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ERRATUM

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 pattern involving rice.
- Appropriate statistical analyses should be done.
- Announcements of the release of new rice varieties are encouraged.
- Pest survey data should be quantified. Give infection percentage, degree of severity, etc.

Style

- For measurements, use the International System. Avoid national units of measure (cavan, rai, etc.).
- Abbreviate names of standard units of measure when they follow a number. For example: 20 kg/ha, 2 h/d.
- Express yield data in tonnes per hectare (t/ha). With small-scale studies, use grams per pot (g/pot) or g/ row.
- Express time, money, and common measures in number, even when the amount is less than 10. For example: 8 min, $2, 3 kg/ha, 2-wk intervals.
- Write out numbers below 10 except in a series containing 10 or higher numbers. For example: six parts, seven tractors, four varieties. *But* There were 4 plots in India, 8 in Thailand, and 12 in Indonesia.
- Write out numbers that start sentences. For example: Sixty insects were put in each cage. Seventy-five percent of the yield increase is attributed to fertilizer.
- Place the name or denotation of chemicals or other measured materials near the unit of measure. For example: 60 kg N/ha, not 60 kg/ha N, 200 kg seed/ha, not 200 kg/ha seed.
- Use common names – not trade names – for chemicals.
- The US$ is the standard monetary unit in the IRRN. Data in other currencies should be converted to US$.
- When using acronyms, spell each out at first mention and put the specific acronym in parentheses. After that, use the acronym throughout the paper. For example: The brown planthoppcr (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- Do not cite references or include a bibliography.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

Panke, a promising rice variety for rainfed uplands in West Bengal

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A direct-seeded trial of semitall variety Panke in different agroclimatic areas of West Bengal (India) was conducted in 1982-84. Soil pH of test locations varied from 5.4 to 8.1. Soil types included silty clay, clay loam, and sandy loam, representing Terai, alluvial, and red-lateritic zones.

Panke consistently performed well at Beldanga, Malda, Krishnagore, Majhian, and Nalhati (see table). In 1982, it was among the five top yielders in 5 of 6 sites; in 1983-84, it produced either more grain than or as much as the highest yielders in most of the test sites. The maximum yield recorded for Panke was 5.1 t/ha at Malda in 1984.

Panke has good panicle weight and 145 to 150 short bold grains in each panicle. The seeds have a dormancy period of about 45 d. Test weight is 18.5 g. Panke matures in 100-105 d.

Grain yield of Panke in multilocational trials, West Bengal.

Test site	Yield (t/ha)					
	Panke			Dular (trial check)		
	1982	1983	1984	1982	1983	1984
Hathwara	0.5	1.9	–	1.4	1.2	–
Malda	2.1	1.6	5.1	1.2	1.0	2.8
Beldanga	3.6	3.6	3.1	2.3	2.3	3.7
Krishnagore	0.9	1.9	2.4	0.8	2.0	2.7
Majhian	2.9	2.9	2.7	2.0	1.4	2.5
Nalhati	2.7	1.7	2.7	2.3	1.8	1.3
Chinsurah	–	2.0	2.0	–	0.8	1.2
Mohitnagar	–	1.3	0.9	–	2.4	0.7
Bankura	–	3.6	1.7	–	2.8	1.8
Mean	2.1	2.3	2.6	1.6	1.8	2.1

ASD16, a new short-duration rice variety for Tamil Nadu

W. W. Manuel, S. Vairavan, K. Ganesan, T. Sundaram, S. Palanisamy, and M. Subramanian, Paddy Experiment Station, Ambasamuduram 627401, Tamil Nadu, India

The elite rice culture ASD19789, isolated from the cross ADT31/CO 39. was released in Jan 1986 as rice variety ASD16 for general cultivation in Tamil Nadu. It is suitable for cultivation during the first crop season (Apr-Jul sowing) as an alternate to TKM9, ADT31, ADT36, CO 37, IET1444, and IR50.

Mean yield was 5.6 t/ ha, 14.3% more than for TKM9, ADT31, and ADT36 (Table 1). Overall performance in research station trials, multilocation trials, adaptive research trials, national trials under the All India Coordinated Rice Improvement Project, and international trials under the International Rice Testing Program was also good. Yield increased 4.3-26.3% over ADT31, ADT36, CO 37, IET1444, IR36, and IR50 and straw yield increased 2.2-59.6% (Table 2).

Total biological yield was 13.6 t/ ha (5.6 t grain and 8.0 t straw) and potential grain yield was 9.8 t/ ha.

ASD16 is a semidwarf (93 cm) and nonlodging rice. Its total duration

Table 1. Performance of ASD16 at Ambasamuduram, India, 1980-84.

Variety	Grain yield (t/ha)	Duration (d)	Plant ht (cm)	Panicles/hill	Panicle wt (g)
ASD16	5.6	114	93	7.5	1.71
ADT31	4.9	112	88	7.8	1.50
ADT36	4.9	115	89	8.9	1.32
TKM9	4.9	112	87	9.0	1.33

ranged from 110 to 115 d, averaging 114 d. Its grain is short and bold with white rice. The 1,000-grain weight is 24.2 g. Its high yield potential is mainly due to a panicle weight of 1.71 g.

The variety has good response to the application of high levels of N, up to 120 kg/ha. Rice recovery was 70.2-71.3%. Protein content of the kernel is 10.25%, higher than TKM9 (6.9%) and ADT36 (8.53%). Cooking quality is highly preferred, with an overall taste score of more than 75%.

ASD16 possesses moderate resistance to narrow brown leaf spot and sheath rot under controlled conditions and to brown planthopper biotype 1 in the field.

Table 2. Overall performance of ASD16 in state, national, and international trials. Tamil Nadu, 1980-84.

Variety	Grain yield (t/ha)	Straw yield (t/ha)
ASD16	4.8	9.1
TKM9	5.0	8.7
ADT31	4.6	8.9
ADT36	4.5	7.9
CO 37	4.1	8.8
IET1444	3.8	5.7
IR36	3.8	–
IR50	4.6	7.4

Seedlings are flexible up to 35 d. In addition to suitability for the first crop season, ASD16 also can be sown in Nov or in Dec-Jan.

Performance of new short-duration rice cultivars at Tamil Nadu Rice Research Institute

M. Subramanian, A. P.M.K. Soundarajan, and V. Sivasubramanian, Tamil Nadu Rice Research Institute (TNRRI), Aduthurai, India

The performance of 36 early-maturing IRRI cultivars was assessed in Jun-Jul 1983 at TNRRI. ADT36, TKM9, IR50, and IR60 were used as controls in a randomized block design replicated twice.

Seeds were sown in elevated nursery beds and 24-d-old seedlings were planted in 4.6-m^2 plots. Spacing was 15 cm between rows and 10 cm within rows. Normal management practices were applied.

All entries had short-statured, nonlodging plants. Duration to 50% flowering was 60 to 77 d.

Yield differences among the entries were highly significant. Although 14 of the 36 cultivars registered more than 5 t/ha, 3 (IR29692-9-1-3-2, IR29725-76-3-3-2, and IR31851-6-3-3-3-2) recorded 7 t/ha (see table); 6.6 t/ha was registered by the highest yielding check, ADT36. Yields of the 3 cultivars were between 10% and 12.1% more than ADT36.

The three possess desirable plant types and long slender grain with consumer appeal.

Performance of new early-duration IRRI cultivars at TNRRI, India.

Source	Cultivar	Days to 50% flowering	Yield (t/ha)	% of ADT36
2443	IR25588-7-3-1	72	5.3	79.9
2444	IR25588-61-2-2	72	4.8	72.5
2446	IR25621-1-5-1-2	73	4.3	64.5
2447	IR25621-135-1-1	75	5.3	80.0
2449	IR25840-83-3-2	77	5.4	80.7
2460	IR28210-68-4-1-3-1	72	4.7	71.0
2465	IR29670-15-2-3	69	5.2	77.5
2466	IR29670-52-3-2-3	67	4.7	70.2
2469	IR29692-9-1-3-2	69	7.6	112.1
2470	IR29692-14-1-1-2	73	4.5	68.3
2471	IR29692-34-1-3-2-2	73	3.9	58.4
2472	IR29692-39-1-2-2-2	76	4.3	64.6
2473	IR29692-65-2-3-3	74	4.6	69.3
2474	IR29692-71-2-2-2	73	4.9	73.3
2477	IR29692-86-2-3-3	72	4.7	71.1
2478	IR29692-94-2-1-3	72	4.3	65.0
2479	IR29692-99-3-2-1	70	6.1	91.1
2481	IR29692-117-1-2-2	73	4.0	59.7
2484	IR29692-131-3-3-3	76	4.9	73.3
2487	IR29705-22-1-2-2	75	5.1	76.5
2489	IR29708-41-2-2-3	72	4.3	64.9
2490	IR29728-113-3-2-3	72	4.2	62.4
2491	IR29725-3-1-3-2	72	4.4	66.5
2493	IR29725-21-1-3-2	72	5.2	78.9
2494	IR29725-22-3-3-3	74	5.0	74.5
2497	IR29725-36-3-1-1	73	4.6	69.1
2500	IR29725-45-1-1-3	72	5.7	85.1
2501	IR29725-63-3-3-2	72	5.4	81.4
2502	IR29725-76-3-3-2	72	7.4	110.7
2505	IR29725-109-1-2-1	72	5.2	78.0
2506	IR29725-110-3-3-2	77	4.4	66.0
2511	IR29725-135-2-2-3	77	4.8	71.4
2536	IR31847-61-2-2-2-1	71	4.4	66.3
2540	IR31851-6-3-3-3-2	77	7.2	110.0
2541	IR31851-44-2-1-3-3	73	4.9	73.3
2543	IR31851-96-2-3-2-1	72	6.2	93.2
IR60		74	4.8	72.3
ADT36		75	6.6	100
TKM9		73	6.2	99.5
IR50		73	5.5	83.1
	CD 0.6 t/ha			
	CV 6.2			

Impact of high-yielding varieties on rice production in Rio Grande do Sul, Brazil

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New varieties released in southern Brazil since 1970 (see table) are mostly short-statured and adapted to climatic conditions. The harvest index has increased and yield potential, grain quality, and adaptability have promoted farmer acceptance.

Among the varieties, Bluebelle and BR-IRGA409 are early, BR-IRGA410 and BR-IRGA411 are medium duration, and BR-IRGA407 is late maturing. Breeding programs have focused on yield improvement, grain quality, cold tolerance, and disease resistance. High yielders with durations of 109-147 d were identified and isolated. Early and medium-duration varieties were selected indirectly.

In 1984, high-yielding rice varieties represented about 98% of 704,000 ha in Rio Grande do Sul, with yields of 4.5 t/ha. BR-IRGA lines alone covered about 70% of this area.

High-yielding varieties released in Rio Grande do Sul, Brazil, 1970-85.

Variety	Origin	Cross-combination	Released		Approximate yield (t/ha)	Maturity (d)	Grain type[b]	Height (cm)	Area planted 1983/84 season (thousand ha)
			By[a]	Year					
Bluebelle	USA	CI 9122/Century Patna 231/CI 92 14	IPEAS	1970	4.7	109	LS	91	195.1
IRGA 407	Brazil	Selected from local variety	EEA/IRGA	1971	4.3	147	LB	130	3.1
BR-IRGA 409	CIAT/IRRI	P790-B4-4-1T (IR930-2/IR665-31-1-4)	EMBRAPA/IRGA	1978	6.1	110	LS	100	457.6
BR-IRGA 410	CIAT/IRRI	P798-B4-4-1T (IR930-53/IR665-31-2)	EMBRAPA/IRGA	1980	6.7	130	LS	110	35.2
BR-IRGA 411	Brazil	Dawn/IRGA407	EMBRAPA/IRGA	1985	4.1	130	LS	103	–

[a] IPEAS = South Agricultural Research Institute, now EMBRAPA; EEA = IRGA's Experimental Station; IRGA = Rio-grandense Rice Institute; EMBRAPA = Federal Agricultural Research System. [b] LS = long slender; LB = long bold.

Rice strain R243-3223 promising for lowland rainfed conditions in eastern Madhya Pradesh, India

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Agronomic conditions in Madhya Pradesh limit the adoption of typical semidwarf varieties. These conditions include dependence on the monsoon, with only 20% irrigation coverage; broadcast crop establishment, which gives low plant populations despite high seed rates; predominance of long duration varieties, which often suffer from failure of September rains; low fertilizer consumption; and lack of varieties with multiple resistance.

Breeding objectives have been modified toward developing semitall varieties of shorter duration that respond to moderate levels of fertilizer and are tolerant of commonly occurring diseases and pests.

Table 1. Yield of R243-3223 and IR36 in Madhya Radesh, India.

Location	Strain	Yield (t/ha)			
		1982	1983	1984	Mean
Waraseoni	R243	4.0	4.1	4.3	4.1
	IR36	3.7	3.7	2.2	3.2
Rewa	R243	4.0	2.9	2.4	3.1
	IR36	2.3	2.8	2.7	2.6
Bagwai	R243	3.7	2.9	3.3	3.3
	IR36	3.7	2.2	3.5	3.1
Raipur (Pathology)	R243	5.9	5.0	4.7	5.2
	IR36	5.8	4.9	4.4	5.0
Raipur (Breeding)	R243	3.4	3.0	2.6	3.0
	IR36	3.2	3.1	2.8	3.1
Jagdalpur	R243	4.4	4.5	6.1	5.0
	IR36	5.0	2.7	5.8	4.5
Jabalpur	R243	2.5	4.3	3.6	3.5
	IR36	3.4	4.2	3.3	3.6
Bilaspur	R243	–	–	4.0	4.0
	IR36	–	–	3.5	3.5
Mean	R243	4.0	3.8	3.8	3.9
	IR36	3.9	3.4	3.5	3.6

A new rice strain R243-3223 (IET8756) was derived from the cross IR36/IR2053-521. Cross IR7516 was received from IRRI in the F_2. This strain has given higher yields than IR36 and Safri 17, the most popular semidwarf and tall varieties of the region (Table 1). Its 100 ± 10 cm stature results in better germination capacity under

Table 2. Reactions[a] of R243-3223, IR36, and 3 other varieties to bacterial leaf blight, blast, sheath rot, and gall midge. Madhya Pradesh, India.

Strain or variety	Mean score					Gall midge (% silver shoots) 1984
	Bacterial leaf blight[b]			Blast[c] 1983	Sheath rot[d] 1983	
	1982	1983	1984			
R243-3223	3.6	3.0	2.9	1.8	3.0	4.0
IR36	4.7	5.0	5.3	–	–	6.8
TN1	7.0	7.2	8.9	5.0	–	62.5
Jaya	5.3	7.0	6.5	4.5	5.5	58.2
Safri 17	5.8	6.3	5.4	–	–	37.6

[a]By the Standard evaluation system for rice scale. [b]0 = no incidence, 9 = 51-100%. [c]Mean of 4 locations: Almora, Cuttack, Ponnampet, and Semliguda. 0 = no lesions, 9 = all leaves dead. [d]Mean of 2 locations: Faizabad and Pusa. 0 = no incidence, 9 = 51-100%.

broadcast sowing and higher drought tolerance than IR36. Its excellent tolerance for bacterial blight. gall midge, blast, and sheath rot makes it distinctly superior to Safri 17 (Table 2). Also, the new line is 15 d earlier than Safri 17, so that it frequently escapes terminal drought.

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

Performance trials of short-duration rice varieties at TNRRI

M. Subramanian, A. P. M. Kirubhakaran Soundararajan, and V. Sivasubramanian, Tamil Nadu Rice Research Institute (TNRRI), Aduthurai, Tamil Nadu, India

Performance trials of short duration, high yielding rice varieties were conducted at TNRRI during 1984 kharif. Seven varieties from IRRI, three from Tamil Nadu, and one from Sri Lanka were evaluated in a randomized block design with three replications.

Seedlings were spaced 15 cm between rows and 10 cm within rows. Fertilizer was 75-38-38 kg NPK/ha. Plots were free from insects and diseases from planting to harvest.

AD85001 and IR58 flowered earliest, 72 and 71 d after seeding (DAS). IR62 was latest, 89 DAS. Other varieties flowered between 82 and 86 DAS. Varietal height ranged from 85 cm (AD85001) to 98 cm (BG367-4).

BC367-4, the Sri Lankan culture, yielded 6.0 t/ha, surpassing all other varieties. IRRI varieties IR52, IR50, IR60, and IR64 recorded more than 5 t/ha (see table). These varieties will be studied in multilocation and adaptive research trials in 1986 kharif.

Performance of short-duration rice varieties at TRRI, India, 1984 kharif.

Variety	Source	Height (cm)	Days to 50% flowering		Yield (t/ha)
AD85001	Tamil Nadu	85	72		4.8
TKM 9	Tamil Nadu	91	86		5.8
ADT36	Tamil Nadu	93	84		4.8
BG367-4	Sri Lanka	98	82		6.0
IR36	IRRI	81	86		4.7
IR50	IRRI	89	82		4.6
IR52	IRRI	92	86		5.1
IR56	IRRI	96	82		5.3
IR58	IRRI	86	71		3.0
IR60	IRRI	92	82		5.1
IR62	IRRI	94	84		4.9
IR64	IRRI	92	86		5.1
				CD	0.3
				CV	7.5

ACK-5, a new variety for Western Maharashtra, India

B.S. Shah, Agricultural Botany Department College of Agriculture, Kolhapuir, M.S., India; R.Y. Thete and A.D. Dumbre, Botany Department, Mahatma Phule Agricultural University, Rahuri 413 722, M.S., India

Rice variety ACK-5, released in 1985, is derived from a cross between tall type D-6-2-2 and stable high yielding semidwarf IR8. The new variety has medium height (65 cm) and matures in 120 d. Its seed has a 20-d dormancy.

It is nonlodging, and is suitable for direct sowing as well as transplanting. It is tolerant of moisture stress and iron chlorosis.

Its grain is short, bold. and coarse with acceptable cooking qualities, suitable for preparing flaked and puffed rice. Yield is 4-6 t/ha under direct-sown conditions and 44.5 t/ha under transplanted conditions. Yield data in various trials arc shown in the table. ACK-5 is moderately susceptible to blast and susceptible to bacterial blight.

Performance of ACK-5 in various trials. Maharashtra, India.

Trial	Year	Mean yield (t/ha)			
		ACK-5	Jaya	RDN185-2	% increase over check
Intial evaluation trial (ET)	1976-78	2.6	2.3	–	11.0
Multilocation trials	1983-84	4.5	–	3.9	14.0
Adaptive trials	1983	3.6	–	3.4	6.3
Cultivator fields	1984	3.4	–	3.2	7.4

PMK1, an improved rainfed lowland rice variety for Tamil Nadu, India

A. Amirthadevarahinam, P. Vivekanandan, P. Gomathinayagam, and P. Shunmugam, Tamil Nadu Agricultural University, Madurai; and R. Arjunan, Agriculture Department, Manamadurai, Tamil Nadu, India

PMKl (Co 25/ADT31), a high-yielding, and widely adapted rainfed lowland rice variety, matures in 115-120 d. It has long, compact panicles with golden yellow grains, white rice, and good cooking quality.

The early seedling vigor exhibited by PMK1 helps it compete with weeds at the early vegetative phase.

Performance of PMK1 in research station and adaptive research trials. Tamil Nadu, India, 1980-83.

Year	Yield (t/ha)		Increase (%) over TKM9
	PMKl	TKM9	
1980	3.4	2.8	21.9
1981	3.0	2.2	36.1
1982	3.0	2.5	18.1
1983	2.2	1.9	19.7
Mean[a]	2.9	2.3	23.9
1983[b]	3.1	2.7	12.1

[a]Research station trials. [b]*Adaptive* research trials, 20 sites.

In yield trials for 4 yr in Aug-Dec season, average grain yield were 2.9 t/ha, 23.9% more than TKM9, a high-yielding. semidwarf, rainfed lowland rice (see table). In the Adaptive Research Trials of 1983-84, PMKl produced an average grain yield of 3.06 t/ ha, l2.1% more than TKM9. It is a good straw yielder as well.

PMKl is 110 cm high, photoperiod insensitive, and lodging resistant. It matures in 120 d. A thousand grains weigh 24 g and cooking quality 15 good.

PMK1 is tolerant of blast and bacterial leaf blight in the field.

NC492 (IET8970), a promising variety for rainfed lowlands in West Bengal

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NC492, a pureline selection from Boyan (Acc. 30250), was identified at Chinsurah after it survived submergence for 3 d in late Sep 1978, when a record 523.9 mm of rain fell at RRS 15 d after planting. In station trials and adaptive trials at 6 sites from 1979 to 1982, NC492 yielded an average 4.7 t/ha, compared to 3.4 t/ha for Mahsuri.

NC492 was nominated for the All India Coordinated Rice Improvement Project (AICRIP) semideep water trial (Uniform Variety Trial 5 [UVT 5]) and tested at 7 sites during 1982 kharif. It ranked first (3.8 t/ha) in overall mean yield (Table 1).

In tests at 11 sites in 1983, NC492 ranked second, with a marginal yield difference of only 45 kg ha less than the first ranking variety CN505-5-32-9 (lET8967). In 1984, NC492 yielded an average 2.9 t/ha at 8 sites. It ranked first in the Physiology Screening Trial for waterlogged conditions (AICRIP) conducted with UVT 5 entries in 1982 and 1983 (Table 2).

NC492 is photoperiod sensitive. lowering in late October. It is semitall (about 150 cm) with moderate culm stiffness and good seedling vigor. The panicle is about 26 cm long with 160-170 golden color grains.

The variety has a shape index of 3.75, 1,000-grain weight of 32 g, and strong

Table 1. Performance of NC492 in 1982-83 national trials (UVT 5). West Bengal, India.

Site	Yield (t/ha)				Maximum water depth (cm)	
	NC492		Tillakkachari			
	1982	1983	1982	1983	1982	1983
Pulla	3.2	2.4	1.8	1.6	70	75
Patna	3.2	2.6	2.8	2.0	–	31
Pusa	2.7	1.4	2.1	0.8	70	60
Sindri	1.3	3.7	1.3	2.9	50	36
Bhubaneswar	4.6	–	2.3	–	–	–
Chinsurah	6.2	3.1	4.3	1.6	40	50
Cuttack Rice Research Institute	–	3.6	–	2.7	–	41
Ranital	–	4.6	–	2.4	–	–
Sabour	–	1.0	–	1.1	–	63
Arundhutinagar	5.1	–	4.1	–	–	–
Mean	3.8	2.8	2.6	1.8		

Table 2. Performance of NC492 in 1982-83 Physiology Screening Trials for waterlogged conditions (AICRIP).

Site	Yield (t/ha)					
	NC492		Tillakkachari		Other check	
	1982	1983	1982	1983	1982	1983
Baruipur	4.5	4.5	3.9	3.8	2.9 (Mahsuri)	1.0 (Pankaj)
Chinsurah	4.9	5.3	3.1	4.7	4.3 (NC488)	4.2 (NC487)
Cuttack	3.4	4.7	3.2	3.7	3.1 (Mahsuri)	3.1 (Mahsuri)
Patna	4.2	3.2	4.6	4.0	2.6 (Pankaj)	2.1 (BR34)
Mean	4.2	4.5	3.7	4.0	3.2	2.6

dormancy of about 12 wk. It is moderately resistant to sheath blight, brown spot, and stem borer.

The 1984 Annual Rice Workshop (AICRIP) recommended NC492 as a promising variety for semideep water situations in West Bengal, Bihar, Orissa, and Andhra Pradesh. It has been recommended for minikit demonstration trials in farmers fields for 2 yr and is in the prerelease stage in West Bengal.

Genetic Evaluation and Utilization

AGRONOMIC CHARACTERISTICS

Character association in upland rice cultivars of India

S.P. Chauhan, R.S. Singh. D.M. Maurya, and C.P. Vaish, Genetics and Plant Breeding Department, Narendra Deva University of Agriculture and Technology, Faizabad (U.P.), India

Ninety-eight local ricecultivars grown in a randomized block design with three replications in july 1983 were assessed for the association among 11 traits at the genotypic (r_g) and phenotypic (r_p) levels (see table).

In general, genotypic associations were higher than phenotypic, but values of both were either positive or negative. This indicates that r_p is slightly reduced by environmental effects. At both the r_g and r_p levels, yield per plant was positive and significantly associated with days to flowering, leaf angle, leaf length, plant height, panicle length, sheath length, tillers per plant, and grains per panicle. Yield per plant was associated with test weight only at the r_g level. Tillers per plant and test weight directly contributed to yield. Other auxiliary traits that showed positive association with yield were also positively associated among themselves. Any one of these traits could be utilized as selection criteria for yield improvement in upland rice.

