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ANNOUNCEMENTS

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 involvingrice.
- 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- Do not cite references or include a bibliography.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

OVERALL PROGRESS

MW10, an upland variety for rainfed areas

E.H. Mallick and S. Biswas, Rice Research Substation, Bankura 722101, W.B., India

We evaluated the performance of some new, short-duration rices in 1981 wet season in direct-sown, rainfed upland conditions. MW10 performed well under drought conditions and was further evaluated in 1982 and 1983.

Yield was very low in 1981 because of severe drought for several consecutive days during booting and dough stage. MW10 yielded an average 3.1 t/ha (see table), 27% more than Sathi, a well-adapted local variety. MW10 had good tillering capacity, high spikelet fertility, and short, bold grains. It matured in 95-100 d. Evaluation is continuing.

Performance of MW10 and other rices in yield trials, Bankura, India.

Variety	Average 1981-83 grain yield (t/ha)	Panicles/m^2 (no.)	Filled grains/ panicle (no.)	1000-grain weight (g)
RP1158-90-1	1.9	357	47	21.2
HPU8020	1.8	253	39	14.4
TNAU6464	2.1	340	65	18.8
UPR82-1-7-1-2-1-1	2.5	378	77	18.8
MW10	3.1	408	77	21.0
OR83-23	2.0	355	54	18.0
ADT36	1.8	350	61	15.4
Cauvery	2.1	432	41	17.1
Sathi (local check)	2.2	380	49	22.2

IR50, a stable variety for kar in Thambiraparani tract

T. Sundaram, W. Wilfred Manuel, S.S. Palanisamy, Paddy Experiment Station, Ambasamuduram 627401, Tamil Nadu, India

IR50, a short duration, long, slender, white rice variety was introduced recently in Tamil Nadu. IR50, two cultures, and ADT36 were tested at 18 sites in Thambiraparani tract, Tirunelveli District, during kar (Jun-Sep). Data were analyzed for stability by Eberhart and Russel's (1966) model. IR50 had the highest mean yield (4.2 t/ha), the highest regression coefficient, and mean squared deviation from the regression coefficient nearer zero than three other rices tested (see table).

Yield stability of four rices analyzed by Eberhart and Russel's (1966) model).

Variety or culture	Grain yield (t/ha)	Regression coefficient	Mean square deviation
IR50	4.21	0.7078	0.2197
AS19789	4.08	0.5923	1.596
AS23254	3.67	0.6103	0.9103
ADT36	3.96	0.6508	2.050
CD (P = 0.05)	0.48		

Calpearl, a very high-yielding California japonica rice with desirable indica characteristics

Chao-Hwa Hu, N.F. Davis Drier and Elevator, Inc., Firebaugh, California 93622, USA

Before 1981, all short-grained rices released in California had poor physical appearance. Calpearl is the first short-grained variety that has milled grains without white belly or notched kernels and with good translucency. Calpearl was developed from IR1318-16/ Earlirose. The F_5 was crossed with Calrose 76.

IR1318-16 was selected from Jin Heung/IR262-43-8-11//Calady and IR262 from Peta/Peta*2//TN1. Its short stature and yield capacity originated from TN1 and the large, translucent kernels from Calady. Jin Heung may be responsible for Calpearl's short grains and Earlirose provided earliness. Calrose 76 has cold tolerance, lodging resistance, and high grain fertility.

Calpearl yields 10 t/ha, about 10% more than the average japonica grown in California and performs well when planted late. Its grains ripen 5 or more days earlier than most japonicas (see table). It can be harvested before the October rainy season, and has 5% lower grain moisture at harvest, which saves fuel during grain drying. Calpearl is easily combine harvested.

Its only disadvantage is that its large translucent kernels closely resemble those of California medium-grain rices. California's Grain Inspection Service has classified Calpearl as a medium-grained variety, but milled Calpearl rice meets US Department of Agriculture short-grain standards. Calpearl was planted on 24% (32.376 ha) of California riceland in 1983.

Average yield and agronomic characteristics of California rices.

Variety [a]	Tests (no.)	Year	Yield (t/ha)	Moisture at harvest (%)	Days to 50% heading	Plant height (cm)	Percent lodging	Seedling [b] vigor	Hull [c] type
S-201 j	20	1980-84	8.9	19.7	95	89	33	4.2	S
M9 j	20	1980-84	8.4	21.6	93	94	57	4.1	S
M-201 j	20	1980-84	9.4	21.4	94	86	9	4.1	S
Calmochi-202 jg	20	1980-84	8.3	22.2	99	94	28	4.0	S
M-302 j	17	1980-84	9.0	19.9	103	94	24	4.2	S
M-401 j	17	1980-84	9.1	20.0	106	94	52	4.3	S
M7 j	17	1980-84	8.9	21.0	110	97	15	4.4	S
Calrose 7 6 j	12	1980-84	9.1	18.4	110	97	22	4.3	P
Calpearl j	10	1982-84	9.9	16.3	89	84	20	4.7	P
M-101 j	10	1982-84	8.7	18.7	88	86	43	4.6	S
California Belle i	9	1982-84	7.6	16.9	88	102	42	3.5	S
L-202 i	9	1982-84	9.1	18.5	95	81	3	3.6	S

[a] j = japonica, g = glutinous, i = indica. [b] Subjective score:l = very poor, 5 = excellent. [c]S = smooth, P = pubescent.

ACK-5 for direct seeded rainfed conditions

B. S. Shah, S. K. Lad, and D. B. Gavit, Mahatma Phule Agricultural University, Kolhapur 416004, Maharashtra, India

ACK-5 was developed from D.6-2-2/IR8 at the College of Agriculture in Kolhapur, India, and released for general cultivation in May 1985.

Performance of ACK-5 in station and adaptive trials, Kolhapur, India.

Variety	Grain yield [a] (t/ha) 1983	1984	Average
Station trial			
Direct seeded [a]			
ACK-5	4.7	4.9	4.8
RDN185-2	5.7	4.5	5.1
Transplanted [b]			
ACK-5	5.7	3.3	4.5
RDN185-2	4.1	3.0	3.9
Adaptive trial [c]			
Direct seeded			
ACK-5	3.8 (10)	4.0 (14)	3.9
RDN185-2	3.4 (10)	3.4 (14)	3.4
Transplanted			
ACK-5	3.3 (3)	3.0 (23)	3.2
RDN185-2	3.4 (3)	3.0 (23)	3.2

[a] Mean of 2 locations. [b] Mean of 3 replications. [c] Numbers in parentheses indicate number of locations.

The semidwaIf can be grown direct seeded in rainfed conditions, or transplanted. It matures in 120-125 d when direct seeded and in 110-115 d when transplanted. Grains are short and bold (1ength:breadth 2.25) without white belly. Cooking quality and taste are acceptable and it has 8.8% crude protein. Recovery is 65% with hulling, 60% with milling, and 54% head rice. Flaked rice is better than that of local varieties.

ACK-5 was evaluated for 8 yr under upland conditions. It yielded significantly higher than several local varieties. Performance in direct seeded and transplanted station and adaptive trials is compared with that of popular, short-duration RDN185-2 (HS-l7/TN1) in the table. ACK-5 yield potential is 4 to 6 t/ ha. It yielded 4.9 t/ ha in direct-seeded trials in 1984, and 5.7 t/ha in transplanted trials in 1983.

ACK-5 is moderately susceptible to blast but is tolerant of Fe chlorosis and drought stress. It has 20 d seed dormancy.

Katrin: a new rice variety for Tanzania

H.M. Ching'ang'a, Tanzania Agricultural Research Institute, Private Bag, Ifakara, Tanzania

IET2397, a strain developed in India, was released as Katrin for general cultivation in Tanzania. A derivative of HR19/2x IR8, Katrin is semidwarf (90 cm), resistant to blast and lodging, photoperiod sensitive, and has medium duration (135 d). Average yield is 5.6 t/ha. Grains are long, slender, and translucent white with good cooking quality. Amylose content is 30%. Grain length-breadth ratio is 3.43, and volume expansion is 4.2. Fifty percent flowering is achieved in 102 d. It produces about 10 panicles/ hill and 1,000-grain wt is 30 g.

CR666, the 60-day rice strains

C. Gangadharan, Central Rice Research Institute, Cuttack 753006. India

CR666 (Sattari/Rasi//Kalinga III) lines

are some of the earliest rice strains. Because of their extreme earliness, they make a harvest possible in unirrigated drought-prone tracts of India and elsewhere.

Many CR666 lines that mature in 60 d have been identified. Some are intermediate in stature and grain size, and yield higher than the parents Sattari and Kalinga III although 10-20 d earlier than either. In progeny row trials during 1984 kharif, the strains were direct seeded and fertilized 1 wk after germination with 40 kg N/ ha. Data on some of the promising lines are given in the table.

Subsequent bulk trials in 1985 confirmed that the lines had a yield potential of 1.8 to 2.5 t/ha, comparable to the early parent Sattari. There has been an upgrading in height and grain quality over Sattari, while reducing duration by more than 10 d. The productivity of these lines is more than 30 kg/ ha daily.

Some agronomic characters of elite CR666 selections and their parents. Cuttack, India.

Culture or variety	Height (cm)	Duration (d)	Yield (t/ha)	Grain size
CR666-36-69	85	60	3.3	Long bold
CR666-36-134	85	60	3.7	Long slender
CR666-36-162	80	57	2.9	Medium slender
CR666-36-173	85	60	4 .0	Medium slender
CR666-36-322	90	58	3.8	Long slender
Sattari	70	70	2.3	Short bold
Kalinga III	125	80	3.8	Long slender
Rasi	85	115	4.2	Short bold

DR92, a rice variety for low and medium altitudes

K.R. Dhiman and R.N. Rai, Indian Council for Agricultural Research, NEH Region, Sikkim Centre, Tadong, Gangtok 737102, India

DR92, a variety suitable for cultivation in puddled and upland conditions, has been released by Sikkim State Varietal Release Committee. A selection from the IET series, DR92 is medium tall, tillers profusely, and has good panicle exsertion. Panicles are compact and number of filled spikelets per panicle is high. The grains are medium sized and bold; kernels are light red and glutinous. DR92 is resistant to blast and stem borer. It yields 40-60% more than predominant local varieties Chirakey, Addey, and Kanchi Addey (see table).

DR92 performance in Sikkim, India.

Variety	Plant ht (cm)	Tillers (no.)	Filled spikelets/ panicle (no.)	Maturity (d)	Yield (t/ha)
DR92	90	14	146	130	5.5
Chirakey	119	9	94	145	1.7
Addey	115	8	89	148	2.0
Kanchi Addey	125	10	90	150	1.4

Three new high yielding rice varieties

J.K. Roy and K.Prasad, Central Rice Research Institute (CRRI), Cuttack 6, Orissa, India

The Orissa State Seed Sub-committee in May 1985 released three promising CRRI-developed varieties for general cultivation in Orissa. CR404-56-1 (Neela), CR407-19 (Sarasa), and CR190-103 (Udaya) have built-in resistance to major insect pests such as gall midge (GM), brown planthopper (BPH), and whitebacked planthopper (WBPH).

Neela is a selection from CR94-1512-6/ Pusa 2-21. It has semidwarf stature (65-70 cm), 90-d maturity (seed to seed), medium bold grains, and yields 3.0-3.5 t/ha. A derivative of PTB21 and PTB18 parents (CR94 series), Neela is resistant to GM, green leafhopper (GLH), and BPH. It is suitable for direct seeding in uplands in kharif and for transplanting in rabi where GM is a problem in the early crop.

Sarasa, a selection from CR94-1512-6/ Ratna, has semidwarf stature (80-85 cm), is weakly photoperiod sensitive, matures in 120-125 d in kharif (1 wk earlier in rabi at Cuttack), has long slender grains with head rice recovery of 50%, and yields 4-6 t/ ha. A derivative of CR94, it is resistant to GM, BPH, and WBPH. Sarasa can withstand submergence for 7-10 d in the early vegetative stage. Sarasa is recommended for areas that are affected by early flooding followed by late season drought such as those in the Orissa coastal belt.

Udaya, a selection from CR129-118/CR57-49-2, is semidwarf (95-100 cm) and medium maturing (130 d). It has long bold grains and yields 5-6 t/ha. It is resistant to **BPH, WBPH, GM,** and **GLH,** and is tolerant of blast and tungro. Udaya is suitable for medium lands in kharif and rabi, particularly for areas where **BPH** is endemic. It has become popular in the second crop season in Cuttack and Puri Districts, where **BPH** infestation had caused farmers to switch to other crops.

Solution pollination in rice breeding

K. D. Dhiman, Indian Council for Agricultural Research, NEH Region, Sikkim Centre, Tadong, Gangtok 737102, India

Mature anthers of rice release pollen grains quickly when exposed to sunlight or electricity, but pollination is somewhat difficult and inefficient. We have adopted a solution pollination technique in which mature anthers are collected in a beaker or petri dish and kept in the sun 15-20 min and then vigorously shaken in distilled water until the water becomes yellowish with pollen suspension.

One drop of the suspension is applied by syringe on freshly emasculated or 1-d-old emasculated florets, which are then covered with paper bags. Fertilization percentage was two to four times as high as when pollen is dusted on the stigma of emasculated florets (see table).

Comparison of solution pollination with pollen dusting.[a]

Variety	Fertilized florets (no.)	
	Solution pollinated	Pollen dusted
Chirakey	45	17
Addey	47	15
Giza 14	56	20
DR92	58	25
Jaya	42	10
IR8	46	22

[a]100 florets each of all varieties were pollinated by solution pollination and pollen dusting.

A new crossing technique

J. Taillehois, Institute for Research on Tropical Agriculture (IRAT), Montpellier, France, and E. M. Castro, Brazilian National Research Center for Rice and Beans, CP 179, 74000 Goiania Go, Brazil

We have developed a new crossing technique that saves greenhouse space and permits handling a large number of crosses. Female panicles are cut with as long a culm as possible and transferred to a bottle containing tap water. The leaves are then clipped from the culm and the panicles are treated normally (emasculation and pollination). After pollination, the panicles are transferred to water-saturated vermiculite. Soon after, roots appear at the nodes. Culms are dark green and the seeds grow normally. Seed set and appearance are similar to that observed with classical methods.

Genetic Evaluation and Utilization

AGRONONOMIC CHARACTERISTICS

Heterosis for root pulling resistance in F_1 rice hybrids

I. J. Ekanayake, D. P. Garrity, and S. S. Virmani, Plant Breeding Department, IRRI

Root pulling resistance (RPR) is the vertical force required to pull a plant from the soil. Studies done at IRRI have shown a clear association between high RPR and tolerance for drought stress during the vegetative growth phase. Deep, thick, and dense root system character contribute to high RPR in rice plants grown in puddled soil.

Superior root growth may be one manifestation of F_1 hybrid vigor in rice. We compared RPR in three F_1 hybrid combinations with that of their parents to assess heterosis for root growth.

The experiment, in randomized complete block design with three replications, measured RPR of seedlings grown in the field. One seedling per hill was transplanted at 0.25 × 0.25 m spacing in well-puddled and leveled soil. Alternate seedlings were pulled in the middle rows of 5-row plots 27 d after transplanting (DT). A modified spring balance with 25-kg capacity was attached to the base of the seedling with a clamping device. Pulling resistance was recorded as the assembly was pulled vertically away from the soil surface. Plant heights and tiller counts were taken at the time of sampling.

F_1 plants were more vigorous than their parents. Table 1 indicates that F_1 plants tillered profusely compared to the check cultivar IR54, but had almost similar seedling heights. RPRs of the parents were 11.3-11.8 kg 27 DT. The rooting performance of the cross combinations was substantially higher than that of the parents (Table 1).

Table 1. Means for root pulling resistance, plant height, and tiller number in F_1 hybrids and parents.[a] IRRI, 1982 dry season.

Hybrids and parents	Root pulling resistance (kg)	Plant (ht.) (cm)	Tillers (no.)
Zhen Shan 97/ IR54	17.3 a	45.5 c	11.2 a
V20/IR54	15.8 b	46.6 b	10.0 a
V41/IR54	16.1 b	45.1 b	11.3 a
V20	11.6 c	39.4 d	9.9 a
Zhen Shan 97	11.3 c	49.4 a	9.2 ab
IR54 (check)	11.8 c	44.5 c	7.8 b

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

Table 2. Heterosis for root pulling resistance in F_1 hybrids compared with that of the check cultivar and the midparent. IRRI, 1982 dry season.

Hybrid	Heterosis[a] (%)	
	Midparent	Check (IR54)
Zhen Shan 97/IR54	47.9**	49.1**
V20/IR54	38.0**	36.2**
V41/IR54	–	38.3**

[a] **Significant at 1% level using t test. In Zhen Shan 97/IR54, V20/IR54, and V41/IR54, heterosis vs the check is a measure of heterobeltiosis since IR54 is the high parent.

Significant and positive heterosis for root pulling resistance was observed in all hybrids (Table 2). Zhen Shan 97/IR54 hybrid had 47% higher RPR than the midparent. In this cross, heterobeltiosis compared to the high parent cultivar (check) was 49%.

The high RPR observed in the F_1 hybrid seedlings indicates substantially superior root growth. Previous studies showed that plants with high RPR had improved drought resistance. These data suggest that F_1 hybrids are superior to their parents in adapting to drought-prone areas.

Reaction of rice varieties to whitebacked planthopper (WBPH)

P.K. Pathak, S.K. Verma, and M.N. Lal, Entomology Department, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar 263145, Uttar Pradesh, India

We evaluated 28 rices for resistance to WBPH *Sogatella furcifera* (Horvath) in the field and in a glasshouse in 1983 kharif. The rices were received through the All India Coordinated Rice Improvement Project. In the field, WBPH populations were recorded 50 and 60 d after transplanting (DT). Mean population was 3.7 to 19.2/hill at 50 DT and 2.6 to 23.9/hill at 60 DT. Populations declined between 50 and 60 DT on all rices except RP2149-88, RP2147-73, and TN1 (see table).

