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Genetic evaluation and utilization

OVERALL PROGRESS

Genetic composition of IR rice varieties

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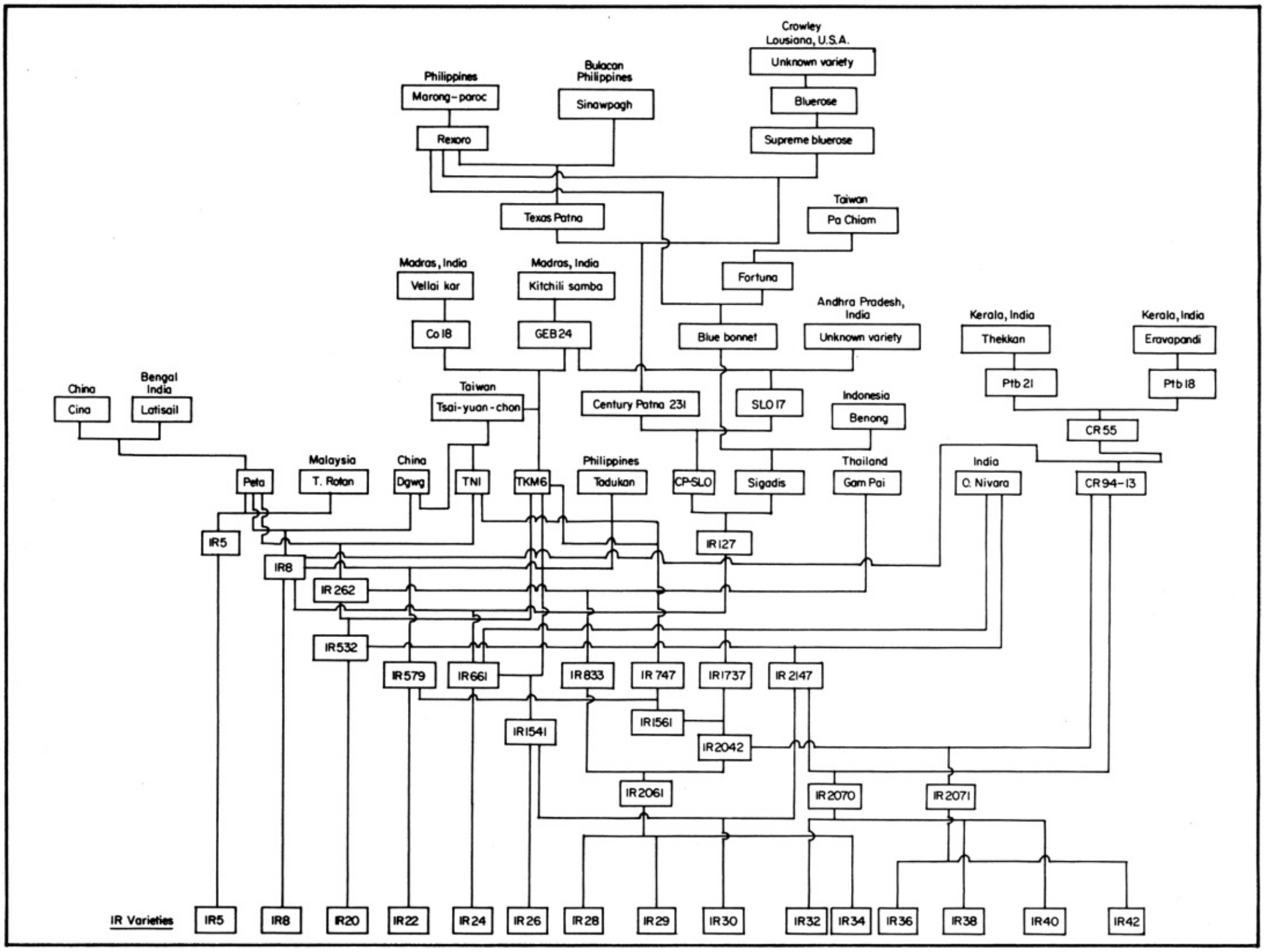
Forces acting over the last two decades have clearly eroded the genetic diversity of cultivated rice varieties. It seems appropriate to assess the situation and consider whether and how future developments might influence genetic diversity. This is the first of several articles that will trace the origin of modern varieties in major rice-growing countries.

Several countries have directly released the IR varieties — beginning with IR8 — and most national programs have used them heavily in crosses. A careful examination of the origin of the 15 IR varieties that have been named (including 4 named by the Philippines) reveals that 11 parents were utilized in their development. The 11 parents are traceable to 18 original varieties from 8 countries (Fig. 1).

Figure 2 traces the series of crosses from which the IR varieties were selected, emphasizing the maternal progenitors. All 15 trace back to the same maternal parent, Cina (formerly known as Tjina), from China via Indonesia. Thus, components of their cytoplasm would be similar.

This situation, while posing no immediate practical problem, is of sufficient concern to demand a prompt broadening of the maternal genetic base of modern rices.



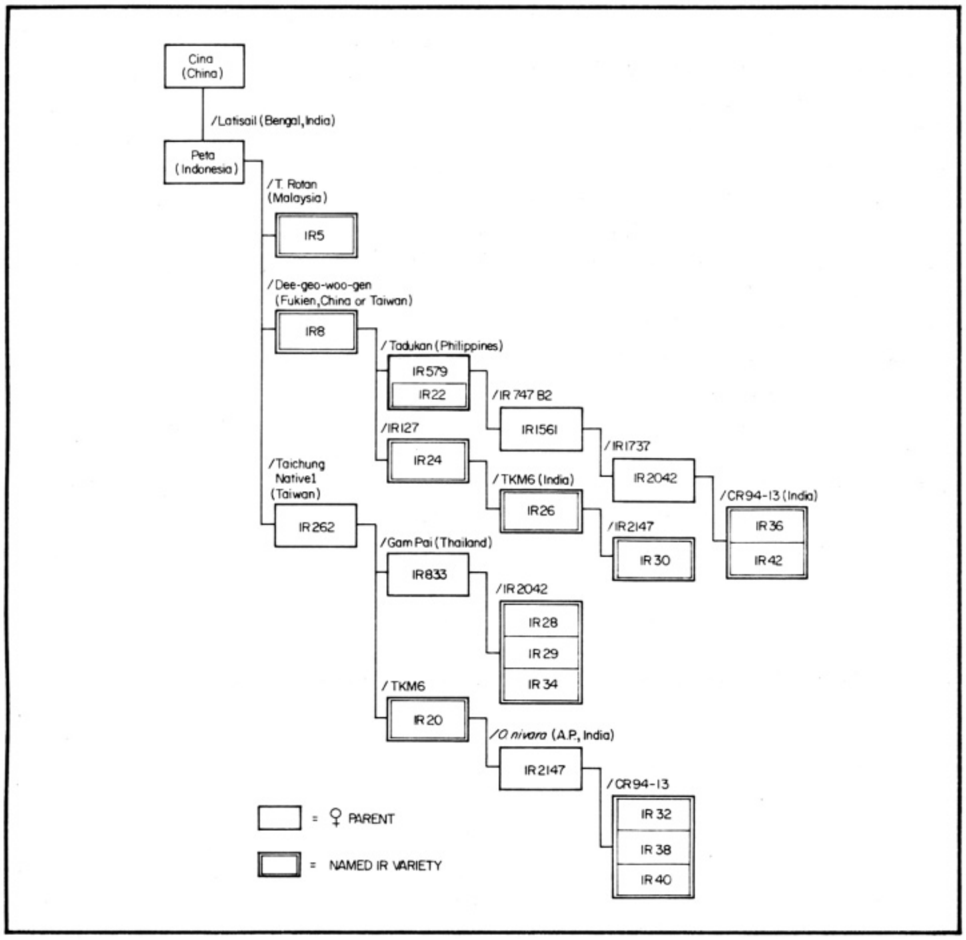
1. The derivation of IR varieties.

However, a newer line from the cross IR2863, being considered for release by the Philippine Seed Board, has a different maternal origin; it traces back to the Philippine variety Marong-paroc. Other lines of different maternal ancestry are being tested.

All of the semidwarf IR varieties derive their dwarfing gene from the variety Dee-geo-woo-gen (DGWG). Only IR5, which is not a true semidwarf, does not carry this gene. We know that virtually all other semidwarf varieties in major rice-growing countries, except the People's Republic of China, carry the DGWG gene. There is some evidence that the Chinese varieties may also carry the same gene.

The seemingly narrow genetic base of the IR varieties is not necessarily a cause for alarm. The analysis of any breeding program on any crop in a developed country, such as the USA or Japan, might reveal a similar situation. Diversification is difficult because of combining ability and other considerations beyond the control of breeders. Nevertheless, we know that any type of genetic uniformity can set the stage for pest epidemics. IRRI hopes to find and utilize alternate sources of semidwarfism and strongly encourages the naming of varieties of diverse maternal origin. With the cooperation and assistance of many other scientists, more extensive and current information will be gathered on the rice varieties being cultivated and developed on a global basis. The findings will be reported through the IRRN.

The issues raised in this paper may not ultimately be of valid concern; however, we should realize that modern efforts in rice improvement and associated technology clearly have the potential to carry us into unintended and unforeseen problems. We should scan the horizon and, to the best of our ability, prepare alternatives.



2. Maternal derivation of IR varieties. Female parents are in boxes on the left; male parents are on the right.

Style for IRRN Contributors

Units of measure and styles vary from country to country. To improve communication and to speed the editorial process, the editors of the *International Rice Research Newsletter (IRRN)* request that contributors use the following style guidelines:

- Use the metric system in all papers. Avoid national units of measure (such as cavans, rai, etc.).
- Express all yields in tons per hectare (t/ha) or, with small-scale studies, in grams per pot (g/pot) or grams per row (g/row).
- Define in footnotes or legends any abbreviations or symbols used in a figure or table.
- Place the name or denotation of compounds or chemicals near the unit of measure. For example: 60 kg N/ha; not 60 kg/ha N.
- The US dollar is the standard monetary unit for the *IRRN* Data in other currencies should be converted to US$.
- Abbreviate names of standard units of measure when they follow a number. For example: 20 kg/ha.
- Express time, money, and measurement in numbers, even when the amount is less than 10. For example: 8 years; 3 kg/ha at 2-week intervals; 7%; 4 hours.
- Write out numbers below 10 except in a series containing some numbers 10 or higher and some numbers lower than 10. For example: six parts; sevcn tractors; four varieties. *But* There were 4 plots in India, 8 plots in Thailand, and 12 plots in Indonesia.
- Write out all numbers that start sentences. For example: Sixty insects were added to each cage; Seventy-five percent of the yield increase is attributed to fertilizer use.
- Type all contributions double-spaced.

Changes in races of parent materials used in rice hybridizations over 10 years in Asia

Thomas R. Hargrove, associate editor, International Rice Research Institute

As part of a survey on the diffusion of genetic materials among Asian rice breeding programs, changes in the races of parents used in hybridizations were traced over a 10-year period.

Crosses were randomly selected from hybridization records at 14 experiment stations and universities in Bangladesh, India, Indonesia, Korea, Philippines, Sri Lanka, and Thailand. Genetic data were collected on 819 parents used in 355 crosses made during 1965–67, 1970–71, and 1974–75.

Over the decade, the increasing use of semidwarf indica rices such as IR8, TN1, and their progeny largely pushed japonica, ponlai, and other races out of the breeding programs. Indicas made up 79% of the parents used in 1965–67 crosses, and 91% of those used in 1974–75 (see table). Japonicas declined in use from 11% to 4%. Although ponlais made up 6% of the 1965–67 materials, they were almost absent in 1974–75 crosses.

The project was partially funded by a research grant from The Rockefeller Foundation.

Races of 819 parents used in 355 randomly selected crosses at 14 agricultural experiment stations and universities in 7 Asian nations, 1965-75.