Genotypic (G) and phenotypic (P) associations among 11 traits of upland rices. [a]

Trait		Culm angle	Leaf angle	Leaf length	Plant height	Panicle length	Sheath length	Tillers/ plant	Grains/ panicle	Test weight	Grain yield/ plant
Days to flowering	G	–0.08	0.45**	0.52**	0.53**	0.58**	0.40**	0.05	0.49**	–0.06	0.31**
	P	–0.08	0.41**	0.37**	0.50**	0.48**	0.26**	0.03	0.41**	–0.07	0.20*
Culm angle	G		0.17	0.14	–0.21*	–0.25**	0.11	–0.10	–0.13	0.20*	–0.08
	P		0.17	0.08	–0.17	–0.17	0.05	0.01	–0.05	0.16	0.01
Leaf angle	G			0.42**	0.55**	0.39**	0.45**	0.15	0.55**	0.06	0.36**
	P			0.30**	0.49**	0.32**	0.32**	0.06**	0.43**	0.06	0.20*
Leaf length	G				0.75**	0.67**	0.89**	–0.29**	0.51**	0.19	0.54**
	P				0.58**	0.58**	0.65**	–0.10	0.36**	0.14	0.31**
Plant height	G					0.73**	0.68**	–0.17	0.57**	0.01	0.63**
	P					0.67**	0.52**	–0.07	0.47**	0.10	0.43**
Panicle length	G						0.57**	–0.16	0.51**	–0.10	0.49**
	P						0.45**	–0.05	0.54**	0.20	0.34**
Sheath length	G							–0.24*	0.53**	0.09	0.43**
	P							–0.26	0.37**	0.06	0.27**
Tillers/plant	G								–0.31**	–0.26**	0.20*
	P								0.22*	–0.19*	0.29**
Grains/panicle	G									0.43**	0.26**
	P									–0.37**	0.36**
Test weight	G										0.27**
	P										0.09

[a] Significant at 5% (*) and 1% (**) levels.

Hot water treatment of rice seed for international shipment

A. K. Ventura and D. P. Garrity, IRRI

Hot water treatment to control several seedborne pathogens of rice is a widely used quarantine practice in the international exchange of germplasm. One limitation to its use is potentially deleterious effects on germination and seedling vigor. The possibility that genotypes may differ substantially in sensitivity to hot water treatment poses serious complications in the interpretation of international testing data.

The effect of different hot water treatments and different posttreatment storage conditions on the seed quality of four rice cultivars was studied. The cultivars were japonica and indica ecotypes to represent sensitive and resistant responses to hot water treatment. Temperature limits and exposure periods tested encompassed the range of treatment conditions recommended for rice by ASEAN quarantine officials.

Seed quality changes were evaluated

under laboratory and upland field conditions in four replications. Laboratory tests were performed according to International Seed Testing Association (1976) rules.

Hot water treatment at 52°C for 15 or 30 min or 57°C for 15 min did not damage seed quality when the seed was not presoaked (see table). Hot water at 52°C for 15 min actually improved field seedling vigor. Treatment at 57° C for 30 min significantly reduced seed quality, with further reduction when the seed was presoaked. Water temperature interacts with the length of hot water exposure, affecting viability.

Hot water-treated seed is seldom planted immediately after treatment. To determine whether hot water-treated seed deteriorates more rapidly over time, seed quality was evaluated after storage for 45 d. Seed quality deteriorated after storage under cool conditions (19° C at 50% relative humidity [RH]) and room temperature conditions (24-32° C and 78% RH). Room-stored seed was more severely affected, especially when treated at 57° C for 30 min.

Seed which was not presoaked tended to maintain viability and field emergence performance scores when subjected to regimes of 52° C for 15 and 30 min and 57°C for 15 min (see table). However, presoaked seed maintained viability and field emergence performance only with the 52°C for 15 and for 30 min regimes. The four cultivars followed a similar trend in response to the hot water treatments but showed some differences in vigor.

Hot water treatment combinations observed to be safe for application to rice seed. IRRI.

	Hot water treatments[a]			
	52°C		57°C	
	15 min	30 min	15 min	30 min
Testing immediately after hot water treatment				
Seed presoaked for 3 h				
Standard germination test	+	+	+	−
Accelerated aging test	+	+	+	−
Field seedling emergence	+	+	+	−
Field seedling emergence rate	+	+	−	−
Field seedling vigor and morphological characters	++	+	+	−
Seed not presoaked				
Standard germination test	+	+	+	−
Accelerated aging test	+	+	+	−
Field seedling emergence	+	+	+	−
Field seedling emergence rate	+	+	+	−
Field seedling vigor and morphological characters	++	+	+	−
Testing after hot water treatment and 45 d storage				
Seed presoaked for 3 h				
Standard germination test	+	−	−	−
Accelerated aging test	+	+	−	−
Field seedling emergence	+	+	−	−
Field seedling emergence rate	+	+	−	−
Field seedling vigor and morphological characters	++	+	+	−
Seed not presoaked				
Standard germination test	+	+	+	−
Accelerated aging test	+	+	−	−
Field seedling emergence	+	+	+	−
Field seedling emergence rate	+	+	+	−
Field seedling vigor and morphological characters	++	+	+	−

[a] + = statistically significant score reductions not observed i.e., safe treatment. ++ = scores significantly improved by the hot water treatment. − = scores significantly reduced by hot water treatment (unsafe treatment).

Hot water treatment of 57° C for 30 min may be considered unsafe for rice seed; the 57°C for 15 min may be considered safe only if the seed is not presoaked before hot water treatment. The 52°C for 15 and for 30 min treatments may be generally safe for rice seed, and are effective in controlling a range of seedborne pathogens.

Genetic variability in 98 upland rice cultivars of India

R. S. Singh, S. P. Chauhan, and D. M. Maurya, Genetics and Plant Breeding Department, Narendra Deva University of Agriculture and Techno1ogy, Faizabad (U.P.), India

Genetic variability and extent of heritability of desirable traits were assessed in 98 upland rice cultivars sown in July 1983. Plots were 5 × 2 m in a randomized block design with 3 replications.

Range, mean, coefficients of variability, heritability, and genetic advance of 12 traits in 98 upland rice cultivars. Faizabad, India.

Trait	Range	Grand mean and SEm	GCV	PCV	ECV	Heritability (%)	Genetic advance (% of mean)
Seedling height (cm)	29.3- 67.0	51.9± 2.1	15.3	15.8	4.2	93.0	30.3
Days to 50% flowering	56.0- 99.0	77.6± 1.0	7.3	7.5	1.6	95.1	14.7
Culm angle	4.0- 27.0	12.3± 2.2	32.8	39.2	21.5	69.9	56.5
Leaf angle	9.2- 54.0	26.4± 2.4	26.7	29.0	11.4	84.5	50.4
Leaf length (cm)	31.1- 60.2	45.6± 2.9	8.9	11.9	7.9	56.2	13.7
Plant height (cm)	55.5-138.9	103.1± 3.0	14.4	14.9	3.6	94.3	28.9
Panicle length (cm)	17.4- 31.2	24.3± 1.1	9.4	10.8	5.4	75.2	16.7
Sheath length (cm)	15.8- 26.4	21.2+ 1.1	6.8	9.4	6.4	52.5	10.2
Tillers/plant	5.4- 20.0	11.1± 3.1	19.5	39.3	34.1	24.7	20.0
Grains/panicle	66.0-405.6	139.0±24.3	30.7	37.5	21.4	67.3	52.0
Test weight (g)	10.4- 34.0	23.4± 1.0	15.9	16.8	5.2	90.5	31.3
Grain yield/plant (g)	5.9- 34.6	18.3± 3.2	17.2	27.7	21.7	4.0	22.1

All traits except length of sheath showed a wide range of phenotypic variation (see table). The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV). PCV ranged from 7.51 (days to 50% flowering) to 39.32 (tillers/plant). Culm angle, grains/panicIc, leaf angle, and grain yield showed high GCV and PCV. The environmental coefficient of variability (ECV) was higher for tillers/plant, yield/plant, culm angle, and grains/panicle, indicating that these traits were more susceptible to environmental factors than the other traits. Heritability ranged from 24.67 to 95.13%. High value for heritability was observed for days to flowering, plant height, 25-d-old seedling height, test weight, leaf angle, and panicle length. Low values were observed for tillers/plant, grain yield, length of sheath, and length of leaf. The remaining traits showed moderate heritability.

Genetic advance in percent of mean was high for culm angle. grains panicle, leaf angle, test weight, seedling height, and plant height. Selection for these traits might be more effective than for the other traits.

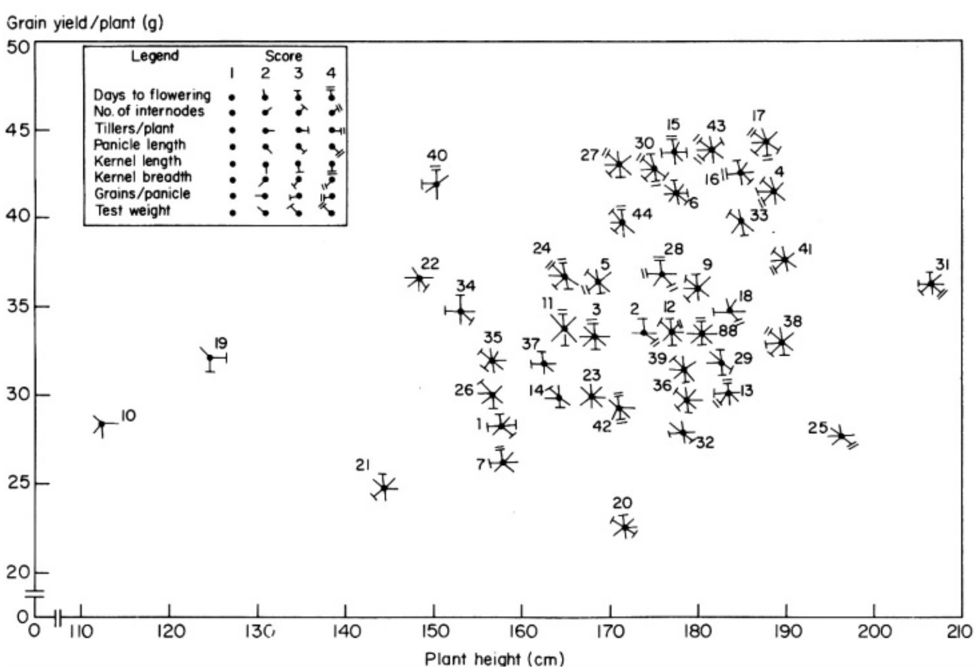
Metroglyph analysis of lowland rice cultivars

R.S. Singh, S.K. Singh, and D.M. Maurya, Genetics and Plant Breeding Department, Narendra Deva University of Agriculture and Technology, Faizabad (U.P.), India

Morphological variations in 44 lowland rice cultivars were studied using score index and metroglyph methods. Index values of range of variability were partitioned into 4 groups using class intervals (see table). All traits except yield and plant height, arc represented by rays on the glyph (the rays for the same trait have the same position on each glyph). The performance of a particular genotypc is denoted by its index score (see figure).

Indices of rice traits.

Character	Range of means	Score 1 Value<	Score 2	Score 3	Score 4 Value>
Days to flowering	104.33-133.00	111.49	111.49-118.65	118.66- 125.81	125.81
Internodes (no.)	4.27- 7.00	5.00	5.00- 5.500	5.51- 6.00	6.00
Tillers/plant	7.33- 25.60	11.89	11.89- 16.45	16.46- 21.01	21.01
Panicle length (cm)	22.43- 35.30	25.64	25.64- 28.85	28.86- 32.06	32.06
Grains/panicle	127.47- 335.60	179.50	179.50- 231.53	231.53- 283.56	283.56
Kernel length (mm)	4.47- 8.00	5.35	5.35- 6.23	6.24- 7.11	7.11
Kernel breadth (mm)	1.50- 2.37	1.71	1.71- 1.92	1.83- 2.13	2.13
Test weight (g)	11.83- 35.67	17.79	17.79- 23.75	23.76- 29.71	29.71



Scatter diagram of metroglyph analysis. List of cultivars: 1. Adamchini, 2. Anandi, 3. Bansfool, 4. Bansfore. 5. Bhainslote, 6. Bhedkabra, 7. Bhatafool, 8. Brahma, 9. Dato, l0. Deharadoon, 11. Derai, 12. Duniapat. 13. Foolbagan, 14. Gajraj, 15. Gauria A, 16. Gauria B, 17. Jilhore, 18. Kanakjiri, 19. Karinga. 20. Karingi, 21. Karanga, 22. Kesar, 23. Lakara, 24. Latera, 25. Lawangchur, 26. Lejura, 27, Madhukar. 28. Motibadam. 29. Ramkajara, 30. Rath, 31. Sahadeia, 32. Saro, 33. Selhi, 34. Sengar A, 35. Sengar B, 36. Silhat, 37. Shyamjira, 38, Sugapankhi A, 39. Sugapankhi B, 40. Sonachur, 41. Sorhi, 42. T-9, 43. T-100, and 44. Tulsifool.

Variability of pigment in lowland rices of Uttar Pradesh, India

D.M. Maurya, S.K. Singh. and K.S. Singh, Genetics and Plant Breeding Department, Narendra Deva University of Agriculture and Technology; Faizabad (U.P.), India

Pigments traits in 5 plant parts were identified in 44 lowland cultivars, using I.S.I. India color chart.

Of 33 pigments found, kernel (K) had 13, grain (G) 12, node (N) 9, internode (I) 7, and leaf (L) 4 (see table).

Serial numbers were assigned to pigments:

1 = eau-de-nil
2 = sea green
3 = grass green
4 = sage green
5 = light bronze green
6 = middle bronze green
7 = light brunswick green
8 = cypress green
9 = light olive green
10 = steel furniture
11 = forest green
12 = deep cream
13 = light buff
14 = middle buff
15 = deep buff
16 = light stone
17 = middle stone
18 = dark stone
19 = portland stone
20 = vellum
21 = light straw
22 = light biscuit
23 = champagne
24 = sunshine
25 = berge
20 = light brown
27 = middle brown
28 = nut brown
29 = golden brown
30 = orange brown
31 = light salmon pink
32 = chocolate
33 = service brown

The broad valiability of kinds and distribution of pigments could be used to document cultivars, in genetic studies. as marker traits, and to incorporate desirable traits in breeding programs.

Pigments in 5 plant parts of lowland rices in 9 districts of Uttar Pradesh, India. 1986.

Cultivar	Pigment				
	N	I	L	G	K
Azamgarh					
Bhainsalote	2	9	11	13	25
Derai	9	3	8	14	25
Lakara	1	9	11	13	25
Ramkajara	1	9	11	13	16
Rath	4	2	7	14	16
Selhi	3	9	8	13	16
Sorhi	3	9	8	13	24
Tl00	6	4	11	13	23
Ballia					
Karinga	7	9	8	14	21
Karingi	3	4	8	18	25
Bahraich					
Madhukar	5	10	11	27	16
Barabanki					
Gajraj	3	4	8	27	24
Basti					
Anandi	1	4	8	32	31
Bansfool	3	4	8	16	19
Bansfore	5	4	11	14	19
Brahma	20	9	8	16	18
Duniapat	5	9	11	13	23
Foolbagan	9	9	7	14	1
Gauria A	1	9	8	13	20
Gauria B	2	9	11	18	1
Kanakjiri	2	9	11	32	21
Motibadam	1	9	8	13	20
Sengar A	2	1	8	26	1
Sengar B	2	9	8	28	16
Sugapankhi A	5	4	8	14	25
Sugapankhi B	7	9	8	18	25
Sonachur	4	1	11	13	25
T9	2	9	8	13	1
Gonda					
Tulsifool	9	9	7	29	19
Mirzapur					
Bhedkabra	9	5	7	27	1
Dato	2	9	8	14	21
Deharadoon	2	9	8	13	22
Jilhore	4	9	11	14	19
Karanga	1	4	11	26	30
Kesar	3	1	11	13	25
Latera	9	9	11	19	1
Lejura	3	9	8	18	16
Saro	2	9	8	12	21
Silhat	1	9	11	13	17
Shyamjira	1	9	3	15	16
Raibarelli					
Bharafool	1	2	7	33	1
Varanasi					
Adamchini	9	4	8	14	31
Lawangchur	1	1	3	28	1
Sahadeia	9	4	3	26	1

Metroglyph analysis of some upland rice cultivars of India

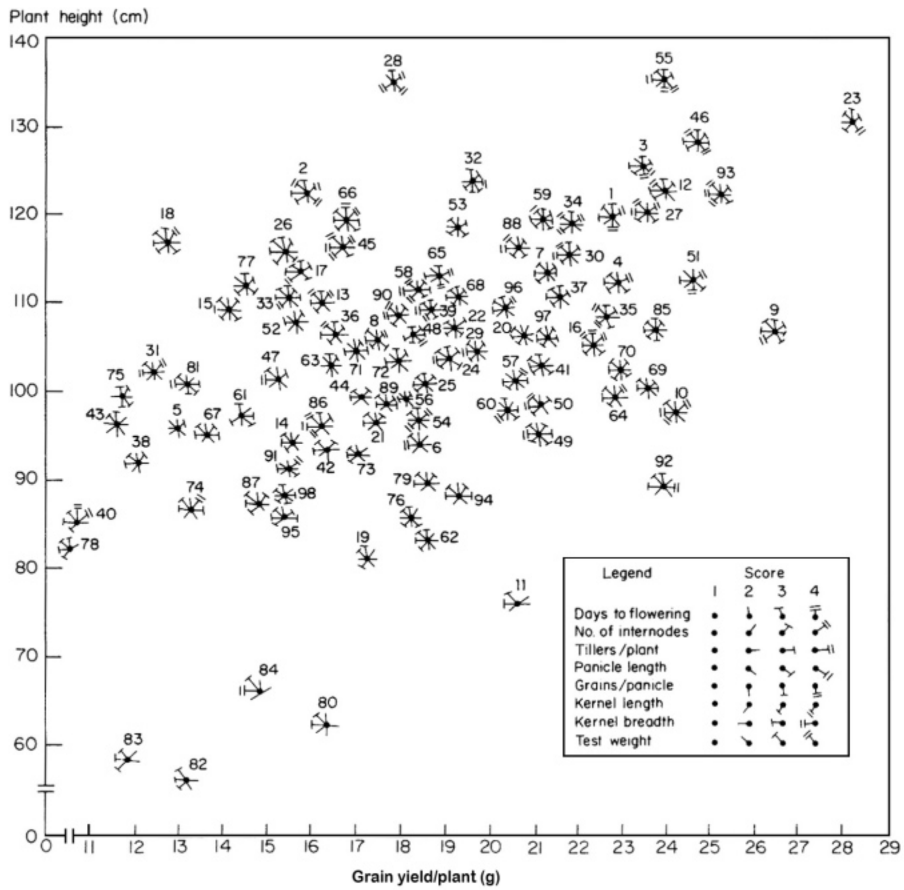
R.S. Singh, S.P. Chauhan, and D.M. Maurya, Genetics and Plant Breeding Department, Narendra Deva University of Agriculture and Technology, Faizabad (U.P.), India

Morphological variation of 98 upland rice cultivars was studied using score index and metroglyph methods. Index values of range of variability were divided into 4 groups using class intervals (see table). All traits except yield and plant height are represented by rays on the glyph (ray for the same trait have the same position on each glyph).

The performance of a particular cultivar is denoted by its index score (see figure).

Index score for different traits of upland rice cultivars.

Character	Range of means	Score 1 Value <	Score 2	Score 3	Score 4 Value >
Days to 50% flowering	57.00- 90.00	67.00	67.00- 78.00	78.10- 89.00	89.00
Internodes (no.)	2.20- 4.80	2.50	2.50- 3.50	3.60- 4.00	4.00
Tillers/plant	5.50- 19.30	8.90	8.90- 12.40	12.50- 15.80	15.80
Panicle length (cm)	18.00- 31.20	21.30	21.30- 24.60	24.70- 28.00	28.00
Grains/panicle	70.00-283.70	123.40	123.40-176.80	176.90-230.30	230.30
Kernel length (mm)	4.25- 6.76	4.88	4.88- 5.51	5.52- 6.15	6.15
Kernel breadth (mm)	1.48- 3.10	1.88	1.88- 2.28	2.29- 2.69	2.69
Test weight (g)	10.89- 31.05	15.93	15.93- 20.97	20.98- 26.02	26.02



Scatter diagram of metroglyph analysis. List of cultivars: 1. Anjani, 2. Ambemohar, 3. ARC-11775. 4. Bagri, S. Bagri white. 6. Bapri red, 7. Beni, 8. Bakki, 9. Badamfarm, 10. Bendi, 11. Bhadailakala, 12. Bhattadhan, 13. Browngora, 14. Champa, 15. Chingurdi, 16. Chitrikar, 17. Chali, 18. Chipti, 19. Cauvery, 20. Dehula A, 21. Dehula B, 22 Dhani, 23. Dular, 24. Dudhi A, 25. Dudhi H, 26. Dhudhi C, 27. Dhudhi, 28. Deharadun 2-13-18-17, 29. Gorakhpuri, 30. Gajgaur, 31. Hansraj, 32. Improved Raskadam, 33. Joginia, 34. Jhona 349, 35. Junagarh 68, 36. Kanyadali, 37. Ketki, 38. Kwari, 39. Kalkeri, 40. Karahani A, 41. Karahani B, 42. Kudia, 43. Kachni A, 44. Kachani B, 45. Karangangora, 46. Kolhapur scented, 47. Lurkan, 48. Lalmati A, 49. Lalmati B, 50. Lalnakanda, 51. Mutmuri, 52. Mutmuri A, 53. Maliwa, 54. Mutri A, 55. Mirkirak, 56. Nutan, 57. N22, 58. Nonhigora, 59. Nagpur 14, 60. Nagpur 22, 61. Nagpur 27, 62. Narendra 1, 63. Padhini, 64. Pawas, 65. Panke, 66. Poongar, 67. Raimunia, B. 68. Rengi A, 69. Rengi B, 70. Rengi C, 71. Ranikajal A. 72. Ranikajal B, 73. Ranikajal C, 74. Ranikajal D, 75. Raskadam, 76. Rasi, 77. Surajmukhi, 78. Sawani bagri, 79. Sonkhareha, 80. Sathi, 81. Satha A, 82. Satha B, 83. Satha E, 84. Satha F, 85. Sankhal, 86. Sakurn, 87. Sarya B, 88. Sarya C, 89. Sarya D, 90. Sarya E, 91. Safedwa, 92. Sapna, 93. Thelai, 94. Tinpakhia A, 95. Tinpakhia C, 96. Tinpakhia E, 97. Tetco, and 98. Viagai.

Variability of pigment in Indian upland rices

S.R Chauhan, R.S. Singh, D.M. Maurya, and C. P. Vaish, Generics and Plant Breeding Department, Narendra Deva University of Agriculture and Technology, Faizabad (U.P.), India

Pigment traits in 6 plant parts were identified in 98 upland rices using the I.S.I. India color chart.

Of 58 pigments found, seedling (S) showed 3, leaf (L) 12, node (N) 15, internode (I) 15, grain (G) 20, and kernel (K) 25 (see table).

Serial numbers assigned each pigment:

1 = dark green
2 = pale green
3 = green
4 = cypress green
5 = sage green
6 = beech brown
7 = grass green
8 = light bronze green
9 = sea green
10 = scamic
11 = scamic green
12 = middle bronze green
13 = light olive green
14 = eau-de-nil
15 = leaf brown
16 = lincoln green
17 = chocolate
18 = olive green
19 = light purple brown
20 = light brunswick green
21 = red oxide
22 = service brown
23 = deep indian green
24 = brilliant green
25 = deep brunswick
26 = light cream
27 = pale huff
28 = light brown
29 = nut brown
30 = light buff
31 = deep buff
32 = ivory
33 = orange
34 = brown
35 = middle buff
36 = pale cream
37 = golden brown
38 = sight buff
39 = adm gray
40 = middle brown
41 = new ivory
42 = salmon pink
43 = light salmon pink
44 = broke white
45 = orange brown
46 = deep rose
47 = pale rose
48 = beige
49 = terracota
50 = kenetian
51 = new mushroom
52 = broken brown
53 = primrose
54 = rose pink
55 = mimosa
56 = traffic red
57 = crimson
58 = special gray

Distribution of pigments in 98 upland rice cultivars in 11 states, India, 1986

Cultivar	Pigments					
	S	L	N	I	G	K
Andhra Pradesh						
Caveri	3	5	7	5	27	44
Rasi	1	8	7	7	27	36
Assam						
ARC11775	3	18	5	8	27	41
Bihar						
Browngora	2	18	7	9	27	37
Karangagora	2	4	16	8	28	50
Nonhigora	1	24	7	9	28	45
Gujarat						
Deharadun-2-13-18-12	1	5	7	8	27	44
Junagarh 68	3	7	9	14	27	44
Kolhapur scented	3	18	4	8	37	51
Maharashtra						
Ambemohar	2	4	5	8	27	41
Improved Raskadam	1	5	13	8	30	47
Nagpur 14	1	24	7	9	27	21
Nagpur 22	3	18	4	8	27	36
Nagpur 27	3	5	8	8	27	41
Raskadam	3	9	9	14	37	55
Tetco	3	7	9	14	28	50
Meghalaya						
Mirkirak	2	4	5	13	27	47
Orissa						
Kalkeri	3	4	7	9	29	37
Punjab						
Jhona 349	2	18	7	9	27	43
Lalnakanda	3	4	7	9	28	50
Tamil Nadu						
Poongar	1	4	13	22	6	28
Chitrikar	1	20	7	9	28	37
Panke	2	4	7	8	32	37
Chali	1	18	7	9	32	45
Chipti	1	4	4	21	17	35
Viagai	1	18	7	14	36	41
Bhattadhan	2	5	4	18	31	46
Surajmukhi	1	12	5	22	35	43
Uttar Pradesh						
Anjani	1	18	4	19	26	28
Bagri	3	4	6	20	27	42
Bagri white	2	4	7	5	27	37
Bagri red	2	5	8	8	28	15
Beni	1	4	9	14	22	42
Bakki	3	20	7	9	29	43
Badamfarm	3	18	7	13	30	44
Bendi	1	18	7	8	30	44
Bhadailakala	2	8	7	5	17	45
Champa	3	9	7	9	28	37
Chingurdi	3	18	7	1	6	42
Dehula A	2	4	8	8	27	37
Dehula B	1	5	9	14	31	47
Dudhi	1	5	10	17	34	37
Dudhi A	2	4	10	23	28	37
Dudhi B	2	16	11	6	27	48
Dudhi C	3	7	7	9	27	24
Dhani	3	20	7	9	22	42
Gordkhpuri	1	20	7	9	27	45
Gajgaur	3	18	12	19	28	49
Hansraj	3	18	6	8	2	37
Joginia	2	20	7	9	35	36
Kanyadali	3	4	10	6	35	47
Ketki	3	18	4	13	32	45
Kwari	2	20	7	9	36	42
Karahani A	1	7	9	14	6	37
Karahani B	3	4	8	8	40	37
Kudia	2	4	14	14	17	15
Kanchi A	1	5	4	8	15	2
Kanchi B	3	4	15	3	40	42
Lurkan	3	13	5	14	32	37
Lalmati A	2	4	4	8	35	42
Lalmati B	3	4	7	9	28	42
Mutmuri	1	7	17	22	27	41
Mutmuria	2	18	7	8	27	45
Maliwa	2	5	13	8	27	36
Mutri A	1	18	7	8	37	52
N 22	1	7	5	8	27	44
Narendra 1	2	18	18	5	27	41
Nutan	3	4	9	7	38	36
Padhini	3	4	9	14	27	44
Pawas	3	18	13	14	22	42
Raimunia B	3	18	8	5	28	45
Rengi A	1	4	4	8	31	44
Rengi B	3	18	7	9	27	45
Rengi C	3	5	8	8	27	45
Ranikajal A	3	13	9	9	30	44
Ranikajal B	2	13	7	9	27	53
Ranikajal C	3	4	13	22	35	54
Ranikajal D	2	18	6	12	35	37
Sathi	3	4	9	14	29	37
Satha A	1	5	7	9	27	42
Satha B	3	5	9	14	17	37
Satha E	1	25	7	14	22	15
Satha F	3	13	9	9	39	37
Sankhal	2	8	7	8	27	36
Sakun	2	5	7	14	27	50
Sarya B	3	18	9	9	28	42
Sarya C	3	4	8	9	28	49
Sarya D	3	4	8	8	28	45
Sarya E	3	7	9	14	27	49
Safedwa	1	12	9	5	27	57
Sapna	3	7	9	14	28	46
Sonkharcha	3	4	7	9	35	56
Sawanibagri	3	8	9	5	29	45
Thelai	1	5	9	14	32	42
Tinpakhia A	2	18	9	14	22	37
Tinpakhia C	2	18	9	14	22	58
Tinpakhia E	3	4	4	8	27	36
West Bengal						
Dular	2	18	4	22	33	43

Pigments 5, 6, 7, 8, 9, 12, 13, 15, 17, and 18 appeared in three traits; pigments 2, 3, 4, 14, 16, 20, 21, 22, 28, 35, 36 and 37 in two traits; and other pigments in only one trait.

