm sized) Luisiana clay, Maahas clay, and Pila loam soils were placed in 16-liter porcelain pots fitted at the bottom with drainage (coarse sintered glass) tubes. The soils were brought to FC moisture using tensiometers.

To collect soil solutions, 0.5% KSCN as displacing solution was poured on the soil surfaces. The displaced solutions were drained into measuring cylinders. We tested the collected solutions for SCN-ion at regular intervals. Drops of acidic $FeCl_3$ solution were used as the indicator (a blood red-colored complex is formed).

From the fast-draining Luisiana clay and Pila loam soils, we could collect only 20-30 ml of soil solution. Beyond this volume, the leachate was diluted by the displacement solution. In slow-draining Maahas clay, no displacement fluid appeared in the first 200 ml. About 175 ml of soil solution is needed for a complete analysis; the displacement method was not appropriate for soils with fast drainage properties.

In a second experiment, we compared soil solution collected by the displacement method with equilibrated saturation extracts of three soils. Equilibrium was ensured by recycling the saturation extracts three times. Saturating a soil to FC, then immediately draining it does not give equilibrium extract. Allowing FC soils to remain saturated for a long time (beyond 8 h in many cases) might cause soil reduction.

We used three soils set up as in the first experiment, replicated six times. Demineralized water, in volumes required to bring the FC soils to saturation, was poured on the soil surface. The first 125-ml leachates were collected as the displacement solutions, and the rest as saturation extract.

The extracts were then recycled through soils three times, first allowing them to remain in contact with soil for about 30 min by keeping the drain tube closed. The final (fourth) extract was collected as the equilibrated saturation extract. To prevent further oxidation, the soil solutions were collected in flasks prefilled with N_2 gas.

We measured solution pH and Eh in an electrometric cell under N_2 environment. The recycled saturation extracts were representative of soil solutions; the displacement solutions were seriously diluted and altered by the displacing liquid (demineralized water, pH 5.38) (see table).

During subsequent experiments, we observed that it is necessary to recycle fast-draining soils three times; recycling once or twice seldom ensured equilibrium. ☐

Comparison of pH and Eh values[a] of solutions from FC moist soils collected by 2 different methods.

Soil	Soil pH (1:1)	pH		Eh (V)	
		Displaced solution	Recycled saturation extract	Displaced solution	Recycled saturation extract
Luisiana clay	4.7	4.6 a	4.5 a	0.31 b	0.32 b
UK–1 clay loam	6.6	5.9 b	6.5 b	0.29 a	0.26 a
Pila loam	7.5	6.9 b	7.3 b	0.27 a	0.23 a

[a]Mean of 6 replications. In a row, treatment means of a given parameter having a common letter are not significantly different by DMRT at 5% level.

Environment and its Influence

Forecasting tungro (RTV) epidemic in Tamil Nadu

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Sporadic RTV epidemics have been reported in several countries. In Tamil Nadu, the disease occurred in 1978, 1979, 1980, 1981, and 1984, but not in 1977, 1982, 1983, and 1985.

RTV can be controlled by timely application of insecticides to check the vector population. But in a nonepidemic year, preventive insecticides are wasted.

Only young rice plants are highly RTV susceptible; infection 45 d after sowing normally does not result in economic loss. A system to forecast possible epidemic RTV outbreak is needed.

We monitored light trap catches of the vector green leafhopper *Nephotettix virescens* population for 9 yr (1977-85) and attempted to correlate weather factors with disease and vector incidence.

The vector population started increasing in mid-Aug, reached its peak between mid–Sep and early Oct, then declined. Highly susceptible rice cultivar TN1 was planted at 2-wk intervals from Jul to Dec. RTV was severe in Sep and Oct; crops sown in the first 2 wk of Sep recorded maximum incidence. The period favorable to vector multiplication and RTV incidence was Sep-Oct.

The 9-yr weather data for Aug–Nov were analyzed critically. No significant difference in maximum and minimum temperatures was found between RTV epidemic and nonepidemic years. Rainfall and humidity patterns were also similar.