Race of parents	Parents analyzed (%)		
	1965–67	1970–71	1974–75
Indica	79	86	91
Japonica	11	10	4
Javanica	1	1	0
Indica-japonica	1	2	4
Indica-javanica	2	*a*	0
Ponlai	6	1	*a*

[a] Less than 1%.

Development and evaluation of derivatives of Mahsuri (Ponni)

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Mahsuri is grown on 50 to 60% of the paddy land during the monsoon season (Aug.-Sept. to Feb.) in Pondicherry state and in South Arcot, North Arcot, Chinglepet, and Tanjor districts of Tamil Nadu. Mahsuri (renamed as Ponni in this region) is popular with farmers because of its fine grain and its medium growth duration that facilitates culture in the late monsoon season.

Despite its wide use and popularity, Mahsuri lodges in heavy rain even under moderate nitrogen and is susceptible to several major insects and diseases. Therefore, an attempt at improvement was made by incorporating into it lodging resistance, high yielding ability, and field tolerance for major pests.

Mahsuri was hybridized with IR8 as the pollen parent. The F_2 through the F_6 progeny were studied. A number of medium-height derivatives and recombinants with Mahsuri-like panicles and grain types, combined with lodging resistance and increased yield potential, were developed. Thirty-seven derivatives were finally identified and compared with Mahsuri. The set was also tested in summer planting.

Mean yield data of the derivatives and the mean and range in values for a few traits are given in the table for the summer and monsoon seasons of 1977. The evaluation indicated that:

- Nine of the progeny tested were photoperiod-sensitive and did not flower when sown in the summer, even though neither parent is sensitive to photoperiod.
- The overall mean yield of the progeny grown in the summer was 77.4% higher than the mean yield in the monsoon season.
- A few of the progeny of Mahsuri/IR8 showed recombinations of grain characteristics of Mahsuri with lodging resistance and yields higher than that of Mahsuri. The photoperiod-insensitive derivative 162/2 yielded 4.7 t/ha in the summer and 3.0 t/ha in the monsoon; 166/3 yielded 5 t/ha in the summer and 2.6 t/ha in the monsoon compared with Mahsuri's 4.3 t/ha for the summer crop and 2.5 for the monsoon crop.
- Yield tests indicated that some nonsensitive progeny can be grown in both the monsoon and summer seasons.
- The growth duration of Mahsuri and the derivatives in summer was 13 to 15 days longer than in the monsoon season.
- Derivatives that had photoperiod sensitivity gave a mean yield of 2.05 t/ha (range, 1.48 to 2.65 t/ha) – 11% lower than that of photoperiod-insensitive derivatives over two seasons. The mean yield of the insensitive derivatives was 2.31 t/ha (range, 1.41 to 3 t/ha).

Mean values and range of the yield and yield components of Mahsuri (Ponni) derivatives in the summer (Feb.–June) and monsoon seasons (Sept.-Jan.) Pondicherry, India, 1977.

Yield component	Derivatives				Mahsuri (Ponni)	
	Summer		Monsoon		Summer	Monsoon
	Mean	Range	Mean	Range		
Plant ht (cm)	133.5	116.0–151.0	102.0	87.0–118	138	119
Productive tillers (no.)	7.7	4.4– 10.9	5.0	3.4– 6.7	7.4	6.4
Grains (no./panicle)	143	95.0–191.0	206	121.0–292.0	145.0	175
Length:breadth ratio of grain	2.7	2.4– 3.0	–	–	3.2	–
Yield (t/ha)	4.1	3.4– 5.0	2.3	1.4– 3.2	4.3	2.5

GENETIC EVALUATION & UTILIZATION

Disease resistance

Fertilizer levels and incidence of bunt disease in rice in India

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The incidence of rice bunt disease or kernel smut caused by *Neovossia horrida* has increased with the introduction of high yielding rice varieties and the stress on fertilizer application. This report deals with the effect of high (100-50-50 kg/ha) and low (50-25-25) doses of NPK fertilizer on bunt incidence in 17 rice varieties tested at the Punjab Agricultural University, Ludhiana. Data on number of grains affected per plant and percentage of bunt-affected panicles (after arcsin transformation) were analyzed.

Differences in both number of affected grains and percentage of affected panicles between fertilizer levels and varieties and their interactions were significant.

At high doses of fertilizer, all varieties except IR506 RP5B, CR44-93, Vijaya, and IR8 had significantly more bunt-affected panicles. Jaya had significantly higher bunt incidence than the other released varieties. CR23-4736 had the highest percentage of bunt-affected panicles. All varieties, except 9435, had significantly more affected grains per plant. CR23-4736 had the largest percentage of affected grains, followed by CR51-3, IR661-1-140-3, Jaya, CR82-10, and CR23-4594.

The varieties 9435, IR506 RP5B, IR8, and Vijaya had fewer affected grains per plant and lower percentage of affected panicles, suggesting that they might be used in hybridization programs. It is suggested that in the development of bunt-resistant lines, segregating materials be screened at higher fertilizer levels.

The effect of low levels (L_1)[a] and high levels (L_2)[b] of fertilization on the number of panicles affected by bunt, number of grains affected per plant, and days to 50% flowering in 17 rice cultures. Kapurthala, India.

Cultivar	Bunt-affected panicles (%)			Affected grains (no./plant)			Days to 50% flowering
	L_1	L_2	L_2-L_1	L_1	L_2	L_2-L_1	
IR506 RP_2B	1.45	13.70	12.25*	0.8	7.8	7.0*	105
IR644 RP_2B	9.22	23.97	14.75*	5.2	15.4	10.2*	104
IR506 RP_4B	2.72	12.17	9.45*	1.8	8.6	6.8*	105
IR506 RP_5B	5.55	10.07	4.52	2.2	6.0	3.8*	103
IR506 RP_9B	4.75	17.30	12.55*	5.2	14.4	9.2*	103
CR23-4594	17.10	40.35	23.25*	10.6	43.0	32.4*	87
CR23-4736	13.32	50.40	37.08*	7.4	54.6	47.2*	94
CR51-3	19.17	34.35	15.18*	18.6	51.6	33.0*	102
CR82-10	16.77	37.97	21.20*	13.0	45.8	32.8*	105
CR44-93	5.27	9.80	4.53	2.8	11.6	8.6*	98
CR66-56	9.67	38.97	29.30*	5.6	29.0	23.4*	94
9435	4.22	10.17	5.95	1.8	4.4	2.6	90
CR100-32	8.77	37.27	28.50*	6.8	34.4	27.6*	98
1R661-1-1-140-3	10.82	44.95	34.13*	7.6	47.2	39.6*	96
Vijaya	8.45	12.10	3.65	2.2	10.0	7.8*	105
Jaya	25.20	39.42	14.22*	11.0	47.00	36.0*	104
IR8	1.40	8.65	7.25	0.4	5.2	4.8*	105
	CD = 5%		8.60			3.62	

[a] 100-50-50 kg NPK/ha.
[b] 500-25-25 kg NPK/ha.

Incidence of leaf scald disease on dryland rainfed rice in Liberia

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Leaf scald *Rhynchosporium oryzae* is widely distributed in the humid tropics of West Africa. Although the precise extent of damage from it is not known, regional rice pathologists consider it a potentially destructive disease.

We have observed leaf scald throughout Liberia on both rainfed dryland and lowland rice; its incidence on dryland rice is higher. The national rice varietal improvement program emphasizes the selection of varieties with low incidence of the disease. Of about 4,000 cultivars evaluated in trials from 1974 to 1976 at Suakoko, none were free from leaf scald; however, Khao Dawk Mali, Tetep, IAC1500, IR4547-6-1-4, IR4547-6-2-5, IR2035-290-2-1-1, and Kanto 15 had lower incidence.

In the 1977 wet season, 156 rice cultivars were compared with recommended variety LAC23 under dryland rainfed conditions at the Central Agricultural Experiment Station, Suakoko, at two fertility levels (0-0-0 and 40-40-40 kg/ha of NPK) and two spacings (30- and 15-cm rows). The first lot of 100 lines, with LAC23 as the check planted after every 10 lines, was seeded on 13 June 1977; the second lot of 56 lines plus 6 plots of LAC23 were seeded on 23 June 1977. Each cultivar was sown in a 10- × 5-m plot, divided into 4 equal parts of 2.5 × 1.5 m each, to accommodate the fertilizer and spacing treatments.

Cultivars were scored on a scale of 1 to 9 for incidence of leaf scald at the flowering stage, in the four fertilizer × spacing treatments. The incidence of leaf scald was higher in the cultivars of the lot seeded on 13 June than in those of the lot seeded 23 June; the trend was similar for the check variety LAC23 (see table). Although no information on weather parameters was recorded, the differences in disease incidence have been due to environmental factors. Fertilizer application increased disease incidence in resistant, moderately susceptible, and susceptible varieties seeded on both dates. Closer spacing did not affect leaf scald incidence.

Observed as resistant were 63–83, M202, D4-135, Moroberekan, Peroda, ROK 3, C46-153, and the locally bred upland lines LS(1)-29-2-NI 2, LS(1)-1-1-NI 3, LS(25)-4-1-NI 1, LS(25)-4-1-NI 4, TOX 95-8-1-1-LS 2, TOX 95-8-1-1-LS 3, TOX 95-8-1-4-LS 5, TOX 95-8-1-4-LS 6, and TOX 95-8-1-5-10.

Susceptible cultivars were Juma 1, M10, TOS 2581, TOS4113, TOS 4169, IR1746-194-1-1-1, IR2737-F4B-1-3-1, IR1754-F5B-16, BPI 76/Bicol, Binotas M1-48, E 425, T19, IR1746-226-1-2-2, IR841-671-2-2-1-2, and IR2053-522-5.

Moderately susceptible cultivars were LAC23, IRAT 13, FT 34061, Mahadampai, C 168-134, Pinilot 330, Payamult, IR2035-108-2, 1R2733-F5B-6-4, IR2151-957-5-3, IR3276-3, T16, TOS 2300, H4, and the locally bred upland lines LS(1)-5-2, LS(1)-7, LS(24)-6-NI 2, LS(24)-6-NI 3, TOX 95-8-1-1-LA 5, TOX 95-8-14-NI 7, TOX 95-8-1-5-NI 4, and TOX 159-2-1-1-LS1.

Incidence of leaf scald on rice cultivars seeded on different dates with different fertilizer and spacing rates. Central Agricultural Experiment Station, Suakoko, Liberia.

Varietal group	Lines (no.)	Seeding date	Disease score[a] 0 NPK at 30 cm	0 NPK at 15 cm	40-40-40 NPK at 30 cm	40-40-40 NPK at 15 cm	Mean
Resistant[b]	4	13 June	2.8	2.8	3.0	3.0	2.9
	23	23 June	1.2	1.1	2.8	2.9	2.0
Moderately susceptible[c]	66	13 June	4.4	4.4	5.7	5.8	5.0
	12	23 June	3.3	3.4	5.4	5.7	4.7
Susceptible[d]	30	13 June	5.8	6.1	7.3	7.2	6.6
	10	13 June	5.7	5.4	7.0	7.1	6.3
Overall mean	100	13 June	4.8	4.8	6.1	6.1	5.4
	56	13 June	2.9	2.8	4.6	4.8	3.9
LAC23 (check)	6	23 June	2.7	3.0	4.5	5.0	3.8

[a]Scale of 1 to 9.
[b]Score: 1–3.
[c]Score: 4–6.
[d]Score: 7–9.

Occurrence of *Cercospora* leaf spot disease of rice in Pakistan

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Cercospora leaf spot, usually known as narrow brown leaf spot and caused by *Cercospora oryzae,* was observed for the first time in Pakistan at the Rice Research Institute, Dokri, in the International Rice Yield Nursery of the International Rice Testing Program. The nursery was planted during the 1977 kharif.