This broad range of variability in pigment shades could be utilized in documentation and genetic studies and as markers in breeding programs.

Effect of storage longevity on the response of rice seed to hot water treatment

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Hot water treatment is an effective plant quarantine measure for a range of rice seed pathogens. However, it may affect seed viability and seedling vigor. Storage longevity also is known to reduce seed germination.

We studied the interaction between thermal treatment and storage longevity to determine whether hot water treatment of old seed is a safe practice. A completely randomized design was used, with seven replications per treatment. Seeds of IR36 and IR42 were obtained from the International Rice Testing Program storage at 20° C and 50% relative humidity (RH). Seed lot age varied from newly harvested to 5 yr old.

Fifty seeds of each entry were treated with hot water at 55°C for 20 min. Entries were subjected to a standard germination test immediately after thermal treatment and after a 30-d storage at 26 to 32° C and 78% relative humidity.

Initial viability of both cultivars was highest in the 1-yr-old seed lots and lowest in the 3-yr-old (Table I). Initial viability was influenced by different seed sources as well as sample age.

The two cultivars responded similarly to the hot water treatment. Viability of newly harvested and 1-yr-old seed tested immediately after thermal treatment was not affected by the hot water (Table 1). Germination of 3-yr-old seed was reduced by the treatment. The 5-yr-old seed of IR42 was affected.

Germination was similar across the two storage periods. Viability of the 3- and 5-yr-old seed was further reduced by hot water treatment followed by 30 d posttreatment storage (Table 2). Reduction in viability was greatest in seed lots which had the lowest initial viability (3 yr old).

Hot water treatment should be used with caution when secds have been stored longer than 1 yr or when the seed lots are of poor initial viability (i.e., below 85% germination).

Table 1. Effect of seed age on germination after hot water treatment of 55°C for 20 min. IRRI

Seed age (yr)	Percentage germination [a]					
	IR36			IR42		
	Untreated	Hot water treated	Difference	Untreated	Hot water treated	Difference
0	85.7	88.9	3.2ns	87.4	90.0	2.6ns
1	96.5	96.9	0.3ns	92.6	95.4	2.8ns
3	73.1	49.7	–23.4**	73.7	66.3	–7.4*
5	86.0	84.3	–1.7ns	87.7	82.3	–5.4*

[a]Significant at 1% (**) and 5% (*) levels. ns = not significant.

Table 2. Effect of seed age on germination of 2 rice varieties hot water treated and stored for 30 d at room temperature. IRRI, 1986.

Seed age (yr)	Percentage germination [a]		
	Untreated	Hot water treated	Difference
0	86.9	88.1	1.2ns
1	93.9	96.3	2.4ns
3	53.1	40.9	–12.2**
5	79.1	70.4	–8.7**
Average	78.2		

[a]Significant at 1% (**) and 5% (*) levels. ns = not significant.

Genetic variability in 48 lowland rice cultivals of Uttar Pradesh, India

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Potent variability in local cultivars are the result of prolonged natural and artificial selection, although it is genetic variation which is heritable, and important. Genetic variability was assessed among 48 lowland rice cultivars sown July 1983. Plots were 5 × 2 m in a randomized block design with 3 replications.

Grains/panicle, plant height, length of leaf, days to flowering, and leaf angle showed wide phenotypic variation (see table). Many cultivars shifted toward the higher limit for yield/plant and toward the lower limit for internode, tillers/plant, and leaf angle. Other traits were intermediate.

Range, mean, coefficients of variability, heritability, and genetic advance of 15 traits in 48 lowland rice cultivars. Faizabad, India.

Trait	Range	Grand mean and SEm	PCV	GCV	Heritability (%)	Genetic advance in % of mean
Days to flowering	104.3-133.0	120.2± 1.3	5.7	5.5	94.8	11.1
Plant height	114.2-206.0	170.2± 7.3	11.7	10.4	79.8	19.2
Culm angle	52.0- 63.2	56.4± 2.9	6.9	2.9	17.3	2.5
Internode number	4.3- 7.0	5.0± 0.4	11.9	5.6	22.4	5.6
Tillers/plant	7.3- 25.6	12.6± 3.1	35.6	18.6	27.4	20.1
Length of leaf	48.7- 87.4	65.2± 5.2	14.2	10.4	53.0	15.6
Length of sheath	24.3- 48.6	30.7± 3.6	16.6	8.1	23.5	8.0
Leaf angle	7.7- 35.7	14.0± 3.5	45.1	33.2	54.2	50.3
Panicle length	20.4- 35.3	28.5± 1.3	10.2	8.5	70.1	14.6
Kernel length	4.5- 8.0	6.1± 0.1	12.3	12.2	97.4	24.8
Kernel breadth	1.5- 2.4	1.9± 0.1	12.3	9.7	62.2	16.0
Length-breadth ratio	2.5- 4.2	3.3± 0.1	12.6	12.2	94.4	24.3
Grains/panicle	127.5-335.6	208.4± 20.1	24.7	21.6	77.0	39.1
Test weight	11.8- 35.7	22.3± 2.8	30.5	26.2	73.2	46.4
Grain yield/plant	17.6- 43.7	33.4± 5.7	24.8	13.3	28.6	14.6

Phenotypic coefficients of variability (PCV) ranged from 5.7 (days to flowering) to 45.09 (leaf angle). The genotypic coefficient of variability (GCV) contributed most to PCV, with less environmental effect on internode, length (L) and breadth (B) of kernel, L:B, test weight, panicle length, and culm angle. High heritability was coupled with high genetic advance for kernel length, L:B, plant height, grains/panicle, test weight, and panicle length. These traits could be effective for high selection response in lowland rice.

How to convert IRS into a low-amylose variety

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The theoretical base for our experiment to incorporate the low-amylose trait of Taichung 65 into IR36 is provided by the following recent advances in rice genetics:

- Several alleles are at the *Wx* locus: Wx^a for high amylose content, Wx^b for low amylose, and the wx gene.
- Many *javanica* rices and almost all Japanese rices that are donors of intermediate or low amylose content show semisterility in the F_1 hybrids when crossed with IR varieties because the female gametes possessing $S_5{}^j$ or a similar allele are aborted due to allelic interaction of $S_5{}^i/S_5{}^j$ genotype, where $S_5{}^i$ is from IR varieties.
- The *wx* locus is closely linked with the *S* locus in the first linkage group of rice. Therefore, Wx^b is likely to be eliminated in crosses with IR varieties through the abortion of $S_5{}^j$ gametes.

The arrangement of relevant genes is in the order of *alk*(alkali digestion)-C^+ (chromogen for apiculus *color)*-$S_5{}^j$—Wx^b in Taichung 65(T65) and of *Alk*-$C^+ S_5{}^i$—Wx^a in IR36. In the F_1 of T65/ IR36, most female gametes carrying $S_5{}^j$ were eliminated. By backcrossing IR36 to the F_1, some surviving female gametes with $S_5{}^j$ and all of the gametes with $S_5{}^i$ are pollinated by IR36. Thus, from 94 B_1F_1 plants of T65/IR36// IR36, some plants with C^+ and lower fertility which indicated $S_5{}^i/S_5{}^j$ genotype were chosen for another backcross by IR36. Some characters of the selected B_1F_1 plants are shown in Table 1. By the marker genes, the possibility to recover Wx^b was predicted, because those plants with d and S (indicated by low fertility) are likely to possess Wx^b due to linkage.

Table 1. Some characters of plants selected from the B_1F_1 of T65/IR36//IR36 for backcrossing by IR36. TARC, Japan.

Plant no.	Spikelet fertility[a] (%)	Genotype for *alk*	Genotype for C^+	Assumed gene arrangement[b]	Possibility for Wx^b
1	65.6	+/+	C^+	*Alk*–x– C^+——S^j–	+
2	80.2†	+/*alk*	C^+	*alk*——C^+–x–S^i–	−
3	63.1	+/*alk*	C^+	*alk*——C^+——S^j–	+
4	57.7	+/*alk*	C^+	*alk*——C^+——S^j–	+
5	79.8†	+/*alk*	C^+	*alk*——C^+–x–S^i –	−
6	28.2	+/*alk*	C^+	*alk*——C^+——S^j–	+
7	82.2 †	+/*alk*	C^+	*alk*——C^+–x–S^i	−
8	61.2	+/*alk*	C^+	*alk*——C^+——S^j–	+
9	69.3	+/+	C^+	*Alk*–x– C^+——S^j–	+
10	40.3	+/*alk*	C^+	*alk*——C^+——S^j–	+

[a]† shows nearly normal fertility, indicating the effect of S^i after the recombination of C^+ and S^i. [b]x marks the point of assumed crossing over.

Table 2. Characteristics of cooked rice of the selected B_2F_2 plants of T65/IR36//IR36///IR36. TARC, Japan.

Plant no.	Genotype for alk	Plants (no.) in each class			Spikelet fertility
		Sticky	Segregating	Nonsticky	
1	+/+	8	5	10	Slightly low
2	+/*alk*		9	9	Normal
3	+/+	3	6	3	Normal
4	+/*alk*	1	5	2	Normal
5	+/*alk*		6		Normal
6	+/*alk*	1			Normal
7	+/+	1	2	4	Normal
8	+/*alk*	4	7	4	Normal
9	+/*alk*	2	1	7	Normal
10		No plant was selected			

About 30 B_2F_1 plants from each of the 10 B_2F_1 crosses were raised during winter 1984-85, and from each B_2F_1 population the plants with C^+ were bulk harvested to grow a B_2F_2 population of 50 plants. Many B_2F_2 plants showed normal fertility. The selected ones showed normal fertility; they were individually harvested and their cooked rice was tested. By cooking small amounts of milled rice in test tubes and tasting the cooked samples, the presence of Wx^b *was* determined (Table 2). Many plants of IR36 type were found to have sticky cooked rice. The recovery of low-amylose genotype in the B_2F_2 matched the expectation in B_1F_1 stage (Table 1).

The preliminary trial demonstrated that many plants with low amylose content can be recovered after two backcrossing of IR36, which is a high-amylose variety. Although we did not handle varieties with intermediate amylose, the principle can be applied for incorporating intermediate amylose content into high yielding varieties the quality of which is not always preferred.

Reaction of rice genotypes to stem rot (SR) fungi and bacterial blight (BB) pathogen

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SR caused by three species of *Sclerotium* (*S. oryzae, S. hydrophyllum,* and *S. oryzae* var. *irregulare*) and BB caused by *Xanthomonas campestris* pv. *oryzae* (Ishiyama) Dye are the major rice diseases in Haryana. We evaluated 125 early to medium duration rices against SR and BB at HAURRS, during 1984-85 kharif.

Each test entry was planted in two 2-m-long rows, at 20- × 15- cm spacing. Plants were clip-inoculated with BB suspension at 21 d after transplanting (DT) for kresek and at 45 DT for leaf blight, and scored for resistance at 30 and 14 d after inoculation. SR screening was done in the field as well as in the laboratory. In the field, disease incidence was recorded at maturity when disease development was highest and scored by the *Standard evaluation system for rice* (1980).

In the laboratory, cut stem pieces were wound-inoculated with a small piece of agar-cultured *S. oryzae, S. hydrophyllum,* and *S. oryzae* var. *irregulare* separately at booting. The inoculated stems were set upright in a test tube rack in a tray with 2.5 cm of water. They were covered with plastic bags to retain moisture and incubated at 28-30° C. Lesion length was measured 10 d after inoculation. Entries with lesions less than 10 mm long were considered resistant; those with 10-30 mm lesions, moderately resistant; and those with more than 30 mm, susceptible.

In the laboratory screening, the location severity index (LSI) was 5.97% for *S. oryzae,* 3.46 for *S. hydrophyllum,* and 7.63 for *S. oryzae* var. *irregulare.* In field tests, LSI was 5.51 for SR, 5.78 for kresek, and 5.10 for leaf blight.

Of the entries tested, 11 entries showed resistance to the combination of *S. oryzae* and *S. oryzae* var. *irregulare,* 10 to *S. hydrophyllum* and *S. oryzae* var. *irregulare,* 28 to *S. oryzae* and *S. hydrophyllum,* and 9 to the 3 *Sclerotium* spp. (Table 1). Against BB, 13 entries showed resistance to the kresek phase and 76 to the leaf blight phase. Of nine entries showing resistance to the three *Sclerotium* spp., all except BR51-331-4 exhibited resistance to the blight phase. RP2151-175-1 and RP2151-192-1 need special mention as they had a resistance to all the *Sclerotium* spp. in the laboratory and in the field and also to both phases of BB (Table 2).

Table 1. Reaction of rice varieties to SR fungi *Sclerotium oryzae, S. hydrophyllum,* **and** *S. oryzae* **var.** *irregulare.* **HAURRS, Haryana, India, 1984–85.**

Resistant to *S. oryzae* and *S. oryzae* var. *irregulare*

HAU39-4020-3, HAU119-362, BR51-331-4, BR52-90-2, RP2151-166-4-1, RP2151-175-1, RP2151-192-1, RP2151-192-2-5, RP2151-221-4-2-4, RP2151-224-1, and CR318-548-7.

Resistant to *S. hydrophyllum* and *S. oryzae* var. *irregulare*

HAU118-104, BR51-3314, RP2151-166-4-1, RP2151-166-4-4-1, RP2151-175-1, RP2151-192-1, RP2151-192-2-5, RP2151-221-4-2-4, RP2151-224-4, and CR318-548-4-2-4.

Resistant to *S. oryzae* and *S. hydrophyllum*

HAU47-3888-2, HAU118-77, HAU118-106, HAU118-108, HAU118-109, HAU118-110, HAU118-111, HAU118-141, HAUl18-162, HAUl18-183, HAU118-184, HAU118-186, HAUl18-206, HAU118-222, HAU118-782, HAU119-309, HAU119-800, HAU120-337, IR9784-142-1-3-3, BR51-331-4, CR318-548-7, RP2135-51-1, RP2151-166-4-1, RP2151-166-4-4-1, RP2151-192-1, RP2151-192-2-5, RP2151-2214-24, and RP2151-2244.

Resistant to 3 *Sclerotium* spp.

BR51-3314, RP2151-1664-1, RF2151-16644-1, RP2151-175-1, RP2151-192-1, RP2151-192-2-5, RP2151-2214-24, RP2151-2244, and CR318-548-7.

Table 2. Reaction to SR, and kresek and leaf blight phases of BB in field of entries with resistance to 3 *Sclerotium* **spp. HAURRS, Haryana, India, 1984–85.**

Entry	Parentage	Reaction[a] to		
		Kresek	Leaf blight	Stem rot
BR51-331-4	IR20/IR5-114-3-1	S	S	R
CR318-548-7	IET4141/CR98-7216	MR	R	MR
RP2151-166-4-1	IET4141/CR98-7216	MR	R	R
RP2151-166-4-4-1	IET4141/CR98-7216	MR	R	R
RP2151-175-1	IET4141/CR98-7216	R	R	R
RP2151-192-1	IET4141/CR98-7216	R	R	R
RP2151-192-2-5	IET4141/CR98-7216	S	R	R
RP2151-221-4-2-4	IET4141/CR98-7216	MR	R	R
RP2151-224-4	IET4141/CR98-7216	MR	R	MR

[a]R = resistant (score of 3 or lower), MR = moderately resistant (5), and S = susceptible (7–9).

Reaction of rice cultivars to bacterial blight (BB)

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BB is a major rice disease in the Tarai region of Nepal. In 1985 kharif, 117 rice cultivars were evaluated for reaction to BB.

Each entry was transplanted into earthen pots 21 d after sowing. At maximum tillering, plants were clip-inoculated with a BB suspension from leaf extract. At 14 d after inoculation, they were scored for resistance using the *Standard evaluation system for rice (SES).* Of 117 entries, 26 were resistant (see table). For the remaining 91, susceptibility ranged from moderate to high.

Varietal reaction to BB at IAAS, Rampur, Nepal, 1985.

Cultivar	Score[a]
Tetep	1.0
BG379-2	1.0
Nigeria 5	1.0
DV85	1.0
IR19661-63-1-2-3	1.0
BG400-1	3.0
IR8608-82-1-3-1-3	3.0
C 1321-9	3.0
ADT36	3.0
BPT3291	3.0
IR19083-22-2-2	3.0
Taichung Sen 1	3.0
BR153-21-10-1-3	3.0
Se 322B-19	3.0
BG367-4	3.0
IR2307-247-2-2-3	3.0
IR5873-9-1	3.0
IR50	3.0
IR9171-60-2-2	3.0
IR2725-63-2-2	3.0
IR36	3.0
IR21820-154-3-2-2-3	3.0
Chainung Sen Yu 29	3.0
IR62	3.0
Thapani	3.0
Saeto Anadi	3.0
TN1 (check)	9.0

[a]By the 1980 SES scale.

Genetic divergence and multiple disease resistance studies in rice (*Oryza sativa* L.)

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Genetic divergence is one criterion in selecting parents to generate crosses that give transgressive segregants in later generations. A parental divergence study was undertaken with released varieties and 120 elite lines (94 semidwarf, 24 intermediate, and 2 tall) primarily selected for their bacterial blight (BB) tolerance. The lines were from IRRI (55), India (42), Bangladesh (10), Indonesia (5), 2 each from USA, Taiwan, and Sri Lanka, and 1 each from Thailand and the Philippines. The crop was grown under recommended agronomic practices in 1977 wet season (WS) at Pantnagar in a randomized block design with three replications. Each line had a 4-m^2 plot and 20- × 15-cm spacing. Mahalanobis D^2 statistics was used to study genetic divergence based on six characters: day to 50% flowering, plant height, effective tillers per plant, grain weight, grains per panicle, and grain yield (14% moisture) per plot. The lines were grouped in 18 clusters per Tocher's method suggested by Rao.

The lines were also screened for BB resistance in WS 1977, 1978, and 1979 at Pantnagar (29°N, 79.3°E, and 243.8 m mean sea level); for leaf blast at Majhera District, Nainital, in hills (29.28°N, 79.32° E, and 900 m); and for brown spot at Ranichauri (30.18°N, 78.290° E, and 2000 m) using the *Standard evaluation system for rice* scale. Eleven lines showed multiple resistance to all three diseases.

Clustering pattern revealed five clusters (see table). One or two lines were further selected from each cluster on the basis of their higher grain yield, effective tillers, grain weight, hulling and milling percentage, and desirable alkali digestion value. IR2070-414-3-9 and BGW-2 in cluster I, IR22 in cluster V, and IR2415-904-3 in cluster VII were most desirable. The intercluster distance revealed that cluster VIII and IX were most divergent, followed by V and VIII, and VII and IX. BKN68 19-33-3-2-1-3 and IR2328-300-2-2 had higher divergence than most entries. The cross combination IR2328-300-2-2 and BKN6819-33-3-2-1-3 had maximum divergence followed by IR22 and IR2328-300-2-2. These crosses can be used to further select recombinants with multiple resistance, higher yield, and other desirable traits.

Intraclusta and intercluster D^2 value in 5 selected clusters and the multiple-resistance tines in each cluster. 1977-79, Bihar, India.

Cluster	D^2 value in different clusters					Multiple-resistance lines
	I	V	VI1	VIII	IX	
I	28.2	75.7	5 1.5	188.0	152.0	IR2070-414-3-9 BG90-2 RP633-519-1-3-4-1
V		36.3	134.2	380.7	216.6	IR2071-527-3-1-3 IR2328-27-3-6 IR22
VI1			24.6	99.8	272.4	IR2415-90-4-3 IR2863-39-2 IR5491-4-80
VIII				28.7	449.7	IR2328-300-2-2
IX					13.9	BKN6819-33-3-2-1-3

Genetic Evaluation and Utilization
INSECT RESISTANCE

Promising rice cultivars with combined resistance to gall midge (GM) and brown planthopper (BPH)

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Breeding for multiple resistance to pests is being emphasized for yield stability in modern varieties. In 1984 kharif (Jun-Jul to Oct-Nov), we evaluated 45 entries from the AICRIP 1983 multiple resistance screening trial against GM in the field. Outbreak conditions were induced by close spacing (10 × 15 cm), adjusting planting time to 20 Jul to coincide with maximum infestation of the season, applying high N rates (100 + 25 + 25 kg N/ha at 0, 15, and 30 d after

Promising entries from the multiple resistance screening trial against GM and BPH. Cuttack, India, 1983 kharif.

Entry	Silvershoots (%)	GM-infested hills (%)	BPH resistance score [a]
RP2068-18-3-5	0	0	1
RP2068-17-3-7	0	0	7
RP2068-18-4-5	0	0	3
RP2068-18-2-6	0	0	7
RP2068-16-9-5	0	0	9
RP2068-18-4-7	0	0	9
Rp2068-18-2-11	0	4	7
TN1	40	100	9
IET8868 (OR 405-4)	0	0	7
IET7800	0	0	–
IET8371	0	0	1
RP2199-84-2	4	4	7
IR4707-106-3-2	29	77	7
RP2071-18-1-1	48	96	3
RP2076-464-2	40	92	3
TN1	26	100	9
RP2069-34-1-2	40	96	3
RP2068-12-1-8-1	28	96	1
RP2068-15-1-4-2	0	0	7
RP1579-28	0	0	9
RP1579-43	0	0	–
RP1579-48	4	4	7
RP1579-53	0	0	9
TN1	32	100	9

[a] By SES.

transplanting), and installing lights. Damage (% silvershoots and % infested hills) was graded when infestation peaked.

The same entries were tested for BPH resistance in the greenhouse by the bulk seedling screening method. Damage was graded on the 0–9 scale of the *Standard evaluation system for rice (SES).*

Thirteen cultivars were highly resistant to GM (see table). Three cultivars — RP2068-18-2-11, RP2199-84-2, and RP1579-48 — had less than 5% infestation. A strong correlation was observed between percentage of silvershoots and percentage of infested hills ($r = 0.786$).

Seven entries were resistant to BPH (score 1–3): and three — RP2068-18-3-5, RP2068-4-4-5, and IET8371 — were resistant to both GM and BPH. The RP2068 cultivars were derived from the cross Swarndhan/ Veluthachem, while IET8371 came from the cross Phalguna/ARC6650, deriving their dual resistance from known donors.

Varietal resistance of rice to leaffolder *Cnaphalocrocis medinalis*

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Rice leaffolder *Cnaphalocrocis medinalis* is a major pest in India, causing 80% yield loss in rice. We screened 18 rice accessions from AICRIP for resistance to leaffolder by a seedling screening technique at the Paddy Breeding Station, TNAU, Coimbatore, and in field trials at Krishi Vigyan Kendra, Pondicheny, during 1984 kharif.