When evaluated in the seedling bulk test, only eight rices were resistant to WBPH (see table). Cultures with Velutha Cheera as parent were resistant and had low WBPH populations in the field. Cultures with Andrewsali, IET6288, Manoharsali, or Ptb 33 as parents were susceptible.

It is interesting to note that IET6288 and Ptb 33 are resistant to WBPH. IET6288 received resistance from Ptb 21 through CR55-35/IR8. Their high degree of resistance may have been lost in the crossing program. Some rices with susceptible reaction in the seedling bulk test had field resistance to WBPH. The nature of resistance of these rices is being further evaluated.

Reaction of some promising rice cultures and cultivars to WBPH in the field and in a glasshouse, Pantnagar, India.

Designation	Donor or cross	WBPH (av no./hill) 50 DT	WBPH (av no./hill) 60 DT	Damage rating[a]	Reaction[b]
Anaikomban	Donor	4.1	6.8	1.4	R
Eswarmanglam	Donor	5.0	5.9	1.5	R
Mudu Kiriyal	Donor	7.7	3.2	2.0	R
Rathu Heenati	Donor	10.4	4.0	2.1	R
MO I	Donor	4.9	6.2	2.2	R
RP2068-17-2-1	Swarndhan/Velutha Cheera	3.7	3.2	2.6	R
RP2068-17-2-2	Swarndhan/Velutha Cheera	4.1	2.8	2.7	R
Ptb33	Donor	6.4	4.4	3.0	R
RP2068-18-4-2	Swarndhan/Velutha Cheera	5.1	4.8	3.6	MR
RP2095-123-1-1	Vikram/Andrewsali	6.2	9.2	5.5	S
RP2095-123-1-5	Vikram/Andrewsali	10.1	4.6	6.1	S
ARC5956	Donor	6.5	4.1	6.8	S
IET7575	Sona/Manoharsali	11.3	9.9	6.8	S
ARC7080	Donor	10.6	7.6	7.4	HS
ARC5984	Donor	3.5	4.5	7.5	HS
Leb Mue Nahng	Donor	6.6	2.6	7.5	HS
IET7948	Ptb 33/TN1	1.2	6.8	7.6	HS
ARC6619	Donor	6.6	7.1	7.9	HS
Andrewsali	Donor	8.1	5.4	7.9	HS
RP2149-109	IET6288/Phalguna	16.4	13.7	8.2	HS
RP2149-71	IET6288/Phalguna	6.2	6.7	8.5	HS
RP2149-73	IET6288/Phalguna	9.3	17.7	8.6	HS
RP2149-88	IET6288/Phalguna	6.8	11.9	8.7	HS
RP2149-58	IET6288/Phalguna	8.1	5.7	8.7	HS
ARC10572 A	Donor	9.3	9.4	8.7	HS
RP2149-96	IET6288/Phalguna	8.7	9.5	9.0	HS
RP2149-86	IET6888/Phalguna	10.0	8.0	9.0	HS
ARC10550	Donor	19.7	17.7	9.0	HS
TN1	–	15.9	23.9	9.0	HS

[a] Based on Standard Evaluation System for Rice. [b] R = resistant, MR = moderately resistant, S = susceptible, HS = highly susceptible.

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Response of different rices to whitebacked planthopper (WBPH) populations from different locations in Indonesia

A. Kartohardjono, Agency for Agricultural Research and Development, Bogor Research Institute for Food Crops (BORIF), Jalan Cimangu Kecil 2, Bugor, Indonesia

WBPH *Sogatella furicifera* (Horváth) is widely distributed in Indonesia. Infestations are generally low, but large populations can cause serious damage. In 1984 dry season, we collected WBPH from Muara Lawai, South Sumatra; Bulu Kumba, South Sulawesi; Munggu, Bali; and Mataram, Lombok. We

Table 1. Resistance of rice varieties to 5 WBPH populations in the greenhouse, Bogor, Indonesia.

Colony	Resistance[a] on indicated variety: TN1	Citanduy	B4032d-Mr-1-3-1	IR36	Colombo
Muara Lawai	8.3	5	3	4	4.3
Bulu Kumba	8.3	3	3	5	2.3
Munggu	7	3	5	5	3.0
Mataram	8.3	4.3	5	5	2.3
Greenhouse	9	3.1	5	–	1.7

[a] On scale of 0-9: 0 = no damage, 9 = all plants dead.

Table 2. Weight of honeydew of some WBPH populations, Bogor, Indonesia.

Colony	Honeydew [a] (mg/female)			
	TN1	Citanduy	B4032d-Mr-1-3-1	Colombo
Muara Lawai	7.21 a	1.09 a	0.55 a	1.15 a
	A	B	B	B
Bulu Kumba	858 a	0.81 a	0.49 a	0.53 a
	A	B	B	B
Munggu	4.85 a	1.18 a	0.52 a	2.39 a
	A	A	A	A
Mataram	5.05 a	2.44 a	1.12 a	1.57 a
	A	A	A	A
Greenhouse	8.74 a	0.96 a	0.56 a	1.67 a
	A	B	B	B

[a] Identical small letters in a column or capital letters in a row indicate no significant difference at the 5% level by DMRT.

Table 3. Population increase of WBPH from different colonies on 1-mo-old rice varieties, Bogor, Indonesia.

Colony	Population increase [a]				
	TN1	Citanduy	B4032d-Mr-1-3-1	IR36	Colombo
Muara Lawai	1217 a	497 b	919 a	334 a	99 ab
	C	AB	BC	A	A
Bulu Kumba	623 a	174 a	289 a	538 a	144 ab
	A	A	A	A	A
Munggu	760 a	127 a	355 a	1084 a	212 b
	A	A	A	A	A
Mataram	904 a	138 a	834 a	496 a	75 a
	C	AB	C	BC	A
Greenhouse	964 a	352 ab	788 a	549 a	24 a
	C	B	B	B	A

[a] Identical small letters in a column or capital letters in a row indicate no significant difference at the 5% level by DMRT.

Table 4. Survival of WBPH nymphs on 1-mo-old rice varieties at 10 d after infestation, Bogor, Indonesia.

Colony	Survival [a] (%)				
	TN1	Citanduy	B4032d-Mr-1-3-1	IR36	Colombo
Muara Lawai	78 a	22 a	67 a	32 a	5a
	C	A	BC	AB	A
Bulu Kumba	65 a	30 a	40 a	70 a	2a
	BC	B	BC	C	A
Munggu	52 a	13 a	47 a	67 a	0a
	BC	AB	BC	C	A
Mataram	80 a	13 a	43 a	70 a	0a
	D	AB	BC	C	A
Greenhouse	87 a	55 a	60 a	75 a	3a
	D	AB	BC	C	A

[a] Identical small letters in a column or capital letters in a row indicate no significant difference at the 5% level by DMRT.

recorded responses to these populations and one greenhouse population at BORIF of rice varieties Citanduy, B4032d-Mr-1-3-1, IR36, TNl (susceptible check), and Colombo (resistant check) in seedbox screening tests with three replications (Table 1).

Reaction parameters were honeydew excretion (10 replications), population buildup (3 replications), and survival and development (3 replications). Rices were in a split-plot design with varieties as main plots and insect populations as subplots.

Reaction of rice varieties to different WBPH colonies was uniform. TN1 was susceptible to all colonies, but Citanduy, B4032d-Mr-1-3-1, Colombo, and IR36 were moderately resistant (Table 2). Population increase of colonies differed only slightly on the varieties tested (Table 3). Survival of nymphs also was similar on resistant varieties (Table 4).

Genetic Evaluation and Utilization
COLD TOLERANCE

Association of traits governing cold tolerance at early seedling stage in rice

R. N. Kaw, Plant Breeding Department, IRRI

Degree of yellowing of seedlings and mortality count are measures of cold tolerance in many countries. In the US, seedling height is the criterion for evaluating cold water tolerance 4 wk after sowing. In Taiwan, cold tolerance is based on the percentage of winter survival. At IRRI, I measured cold hardiness by computing a tolerance index (TI) based on degree of discoloration and percent survival of the seedlings compared to a resistant check.

I screened 23 parents and their 102 hybrids (17 lines × 6 testers) for cold tolerance at the early seedling stage to evaluate the cultures for relative cold

Correlation coefficients[a] between tolerance index (TI) and other attributes of rice at early seedling stage. IRRI, 1986.

Character	Seedling height on			Discoloration score on			Survival (%) on		TI based on survival on	
	Day 8	Day 15	Day 22	Day 8	Day 15	Day 22	Day 15	Day 22	Day 15	Day 22
Emergence coefficient	0.661**	0.310**	0.194	–0.315**	–0.141	–0.093	0.115	–0.031	0.141	0.084
Seedling height, day 8		0.555**	0.541**	–0.471**	–0.375**	–0.292**	0.257**	0.023	0.322**	0.225*
Seedling height, day 15			0.869**	–0.877**	–0.857**	–0.807**	0.808**	0.520**	0.836**	0.749**
Seedling height, day 22				–0.819**	–0.789**	–0.789**	0.732**	0.567**	0.770**	0.743**
Discoloration score, day 8					0.892**	0.869**	–0.834**	–0.564**	–0.869**	–0.793**
Discoloration score, day 15						0.938**	–0.889**	–0.634**	–0.931**	–0.814**
Discoloration score, day 22							–0.932**	–0.716**	–0.956**	–0.883**
Survival (%) day 15								0.707**	0.981**	0.899**
Survival (%) day 22									0.695**	0.798**
TI based on survival, day 15										0.907**

[a] * = significant at P <0.05, ** = significant at P <0.01 levels.

tolerance and to determine interrelationships, if any, between traits used as evaluation criteria.

Twelve presprouted seeds, 1 row per culture, were sown in soil-filled porcelain trays with adequate nutrient and water, and then kept in artificially lighted Koitotron KG cabinets at 15 ± 0.5 °C for 3 wk. Each tray contained 10 test cultures and the resistant check Fujisaka 5 distributed at random. There were two replications.

Emergence data were recorded every 4 h for 12 d. The seedlings were scored as emerged when the shoot tip was visible on the soil surface. An emergence coefficient was worked out based on speed and vigor of emergence. The cultures were scored for discoloration (1 = plants have natural color, 9 = almost dead or dead plants) at 8, 15, and 22 d. Seedling height of the seedlings in a culture was also measured. Survival percentage of the emerged seedlings was recorded at 15 and 22 d on a scale of 0-1. The sum of survival scores for each culture per replication was converted to a percentage of the average score of Fujisaka 5.

TI, emergence coefficient, seedling height, and discoloration scores were the criteria used for evaluating genotypes for cold tolerance at the early seedling stage.

Intercharacter associations between TI and other traits are shown in the table. TI or cold tolerance at early seedling stage is positively correlated with seedling height at 15 and 22 d, negatively correlated with leaf discoloration score at 8, 15, and 22 d, and positively correlated with percent survival at 15 and 22 d.

Evaluation of rice genotypes for cold tolerance at vegetative stage

R. N. Kaw and R. M. Visperas, IRRI; H. P. Moon, Crop Experiment Station (CES), Rural Development Administration (RDA), Suweon; and J. D. Yae, CES, RDA, Chuncheon, Korea

Ninety F_1 hybrids and their 21 parents were transplanted in 2.25-m single-row plots, with 3 replications, in the cold tolerance screening nursery at the CES, RDA, Chuncheon. Plants were subjected to cold water stress at 17 and 20 °C in separate blocks from 20 d after transplanting until maturity at a constant water depth of 5 cm. Cold tolerance at the vegetative stage was measured by leaf discoloration, scored twice at 17 °C and once at 20 °C. The average of the three observations were used for statistical analyses.

None of the six IRRI lines used as pollinators had a leaf discoloration score of 3 or lower (Table 1). Among the

Table 1. Mean and general combining ability (GCA) effects of parents for leaf discoloration score in Chuncheon, Korea, 1986.

Parent	Mean	GCA effects
Males (IRRI lines)		
IR29506-60-3-3-2	5.4	–0.455**
IR8455-K2	5.4	–0.213**
IR9202-10-2-1-5-1	5.8	0.047
IR8866-30-14	5.9	0.496**
IR7167-33-2-3	6.3	–0.147*
IR15889-32-1	6.4	–0.022
		SE (gi) ± 0.069
Females (indica)		
Leng Kwang	3.4	0.716**
Shoa-Nan-Tsan	4.2	1.610**
Suweon 281	4.5	0.566**
Silewah	5.2	0.627**
Samgangbyeo	5.5	0.655**
K39-96-3-1-1-1-2	5.6	1.960**
China 988	6.3	1.938**
Females (japonica)		
Stejaree	1.3	–1.023**
SR3044-78-3	1.3	–0.845**
SR5204-914-1	1.5	–1.051**
Shimokita	1.7	–1.379**
K84	1.7	–1.084**
Barkat	1.8	–0.995**
K332	2.0	–0.990**
Suweon 235	2.0	–0.706**
	LSD 5% = 0.74	SE (gi) ± 0.109
	LSD 1% = 0.98	

Table 2. Correlation coefficients of cold tolerance scores in the field in Korea with traits related to cold tolerance at early seedling and seedling stages in controlled environment at IRRI. 1986.

Characters correlated [a]	Cold tolerance score in field
	r coefficient
Early seedling stage	
Emergence coefficient	–0.191**
Seedling height, day 8	–0.370**
Seedling height, day 15	–0.640**
Seedling height, day 22	–0.570**
Cold tolerance score, day 8	0.692**
Cold tolerance score, day 15	0.753**
Cold tolerance score, day 22	0.746**
TI based on 15 d survival	–0.758**
TI based on 22 d survival	–0.684**
Seedling stage	
Cold tolerance score after first cold water treatment	0.680**
Cold tolerance score after second cold water treatment	0.823**
TI based on revival 5 d after first treatment	–0.699**
TI based on revival 10 d after first treatment	–0.722**
TI based on final survival after second treatment	–0.771**

[a] TI = tolerance index (integrates both cold tolerance score and percent revival or survival, relative to the resistant check).

indica females, Leng Kwang had the best score of 3.4. All japonica parents, however, had mean cold tolerance scores below 3. Notable cultures were Stejaree 45, SR3044-78-3, SR5204-91-4-1, Shimokita, K84, and Barkat.

Parental performance per se was a good index of their general combining ability (GCA) for leaf discoloration in the field (*r* = 0.712**). The japonica parents exhibited highly significant GCA effects for low leaf discoloration (high cold tolerance). IR29506 and IR8455-K2 were the only male parents with highly significant GCA effects for low score. The development of cold-tolerant, homozygous lines should be possible through simple selection pressures, and japonicas would be good donors for seedling stage cold tolerance. Of 48 crosses showing specific combining ability (SCA) effects in the desired direction (low score), only 7 were significant. With the exception of China 988/IR8455-K2, SR3044-78-3/IR7167, and Shoa-Nan-Tsan/IR29506, where one of the parents was a good general combiner for cold tolerance, all other good and significant SCA combinations involved at least one parent with significantly poor GCA. High SCA values would not necessarily mean a high performance by the hybrid. Selection of cold-tolerant hybrids on the basis of performance per se appears more realistic.

At IRRI, cultures at the early seedling stage were screened in the phytotron at a constant temperature of 15 °C for 3 wk, and at the seedling stage by the cold-water tank method at a constant temperature of 12 °C for 10 d. All traits scored in the field in Korea and in the controlled environment at IRRI were highly significantly correlated. Except for the association with emergence coefficient and seedling height on day 8, all other associations were of high magnitude (Table 2). Evidently the test cultures behaved consistently in the controlled environment or in the field. Results also indicate that performance in the controlled environment was a good indicator of field performance. Both methods appear equally effective in ranking cultures for cold temperature tolerance at the vegetative stage. For a quick determination of cold temperature tolerance at the seedling stage, however, the cold-water tank method appears highly satisfactory.

Chlorophyll meter (SPAD-501) to quantify relative cold tolerance in rice

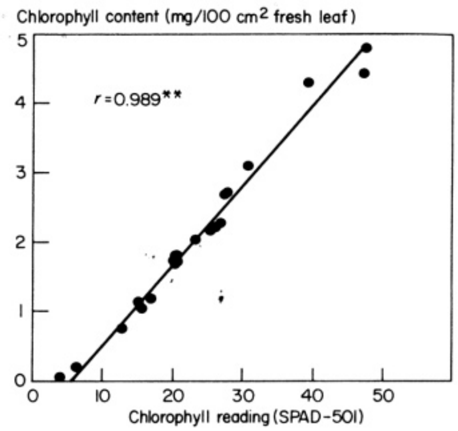
Jiang Xian-Xiang and B.S. Vergara, Plant Physiology Department, IRRI

One effect of low temperature on rice is leaf discoloration due to chlorophyll degradation. Quantifying relative cold tolerance by measuring extracted chlorophyll is tedious and time consuming. This study was conducted to evaluate the use of a new chlorophyll meter (Minolta SPAD-501) to quantitatively assess relative cold tolerance in rice. The meter is simple to use and operates on alternating current or batteries. By inserting a leaf into a slit at the head of the instrument and pressing a button, one gets an instant reading.

IR8 and Fujisaka 5 seedlings were grown in culture solution for 34 d in the greenhouse and then held in the cold water tank (12°C) for 7 d. Initially, three readings were taken 12 cm from the tip of the first fully developed leaf or second to the youngest leaf (leaf no. 6). Subsequent readings at the same position were taken on the 4th and 7th days. After 4 d of cold water treatment, the SPAD-501 reading of cold-susceptible IR8 decreased from 30 to 27.1, while in cold-tolerant Fujisaka 5, the readings decreased only slightly — from 30.5 to 29.1 although no color change could be detected by the unaided eye at that time (see table). The trend continued in the readings on the 7th day.