The fungus usually attacked the leaves, but, in severe cases of infection, also attacked the grains. Reddish to blackish-brown streaks were produced on the leaves, and, in some cases, also yellow margins and brownish-grey center. The spots had a linear appearance and were parallel to the leaf veins. They varied from 3 to 22 mm in length and from 1 to 4 mm in breadth.

Entries with the best resistance to both leaf and grain infection, with ratings of less than 4, were TNAU13471, C038, IET5656, IETS854, IET2911, MTU8431, MTU9416, BKN6987-128-2-4, IR579.

The incidence of the disease is not regarded as serious at present, but a keen watch is necessary to check its spread.

Reaction of certain promising rice selections to tungro virus disease

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A field trial to evaluate 14 promising rices for resistance to rice tungro virus was conducted during the 1977–78 pishanam season (Dec.–March). Tungro incidence at the maximum tillering stage was recorded with the standard evaluation method used at IRRI.

Rice tungro virus incidence was comparatively lower in AS2422, AS5250, AS5272, AS3827, AS1391, and AS4003 (see table). AS2572, AS2690, AS2686, AS651, and AS5284 were found moderately resistant; AS3699, AS3704, and AS3799 were susceptible. The tungro-resistant rices may be used in breeding programs.

Reaction of promising rice cultures to tungro virus disease. Tamil Nadu, India.

Rice culture	Parentage	Disease incidence (%)
AS3821	IR26/IR22	1.8
AS2512	AD9588/ADT30	11.9
AS2686	Sel. from RP533-200-2-2-1-1	9.3
AS2690	Sel. from RP533-200-2-2-1-5	11.1
AS3704	ADT31/Culture 198	28.0
AS5391	ASD 14/Ratna	3.5
AS5272	ASD 8/IR8	1.6
AS3699	ADT31/Culture 198	58.1
AS4003	ASD 7/AS 2	4.5
AS2422	ASD 14/IR127	1.2
AS5250	ASD 8/IR8	1.4
AS3199	IR26/CR 106-90	38.0
AS5284	ADT31/Ratna	11.1
AS651	ASD 5/IR8	8.7

Leaf scald disease of rice in Manipur, India

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Leaf scald disease of rice first occurred on 10–15 acres in Manipur (at the State Seed Multiplication Farm, Mantripukhri, Imphal) during 1973–74. Since then the disease has occurred widely in the state's major rice belt. In 1976–77, the disease was found infecting China 1039 in the State Rice Research Station, Wangbal. Recently a number of local and newly introduced high yielding varieties (see table) were infected by the disease. Ratna appears to have some resistance to the disease.

Occurrence of rice leaf scald in Manipur, India.

Variety	Location	Reaction to the disease[a]	Remarks
Moirangphou	Thoubal, Bishenpur, and Imphal West I	S	A popular local variety
Cheena No. 1	Imphal West II	HS	A nondescript local cultivar gaining popularity
IET 1991	Imphal West I	S	First recorded on this variety and Jaya, 1973–74
China 988	Whole central valley	S	Popular variety introduced recently
China 1039	- do -	S	- do -
Jaya	- do -	S	This high yielding variety is extremely popular and widely cultivated
Ratna	- do -	MR	- do -
IR24	- do -	S	- do -

[a]S = susceptible, HS = highly susceptible, MR = moderately resistant.

Although leaf scald is not as threatening as blast, its importance in Manipur is increasing because of the changes in agrotechniques adopted in the state.

Phenol content: a possible biochemical parameter for resistance and susceptibility of the rice plant to *Helminthosporium oryzae*

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Brown spot disease of rice caused by *Helminthosporiurn oryzae* appears as brownish to greyish oval-shaped lesions on the coleoptile, leaf lamina, leaf sheath, and glume, but rarely on the stem of the rice plant. Establishment of the disease depends on the compatibility between the host and the pathogen.

The parameter used to measure the resistance and susceptibility of the rice plant to brown spot is the number of lesions as well as their size. The present investigation indicates that phenol content of rice leaves could serve as the biochemical parameter.

Different varieties of rice were screened for resistance and susceptibility to *H. oryzae* in the field with the conventional method. The varieties were classified as resistant (R), moderately resistant (MR), and susceptible (S). Twenty-four varieties (8 resistant, 8 moderately resistant, and 8 susceptible) were selected and the total phenol content of the healthy leaves was determined colorimetrically. A strong correlation existed between phenol content of rice leaves and susceptibility of the host to pathogenic attack; phenol content was highest in the resistant variety.

An artificially inoculated susceptible variety, pretreated with catechol (a phenolic compound), showed resistance to *H. oryzae.* Potato-dextrose agar, supplemented with different concentrations of catechol, inhibited pathogen growth. The catechol concentration in the medium and the inhibitory growth of the pathogen were correlated. The results indicate that the phenol content of rice leaves acts as a possible biochemical parameter for disease resistance and susceptibility of the rice plant to *H. oryzae.*

Sugar, amino acids, protein, nitrogen, phosphorus, potassium, and manganese contents were also analyzed, but varietal differences were not significant.

Reaction of some rices to bacterial blight, blast, and *Helminthosporium* leaf spot under field conditions

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One hundred and ninety rice selections and four standard cultivars — Jaya, PR106, Palman 579, and Basmati 370 – were sown in a randomized block at the Regional Rice Research Station, Kapurthala, and at the Regional Research Station, Gurdaspur, of Punjab Agricultural University. Their reactions to bacterial blight were recorded in September 1977. Observations on blast and *Helminthosporium* leaf spot were recorded only at Gurdaspur, where conditions are ideal for their development.

Bacterial blight incidence was higher in all the cultures at Gurdaspur than at Kapurthala because environmental conditions there were more favorable (see table). The cross combinations Basmati 370/IR8, Basmati 370/IR480-5,

Reaction of rice cultivars to bacterial blight, blast, and *Helminthosporium* leaf spot under natural conditions. Punjab, India.

Cross combination	Selections (no.)	Reaction to disease			
		Bacterial blight [a]		Blast [b] at Gurdaspur	*Helminthosporium* leaf spot [c] at Gurdaspur
		Kapurthala	Gurdaspur		
Basmati 370/Jaya	54	1.7	2.5	2.8	3.5
Norin 18/Hyb 27	52	0.8	2.0	4.7	3.3
Mutants of Basmati 370	33	1.3	2.2	2.1	3.0
Basmati 370/Hamsa	22	1.2	2.2	4.0	3.1
Basmati 370/IR127-80-1-10	5	1.6	2.6	2.4	2.2
IRB/Basmati 370	4	0.7	2.0	3.0	2.5
Phulpattas 72/Mut 65	4	1.7	2.7	2.5	3.5
Basmati 370/IR8	3	1.0	1.7	3.0	2.7
Hyb 27/Mut 65	2	3.5	3.5	2.5	4.5
Mut 52/Basmati 370	1	3.0	3.0	3.0	2.0
Basmati 370/IR480-5	1	1.0	1.0	3.0	5.0
UPR71-12	1	1.0	2.0	3.0	3.0
UPR71-21	1	3.0	2.0	2.0	3.0
UPR70/30-4	1	3.0	3.0	3.0	3.0
UPR70/30-7	1	2.0	3.0	2.0	3.0
UPR70/30-14	1	3.0	3.0	3.0	3.0
UPR70/30-15	1	3.0	3.0	2.0	3.0
UPR70/30-25	1	3.0	3.0	3.0	2.0
UPR70/30-26	1	0	3.0	3.0	5.0
UPR70/30-39	1	3.0	3.0	2.0	3.0
Jaya	–	1.0	2.0	2.0	3.7
PR106	–	1.3	1.7	2.0	3.0
Palman 579	–	2.0	2.3	1.7	3.0
Basmati 370	–	1.3	2.7	1.7	3.0

[a] 0 = no infection (immune); 1 = 1–1% of leaf area infected (moderately resistant); 2 = 11–25% (moderately susceptible); 3 = 26–50% (susceptible); 4 = more than 50% infection (highly susceptible).
[b] Rated only at Gurdaspur. 1 = immune, 2 = resistant, 3 = moderately resistant, 4 = susceptible, 5 = 50% of leaves infected, 6 = 75% of leaves infected, 7 = 100% of leaves infected.
[c] Rated only at Gurdaspur. 1 = highly resistant, 2 = resistant, 3 = moderately resistant, 4 = moderately susceptible, 5 = susceptible, 6 = very susceptible.

and the cultivar PR106 were moderately resistant to bacterial blight. Palman 579 and Basmati 370 were resistant to blast. Most of the rices gave resistant to moderately resistant reactions to *Helminthoporium* leaf spot.

Reaction of rice breeding lines to bacterial blight

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Bacterial blight of rice incited by *Xanthomonas oryzae* is a serious disease in Kuttanad tract of Kerala, India. Forty-one advanced promising rice cultures developed at the Rice Research Station, Moncompu, were artificially inoculated with a viable and fresh bacterial suspension to study their reactions to bacterial blight. The IRRI leaf clipping method was adapted to the greenhouse for the study. Twelve cultures recorded disease scores below 4: M24-179-1, M24-39-1, M23-57-2-1, M23-17-1-2, M23-33-2-1, M23-57-1-2, M23-83-1-1-2, M23-33-3-1, M23-9-1-1, M23-73-1-1-2, M13-116-1, and M23-16-1-1.

GENETIC EVALUATION & UTILIZATION

Insect resistance

Feeding of brown planthopper on rice varieties labeled with ^{32}P

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The importance of the brown planthopper (BPH) *Nilaparvata lugens* has increased in recent years in the Republic of Korea. A 1975 BPH outbreak was especially severe because unusually warm summer temperatures caused a generation advance (BPH do not overwinter in Korea; they migrate annually in late spring and early summer from the Asian mainland).

The use of radioisotopes to complement conventional screening and evaluation of new breeding lines and varieties was investigated in 1976. In initial trials, three varieties that differed widely in BPH resistance in conventional trials were evaluated by radiotracer methods. The varieties were Yushin, a new high yielding variety; Jinheung, an indigenous japonica; and IR747, a BPH-resistant line.

Six 10-day-old seedlings of each variety were wrapped lightly with a band of absorbent cotton and inserted in 1.27-cm (½-inch) holes in a stainless steel plate. The plate was suspended over a tray containing $^{32}P\text{-}H_3PO_4$ (at a concentration of 0.5 c/ml) in distilled water. The solution level in the tray was high enough to cover most of the seedlings' root area. After 24 hours, the seedlings were transferred to a tray containing only distilled water and then infested with female and male BPH adults that had received no food or water for 3 hours.

The insects were allowed to feed for 24 hours, then were placed in a freezer to kill them. They were placed on a 1.27-cm strip of doublestick cellophane tape affixed to the bottom of a 0.32- × 3.18-cm (1/8 × 1-1/4 in.) aluminum planchet and counted with an Aloka Model TDC-6 scaler.

The female BPH on Yushin seedlings were the most active feeders as indicated by the number of radioactive counts/minute (Table 1). Feeding was intermediate on the japonica Jinheung and lower on the resistant IR747. Female feeding was always higher than that of the male.

In a more extensive trial, eight varieties, each with six replicate seedlings per tray, were compared. The concentration of ^{32}P was 0.43 µc Na_2HPO_4/ml of water solution. Seedlings were placed in the ^{32}P solution for 24 hours followed by replacement of the ^{32}P solution with plain distilled water. One pair of adult BPH per plant was allowed to feed for 24 hours and then anesthetized with ethyl acetate. The insects were prepared as before and then

Table 1. Radioactive counts[a] of brown planthopper *Nilaparvata lugens* fed on rice varieties labeled with ^{32}P. Republic of Korea

Variety	Reaction[b] to brown planthopper	Brown planthopper Sex	Counts (no.)[c]
Yushin	S	Female	1898 a
		Male	842 b
Jinheung	S	Female	336 bc
		Male	180 c
IR747	R	Female	168 c
		Male	17 c

[a]Based on av. of 5 replicates corrected for background.
[b]R = resistant; S = susceptible.
[c]Any two means followed by the same letter do not differ significantly at the 5% level.