Pregerminated seeds of test accessions were sown 6 cm apart in 6 rows in 50 × 40 × 10 cm wooden seedboxes. Each accession was planted in a replication across the width of the seedbox in such a way to maintain at least 5 hills (3 plants/hill) per row. One row of susceptible check TN1 and two rows with resistant checks ASD11 and PTB33 were sown at random in the seedboxes.

Leaffolder resistance in rice accessions.

Rice accession	Cross/Parents	Damage rating	
		Glasshouse (Coimbatore)	Field (Pondicherry)
RP 2068-18-2-9	Swarndhan/Veluthachera	3	1
RP 2068-184-2	Swarndhan/Veluthachea	5	3
RP 2068-18-4-5	Swarndhan/Veluthachera	3	3
IR4707-106-3-2	IR1888-156/IR2061-213-2 IR1561-228-3-3	3	3
Bangelei	Donor	5	3
ARC 6650	Donor	3	3
CO 29	Donor	5	3
PTB 12	Donor	5	3
TNAU LFR831333	Vaigai/ARC 10550	5	3
TNAU LFR832036	IR20/ARC 10550	3	1
TNAU LFR832038	IR20/Vazhaippoo Samba	5	3
TNAU LFR831311	CO 41/BKNBR1088-83	3	1
TNAU LFR832035	CO 41/BKNBR1088-83	3	3
TNAU LFR831331	Bhavani/T2005	3	3
ARC10660	Donor	3	3
W 1263	Donor	5	1
TKM 6	Donor	5	3
IET 5741	Imp. Sab./Sona	3	3
ASD11	(Resistant check)	3	–
FTB33	(Resistant check)	3	–
TN1	(Susceptible check)	9	5

On the 7th day of seeding the wooden seedboxes were transferred to iron trays (62 × 47 × 15 cm) filled with 5 cm of water. Twenty days after seeding, the plants in the seedboxes were covered with rectangular nylon net cages into which field-collected leaffolder moths were released continuously for 3 d at 20 moths/cage (♂:♀ 1:1). A cotton swab soaked in 1% sugar solution was hung inside the cage as food for the moths. Moths were allowed to oviposit for 3-4 d. Fifteen days after release of the moths, the leaffolder damage was assessed by counting the number of damaged leaves with reference to total leaves in each row, and infestation percentage was calculated. Based on infestation percentage, the accessions were rated for damage using the *Standard evaluation system for rice.*

The same accessions were screened in the field in two replications, at Pondicherry where leaffolder infestation was high.

Accessions RP2068-18-4-5, IR4707-106-3-2, ARC6650, ARC10660, TNAU LFR832035, and TNAU LFR831331 had a damage rating of 3 both in seedling screening and in the field. RP2068-18-2-9, TNAU LFR832036, and TNAU LFR 831311 had a score of 3 in seedling screening and 1 in the field (see table).

Promising long-duration lowland rices with resistance to key insect pests of kharif rice

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Host plant resistance to insect pests and diseases is the key to increased productivity of lowland kharif rice. Several promising lines from the crosses CR260 (CR151-79/CR1014), CR254 (Haldia-Magura/CR151-79), CR256 (Haldia-Magura/Pankaj) and CRM10 (Mahsuri mutant) adapted to lowlands (water stagnation of up to 60 cm), of long duration (145-180 d), and with good grain quality and high yields (3-5 t/ ha) were identified in recent years at CRRI. In wet season, however, the yellow stem borer *Scirpophaga incertulas* Walker and the gall midge *Orseolia oryzae* Wood-Mason limit production in many rice tracts. Pest-resistant cultivars can stabilize rice yields in these regions. We identified such cultivars from a set of 72 promising lines from the above crosses.

In six cultivars of CR260 grown in lowlands at CRRI in 1981 and 1982 kharif together with yield standards in replicated trials, stem borer incidence at heading was very high, up to 28.5% whiteheads (WH) in 1981 and 27.6% in 1982. Cultivar CR260-30 was outstanding and superior to the others with zero WH in 1981 and 0.3% in 1982.

In 1983 kharif, all 72 lines were field tested. Plants were infested by implanting 4 healthy, laboratory-laid 4-d-old borer egg masses per plant on 4 growing plants per cultivar 50-75 d after planting (DAP) (2 at 50-55 DAP, 1 at 65 DAP, and 1 at 75 DAP). Percentage of deadhearts (DH) was as high as 78.8; WH, 75.8; and gross borer infestation, 77.3. The following cultivars were identified as outstandingly superior to the others and superior to or on par with the resistant checks: CR260-163-238, CR260-151-81-2-710, CR260-176-1-702, CR260-167-247-179, CR260-228, and CR260-30 (Table 1). Sashyashree released as resistant to stem borer was highly susceptible with the egg mass implantation technique.

We tested all 72 cultivars in another replicated field trial in 1983 kharif. Plants were transplanted in Jul at 15 × 15 cm spacing, with high fertilizer input (150 + 50 + 50 kg N/ha). Lights were installed and 3-5 cm standing water was maintained to induce high gall midge infestation (up to 100% infested hills and 39.3% silvershoots) in susceptible Jaya. Although no entry was highly resistant, CR260-21-2-716, CR260-21-715, CR254-43-126, CR256-31-36, CR254-43-42-3, and CR260-30 were the least susceptible and significantly superior to the other cultivars and the susceptible check (Table 2).

Table 1. Some promising stem borer-resistant late-duration cultivars with implantation of egg masses on growing plants in field, kharif 1983, CRRI.[a]

Cultivar	DH (%)	WH (%)	Infestation (%)	Height (cm)	Duration (d)	Yield (t/ha)	Grain type
CR260-163-238	21.3	2.6	15.0	120	150	4.5	LS
CR260-151-81-2-710	14.3	nil	9.7	115	145	3.5	MS
CR260-176-1-702	22.4	3.1	17.3	125	150	4.0	MS
CR260-167-247-179	23.0	nil	10.0	125	155	4.0	MS
CR256-30-211-2-708	58.7	14.3	47.9	120	155	3.5	MS
CR260-151-224	80.0	nil	76.4	120	155	4.5	LS
CR260-228	29.6	NA	29.6	120	150	4.0	LS
CR260-30	22.5	5.0	17.4	130	185	4.5	MS
IR9828-23-1 (R check)	27.0	22.2	25.0				
IR15723-45-3-2-2-2 (R check)	28.6	27.8	28.0				
Jaya (S check)	51.7	73.1	61.8				
Sashyashree	78.8	75.8	77.3				

[a]R = resistant, S = susceptible, DH = deadhearts, WH = whiteheads, NA = not available, LS = long slender, MS = medium slender.

Table 2. Some promising gall midge-tolerant late-dulation cultivars. CRRI, 1983 kharif.

Cultivar	Mean % silvershoots	Angular values	Height (cm)	Duration (d)	Yield (t/ha)	Grain type[a]
CR260-21-2-716	14.6	22.43	110	145	4.0	MS
CR260-21-7 15	15.1	22.72	110	145	4.0	MS
CR254-43-126	12.4	21.50	130	155	4.5	SB
CR256-31-36	12.7	20.55	100	140	4.0	SB
CR254-43-42-3	12.5	22.73	130	155	4.0	SB
CR260-30	11.3	19.36	130	185	4.5	MS
CR260-85-230	31.7	34.23	120	160	4.0	MS
Jaya (susceptible check)	39.3		90	135	3.0	LB
CD 0.05		7.25				
CD 0.01		9.62				

[a]MS = medium slender, SB = short bold, LB = long bold.

CR260-30 was promising against both gall midge and yellow stem borers. Because of excellent grain quality, stable high yields, pest resistance, and tolerance for periodic submergence during flash floods, CR260-30 and other resistant cultures have become widely accepted by the lowland rice farmers of Orissa in recent years.

Field evaluation of rices for resistance to thrips

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Rice thrips *Baliothrips biformis* (Bagnall) cause serious damage to rice at the seedling stage and to the transplanted crop. Thrips incidence is severe during Jul-Sep at Coimbatore. We evaluated 62 rice accessions received from the All India Coordinated Rice Improvement Project (AICRIP) for field resistance to thrips during Sep 1985. Each accession was planted in a 3-m-long row at 20 × 15 cm spacing. The susceptible check TN1 was planted after every 10 accessions. The accessions were not replicated. Thirty days after planting, the accessions were rated for damage using the *Standard evaluation system for rice.*

Of the 62 rice accessions screened, 14 had resistance (score of 1) to *Baliothrips biformis:* IET7568, IE-1-7575, IET8659, IET8661, IET9177, Manoharsali, RP2068-18-26, RP2068-18-2-9, RP2068-18-4-2, RP2068-32-2-3, RP2069-3-5-2-2, VRS286-4-1, WGL47969, and WGL47970.

Screening of rice cultivars against rice whorl maggot (RWM)

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In 1984 kharif, 219 rice cultivars were screened against RWM *Hydrellia philippina* Ferino in the National Screening Nursery Programme at Masodha. At 20 d after transplanting, damage reached a maximum of 51% in KP20. Among the entries. 7 had more than 40% damage and were considered highly susceptible; 42 scored between 15 and 25% damage and were considered moderately resistant. None had below 15% damage (see table).

Cultivars rated as highly susceptible and moderately resistant to RWM. Faizabad, India, 1984 kharif.

Designation	Cross combination	Leaf damage (%)
	Highly susceptible	
RP20	Jaya/ARC5848	51.0
RP21	Jaya/ARC5848	46.5
NDR88-1-1	IR36/T21	42.8
HKRll3	–	42.7
HAUK6-11-1-1-1	IR28/Basmati 370	42.7
TNAU83735	TKM6 mutant	42.3
RP1579-1613-35	RPW6-17/ARC6650	41.3
	Moderately resistant	
CR13-3512-8	–	15.7
IR1820-154-3-2-2-3	–	16.7
RNR10208	–	16.7
CR404-20	–	17.1
RP1641-594-2 B	Vikram/Benong III	17.5
RP2199-271-13	TKM6/Phalguna	18.2
RP2091-272-4-5-3	IR32/Phalguna	18.4
MTU534122	–	18.5
NRL 88-95	–	18.9
NDR309	IR36/Saket-l	19.3
OR489-80-22	IR2070-1054/Shakti	19.6
SYE104-9-32	SKL6/Kakeri	21.5
OR448-7-1	ORl58-7-1/IR28	21.4
TNAU83095	TNAU6464/TKM9	21.4
VL27	–	21.7
HKR117	–	21.7
PR25	Jaya/BR34	21.8
BAU149-2	Bala/Blackgora	21.9
KJT2-32-43-20	KJT-2-3243-20/K 35-3//RPW-6-15	21.9
RP1125-629-2-1	RPW 6-13/Ptb 2	22.0
BAU149-27	Bala/BIackgora	22.5
BAU152-64-7	IR2058-436/IR854-65// IR2070-423-2-56	22.6
DSI 15	–	22.6
BAU11-54	Mutant 14/IET5374	22.9
CR406-16	–	22.9
OR371-IP-2	Obs 677/IR2070-423-5	23.1
BS54	Bhawani/IR20	23.2
SYE158-32-36-23	Tuljapur-l/Cauvery	23.2
CRM10-4733-11-422	–	23.2
OR451-3-2	Dasal/OR132-127	23.5
RP2087-14-6-12.4	IET5854/IET6314	23.5
RNR89128	–	23.5
UPR82-83	–	23.5
BAU147-2-2	Mutant gora/N22	23.5
VRS163-2-2-3	–	23.8
IR28224-66-3-2	–	24.2
RNR64118	–	24.2
BAU149-2A	Bala/Blackgora	24.2
OR377-85-6	IR2061628-2-6-4-3/N22	24.4
TNAU83736	TKM6 mutant	24.5
PR27	–	24.6
TNAU83091	TNAU6464/TKM9	24.7

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Genetic Evaluation and Utilization

ADVERSE SOILS TOLERANCE

Effect of soil acidity on germination of rice

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Ninety germplasms from the 1985 Acid Lowland Soils Screening Set (I RTP) were evaluated for direct seeding in saline acid lowland soils, where high germination is a prerequisite.

Seeds were sown in triplicate, at 20 seeds/dish, in petri dishes containing 60 g of soil (silty clay) having ECe 11.3 dS/m and pH 3.2. After sowing, 40 ml of distilled water was added immediately and 10 ml water at 5d intervals. The dishes were kept at room temperature (30°C) in the laboratory for 15 d. Germination was recorded daily and the average height of seedlings per dish was measured on day 15 (see table).

Of the 90 lines, 45 did not germinate. Five entries had more than 80% germination and another 5 had 70-80%. These 10 lines seem to be promising in acid saline soils.

Germination of rice germplasm in acid soil (pH 3.2, ECe 11.3 dS/m). West Bengal, India.

Varieties and lines with indicated germination percentage			
100–80%	79–10%	69–50%	49–40%
IR13423-17-1-2-1	IR13149-43-2	B2149b-Pn-26-1-1	BW295-4
IR19661-13-3-2	IR13419-113-1	IR13146-45-2	IR13168-143-1
ITA230	IR25588-7-3-1	IR13146-45-2-3	IR32
Khao Tah Haeng 17	IR31917-31-3-2	IR9764-45-2-2	IR42
Mahsuri	IR3839-1		IR4227-109-1-3-3
			IR5
			IR8192-31-2-1-2
Average height on day 15 (cm)			
6.7	6.7	6.4	5.7

Field screening of rice cultivars in acid sulfate soils, South China

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In the more than 67,000 ha of acid sulfate soil and acid sulfate swamp in China, major factors limiting rice growth are low pH, Fe and Al toxicity, P deficiency, and excess sulfate.

Eighteen rice varieties and lines (15 from the International Rice Testing Program) were screened under 2 fertilizer treatments, N + K and N + K + P + Ca, in an acid sulfate soil (Table 1) at Duanfen, Taishan county, Guangdong Province, Apr 1985. The amount of

Table 1. Chemical characteristics of the acid sulfate soil at Duanfen, South China.

Item	Depth (cm)	
	0-15	30-40
pH (H_2O)	3.85	3.07
pH (KCl)	3.17	2.65
Total N (%)	0.221	0.170
Organic C (%)	3.13	3.19
Available P (Olsen, ppm)	1.63	1.53
Exchangeable K (meq/100 g)	0.290	0.490
Available Zn (ppm)	7.8	8.0
Water soluble SO_4 (meq/100 g)	0.44	4.59
Active Fe (%)	2.7	2.36
Active Mn (ppm)	20.1	25.1
Particle size (%)		
Sand (0-0.05 mm)	6.6	23.8
Silt (0.05-0.001 mm)	62.9	52.6
Clay (<0.001 mm)	30.4	23.6

Table 2. Iron toxicity tolerance scores and yields of rice with 2 fertilizer treatments on an acid sulfate soil, Duanfen, South China.[a]

Variety	Iron toxicity tolerance scores[b]		
	4 WT	8 WT	Grain yield[c] (g/plot)
	40 kg N + 33 kg K/ha		
IR36	3.5 bc	2.0 ab	725 cd
IR50	3.5 bc	2.3 cd	815 bcd
IR58	3.4 ab	2.2 bcd	540 f
IR19058-107-1	3.6 bc	2.3 cd	125 cd
IR29725-22-3-3-3	4.0 d	2.5 d	460 f
IR13427-60-1-3-2-2	3.1 cd	2.3 bcd	750 cd
Duansan (local variety)	3.5 bc	2.1 abc	760 cd
Shanyou (hybrid variety)	3.5 bc	2.1 abc	915 ab
Guichao (local variety)	3.1 a	1.9 a	1085 a
	40 kg N + 33 kg K + 17.6 kg P + 3000 kg CaO/ha		
IR36	2.9 a	2.1 ab	150 cdef
IR50	3.1 a	2.3 abc	790 bcd
IR58	2.9 a	2.6 c	757 f
IR19058-107-1	2.9 a	2.3 abc	735 def
IR29725-22-3-3-3	3.4 a	2.4 bc	515 f
IR13427-60-1-3-2-2	3.5 a	2.4 bc	700 def
Duansan (local variety)	3.1 a	2.5 c	935 ab
Shanyou (hybrid variety)	3.0 a	2.4 bc	925 abc
Guichao (local variety)	2.9 a	2.0 a	1060 a

[a]In the column in the same treatment, values followed by the same letter are not significantly different at the 5% level. [b]1 = normal plant, 9 = nearly dead or dead plant, 3 = tolerant, 6 or more = susceptible. WT = weeks after transplanting. [c]Av of 3 replications.

fertilizer was 40 kg N (urea), 17.6 kg P (superphosphate), 33 kg K (potassium chloride), and 3,000 kg CaO (calcium carbonate)/ ha .

Forty-day-old seedlings were planted at 20-× 20cm spacing in a randomized complete block design. Plants were scored for Fe toxicity on a 1-9 scale at 4 and 8 wk after transplanting. Grain yield was recorded at maturity.

Varietal differences in tolerance for Fe toxicity were noticed. Fe toxicity was more severe at 4 wk than at 8 wk after transplanting (Table 2). Addition of P and Ca fertilizers reduced its extent. Local variety Guichao yielded significantly more than any of the test varieties.

Genetic Evaluation and Utilization

HYBRID RICE

Experimental mutagenic method for improving rice strains in Vietnam

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The National Strain Testing Centre (NSTC) of Vietnam has tested two rice mutants. Mutant DB250 is the result of irradiating F_1 dry grains from the cross of TB_1 (a Vietnamese local variety) and IR22 at 25 kR along with 0.02% N-Nitrozo N-dimethylurea as spray for 6 h.

DB250 is 1.35-1.50 m high, has a hard and big culm, is adapted to deep water, and responds to 120 kg N/ha. It was submerged 7-10 d after 4 wk of culture, but mortality was not high. At maximum tillering, submergence for 12 d resulted in 20% mortality, compared with 80% for IR27 and several IRRI strains. DB250 has a 1000-grain weight of 26-27 g and yields 4.5 t ha over a large area. In NST-C tests in 1980-83 in 14 provinces of the North, DB250 was first among 16 adapted submergence-tolerant rices.

Mutant NN22-98 was obtained in 1973 by treating IR22 grains with 0.02% N-NitroLoethylurea for 18 h (pH 7). It was separated from the M_2 population in 1974.

NN22-98 is 1.2-1.4 m high, has a hard culm, is adapted to deep water, and responds to as much as 100 kg N/ ha. Its 1,000-grain weight is 29-31 g, compared with the normal 23-25 g. The plant has field resistance to brown planthopper biotypes 1 and 2. Mean yield is 4.4-4.6 t/ha. Grain quality is better than that of IR22.

NN22-98 was third among 16 strains of summer rice tested by the NSTC in 1980-83 in 19 provinces of the North. It is still being tested by the Ministry of Agriculture.

Comparison of rice hybrids and local varieties at TNRRI

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Seven rice hybrids from IRRI were tested against three short-duration and five medium-duration Tamil Nadu varieties during 1984 kharif. The trial was laid out in a randomized block with three replications. The 24-d-old seedlings were planted, 1 seedling/ hill spaced 20 cm between rows and 15 cm within rows, in 10.35 m^2 plots and fertilized 100-50-50 kg NPK/ ha. No plant protection measures were taken, as there was no pest or disease incidence during growth.

Performance of rice hybrids and local varieties. TNRRI, Aduthurai, India.

Hybrid and variety	Days to 50% flowering	Height (cm)	Yield (t/ha)
Wei You 64	72	89.6	4.5
IR46831A/IR54	87	87.5	4.2
IR41828A/Milyang 54	77	81.9	3.7
IR365A/Milyang 54	87	93.7	3.5
97A/Milyang 54	78	97.3	3.1
IR21895-90-3A/IR54	106	123.3	4.0
IR46830A/IR13292-5-2	106	89.4	4.2
IR50 (IR2153-14-1-6-2/IR28//IR36)	76	85.3	4.1
TKM9 (TKM7/IR8)	77	94.9	4.0
ADT36 (Tiruveni/IR20)	79	94.3	4.0
Co 42 (RP-31-49-2/Lab Muey Mahag)	102	124.0	4.2
IR20 (Peta*3/TN1//TKM6)	103	104.4	3.9
Co 44 (ASD5/IR20)	99	104.4	4.1
Co 43 (Dasal/IR20)	99	101.4	4.0
White Ponni (AD)	101	152.8	3.9
CD			3.8
CV			9.5

Among the hybrids studied, Wei You 64 flowered very early (72 d after seeding [DAS]); I R21895-90-3A/ IR54 and IR46830A/ IR 13292-5-2 flowered late (106 DAS). The remaining hybrids flowered between 77 and 87 DAS (see table).

IR21895-90-3A/IR54 was tallest of the hybrids, and lodged. White Ponni (AD), one of the medium-duration tall check varieties, also lodged. Check Co 42 partly lodged.

Although yield differences among the hybrids and the check varieties were significant, the yield potential of the hybrids was less than 4.5 t/ha. The maximum yield (4.5 t/ha) was registered by Wei You 64, against 4.03 t/ha registered by early-maturing check variety IR50 and 4.05 t/ha by TKM9.

Of the 2 mediumduration hybrids. IR46830A/IRl3292-5-2 registered the highest yield (4.2 t/ha), on a par with the yield of local check Co 42. Although the hybrid had a long panicle (av length 29.4 cm), high spikelet sterility (40%) reduced the yield.

Genetic Evaluation and Utilization

TISSUE CULTURE

Anther culture of Basmati 370 at IRRI. A. Gamma ray-induced green plant regeneration

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Breeding studies for the improvement of high quality Basmati rice have long been undertaken. So far no variety comparable or superior to Basmati rice has been released.

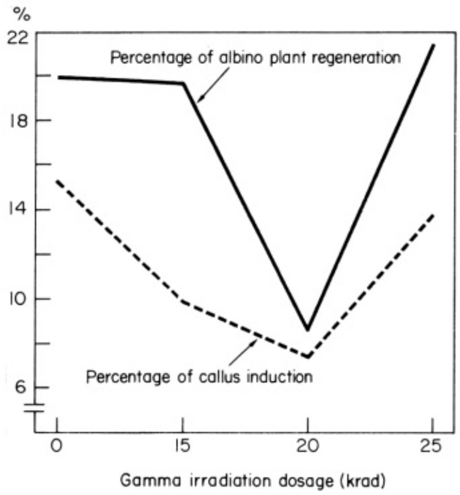
We conducted experiments on the improvement of the Basmati-type rice through anther culture in the Tissue Culture Facility at IRRI. Gametoclonal variants for plant type and soil constraints can be obtained and consequently fixed when anthers of rice varieties are passed through anther culture. Preliminary studies (Table 1) using different callus induction media showed the predominance of albino plant regeneration. Green plant regeneration was not observed.

To find out if irradiation stress would produce genetic alterations in the cell which would improve callus induction and green plant regeneration. Basmati 370 seeds were subjected to irradiation dosages of 15, 20, and 25 krad at an application dose rate of 1.2 krad / min from Cobalt 60 gamma cell. Anthers collected from plants of irradiated seeds in the middle uninucleate to early binucleate stages of pollen development were plated in G4 medium (E10 medium without glucose). Calli produced were transferred to a liquid Murashige and Skoog (MS) regeneration medium with 1 mg kinetin/liter, 1 mg naphthalene acetic acid/liter, and 20 mg abscisic acid (ABA)/ liter for 4 wk and then to ABA-free semisolid MS regeneration medium.

Table 1. Anther culture of Basmati 370 in three media.

Media[a]	Callus production (%)	Calli plated (no.)	Albino plant production (no.)
E10	5.71	41	148.78
E10 M	2.56	10	80
E10 T	1.29	6	50

[a] E10 consists of Gamborg's B5-basic media with 1 mg 2,4 dichloro-phenoxyacetic acid 2,4-D/liter, 0.5 mg 6-benzylaminopurine (BAP)/ liter, 0.5 mg indole-3-acetic acid (IAA)/liter, and 5 mg glucose/liter; E10M consists of E10 with 0.002 M 2 [N-morpholine] ethane sulfonic acid; E10T consists of E10 without 2,4-D, but with 1.5 mg 2,4-5 trichlorophenoxy acetic acid/liter.



Percentage of callus induction and albino plant regeneration as affected by gamma irradiation dosage on Basmati 370.

Callus production percentage and albino plant regeneration (Fig. 1) were lowest at 20 krad. Green plant regeneration was observed only in 20 krad gamma ray (Table 2). These results show that genetic alterations may have been induced by gamma irradiation which decreased callus production efficiency, but lessened albinism, and triggered green plant regeneration. Although irradiation was directed randomly to the plant cells, genetic alterations manifested were favorable for green plant regeneration.

Table 2. Effect of irradiation on plant regeneration of Basmati 370 in G4 medium.

Irradiation dosage (krad)	Calli plated (no.)	Calli with green plants (%)
0	10	0
15	61	0
20	23	26.1
25	84	0

We are screening regenerated green plants for agronomic characters and yield.

Anther culture of Basmati 370 at IRRI. B. Effect of glucose in anther culture of irradiated Basmati 370

F.J. Zapata. K.K. Aldemita, L.B. Torrizo, A. U. Novero, S. K. Raina, and R. R. Rola, IRRI

Previous report on the anther culture of Basmati 370 showed that applying 20 krad gamma rays to rice seeds triggered green plant regeneration. However, callus production efficiency remained low. To improve callus induction, glucose was added to the medium.