SPAD-501 reading of chlorophyll content of IR8 and Fujisaka 5 at 12°C. IRRI, 1986.

Variety	Spad-501 reading		
	Initial	4th day	7th day
IR8	30.0	27.1	22.5
Fujisaka 5	30.5	29.1	28.2



Correlation between chlorophyll content determined by DMSO method and chlorophyll reading from SPAD-501. IRRI, 1986.

Additional data were collected at 2 temperatures (12 and 30° C) during measurement. The results indicate that temperature during measurement did not affect chlorophyll reading, suggesting that SPAD-501 can be used under high or low temperatures.

Leaf samples were taken from plants having different degrees of yellowing. The chlorophyll content was extracted by dimethyl-sulfoxide (DMSO) method There was a very high correlation (*r* =

0.989**) between SPAD-501 reading and chlorophyll content (see figure). The instrument manufacturer obtained a correlation of 0.815 between chlorophyll reading and actual chlorophyll content using data from several crop species. SPAD-501 is reliable in determining relative chlorophyll content as an index of cold tolerance.

This method has considerable potential in quantifying leaf discoloration due to low temperature as well as yellowing caused by other stresses such as nutrient deficiency, diseases, and drought.

Genetic Evaluation and Utilization

DROUGHT TOLERANCE

Response of rice varieties to protective irrigation

S.T. Thorat and B.P. Patil, Konkan Krishi Vidyapeeth, Dapoli District, Ratnagiri, Pin 415712, Maharashtra, India

Extended breaks in monsoon rainfall significantly reduce yield of rice grown on lateritic soils with high infiltration, medium to high total N, high K, and low P in Konkan, India. Yield losses are greatest on newly developed, terraced uplands. Protective irrigation may reduce those losses.

We evaluated 135-d Jaya and RP4-14 for response to protective irrigation in a factorial randomized block design with 5 replications on newly developed terraces of lateritic soil. Rice was sown 9 Jun 1984 and transplanted on 5 Sep at 3 seedlings/hill and 20- × 15-cm spacing. Plots received 50-22-41.5 kg NPK/ha at transplanting and 50 kg N in 2 equal splits at 1-mo intervals. Plots received 251.84 mm of water at each protective irrigation (13 Jul; 19, 21, 24, and 27 Sep; and 1 Oct). Recommended pest control measures were applied. Harvest was 25 Oct.

Yields were relatively low. Protective irrigation increased yield an average 30% over that of the control (see table).

Influence of protective irrigation on grain and straw yield, Maharashtra, India.

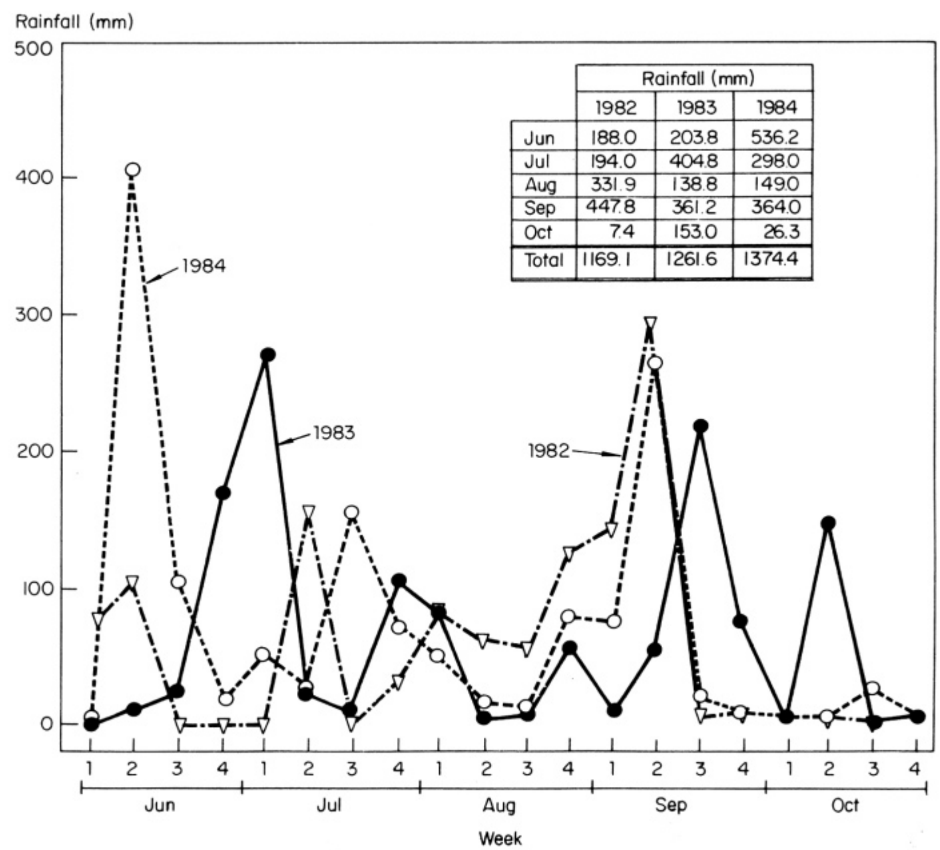
Variety	Yield (t/ha)			
	Control		Protective irrigation	
	Grain	Straw	Grain	Straw
Jaya	2.9	3.1	3.9	4.1
RP4-14	3.1	3.1	3.9	4.0
Mean	3.0	3.4	3.9	4.0

		S. Em. ±	CD at 5%
Variety:	Grain	0.1	ns
	Straw	0.1	ns
Irrigation:	Grain	0.1	0.4
	Straw	0.1	0.3
Interaction:	Grain	0.2	ns
	Straw	0.1	0.4

IET7613, a drought-resistant upland rice

G. Singh and T.N. Singh, Crop Physiology Department, Narendra Dev University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

Improved short-duration, drought-resistant, upland varieties are needed for the Uttar Pradesh plains, where rainy season seldom lasts more than 90 d. Newly developed IET7613 (M63-83/Cauvery) yields 15% more at low to moderate soil fertility than locally grown N22. IET7613 is a semidwarf, drought-resistant upland rice that matures in 85 d.



Rainfall distribution in Faizabad, India, during upland trials in 1982-84.

Six All India Coordinated Rice Improvement Project upland trials from 1982 to 1984 at Faizabad compared IET7613 with N22. Soil was a sandy loam with 57% sand, 27% silt, and 14% clay. Field capacity and permanent wilting coefficient of the 0-15 cm soil profile were 22.5 and 4.6% with bulk density 1.42 g/cm^3. After rains had softened the soil, it was tilled and 100 kg seed/ ha was drilled 4-5 cm deep in open furrows at 20-cm spacing and covered with soil. Fields were sown the 1st wk of July, except for 1 yr, when sowing was in the 1st wk of August. The crop received 60-13-25 kg NPK/ha and a foliar spray of Zn sulfate 2 wk after germination. Weeding was by hand.

Average rainfall for the 3 seasons was 1268 mm but distribution was erratic (see figure). In 1982, a 10-d dry spell occurred at seedling stage and rains almost stopped after 14 Sep. In 1983, there were 15-d dry spells in mid-July and August and rain stopped on 13 Oct. In 1984, rainfall exceeded 400 mm the 2d wk, there were dry periods in August, and rains stopped in mid-September.

IET7613 performed better than N22 because it has greater sink potential, higher nutrient use efficiency, and better drought resistance (see table).

Characters of improved IET7613 and traditional N22 grown at Faizabad, India.

Character	N22	IET7613[a]
Agronomic		
Duration (d)	85	85 n.s.
Height (cm)	104	86***
Leaf	Large groopy	Small erect
Maturity synchrony		
Between panicles	Synchronous	Synchronous
Within panicles	Acropetal uniform	Acropetal uniform
Grain type	Short bold	Long bold
Yield		
Panicles (no./m^2)	315	410 n.s.
Grain (no./panicle)	69	62***
l000-grain weight (g)	20	27***
Ripening (%)	78	81 n.s.
Yield (t/ha)	3.3	3.8***
Physiological		
Sink potential (g/panicle)	1.24	1.90***
Nutrient use efficiency (kg grain/kg N)	52	61***
Harvest index (%)	47	49 n.s.
Productivity (kg grain/d per ha)	39	45***
Spikelet sterility (%)	22	19 n.s.
Seed dormancy (fresh harvest)	Present	Absent
Lodging	Susceptible	Resistant
Root growth	Abundant thick	Abundant thick
Root penetration	Strongly geotropic	Moderately geotropic
Drought response		
Leaf water potential (–bar)	19	21***
Relative water content (%)	66	64***
Leaf rolling (score)	5 (complete rolling)	3 (partial rolling)**
Drought sustenance (d)	9.1	10.4**
Panicle exsertion	Well exserted	Moderately well exserted**
Stem extension growth	Very slow	Almost ceases
Drought injury	2	3 n.s.
Post-drought recovery score	2 (slow)	1 (fast) n.s.

[a]***significant at P = 0.001, ** significant at P = 0.01, n.s. (not significant).

Genetic Evaluation and Utilization
ADVERSE SOILS TOLERANCE

Varietal evaluation of rice genotypes in coastal saline soil

T. S. Sinha, Central Soil Salinity Research Institute, Regional Research Station Canning, Canning Town 743329, India

The IRSATON screening set (61 entries) from IRTP was evaluated for salinity tolerance and grain yield along with local checks CSRl, CSR3, and CSR6. The seeds of 64 genotypes were sown on 13 Jul and transplanted on 17 Aug 1983 in randomized block design with 3 replications. Each entry was transplanted in 3 rows of 20 hills each; row and plant spacing was 25 cm. N at 70 kg/ha was in 2 splits. In situ soil salinity ranged from 7.5 to 8.4 dS/ m at transplanting and 5.8 to 10.1 dS/m at flowering. Data on agronomic attributes were collected from five plants selected at random in each replication, and survival rate at maturity was determined. Data on quantitative characters of 25 genotypes whose tolerance scores at the vegetative stage, at maturity, or at both stages ranged from moderate (4 to 5) to excellent (3) are given in the table.

CSR1, CSR3, and CSR6 were scored highly tolerant at vegetative and maturity stages. CSR1 grain yield was highest (1.4 kg/ plot), followed closely by that of CSR3 (1.3 kg/plot) and CSR6 (1.28 kg/plot). Spikelet sterility, which is highly affected by soil salinity, averaged 22%; the maximum was 31% in CSR6 and the lowest was 14% in CSR3. Plant survival at maturity was 98%. Other genotypes rated highly tolerant with similar spikelet sterility and plant survival were, in order of merit, C14-1, IR4630-22-2-5-1-3, and IR4422-6-2. Their lower yield may be due to their lower yield potential.

IR4630-22-2-17 had a salinity tolerance score of 3 at the vegetative stage, but was scored 4 at maturity. Its spikelet sterility of 18% was the second lowest of the entries. With 97% plant survival and low spikelet sterility, IR4630-22-2-17 appeared highly promising.

Performance of rice genotypes in coastal saline soil, India.

Designation	Plant ht (cm)	Panicles/ hill (no.)	Panicle length (cm)	Filled spikelets/ panicle (no.)	Spikelet sterility (%)	Days to heading (no.)	Plant survival at maturity (%)	Salinity tolerance score		Grain yield (kg/plot)
								Vegetative	Maturity	
CSR4	71	19	15.8	78	27	81	91	4	3	0.7
C100	65	16	16.8	80	41	102	81	4	4	0.9
C14-1	78	12	20.1	90	25	102	95	3	3	1.0
IR10198-66-2	85	16	22.7	85	12	105	85	4	4	0.8
IR2053-436-1-2	91	14	18.1	93	29	107	80	5	4	0.7
IR36	64	18	17.3	71	32	106	76	5	4	0.4
IR4227-109-1-2-3	81	14	19.1	71	29	104	89	4	4	0.7
IR4422-6-2	83	12	21.0	81	35	114	95	3	3	0.7
PNL 5-30	71	16	18.0	68	44	111	81	4	5	0.7
IR4432-28-5	79	19	20.2	68	47	111	84	5	5	0.8
IR4595-4-1-13	75	9	18.5	64	39	115	99	4	4	0.4
IR4630-22-2-17	83	11	19.9	70	18	113	97	3	4	0.8
1R4630-22-2-5-1-3	85	11	19.0	68	28	108	94	4	3	0.8
IR50	66	19	15.6	67	25	96	73	7	7	0.6
IR8241-B-B650-2	127	14	20.6	64	31	103	92	4	5	0.6
IR8608-189-2-2-1-3	68	16	19.0	55	23	93	85	4	4	0.5
IR8608-298-3-1-1-2	72	19	19.0	67	24	89	89	4	4	0.8
IR9575 Sel	90	11	21.1	104	27	113	87	5	4	0.8
IR9732-119-3	75	19	19.1	99	33	102	79	5	5	0.9
Pokkali (resistant check)	119	17	20.1	70	17	104	83	6	4	0.5
IR9884-54-3	78	13	19.8	84	30	134	88	4	4	0.3
PNL-11-2	71	19	18.0	78	31	111	88	4	4	0.5
CSR1 (local check)	99	18	17.8	69	21	96	99	3	3	1.4
CSR3 (local check)	101	15	18.2	88	14	98	96	3	3	1.3
CSR6 (local check)	118	14	21.0	77	31	110	99	3	3	1.2

[a] Standard Evaluation System for Rice, IRRI, 1980.

CSR4, IR36, IR4595-4-1-13, IR9884-54-3, and PNL-11-2 were scored 4 at maturity. Spikelet sterility of these genotypes ranged from 27 to 39% and survival rate from 76 to 99%. CSR4 gave the highest yield. Other entries whose tolerance scores remained almost the same at both stages but whose survival was more than 80% are also considered tolerant at maturity.

Some entries were scored 4 or 5 (tolerant) at the vegetative stage. Although they had survival rates greater than 75%, their tolerance at maturity decreased. Spikelet sterility in these entries was as high as those of entries such as PNL5-30 and IR4432-28-5.

Tolerance scores at vegetative stage and at maturity highly but negatively correlated (r = -0.58**) with plot yield, as did spikelet sterility (r = -0.48**). Only plant survival at maturity was highly and positively correlated with yield (r = 0.60**)).

Chemical tests for screening rice genotypes tolerant of Zn deficiency under calcareous Fluvents

B. P. Singh, Indian Council of Agricultural Research Complex for NEH Region, Agronomy Division, Bishnupur, Shillong 793004, India; and B. N. Singh, Genetics and Plant Breeding Department, and M. K. Sinha, Soil Science and Agricultural Chemistry Department, Hajendra Agricultural University, Pusa, Samastipur, Bihar 848125, India

In Fluvent soils in North Bihar, India, Zn deficiency is largely caused by calcareous conditions. More than 75% of soils have low Zn. We evaluated 19 semidwarf indica rices for tolerance for Zn deficiency in calcareous Fluvents and evaluated chemical tests for screening Zn-efficient genotypes at the Sugarcane Research Institute Farm, RAU, Pusa, in 1982.

Soil was a calcareous sandy loam with pH 8.5, EC 0.48 dS/m, 0.45% organic C, 37.5% free $CaCO_3$, DTPA Zn 0.35 mg/ kg, and DTPA Fe 9.10 mg/ kg soil. Twenty-five-day-old seedlings were transplanted in 14.4-m^2 plots in a randomized block design with 3 replications. NPK was applied basally at 60-22-33 mg/ kg soil as urea, triple superphosphate, and muriate of potash.

Tolerance for Zn deficiency was visually scored by the 1976 *Standard evaluation system for rice.* For chemical analysis, 25 plants were taken from each plot 30 d after transplanting. Samples were washed in acidified detergent solution and rinsed with deionized water. Shoots were dried in a forced-air circulation oven at 65° C and dry matter yield was recorded. The 3d and 4th leaves from the top of plants were separated and pulverized in a Waring blender and digested in HNO_3 : $HClO_4$: H_2SO_4. Zn and Fe were determined in the clear aliquot with an atomic absorption spectrophotometer and P was determined colorimetrically.

In most varieties, visual symptoms of Zn deficiency developed 10-15 d after transplanting. Symptoms appeared first on the 3d and 4th leaves and gradually extended to lower leaves. Light yellow spots at the base of leaves were early symptoms. They later coalesced to give a rusty brown appearance. Plants were stunted and affected foliage dried. Zn deficiency symptoms varied widely among varieties. Percentages of affected hills were averaged and varieties were grouped as tolerant (less than 3% affected hills), moderately tolerant (5-25% affected hills), susceptible (25-50% affected), and highly susceptible (50-100%). Only RAU4009-3 and RAU4005-26 were tolerant.

Shoot dry matter accumulation was markedly reduced by increasing Zn deficiency. Shoot weight, Zn concentration, P to Zn and Fe to Zn concentration ratio are in the table. Zn concentration was between 12.8 and 45.0 ppm, and was positively and significantly correlated with shoot yield (r = 0.97**). There was a significant negative correlation with P:Zn (-0.95**) and Fe:Zn (-0.97**) concentration. Zn concentration was below the critical 19 ppm in highly susceptible varieties. Tolerant varieties had P:Zn > 192 and Fe:Zn > 7.6.

About 97% of the variability (R^2 = 0.969**) in Zn responses was attributed to Zn concentration and P:Zn and Fe:Zn. The contribution of Zn and P:Zn are shown in the multiple regression equation

$$Y = 4.375 + 0.05^{**} X_1 + 0.014 X_2 + 6.286 X 10^{-3**} \times 3$$

Where,
Y = shoot yield,
X_1 = Xn content,
X_2 = Fe:Zn, and
X_3 = P:Zn.
(** denotes significance at 1 %)

Fe:Zn, however, did not contribute significantly to variability in Zn deficiency tolerance.