Table 2. Counts[a] of brown planthopper (BPH) *Nilaparvata lugens* on rice varieties labeled with ^{32}P. Republic of Korea.

Variety	Reaction to BPH[b]	Radioactive counts/minute Females	Males	Count ratio	Relative count of females (%)
Tongil	S	19,765	3,129	6.32	100.0
Yushin	S	14,214	2,056	6.91	71.9
Milyang 30	MR–R	4,364	292	14.95	22.1
Jinheung	S	4,321	620	6.97	21.9
IR747	R	1,394	172	8.10	7.1
ASD 7	R	1,188	306	3.88	6.0
Suweon 264	MS	1,098	408	2.69	5.6
Mudgo	R	789	934	0.84	4.0

[a]Av. of 6 counts/sex per variety, corrected for background.
[b]R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible.

counted with a Tracerlab Versamatic 11 Scaler.

The highest counts were for BPH that fed on Tongil and Yushin varieties (Table 2). These two varieties, which now grow on about 60% of Korea's rice land, were injured somewhat during the 1975 BPH epidemic. But because they matured earlier, they suffered less injury than the local japonica. The resistance of the newer selections Milyang 30 and Suweon 264 is promising. Again differences in the counts of female and male insects, expressed as a ratio, were significant. Only on Mudgo, which is resistant to BPH biotype 1, were counts of males higher than counts of females, but the difference was not significant. (The presence of BPH biotypes has not been observed in Korea.) Assuming a relative preference of 100% for Tongil, the relative counts of females matched the results of conventional varietal screening tests perfectly (Table 2).

Additional trials include other leafhopper and planthopper species. Radiotracers not only facilitate resistance screening but could conceivably be used in the analysis of biotypes and in tests requiring quantitative assessment of insect activity.

Field reaction of rices to the brown planthopper and ragged stunt virus

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The incidence of ragged stunt virus, transmitted by the brown planthopper (BPH) *Nilaparvata lugens,* has been high at IRRI since late 1976. In 1977, three experiments were conducted to determine the field resistance of the IR varieties, breeding lines, and entries in the International Rice Brown Planthopper Nursery (IRBPHN) to BPH and ragged stunt.

In all experiments, the BPH population was promoted by spraying susceptible border plants surrounding the test entries with synthetic pyrethroids, cypermethrin, or decamethrin (see article in this issue for details).

The following IR rices evaluated in the field at IRRI were resistant to BPH and had low ragged stunt incidence (less than 17% of hills infested): IR32, IR2863-38-1-2, IR4432-52-6-4, IR4432-103-6-4, IR4570-83-3-3-2, and IR5853-118-3. IR29 had 76% and 100% of hills infested in two experiments. IR32 is resistant and IR29 is susceptible to biotype 2 of the BPH, currently considered the predominant biotype at IRRI. In greenhouse tests these breeding lines are resistant to the three biotypes of BPH. All have CR94-13 (PTB18/PTB21//IR8) as a common resistant parent, except IR4570-83-3-3-2 which has PTB18 in its ancestry.

Evaluation of the 1977 IRBPHN indicated that varieties such as PTB19,

Evaluation of selected third International Rice Brown Planthopper Nursery (1977) entries to brown planthopper and ragged stunt. IRRI, wet season, 1977.

Variety [a]	BPH count/hill [b] 70 DT	Ragged stunt (%)	BPH damage rating [c] 80 DT	Resistance to BPH biotypes [d] in greenhouse		
				1	2	3
B2360-11-3-2-3	118	100	5	R	S	R
Chianung sen yu 19	279	90	7	R	S	S
CR94-13	60	79	3	R	R	S
CR179-1-717	56	72	5	R	R	S
IR2307-72-2-2-1	65	75	7	R	S	R
Taichung sen yu 204	57	98	7	R	S	S
Triveni	36	61	5	S	S	S
ARC 6650	37	96	7	R	R	S
Babawee	9	29	1	R	R	R
Balamawee	33	8	1	R	R	R
Gangala	29	28	1	R	R	R
Heendoramawee	15	58	1	R	R	S
Hondarawala	30	34	1	R	R	R
Lekam Samba	100	13	1	R	R	R
Muthumanikam	160	23	1	R	R	R
PTB19	56	7	1	R	R	R
PTB21	38	0	1	R	R	R
PTB33	48	0	1	R	R	R
Rathu Heenati	37	19	1	R	R	R
Sinna Sivappu	14	4	1	R	R	R
Sudu Hondarawala	44	56	1	R	R	R
Thirissa	16	59	1	R	R	R
Suduru Samba	69	31	1	R	R	R
ASD 7	58	61	5	R	R	S
Mudgo	238	76	7	R	S	R
TN1	121	100	9	S	S	S

[a] Field study replicated four times. Four border rows of IR19173-17 planted at ends of test entry rows and two rows planted between each test entry. Plot size of test entries was 1 m^2 and consisted of four rows of four plants each, spaced at 25 × 25 cm.
[b] Collected with a D-Vac suction machine. All BPH adults at 30 days after transplanting (DT) and mostly nymphs at 70 DT.
[c] Based on the Standard Evaluation System for rice: 1 = no damage; 9 = plants dead.
[d] R = resistant; S = susceptible.

PTB21, PTB33, and Sinna Sivappu, all of which have high resistance to the three biotypes in greenhouse studies, had the lowest BPH damage rating and the least ragged stunt (see table). Because of the small plots and high BPH populations in the susceptible border rows, hoppers were abundant even on resistant varieties at 70 days after transplanting. Varieties that were susceptible to biotype 2 generally had a high incidence of ragged stunt. It was not determined whether resistance to the vector or resistance to the disease, or both, caused the low ragged stunt incidence in certain varieties.

Allelic relationships among four genes for BP13 resistance

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Three years after the rice variety IR26 was released, its resistance to the brown planthopper (BPH) broke down. Several breeding strategies for the control of BPH have since been suggested. At the international symposium on BPH held at IRRI in 1977, four strategies were proposed: 1) sequential release, 2) pyramiding the major genes, 3) multiline varieties, and 4) horizontal resistance.

In combining two or more resistance genes, the allelic relationships among the four known resistance genes must be determined. We made crosses among the four resistant cultivars Mudgo, ASD7, Rathu Heenati, and Babawee, representing *Bph 1, bph 2, Bph 3,* and *bph 4* genes, respectively. Then the F_2 and B_1F_1, populations from each cross were analyzed by the bulk seedling test, using BPH biotype 1.

Results indicate that 1) *bph 2,* as well as *Bph 1,* segregates independently of both *Bph 3* and *bph 4;* 2) not only *Bph 1* and *bph 2* are either allelic or closely linked, *Bph 3* and *bph 4* are also closely linked.

According to the results, we may be able to combine *Bph 1* with *Bph 3, Bph 1* with *bph 4, bph 2* with *Bph 3,* or *bph 2* with *bph 4* in a cultivar. On the other hand, it may be difficult to combine *Bph 1* with *bph 2,* or *Bph 3* with *bph 4.*

According to Lakshiminarayana and Khush (1977), PTB 21 has one dominant and one recessive gene, and one of them is either *Bph 1* or *bph 2.*

To identify the other gene of PTB 21, the cultivar was crossed with Rathu Heenati and Babawee. No susceptible plants were observed in the F_2 populations of either cross. It appears that the other gene of PTB 21 is either *Bph 3* or *bph 4.* It may be concluded that the resistance in PTB 21 is controlled by either *Bph 1* and *bph 4,* or *bph 2* and *Bph 3* gene pairs.

Influence of fertilization on stem borer incidence on four rice cultivars

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The effect of two levels of NPK fertilization (80-40-40 and 100-50-50 kg/ha) on the incidence of the yellow rice borer *Tryporyza incertulas* was studied on four rice cultivars—Ponni (Mahsuri), IR20, CO 38, and Bhavani (C4-63, from the cross Peta/BPI 76)—in a 1975 experiment.

Stem borer incidence was significantly lower in plots that received lower nutrient levels. Infestation was maximum in Bhavani and minimum in Ponni (see table).

Effect of level of fertilization on stem borer incidence on different rice cultivars. Tamil Nadu Agricultural University, Madurai, India.

Variety	Stem borer incidence[a] (%) at		Mean
	80-40-40[b]	100-50-50[b]	
Bhavani	9.2 (17.6)	10.2 (18.5)	9.7 (18.1)
CO 38	6.2 (14.4)	6.1 (14.3)	6.2 (14.3)
IR20	4.7 (12.1)	5.7 (13.7)	5.2 (12.9)
Ponni	2.1 (8.3)	2.7 (8.9)	2.4 (8.6)
Mean	5.5 (13.1)	6.2 (13.9)	

[a]Mean of 4 replications. Figures in parentheses are transferred values. Between varieties, significant at 1% C.D. (P=0.05) = 2.4. Between fertilization, significant at 5% C.D. (P=0.05) = 0.4.
[b]Kg/ha of NPK.

GENETIC EVALUATION AND UTILIZATION

Drought resistance

Some upland rice selections of international origin (IRTP) promoted for minikit tests in Karnataka, India

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Rice in Karnataka is grown over an area of 1.2 million ha. About 0.7 million ha is rainfed. In hilly and coastal sections, rainfed rice is transplanted; in the transition belts, it is drill-sown. Drill-sown rice occupies 0.2 million ha in Dharwar and Belgaum districts and in parts of Shimoga and northern Kanara. Farmers drill rice early in May and June under relatively dry conditions. The upland crop remains unflooded throughout most of the crop season. Seasonal rainfall ranges from 600 to 800 mm and the rice crop (upland and wetland) is often subject to drought.

A range of locally adapted rice varieties is grown. Some are dryland types such as D6-2-2 and Waner 1. Others are grown as semidryland rice (A67 and M161) or wetland rice (Y4 and HY26-lo), or both. These ecotypes have considerable drought resistance but yield poorly, have poor grain quality, and are susceptible to blast and lodging.

Research on drill-sown rice is conducted at the Agricultural Research Station, Mugad, Dharwar district. The work has recently been intensified in collaboration with IRRI and the All India Coordinated Rice Improvement Project (AICRIP) center, Hyderabad. In the 1977 kharif season, the 1976 set of the International Upland Rice Yield Nursery (IURYN) was grown and evaluated at Mugad.

The best rated entries were IR2071-625-1-252 (5.1 t/ha), B541b-Kn-19-3-4 (5.0 t/ha), and IRl529-430-3 (4.9 t/ha). These entries are being promoted to minikit trials in the Karnataka area.

GENETIC EVALUATION & UTILIZATION

Deepwater

Elongation ability and submergence tolerance of some deepwater (floating) rice varieties in Bangladesh

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Rice varieties were evaluated in 1978 for elongation ability and submergence tolerance. The varieties, except Haloi, represent popular deepwater (floating) rices in Bangladesh.

Materials were grown in pots in a net house. After 45 days, they were subjected to flooding and submergence. For evaluation of elongation ability, the pots containing the plants were suspended by ropes from iron bars and submerged in water in the deep flooded areas of Habiganj Rice Research Station, BRRI. The pots were kept under water so that about 20 cm of the leaves remained above the surface. Plant height above the water surface was readjusted daily for 10 days. For testing submergence tolerance, the pots were submerged below 20 cm water for 5 days.