Anthers derived from 20 krad irradiated plants at middle uninucleate to early binucleate stages of pollen development were plated in 2 liquid callus induction media consisting of basic Gamborg's medium with 1 mg 2,4-D/ liter, 0.5 mg indole-3-acetic acid (IAA)/ liter, 0.5 mg 6-benzylaminopurine (BAP)/ liter and 5 g glucose/ liter (E10), and without glucose (G4). Calli produced were transferred to a liquid Murashige and Skoog (MS) regeneration medium with 1 mg kinetin/liter and 1 mg naphthalene acetic acid/liter and 20 mg abscisic acid (ABA)/liter for 4 wk and then to ABA-free semisolid MS regeneration medium.

Results (Table 1) showed that at 20 krad, glucose addition increased callus production efficiency. Irradiation at 20 krad resulted in genetic alterations in the irradiated seeds such that adding glucose is necessary to induce high percentage of callus production. Such an improved efficiency may have been brought about by an increased requirement for glucose uptake and metabolism and by a change in the requirement of other cells for osmoticum.

Studies on plant regeneration showed that percentage of calli producing albino plants and average albino plant production were higher in E10 compared to G4, but the reverse was true in green plant regeneration (Table 2). This indicates that although glucose enhances callus production and albinism, it diminishes green plant regeneration.

Table 1. Effect of glucose on irradiated Basmati 370 plants.

Media[a]	Irradiation dosage (krad)	Anthers plated (no.)	Calli produced (no.)	Callus production (%)
E10	0	1910	221	11.6
	20	694	220	31.7
G4	0	506	77	15.2
	20	708	52	7.3

[a]E10 = with 5 g glucose/liter, G4 = without glucose.

Table 2. Effect of glucose on plant regeneration of irradiated Basmati 370.

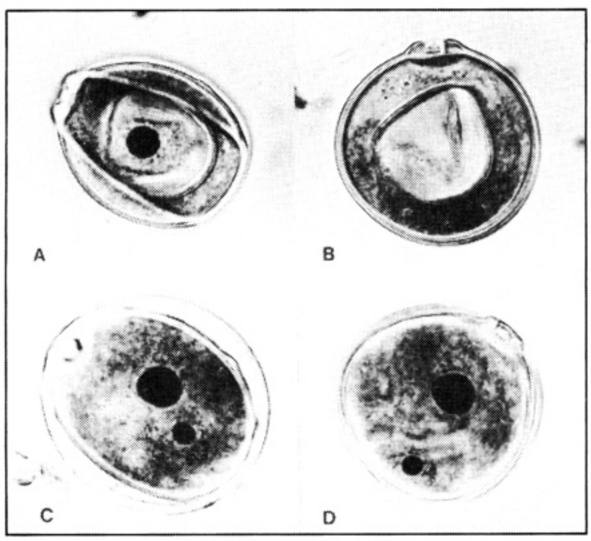
Media[a]	Irradiation dosage (krad)	Total calli plated (no.)	Calli with green plants (%)	Av green plant production	Calli with albino plants (%)	Av albino plant production
E10	0	60	0	0	15.00	4.6
	20	84	1.2	5	34.52	1.79
G4	0	10	0	0	10.00	2
	20	23	26.1	5.2	8.7	1

[a]E10 = with 5 g glucose/liter, G4 = without glucose.

Effect of pollen development stage on callus induction and its relation to auricle distance in two rice varieties

S. T. Mercy and F.J. Zapata, Tissue Culture Facility, IRRI

Callus production from uninucleate and binucleate pollen of japonica varieties Taipei 309 and Kulu was evaluated. Nuclear stages of pollen from panicles with auricle distances varying between 4.5 and 12.5 cm were scored before plating. A cold shock of 8°C for 8 d was given. Two liquid media, G4 and E10, were used. G4 contained B5 salts, vitamins, 20 g sucrose, 1 mg 2,4-D and 0.5 mg each of BAP and IAA/liter. E10 had an additional 5 g glucose/liter. Calli induced were scored 90 d after plating.



Stages of pollen development: A. mid-uninucleate, B. late uninucleate, C. early binucleate, D. mid-binucleate.

As overlapping of nuclear developmental stages was common (in the same spikelet, different pollen nuclei showed combinations of early and mid-uninucleate, mid- and late uninucleate, late uninucleate and early binucleate, etc.), the stage of each half of the panicle used for inoculation was fixed on the basis of the nuclear stage found in the majority (75%) of the pollen stained. Plating of spikelets which had both uninucleate and binucleate pollen was avoided. Early uninucleate and late binucleate stages were discarded and only panicles with either mid- to late uninucleate or early to mid-binucleate pollen (see figure) were used for inoculation.

The nuclear stage of the pollen could be approximated to some extent by external features of the spikelet, but such visual scoring was often erroneous. Microscopic scoring was done to determine pollen stage. Uninucleate stage anthers of both varieties induced a very high number of calli; those in the binucleate stage showed less (see table). Taipei 309 responded better to E10, while Kulu was better in G4.

Auricle distances of panicles could not be correlated with stage of pollen nuclear development and callus production efficiency. In both varieties,

Relation between auricle distance, nuclear stage,[a] and callus induction in anther culture of Taipei 309 and Kulu. IRRI, 1986.

Taipei 309

Auricle distance (cm)	5.0		6.5		7.0		7.5		8.0		8.5		9.0		12.5	
Stage of pollen	UN	BN	UN	BN	UN	BN	UN	BN	UN	BN	UN	BN	UN	BN	UN	BN
Anthers plated (no.)	125	50	75	175	125	75	200	175	500	200	175	125	475	200	–	100
Calli induced (no.)	807	503	117	410	2278	538	1825	1021	3168	204	809	249	3951	447	–	373

Kulu

Auricle distance (cm)	4.5		1.5		8.0		8.25		8.5		9.0		9.5		11.5	
Stage of pollen	UN	BN	UN	BN	UN	BN	UN	BN	UN	BN	UN	BN	UN	BN	UN	BN
Anthers plated (no.)	175	–	125	–	225	–	100	150	125	–	150	550	400	175	375	250
Calli induced (no.)	42	–	196	–	1923	–	0	916	1877	–	350	250	1016	0	1905	345

[a]UN = uninucleate, BN = binucleate.

panicles of varying auricle distances had both uninucleate and binucleate pollen (see table). In Taipei 309, panicles with 12.5 cm auricle distances were as efficient as those with 8.5 cm distance; in Kulu, panicles with 11.5 and 8.25 cm auricle distances were equal in total callus production. The most efficient auricle distances for callus induction were 7.0 cm in Taipei 309 and 8.5 in Kulu.

The very high callus induction frequency recorded may be due to the long induction period (90 d) and the use of a liquid medium for callus induction. A liquid medium allows for fast dispersal of calli away from the anther, leading to the production of more and more calli by lessening overcrowding within the responding anther. The calli can also undergo fragmentation in the medium, causing an apparent increase in the efficiency of callus induction.

Plant regeneration and screening from long-term NaCl-stressed rice callus

F. J. Zapata and E.M. Abrigo, Tissue Culture Facility, IRRI

Salinity is one of the major causes of reduced productivity in rice growing areas. Tissue culture could complement breeding techniques to produce variants which are tolerant of salt. The objectives of our study were to regenerate rice plants from long-term NaCl-stressed callus of variety Reiho and to determine if there is a direct relationship between tolerance for salt at the cellular level and at the plant level.

The response of calli of variety Reiho in different concentrations of NaCl.

Treatment (g NaCl/liter)	Initial weight[a] (g)	Final weight (g)	Relative increase in weight[b] (%)
0	0.0498	0.6882	1281.93
5	0.0513	0.6446	1156.53
10	0.0512	0.4551	788.87
15	0.0497	0.2762	455.73
20	0.0521	0.1607	208.44

[a]Average of 10 calli.
[b]$\frac{\text{Final weight} - \text{initial wejght}}{\text{Initial weight}} \times 100.$

Dehulled mature seeds of variety Reiho were surface-sterilized with 70% ethyl alcohol followed by 0.1% mercuric chloride, then washed 4 times with sterile distilled water. The seeds were inoculated on Murashige and Skoog's medium (MSYC) with 2 mg 2,4-D/ liter, 2 g casein hydrolysate/liter, 2 g yeast extract/liter, 30 g sucrose: liter and 8 g agar/liter at pH 5.8. The induced calli were allowed to proliferate for 4 wk (1 passage).

The proliferated calli were inoculated on selection medium (MSYC with 15 g NaCl/liter) and transferred to fresh medium every 4 wk. The cultures were kept in darkness with temperature maintained at 26-27 °C. After 32 passages, calli were transferred to Linsmaier and Skoog's regeneration medium with 1 mg benzylaminopurine/liter, 0.5 mg a-naphthaleneacetic acid/liter, 40 g sucrose/liter, and 8 g agar; liter at pH 5.8. The cultures were kept under continuous light (3 klx) at 26-27°C.

Eighteen individual calli stressed with NaCl were transferred to regeneration medium and only 30% produced plants totalling 35. The regenerated plants were grown in Yoshida's culture solution for 30 d and then transferred to the same solution with different concentrations of NaCl: 0, 5, 10, and 15 g liter.

Although the calli tolerated exposure to 1.5% NaCl for 32 passages (32 mo), the regenerated plants did not survive when grown in culture solution containing 5, 10, and 15 g NaCl liter. Plants kept on control (no NaCI) flowered, but showed 100% sterility. The regenerated plants did not carry the NaCl tolerance trait present in the calli.

The regenerated plants exposed to different concentrations of NaCl showed an inverse relationship between the number of days of survival and NaCl concentration in the culture solution.

Similarly, calli that have been cultured in NaCl-enriched medium (15 g NaCl/ liter) for 32 mo were placed in different concentrations of NaCl. Calli growth was inversely proportional to the concentration of NaCl in the medium. suggesting that stressed cells have only physiologically adjusted to high NaCl concentrations but are not truly mutants (see table).

Preliminary studies on the chromosome number of the regenerated plants show aneuploidy, a chromosomal abnormality that may have been induced by the prolonged exposure of the calli to the *in vitro* culture conditions.

This is the first report on green plant regeneration from salt-stressed, long-term somatic cell culture.

Effect of sucrose on callus induction and plant regeneration in Taipei 309

S. T. Mercy and F.J. Zapata, Tissue Culture Facility, IRRI

The influence of sucrose on the callusing ability of japonica rice variety Taipei 309 anthers was compared in three induction media: N6, potato medium, and E 10 (modified B5). The N6 and potato media had 60 and 120 g sucrose with 2 mg 2,4-D/liter. The E10 medium had 20, 60, and 120 g sucrose in addition to 5 g glucose/liter with 1 mg 2,4-D/liter, 0.5 mg BAP/ liter, and 0.5 mg IAA/ liter. Regeneration for all treatments was done in standard MS medium with 30 g sucrose/ liter, 1 mg kinetin/ liter, and 1 mg NAA/ liter.

All calli transferred for regeneration were healthy and compactly growing, with a pale yellowish white appearance. But only 9-22% differentiated into green plants in the treatments. Some calli produced green as well as albino plantlets. Altering the cytokinin-auxin ratio of the regeneration medium to 2 mg kinetin/liter + 0.5 mg NAA/ liter did not change the differentiation pattern.

Influence of sucrose on callusing of anthers and differentiation of plantlets in Taipei 309.[a] IRRI, 1986.

Medium	Sucrose concentration (%)	Inoculated anthers (no.)	Callusing anthers (%)	Calli (no.) transferred for regeneration	Calli (no.) differentiating into: Green or green + albino plantlets	Albino plantlets only	Roots only
N6	6	800	23	198	34	23	7
N6 A	12	850	32	209	45	36	10
P	6	900	26	216	20	35	12
PA	12	800	37	245	40	47	14
E10	2	900	20	197	22	11	9
E10 A	6	900	28	234	37	33	15
E10 B	12	950	45	283	51	48	22

[a] N6, E10, and potato media were used for callus induction, and MS medium for plantlet regeneration.

In calli induced by the N6 medium, more calli differentiated into green plants than into albinos. The reverse pattern appeared with the potato medium. On the E10 medium (B5), green and albino plantlets were produced in about equal proportions (see table). About 36% of the calli that differentiated produced roots only. In all three media, at higher sucrose levels more calli and more green plants were produced, although the frequency of albino plants was also higher.

Results indicate that higher concentrations of sucrose can be advantageously used to increase green plantlet regeneration.

Heat treatment to increase callus induction efficiency in anther culture of IR42

F.J. Zapata and L.B. Torrizo, Tissue Culture Facility, IRRI

Indica rices are generally regarded as recalcitrant varieties in anther culture because of their low, if ever, callus production and plant regeneration efficiencies. IR42 is one of the more important IR varieties because of its resistance to major insect pests and diseases and high yielding ability. One of the drawbacks to its popularity in farmers' fields, however, is its late maturity. It is important to get variants that not only retain IR42's agronomic characteristics but also are early maturing. Anther culture can be a potential tool for producing such variants but the problem of callus induction and plant regeneration efficiencies should first be solved. By applying heat treatment to rice panicles before culturing the anthers and manipulating media components, we were able to increase callus production in IR42.

Rice panicles with 5-10 cm distance between the auricle of the flag leaf and that of the subtending leaf were collected for the study. Each panicle was divided into the upper and bottom portions and a floret was collected from the middle section of each half for determination of the stage of pollen development. Only anthers with pollen grains between the mid-uninucleate to early binucleate stages of development were plated. The remaining spikelets of each portion were divided into 3 lots and placed separately in petri dishes

Effect of heat treatment on callus induction efficiency in IR42 anther culture.

Treatment	Anthers plated (no.)	Calli produced (no.)	% callus production
	E10 medium		
H_0	345	34	9.8
H_5	623	76	12.2
H_{15}	439	90	20.5
	ER medium		
H_0	565	64	11.3
H_5	706	102	14.4
H_{15}	577	84	14.6

containing 1.5% water agar. Each lot was subjected to 1 of the following heat treatments at 35 °C: 0, 5, and 15 min, followed by a cold treatment at 10 °C for 7 d. Anthers from all treatments were plated in two media which contain the salts and vitamins of Gamborg's B5 medium but differ in growth regulators. E10 contained 0.5 g benzyladenine/liter,

0.5 mg indole acetic acid/liter, and 1 mg 2,4-D/ liter while ER had 0.11 mg zeatin/liter, 2 mg 2,4-D/liter, and 0.07 mg picloram/liter.

Heat treatment increased callus induction efficiency in both media (see table). At 0 and 5 min, ER induced higher efficiencies than E10. At 15 min, however, there was a dramatic increase using E10 media. Cold shock, which has been a part of the standard operational procedure in anther culture in most cereals, promotes the synchrony and viability of the pollen grains and may activate some enzymes which are necessary in callus production. On the other hand, heat treatment has been popular in *Brassica* genus. This study demonstrates that heat treatment before cold shock could increase callus production in IR42. In the same manner as in cold shock, heat may. aside from promoting synchrony and viability, activate enzymes necessary to induce the pollen grains toward vegetative development (in this case, callus production) instead of their normal generative function.

Some of the calli produced have been transferred to plant regeneration medium to determine the plant regeneration efficiency after heat treatment.

Pest Control and Management

DISEASES

Seedling age in relation to sheath rot (ShR) occurrence in rice

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ShR caused by *Sarocladium oryzae* is becoming an important disease in rainfed lowland rice, especially in delayed plantings. In 1984 wet season, ShR occurrence was observed in a replicated yield trial comprising 32 entries. Seedlings (25- and 50-d-old) were transplanted in 3 replications in 11-m^2 plots; 60 kg N/ha, 18 kg P/ha, and 17 kg K/ha were applied. N was used in 4 splits: 1/4 basal and the remaining as topdressing in 3 splits. Scoring followed the 1980 *Standard evaluation system for rice* at harvest under natural infection. The maximum score over three replications was recorded to avoid escapes.

ShR score and other characters of 32 varieties.

Variety	ShR score [a]		Av days to 50% flowering	Photoperiod sensitivity [b]	Plant height [c]
	25 d	50 d			
RAUSBS80-565	1	5	124	S	9
RAUSBS 80-566	3	5	124	S	9
RAUSBS 80-571	1	5	121	S	9
TCA190-1	1	3	132	S	9
TCA72	1	1	115	S	9
TCA148-3	1	3	115	S	9
TCA80-4	1	5	115	I	5
TCA48	1	1	115	S	9
TCA225	1	3	122	S	9
TCA227	1	1	125	S	9
RAUSBS 80-585	5	9	124	S	9
RP1491-24	5	9	122	I	1
RAU83-18-8	1	5	116	I	1
R114-2-1-1-1	9	9	128	I	1
IR4570-74-2-2-3-3	1	5	108	I	1
MTU7029 (Swarna)	7	9	122	I	1
RAU73-16-1-40-1	1	3	112	I	1
CR1002	1	9	119	I	1
RAU83-8-4	5	5	111	I	1
Pankaj	5	9	121	I	1
BR8	1	3	117	S	9
Jaishree	1	9	120	I	9
Mahsuri	3	5	115	I	9
Radha	5	9	115	I	5
BR34	3	3	108	S	9
Janki (64-117)	1	3	114	S	9
IR4819-17-3-2	3	9	112	I	1
CR1009 (Savitri)	9	9	102	I	1
ET759 1	1	7	123	I	1
IET6286	1	3	115	I	5
IR13146-45-2-3	7	9	115	I	1
RP975-109-2	5	9	120	I	1
Mean	2.9	5.7			

[a]By SES. [b]S = photoperiod sensitive, I = photoperiod insensitive. [c]1 = semidwarf, 5 = intermediate, 9 = tall.

ShR occurrence was high in 50-d-old seedlings. TCA72, TCA48, and TCA227 were highly resistant at both ages. CR1002, Jaishree, IR4819-17-3-2, and IET7591, which were resistant at 25 d were susceptible to highly susceptible when transplanted at 50 d (see table). TCAl90-1, TCA148-3, TCA225, lR4570-74-2-2-3-3, RAU73-76-140-1, BR8, BR34, Janaki, and IET6286 were resistant to moderately resistant at both ages. In general, photoperiod-sensitive tall varieties were more resistant than photoperiod-insensitive ones. The mean score was 2.9 for 25d-old seedlings and 5.7 for 50-d-old.

Rice grassy stunt (GSV) and rice ragged stunt (RSV) carriers

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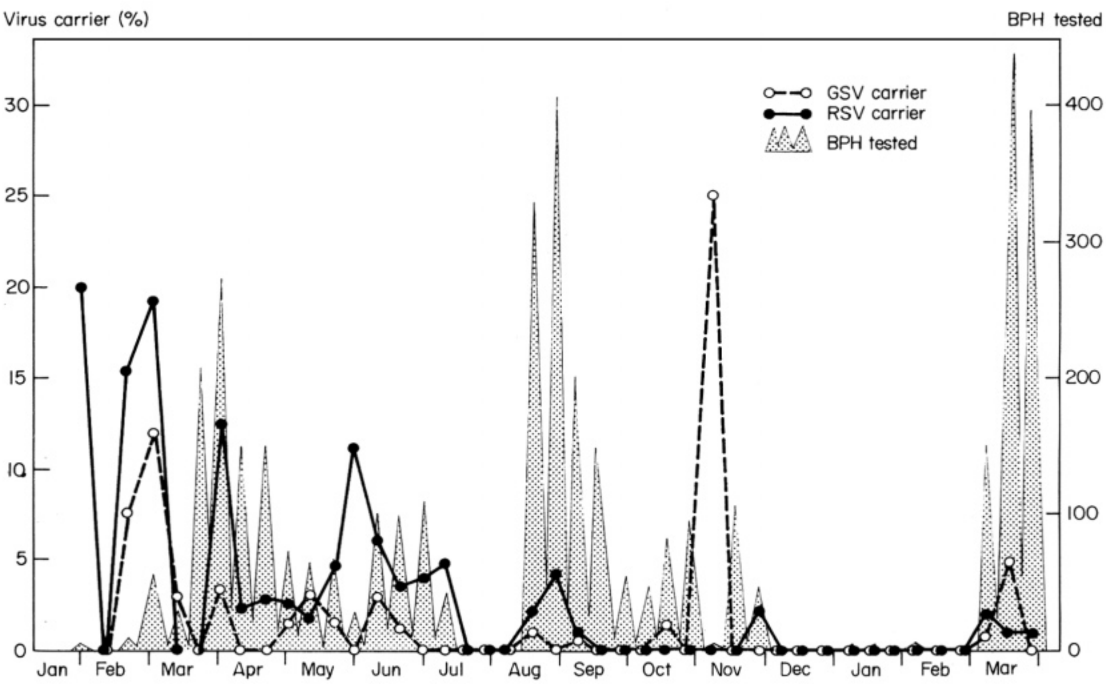
ELISA tests on brown planthopper (BPH) *Nilaparvata lugens* collected daily in a high-beam light trap on the top of a three-floor building at IRRI were conducted to identify GSV and RSV carriers. The light trap was designed to catch migrating BPH.

Individual BPH were homogenized with 0.50 ml-0.02 M phosphate buffer

GSV and RSV carriers in BPH caught in a high-beam light trap, IRRI, 1983–84.

Collection dates	BPH tested	GSV carrier		RSV carrier		Collection dates	BPH tested	GSV carrier		RSV carrier	
	no.	no.	%	no.	%		no.	no.	%	no.	%
28 Jan-6 Feb	5	0	–	1	20.0	5-14 Sep	199	1	0.5	2	1.0
7-16 Feb	0	–	–	–	–	15-24 Sep	145	0	–	0	–
17-26 Feb	13	1	7.7	2	15.4	25 Sep-4 Oct	55	0	–	0	–
27 Feb-8 Mar	67	8	11.9	13	19.4	5-14 Oct	43	0	–	0	–
9-18 Mar	33	1	3.0	0	–	15-24 Oct	77	1	1.3	0	–
19-28 Mar	207	0	–	0	–	25 Oct-3 Nov	92	0	–	0	–
29 Mar-7 Apr	271	9	3.3	34	12.5	4-13 Nov	4	1	25.0	0	–
8-17 Apr	134	0	–	3	2.2	14-23 Nov	109	0	–	0	–
18-27 Apr	139	0	–	4	2.9	24 Nov-3 Dec	45	0	–	1	2.2
28 Apr-7 May	74	1	1.4	2	2.7	4-13 Dec	0	–	–	–	–
8-17 May	50	2	3. 3	1	1.7	14-23 Dec	0	–	–	–	–
18-27 May	65	1	1.5	3	4.6	24 Dec-3 Jan 1984	0	–	–	–	–
28 May-6 Jun	27	0	–	3	11.1	4-13 Jan	2	–	–	–	–
7-16 Jun	99	3	3.0	6	6.1	14-23 Jan	2	–	–	–	–
17-26 Jun	91	1	1.1	3	3.3	24 Jan-2 Feb	0	–	–	–	–
27 Jun-6 Jul	108	0	–	4	3.7	3-12 Feb	8	–	–	–	–
7-16 Jul	41	0	–	2	4.9	13-22 Feb	3	–	–	–	–
17-26 Jul	0	–	–	–	–	23 Feb-3 Mar	2	–	–	–	–
27 Jul-5 Aug	0	–	–	–	–	4-13 Mar	147	1	0.7	3	2.0
6-15 Aug	0	–	–	–	–	14-23 Mar	431	21	4.9	4	0.9
16-25 Aug	339	3	0.9	7	2.1	24 Mar-2 Apr	399	0	–	3	0.8
26 Aug-4 Sep	407	0	–	17	4.2	Total or average	3943	55	1.4	118	3.0



Percentage GSV and RSV carriers among migrating BPH from daily catches in a high-beam light trap at IRRI, 1983–84.

(pH 6.5) containing 0.15 M NaCl, 0.05% Tween 20, 0.02% NaN_3 and 2% polyvinylpyrrolidone. The homogenate was separately tested in ELISA using a purified immunoglobulin against GSV and RSV.

Of 3,943 BPH tested from Jan 1983 to Mar 1984, 1.4% carried GSV, 3.0% carried RSV, and 0.3% carried both viruses. Carriers per 10-d catch vaned from 0.5 to 25.0% for GSV and from 0.8 to 20.0% for RSV (see table). Large numbers of BPH were trapped in Mar-Jun and Aug–Nov (see figure).

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

Effect of foliar spray of macro- and micronutrients on sheath rot (ShR) incidence and rice grain yield

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ShR caused by *Sarocladium oryzae* is found in most rice-growing areas in

Tamil Nadu, causing yield losses up to 85%. To study the influence of foliar sprays of macro- and micronutrients on the development of ShR, a pot experiment using IR20 was conducted at the Paddy Experiment Station, Ambasamuduram, in 1984-85. The nutrients were sprayed twice at 30 and 55 d after transplanting (DT), and the plants were inoculated artificially with *S. oryzae* by inserting a single infected rice grain between the leaf sheath enclosing the panicle and the culm of a tiller. Inoculation was done at 65 DT and the disease incidence recorded 30 d after inoculation. Five tillers from each hill were selected at random and graded for disease incidence by SES and the percentage disease index was calculated.

ShR incidence was significantly lower in $CaSO_4$, $ZnSO_4$, and KCl treatments (see table). $CaSO_4$ and $ZnSO_4$ gave the highest grain yield. Spraying with $CuSO_4$ also produced increased yield and decreased ShR incidence. Foliar spray with urea had no effect on disease incidence or grain yield.