The study showed that Zn concentration and P:Zn could be a reliable tool for screening Zn-efficient varieties.

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Reaction of rice varieties grown in highly calcareous Fluvents to Zn deficiency, Bihar, India.

Variety	Reaction[a]	Shoot yield (t/15 plants)	Zn concentration (mg/kg)	P:Zn	Fe:Zn
RAU4009-3	T	0.6	41.6	132	6.0
RAU4005-26	T	0.6	45.0	129	5.7
IET6155	M	0.5	30.2	192	7.5
UPR82-1-7	M	0.5	33.5	176	7.3
RAU32-2-1	M	0.5	32.8	180	7.6
IR2071-586-5-6-3	M	0.5	35.0	171	6.7
IR36	S	0.4	20.6	286	13.8
IET4786	S	0.4	21.0	290	13.6
IET2881	S	0.4	22.6	265	12.8
Ratana	S	0.5	24.0	258	12.0
Prasad	S	0.4	23.5	255	11.1
Saket 4	S	0.4	20.5	317	12.2
Rajendra Dhan 201	H	0.3	15.5	406	16.5
Sita	H	0.3	13.5	459	19.1
IET3273	H	0.2	12.8	500	23.1
UPR304-40-2	H	0.3	16.5	388	18.2
UPR231-28-1-2	H	0.3	14.5	455	22.4
Pusa 33	H	0.3	18.5	351	16.4
Pusa 2-21	H	0.3	19.0	331	15.0

[a]T = tolerant, M = moderately tolerant, S = susceptible, H = highly susceptible.

Varietal evaluation of rice in waterlogged saline soil

T.S. Sinha and A.K. Bandyopadhya, Central Soil Salinity Research Institute (CSRRI), Karnal 132001, Haryana, India

Uniform variety trial-5 comprising 21 entries [including 2 local checks, Kalamota (sel), and SR26B], 8 genotypes found superior during the 1983 trial, and Pankaj (high yielding check) were evaluated at CSSRI,

Performance of 30 promising entries in waterlogged saline soil. Haryana, India. 1985.

Designation	Plant ht (cm)	Panicles/m²	Days to flowering	Spikelet sterility (%)	Plant survival at maturity (%)	Yield (g/plot)
CR117-215	105	75	137	38.7	7	15
CR292-5258	103	135	145	77.6	11	08
CR292-7050	109	100	140	39.4	12	40
CR221-1030	108	100	139	35.8	8	22
CN499-160-2-1	114	108	135	26.3	9	22
CN499-160-13-6	111	100	136	25.3	6	80
CN506-147-14-1	119	95	141	29.4	20	63
CN506-147-14-2	97	47	143	38.0	4	15
RPAR7360	–	–	–	–	0	–
NC498	118	117	172	17.3	24	147
OR456-30	122	67	140	51.1	14	15
TCA212	133	111	130	16.8	60	78
WC490	137	95	138	23.1	28	115
WC497	130	94	140	11.0	29	85
NC519	127	89	140	17.8	12	43
TCA72	139	108	128	22.4	44	160
PLA1100	–	–	–	–	0	–
NC513	124	78	140	31.3	44	153
NC492	137	142	137	18.1	56	348
Kalamota (sel)	139	105	136	13.4	68	392
SR26B	137	108	135	14.7	85	743
NC487/77	134	103	170	14.3	86	490
NC491	153	92	137	14.0	91	780
NC540	155	102	132	12.8	95	227
BKNPR-7601-4-1-2-3	150	89	145	62.0	81	250
BKNFR7601-4-1-9-2	146	91	136	40.6	88	345
SPR7295-53-1-2-1-2	123	81	144	31.0	90	212
Bowrah	125	61	135	23.6	40	157
IET6905	131	108	133	37.7	80	352
Pankaj	97	75	146	38.2	5	40
CD at 1%	–	54	–	33.2	25.4	297

Research Station Canning, West Bengal. The trial was in a randomized block design replicated 3 times in a 1-m-deep plot. All 30 entries were sown 22 Jun 1984 and transplanted on 23 Aug. Each entry was transplanted in 4 rows, at 30 hills/row. Spacing between rows and plants was 30 cm. Standing water depth at transplanting was 12 cm and surface soil (0–15 cm) salinity (EC_{sw}) in situ was 9.0 dS/m. Standing water depth during crop growth was 29-58 cm in Aug, 47-50 cm in Sep, 41-51 cm in Oct, and 38 cm in Nov and Dec. The crop was harvested in Jan 1985.

Survival rate of the plants that survived to maturity ranged from 4 to 95% (see table). RPAR7360 and PLAl 100 did not survive. NC540 had maximum survival of 95%, followed by NC491 with 91%. Panicles/ m^2 ranged from 47 to 142, with NC492 producing the most. CR292-5258 produced 135 panicles/m^2, but it also exhibited maximum spikelet sterility (77.6%). Kalamota (sel) had 68% survival and 105 panicles/m^2, whereas Pankaj had a survival rate of 68% and produced 75 panicles/m^2. The three highest yielding entries were NC491, 780 g/plot; SR26B, 743 g/plot; and NC487/77, 490 g/plot. Local check Kalamota (sel) yielded 392 g/plot.

Genetic Evaluation and Utilization

HYBRID RICE

Utilization of wide compatibility gene (S_5^n) for rice breeding

H. Araki, K. Toya, and H. Ikehashi. Tropical Agriculture Research Center, Okinawa, Japan

F_1 hybrids of indica-japonica crosses show semisterility, while some wide compatibility varieties (WCVs) produce fertile F_1 plants when crossed with indica or with japonica varieties. We analyzed the genetic base for F_1 sterility and wide compatibility as follows. A set of multiple alleles was located between the *C* (chromogen for apiculus color) and *wx* (waxy endosperm) loci; S_5^n for WCVs, S_5^i for indica varieties, and S_5^j for japonica varieties, and the genotypes of S_5^n/S_5^i and S_5^n/S_5^j were fertile, but S_5^i/S_5^j was semisterile because of partial abortion of gametes carrying S_5^j. So far, some javanicas or derivatives such as Ketan Nangka, Calotoc, and CPSLO 17 have been found to possess S_5^n, and they also have the complementary genes for apiculus color, i.e. C^+ and A^+. Since C^+ is closely linked with S_5^n, the progeny of indica/ WCVs or japonica/ WCVs showing apiculus color are likely to possess S_5^n.

We have selected several lines from Ketan Nangka (KN) crosses. The progeny of IR50//IR36/ Ketan Nangka showed indica-like plant type as well as good fertility of F_1 when crossed with japonica testers (see table). Likewise, some lines selected from Akihikari//Akihikari/ (a line from Nihonmasari/ Ketan Nangka) showed normal F_1 fertility when crossed with IR36, although the lines are morphologically japonica type (see table).

Characteristics of some promising lines with wide compatibility gene S_5^n, 1986.

Line	Cross or variety	Generation	Flowering date	Plant ht (cm)	F_1 fertility	
					Tester	Fertility (%)
A1	Akihikari/NK4[a]	F_5	20 May	94	IR50	89.4
A9	Akihikari/NK4	F_5	22 May	87	IR50	85.4
B5	Akihikari//Akihikari/NK4	F_4	20 May	80	IR36	90.7
B20	Akihikari//Akihikari/NK4	F_4	18 May	92	IR36	86.9
C1	IR50//IR36/Ketan Nangka	F_5	29 May	92	Akihikari	83.5
C2	IR50//IR36/Ketan Nangka	F_5	29 May	98	Akihikari	90.3
	Ketan Nangka		15 Jun	158	IR36	88.2
					Akihikari	93.4
	Toyonishiki (check)		21 May	88		96.1
	IR36 (check)		4 Jun	81		89.1
	IR50/Akihikari F_1 (check)		(test in 1983)			42.8

[a] NK4 is an F_6 line from Nihonmasari/Ketan Nangka.

The incorporation of S_5^n gene to indica or japonica breeding lines is expected to alleviate the sterility problem in indica-japonica crosses. Specifically, those lines with S_5^n can be used for hybrid seed production, inasmuch as they would reveal high level of heterosis without F_1 sterility. As some IR varieties, including IR36 and IR50, possess a restorer gene for cytoplasmic male sterility of japonica type, indica-like lines with the S_5^n can be used directly as parents for hybrid seed production.

Pest Control and Management

DISEASES

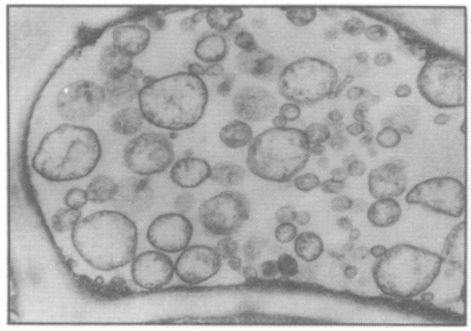
Etiology of rice orange leaf

H. Hibino, G.B. Jonson, and F. C. Sta. Cruz, Plant Pathology Department, IRRI

In Thailand, Malaysia, and Indonesia, orange leaf is known to be associated with mycoplasma-like organisms (MLO). Recent reports from China indicated that virus-1ike particles are associated with orange leaf.

We collected 34 rice plants with orange leaf-like symptoms from 6 Philippine sites. *Recilia dorsalis* nymphs were allowed to feed on each plant for 2 and 4 d, and then were transferred to healthy 7- to 10-d-old TN1 seedlings at 1 insect/seedling, where they remained until they died.

An average 13% of the insects transmitted the disease agent. Incubation period was 15-33 d. About 10% of the infective insects could transmit the disease agent until they died. Disease agent retention was 18-43 d. Incubation period in plants was 10-28 d. In addition to orange leaf symptoms, young leaves of inoculated seedlings were ragged and twisted. Infected seedlings died 3-4 wk after symptoms appeared.



Electron micrograph of MLO in a sieve tube of rice leaves infected with orange leaf (20,000X).

Under the electron microscope, ultrathin sections of leaf tissue from plants infected with each isolate showed MLO in the sieve tubes. The MLO were bounded by a unit membrane and a pleomorphic 50-1100 nm in diameter (see figure), which indicates that the pathogen causing orange leaf in the Philippines is not a virus and is most likely a MLO.

Tungro (RTV) incidence in Andhra Pradesh in 1984

A. Ghosh and A.P.R. Reddy, Directorate of Rice Research, Rajendranagar, Hyderabad 500030, India

RTV is a major problem in India. Since 1970, it has been recorded in Oct-Nov in isolated areas of Andhra Pradesh. In 1984 rabi and kharif it reached epidemic proportions (Table 1). Except for IR50, most varieties grown in Andhra Pradesh are susceptible.

Disease surveys were conducted in Ranga Reddy, Medak, Karim Nagar, West Godavari, Guntur, Prakasam, Nellore, and Chittoor Districts from Jan to Nov 1984. Field diagnosis used visual symptoms and the IRRI iodine test. Transmission tests were conducted on all samples with positive iodine tests. Selected virus isolates from TN1 were evaluated in serodiagnostic tests using antisera from IRRI. The tests confirmed that the disease was RTV (Table 2).

Table 1. RTV-affected areas in Andhra Pradesh in 1984.

District	Months	Varieties affected	Area affected (ha)	Severity
Ranga Reddy	Jan-Feb	Tellahamsa	8,000	Severe
Medak	Mar	Tellahamsa	1,500	do-
Karim Nagar	Mar	Tellahamsa	1,500	Moderate-severe
West Godavari	Jan-Feb	BPT1235	5,000	do-
Nellore	May-Jun	IET2508 Rasi	3,000	do-
Chitoor	Jun-Jul	Rasi IET2508	5,000	Severe
Prakasam	Oct-Nov	NLR9674 MTU9029	15,000	do-
Guntur	Oct-Nov	NLR9674	15,000	do-

Table 2. RTV incidence[a] in rice varieties grown in RTV epidemic areas during 1984.

District	Variety	Planting date	RTV incidence (visual)	Iodine test	Transmission	GLH population
Medak	Tellahamsa	Oct 1983	H	+	+	M
	RNR1446	Nov 1983	H	+	+	M
	IR50	Nov 1983	L	−	−	−
Ranga Reddy	Tellahamsa	Nov-Dec 1983	H	+	+	M
Nellore	IET2508	Mar 1984	H	+	+	M
	Rasi	Mar 1984	H	+	+	H
	IR50	Mar 1984	L	−	−	L
	NLR9672	Aug 1984	H	+	+	M
Prakasam	NLR9674	Aug 1984	H	+	+	M
Chitoor	Rasi	May-Jun 1984	M	+	+	M
	IET2508	May-Jun 1984	M	+	+	M
	IR50	May-Jun 1984	−	−	−	−
	RGL 2624	Jun 1984	M	+	+	M

[a] L = low, M = moderate, H = high.

Granular fungicides for controlling blast (Bl)

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

Bl caused by *Pyricularia oryzae* is increasing in Tamil Nadu. Foliar fungicides are advocated for disease control. Sometimes, however, lack of sprayers prevents proper spray application. Granular fungicides require no special equipment. Soil-applied granular fungicides are absorbed by roots and systemic action protects rice stems, nodes, panicles, and foliage. Granular fungicides require fewer applications and less labor to apply than do sprays.

We evaluated probenazol (Oryzemate 8G), pyroquilon (Coratop 5G), chlorbenthiazone (S. 1901 6G), and IBP (Kitazin 17G) for Bl control. Highly Bl-susceptible IR50 was planted in Oct-Jan 1984-85 in a randomized block design with four replications.

Fungicides were applied at tillering and panicle initiation at 30 and 40 kg formulated product/ha. IBP, which has a much higher active ingredient content than the other granules, was also applied at 15 and 20 kg/ha.

Ten days after the last fungicide application, Bl incidence was recorded for 25 randomly selected plants from each plot. Scoring was by the *Standard evaluation system for rice* and mean disease intensity in grade values was calculated. Neck B1 was recorded for five randomly selected hills per plot, and yield was recorded (see table). All fungicides effectively controlled Bl. Pyroquilon and chlorbenthiazone provided outstanding control and plots that received them yielded highest, followed by IBP at the higher dose.

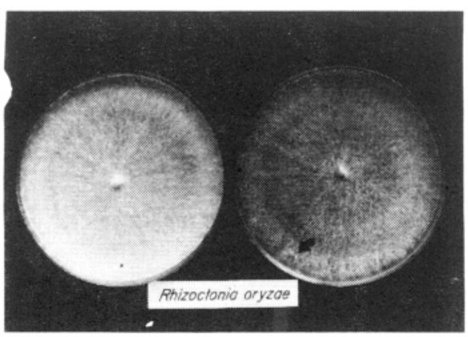
Effect of granular fungicides on Bl and grain yield, Aduthurai, India.

Treatment	Dosage (kg ai/ha)	Leaf Bl intensity (grade)	Neck Bl (%)	Mean grain yield (t/ha)
Probenazol 8G	3.2	5.6	20	2.6
Pyroquilon 5G	2.0	2.1	20	4.8
Chlorbenthiazone 6G	2.4	2.9	21	4.9
IBP 17G	6.8	4.0	26	3.2
IBP 17G	3.4	6.4	28	2.8
Untreated check	–	7.7	32	2.0
CD		0.4	ns	0.8

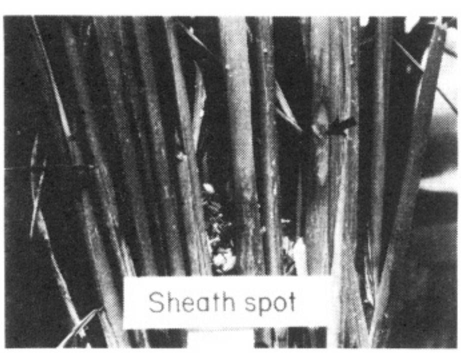
Sheath spot of rice in the Philippines

A.K.M. Shahjahan and T.W. Mew, Plant Pathology Department, IRRI

Rice plants with symptoms similar to those of sheath blight were found in farmers' fields at IRRI in 1985 dry season. Symptoms developed at the water line. Lesions were restricted, water soaked, 1.5-3.0 cm wide, and had ashy-grey centers and dark brown borders. Two or more lesions often coalesced to form a larger lesion. Lesions usually developed at the lower-middle of the outer leaf sheath.



1. Two cultures of *R. oryzae* isolated from sheath spot lesions of rice plants and showing the texture of the colony. The arrow points to the sclerial initials.



2. Typical sheath spot symptom (arrow) produced on IR58 on inoculation with an isolate (RO 35-3) of *R. oryzae* in the greenhouse. Note the dark border and light center of the spot.

Diseased plants were collected and the causal organism was identfied as *Rhizoctonia oryzae* Ryker and Gooch, which causes sheath spot of rice. It is a fast growing sterile fungus with pinkish pigmentation and produces small, pink, globose-flat sclerotia (0.5-1.5 mm) submerged in the medium. Often, sclerotia coalesce to form a crust on the surface of the medium (Fig. 1). The mycelium is thinner than that of *R. solani.* No sclerotia were observed in the infected plant tissues. We tested the pathogenicity of three *R. oryzae* isolates on IR58 in the greenhouse. All three produced typical sheath spot symptoms (Fig. 2).

The disease was present in about 10% of the fields surveyed. This is the first record of sheath spot in the Philippines.

Bacterization of rice with *Pseudomonas fluorescens* reduces sheath rot (ShR) infection

N. Sakthivel and S.S. Gnammanickam, Center for Advanced Studies in Botany, Guindy Campus, University of Madras, Madras 600025, India

ShR-infected plants were collected from naturally infected fields in Tanjore, Madurai, Coimbatore, North Arcot, and Salem Districts of southern India. *Sarocladium oryzae* was isolated from CO 41, CO 43, CO 44, TKM9, ADT36, IET1444, IR20, IR36, IR60, and White Ponni. We also isolated strains of

Effect of *P. fluorescens* treatment on ShR incidence and rice yield, Madras, India. [a]

Variety and treatment	Grains/ tiller [b] (no.)	Infected grains (%)	1000-grain wt (g)	Yield/ plot (kg)
IET1444				
Untreated	112	16	19	3.6
Treated	121ns	8	22	4.5*
IR20				
Untreated	108	46	13	2.6
Treated	150	26	17	4.2**

[a] Calculated 't' value significant at P = 0.05 (*), at P = 0.01 (**), ns = not significant. [b] Average of 100 tillers.