The data, however, revealed one important fact: when RTV occurred, the vector population increased (see table). This increase could be used to forecast a RTV epidemic. Vector populations during Aug cannot be taken as criteria, but population during the first 2 wk of Sep differentiated RTV epidemic and nonepidemic years. Total vector populations during Sep of epidemic and nonepidemic years were clearly distinguishable. Populations were more than 10^5 in RTV epidemic years and around 10^3 in nonepidemic years. ☐

RTV incidence and the vector population in Tamil Nadu during 1977-85.

Year	RTV incidence (%)	Green leafhopper[a] (no.)								
		Aug		Sep		Oct		Nov		Total during the season
		1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	
1977	0	5	1,786	202	1,059	7,821	3,672	510	228	17,283
1978	18	175	167	3,639	20,882	92,783	143,150	7,537	584	268,917
1979	100	171	7,556	25,016	455,269	69,789	81,899	10,751	5,562	656,013
1980	40	555	4,114	49,310	53,005	148,940	21,072	148,940	21,072	447,008
1981	60	162	1,181	2,837	32,882	175,574	42,816	31,119	1,583	288,154
1982	0	1,330	2,544	1,494	2,544	7,449	1,733	343	118	16,555
1983	0	122	308	996	561	9,265	23,439	7,138	331	42,160
1984	70	1,223	1,995	106,115	15,308	33,543	6,102	168	66	164,510
1985	0	9	38	83	670	4,472	490	1,420	314	7,496
Mean		4 16	2,188	21,077	64,687	61,071	36,041	23,103	3,540	

[a]Population was counted using a light trap.

Rice-Based Cropping Systems

Yield of rice-fish cultivation at Cuttack, India

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We explored the prospects of aquaculture by controlled breeding and short-term (4½ mo) seed-rearing of air-breathing clariid catfish *Clarias batrachus* in renovated fields cropped with high-yielding rice cultivar CR1018 (Pankaj/Jagannath).

The experiment consisted of a control plot of rice alone and plots of rice with fish. The plots were 0.05 ha each and had a gradient of 1.80%. A 10% area was excavated at the lower end of each rice-fish plot for a fish-shelter pit. Farmyard manure (5 t/ha) was applied to all plots during land preparation. A basal application of 40-9-17 kg NPK/ha was incorporated before direct seeding rice the first week of Jun 1985. Standard cultivation practices were followed.

One month after sowing, four male and four female catfish were released in each plot. To encourage breeding, a few round earthen pots were embedded in the soil at the periphery of the plots. The spawners bred profusely 10-15 d from release. The fish spawns were fed daily with low-cost feed — minced fish offal and raw cow dung. Fish were harvested with rice in late Nov 1985. Plots were slowly drained, allowing the fish to move to the pits where they could be collected by drag-netting and hand.

Rice production was about the same in both treatments (see table). Growing clariid catfish with rice under intermediate rained lowland conditions, with provision of the fish-shelter pit, could boost farm returns 55.4% over rice monocropping. □

Compatibility of rice caltivar CR1018 with air-breathing clariid catfish at CRRI, Cuttack, India.

Item	Rice alone	Rice + fish
Grain yield (t)	4.1	3.1
Fish yield (t)	–	0.4
Grain value ($)	440.40	400.3[a]
Fish value ($)	–	361.9[b]
Total value ($)	440.4	768.2
Additional costs ($) to raise fish crop/ha		
Land preparation		32.8
20 g/160 brood fish		32.8
1 t fish offal		free[c]
1 t cow dung		2.9
Harvesting		12.3

[a]Sale price is $108/t on farm. [b]Sale price is $l/kg on farm. [c]Collected from fish market.

A rice - grain legume cropping system

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Rice farmers of Kerala find cultivating grain legumes during the rice fallow season a promising technology to augment their family incomes. To identify a viable rice - grain legume cropping system for rice fallows, we studied four grain legumes (greengram *Vigna radiata,* blackgram *Vignu mungo,* cowpea *Vigna unguiculata,* and redgram *Cajunus cajun)* and two cropping systems: relay (sowing legume in standing crop of rice) and sequential (sowing legumes soon after harvest of rice) during kharif and rabi, 1985-86.