Influence of foliar spray of macro- and micronutrients on ShR incidence and rice grain yield.[a]

Nutrient	Concentration (%)	ShR disease index (%)	Grain yield (g/hill)
Urea	2.0	36.6 d	9.8 c
KCl	1.0	21.0 a	10.5 b
K_2SO_4	1.0	25.8 b	10.2 bc
$CaSO_4$	2.0	18.5 a	11.3 a
$MgSO_4$	1.0	27.0 b	10.2 bc
$ZnSO_4$	1.0	20.4 a	11.2 a
$CuSO_4$	0.2	24.6 b	10.4 b
$MnSO_4$	1.0	30.6 c	10.3 bc
$FeSO_4$	1.0	32.4 c	10.0 c
Mixture (Zn: Cu: Mg: Fe: Mn = 10: 5: 2: 2: 1)	1.0	25.2 b	10.2 bc
Control	–	35.4 d	9.9 c

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

Pest Control and Management

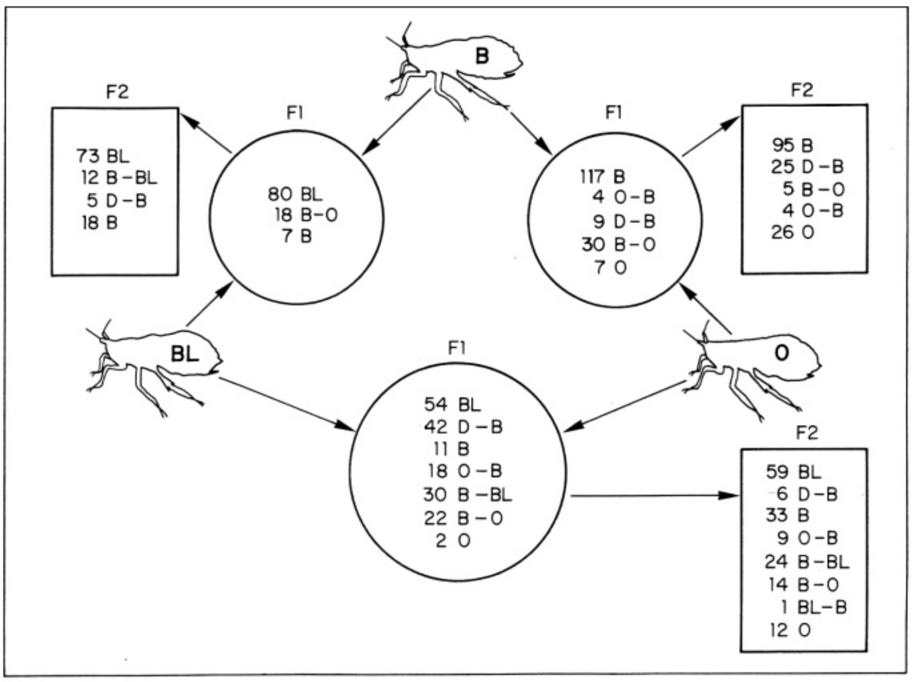
INSECTS

Multiple allelism in brown planthopper (BPH) body color

A. A. Barrion, Institute of Biological Sciences, University of the Philippines at Los Baños; and R. C. Saxena, International Centre of Insect Physiology and Ecology, Nairobi, Kenya, and IRRI

Adult BPH *Nilaparvata lugens* generally are brown. Occasionally, however, a few orange (O) and black (BL) variants appear in stock cultures maintained on rice plants. Crossbreeding these purified discrete color morphs and inbreeding their progenies have enabled the expression of intermediate color morphs that are dark brown (D-B), brownish orange (B-O), orange brown (O-B), blackish brown (BL-B), and brownish black (B-BL). To understand how BPH body color is inherited and to determine the influence of environment, we conducted breeding experiments involving at least two generations.

Parent insects came from pure breeding lines and were homozygous for body coloration. The figure summarizes the results of the hybridization experiments. Inheritance of color morphism had the following trends:



Hybridization scheme between brown (B), orange (O), and black (BL) BPH color morphs. F1 and F2 progenies comprising additional color morphs — dark brown (D-B), brownish orange (B-O), orange-brown (O-B), blackish brown (BL-B), and brownish black (B-BL) — are depicted within circles and rectangles. IRRI, 1985.

1. The BPH gene for color morphism exists in three allelic forms, although any diploid male or

female can carry no more than two alleles. Thus, body coloration exhibits multiple allelism. The three alleles can be designated as b^+ (brown or wild type allele), b^o (orange allele), and b^b (black allele). The results of backcrosses show BPH has six possible genotypes — three homozygotes: b^+b^+ (brown), $b^\circ b^\circ$ (orange), and b^bb^b (black), and three heterozygotes: b^+b° (brownish orange), b^bb^+ (blackish brown), and b^bb° (dark brown). These heterozygotes exhibited some other allelic interactions leading to further variations, such as $b^\circ b^+$ (orange-brown) and b^+b^b (brownish black), in the expressivity of body coloration; no allelic interaction occurred between b^b and b^o.

2. The six possible genotypes produced as many as eight different phenotypes, indicating that in this species, the relation between phenotype and genotype is not fixed. The observed phenotypes may result from an interaction between different genes or between genes and the environment. All possible color morphs were obtained in reciprocal crosses of black and orange BPH.
3. Crosses between B and O and B and BL individuals produced F2 frequency ratios that fit with monogenic inheritance or segregation of a pair of alleles at a single locus. B had some dominance over O, and B1 over B. No specific pattern of inheritance could be depicted between BL and O; however, B had partial dominance over O (see figure).
4. Intermediates between the extreme parents in the F1 and F2 of all the crosses were manifestations of certain variabilities that can be attributed to
   a. residual heredity or filial regression due to incomplete dominance, environment, and epistasis, or
   b. modifier genes that change the phenotypic effects of other genes in quantitative fashion through dilution or enhancement of major gene effects.

Ephydrid flies [Diptera:Ephydridae] of rice in the Philippines

A. T. Barrion and J.A. Litsinger, Entomology Department, IRRI

Rice whorl maggot (RWM) *Hydrellia philippina* Ferino is the only ephydrid rice pest recorded in the Philippines. RWM damages rice leaves at early vegetative stage all year in rainfed and irrigated lowlands.

We collected ephydrid flies by D-Vac suction machine, sweep net, and mylar plastic cone traps from 1977 to 1980 from different rice cultures in the Philippines. Cone traps were placed open-end-down over flies on plants. The mylar plastic cone trap caught more flies than D-Vac or sweep nets. Plants with leaf damage were dissected for larvae and pupae, which were reared to adulthood on leaf sections kept on moist filter paper in plastic dishes.

The ephydrid fauna of Philippine rice fields includes 10 genera and 18 species. Of the species, 12 are phytophagous, 5 are scavengers, and 1 is a predator (see table), as determined by P.J. Clausen, Entomology Department, University of Minnesota, USA, except *Ochthera*. Eleven species in seven genera are new Philippine records.

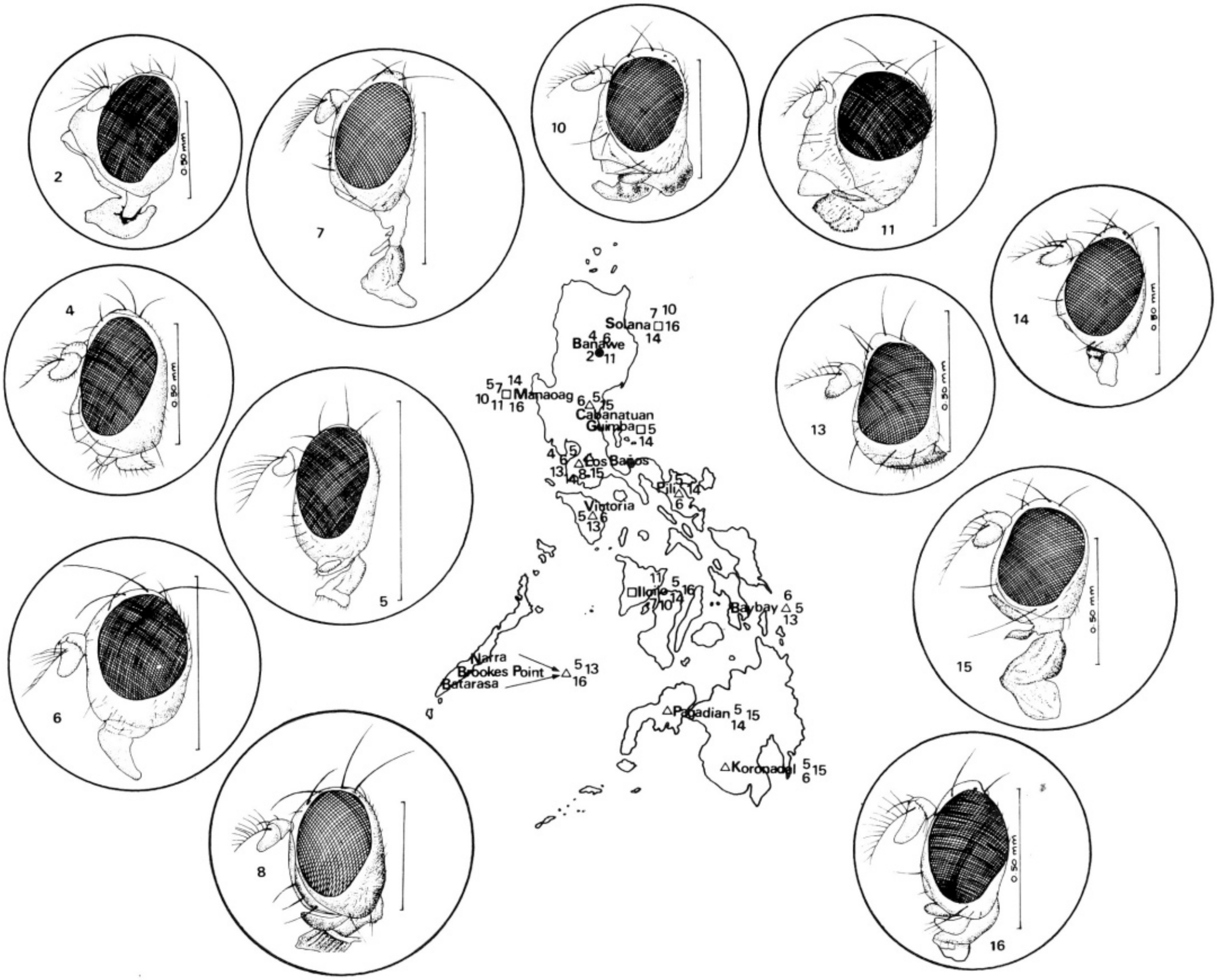
Ephydrid flies of rice in the Philippines.

Species	Rice culture[a]			
	Upland	Rainfed lowland	Irrigated lowland	Irrigated rice terraces
1. *Actocetor beckeri* de Meijere [be]	+	–	–	–
2. *Brachydeutera longipes* Hendel [c]	++			+[f]
3. *Discomyza maculipennis* (Weidemann) [be]	–	+	–	–
4. *Hydrellia griseola* (Fallen) [ce]	–	–	+[f]	+[f]
5. *Hydrellia philippina* Ferino [c]	–	+[f]	+[f]	–
6. *Notiphila latigenis* Hendel [ce]	–	+	+[f]	+[f]
7. *Notiphila similis* de Meijere [ce]	–	+[f]	+	–
8. *Notiphila spinosa* Cresson [c]	–	+	+[f]	+
9. *Ochthera* sp. [d]	–	+	+	+
10. *Paralimna lineata* de Meijere [c]	+	+[f]	–	–
11. *Paralimna picta* Kertesz [c]	–	+[f]	–	+[f]
12. *Polytrichophora brunneifrons* (de Meijere) [be]	–	+	+	+
13. *Psilopa flavimana* Hendel [ce]	–	–	+[f]	–
14. *Psilopa pollinosa* (Kertesz) [ce]	–	+[f]	+[f]	–
15. *Psilopa rufipes* Hendel [c]	–	–	+[f]	+
16. *Psilopa sorella* Becker [ce]	–	+[f]	–	–
17. *Scatella callisicosta* Bezzi [be]	–	–	+	–
18. *Scatella* sp. [be]	–	–	+	–
Total	3	11	13	8

[a] + = collected, – = not collected. [b] Scavenger. [c] Phytophagous. [d] Predator. [e] New Philippine record. [f] Reared from plants with leaf damage.

Three species live in uplands, 11 in rainfed lowlands, 13 in irrigated areas, and 8 in irrigated rice terraces. All but *Actocetor beckeri* de Meijere were recorded in lowland and irrigated areas, which suggests that ephydrid flies prefer aquatic or semiaquatic environments. The Banawe rice terraces, which have high elevation and low temperature, and produce two rice crops a year, had almost the same species as the rainfed and irrigated lowlands.

Twelve species belonging to the subfamilies Psilopinae and Notiphilinae (except *B. longipes*) emerged from the plants with whorl maggot leaf damage and were considered phytophagous (see table and figure). *Hydrellia Notiphila, Paralima,* and *Psilopa* are phytophagous genera from the rainfed



Distribution and head morphology of 12 phytophagous ephydrid flies on rice in the Philippines. Numbers refer to species in table. □ = rainfed wetland, Δ = irrigated lowland, • = irrigated rice terraces. Scale = 1 mm except for nos. 2, 4, 13, 14, 15, and 16.

and irrigated lowlands. *Brachydeutera* was found in the terraces.

Hydrellia philippina was most common in imgated lowlands, *Psilopa* spp. in rainfed lowlands, and *H. griseola* in terraces. This fly is commonly called rice leaf miner and has limited distribution in temperate zones. including the USA, Europe, North Africa, Japan, and Korea.

Notiphila laligenis and *N. similis* were numerous on emergent vegetation and usually laid eggs on the stem of the perennial fern *Marsilea minuta* L. The eggs were an alternate host of the stem borer egg parasite *Trichogramma.*

Discomyza maculipennis (Weidemann) is a scavenger and emerged from dead *Lymnaea* and *Pila* snails.

Ephydrid flies are generally beneficial, and provide food for spiders, toads and frogs, and wildlife that inhabit rice fields and marshes.

Whitebacked planthopper (WBPH) attack in Assam, India

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WBPH Sogatella furcifera (Horvith) seriously damaged rice for the first time in Assam in May-Jun 1985. More than 8,000 ha in Cachar and Karimganj Districts of the Barak Valley were hopperburned. Infestations also were reported in Sibsagar and Jorhat Districts of the Bramaputra Valley.

In Barak Valley, high yielding Krishna, Cauvery, Jaya, and IR8 were more severely infested than local cultivars. WBPH first attacked nursery seedlings and then newly transplanted rice. Infested plants turned yellow and then rust red. Brown spots appeared at feeding sites. Plants were stunted, and severely infested plants died. Sweep net (0.4 m diam, 0.5 m long) samples from highly infested fields in Raipur, Choto Jalenga, Duarbond, and Hailakandi had 800-1,400 hoppers/sweep.

Large WBPH populations were accompanied by high rainfall in early Apr, followed by a prolonged dry period with high temperature and humidity in May. Heavy rainfall in early Jun reduced populations.

Seedlings treated with granular carbofuran 3 G or phorate 10 G at 1 g ai/ ha were free from WBPH. Spraying infested nursery seedlings with chlorpyrifos 20 EC, fenitrothion 50 EC, and phosphamidon 100 EC at 0.5 kg ai/ ha also effectively controlled the pest.

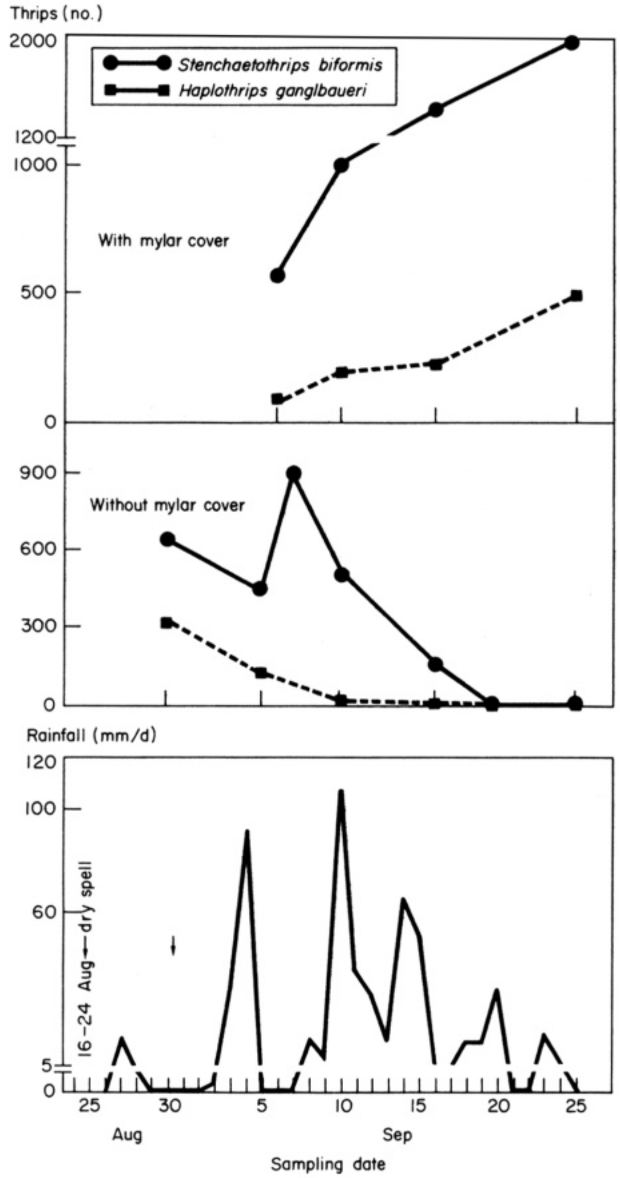
Effect of heavy rains on rice thrips

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

A slash-and-burn upland rice site in Siniloan, Laguna, Philippines, has regular high rainfall in Aug and Sep. An unusually dry spell in Aug 1985 affected the vegetative plants. Thrips settled on rice and the lack of rainfall favored their rapid multiplication in less than 2 wk. Thrips and water stress caused the rice leaves to roll and be partially dried.

Two thrips — *Stenchaetothrips biformis* (Bagnall) and *Haplothrips ganglbaueri* Schmut — were isolated from the damaged leaves. *S. biformis* was found only in rice. *H. ganglbaueri.* in contrast, was common in cogon grass but rare in rice. The larvae and adults of both species fed inside the rolled leaves, causing stippling damage to the leaf tissue.

In anticipation of a heavy rain, 16 thrips-infested hills of rice and the same number for cogon were covered with 10- × 64- cm cylindrical mylar cages provided with side vents. Thrips populations were counted before and after the rain on uncovered plants (n = 25 rolled leaves/sampling date) and covered plants (n = 4 hills/sampling date). During the drought period, initial *H. ganglbaueri* population was high (300 individuals per 4 hills). This was subsequently reduced to 100 after the first heavy rain on 3-4 Sep and a 2-wk continuous downpour on 8-24 Sep. *S. biformis* population likewise declined from 600 to 400 under the same weather conditions. In contrast, there was a population buildup inside the cages for both species — *S. biformis* increased from 500 to 2000 individuals and *H. ganglbaueri* swelled from 90 to 500 (see figure). Heavy rainfall, therefore, is a natural mortality factor against thrips.



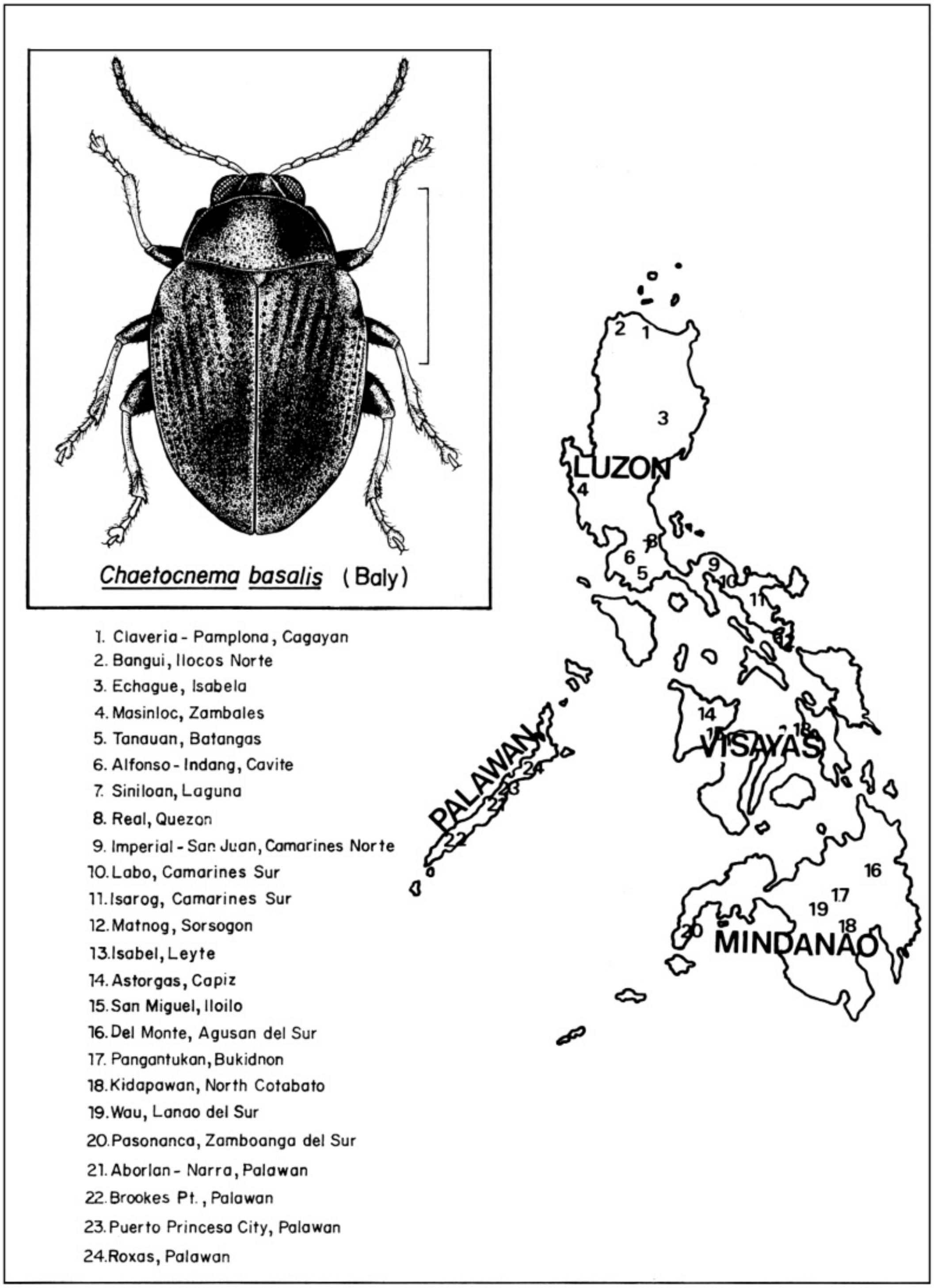
Effect of rainfall on grass thrips (rice: ●–●; cogon; ■–■) in Siniloan, Laguna, Philippines, 24 Aug-25 Sep 1985.

Flea beetle *Chaetocnema basalis* (Baly) (Coleoptera: Chrysomelidae), a pest of slash-and-burn upland rice in the Philippines

A. T. Barrion and J.A. Litsinger, Entomology Department, IRRI

Chaetocnema spp. are common upland rice pests extending 40° N and S of the equator in Africa, Latin America, and Asia. *C. pulla* Chapuis transmits rice yellow mottle virus in Kenya. *C. concinnipennis* Baly in India and *C. denticulata* Stephens in Latin America cause foliage damage similar to that caused by rice hispa *Dicladispa armigera* (Olivier), but vector no disease.

In the Philippines, *C. (Tlanoma)*



Distribution of *Chaetocnema basalis* (inset, scale = 1 mm) in the Philippines.

basalis is widespread (see figure) in the highlands and feeds on the seedlings of nine grasses — *Brachiaria distachya* (L.) Stapf., *Chrysopogon aciculatus* (Retz.) Trin., *Dactyloctenium aegyptium* (L.) Beauv., *Digitaria ciliaris* (Retz.) Koel., *Ischaemum rugosum* Salisb., *Paspalum conjugatum* Berg., *Pennisetum polystachyon* (L.). Schult., *Sorghum bicolor* (L.) Moench., and *Zea mays* (L,). Host records on rice were determined by keeping adults on potted seedlings and on weeds.

C. basalis removes leaf tissue parallel to the leaf veins 1-80 d after emergence in rice planted in slash-and-burn cleared secondary rain forest. Rice seedlings wither and die in 3-5 d. Infestation occurs only in fields less than 1000 m^2.

Other *Chaetocnema* species in the Philippines that feed on solanaceous and cruciferous plants differ from *C. basalis.* Adult *C. basalis* are small-bodied (male, 1.5-2.08 mm; female, 2-2.30 mm) and glossy black, with yellow basal antennal segments, yellow-brown apices of femora, tibiae, and tarsi (see figure). The pronota are smoothly punctated and each elytron has 10 longitudinal rows of minute pits. The tibiae of the third pair of legs possess a small apophysis along the mid-dorsum, dorsolateral combs of hairs near the apical half, and a tooth at the apices.