Pseudomonas fluorescens from the rhizospheres of rice, citrus, cotton, peanut, and other crops that reduced ShR.

In in vitro assays, *P. fluorescens* isolated from citrus restricted *S. oryzae* growth. In the greenhouse, treating *S. oryzae*-inoculated rice plants with *P. fluorescens* restricted development of ShR lesions.

In a field experiment, replicated plots were planted with IR20 and IET1444 seedlings with and without *P. fluorescens* treatment. The treated plants also were sprayed with 10^8 cfu/ ml *P. fluorescens* at early and late booting. At booting, the middle of the uppermost flag leaf of all plants was inoculated with *S. oryzae* using the standard grain inoculum technique. ShR incidence was recorded from 100 randomly selected tillers per plot. At harvest, number of grains per tiller and infected grains per tiller, 1,000-grain weight, and yield per plot were recorded (see table). Treatment with *P. fluorescens* substantially reduced ShR seventy and increased grain yield.

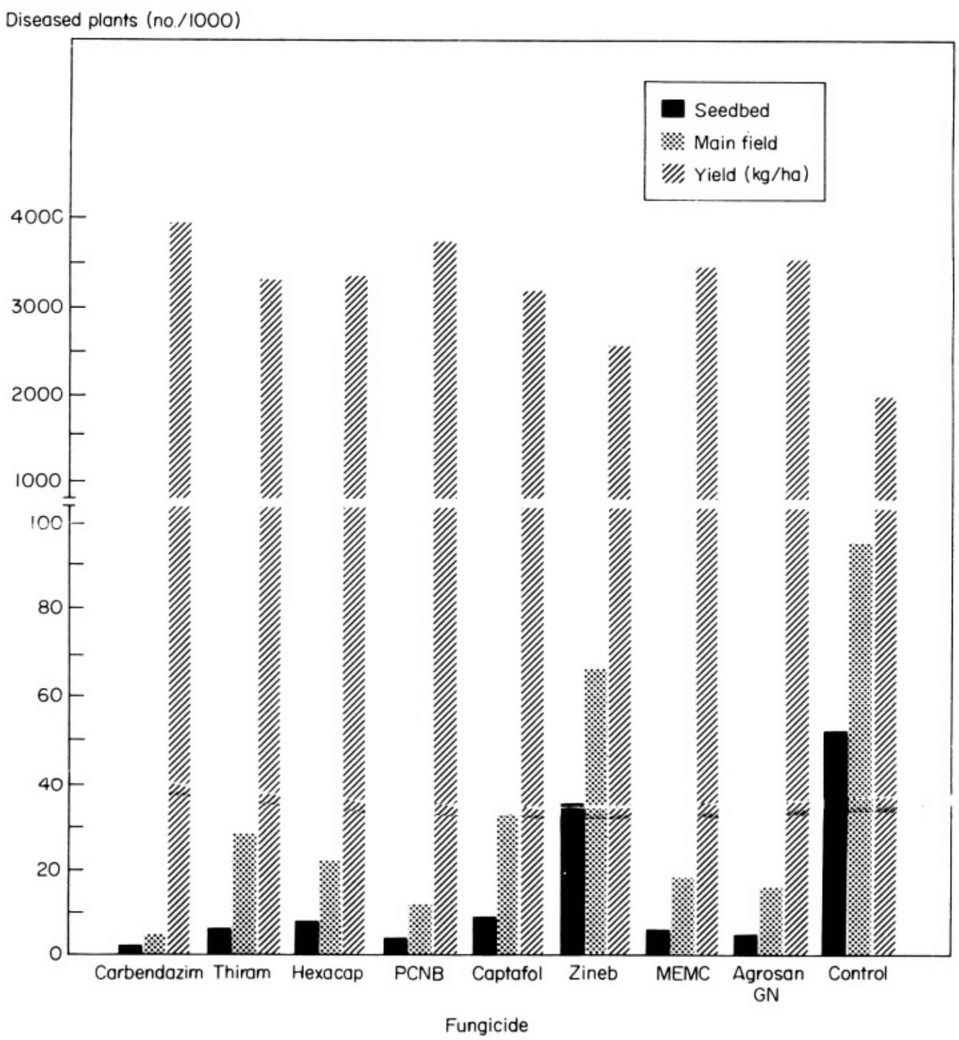
Controlling bakanae (Bak) and foot rot disease with fungicide seed treatments

B. B. Sarkar, Plant Protection Research Wing, State Agricultural Research Station, Arundhutinagar 799003, Tripura, India

We tested eight fungicide seed dressings for controlling Bak and foot rot disease (*Gibberella fujikuroi* (Saw.) Wr. = *Fusarium moniliforme* Sheldon) on IET1444 in 1984 kharif.

Seed was collected from a field severely infected with Bak and foot rot disease. All fungicides except carbendazim were thoroughly mixed with dry seed at 5 g/kg seed. Carbendazim was mixed at 2 g/kg seed. An untreated control was maintained. Sprouted seeds were sown in seedbeds and transplanted into the main field 21 d later. Disease incidence was recorded 20 d after sowing and 35 d after transplanting.

Average disease intensity and yield (see figure) showed that all fungicide treatments significantly reduced disease incidence, although none gave complete control. Carbendazim performed best, followed by PCNB and Agrosan GN.



Efficacy of seed treatments for controlling bakanae and foot rot disease, Tripura, India.

Correlation between green leafhopper (GLH) incidence and tungro (RTV)

R. Saroja, M. Suriachandraselvan, and N. Raju, Paddy Experiment Station (PES), Tamil Nadu Agricultural University, Tirur 602025, Tamil Nadu, India

In 1984-85 sornavari (Apr-May to Aug-Sep), RTV destroyed 28,000 ha of rice in Chingleput District. Experiments and

Correlation between GLH occurrence and RTV incidence, 1984-85, Tirur, India.

Month	GLH density		RTV (%)
	Light trap catch (no.)	GLH/ hill	
Apr	428	0	0
May	586	0	0
Jun	926	11	8
Jul	181,196	90	93
Aug	30,343	17	35
Sep	2,407	11	21
Oct	906	10	10
Nov	1,278	5	0
Dec	10,221	5	0
Jan	8,130	3	5
Feb	926	4	3
Mar	418	5	0

crops at PES also were severely damaged. We correlated GLH incidence with RTV infection based on light trap catches and field scores.

A modified Robinson light trap with a 120-watt M.V. lamp was operated from 1800 to 2400 h. GLH catch and RTV infection were recorded daily. GLH field infestation was recorded 30 d after transplanting (DT) and RTV infection 45 DT on TKM9 in sornavari, CO 43 in samba (Jul-Aug to Dec-Jan), and ADT36 in navarai (Dec-Jan to Apr-May).

GLH were present all year, but the population peaked on 9 Jul 1984, when 36,000 GLH were trapped. Field counts confirmed the trend (see table). Level of RTV infection followed a similar pattern, peaking in Jul, and gradually declining from Aug to Oct.

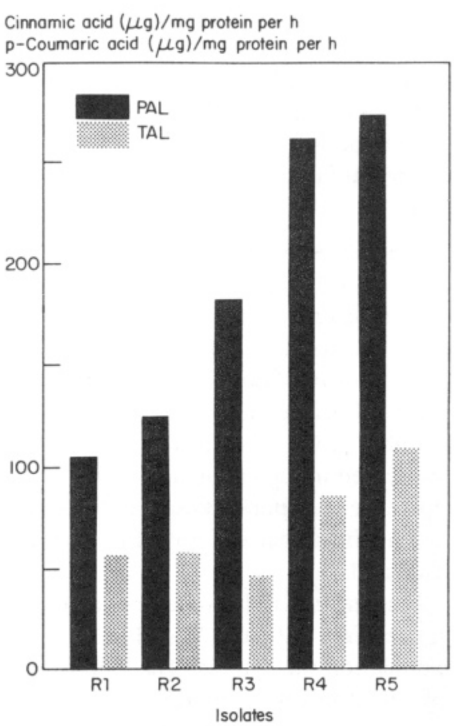
Changes in the key enzymes of *Rhizoctonia solani* Kuhn

P. Ramalingam, Government Arts College, Cuddalore 607001, India

Sheath blight disease caused by *Rhizoctonia solani* Kuhn is a serious problem in India. Phenyl acetic acid and its hydroxy isomers have been identified as the major phytotoxic metabolites of several isolates of *R. solani.* Most of these metabolites are produced during the degradative metabolism of phenylalanine and tyrosine. We studied the involvement of the enzymes phenylalanine ammonia lyase (PAL) and tyrosine ammonia lyase (TAL) in phenylalanine and tyrosine degradation.

Five *R. solani* isolates with different virulence were inoculated in 20 ml of Czapek's (Dox) broth for 7 d at 25° C and grew as stationary cultures. PAL and TAL activities of the cell-free mycelial extracts were assayed.

There was no relationship between TAL activity of the isolates and their virulence. However, there appeared to be a relationship between virulence and PAL activity (see figure).



PAL and TAL activities of 5 differentially virulent *R. solani* isolates, Cuddalore, India.

Management of seedborne *Drechslera oryzae* of rice with plant extracts

D. Alice and A. V. Rao, Plant Pathology Department, Centrefor Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore 641W3, Tamil Nadu, India

We identified plant extracts to control *Drechslera oryzae* (Breda de Haan) Subram and Jain.

Extracts of *Azadirachta indica* bark, *Eupatorium cannabinum* leaf, *Allium sativum* cloves, *Acorus calamus* rhizome, *Piper nigrum* seeds, and *Mentha piperita* leaf were prepared at 25 g each in 50 ml of distilled water by crushing in a mortar and pestle. IR20 seeds, which have high natural infection of *D. oryzae,* were soaked in the filtrate for 24 h before sowing. Dry infected seeds and seeds soaked in distilled water were used as control treatments. Percentage of *D. oryzae*- infected seeds was recorded using the blotter method, and germination and seedling vigor were assessed by the paper towel method.

M. piperita and *A. sativum* extracts significantly reduced seed infection by *D. oryzae,* and treated seeds had significantly higher viability (see table). Extract-treated seeds produced seedlings with longer shoots and roots than those in the untreated check.

Efficacy of plant extracts as seed treatments for controlling *Drechslera oryzae,* **Tamil Nadu, India.**[a]

Extract	Seeds infected with *D. oryzae* (%)	Seed germination (%)	Seedling vigor: Root length (cm)	Seedling vigor: Shoot length (cm)
Allium sativum	11 (18.92)	81 (69.11)	20.7	9.8
Mentha piperita	11 (18.92)	85 (69.04)	20.2	9.7
Eupatorium cannabinum	72 (53.35)	64 (54.14)	18.8	8.8
Azadirachta indica	73 (58.92)	64 (54.14)	18.6	8.8
Acorus calamus	75 (60.24)	65 (53.14)	18.5	8.6
Piper nigrum	76 (60.86)	63 (52.58)	18.2	8.6
Seeds soaked in water for 24 h	72 (58.35)	13 (58.92)	16.3	8.6
Infected dry seeds	85 (61.33)	43 (38.43)	15.3	7.5
CD (P=0.01)	9	5	3.55	1.13

[a] Transformed values in parentheses.

Pest Control and Management
INSECTS

Response of the leaffolder (LF) to extracts of resistant rice varieties

E.B. Medina and E.A. Heinrichs, Entomology Department, IRRI

We evaluated the response of LF *Cnaphalocrocis medinalis* Guenée to extracts of resistant rices. Extracts of leaves were obtained by steam distillation followed by diethyl ether extraction. A 2,000 ppm solution of the oily extract was prepared by adding acetone. Ten 6-cm leaf pieces of susceptible TNI were dipped in the solutions, dried, and infested with 5 4th-instar LF larvae per petri dish. The larvae had been starved for 3 h.

Extracts from TKM6, Darukasail, IR5865, and Kataribhog caused 39-46% larval mortality, compared with 9% mortality for IR36 extract (see table). In another test, eggs laid on TN1 leaves were dipped in a 2,000 ppm extract of the distillate. Extracts from Darukasail and ASD7 significantly reduced hatching, causing 30 and 26% unhatched eggs, compared with 5% for IR36 extract.

Toxicity of extracts of some resistant rices to LF eggs and larvae,[a] IRRI, 1985.

Variety	IRRI accession no.	Larval mortality[b] (%)	Unhatched eggs[c] (%)
TKM6	237	46 a	18 abc
Darukasail	45493	42 a	30 a
IR5865	39433	39 ab	11 abc
Kataribhog	46076	39 ab	14 abc
IR60	63493	37 abc	14 abc
BKN BR1008-21	–	31 abc	13 abc
IR50	53433	23 abc	20 abc
W1263	11657	18 bc	9 bc
ASD7	6303	13 bc	26 ab
IR36 (susceptible check)	30416	9 c	5 c

[a]Means followed by a common letter are not significantly different at the 5% level by DMRT. [b]Larvae were fed TN1 leaves dipped in a 2,000 ppm solution of the extract. [c]Eggs laid on TN1 leaves were dipped in a 2,000 ppm solution of the extract.

Laboratory evaluation of insecticides for controlling greenhorned caterpillar

V.K.R. Sathiyanandam, M.S. Venugopal, M. Gopalan, and R. Janarthanan, Agricultural College and Research Institute (ACRI), Tamil Nadu Agricultural University, Maduai 425104, India

Greenhorned caterpillar *Melanitis leda ismene* (Cramer) attacked the second season IR20 crop 1983-84 at ACRI. In a laboratory experiment, we evaluated four synthetic pyrethroids, two new insecticides, one chitin inhibitor, and two commonly used insecticides for caterpillar control. Potted IR20 plants were sprayed with insecticides and their leaves were fed to 4th-instar larvae. Treatments were in three replications of five larvae per treatment. Dead larvae were counted 24 h after spraying and percent mortality was calculated (see table).

Fenvalerate, FMC54800, chlorpyrifos, and endosulfan were the most effective chemicals. Diflubenzuron caused only 25% mortality, and 75% of the surviving larvae became mosaics in larval or larval to pupal moltings.

Efficacy of insecticides for controlling greenhorned caterpillar larvae, Madurai, India.

Insecticide	Application rate (g ai/ha)	Larval mortality[a] (%)
Chlorpyrifos 20 EC	200	100 a
Fenvalerate 20 EC	50	100 a
FMC54800 100 EC	40	100 a
Endosulfan 35 EC	350	100 a
FMC65318 150 g/L	90	95 ab
FMC35001 25 EC	250	95 ab
Deltanet 400 EC	200	85 bc
Fenpropathrin 10 EC	100	80 bc
Diflubenzuron 25 WP	75	25 d
Check	–	–

[a]Calculated 24 h after insecticide treatment. Means followed by a common letter are not significantly different at the 5% level.

Light trap catches cannot predict field population of green leafhopper (GLH)

S. Murugesan and R. Rajendran, Tamil Nadu Agricultural University, Coimbatore 641003, and S. Chelliah, Tamil Nadu Rice Research Institute, Aduthurai, India

We studied the relationship between light trap catches and field populations of GLH at the Paddy Breeding Station, Coimbatore.

GLH on 20 randomly selected hills of Jaya were counted weekly from 30 to 60 d after transplanting in plots planted at monthly intervals from Jan 1982 to Dec 1983. During the same period, light trap catches were recorded from a modified Robinson trap with a 125-W mercury vapor lamp. Mean daily catch over 7 d before the field count and the number of GLH/20 hills in the field were used in regression analysis to correlate field population with light trap catch. Ninety pairs of observations were analyzed.

The mean GLH trapped per night ranged from 0.01 to 138 and field population was 0 to 64. The regression of field population on light trap catch was not significant, and there was no correlation between light trap catches and field populations.

Egg predators of rice leaffolder (LF) and their susceptibility to insecticides

J.P. Bandong and JA. Litsinger, Entomology Department, IRRI

In transplanted fields in Nueva Ecija, Philippines, a mixed population of LF *Cnaphalocrocis medinalis* and *Marasmia patnalis* exceeded 1 moth/linear m. In insecticide-free plots, however, leaf damage did not exceed 15%, leading us to suspect that egg predators were suppressing LF. We screened five possible predators in mylar cylinder cages kept outdoors.

Field-collected LF adults oviposited overnight on potted reproductive-stage rice plants. Leaves with about 50 eggs per plant were marked. Plants were placed in cages for 24 h with 5 of each suspected predator species. The predators significantly reduced the number of oviposited eggs (Table 1). Five adult *Micraspis crocea* and *Synharmonia octomaculata,* and nymphs and adults of *Cyrtorhinus lividipennis* caused 21-32% egg mortality. Egg numbers were reduced 85% by five *Metioche vittaticollis* and 13% by *Anaxipha longipennis.*

Farmers normally spray insecticide 2-4 times beginning 3-5 wk after transplanting. Many fields subsequently have 40-80% LF damage, a possible sign of insecticide-induced resurgence. To confirm this, we studied the mortality of the two cricket predators after applying commonly used insecticides.

Forty-five days after transplanting, potted rice plants were sprayed with insecticides at 0.4 kg ai/ ha. When the spray dried, 10 adult crickets collected from insecticide-free plots were caged on the plants. Mortality was measured after 48 h. Both species were highly susceptible, but *Metioche* less so, to all insecticides except azinphos-ethyl and endosulfan (Table 2).

Table 1. Evaluation of LF egg predators,[a] Nueva Ecija, Philippines, Oct-Nov 1984.