Soil was a sandy loam (pH 5.07, organic C, 1.6%; Bray's available P, 47 kg/ ha; and exchangeable K, 248 kg/ ha). The experiment was in a randomized complete block design with four replications. Treatments were factorial combinations of grain legumes and cropping systems.

Triveni rice was transplanted on 6 Aug 1985 at 15 × 10 cm spacing and fertilized with 70-15-29 kg NPK/ha. Harvest was on 27 Oct 1985. Grain legume seeds were dibbled on 19 Oct in relay cropping and on 28 Oct in sequential cropping. Redgram was dibbled at 30 × 20 cm spacing and other legumes at 30 × 15 cm. Fertilizer for the legumes was 20-13-17 kg NPK/ ha, half N and full P and K basally and the remaining N as a combined foliar spray of 2% urea and 0.1% phosphamidon 100 EC at 25 d after dibbling. The rabi legumes were raised without tillage and irrigation.

The main effects of grain legumes and cropping systems are presented in Table 1, and the interaction effects in Table 2. Legume grain yield showed a significant interaction of legume and cropping system. Blackgram relay-cropped with rice produced significantly high grain yield (0.92

Table 1. Yields of kharif rice and rabi grain legumes by cropping system.[a] Kerala, India, 1985-86.

Treatment	Rice grain yield (t/ha)	Legume Grain yield (t/ha)	Straw yield (t/ha)	Grain-to-straw ratio	Threshing percentage	Pod length (cm)	Days to 50% flowering	Plant ht (cm)
Grain legume varieties								
Greengram ML-5	2.3	0.05	0.25	0.21	52	6.1	38	26.2
Blackgram PDU-3	2.3	0.71	0.86	0.82	63	5.3	38	30.9
Cowpea PTB-1	2.3	0.48	1.25	0.38	69	16.9	45	46.8
Redgram DA-9	2.5	0.19	0.44	0.43	41	4.6	61	36.2
CD (5%)	ns	0.10	0.22	–	3.3	0.4	0.8	3.4
Cropping systems								
Relay cropping	2.3	0.42	0.69	0.6 1	55	8.8	46	36.7
Sequential cropping	2.4	0.30	0.71	0.42	58	7.6	46	33.3
CD (5%)	ns	0.07	ns	–	2.3	0.3	ns	2.4

[a] ns = not significant.

t/ha). Yields of blackgram after rice (0.49 t/ha), cowpea after rice (0.49 t/ha), and cowpea relayed with rice (0.47 t/ha) were statistically equal. All other combinations produced very low yields.

Grain-to-straw ratios were maximum for blackgram and for relay cropping. Other crop attributes — threshing percentage, pod length, days to 50% flowering, and plant height — also were significantly influenced by the interaction of legume species with cropping systems.

Results indicate that kharif rice with a relay-planted rabi blackgram may be a promising rice - grain legume cropping system. □

Table 2. Grain legumes and cropping systems effects on grain yield and ancillary characters of rabi grain legumes. Kerala, India, 1985-86.

Cropping system and character	Grain legume Greengram	Blackgram	Cowpea	Redgram	CD (5%)
Grain yield (t/ha)					
Relay cropping	0.05	0.92	0.4 7	0.24	0.15
Sequential cropping	0.06	0.49	0.49	0.14	
Threshing percentage					
Relay cropping	43	66	70	40	4.6
Sequential cropping	62	59	68	42	
Pod length (cm)					
Relay cropping	6.4	5.9	18.0	4.7	0.50
Sequential cropping	5.8	4.6	15.7	4.5	
50% flowering (d)					
Relay cropping	40	40	45	59	1.2
Sequential cropping	37	36	46	63	
Plant height (cm)					
Relay cropping	28.2	35.0	48.6	35.1	4.8
Sequential cropping	24.2	26.8	45.0	37.3	

Announcements

International Hybrid Rice Symposium Recommendations

About 220 delegates and observers from 17 countries and IRRI attended the First International Symposium on Hybrid Rice, Changsha, China, 6-10 October 1986.