Granulosis of the rice brown semilooper *Mocis frugalis*

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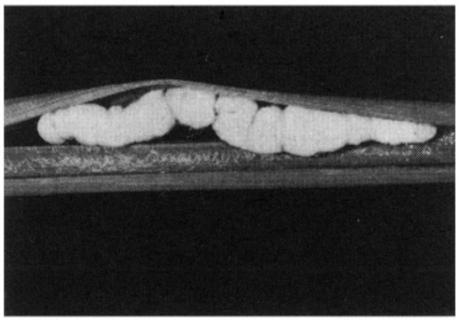
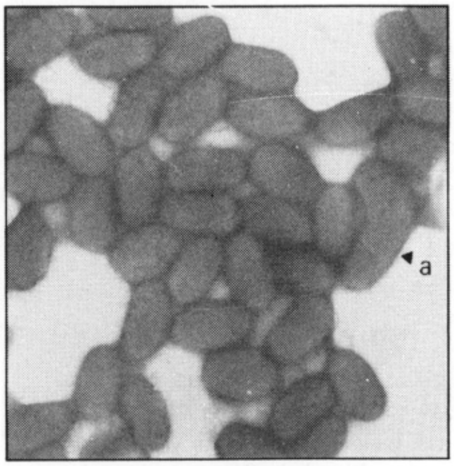
Rice brown semilooper *M. frugalis* (Fab.) (Lep: Noctuidae) is one of a complex of tropical lepidopterous rice pests. It occurs in flooded rice, but is more abundant in upland rice. *M. frugalis* populations seldom occur in damaging levels because they are inhibited by natural parasites, predators, and diseases.

We collected last-instar *M. frugalis* larvae that were infected with a virus disease from a lowland field near Roxas, Palawan, Philippines. Diseased larvae were lemon yellow with swollen abdominal segments (Fig. 1). At later disease stages, the larvae turned dark and milky-white fluid oozed through the integument. Examination of the fluid with a phase contrast microscope showed refractive granules with Brownian movement.

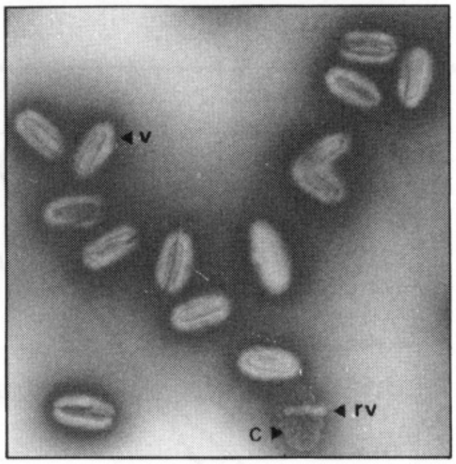
Diseased larvae were macerated in distilled water with a glass homogenizer for further identification and purification. The suspension was filtered through cotton wool and centrifuged for 30 min to remove the bacteria. The precipitate was washed three times with distilled water to obtain a crude extract.



1. Larva of *Mocis frugalis* (Fab.) infected with granulosis virus.



2. Electron micrograph of capsules of *Mocis frugalis* stained with 2% phosphotungstic acid (X 27,600). a =an aberrant, sickleform capsule.



3. Virion released from the capsule after 2 h treatment with 0.05 M $NaCO_3$ + 0.17 M NaCl at room temperature. (X 22,380). c = empty capsule, rv = released virion, v = virion in the capsule.

The extract was layered on a 20–70% (V/V) glycerol gradient, then centrifuged at 10,000 rev/ min for 15 min in a Beckman SW 27 rotor. The virus was collected at the 35–40% glycerol band. These bands were centrifuged at 12,000 rev/min for 20 min using a Beckman Mod. L5-65 and the resulting pellet was resuspended in a small amount of water.

The virus suspension was layered on 30–65% (W/W) linear sucrose density gradient then centrifuged at 25,000 rev/min for 90 min. The band was collected at 55% sucrose band and centrifuged again at 20,000 rev/ min for 30 min. The pellet was collected, diluted with water, and the process was repeated.

After centrifugation, the purified virus capsules were resuspended in water and centrifuged at 12,000 rev/min for 20 min to form a precipitate. A small amount of the virus capsule suspension was stained in a grid for 1 min with 2% phosphotungstic acid (PTA) for electron microscope examination.

The capsules were ellipsoidal, but an aberrant sickle-form also was observed (Fig. 2). Capsules were 433 nm long and 243 nm wide. Each capsule contained a single virion (nucleocapsid). A single rod-shaped virion typical of granulosis was embedded in a capsule (Fig. 3). They averaged 301 nm long and 83 nm wide. The virions were negatively stained with 2% PTA.

Virions in the capsules were obtained after treatment on the slide with equal volume of 0.05 M $NaCO_3$ + 0.17 M NaCl at room temperature. The protein capsule dissolved after 2 h of gentle stirring, but the virions were released after more than 3 h.

The disease was identified as granulosis. This is the first report of it attacking *M. frugalis.*

Effect of neem product foliar sprays on rice pests

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We studied the effect of foliar spraying of three neem products on the incidence of rice pests in two field experiments at PES in Tirur. The 1984–85 trials comprised five treatments replicated four times and laid out in a simple

Effect of foliar sprayings of 3 neem products on rice pests, PES, Tirur, India, 1984-85.[a]

Treatment	Quantity/ha per round	Navarai 1984-85 GLH (no./hill)	Navarai 1984-85 Grasshopper (%)	Navarai 1984-85 Grain yield (t/ha)	Sornavari 1985 GLH mortality (%)	Sornavari 1985 GM silver shoots (%)	Sornavari 1985 SB whiteheads (%)	Sornavari 1985 Grain yield (t/ha)
Neem seed kernel extract, 2%	10 kg	1.9 (1.39) a	9.4 (17.83) b	5.8 a	58.9 (50.07) b	7.2 (15.57) a	25.0 (29.98) bc	6.6
Neem cake extract, 5%	25 kg	2.7 (1.65) b	8.9 (17.33) ab	4.9 b	45.2 (42.24) c	8.3 (16.74) b	25.9 (31.60) cd	6.0
Neem leaf extract, 5%	25 kg	2.4 (1.54) ab	5.9 (14.05) a	5.1 b	66.6 (54.71) a	8.8 (17.25) b	22.3 (28.15) b	6.2
Phosphamidon 100 EC	500 ml	2.9 (1.70) b	9.8 (18.22) b	5.4 ab	63.6 (52.90) a	13.0 (21.13) c	12.5 (20.65) a	6.3
Control	–	4.7 (2.17) c	15.5 (23.21) c	5.1 b	10.9 (19.28) d	29.2 (32.71) d	30.4 (33.46) d	5.7
CD		(0.30)	(3.68)	0.59	(2.33)	(1.05)	(2.80)	ns

[a]Figures in parentheses are transformed values.

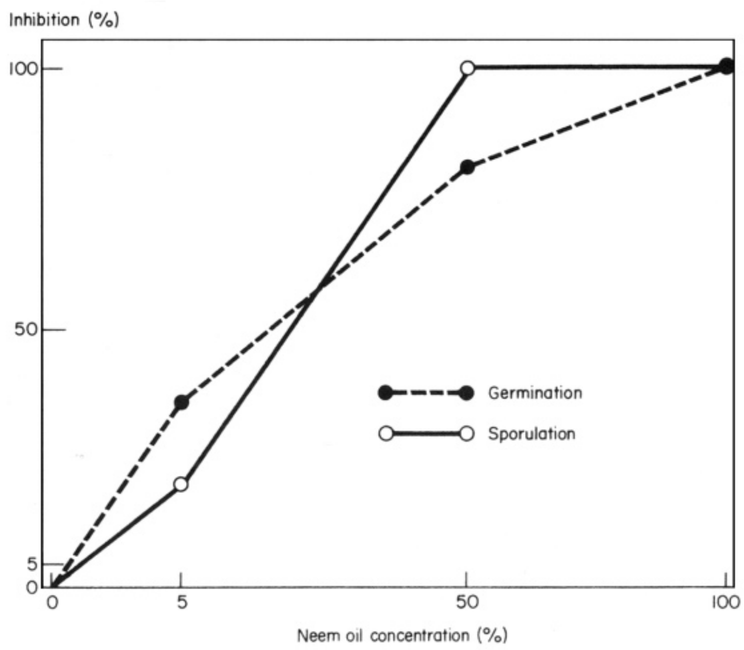
randomized block design. Twenty-five-day-old seedlings of TM8089 and TKM 9 were planted in 3- × 3-m plots at 20- × 10-cm spacing. These were fertilized with 100-50-50 kg NPK/ha. Three spray applications were made 15, 30, and 45 d after transplanting. Infestations by green leafhopper (GLH), stem borer (SB), gall midge (GM), and grasshoppers were assessed at periodic intervals. Data on pest incidence and grain yield were analyzed statistically.

Results indicated that the neem products effectively controlled the major rice pests and were even superior to phosphamidon in controlling GM, GLH, and grasshoppers (see table). However, phosphamidon was superior to neem products in controlling SB. Plots sprayed with 2% neem seed kernel extract had the highest grain yields of 5.8 and 6.6 t/ha in navarai and sornavari seasons, respectively.

Effect of neem oil on germination and sporulation of the entomogenous fungus *Metarhizium anisopliae*

R. M. Aguda, IRRI; M. C. Rombach, Boyce Thompson Institute for Plant Research, Ithaca, NY, USA; and B. M. Shepard, IRRI

Entomogenous fungi are important biological control agents that can infect insect pests and reduce their populations. We are evaluating them for possible control of brown planthopper *Nilaparvata lugens* and black bug *Scotinophara coarctata.* However, the effectiveness of naturally occurring and artificially applied fungi may be seriously affected by chemical applications.



Inhibitory effect of neem oil on germination and sporulation of *M. anisopliae.*

We sought to determine the effect of neem oil on the germination and sporulation of *Metarhizium anisopliae,* an entomopathogenic fungus that infects several important rice insect pests.

Conidia germination was observed in a liquid medium (1% saccharose/1% yeast extract) with 0, 5, 50, and 95% neem oil. Each treatment had five replications. Small amounts of conidia were added to the medium, which then was incubated for 24 h in vials on a rotary shaker. Germination was evaluated under a microscope.

Mycelium sporulation was studied by soaking dry mycelium particles in concentrations of neem oil similar to those of the germination experiment. The particles were incubated on moist filter paper in petri dishes. Evaluation was concurrent with completion of sporulation in the control treatment (no neem oil).

Virtually all the mycelium particles

contained the characteristic layer of green conidia. The highest neem oil concentration completely inhibited both conidia germination and mycelium sporulation (see figure). The effects of neem oil at lower concentration were not so severe but even at 5% concentration, neem significantly ($P<0.01$) inhibited germination and sporulation.

Neem oil normally is applied in the field as an ultralow volume spray containing up to 50% of the oil. If it is used in a control program with *M. anisopliae,* they should be applied separately.

Although the inhibitory effects of neem oil on entomogenous fungi have not been tested in the field, it is likely that neem at high concentrations may reduce the overall effectiveness of naturally occurring entomopathogenic fungi.

Relative abundance of three species of egg parasitoids of rice brown planthopper (BPH)

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Egg parasitoids of BPH *Nilaparvata lugens* Stal. such as *Anagrus optabilis* (Perkins) (Mymaridae), *Oligosila naias* Girault (Trichogrammatidae), and egg predator *Tetrastichus* spp. (Eulophidae) are common in Tamil Nadu between Sep and Jan when climatic conditions are optimum for the host.

Potted rice plants laden with BPH eggs were placed in the field periodically between Oct and Dec 1984. Eggs were collected (see table) from the sheaths and placed on moist filter paper in a petri dish for further development. The BPH emerging from normal eggs were recorded daily and removed immediately. Similarly, the larvae of *Tetrastichus* spp. were periodically removed and recorded as soon as the 1st-instar larvae emerged from the host egg. The two other parasitoids were differentiated by the color of the host egg. In case of doubt, records were made after the parasite emerged from the host egg. The percentage parasitism for each species was calculated from the total number of eggs parasitized during each period and the number parasitized by each species.

Relative occurrence of the three egg parasitoidal predators of BPH, Oct-Dec 1984.

Period	Total eggs observed (no.)	Parasitization (%)	Parasitization (%) by species		
			Anagrus sp.	*Tetrastichus* sp.	*Oligosita* sp.
1 Oct	567	49	60	35	3
18 Oct	602	40	58	29	13
27 Oct	551	74	72	4	23
3 Nov	416	46	57	15	27
24 Nov	717	4	57	34	8
4 Dec	463	44	62	23	14
19 Dec	376	35	48	24	27
28 Dec	544	42	51	19	
	$\bar{X}$	47	58	23	18
			27	11	8

Overall parasitization and predation was 42%. *Anagrus* was the dominant species (27%) throughout the season, followed by the eulophid (11%). The incidence of *Oligosita* was inconsistent (8%), but when *Oligosita* showed an increase, the number of eulophids decreased and vice versa. However, the dominant mymarid had its share of host eggs unopposed by the two other egg parasitoids.

Occurrence of rice mealy bug in Tamil Nadu, India

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In December 1985, a severe incidence of the mealy bug *Heterococcus rehi* (Lindinger) occurred over an area of 100 ha in Annavasal, Pudukottai district, Tamil Nadu, India. White Ponni and IR20 raised in garden lands were severely infested in the postflowering stage. The nymph and adult populations ranged from 650 to 700 per hill. Infestation occurred in patches and affected plants turned yellow, were severely stunted, and failed to produce panicles. Prolonged drought as a result of inadequate water supply probably accounted for the high population of mealy bug.

Effects of 6 granular insecticides on rice rhizosphere microflora in India

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Granular insecticides may influence the activity of rice rhizosphere microflora, and the microflora may regulate decomposition, dissipation, and persistence of granular insecticides. In Bhubaneswar, rice soils had 165 fungi species, predominantly *Aspergillus, Cephalosporium, Curvularia, Neocosmospora, Penicillium, Rhizopus, Spicaria,* and *Trichoderma;* many species of facultative anaerobes such as *Escherichia, Aerobacter, Erwinia, Aeromonas, Streptococcus,* and *Bacillus;* and N-fixing bacteria such as *Azospirillum, Pseudomonas,* and *Paucimobilis.*

We studied the effects of six commonly used granular insecticides on rice soil microflora in 1983 wet season (Jun-Dec). The insecticides were broadcast in field water at 1.5 kg ai/ha 10 d after transplanting Jaya. Soil samples were collected randomly from treated and untreated plots 1 d before treatment (DBT) and 7 and 14 d after treatment (DAT). Culture media for fungi and bacteria were prepared and inoculated using the Ricker and Ricker (1936) procedure. Fungus colonies were counted 3 d after incubation and bacteria colonies 7 d afterward. Two subsamples of each sample were evaluated in the laboratory to determine mean fungi and bacteria population per gram soil.

With time, both fungus and bacteria populations were inhibited by all insecticides except ethoprophos, where populations increased 14 DAT (see table). We are studying the long-term effect of these chemicals on microflora.

Population[a] of fungi and bacteria in rice rhizosphere soil treated with 6 granular insecticides at Bhubaneswar, India, Jun-Dec 1983.

Treatment	Population ($\sqrt{x + 0.5}$/g soil)					
	Fungi (× 10^3)			Bacteria (× 10^6)		
	1 DBT	7 DAT	14 DAT	1 DBT	7 DAT	14 DAT
Untreated	5.4 bc	5.0 c	4.3 d	1.5 a	1.7 d	1.8 d
BPMC	5.3 bc	1.9 a	1.5 abc	1.7 ab	1.4 bc	1.2 ab
Carbofuran	5.8 d	3.4 b	1.3 abc	1.8 ab	1.6 cd	1.5 c
Carbosulfan	8.7 e	4.8 c	1.9 bc	1.6 ab	1.3 b	1.3 bc
Chlorpyrifos	4.7 b	2.8 b	1.2 ab	1.9 b	1.5 c	1.2 ab
Ethoprophos	5.4 bc	1.6 a	2.0 c	1.6 ab	0.9 a	1.2 ab
Phorate	3.9 a	3.3 b	1.0 a	1.6 ab	1.5 bc	1.1 a

[a]Separation of means in a column by DMRT at the 5% level.

Plant parasitic nematodes in rice fields under freshwater and saline soil conditions in Orissa, India

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Rice is extensively grown in Orissa, from the saline coastal belt (SCB) to the interior districts with freshwater habitats (FWH). An examination of 75 rice rhizosphere samples from FWH [where the electrical conductivity of saturation extract (ECSE) ranged from 0.75 to 1.60 mmho/cm and the osmotic pressure (OP) of the soils registered 0.27 to 0.57 atm] revealed associations of 20 plant parasitic nematode species. Twelve samples from the SCB (ECSE, 2.87 to 5.85 mmho/cm and OP, 1.03 to 2.10 atm) yielded 6 plant parasitic nematodes, 5 of which also prevailed in FWH. The frequency and density of nematodes prevailing in the two habitats were varied (see table). Of all the parasites, *Hirschmanniella gracilis* was the most adaptable followed by *Criconemella ornata.*

Plant parasitic nematodes associated with rice under freshwater and saline soil conditions in Orissa, India.

Species	Freshwater habitat[a]		Saline coastal belt[b]	
	Frequency[c] (%)	*Density*[d] (no.)	Frequency[c]	Density[d] (no.)
Helicotylenchus dihystera	25.9	M – H	–	–
H. crenacauda	10.4	H	–	–
H. pseudorobustus	30.3	M – H	–	–
H. abunaamai	1.5	M – H	–	–
H. ptercercus	5.2	H	–	–
Hoplolaimus indicus	8.8	M	–	–
H. columbus	–	–	25.0	L
Tylenchorhynchus mashoodi	46.6	M – H	25.0	L – M
Pratylenchus zeae	16.7	M – H	–	–
Hirschmanniella gracilis	61.4	H	100.0	M – H
H. mucronata	25.9	M – H	–	–
Hemicriconemoides cocophilus	2.2	L – M	–	–
H. mangiferae	0.7	L	–	–
Criconemella ornata	7.4	M – H	33.3	M
Caloosia exilis	18.5	M – H	8.3	L
C. heterocephala	2.2	L – M	–	–
R. reniformis	2.2	L – M	–	–
Heterodera spp.	1.5	L	–	–
Aphelenchoides besseyi	23.8	L	58.1	L
Siddiqia citri	3	L	–	–
S. boshi	1.5	L	–	–

[a]ECSE = 0.75-1.6 mmho/cm; OP = 0.27-0.57 atm. [b]ECSE = 2.81-5.85 mmho/cm; OP = 1.03-2.10 atm. [c]Out of 75 samples from FWH; out of 12 samples from SCB. [d]L = light = less than 100 in 250 ml of soil sample. M = medium = 101-500 in 250 ml of soil sample. H = heavy = more than 500 in 250 ml of soil sample.

Black beetle — a serious rice pest in western Himalayas

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Extensive field surveys conducted in the 1981–83 kharif season showed that black or Bhatula beetles *Heteronychus lioderes* Redt infest the low-lying irrigated as well as unirrigated rice fields in western Himalayas. This beetle is a serious menace to both transplanted and direct seeded rice in irrigated and rainfed areas. Fields enriched with humus or supplied with a high quantity of decomposed or undecomposed farm-yard manure (FYM) are more prone to beetle attack. In such fields, 20–40% of damage to rice is done by these notorious soil-inhabiting pests. Seventy of damage depends upon the soil type, FYM applied, and the moisture content of the field.

In the initial stages of infestation, the central leaves of the plant dry up, like those of plants under stem borer attack. The beetle burrows into the base of the rice plant and cuts the stem from the ground level below the soil surface. After feeding on one plant, the beetle feeds on another from the same hill thus killing the entire hill. A maximum of 5 beetles per hill (av 2) were observed.

The beetles cause patchy damage in the field. Their peak activity period is at night. Peak damage by this pest is observed in Jan-Jul when the crop is in the vegetative growth stage.

This pest attacks rice seedlings in the nursery stage and also the irrigated crops in flooded fields. Severe infestation by black beetles is sporadic and normally restricted to small areas. Only rice is attacked by this insect pest while other kharif crops remain unmolested under natural infestation conditions.

Effect of *Leptocorisa* sp. on rice grain filling

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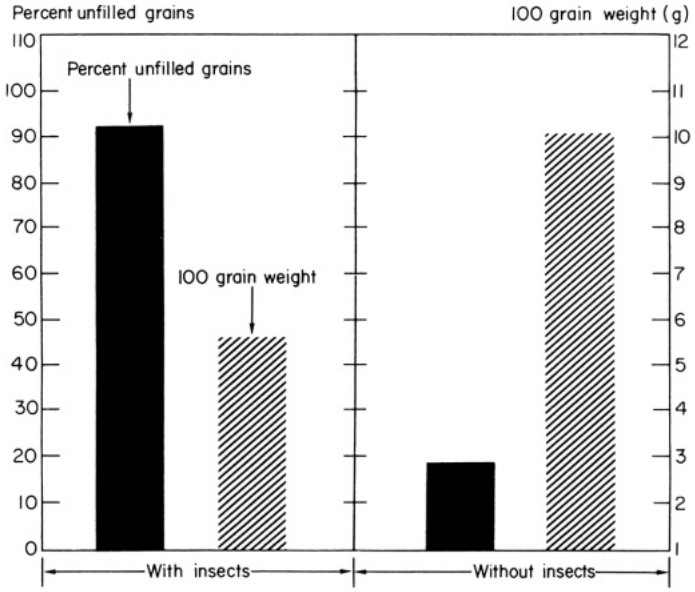
Leptocorisa sp. are common rice bugs in the low country wet zone of Sri Lanka. Nymphs and adults damage rice from flowering through dry dough stage.

We recorded damage caused by *Leptocorisa* sp. in observational trials with BW267-3 and Bg 94-1. Agronomic practices were common to all treatments. Complete insect control was used from seeding to flowering.

At early flowering, 12 panicles were randomly selected. Six were placed individually in plastic cages with 10 *Leptocorisa* nymphs/cage, and 6 were caged without insects. Cages were checked daily and insect density was maintained until harvest. Grain discoloration, percent unfilled grains, and grain weight were recorded. Grain weight was determined by weighing the whole panicle, which included filled, partially filled, and unfilled grains.



Percent unfilled grains and total grain weight with and without *Leptocorisa* sp. infestation, Bombuwela, Sri Lanka. Av of 2 treatments.

Nymphs began feeding at flowering and adults fed until hard dough stage. Although puncture marks were not visible, milk exuded from some grains.

Level of grain discoloration was similar in all treatments, indicating that the insects were not its cause.

Treatments with *Leptocorisa* had nearly 100% unfilled grains (see figure); insect-free treatments had 20% unfilled grains. Average 100-grain weight was 5.5 g with insects and 10 g without.

Controlling brown planthopper (BPH) with granular insecticides in India

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Summer rice (Jan-May) grown on irrigated coastal areas in Orissa is regularly attacked by BPH. In 1981-83, we evaluated 12 granular insecticides for controlling BPH at OUAT.

Three replications of insecticides were broadcast at 1.5 kg ai/ ha at 45 d after transplanting in fields planted to

Field evaluation of 12 granular insecticides for controlling BPH, Bhubaneswar, India. [a]

Insecticide	Adults + nymphs/10 has at 20-25 DAT			Grain yield (t/ha)		
	1981	1982	1983	1981	1982	1983
Control	40 cd	49 c	1090 e	1.9 a	3.6 a	1.4 a
Bendiocarb 4G	36 bcd	–	–	2.5 abc	–	–
BPMC 4G	21 a	12 a	80 b	3.3 de	4.3 bc	3.7 bcd
Carbofuran	24 ab	12 a	0 a	3.5 e	4.4 c	4.7 d
Carbosulfan	–	25 ab	102 bc	–	4.4 bc	4.2 cd
Carbaryl + lindane	–	–	935 e	–	–	1.5 a
chlorpyrifos	–	34 bc	763 e	–	4.3 bc	1.3 a
Diazinon	–	–	920 e	–	–	2.4 ab
Disulfoton	32 bcd	22 a	245 cd	2.4 ab	3.6 a	3.3 bcd
Ethoprophos	–	–	398 de	–	–	2.6 abc
Isoprocarb	27 abc	13 a	–	2.7 bcd	3.8 ab	–
Phorate	43 de	10 a	645 e	3.2 cde	4.0 abc	2.2 ab
Quinalphos	62 e	–	–	3.0 bcde	–	–

[a]Separation of means in a column by DMRT at the 5% level; – = not included in study, DAT = days after treatment.

susceptible Jaya. At 20-25 d after treatment, when BPH population peaked, adults and nymphs were counted on 10 randomly selected hills per treatment. BPH populations were larger in 1983 than in 1982.

Carbofuran, BPMC, and carbosulfan controlled BPH best (see table).

Mites attack IR56 in Vallanad, Tamil Nadu

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Rice mite *Oligonychus oryzae* (Hirst) attacked IR56 on the State Seed Farm in Vallanad in Sep 1985. The farm is irrigated for three seasons in a year. At 50 d after planting in a 6.5-ha block with 4 ha of IR50 and 2.5 ha of IR56, IR56 had 90-100% infestation and IR50 was mite-free.

IR56 had a mean population of 70 nymphs and adult mites/2 cm^2 leaf area and a mean of 96 eggs/cm^2 leaf area. Eggs, nymphs, and adults were on both leaf blade surfaces. Eggs were globular and pale white, nymphs were white, and adults were greyish white.

Mite feeding caused white spots on leaf surfaces, which later coalesced into white patches. Infested plants became yellowish white with severe leaf mottling.

Unusually high temperatures and dry weather (mean maximum temperature 35°C and minimum 30°C) for 30 d before the infestation may have encouraged high populations.