Species	Egg mortality[b] (%)
Gryllidae (adults)	
Metioche vittaticollis (Stal)	85 a
Anaxipha longipennis (Serville)	73 a
Coccinellidae (adults)	
Micraspis crocea (Mulsant) and *Synharmonia octomaculata* (Fabricius)	32 b
Miridae	
Cyrtorhinus lividipennis Reuter	
adults	28 b
nymphs	21 b
Untreated	0 c

[a]Av of 10 replications. Each replication received 5 field-collected predators from insecticide-free plots, [b]Mortality 24 h after predator release. Means followed by a common letter are not significantly different (P < 0.05) by DMRT.

Table 2. Contact toxicity of commercial insecticides against 2 species of gryllid predators.[a] Nueva Ecija, Philippines, Oct-Nov 1984.

Insecticide[b]	Mortality[c] (%)	
	Metioche sp. 48 HAT	*Anaxipha* sp. 48 HAT
Monocrotophos 30 EC	95 a	95 a
MIPC 50 WP	95 a	100 a
Chlorpyrifos 20% + BPMC + 11% EC	100 a	100 a
Methyl parathion 50 EC	100 a	100 a
Azinphos-ethyl 40 EC	20 c	44 c
BPMC 50 EC	83 ab	100 a
Cypermethrin 5 EC	68 b	97 a
Methomyl 20 EC	100 a	100 a
Endosulfan 35 EC	34 c	80 b

[a]Av of 6 replications. HAT = hours after treatment. In a column, means followed by a common letter are not significantly different (P = 0.05) by DRMT. [b]Applied as foliar spray at 0.4 kg ai/ha. [c]Mortality adjusted by Abbott's formula.

Efficacy of four insecticides against major rice pests in Tamil Nadu, India

C. Kandasamy and S. Ravikumar, Entomology Department, Fredrick Institute of Plant Protection and Toxicology (FIPPAT), Padappai 601301, Tamil Nadu, India

In Sep 1984 and Feb 1985 we assessed the efficacy of four insecticides (see table) against yellow stem borer (YSB), leaffolder (LF), and whorl maggot (RWM). Insecticides were applied to CR 1009 3 times at 20-d intervals beginning 10 d after transplanting (DT). Insect populations were recorded at 10-d intervals beginning 20 DT. Percent YSB incidence was determined by counting total tillers and those with deadhearts and whiteheads. LF and RWM incidence was calculated based on total leaves and infested leaves.

All insecticide treatments significantly and similarly reduced pest incidence and gave higher yield than the untreated control (see table).

Cartap and 3 other insecticides for controlling YSB, LF, and RWM, Tamil Nadu, India.

Treatment	Rate (kg ai/ha)	Mean percent incidence[a]			Yield (t/ha)
		YSB	LF	RWM	
Granules					
Cartap 50 SP	1.0	14 a	9 a	14 a	1.3
Cartap 50 SP	1.5	14 a	9 a	14 a	1.5
Carbofuran 3 G	0.75	14 a	9 a	14 a	1.5
Chlorpyrifos 10 G	1.0	14 a	9 a	14 a	1.7
Untreated check	–	21 b	13 b	18 b	1.0
Spray					
Cartap 50 SP	1.0	17 a	11 a	11 a	1.3
Cartap 50 SP	1.5	17 a	10 a	11 a	1.2
Phosphamidon 85 EC	0.5	17 a	11 a	13 a	1.0
Chlorpyrifos 20 EC	0.5	17 a	11 a	12 a	1.6
Untreated check	–	25 b	14 b	17 b	0.8

[a]Arcsine transformed values for the mean percent incidence of 5 replications. Separation of means by DMRT at the 5% level.

Granular insecticides for controlling brown planthopper (BPH) and green leafhopper (GLH)

S. Uthamasamy and S. Suresh, Tamil Nadu Rice Research Institute, Aduthurai 612 101, India

BPH *Nilaparvata lugens* (Stål) and GLH *Nephotettix virescens* (Dist.) cause heavy losses in Jun-Sep in Thanjavur District. In 1984, we compared four granular insecticides with carbofuran for BPH and GLH control. Treatments (see table) were arranged in a randomized complete block design with 4 replications in 30- m^2 plots planted with ADT31. Insecticides were broadcast in 5.0 cm standing water 10 and 40 d after transplanting (DT) and impounded for 48 h. BPH and GLH adults and nymphs were counted in 10 randomly selected hills/plot at 20, 35, and 50 DT.

Insecticide-treated plots had lower insect populations than the untreated check. Carbofuran 3 G at 1.0 kg ai/ ha effectively reduced BPH population. Ethoprop 10G effectively reduced GLH on 20 and 35 DT, and on 50 DT bromophos ethyl plots had fewest GLH. Carbofuran-treated plots yielded 4.8 t/ha compared with 3.2 t/ha for the untreated check. Increase in yields in Benfuracarb- and carbofuran- treated plots may be due to phytotonic effect.

Mean incidence of brown planthopper and green leafhopper, and grain yield after application of granular insecticides.[a]

Treatment	Formulation	Dose (kg ai/ha)	BPH (no./hill)			GLH (no./hill)			Grain yield (t/ha)
			20 DAT	35 DAT	50 DAT	20 DAT	35 DAT	50 DAT	
Benfuracarb	3 G	1.5	0.66 ab	5.66 ab	22.66 ab	4.33 ab	8.33 ab	8.66 ab	4.1 b
Bromophos ethyl	5 G	1.5	1.66 b	11.33 b	18.00 ab	3.66 ab	11.33 ab	6.00 a	2.9 c
Ethoprop	10 G	1.5	2.00 b	5.66 ab	27.00 b	3.00 a	7.66 a	8.66 ab	3.2 c
Quinalphos	3 G	1.5	1.00 ab	7.33 b	34.00 b	3.33 ab	12.33 b	10.00 b	2.8 c
Carbofuran (standard check)	3 G	1.0	0.33 a	4.33 a	14.00 a	3.33 ab	8.00 ab	6.33 ab	4.8 a
Untreated control	–	–	3.00 c	12.00 b	57.33 c	11.00 c	17.66 c	20.00 c	3.2 c

[a]Means followed by a common letter in a column are not significantly different. DAT = days after treatment.

Beauveria bassiana for controlling brown planthopper (BPH) and green leafhopper (GLH)

Li Hongke, Institute of Plant Protection, Hunan Academy of Agricultural Sciences, Changsha, China

We studied the host range of *B. bassiana* on rice insects. The fungus was isolated from 17 insect species of 6 orders, and occurred most frequently on BPH and GLH.

We evaluated *B. bassiana* for controlling BPH and GLH in the field. Four fungus isolates were tested in 40- × 40- × 100-cm cages covering 4 hills of rice. GLH were placed in the cages and treated with dusts containing 11 × 10^8 *B. bassiana* conidia/g (see table). In a similar experiment, BPH mortality was 60-90% 15 d after treatment. GLH was more susceptible to *B. bassiana* than BPH.

GLH and BPH mortality after *B. bassiana* infection.

Isolate origin	Mortality (%) 7d after treatment	Mortality (%) 10 d after treatment
GLH	78	96
BPH (1)	67	92
BPH (2)	65	91
C. suppressalis	60	91
Control	0	8

Influence of nitrogen fertilizer level and timing on stem borer (SB) incidence

M.S. Purohit, P.M. Bhatt, A.H. Shah, and S. Raman, National Agricultural Research Project (NARP), Gujarat Agricultural University, Navsari 396450, India

We evaluated the influence on SB incidence of four N sources at three application levels and two timings at NARP in summer 1985.

IR22 seedlings were transplanted in 7.2-m^2 plots in a split-plot design with 3 replications. No insecticides were applied. Percent deadhearts and total tillers in 30 hills/plot were recorded 50 d after transplanting.

SB damage was significantly lower when N was applied as ammonium sulfate (see table).

Influence of N fertilizer source, level, and timing on SB damage,[a] Navsari, India, 1985.

N source	SB deadhearts (%) 100 kg N/ha		80 kg N/ha		60 kg N/ha		Av (%)
	T1	T2	T1	T2	T1	T2	
Ammonium sulfate	11	12	10	18	17	21	15
Urea	13	21	30	24	27	15	22
Neem cake-coated urea	16	15	21	21	22	16	19
Urea supergranules	30	11	14	12	20	14	17
Mean	17.50	14.92	19.08	18.90	21.74	16.97	
CD for N source	3.3						
CD for level and time	ns						
CD for interaction	10.1						

[a] T1 = basal application, T2 = 50% basal + 50% 20 d after transplanting.

Whitebacked planthopper (WBPH) and leaffolder (LF) in Haryana

P. Ram, Entomology Department, Haryana Agricultural University, Hissar 125004, Haryana, India

WBPH *Sogatella furcifera* Horvath caused widespread hopperburn, and a severe outbreak of LF *Cnaphalocrocis medinalis* Guenée occurred in Haryana in 1983 kharif. WBPH population reached 5-1 0 insects/ hill in mid-Sep and epidemic levels in mid-Oct when sweep net samples from highly infested fields had 1,000-l,500 insects/sweep (see table). Seventy percent of the fields had hopperburn. PR106 and local Basmata were seriously damaged.

LF populations peaked in Oct, when about two-thirds of the leaves in infested fields were folded (see table). Most damaged plants were white with papery leaves.

WBPH and LF damage in Haryana, India, 1983 kharif.

District	Block	Villages surveyed (no.)	WBPH infestation	LF (% leaf infestation)
Kurukshetra	Thaneshwar	9	Very severe	70
	Pehowa	11	Very severe	75
	Pundri	8	Very severe	50
	Radaur	5	Severe	23
Karnal	Nilokheri	8	Severe	25
	Indri	6	Moderate	22
Ambala	Ambala	6	Moderate	15
	Jagadhari	7	Moderate	22

Factors that may have contributed to the insect outbreaks include

- early, heavy monsoon rains followed by a long period of dry, humid weather;
- application of 175-250 kg N/ ha; and
- poor WBPH control by recommended insecticides.

Selective insecticides for WBPH control are needed and the extent of yield reduction caused by LF should be determined.

Relation between brown planthopper (BPH) biotype 2 infestation and sheath blight (ShB) infection

J. Soriano, E.A. Heinrichs, T.W. Mew, A. Rosales, and N. Fabellar, IRRI

IR22, IR36, ASD7, and Utri Rajapan were tested to learn if BPH infestation increased ShB infection. Treatments were male BPH + ShB, female BPH + ShB, and ShB alone (Table 1). BPH infestation did not affect ShB severity. Results also showed that IR22 and IR36 were more resistant to ShB than Utri Rajapan and ASD7 (Table 2).

Table 1. Mean lesion length of BPH-infested and ShB-infected rice plants, IRRI.

Treatment	Lesion length[a] (mm)				
	Utri Rajapan	ASD7	IR36	IR22	Mean
Male BPH + ShB	287 a	321 ab	112 c	107 c	207 a
Female BPH + ShB	395 b	352 ab	146 c	130 c	256 a
ShB	339 ab	309 ab	125 c	108 c	220 a
Mean	340 a	328 a	128 b	115 b	228

[a] Means followed by a common letter are not significantly different at 5% level by DMRT.

Table 2. Mean number and length of ShB lesions on different rices, IRRI.

Days after inoculation	Variety		Difference[a]
	Utri Rajapan and ASD7	IR36 and IR22	
	Lesions (no.)		
7	4.2	3.4	0.8 ns
14	7.0	4.3	2.7**
21	8.8	4.0	4.8**
28	9.6	5.2	4.4**
	Lesion length (mm)		
7	118	66	52**
14	200	89	111**
21	367	122	245**
28	652	210	442**

[a] ns = not significant at 5% level, ** = significant at 1% level.

Sex ratio and productive status of *Scotinophara coarctata* collected from light traps and rice fields

B.M. Shepard and G.S. Arida, Entomology Department, IRRI, and K.L. Heong, Central Research Laboratories, MARDI, Serdang, P.O. Box 12301, Kuala Lumpur 01-02, Malaysia

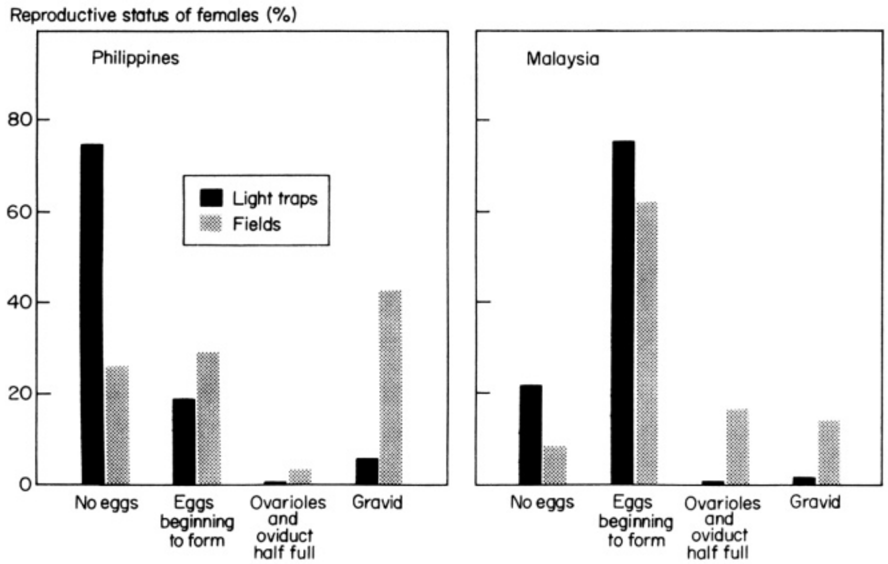
Adult black bugs *Scotinophara coarctata* (F.) were collected from light traps, street lights, and rice fields in Malaysia and the Philippines to determine their sex ratio and reproductive status.

In Sep-Nov 1984, 755 adults were collected from rice fields and 792 on fluorescent street lights or in light traps at several sites on Palawan, Philippines. In Malaysia, 173 black bugs were collected from fields and 478 from street lights. All samples were sexed and preserved in 85% ethyl alcohol. Each female was dissected to determine her reproductive status: no eggs present, eggs beginning to form in ovarioles, oviducts approximately half full of eggs, and gravid.

Philippine fields yielded 44% males and 56% females; light traps and street lights, 49% males and 51% females. The trend was similar in Malaysia, where field collections were 64% females. But only 40% of those collected on lights were females. In both countries, the most eggless females were in light traps (Fig. 1).

The lower percentage of gravid females in light traps indicated that adults that migrate or disperse are mainly newly emerged adults that may be moving to colonize new habitats or females that already have laid their eggs. More gravid females and those with ovarioles and half-full oviducts were collected from rice fields in the Philippines (Fig. 1a) and Malaysia (Fig. 1b).

Light trap collections were not typical of the total populations in an area. It is unlikely that light traps could be used to monitor the activity of reproductively active black bugs, which usually were found in the field.



Reproductive status of female black bugs collected from light traps and rice fields in the Philippines and Malaysia.

Occurrence and control of rice black bug at Coimbatore

A. Subramanian, S. Murugesan, R. Rajendran, and P. C. Sundara Babu, Centre for Plant Protection Studies, Tamil Nadu Agricultural University (TNAU), Coimbatore 641003, India

In early Jul 1985, population of black bug *Scotinophara coarctata* (F.) adults and nymphs reached 10 bugs/hill on most rices grown at the Paddy Breeding Station, TNAU. Population density on IR60, IR36, Vaigai, ADT36, IR56, PY3, IR50, ADT31, TKM9, Rasi, and PY2 ranged from 6 to 12 bugs/10 hills. There was no significant difference in numbers on different varieties at 30 d after transplanting.

Efficacy of 5 insecticides in reducing black bug population in rice, Tamil Nadu, India.

Insecticide	Concentration	Reduction of black bug population over control[a] (%)
Monocrotophos	0.04%	91 a
Endosulfan	0.05%	66 b
Phosalone	0.15%	61 b
Quinalphos	0.05	59 b
Dichlorvos	0.05	58 b

[a] Mean of 5 replications, in a randomized block design. Plot size was 20 m^2. Separation of means by DMRT at the 5% level.

We evaluated the efficacy of 5 insecticides for black bug control on 45-d-old IR50. Adult black bugs were counted on 20 randomly selected hills per plot 1 d before and 2 d after treatment. Monocrotophos reduced black bug population most effectively (see table).

Pest Control and Management
OTHER PESTS

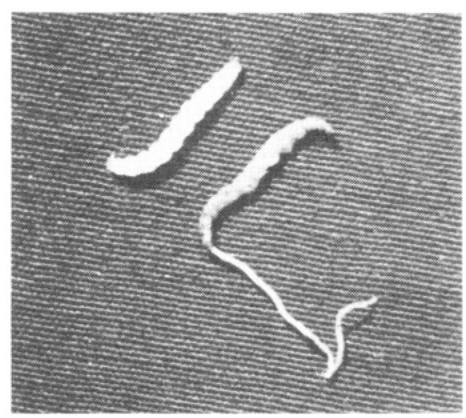
Entomophagous nematode infection of leaffolder (LF)

T. Manoharan and N. Chandramohan, Tarnil Nadu Agricultural University, Research Centre, Vellore 632001, India

During a survey to identify natural enemies of rice pests in North Arcot District of Tamil Nadu, we noted a natural infection of entomophagous nematode *Agamermis* in LF *Cnaphalocrocis medinalis* G. (see figure).

Fifty larvae per week were collected from fields to study the level of infection and other gross pathological symptoms. The larvae and 5-cm-long rice leaf sections were kept in 1km petri dishes with moist filter paper. The cut ends of the leaves were covered with moist cotton to prevent drying.