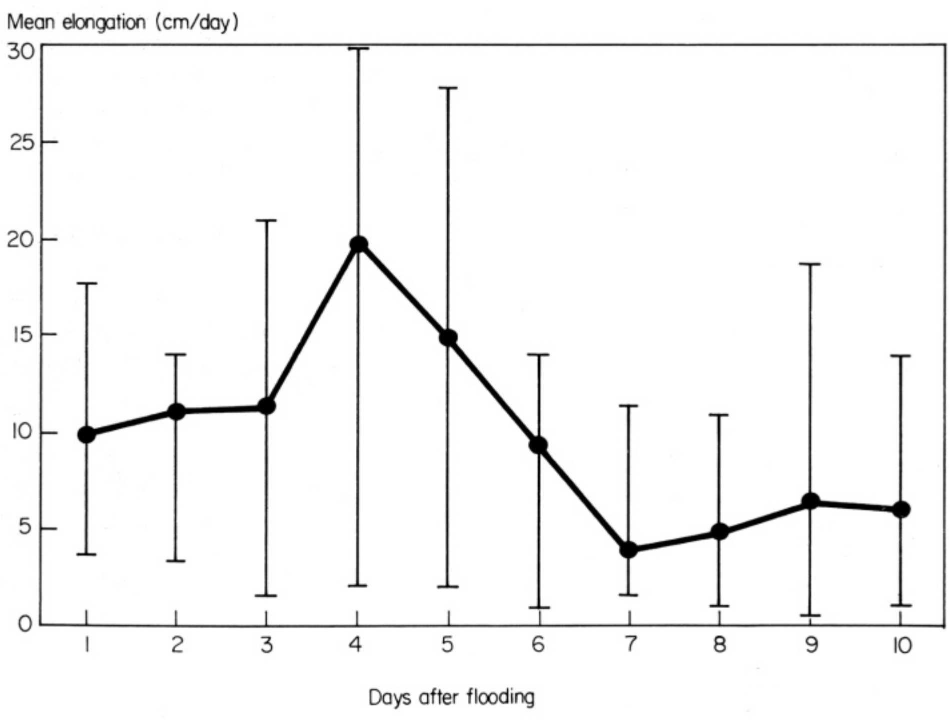
The results are in the table. Rayada 16-04 was the shortest (64.0 cm) before flooding but its elongation ability was the highest (141%). Haloi, not a deepwater rice, was 81 cm tall before flooding, but had the lowest elongation ability (26%) and daily elongation rate (2.5 cm). Elongation ability and daily elongation were not identical (see table). The elongation rate was highest in Habiganj Aman 3 and 7 (1 2.3 cm). Habiganj Aman 1 was tallest (113 cm) before flooding but its elongation ability was 81% and elongation rate was 9.2 cm/day. In general, varieties such as Rayada, which are short before flooding, showed a low elongation rate but a high elongation ability. All the varieties showed little or no tolerance for submergence even at the age of 45 days.

The nature and range of elongation are shown in the graph. During the first

Plant elongation ability and submergence tolerance of deepwater (floating) rice varieties of Bangladesh, BRRI, Joydebpur, Dacca, Bangladesh, 1978.

Variety	Plant ht before flooding [a] (cm)	Plant elongation ability [b]	Elongation (cm/day)	Submergence tolerance [c]
Habiganj Aman 1	113	81	9	5
Habiganj Aman 2	98	119	12	5
Habiganj Aman 3	92	134	12	6
Habiganj Aman 4	98	104	10	6
Habiganj Aman 5	91	121	11	6
Habiganj Aman 6	92	129	12	7
Habiganj Aman 7	103	119	12	6
Habiganj Aman 8	90	122	11	8
Rayada 15-01	88	99	9	6
Rayada 16-02	86	96	8	7
Rayada 16-04	64	141	9	6
Rayada 16-10	67	135	9	8
Lal Aman 6 34	83	104	9	8
Lal Aman 594	100	97	10	6
Lal Aman 127	95	96	9	8
Lal Aman 648	86	105	9	8
Kala Aman 735/1	74	129	10	9
Matia Aman 738/1	94	89	8	8
Matia Aman 5 75	96	110	10	8
Gowai 576	96	107	10	8
Haloi	87	28	2	7

[a] Ht measured at 45 days after sowing.
[b] Measured in percentage of height increase over basal height after 10 days of flooding.
[c] Rated according to Standard Evaluation System for rice of IRTP 5 days after submergence.



Mean and range of elongation (cm/day) of floating rice varieties during 10 days of flooding, Joydebpur, Dacca.

3 days, elongation was fairly stable (10–11 cm/day), but on the 4th day, it suddenly rose to as high as 20 cm/day, then dropped on the 5th to 7th days. On the 8th and 9th days, elongation rate rose slightly before it again stabilized.

The mechanism of deepwater effect on rice

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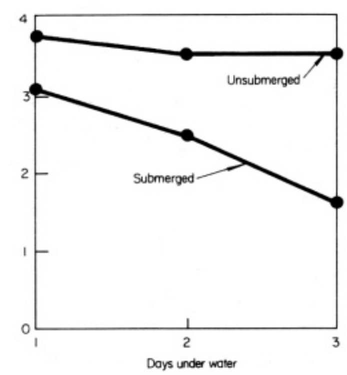
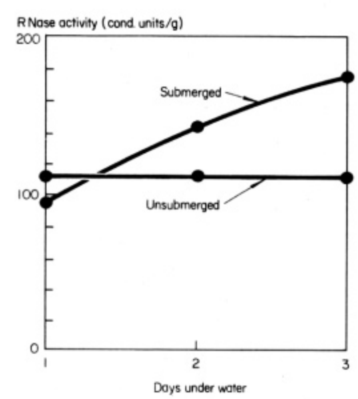
Some plants of the variety Krasnodarsky 424 were submerged in water for 72 hours at the 2-leaf stage while the control plants were not submerged. Every 24 hours the contents of ribonucleic acid (RNA) and deoxyribonucleic acid (DNA), the RNA:DNA ratio, the content of histones, and the ribonuclease (RNase) activity were determined in the plant apexes.

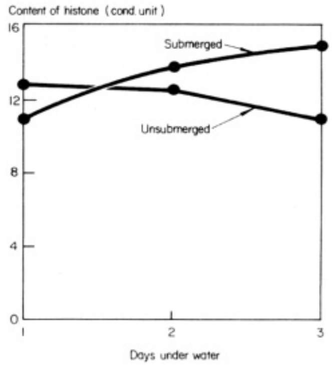
The RNA: DNA ratio of submerged plants decreased (Fig. 1). Simultaneously



1. The dynamics of DNA: RNA ratio in apexes of unsubmerged and submerged plants. Krasnodar, Kalinina, USSR.



2. The dynamics of ribonuclease (RNase) activity in apexes of unsubmerged and submerged plants. Krasnodar, Kalinina, USSR.



3. The dynamics of histone contents in apexes of unsubmerged and submerged plants. Krasnodar, Kalinina, USSR.

there was a sharp increase in RNase activity (Fig. 2) and RNA destruction. The results also indicated a blocking of new DNA regions with histones (Fig. 3), which also caused the DNA functional activity (RNA:DNA) to decrease.

The yield of the experimental plants was greater than that of the control because productive tillering increased in the experimental plants. The difference in silicon dioxide content in the straw of experimental and control plants was not statistically significant.

Pest management and control
DISEASES

Incidence of udbatta in the mangrove swamps of northern Sierra Leone

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The occurrence of the cattail fungus, sugary disease or udbatta disease, on rice in the mangrove swamps of northern Sierra Leone was first reported by Deighton in 1946. The disease, however, had been observed much earlier on wild graminaceous alternate hosts, including *Oryza brachyantha.* The disease appears identical to that reported from India and other Asian countries but the causative organism in Sierra Leone is *Ephelis pallida. E. pallida* has smaller spores than *Ephelis oryzae,* the Indian organism. Little is known about its biology and mode of infection.

Disease symptoms appear after flowering when the inflorescence emerges as a small, cylindrical rod with spikelets matted together by mycelium. The infected spikelet exudes small, black fruiting bodies, and no grain formation takes place. When the disease develops later, only a few spikelets may show mycelium and fruiting body development; the remaining spikelets are usually sterile. The yield of an affected panicle is practically nil, therefore the percentage of infection can roughly be translated as that percentage in yield reduction.

Sometimes the panicle bases are spirally twisted, and the flag leaf is invariably covered with a fine layer of white mycelium that spreads to the base of the leaf and into the culm. The flag leaf is greatly reduced in some varieties, but not in others. A few unproductive tillers, nonetheless disease-free externally, are also observed in the same infected hill. Ratoons growing from infected hills develop typical symptoms of udbatta, indicating the systemic nature of the disease. Ratoons appear to be an efficient mechanism of disease persistence in the off-season and possibly in the subsequent crop.

Of 400 rice varieties in experimental plots and seed multiplication areas at Rokupr in 1977, 25 were infected: BD2, L78, Moroberekan, ROK 1,2526, 7446, 563, Faro 14, Gissi 25, IR5, AA8A, Thoo 2, BG32-2, RH2, Pa Panell, CJ5-2, Murungakayan 304 B, Murungakayan, Anethoda, ROK 4, ROK 3, AUS 61, SR 26, Nachin 11, and ROK 7. The level of infection found indicated varietal differences, but earlier reports indicate that disease incidence varies considerably from season to season. Therefore, it is unsafe to draw conclusions based on 1 year's results.

Preliminary disease surveys in the 1977 cropping season in the mangrove swamps along the Scarcies Rivers estuary in Sierra Leone established udbatta as a potential major disorder of rice inflorescence in this ecology. The disease incidence was recorded using the following procedure. In each site, farmers' fields along the rivers and creeks were

Incidence of udbatta disease and its effect on panicle development in farmers' fields in the Scarcies Rivers estuary, Sierra Leone, October 1977 to January 1978.

Location/ variety	Samples (no.)	Hills (no./sample)	Diseased hills (no./sample)	Disease incidence (%)	Diseased panicles per infected hill (%)	Panicles affected (%)
Kasiri/ Local, unknown	15	9.7±0.9	1.5± 0.9	18.6±6.4 (8.3–66.7) [a]	9.2± 4.3 (4.3–18.8) [a]	0.7
Rokupr/ Local, unknown	11	18.4±3.3	1.5± 0.7	8.6± 4.7 (5.0–17.0)	9.6± 4.8 (4.0–20.0)	0.8
Tumbu Walla/ Pa Dohnut	13	12.8±2.5	1.6± 0.7	12.9±10.1 (6.3–22.2)	17.4±12.1 (4.8–50.0)	1.1
Mambolo/ Pa Compan	10	10.5±2.2	1.8± 1.3	17.8±13.2 (6.7–50.0)	13.7±7.3 (4.3–27.8)	1.3
Balansera/ Pa Merr	3	23.0±2.7	4.0± 1.0	18.0±6.2 (13.0–25.0)	19.2±10.3 (11.8–31.0)	6.3
Mapotolon/ Pa Taylor	3	30.3±4.9	15.7± 11.7	49.0±33.2 (11.0–72.0)	23.7±19.9 (8.0–46.0)	7.6

[a] Figures in parentheses give range of incidence.

visited. Where the disease was .present, samples were taken to determine its incidence. From each 1-m^2 plot, samples were taken at random to represent roughly 10% of the total area, except at Balansera and Mapotolon where only 3 samples were collected. For each sample the number of diseased and healthy hills was recorded and the total number of diseased and healthy tillers in each diseased hill was noted (see table).

Studies on rice tungro virus disease and its vector *Nephotettix* spp. in West Bengal, India, in 1976–77

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Rice green leafhoppers were collected daily with light traps at the Plant Virus Experimental Field, Kalyani; Habra Model Farm; and Central Soil Salinity Research Institute, Canning, in a study funded by the Indian Council of Agricultural Research.

Leafhoppers were found from April to December at Kalyani, from April to the second week of February at Habra, and throughout the year at Canning. The peak population differed slightly from location to location. The peak appeared during the third week of October at Kalyani, during the second week of October at Canning, and during the first week of November at Habra.