Rice gall midge (GM) in Tarai region of Uttar Pradesh

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The rice GM *Orseolia oryzae* is considered to be one of the major pests of rice. It has been reported in small pockets of Eastern Uttar Pradesh. In 1972, in the central and western Tarai region where rice is grown as a kharif crop, gall midge was reported from a very small area in Lakhimpur Kheri district. Since then, there was no report of its occurrence. While conducting a production oriented survey in 1984, we came across GM-infested fields in Mala village and the Amaria block of Pilibhit district. Infestation was observed in the widely grown variety Jaya, which was then in the panicle initiation stage. There was 20-25% infestation in Mala, and 10-15% in the Amaria block.

Infested tillers were brought to the glasshouse to observe adult emergence. Only one female fly emerged and was identified as *Orseolia* sp. (presumably rice GM). Along with the adults, some parasites also emerged and were identified as *Propieroscytus mirificus* Girault (Pteromalidae). These may be larval, pupal, or larval-pupal parasites.

The infested fields were along the forest but areas one kilometer away from it showed no GM infestation. The same forest belt continues toward the western side, Pantnagar being about 40 km away from Mala village. The GM appears to spread toward the western side of Tarai along the forest at a slow rate. Although no widespread infestation has been reported in Tarai, the trend is alarming.

In Tarai region, the temperature goes down below 0°C during winter. The survival and perpetuation of GM during off season is worth investigating, particularly its behavior in biotype differential rice varieties.

Pest Control and Management

WEEDS

Influence of different ecological situations on weed emergence in wetland rice

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Thirteen locations surveyed during the rabi season (Sep-Dec) of 1984 revealed the predominance of sedges in double-cropped wet rice fields in Trichur district. Eleven species of weeds classified under five groups were identified as follows: *Echinochloa crus-galli* (grass); *Cyperus iria, C. difformis, Scirpus supinus,* and *Fimbristylis miliacea* (sedges); *Ludwigia octovalvis,*

Table 1. Effect of different ecological conditions on weed count.

Treatment	Weed count (no./m^2)										
	Echinochloa crus-galli	*Scirpus supinus*	*Cyperus iria*	*Cyperus difformis*	*Fimbristylis miliacea*	*Sphaeranthus indicus*	*Sphenoclea zeylanica*	*Ludwigia octovalvis*	*Nymphaea nouchali*	*Monochoria vaginalis*	*Marsilea quadrifolia*
Transplanted rice	2.4	98.0	0.0	2.4	0.0	0.8	9.8	1.2	3.2	18.4	2.2
	(1.4)	(9.6)	(0.6)	(1.4)	(0.6)	(0.9)	(2.9)	(1.1)	(1.5)	(4.0)	(1.4)
Wet sown rice	0.0	56.8	10.0	67.2	6.4	0.0	2.4	0.0	0.0	14.4	0.0
	(0.6)	(7.2)	(3.2)	(7.6)	(2.3)	(0.6)	(1.4)	(0.6)	(0.6)	(3.7)	(0.6)
Wet fallow	2.4	267.2	6.4	10.6	0.0	0.0	6.6	4.2	1.6	8.8	1.2
	(1.4)	(16.3)	(2.5)	(3.2)	(0.6)	(0.6)	(2.5)	(2.0)	(1.1)	(2.5)	(1.1)
Dry fallow	0.2	273.6	8.2	24.2	149.2	24.8	0.0	0.0	0.0	0.0	0.0
	(0.7)	(16.4)	(2.9)	(4.8)	(11.7)	(4.9)	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)
CD at 5%	ns	3.4	0.7	3.0	2.8	1.0	1.2	0.8	ns	2.3	0.7

[a]Figures in parentheses are converted values.

Sphaeranthus indicus, Sphenoclea zeylanica, and *Nymphaea nouchali* [broadleaf weeds (dicots)]; *Monochoria aginalis* [broadleaf weeds (monocot)]; and *Marsilea quadrifolia* (fern).

In field experiments conducted at the Agricultural Research Station, Mannuthy, Trichur, during the 1985 rabi, the ecological requirements of the major weeds found in wetland rice were studied. Identification of weed species and their intensities of occurrence were observed in puddled and leveled rice fields under four situations: transplanted rice, wet sown rice, fallowing with 5 cm layer of water, and fallowing after the land is dried. The cultivar used was Jyothi (115 d). The experiment was laid out in randomized block design, replicated 5 times using 8- × 8-m plots.

Forty days after transplanting and wet sowing, the weed species that appeared in the experimental plots were identified and counted, *S. supinus* was found to be the most ubiquitous weed in either cultivated or fallowed fields. Occurrence was as high as 98 and 56.8 per square meter in transplanted and wet sown paddy crop (Table 1). *S. supinus* alone occupied 71% of the total weed population in transplanted rice, and 86% in wet fallow (Table 2). Wet sown rice favored the emergence of *C. iria. C. difformis* emerged as the major weed in wet sown rice, accounting for 43% of the total weed population. Both *C. difformis* and *S. supinus* constituted 79% of the total weed population in wet sown rice. *C. difformis* was appreciably suppressed in transplanted rice. Transplanting favored the emergence of *S. supinus* but suppressed *C. difformis* and *C. iria.* On the other hand, wet sowing suppressed *S. supinus* and favored *C. difformis* and *C. iria. F. miliacea* did not emerge under transplanting and wet fallowing conditions but appeared under wet sowing (6/m^2) and dry fallowing (149/m^2).

Broadleaf weeds, ferns and the grasses did not have widespread occurrence in any of the four situations studied. The spectrum of weed species occurring under wet sowing and dry fallowing was comparatively less (almost limited to 6) compared to transplanting and wet fallowing with 9 or 10 species. Sedges occurring under transplanting, wet sowing, wet fallow and dry fallow constitute 73, 89, 92, and 95%, respectively, of the total population.

Table 2. Percentage of weed species observed. Kerala, India.

Weed species	Percent per square meter			
	Transplanted rice	Wet sown rice	Wet fallow	Dry fallow
Grass				
Echinochloa crus-galli	1.7	0.0	0.8	0.1
Sedges				
Scirpus supinus	71.0	36.0	86.0	57.0
Cyperus iria	0.0	6.0	2.0	1.7
Cyperus difformis	1.7	43.0	3.4	5.0
Fimbristylis miliacea	0.0	4.0	0.0	31.0
Broadleaf weeds (dicots)				
Sphaeranthus indicus	0.6	0.0	0.0	5.0
Sphenoclea zeylanica	7.0	1.5	2.0	0.0
Ludwigia octovalvis	0.9	0.0	1.4	0.0
Nymphaea nouchali	2.3	0.0	0.5	0.0
Broadleaf weeds (monocot)				
Monochoria vaginalis	13.3	9.0	2.9	0.0
Fern				
Marsilea quadrifolia	1.6	0.0	0.4	0.0

Integrated weed management in upland irrigated rice in Marathwada

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In Marathwada, acreage under upland irrigated rice is increasing very fast. Losses due to weeds in upland rice are reported to be more severe than in transplanted rice. To evaluate weed control methods in upland irrigated rice, the use of herbicides with hand weeding was compared with higher rates of herbicides and hand weeding alone. The

Effect of herbicide treatment on grain yield and weed dry weight, showing additional profit over the control, Parbhani, India.

Treatment	Grain yield (t/ha)	Increase in yield over control (%)	Dry weed weight (g/m^2)	Additional profit over control ($/ha)[c]
Unweeded control	1.0	–	14.20	–
Recommended cultural practice, i.e. weeding and hoeing at 3 & 6 WAS[a]	2.0	106.3	3.39	106
1 hand weeding at 6 WAS	1.5	55.8	3.24	58
Butachlor				
1.50	1.4	51.0	8.63	35
1.00[b]	1.8	85.9	1.00	83
Thiobencarb				
1.50	1.1	15.7	12.94	–
1.00[b]	1.6	67.4	1.52	–
Pendimethalin				
1.00	2.1	115.1	1.55	–
0.75[b]	2.2	134.2	1.10	–
Oxadiazon				
0.75	1.7	74.4	1.10	62
0.50[b]	1.8	83.8	1.30	79
SE ±	0.2	–	0.70	–
CD at 5%	0.6	–	2.60	–
Mean	1.642	–	4.54	

[a]WAS = weeks after sowing. [b]With one hand weeding at 6 WAS. [c]Cost of butachlor, $8 per kg; oxadiazon, $10 per kg; thiobencarb and pendimethalin, not available; grain, $13/g; straw, $1/g; labor, $0.6l/day; bullock pair, $2/day.

experiment was carried out in the Jayakwadi Command Area during kharif (Jul-Nov) 1984 at MAU. The dominant weeds were *Acalypha indica, Dinebra retraflexa, Corchorus aestuans, Digera arvensis, Cynodon dactylon, Alysicarpus rugosus, Abutilon indicum,* and *Cyperus rotundus.*

Maximum grain yield (2.2 t/ha) was recorded with pendimethalin at 0.75 kg ai/ ha supplemented with one hand weeding at 6 wk after sowing (WAS). Grain yield was significantly superior to those with one hand weeding at 6 WAS and butachlor and thiobencarb application at 1.50 kg ai/ ha. One hand weeding at 6 WAS, and applying butachlor and thiobencarb each at 1.50 kg ai/ha proved ineffective in controlling weeds in upland irrigated rice. Among the herbicides, pendimethalin was the most effective in increasing grain yield, followed by oxadiazon (see table).

Economic analysis indicates that weeding and hoeing done twice at 3 and 6 WAS gave the highest profit. The price of pendimethalin is not available, but yields were higher than with the recommended cultural practice. When labor is short, preemergence application of pendimethalin at 1 kg ai/ ha can be done, provided it is economical.

Pest Control and Management

OTHER PESTS

A new virulent strain of rice root-knot nematode from Agartala, India

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Root-knot nematodes are considered severe pests of upland rice. We surveyed rice nematodes in eastern India and found rice plants heavily infested with *Meloidogyne grarninicola* in Agartala. These showed bigger galls on roots compared to those produced in Cuttack and Kerala. To know whether the Agartala population is different from the Cuttack and Kerala populations, a pot experiment was carried out. The three populations were inoculated into 5 rice varieties planted in 200 ml sterilized soil at 200 larvae/pot. Egg mass counts were taken after the first generation (21 d after inoculation) and compared (see table). The Agartala isolate reproduced equally well in all the five varieties while the two other isolates differed significantly in their reproduction. CR190, MW10, and IR36 were rated resistant to Cuttack and Kerala isolates while Annapurna and Parijat were susceptible. The Agartala isolate is considered as a new biotype for all the five varieties found susceptible to it.

Rice root-nematode egg masses (transformed values) 21 d after inoculation, India.

Variety	Egg masses (no.) from		
	Cuttack	Agartala	Kerala
Annapurna	4.88	4.05	6.52
Parijat	4.95	6.57	4.13
IR36	2.40	4.97	2.36
MWl0	1.47	3.33	1.39
CR190	2.37	4.54	2.09
CD at 5%	1.20	ns	1.06
at 1%	1.71	ns	1.50

Plant nematodes in rice fields

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We surveyed 3 districts in Tamil Nadu, India (South Arcot, North Arcot, and Chingleput), for the occurrence of rice phytonema. We covered a total of 110 blocks: 28 in Chingleput, and 36 in each of the 2 other districts. The reported genera in the rice rhizosphere were *Hirschmanniella, Tylenchorhynchus, Helicotylenchus, Criconemoides,* and *Hoplolaimus* spp. Their relative proportion in the soil and roots are given in the table.

The predominant nematode is *Hirschrnanniella* sp. which is found in both soil and roots. *Criconemoides* and *Hoplolaimus* spp. were not recovered from the roots. They occur in small proportion and were not economically important.

Proportion of different nematode genera in the soil and mots of rice.

Genus	Proportion in soil (%)	Proportion in roots (%)
Hirschmanniella	72.2	93.3
Tylenchorhynchus	17.9	5.4
Helicotylenchus	7.2	1.3
Criconemoides	2.0	–
Hoplolaimus	0.7	–

Efficacy of nets to prevent bird damage to rice

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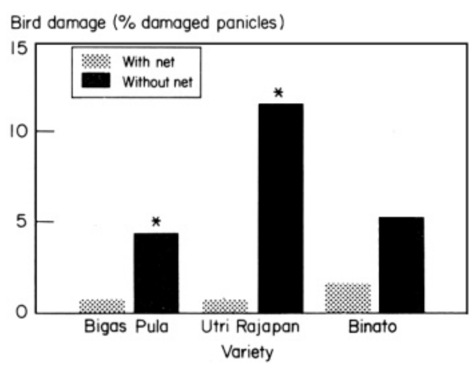
Nylon nets were placed over three rice varieties to determine their effectiveness against bird damage during the 1985 dry season.



Bird damage percentage in traditional varieties. Masapang, Victoria, Philippines, 1985 DS. * = significant difference between treatments 1 P = 0.05.

Two nets, 561 m^2 each with 36-cm^2 mesh, were supported 2.5 m above ground level by bamboo stakes at Masapang, Victoria, Philippines. The nets were positioned in such a way that they completely covered the plants within each plot.

Treatments involved the Binato, Utri Rajapan, and Bigas Pula varieties with four replications. Similar varieties without a net served as the control. Plots were assessed before and after the nets were set up to determine the extent of bird damage. Beginning 94 d after transplanting nets were kept in place for 9 d over Utri Rajapan and Binato, and 17 d over Bigas Pula.

Bird damage was assessed by counting the total number of damaged and undamaged panicles from 10 randomly selected hills per plot (21 m^2). In addition to the random samples, three to four hills from the borders of each plot were sampled because we observed that birds preferentially attack the border plants.

Bigas Pula and Utri Rajapan plots without a net sustained significantly more bird damage, compared to those with a net. However, no difference was found for Binato because bird damage occurred before the net was installed. It is also likely that this variety sustained more damage because it was located at the outermost portion of the experimental field making it more susceptible to bird attack.

Although this is a preliminary test, our results show that nets may be a satisfactory solution to the problem of bird damage, especially in plots where maximum protection is needed.

Soil and Crop Management

Effects of pyrite used as farmer on normal soils

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Pyrite is generally used to normalize saline-alkali soils.

During 1980-81, some farmers who casually applied pyrite as a topdressing obtained surprisingly good results. They contacted us to verify the relevance of pyrite application and the appropriate application rates. A trial under normal soil achieved positive results and a detailed experiment was undertaken.

Variety Sarjoo 52 was grown in a split-plot design with three replications. Soil texture was silty loam with 7.6 pH, 0.82% organic matter, 17.6 kg available P, and CEC 24.8 meq 100 g of soil. Chemical composition of the pyrite used was 22.3% S, 20.5%; Fe, 0.58% MgO, 0.13% CaO, 6.8% Al, 36.8% Si, 2.72%, C, 200 ppm Zn, 500 ppm CuO, and 122 ppm Mn.

Four levels of ground pyrite — 200 kg, 400 kg, and 600 kg, and no pyrite (control) were tested at 3 fertility levels — 60-13.6-24, 80-18-32, and 120-27.248 kg NPK/ha. All P and K and half N were applied basally; the remaining N was applied in two equal installments at tillering and panicle initiation.

Table 1. Effect of pyrite levels at different fertility levels on grain yield of rice. Faizabad, U. P., India.

Fertility level (kg NPK/ha)	Yield (t/ha) at pyrite level of				Mean yield (t/ha)
	0	200 kg	400 kg	600 kg	
Low (60-13.6-24)	2.7	2.7	2.9	3.3	2.9
Medium (80-18.0-32)	2.9	3.0	3.3	3.6	3.2
High (120-27.2-48)	3.5	3.8	3.9	3.9	3.8
Mean	3.0	3.2 (1.51)	3.4 (3.32)	3.6 (5.73)	

	Fertility combination	pyrite	Interaction
CD at 5%	0.1	0.2	ns

Table 2. Grain yield and ancillary characters as affected by pyrite topdressing at different fertility levels. Faizabad, U. P., India, 1984-85.

Treatments	Panicles/ linear m	Wt/panicle (g)	Grains/ panicle	1000-grain wt (g)	Grain yield (t/ha)
Fertility levels (kg NPK/ha)					
Low (60-13.6-24)	48	2.89	114	22.3	2.9
Medium (80-18-32)	50	2.95	118	22.4	3.2
High (120-27.2-48)	53	2.89	124	22.5	3.8
CD at 5%	–	–	5	–	1.4
Pyrite doses (kg/ha)					
0	47	2.80	115	22.4	3.0
200	49	2.85	117	22.4	3.2
400	51	2.91	119	22.3	3.4
600	55	3.08	121	22.4	3.6
CD at 5%	–	0.14	–	–	1.7

The pyrite was topdressed 20 d after transplanting. The crop was irrigated as needed.

Grain yields increased at all application levels up to 600 kg/ ha (Table1). Response was highest at medium fertility.

The yield increase was due to increased panicle weight (Table 2). Although the data did not show significant increases in panicle numbers per linear m or grain numbers per panicle, both characters increased with pyrite applications.

That pyrite is rich in S, Fe, and Si and has traces of Zn and Mn might be responsible for the yield increase. At this stage, the response to different levels of pyrite appears to be due to widespread deficiencies of many elements in Uttar Pradesh soil.

Effect of nitrogen source, rate, and placement method on growth and yield

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The efficiency of urea, urea supergranules (USG), and NPK (12-32-16) rates and placement methods in flooded lowland transplanted rice was studied in 1984 kharif. The design used three N rates and placement methods in a randomized block design with three replications.

Twenty-three-day-old Jaya rice seedlings were transplanted at 20- × 10-cm spacing. The soil (Beni silty clay loam) had pH 7.2, 1.51% organic C, CEC 23.91 meq/ 100 g of soil, and percolation rate of 15.3 mm/d. Treatments are described in the table.

All plots except NPK treatments received 28 kg P/ ha as single superphosphate and 26 kg K/ ha as muriate of potash.

Effect of source, rate, and placement of N on yield attributes of rice.

Treatment[a] Rate (kg N/ha)	Source and application	Plant ht (cm)	Tillers/m²	Gram yield (t/ha)
0	(control)	75.3	157	2.9
60	Urea, 3 splits	78.0	199	4.1
90	Urea, 3 splits	81.9	218	5.1
120	Urea, 3 splits	84.2	239	5.4
60	USG B&I at transplanting	76.8	207	4.0
90	USG B&I at transplanting	79.6	220	4.8
120	USG B&I at transplanting	84.0	290	5.2
60	USG deep placed 11 DT	84.4	243	4.8
90	USG deep placed 11 DT	88.2	253	5.3
120	USG deep placed 11 DT	89.2	303	5.4
60	2/3 N as USG B&I at transplanting + 1/3 N as urea at panicle initiation	77.9	191	4.0
90	2/3 N as USG B&I at transplanting + 1/3 N as urea at panicle initiation	81.5	209	4.9
120	2/3 N as USG B&I at transplanting + 1/3 N as urea at panicle initiation	84.4	214	5.3
120	24 kg N/ha at transplanting + 96 kg N/ha as urea in 2 equal splits at tillering & panicle initiation	90.8	296	5.8
120	24 kg N/ha at transplanting + 96 kg N/ha as USG deep placed 11 DT	89.3	308	5.1
	CD (0.05)	2.6	14	0.2

[a] B&I = broadcast and incorporated. Deep placed USG is put in the center of 4 hills in alternate rows at 8-10 cm depth. DT = days after transplanting.

At 60 kg N/ ha, yields from deep placed USG were significantly superior to those from 3 splits of urea, USG broadcast and incorporated (B&I) at transplanting, and 2/3 N as USG B&I at transplanting, and 1/3 N as urea at panicle initiation. Above 60 kg N/ ha, response to deep placed USG was less than the response to N applied by other methods.

Rice-Based Cropping Systems

Energy use in rice-based farming system in India

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We estimated and compared the energy requirements of rice and wheat crops at farmers' and improved levels of technology. Data on direct energy inputs in rice and wheat were obtained from a randomly selected sample of 191 farmers for one agricultural year. Indirect energy inputs (which represent about 20% of the total direct energy inputs) are not accounted for in this study.

The data on per hectare energy input and output for rice and wheat at farmer's field (farmers' technology) and NDRI demonstration unit (improved technology) are presented in the table. The data suggest that farmyard manure and chemical fertilizerd were the major energy inputs for rice and wheat crops under both technology levels. The use of energy from these sources was comparatively higher under the improved technology level than under the farmers' technology level for both crops. Bullock and human labor were the next important energy inputs under farmers' technology and machinery under improved technology.

Under farmers' technology, energy use was higher for wheat; under improved technology, energy use was higher for rice. Total energy inputs, in general, were higher under farmers' technology. Nevertheless, energy output was higher with the improved than with the farmers' technology, resulting in a relatively higher energy output-input

Per hectare energy input and output in rice and wheat production (MJ).[a]

Energy source	Farmers' technology		Improved technology	
	Rice	Wheat	Rice	Wheat
Seed	318.19 (2.54)	1,366.23 (9.40)	446.77 (1.35)	1,836.72 (8.43)
Farmyard manure	3,549.17 (28.30)	5,202.06 (35.79)	10,972.36 (33.25)	–
Chemical fertilizer	3,828.94 (30.53)	3,584.35 (24.66)	13,324.03 (40.38)	14,933.23 (68.62)
Machinery				
Diesel engine or electric motor	1,574.25 (12.55)	1,041.53 (7.17)	4,321.09 (13.09)	2,632.93 (12.10)
Tractor	182.41 (1.46)	289.41 (1.99)	1,552.28 (4.70)	1,725.23 (7.93)
Human labor	1,126.57 (8.98)	590.22 (4.06)	1,818.85 (5.51)	634.89 (2.92)
Bullock labor	1,961.45 (15.64)	2,460.38 (16.93)	568.89 (1.72)	–
Total energy input	12,540.99 (100.00)	14,534.18 (100.00)	33,004.27 (100.00)	21,763.00 (100.00)
Total energy output	50,436.77	64,739.39	144,077.18	105,203.40
Energy output-input ratio	4.02	4.45	4.37	4.83
Energy input/t	4,118.54	6,884.98	4,929.56	5,230.23

[a]Figures in parentheses indicate percent of total energy input.

ratio for the improved technology. In terms of energy output-input ratio, wheat performed better than rice under both situations. It may be inferred that farmers in the study area were better equipped with wheat technology than with rice technology. It is interesting to observe that I calorie of energy input could produce 4-5 calories of food from rice or wheat.

Announcements

D. L. Umali honored

Dioscoro L. Umali has been conferred the rank and title of National Scientist of the Philippines by President Corazon C. Aquino. The citation issued 11 Jul 1986 lauds Umali as an academician, scientist, educator, research organizer, development administrator, and science statesman. Currently, Umali is affiliated with IRRI as parttime liaison scientist for China.

ISS award for S. K. De Datta

S.K. De Datta has been selected for the 1986 International Soil Science Award. He is being recognized for his outstanding contributions to the growth and development of international soil science, his creativity in the establishment of scientific research, and his influence in bringing about long-lasting change in practices related to soil science in the developing nations. De Datta is principal scientist and head of IRRI's Agronomy Department. The award will be presented 2 Dec at the Soil Science Society of America annual meeting in New Orleans, LA, USA.

ASA award for B. S. Vergara

Benito S. Vergara has been selected to receive the 1986 Fellow award by the American Society of Agronomy. He is the author of *A farmer's primer on ,growing rice,* probably the most widely published agricultural book in existence, with 35 translated editions published in 30 languages of Asia, Africa, and Latin America and about 20 additional translations in progress. For the last 15 yr, he has conducted basic studies on the physiology of deep water rice. Vergara is head of IRRI's Plant Physiology Department. The award will be presented 3 Dec at the annual ASA meeting in New Orleans, LA, USA.

New IRRI publications

Development and spread of high-yielding rice varieties in developing countries
Farmer's primer on growing rice (Waray and Maguindanao eds.)
Global aspects of food production
Rice genetics proceedings of the international rice genetics symposium

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

ERRATUM

Reprinted from the Jun 1986 issue where the figure was omitted

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

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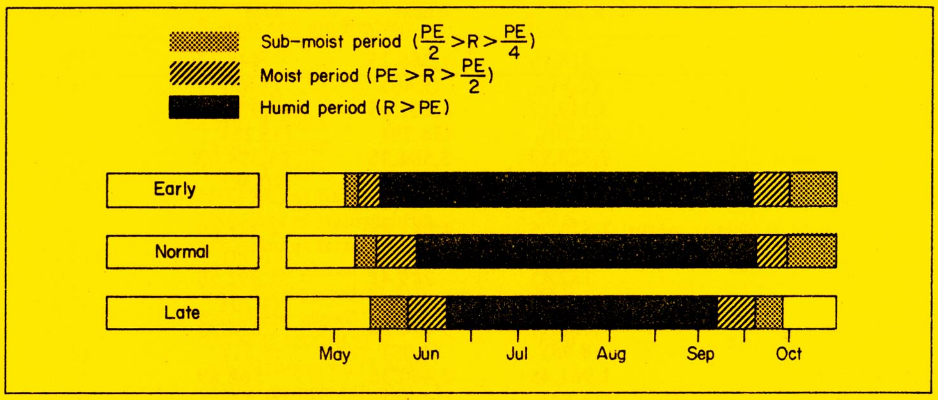
In Madhya Pradesh, India, rice is grown in about 4.7 million ha, of which 80% is rainfed. Rice yields are about 1.0 t/ha and depend entirely on the monsoon.

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).



Water availability periods under early, normal, and late onset of monsoon at Raipur, India. PE = potential evapotranspiration, R = rainfall.

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.

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

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