Infection rate was highest, averaging 14%, in Dec-Jan. Nematode infection



Healthy (left) and nematode infected (right) LF larvae, Vellore, India.

changed larvae from green to yellow, reduced feeding rate, lessened response to external stimuli, and increased flaccidity. Only one nematode emerges from the cadaver and the pathogen emerges mostly from the anal end of the host larva.

Reaction of some rices to root-knot nematode

B. Swain, J.S. Prasad, and Y.S. Rao, Central Rice Research Institute, Cuttack 753006, India

We screened 26 rices for resistance to root-knot nematode *Meloidogyne graminicola* Golden and Birchfield 1968. Polypots (150 g capacity) were filled with steam sterilized soil (3 loam: 1 sand) and 10 seeds of each rice variety were sown, 1/pot in 3 sets. When seedlings were 5 d old, 200 infective *M. graminicola* juveniles were inoculated in each pot. Thirty-five days after inoculation, the seedlings were uprooted, washed, fixed in 4% formalin, stained in lactophenol cotton-blue, and the number of egg masses per plant was recorded. Varieties with less than one egg mass were classified as resistant and the others as susceptible.

MW-10, Daya, CR190-103, and IR36 were highly resistant (see table). Although earlier reports indicated that Ramsa and TKM6 were resistant, our test at a high inoculum level showed they were susceptible.

Reaction of rice varieties to root-knot nematode, Cuttack, India.

Variety	Mean number of egg masses[a]
MW10	0.6 a
Daya	0.9 ab
IR36	0.9 ab
CR190-103	1.0 ab
Pratap	1.4 abc
Lalnakanda-41	1.5 bcd
IR50	1.7 bcde
Kesari	1.8 cde
TKM 6	1.8 cde
Ratna	1.8 cde
Jajati	1.9 cde
TKM 9	1.9 cdef
Hamsa	2.2 cdef
Rajeswari	2.2 cdef
Kumar	2.3 defg
Rudra	2.4 efg
Jaya	2.4 efg
Sankar	2.4 efg
Sathi	2.4 efg
Akashi	2.4 efg
Suphala	2.7 fgh
ORl64-7-1	2.7 fghi
Hema	3.1 ghij
IR8	3.5 hij
Annapurna	3.6 ij
Parijat	4.0 j

[a] Average of 3 replications. Separation of means by DMRT at the 1% level.

Soil and Crop Management

Efficacy of slow-release N fertilizers on rice in coastal soils of Karnataka

A.M. Krishnappa, K. Kenchaiah, B.N. Patil, B.K. Balakrishna Rao, and N.A. Janardhana Gowda, Agricultural Research Station, Kankanady, Mangalore 575002, Karnataka, India

In 1984 wet season, we evaluated prilled urea (PU), lac-coated urea (LCU), neem cake-blended urea (NCU), urea supergranules (USG), and sulfur-coated urea (SCU) at 38, 75, 113, and 150 kg N/ha for rice in midland soils of coastal Karnataka. Soil was a fine, loamy, mixed isohyperthermic Ustoxtropept with pH 5.2, 0.99% organic C, 292 kg available P/ha, and 92 kg available K/ha. The experiment was in split-plot design, with N as main plots and sources as subplots. A no-N control was included.

Three 29-d-old IET3232 (medium duration) seedlings were transplanted at 20- × 15-cm spacing on 20 Jan. All plots received 75-88 kg PK/ha at planting. One-half PU was applied at planting and 25% at tillering and at panicle initiation. LCU, NCU, and SCU were applied at transplanting, and USG was applied 8-10 cm deep between 4 hills in alternate rows, 7 d after transplanting. The field was flooded from transplanting to maturity. The crop was protected from insects, diseases, and weeds, and was harvested 6 Nov.

Fertilizer levels, sources, and interactions gave significantly different yields (see table). Yield increased with N level. Slow-release fertilizers performed better than PU at all N levels, with SCU giving highest yields. Yield with SCU or USG at 38 or 75 kg N/ha was similar to yield with PU at 113 or 150 kg N/ha. At 150 kg N/ha, yields with SCU and USG declined. N level did not significantly affect tiller number or grain weight per hill, but sources did.

Influence of N levels and sources on rice yield, Mangalore, India.

N form	Grain wt/hill (g)	Grain yield (t/ha)
	No N (control)	
None	12.1	4.0
	38 kg N/ha	
PU	13.0	4.3
LCU	13.0	4.3
NCU	14.1	4.7
USG	14.7	4.9
SCU	15.1	5.0
	75 kg N/ha	
PU	13.9	4.6
LCU	13.9	4.8
NCU	14.2	4.9
USG	14.2	4.9
SCU	15.8	5.3
	113 kg N/ha	
PU	13.7	4.7
LCU	15.1	5.0
NCU	14.4	5.0
USG	15.2	5.1
SCU	17.7	5.9
	150 kg N/ha	
PU	14.9	4.9
LCU	15.1	5.0
NCU	15.5	5.2
USG	13.3	4.4
SCU	15.4	5.1
CD (0.05)		
Levels	ns	0.3
Sources	1.2	0.2
Sources at fixed level of N	ns	0.5
Levels at different source	ns	0.5

Yield response of rice to unburned and burned rice husk

A.A. Jakhro, Institute of Agriculture, Timbang Menggaris, Kota Belud, Sabah, Malaysia

We studied the effect of unburned and burned rice husk on rice yield in a pot experiment. Soil was a clay loam with pH 5.6, 1.2% organic matter, 10 ppm Bray P, 2.8 meq available K/100 g soil, and 0.08% N. Treatments of no rice husk (control) and unburned or burned rice husk at 10 t/ha were assigned in a randomized complete block design with 6 replications. Four IR42 seedlings were transplanted in each pot. Water level was 5 cm throughout the growing season.

Plant height and tillers per pot were significantly higher with rice husk. Thirty days after transplanting, growth response to burned husk was significantly better than to unburned husk (Table I), perhaps because unburned husk decomposes more slowly. At later growth, both treatments performed similarly. The trend was similar for panicle number, spikelets per panicle, 1,000-grain weight, and grain yield (Table 2). Compared with the control, plants yielded 22% more with unburned husk and 25% more with burned husk.

Table 1. Effect of rice husk on rice plant height and tillering in rice. Sabah, Malaysia.

Treatment	Plant height [a] (cm)			Tillers (no./pot)	
	30 DT	60 DT	90 DT	30 DT	60 DT
No rice husk	20 c	30 b	46 b	15 c	25 b
Unburned rice husk	26 b	59 a	73 a	23 b	50 a
Burned rice husk	31 a	60 a	74 a	30 a	52 a

[a] Means with a common letter are not significantly different at 5% level by Duncan's Multiple Range Test.

Table 2. Effect of rice husk on yield components and rice grain yield.[a] Sabah, Malaysia.

Treatment	Panicles (no.)	Spikelets per panicle	1000-grain weight (g)	Grain yield (g/pot)
No rice husk	25 b	58 b	18 b	180 b
Unburned rice husk	35 a	68 a	22 a	200 a
Burned rice husk	36 a	70 a	23 a	202 a

[a] Means with a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Effect of organic N fractions in submerged soil on rice yield

B.S. Mahapatra, K.C. Sharma, and G.L. Sharma, Agronomy Department, G.B. Pant University of Agriculture and Technology, Pantnagar, Nainital, Uttar Pradesh 263145, India

Applied N fertilizer becomes part of soil N. Soil N, although modified by applied N, plays the dominant role in N nutrition for rice. In a 1983-84 wet season experiment, we found that hydrolyzable soil N (using 6 N HCl extractant) at 15, 30, 45, and 60 d after transplanting (DT) was positively and significantly related to rice grain yield (see table), indicating that the hydrolyzable soil N fraction is highly important to N nutrition in submerged rice soil. Nonhydrolyzable soil N was negatively related to grain yield at 60 DT.

Relation between rice yield and the hydrolyzable and nonhydrolyzable soil N fractions, Pantnagar, India.

Parameter	Regression equation [a]	r [b]
Hydrolyzable soil N		
15 DT	$Y = 525 + 1.908\ X$	0.912**
30 DT	$Y = 1511 + 1.236\ X$	0.857**
45 DT	$Y = 1586 + 1.262\ X$	0.884**
60 DT	$Y = 1445 + 1.481\ X$	0.572*
Nonhydrolyzable soil N		
60 DT	$Y = 5994 - 3.114\ X$	-0.553*

[a] Y = grain yield, X = respective organic N fraction. [b] Significant 5% (*) and 1% (**) levels.

Effect of onset of monsoon on length of growing season and productivity of rainfed rice in Madhya Pradesh

A.S.R.A.S. Sastri, Zonal Agricultural Research Station, Jawaharlal Nehru Agricultural University Raipur, India 492012

In Madhya Pradesh, India, rice is grown in about 4.7 million ha, of which 80% is rainfed. Rice yields are about 1.0 t/ ha and depend entirely on the monsoon.

Analysis of 80 yr (1901-80) of rainfall data from Raipur Station showed that the monsoon usually begins 11-17 Jun on 24th standard meteorological wk. We used daily rainfall data from 1941 to 1981 to determine the probability of early (19%), normal (34%) and late (47%) onset of monsoon.

Rainfed rice depends entirely on rainfall. Length of rainy season determines the optimum duration of rice varieties. From 40-yr data, we calculated the average length of the growing season under early, normal, and late onset of monsoon (see figure) and averaged the rice productivity for the corresponding years (see table).

Data in the table suggest that early duration varieties are best for this area.

Length of growing season under early, normal, and late onset of monsoon in Raipur, India.

Monsoon onset	Recent probability (%)	Av rainfall (mm)	Water availability period [a] (d)			Total growing period (d)	Av rice yield (t/ha)
			Moist I (PE > R > PE/2)	Humid (R > PE)	Moist II (PE > R > PE/2)		
Early	19	1607	7	127	12	146	1.2
Normal	34	1366	14	115	10	139	1.1
Late	47	1044	13	91	14	118	0.8

[a] PE = potential evapotranspiration, R = rainfall.

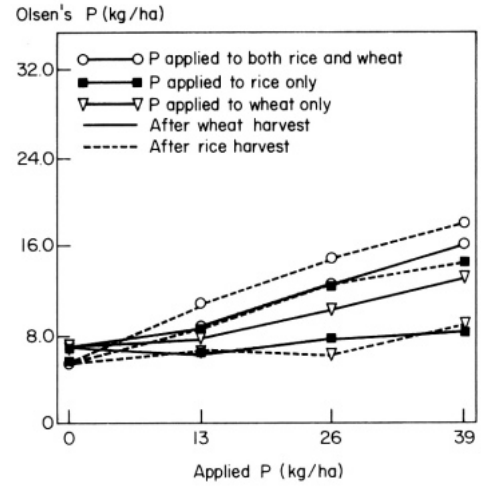
Available soil phosphorus in a rice - wheat rotation after extended superphosphate application

S. Saggar, G. Dev, and O.P. Meelu, Punjab Agricultural University (PAU), Ludhiana 141004, India

High yielding rices and improved management practices have extended rice - wheat rotations to areas with coarse-textured soils and low available P. We found that in rice - wheat rotation, fertilizer P should be applied to wheat rather than to rice, and that if wheat receives adequate P fertilizer over time, P application to rice can be reduced. This long-term study evaluated

Rice and wheat yield and P removal by year as affected by P fertilization, Ludhiana, India.

Applied P (kg/ha)	Grain yield (t/ha)					P removal (kg/ha)				
	1st	2d	3d	4th	Mean	1st	2d	3d	4th	Mean
						Wheat				
0	1.9	1.3	2.1	1.7	1.8	5.5	3.8	6.1	5.4	5.2
13	2.7	2.2	3.3	3.2	2.8	8.7	7.1	9.6	9.4	8.7
26	2.9	2.6	4.0	3.8	3.3	9.9	8.8	13.6	12.5	11.2
39	3.2	2.8	4.3	4.5	3.7	11.4	10.0	15.3	16.1	13.2
LSD (0.05)	0.2	0.3	0.3	0.4	0.3	1.8	1.6	1.7	2.1	1.8
						Rice				
0	6.6	3.3	5.5	5.2	5.2	13.7	6.8	11.4	11.3	10.8
13	6.7	5.1	6.2	6.6	6.2	17.5	13.3	16.2	17.8	16.2
26	6.7	5.1	6.0	6.6	6.1	17.4	13.2	15.6	18.2	16.1
39	7.0	5.1	6.1	6.6	6.2	18.9	13.8	16.5	18.0	16.8
LSD (0.05)	ns	0.4	0.3	0.2	0.3	2.8	2.9	3.2	4.4	4.1



Cumulative direct and residual effect of different levels of applied P on Olsen's P in soil (0-15 cm depth) after 4 yr of fertilization.

P removal and changes in available P in soil with extended superphosphate use.

The results are from the PAU farm, where P was applied at graded levels to rice and wheat or to rice or wheat, in which case residual P was measured. Soil was a nonsaline Tulewal loamy sand Ustipsamment with pH 8.4, EC 0.20 mmho/cm, CEC 8.2 meq/ 100 g soil, 0.23% organic C, and 66-6-108 kg NPK/ha.

P uptake of wheat increased significantly up to 39 kg P/ha and rice yield and P uptake increased significantly up to 13 kg P/ha (see table). Averaged over 4 yr, rice yielding 5.9 t/ha removed 15.0 kg P/ha; wheat yielding 2.8, 3.3, and 3.7 t/ha removed 8.7, 11.2, and 13.2 kg P/ha. Thus, for an annual 9.9 t/ha of rice and wheat, 29 kg of 52 kg applied Pi ha was removed.

Over 4 yr, available soil P increased with successive levels of P application (see figure). The increase was greatest when P was applied to both wheat and rice. Available P increased from 6.8 to 18.4 kg P/ha when 39 kg P/h a was applied to both crops. P increase was fastest when P was applied to rice. P was more available after rice harvest than after wheat harvest because soil P is more available in submerged than in aerated soils. When P was applied to wheat alone, available P decreased after the next rice crop.

Control of the azolla pest *Limnea natalensis* with molluscicides of plant origin

P. A. Reynaud, French Institute for Research and Development in Cooperation (ORSTOM), Soil Biology Department, B. P. 1386, Dakar, Senegal

The freshwater snail *L. natalensis* is a serious azolla pest in rice fields and azolla multiplication plots in central Senegal (Saloum Province). Its populations may reach 100 g fresh weight/m^2 and in 2 wk destroy 500 g azolla inoculum. *Limnea* eat azolla roots, then leaves. They embed eggs on firm translucent sheaths on the lower lobe of the fronds.

L. natalensis also vectors *schistosomiasis,* and control in azolla plots should be considered as a necessary disease prophylactic.

We compared a commercial molluscicide containing metaldehyde with materials obtained from the local trees *Azadirachta indica, Balanites aegyptiaca,* and *Detarium heudelotianum.*

Azolla inoculum corresponding to 500 g fresh weight/m^2, 2 g fresh weight *L. natalensis,* and the test molluscicide were placed in plastic containers with 1 litre of medium for azolla. Each treatment had 4 replications. Results were recorded 8 and 15 d after inoculation (see table).

Metaldehyde and neem cake at 1.5

Effect of limnicide treatments on *Limnea natalensis* **and** *Azolla pinnata* **var.** *africana,* **Dakar, Senegal.**[a]

Treatment[b] (g/litre)		8 days		15 days	
		Azolla[c] (%)	*Limnea*[d] (%)	*Azolla* (%)	*Limnea* (%)
L. natalensis	2	79 a	130 a	21 a	100 a
+ metaldehyde	0.025	80 a	60 b	45 ab	30 b
	0.25	75 a	43 b	60 b	10 bc
	1.5	85 a	72 b	110 c	105 a
+ neem cake	1.5	76 a	96 c	61 b	90 a
+ *B. aegyptiaca*					
nut powder	1.5	73 a	95 c	60 b	0 c
leaf powder	0.25	87 a	86 bc	71 b	0 c
	0.75	94 a	95 bc	72 b	0 c
	1.5	57 b	56 b	0 d	10 bc
	3.0	32 b	31 d	0 d	15 bc
+ *D. heudelotianum*					
bark powder	0.25	80 a	0 c	81 bc	0 c

[a] Values followed by the same letter are not significantly different at P = 0.10. [b] Concentrations of plant material are expressed on d.w. basis. [c] f.w. expressed as % of the control with out L. natalensis. [d] f.w. of living animals expressed as % of inoculum (2 g).

g/litre did not control *L. natalensis.* Metaldehyde inefficiency at the highest concentration and efficiency at lower concentrations may have been due to a protective mechanism developed by *Limnea. B. aegyptiaca* nut and leaf powder controlled *L. natalensis,* but concentrations higher than 0.75 g leaf powder/litre harmed azolla. *D. heudelotianum* affected neither *Limnea* nor azolla. Treating azolla multiplication plots with 0.25 g *D. heudelotianum* bark powder or *B. aegyptiaca* leaf powder provides an effective, inexpensive control.

Nitrogen use efficiency in rice

J.P. Singh, J.S. Bohra, and K. Singh, Agronomy Department, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221005, India

We evaluated urea split, sulfur-coated urea (SCU), neem-coated urea (NCU), lac-coated urea (LCU), gypsum-coated urea (GCU), urea supergranules (USG), and urea coal acid (UCA) with 0, 40, 80, and 120 kg N/ ha for rice at Varanasi. The experiment was in a split-plot design with N sources in main plots and levels in subplots.

Four doses of the coated fertilizers and USG were applied 1 wk after transplanting Jaya. Half of urea split was basal and half in equal splits at tillering and panicle initiation. PK at 22-42 kg/ ha were applied at transplanting. Fields were flooded with 5±2 cm water throughout the study.

USG performed best, followed by SCU and NCU (see table). Each N increment significantly increased grain yield.

Effect of N sources and levels on rice grain yield, Varanasi, India.