At the peak period, the greatest number of leafhoppers was found at Habra where the insects averaged 1,129/day. The average at the peak period was 913/day at Kalyani, and 339/day at Canning. There were more *Nephotettix virescens* than *N. nigropictus.* More males of *N. virescens* appeared during the peak period, but during the remaining period females predominated.

Weeds were collected from sites where tungro virus disease had been previously observed. *Echinochloa colonum* was predominant. Transmission studies during boro 1976–77 showed that the weeds did not carry any virus. But when inoculated, they can retain the virus for more than 2 months as a symptomless carrier. Adult leafhoppers fed on ***E. colonum*** could not survive more than 120 hours. Infected stubble obtained from the 1976 kharif crop and transplanted in pots retained the virus for more than 90 days. But under cage conditions the virus could not be transmitted by releasing nonviruliferous leafhoppers on seedlings growing in soil containing chopped-off stubbles.

The possibility of symptomless rice plants or those with mild symptoms grown in one season acting as the source of the virus during the next was studied. Transmission tests were performed during the 1976–77 boro with IR20, IR30, IR26, IR442-58, Vijaya, Cavery, Ratna, Bala, Krishna, Jaya, Palman, IET 849, and IET 2239. The presence of virus in Jaya was detected although prominent symptoms did not develop during the season. Prominent symptoms developed in IET 849, IET 2239, and Palman.

The relationship between vector population and tungro virus spread in the fields was studied. The leafhopper population differed among locations in both number and time of appearance. In the study of the natural occurrence of viruliferous leafhoppers, 50% of the leafhoppers collected from fields showing virus symptoms carried the virus; leafhoppers from normal fields appeared to be virus free during the period of observation.

Operational research on sheath blight control

P. Varadarajan Nair and K. M. Rajan, Rice Research Station, Moncompu, Alleppey, Kerala, India

Eight promising foliar fungicides belonging to different groups were tested in farmers' fields during rabi 1977–78 to determine their control of rice sheath blight. Two sites in each of two villages were selected for the study. The experimental area in each site was 14.6 ha (36 acres).

Plots treated with benlate (benzimidazole), difolatan (heterocyclic nitrogen compound), or hinosan (organo-phosphorus compound) had significantly lower disease scores than the control (see table). Plots treated with other chemicals also showed lower disease scores. Grain yields in treated plots generally increased. Plots treated with benlate had the highest yield.

Mean sheath blight disease scores and yield in plots treated with 8 fungicides. Kerala, India, 1977–78.

Treatment	Mean score [a] (0–9)	Mean yield (t/ha)
Benlate	0.56	6.03
Captan	4.61	5.54
Cuman - L	2.38	5.29
Difolatan	1.24	5.38
Dithane M - 45	1.70	5.51
Fytolan	2.69	5.23
Hinosan	1.40	5.74
Kitazin	2.01	5.44
Untreated control	4.63	5.36
CD P ± 0.05	1.10	NS

[a] 0 = no infection; 9 = severe infection.

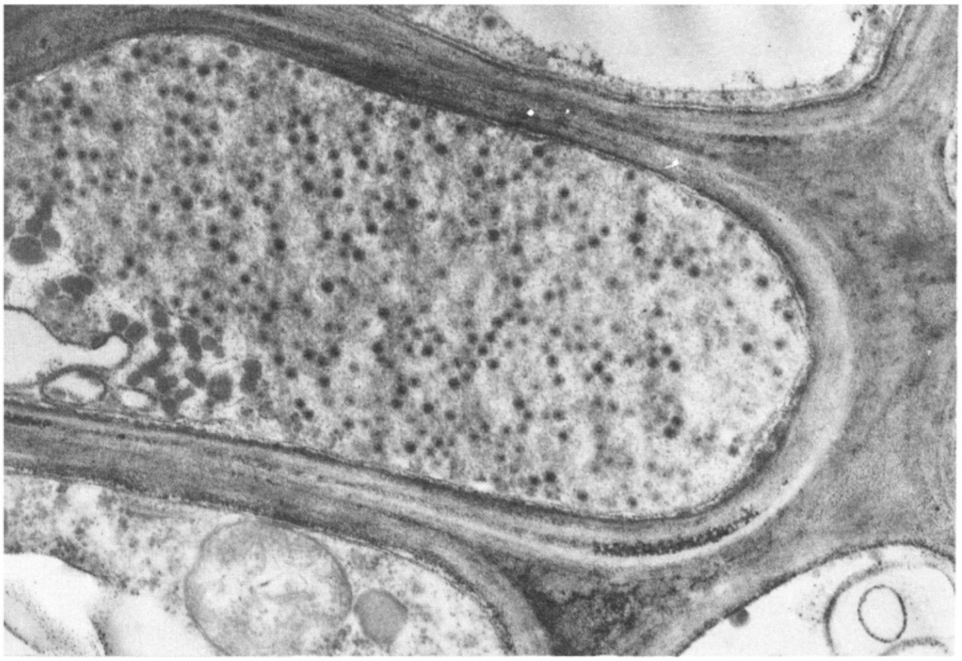
Rice ragged stunt in Thailand

Dara Chetanachit, Metie Putta, and Somkid Disthaporn, Rice Disease Branch, Plant Pathology Division, Bangkok, Thailand

Ragged stunt disease of rice in Thailand was observed for the first time in a farmer's field at Chacheongsao province in 1977. Experiments were carried out to determine the manner in which the disease was transmitted.

Sections of the infected plants collected from the farmer's field were examined by Dr. Y. Saito at the Institute for Plant Virus Research, Japan. The electron micrograph revealed abundant polyhedral particles in phloem cells (photo 1).

Four species of sucking insects naturally found in paddy fields — *Nilaparvata lugens, Nephotettix virescens, N. nigropictus,* and *Recilia dorsalis* — were fed directly on diseased plants for 3 days, then were transferred to healthy rice seedlings grown in an insect-proof screenhouse. Only the brown planthopper *Nilaparvata lugens* could transmit the disease. The infected plants developed symptoms typical of the disease as described by K. C. Ling at IRRI.



1. Electron micrograph shows virus particles in phloem cell of a rice plant infected with ragged stunt disease in Thailand.

Inoculation of from 15 to 20 healthy plants with 1, 2, 3, 4, and 5 viruliferous insects/seedling resulted in 15, 20, 13, 47, and 61% infected plants, respectively.

Healthy insects were confined on diseased plants for acquisition feeding for 0, 0.5, 1, 3, 6, 24, and 48 hours. The insects were then used to inoculate from 15 to 19 seedlings at 5 insects/seedling for 24 hours. Infection for the 7 feeding periods was 0, 0, 0, 13, 11, 16, and 22% of the plants, respectively, indicating that 3 hours was the shortest time required for the insect to acquire the virus.

Five viruliferous insects per plant were used to inoculate sets of from 17 to 22 healthy plants, for periods of 0, 0.5, 1, 3, 6, and 24 hours. Infection was 0,0, 5, 18, 39, and 25%, respectively, indicating that the shortest time required for insects to successfully inoculate a plant was 1 hour.

Photo 2 shows symptoms of artificially infected TN1 plants.

2. TN1 plants that were successfully infected with ragged stunt disease showed typical symptoms: ragged and twisted leaves.

Pest management and control

INSECTS

Use of multihole vinyl tube to dust insecticides for brown planthopper control

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During massive and extensive outbreaks of brown planthoppers (BPH), conventional insecticide treatments are often ineffective. Some major factors that contribute to such ineffectiveness are the failure to cover the entire affected area lapidly and simultaneously, and the incomplete penetration io the plant bases. Application systems that could overcome such limitations would undoubtedly be advantageous. Therefore, dusting from a multihole vinyl tube was evaluated using approximately 33.6 kg Sogatox® (2% MTMC:2% phenthoate) of dust/ha. Basically, the system consists of a Maruyama Knapsack Power Mist Duster that drives the insecticidal dust over the plants through regularly spaced openings on the underside of a long vinyl tube (see photo).

Two trials were conducted: the first at dusk over 1.5 ha in Parit 3 (Sg. Burong), and the second at dawn over 3 ha in Parit 4 (Sg. Burong). In both treated fields the rice variety was Mat Candu. Just before and periodically after treatment (at 2 months after transplanting), populations of BPH and of the common predators on 50 random hills from each field were determined. Parallel counts were made in two untreated fields.

Except in the controls, BPH mortality was 100% within 1.5 to 2 hours after dusting (see table). However, first-instar nymphs emerged 2 days after treatments and increased rapidly, suggesting that BPH eggs already present were not affected, and that the treatments had little residual effects. More than one treatment was necessary to ensure effective control.

Such limitations may have contributed to the numerous past unsuccessful attempts to control large-scale BPH outbreaks with chemicals. Besides causing a sharp decline in the infesting BPH populations, the treatments also adversely affected such common predators as *Casnoidea interstitialis, Coccinella arcuata, Orthorhinus lividipennis,* and *Paederus fuscipes* (see table). The population of these predators, however, gradually built up again.

Although it has limitations, the tube dusting system appears to possess several advantages over most other methods in ground application of insecticides: 1) handling is relatively simple and easy — only two persons are needed to operate it; 2) neither water nor mixing of insecticides is needed; 3) extensive areas can be rapidly treated — only 15–20 minutes is necessary to cover 0.4 ha; 4) the treatment is uniform and thorough, and penetration is good; and 5) BPH suppression is rapid and highly effective. As these advantages constitute some of the basic operational features desired of chemical control, the tube dusting system would thus play a major role in combatting BPH infestations, especially during outbreaks.

Use of the multi-hole vinyl tube to dust insecticides against brown planthoppers. Sg. Burong, Malaysia.

Effects of Sogatox® (2% MTMC:2% phenthoate) at 33.6 kg formulated dust/ha on the rice brown planthopper and its common predators. Sg. Burong, Malaysia, 1978.

Date	BPH and predator populations (no./50 hills)									
	Treated[a]					Control[a]				
	BPH	Cl	Ca	Pf	Ci	BPH	Cl	Ca	Pf	Ci
Trial 1										
Pretreatment count										
21 Jan.	552	14	2	8	0	552	14	2	8	0
Posttreatment count										
2 h later	0	0	0	0	0	309	68	1	1	4
1 Feb	0	0	0	0	0	608	36	1	1	0
2 Feb	34[b]	0	0	0	0	–	–	–	–	–
3 Feb	–	–	–	–	–	686	31	5	6	2
9 Feb	711[c]	14	1	1	3	–	–	–	–	–
Trial 2										
Pretreatment count										
1 Feb	1,131	5	9	1	1	608	37	1	2	2
Posttreatment count										
1½ h later	0	0	0	0	0	–	–	–	–	–
2 Feb	0	0	0	0	0	–	–	–	–	–
3 Feb	56[b]	0	0	1	0	602	54	1	0	1
9 Feb	711[c]	3	0	0	1	–	–	–	–	–

[a] BPH = brown planthopper, CI = *Cyrtorhinus lividipennis,* Ca = *Coccinella arcuata,* Pf = *Parderus fuscipes,* Ci = *Casnoidea interstitialis.*
[b] First-instar nymphs.
[c] Predominantly early instar nymphs.