Delegates reviewed the status of hybrid rice in China, India, Indonesia, Italy, Japan, Malaysia, Mexico, Republic of Korea, and the United States and discussed the prospects for hybrid rice production in Asia and the Pacific Region.

Three task forces recommended target environments for hybrid rice, directions of future research, and mechanisms for collaborative research. Irrigated and favorable rainfed areas are the most likely target environments for hybrid rice development because yields are already high, infrastructure to aid hybrid seed production is well developed, and farmers in those areas can more likely meet the cost of hybrid seed purchases each crop season.

Research priorities identified were methods of hybrid development, raising the level of heterosis, developing cultural practices for growing hybrids, and the economics of hybrid rice production. Asexual seed production is considered the most important long-term breeding goal.

Because hybrid rice programs outside China are in their infancy, the task force on collaboration recommended that an international network on hybrid rice be established and that individual countries establish national programs and mechanisms for network participation. □

Award for IRGC

The International Rice Germplasm Center (IRGC), IRRI, received a certificate of honor for its contributions and service to rice germplasm conservation and use. The award was given by the International Board for Plant Genetic Resources at a recent ceremony in Bangkok, Thailand. □

Pests of rice and their natural enemies in Peninsular Malaysia

Authors: G. van Vreden and Abdul Latif Ahmadzabidi. 1986. 238 pages, hardbound, 304 color photographs, bibliography with 207 references, glossary, index, index of pesticides, ISBN 90-220-0890-8

Price: US$20.00

This book provides comprehensive information about both harmful and beneficial insects and other organisms of rice, including species which are potential pests.

Substantial attention is given to beneficial species — parasites, predators, and pathogens — which are alternatives to chemical control.

The photography is excellent.

The book is based on 1980-84 work at the Rice Research Station, Bumbsng Lima, Malaysian Agricultural Research and Development Institute.

Contents: Rice cultivation in Peninsular Malaysia, The insect fauna of ricefields, Crop losses, The ecology of natural systems and agroecosystems, Outbreaks, Control of pests, Pests of rice, Storage of paddy and milled rice, Storage insects, Natural enemies of rice pests: predators, Natural enemies of rice pests: parasites, Natural enemies of rice pests: pathogens, Other insects in the rice ecosystem.

Send orders to the publisher: PUDOC (the Centre for Agricultural Publishing and Documentation), P.O. Box 4, 6700 AA Wageningen, The Netherlands.

Waray edition of "A farmer's primer" published

A Waray edition of *A farmer's primer on growing rice* was published in Aug 1986. Noel P. Policarpio of Northern Samar translated the primer into the dialect used in Northern Samar.

The printing of 5,000 copies of this edition and their distribution to farmers was sponsored by the Northern Samar Integrated Rural Development Project, a program of the Australian Government.

A second Waray edition, in the dialect specific to Leyte, is in press.

New IRRI publications

Annual report for 1985
Helpful insects, spiders, and diseases — friends of the farmer

Rice-Weather Parameters Workshop Recommendations

The workshop Impact of Weather Parameters on the Growth and Yield of Rice, 7-10 Apr 1986, drew more than 60 participants to IRRI. Central to program discussions was the rice-weather 1982-85 research project results. In that study, 65 trials in 23 sites provided data to analyze the effects of temperature and light on yields of irrigated rice.

Workshop recommendations included a general resolution to continue and extend the rice-weather project. Specific recommendations from three working groups included:

- incorporating pest monitoring into rice-weather studies,
- adding water balance to the basic data collected in weather studies, and
- expanding the development and use of computer modeling in studies of rice and related crop environments.

Proceedings comprising a synopsis of the 1982-85 Rice-Weather study and 22 papers presented at the workshop will be published by IRRI in 1987. □

The International Rice Research Newsletter (IRRN) invites all scientists to contribute concise summaries of significant rice research for publication. Contributions should be limited to one or two pages and no more than two short tables, figures, or photographs. Contributions are subject to editing and abridgment to meet space limitations. Authors will be identified by name and research organization.

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