Treatment	Grain yield (t/ha) 1982	Grain yield (t/ha) 1983
N sources		
Urea split	3.1	3.0
SCU	3.5	3.2
NCU	3.2	3.2
LCU	2.8	3.1
GCU	3.2	3.0
USG	3.5	3.2
UCA	2.5	3.0
S. Em ±	0.1	0.08
LSD 5%	0.4	0.2
N levels (kg/ha)		
0	2.2	1.9
40	3.0	2.8
80	3.4	3.6
120	3.9	4.1
S. Em ±	0.1	0.06
LSD 5%	0.4	0.2

Effect of sowing time on yield of rice varieties in two locations in Cuba

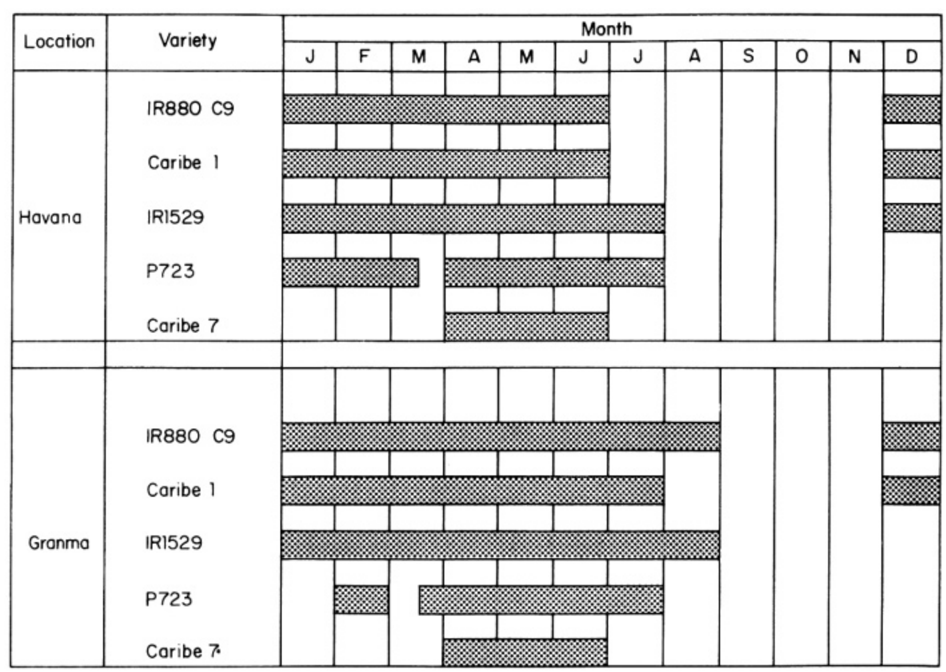
R. Canet, Central Rice Research Station, Ministry of Agriculture, Havana, Cuba

Even slight changes in sowing time will substantially change yield and duration of rice varieties. In 1977-80 we recorded the effect of year-around sowing on modern rices.

Varietal response and interaction between variety and sowing date was highly significant in all 36 sowings. Dry season (Nov-Mar) grain yield averaged 1.5 t/ha more than that in wet season (Apr-Oct), independent of variety.

Medium-duration IR880-C9, Caribe-1, and IR1529 performed best when planted from December to August (see figure), depending upon location. Short-duration P723 yielded better when planted from late December to March, and from April to early August. Photoperiod-sensitive Caribe-7 should be planted from April to June.

Because of low temperature during reproductive stage, September to November sowings generally yielded lowest.



Favorable sowing range for 5 rices in Cuba.

Seasonal variation in azolla biomass production in Jorhat

H. Talukdar and H.P. Barthakur, Assam Agricultural University, Jorhat 785013, India

Azolla pinnata grows naturally in low-lying fields, shallow ditches, and channels in Assam. In 1981-82 we studied azolla biomass production with different levels of inoculants and nutrients (see table) in 4-m^2 dugout plots lined with 750 gauge black polythene. The experiment had three replications.

Seasonal azolla growth varied significantly. Azolla biomass production increased from Mar to Jun, declined in

Azolla biomass production, Jorhat, India, 1981–82.

Treatments[a]	Azolla biomass (t/ha)												
	1981						1982						Mean
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
$L_0P_0I_1$	23.8	6.8	21.0	19.3	14.0	18.5	6.3	18.4	17.5	19.4	21.2	26.5	17.7
$L_0P_0I_2$	28.5	6.7	26.0	22.2	17.4	20.0	8.8	15.0	17.0	18.4	24.0	26.4	19.2
$L_0P_1I_1$	30.3	14.2	27.5	20.8	17.5	25.3	13.5	21.9	25.3	20.2	26.0	29.6	22.7
$L_0P_2I_1$	34.6	14.0	31.0	26.1	23.7	21.3	11.0	21.0	26.4	24.7	22.2	30.3	23.8
$L_0P_1I_2$	29.5	14.7	30.0	25.5	26.6	26.9	15.7	22.5	25.1	20.9	27.1	32.4	24.7
$L_0P_2I_2$	31.9	13.7	32.4	27.7	25.3	30.4	16.3	17.0	19.5	25.0	24.6	34.9	24.9
$L_1P_0I_1$	16.0	4.1	26.0	17.3	12.9	15.4	11.3	12.9	18.6	20.5	23.7	30.8	17.4
$L_1P_0I_2$	28.3	5.6	25.8	20.9	18.0	26.5	18.5	17.0	20.3	19.3	24.4	18.6	20.3
$L_1P_1I_1$	30.0	16.9	31.2	35.2	24.7	28.4	19.2	219	20.8	28.1	27.9	35.1	26.6
$L_1P_2I_1$	35.3	12.5	30.4	32.0	27.6	29.2	17.4	25.1	27.2	25.4	29.2	39.3	27.7
$L_1P_1I_2$	31.3	15.9	28.8	30.1	30.1	26.0	19.6	23.0	22.9	24.8	29.9	28.4	25.9
$L_1P_2I_2$	33.7	16.0	33.8	31.0	26.4	30.1	18.4	26.3	26.1	20.5	30.0	34.1	27.2
Mean	29.4	11.7	28.7	25.7	22.0	24.8	14.7	20.2	22.2	22.4	25.8	30.6	
	Mean av water temp (°C)												
	29	38	32	31	26	24	22	25	28	30	30	30	

	CD (0.05)	
Season (mo)	2.768	CV = 14.77%
Lime (L)	1.1 51	
Phosphate (P)	1.384	

[a] L_0 = no lime, L_1 = 1 t lime/ha, P_0 = no P, P_1 = 9 kg P/ha, P_2 = 18 kg P/ha, I_1 = 0.5 t inoculum/ha, I_2 = 1 t inoculum/ha.

Jul, and was lowest in Aug. Production increased in Sep and then remained stable until Dec (see table). Variations in production were related to weather, particularly temperature. In Aug, when production was lowest, water temperature reached 44° C and averaged 38°C.

Production also vaned with nutrient management. Applying 1 t lime and 18 kg P/ha significantly increased production over no-lime and no-P treatments (see table). P affected production more than lime did. Inoculum amount did not affect biomass production.

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Effect of salinity on *Azolla pinnata*

K. Nandabalan and S. Kannaiyan, Agricultural Microbiology Department, Tamil Nadu Agricultural University, Coimbatore 641003, Tamil Nadu, India

We studied the effect of salinity on *A. pinnata,* Coimbatore strain, with a soil extract solution with 20 ppm superphosphate as base medium. Sodium chloride was applied at 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, and 0.2%. *A. pinnata* was inoculated at 5 g per plastic container and fresh weight was recorded after 14 d. In another experiment, 500 ppm neem *Azadirachta indica* cake was added to the medium.

A. pinnata yield decreased as salinity increased (see table), but neem cake reduced the detrimental effect of salinity.

Effect of salinity on *A. pinnata,* **Tamil Nadu, India.**

Sodium chloride (%)	Biomass (g/tub)	% decrease over control	Biomass (g/tub) with neem cake amendment (500 ppm)	% increase or decrease over control
Control without superphosphate	5.3	-	5.4	–
Neem cake alone	NT[a]	-	8.8	+62
0.01	5.2	3	8.5	+57
0.02	5.0	6	7.5	+38
0.03	4.7	11	7.0	+30
0.04	4.7	11	6.7	+24
0.05	4.6	13	5.4	+ 0
0.06	4.4	18	5.2	– 3
0.07	4.3	20	5.2	– 3
0.08	4.0	25	5.2	– 3
0.09	4.0	25	4.8	–11
0.10	3.7	31	4.7	–13
0.20	3.6	32	4.0	–26
SE	0.006		0.577	
CD	0.017		1.678	

[a]Not tested.

Rice response to and residual effect of Zn application in a sandy lowland soil

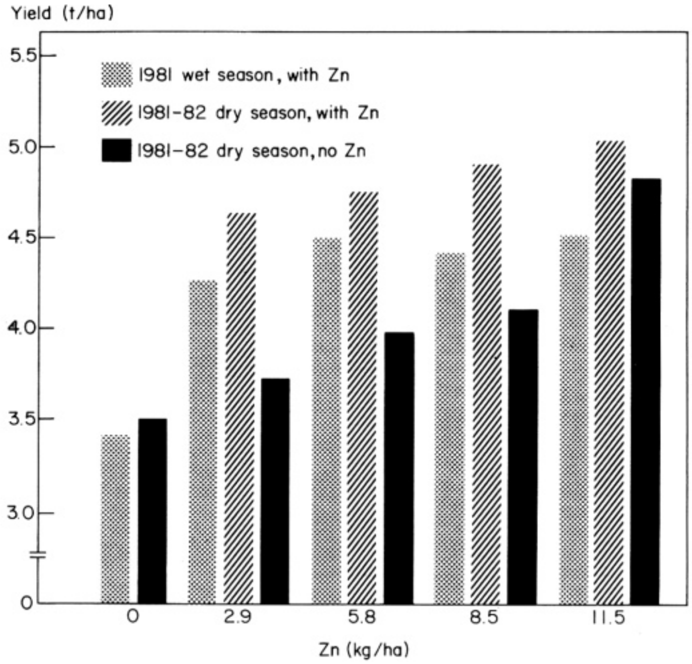
R. Sanzo, Sur del Jibaro Rice Experiment Station; and M. Socorro, Agricultural Science Faculty, Las Villas Central University, Cuba

In 1981 wet season and 1981-82 dry season, we studied IR880 rice response to and residual effect of Zn application in a sandy soil with 1.77 ppm available Zn and pH 7.1. Zn at 0, 2.8, 5.8, 8.5, and 11.5 kg/ha was applied before seeding.

In wet season, plots were in a randomized complete block design with eight replications. To study residual effect in dry season, Zn was applied to four of the same plots and the remaining four received no Zn.

In wet season, all treatments were significantly better than no-Zn control. Rice yield increased from 3.4 to 4.5 t/ha (see figure). In dry season, rice yield increased from 3.5 to 5.0 t/ha (see figure), and best results were obtained with 8.5 and 11.5 kg Zn/ ha.

Zn application had a substantial residual effect (see table). Although



Response of IR880 to Zn application in sandy soil, Sancti-Spiritus, Cuba.

initial soil Zn was a little more than the critical levels of 1.0 and 1.5 ppm, the positive response to Zn application may have been due to the near neutral pH of the soil.

Residual effect of Zn in a sandy lowland rice soil, Sancti-Spiritus, Cuba.

Treatment (kg Zn/ha)	Zn (ppm) 1981 Jun[a]	Dec[b]	Jul 1982[c] with Zn	no Zn
Control	1.77	1.97	1.97	1.97
2.9	1.72	3.79	3.00	3.83
5.8	1.93	4.47	3.59	2.75
8.5	1.89	4.94	4.59	2.89
11.5	1.93	4.41	4.58	4.11

[a] Before seeding. [b]After first crop. [c]After second crop.

Rice-Based Cropping Systems

Potential of rice-based multiple cropping systems in Pakistan

P. Amir, Winrock International, Morrilton, Arkansas 72110, USA

In 1984, we surveyed 240 rice farmers to determine the economic potential of mungbean and sunflower in the thesils of Daska, Sheikhupura, and Hafizabad in the Punjab. Short-duration (55 to 60 d) mungbean varieties developed at the Nuclear Institute of Agriculture and Biology, Faisalabad, can be sown in Apr, after wheat harvest, and harvested before basmati rice is planted in Jun. Sunflower can be sown in Feb instead of late, low yielding wheat or in July as an alternative to rice.

Mathematical models were constructed of representative farms in Daska and Hafizabad. Sheikhupura conditions are very similar to those in Hafizabad.

Table 1 compares Daska farmers' cropping patterns for 1983-84 with profit maximizing solutions. The model

Table 1. Comparison of base model with 1983-84 crop plan on the Daska farm.

	Actual cropping pattern	Optimal cropping pattern, base model
Value of objective function		$105 6
	Area (acres)	
Basmati rice	4	5.7[a]
IRRI rice	2	1.3[b]
Kharif fodder	2.1	3
Wheat	11	10.2[c]
Rabi fodder	1.5	2.7
	Cropping intensity (%)	
	175	178

[a] Basmati on excellent land with farmyard manure (FYM) (2.62 acres) + Basmati on average land with FYM (3.1 acres) = 5.72. [b]IRRI rice grown on excellent land with FYM. [c]Wheat on excellent land (3.9 acres) + on average land (6.3 acres) = 10.2.

Table 2. Comparison of base model with sunflower and sunflower and mungbean for the Daska farm.

Activity	Optimal cropping pattern: Base model	Sunflower	Sunflower and mungbean
		Value of objective function ($)	
	984	2017	2990
		Area (acres)	
Basmati on excellent land with farmyard manure (FYM)	2.6	3.9	3.9
Basmati on good land with FYM	3.1	1.26	1.26
IRRI rice on excellent land with FYM	1.3	–	–
Wheat on excellent land	3.9	3.9	3.9
Wheat on average land	6.3	–	3.9
Kharif fodder	3.0	2.1	2.1
Rabi fodder	2.7	1.5	2.1
Spring sunflower	–	7.5	4.9
Kharif sunflower	–	5.6	5.6
Mungbean	–	–	8.0
		Cropping intensity (%)	
	178	200	261

identifed optimum cropping intensity as only 3% higher than farmers' cropping patterns. Cropping intensities increased by 22% when sunflower and mungbean were introduced into the model (Table 2). Introducing mungbean and sunflower at Sep prices increased cropping intensity 178-260% over the base model, and increased income almost 200%. Similar results were obtained in Hafizabad.

Sunflower has begun replacing late wheat and kharif rice in parts of Daska, but farmers are unfamiliar with mungbean. Further research is needed on biological, economic, and marketing implications of alternative crop rotations. The rice group at the National Agricultural Research Center, Islamabad, is collaborating with the Punjab Rice Research Institute and IRRI to expand multiple cropping research in the Punjab.

Announcements

Rice: Chemistry and Technology (2d edition)

The revised edition of *Rice: chemistry and technology* incorporates advances in rice chemistry and technology since 1972. The book was primarily planned, written, and edited by B. O. Juliano, IRRI cereal chemist, during 1983 and 1984 when he was on study leave. There are new chapters on parboiling and milling emphasizing the Asian situation, extrusion-cooked rice foods, rice noodles, Japanese convenience foods, and rice straw. All technology and processing chapters were contributed by well-known authorities. Published by the American Association of Cereal Chemists, the book is priced at $69.00 for AACC members and $87.00 for nonmembers. Send orders to AACC Books, 3340 Pilot Knob Road, St. Paul, MN 55121, USA.

IRRI cropping systems book published in Spanish

The International Research Development Centre of Canada has published *A methodology for on-farm cropping systems research* in Spanish. For ordering information, write: IDRC, P.O. Box 8500, Ottawa, Canada K1G 3H9.

Inventors award to Khan

Amir U. Khan, head, Agricultural Engineering Department, IRRI, will receive the International Inventors Award (Industry) in Stockholm, Sweden, on 13 Jun 1986. Khan is being cited for his contributions to the development of the farm machinery industry in Asia. The award will be formally presented by the King of Sweden during the 100th anniversary of the Swedish Inventors Association.

New IRRI publications

Field problems of tropical rice (Hiligaynon and Tamil editions)
A farmer's primer on growing rice (Hiligaynon, Pangasinan, and Creole editions)
Publications of the international agricultural research centers (1985 edition)

Rice ratooning workshop

The Rice Ratooning Workshop was held in Bangalore, Kamataka, India, 21-25 Apr 1986 to review current knowledge, identify priority problems requiring research, and develop plans for collaborative varietal improvement for rice ratooning. The workshop, sponsored jointly by IRRI, the Indian Council of Agricultural Research, and the University of Agricultural Sciences, Bangalore, was attended by 37 participants from 10 countries.

Technical sessions were held on 1) morphology and physiology of rice ratoons, 2) evaluation and potential of rice ratooning, 3) cultural practices, and 4) genetics and varietal improvement. The technical sessions were followed by a 2-d field tour.

Workshop participants also devoted a final session to determining research priorities in 1) varietal improvement and agronomic practices, 2) cultural management, and 3) physiology. Major recommendations of the workshop are to:

- pool at IRRI and at other sites all cultivars of proven ratooning ability,
- screen all high yielding varieties for ratooning ability,
- consider main crop and ratoon crop yield as the ultimate measure of ratoonability,
- devise tests of ratooning ability that do not compromise main crop yield,
- include in genetic studies other traits that have a potential influence on ratooning,
- include water management in ratoon crop fertilizer management studies, and
- use growth analysis to compare physiological differences between ratooning and nonratooning cultivars.

IRRI will publish the 32 papers presented at the workshop along with the complete set of recommendations.

The International Rice Research Newsletter and the IRRI Reporter are mailed free to qualified individuals and institutions engaged in rice production and training. For further information write: IRRI, Communication and Publications Dept., Division R, P. O. Box 933, Manila, Philippines.

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