Some common predators associated with the brown planthopper in Malaysia

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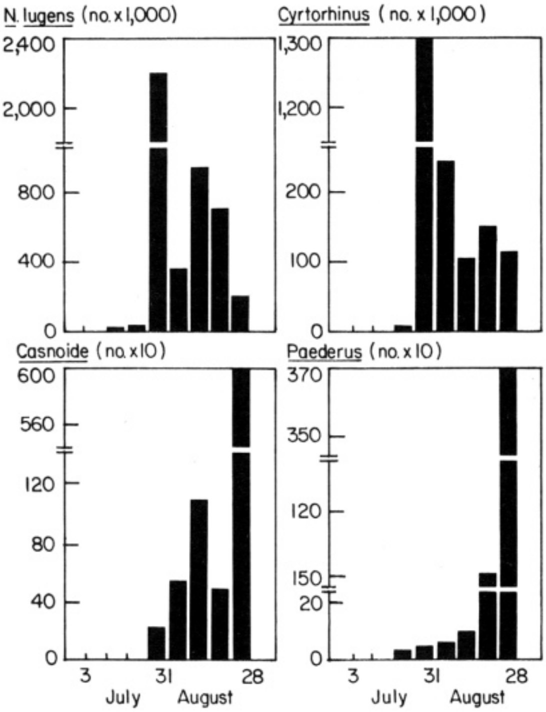
In mid-1977, the most serious brown planthopper (BPH) outbreak recorded in Malaysia in at least a decade occurred in Tanjung Karang, Selangor. About 1,620 ha were severely affected.

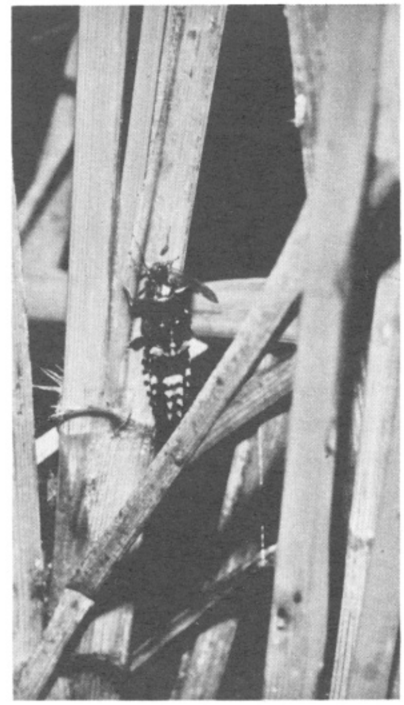
An integrated control approach, adopted to combat the outbreak, included continual surveillance, suitable insecticide application (spraying, mistblowing, fogging, and granular application), light trapping, and cultural methods. Such an approach appeared to be the most appropriate because natural enemies were numerous among the BPH; predators were most active.

The mirid bug *Cyrtorhinus lividipennis,* an effective predator of BPH in Southeast Asia, Australia, and the Pacific islands, was important in Malaysia. A light trap in the area of the outbreak monitored the abundance of *C. lividipennis* and BPH. A sharp increase in light-trap catches showed an explosive and sudden outbreak in July, closely associated with a corresponding increase in *C. lividipennis* catches (see figure).

Two other predators — *Casnoidea interstitialis (Coleoptera: Carabidae)* and *Paederus fuscipes (Coleoptera: Staphylinidae)* — were also common in the rice fields. Their sudden increase in the light trap suggests that they may also be active predators of BPH. The coccinellid *Coccinella arcuata,* an active predator of BPH, occurred in large numbers toward the end of the outbreak. Larvae of the predator were observed feeding voraciously on adult BPH (see photo). *C. arcuata* has been reported as the most common coccinellid predator of BPH in India, Fiji, Australia, and Papua New Guinea.



Weekly light-trap catches of *Nilaparvata lugens* and its common predators at the Malaysian Agricultural Research and Development Institute Rice Research Station, Tanjong, Karang, Malaysia, 1977.



Cocinnella arcuata feeding on an adult brown planthopper.

Serious attempts were made to conserve the major predators during the outbreak. The controlling effects of the predators, together with those of other supplementary measures, helped decrease the BPH population rapidly. The outbreak was suppressed and fully contained by September.

Brown planthopper situation in Bangladesh

S. Alum, M. S. Alam, and M. A. Chowdhury, Bangladesh Rice Research Institute, Joydebpur, Dacca, Bangladesh

During the 1978 boro, 6 Bangladesh districts — Dacca, Comilla, Tangail, Noakhali, Chittagong, and Chittagong Hill tracts — reported brown planthopper (BPH) outbreaks. Two unconfirmed reports of outbreaks were received from Mymensingh and Dinajpur districts.

The first BPH outbreak was observed during April–May1976 in the boro crop near Sher-e-Banglanagar, north of Dacca City. The second was in October 1976 at BRRI farm in a transplanted aman crop. In 1977, BPH spread to more boro areas. Outbreaks were also reported in the transplanted aman crop from Rajshahi district in northwest Bangladesh.

In Dacca district, BPH outbreaks occurred mainly in the single-rice area in places that remained flooded from June to October. Generally the crop had luxuriant growth, which suggested that the soil was heavily or excessively fertilized. The macroclimate during April–Mayand October remains almost rain free, sunny, and hot. The microclimate inside rice fields during the time remains humid. Long-duration or late-planted varieties IR8 and BR3 were mainly affected. Short-duration varieties Chandina and Purbachi were harvested more than a week before the pest population peaked. Hopperburn occurred at flowering to hard dough stage. In hopperburned plots the estimated crop loss was 50-100%.

In several hopperburned fields, the whitebacked planthopper (WBPH) population was also high. But the total area with hopperburn caused by WBPH was negligible compared with that with BPH-caused hopperburn. Comilla and Dacca districts also reported hopperburn from WBPH in 1963, 1967, and 1977.

Light-trap collections at BRRI farm indicated two major BPH peaks in a year (April–May and Oct.–Nov.); the population has increased 3–7 times since 1976. It appears that BPH may spread to more districts where varieties with high yield potential are cultivated and may ultimately threaten rice production in Bangladesh. BPH has become the most serious rice pest in Bangladesh.

Resistance of the brown planthopper to carbofuran at IRRI

E. A. Heinrichs, entomologist, and S. L. Valencia, research aide, International Rice Research Institute

Carbofuran has been used for about 7 years at IRRI. In 1977 it failed to control the brown planthopper (BPH) *Nilaparvata lugens* in an experiment where carbofuran granules had been applied repeatedly at 2-week intervals in continuous crops over a 3-year period. In a nearby plot, carbofuran at the rate of 6 kg active ingredient/ha applied as a broadcast treatment to paddy water also failed to control the hopper.

Brown planthoppers collected from those plots were reared in the greenhouse for four generations. The susceptibility to carbofuran of the field strain was compared with that of a greenhouse strain never exposed to insecticide. Two application methods were used: in the contact toxicity study, insecticide was sprayed directly on adult hoppers; in the paddy-water test, carbofuran granules were applied to the paddy water and hoppers were allowed to feed on the treated plants.

In the contact toxicity study, the field strain was significantly more resistant to carbofuran than the greenhouse strain at all rates tested (see table). In the paddy-water test, 6 kg/ha was required to kill 98%) of the field strain while 1 kg/ha killed 100% of the greenhouse strain. LD_{50} studies indicated that the field strain was seven times more resistant than the greenhouse strain (see article, this issue).

Comparison of the resistance of a field strain and a greenhouse strain of the brown planthopper to carbofuran.[a] IRRI greenhouse, 1977.

Rate (kg a.i./ha)	Mortality (%) Green-house strain[b]	Field strain[c]	Difference[d]
	Contact toxicity[e]		
0.025	25 a	Sa	20*
0.050	68 b	9 a	59*
0.100	83 c	29 b	54*
0.250	100 d	56 c	44*
0.500	100 d	59 c	49*
	Paddy-water application		
0.5	67 b	21 c	46*
1.0	100 a	32 c	68*
4.0	100 a	77 b	23*
6.0	100 a	98 b	2 ns

[a]Means within a column followed by a common letter are not significantly different at the 5% level.
[b]Cultured in the greenhouse for about 30 generations.
[c]Collected from field plots that had received repeated application of 2 kg a.i. carbofuran/ha over a 3-year period and reared in greenhouse culture cages for 4 generations.
[d]An asterisk indicates a statistical difference between the greenhouse and field strains at the 1% level.
[e]Applied with Potter's spray tower.

Residual activity of acephate sprays on rice as influenced by spreader-stickers

E. A. Heinrichs, entomologist, and M. Arceo, research assistant, International Rice Research Institute

Spreader-sticker compounds are rarely mixed with insecticides, in spite of the common assumption that frequent showers during the tropical rainy season wash insecticide spray deposits off rice foliage. In 1977 a preliminary study was conducted to determine whether various spreader-sticker compounds mixed with acephate had any beneficial effect on the amount of the initial deposit and on residual activity of the insecticide.

Acephate at the rate of 0.75 kg a.i./ha was applied in combination with each of four different spreader-stickers at a concentration of 0.5%. Leaves were analyzed at 1, 5, and 10 days after treatment (DAT) by gas chromatography. At 1 DAT all treatments with spreader-stickers had higher amounts of acephate, the Citowett treatment having the highest (see table). At 5 DAT the Adhesol treatment had the largest amount of acephate, but at 10 DAT the differences among treatments were slight. In the treatments with spreader-stickers the initial deposit of acephate on the leaves was larger but the residual activity was not significantly longer than that in the treatment with acephate alone, as indicated by the acephate residues at 5 and 10 DAT.

The mortality of caged brown planthopper *Nilaparvata lugens* and green leafhoppers *Nephotettix virescens* in the various treatments at 1, 5, and 10 DAT indicated that the spreader-stickers did not prolong residual activity.

Residues of acephate on leaves of IR22 rice treated with foliar sprays containing spreader-sticker. IRRI, 1977 wet season.

Treatment[a]	Residues (ppm)[b] 1 DAT	5 DAT	10 DAT
Acephate	19.5 b	4.3 cd	0.09 cd
Acephate + Adhesol	26.1 b	21.3 a	0.11 bcd
Acephate + Triton B-1956	37.2 ab	7.5 bc	0.08 cd
Acephate + Tenac	38.2 ab	12.6 b	0.14 bcd
Acephate + Citowett	51.2 a	7.8 bc	0.34 a
Control	nd[c]	nd	0.00 d

[a]Spreadersticker applied at a concentration of 0.5%; foliar sprays at 0.75 kg a.i./ha.
[b]Figures are averages of 4 replications. In a column, any 2 means followed by a common letter are not significantly different at the 5% level.
[c]nd = none detected (< 0.005 ppm).

Retention of aldrin in soil

P. B. Chatterjee, Operational Research Project on Integrated Control of Rice Pests, P. O. Pandua 712149, Hooghly, West Bengal, India

Soil-inhabiting gryllids *Brachytrypes portentosus* and *Gryllotalpa africana* frequently pose a problem to direct-seeded upland rice in northern West Bengal. The infestation is generally prevented by the application of 5% aldrin dust. Aldrin, one of the most persistent cyclodiene insecticides, is being phased out, however.

Aldrin disappears from European and American soils in approximately 3 years on the average. In terai soils of Jalpaiguri district in North Bengal, its bioactivity rapidly wanes and insect reinfestation occurs within about 5 months after application. An experiment on the retention of aldrin in sandy loam and alluvial soils was therefore conducted.

To study the soil retention of aldrin a copper cylinder 23.1 cm high and 7 cm in diameter with 1 outlet through a short spout in the bottom was used. Filter paper was wrapped around a perforated copper disc that just fitted the bottom of the cylinder. Two grams of fresh 5% aldrin dust of 75 µm particle size was thoroughly mixed with 2.4 kg of each air-dried soil type. Then 800 g samples were placed in copper cylinders and lightly compacted, making the soil column 14.22 cm high. The cylinders were then clamped to a stand.

Next 97.8 ml distilled water was percolated through the soil columns in installments. Soil in a control cylinder received no water. After the experiments, the soils were collected from the cylinders, air-dried, and analyzed for residue by gas liquid chromatography at the Indian Agricultural Research Institute, New Delhi. The results are in the table.

Aldrin is substantially displaced or inactivated in both soil types. The reduction, however, is most appreciable in the sandy loam soil, which contains more organic matter (mostly undecomposed). Possibly because of rapid aldrin reduction, reinfestation by soil insects occurs.

Residue of aldrin in 2 different soils (mean of 3 samples) of Jalpaiguri district, northernwest Bengal, India.

Soil type	Aldrin recovered (ppm) when leached with				Control (ppm)
	153.24 mm water	229.86 mm water	510.80 mm water	1532.40 mm water	
Terai (sandy loam)	26	22	12	5	36
Alluvium (silty loam)	22	16	2	1	35

Invitation to authors

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 paragraphs and a table, figure, or photograph. They are subject to editing and abridgement to meet space limitations. Authors will be identified by name, title, and research organization.

Pest management and control

WEEDS

Weed management studies on direct-seeded and transplanted rice in 1976 aus in Bangladesh

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A study was begun in 1976 to compare the effectiveness of herbicides with that of hand weeding to identify weed differences between plots of short-statured and of taller local varieties and to determine the weed-caused yield reduction in direct-seeded and transplanted rice.

BR3 – a short-statured, high yielding rice variety – and Dharial – a tall local variety – were direct-seeded in rows into dry soil 13 April. Thirty-day-old seedlings were transplanted 4 May in rows 20 × 20 cm apart. Herbicides for six weed control treatments (see table) were applied 3 days after seeding and were activated by irrigating the plots. The recommended levels of cultural practices

Yield of BR3 and Dharial rice under various weed management practices in the 1976 aus season, Dacca, Bangladesh.

Treatment	Herbicide rate[a] (kg a.i./ha)	Yield[b] (t/ha)					
		Direct seeded			Transplanted		
		BR3	Dharial	Mean	BR3	Dharial	Mean
Butachlor + hand weeding	0.5	5.99	3.04	4.52 a	6.68	1.49	4.09 a
Hand weeding	–	5.69	2.45	4.01 ab	6.43	1.45	3.94 ab
Butachlor	1.5	4.11	2.05	3.38 b	6.09	1.39	3.14 b
Thiobencarb	1.5	4.44	2.49	3.46 b	5.99	1.39	3.69 b
Piperophos/ dimethametryn	1.2/0.3	4.12	1.91	3.55 b	5.91	1.36	3.66 b
Control	–	3.25	1.32	2.30 c	5.95	1.36	3.66 b
Av.		4.80 b	2.22 c	3.52	6.19 a	1.41 d	3.79

[a] Applied 3 days after seeding,
[b] Any two means followed by the same letter are not significantly different at the 5% level.

and fertilizer were followed. Rice yield, weed species, and weed weights were determined at harvest.

Results are shown in the table. Whether direct-seeded or transplanted, the high yielding variety BR3 outyielded the local variety. When transplanted, it produced 31% more yield than when direct-seeded. The local variety had lower yields because of its low tillering rate when transplanted; however, it yielded 40% more when direct-seeded.

Weeds were a problem in the direct-seeded plots. The control plot had significantly lower yields, 39% less than the herbicide-treated and hand-weeded plots.

The best treatment combined a low dose of herbicide and hand weeding. Although the yield it gave did not differ significantly from that of hand weeding, it was better than that of any of the three herbicide treatments. In Bangladesh, the combination of a low dose of herbicide and weeding would be practical and would complement the existing hand-weeding methods.

The transplanted plot had less weed infestation and showed no significant reduction in yield between the control and the herbicide-alone plots. A low dose of herbicide plus hand weeding, however, increased yields by 9% over the control. The cultural practice of puddling plus the competitive advantage of the transplanted rice plant over weeds greatly reduced weed problems where water management was good.

The weed species present in the BR3 and Dharial plots differed. In BR3 the sedges *Cyperus iria, Cyperus difformis,* and *Fimbristylis littoralis* were the major weeds. In the plots of the taller Dharial, sedge growth was much reduced, and the grass *Echinochloa crus-galli* was the dominant weed. Weed weights in the Dharial direct-seeded control plots were 92 g/m^2 compared with 133 g/m^2 in BR3.

Soil and crop management

Residual effect of blue-green algae application on rice yield

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Field trials to determine the residual effect of blue-green algae for nitrogen fixation on rice yields were laid out using ADT31 during the 1975 and 1976 kar (July–Oct.)season and using IR20 during the 1975 and 1976 pishanam (Nov.–March) season. The treatments were 50-25-25 kg NPK/ha, 50-25-25 kg NPK/ha plus 10 kg algae/ha, 25-25-25 kg NPK/ha, 25-25-25 kg/ha plus 10 kg algae/ha, algae alone at 10 kg/ha, and the untreated control.

After four seasons, the same treatments were repeated during the 1977 kar and 1977–78 pishanam seasons, with no algae added. Withholding algae did not generally affect the yield trend much (see table). In the plots where algae alone were applied, however, yields decreased slightly in the 1977 kar season. The results indicate that the residual effects of application of blue-green algae for a continuous period of four seasons will provide sufficient inoculum for subsequent crops.

Effect of blue-green algae on rice yields, Tamil Nadu, India.

Treatment	1977 kar season [a]		1977–78 pishanam season [b]	
	Yield (t/ha)	Increase or decrease over control (%)	Yield (t/ha)	Increase or decrease over control (%)
0 NPK	3.3	–	4.8	–
0 NPK +blue-green algae	3.2	3.2	5.4	13.9
25-25-25 kg NPK/ha	3.3	2.2	5.2	7.6
25-25-25 kg NPK/ha + blue-green algae	3.8	17.1	5.2	9.8
50-25-25 kg NPK/ha	3.8	11.2	5.1	7.6
50-25-25 kg NPK/ha + 10 kg/ha blue-green algae	4.1	24.6	5.1	7.6
F test:	S		NS	
CD:	456		–	

[a] July–October. [b] November–March.

Fertilizers for deep placement and slow release of nitrogen for rice

E. T. Craswell, visiting scientist, International Rice Research Institute, and P. L. G. Vlek, soil scientist, International Fertilizer Development Center (IFDC), Muscle Shoals, Alabama, USA

Rice commonly uses only 30 to 40% of applied fertilizer nitrogen. A great deal of research has therefore been carried out to develop more efficient nitrogen fertilizer sources and management practices.

Three major approaches that have been developed are split application, deep placement, and controlled release. The latter two approaches — as mudballs or urea supergranules and sulfur-coated urea, respectively — have frequently proven superior to split application of urea in experiments conducted in the 10 countries of the International Network on Fertilizer Efficiency in Rice.

A fourth approach combines the deep placement and slow-release concepts. A

Comparative effects of basal broadcast urea (BU), split urea (SU), supergranules (SG) of urea placed at 10-cm depth, basal broadcast sulfur-coated urea (SCU), and sulfur-coated supergranules of urea (SCSG) placed at 10cm depth on growth and nitrogen recovery by IR38 in the greenhouse.

Fertilizer[a]	Panicles (no.)	Dry matter (g/pot)		Apparent nitrogen recovery[b] (%)
		Grain	Total tops	
O	27	33	99	–
BU	31	38	123	28
SU	31	41	134	48
SG	31	45	151	69
SCU	34	46	140	56
SCSG	39	52	163	89

[a]All fertilizers were applied at the rate of 460 mg N/pot.

[b]Apparent N recovery $= \frac{\text{N uptake in fertilized plant} - \text{N uptake in control (mg)}}{460 \text{ mg}} \times 100\%$.

practical means of achieving such combination was provided by the Fertilizer Technology Division of the International Fertilizer Development Center (IFDC) in the form of sulfur-coated urea supergranules. Preliminary results obtained with this experimental material in a greenhouse study at IFDC headquarters in Alabama are reported here.

The table shows the mean data from two soils and two water regimes (which had only minor effects on rice growth). The results suggest that the combination of deep placement and slow release shows considerable promise for improving fertilizer efficiency.

The sulfur-coated supergranules of urea are being tested at IRRI in 1978 as part of a joint IRRI-IFDC project aimed at improving nitrogen fertilizer efficiency for rice.

Environment and its influence

Possible causes of a new physiological disorder of rice in Korea

J. H. Lee, postdoctoral fellow, and S. Yoshida, plant physiologist, International Rice Research Institute

New varieties derived from indica/ japonica crosses have been successfully grown in the Republic of Korea. These short, lodging-resistant, and high-tillering varieties are now planted on 660,000 ha, about half of Korea's total rice land. Consequently, the national average rice yield in Korea reached 6.64 t/ha, the world's highest, in 1977.

Yushin, one of the best indica/ japonica varieties, has many good characteristics and gives high yields under favorable weather and soil conditions. But in 1976, it suffered *sudden wilting* in farmers' fields while other varieties such as Tongil seemed healthy under similar or identical conditions. Subsequent investigations into this new physiological disorder suggested that low sunlight, excessive nitrogen application, and highly reductive soil conditions either singly or combined, might be possible causes of the disorder.

Some visual symptoms of *sudden wilting* are orange discoloration of leaves, development of nodal roots above the soil surface, total root rot, and lodging. Those observations led to the hypothesis that suffocation of root tissues was a direct cause of the disorder.

The oxygen transport characteristics of Yushin, Tongil, and IR262 were examined by two methods. First, the number and size of the air spaces in each internode were investigated (see table). In the 5th internode from the top, all three varieties have a similar number of air spaces, although the air spaces of Tongil were larger. In the 4th internode, Tongil had 31 air spaces, Yushin had only 2, and one of Tongil's parents, IR262, had none. The observations indicated that the ability of Yushin and IR262 for oxygen transport is very limited compared with that of Tongil.

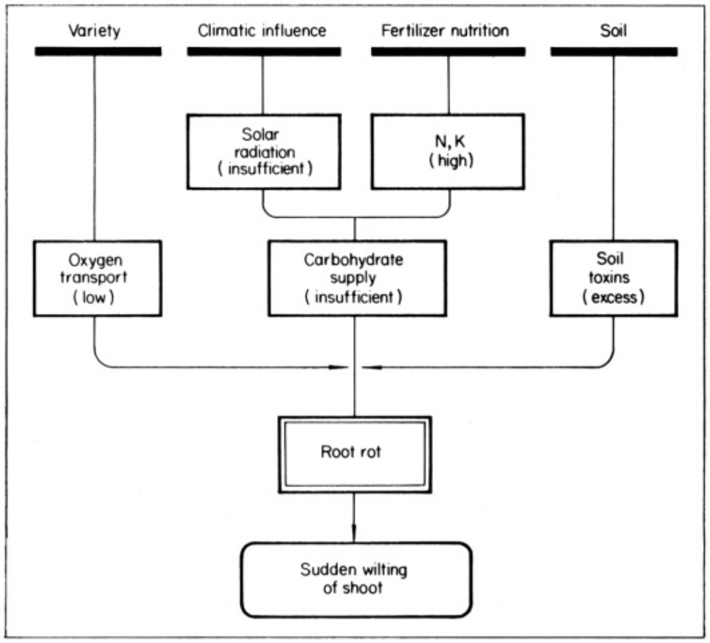
Second, soil-cultured plants of the three varieties were subjected to paraffin treatment. To decrease the oxygen supply from the air to root tissues through the soil-water system, a layer of liquid paraffin about 5 to 6 mm thick was applied to the water surface in the pots at 47 days after seeding. The experiment was repeated twice. Each time *sudden wilting* was observed on Yushin and IR262 at about 1 week after the treatment, but Tongil remained green and healthy.

The findings suggest that Yushin has limited ability to transport oxygen. The limited oxygen supply may cause suffocation of root tissues, weaken metabolic activity of the tissues, and induce root rot, subsequently inducing *sudden wilting* and lodging under

Varietal difference in number and size of air spaces in the internodes of rice plants at the ripening stage. IRRI, 1978.

Internode position[a]	Air spaces	
	No.	Mean diameter (mm)
	Tongil	
3d	0	–
4th	31	0.15
5th	31	0.31
	Yushin	
3d	0	–
4th	2	–
5th	29	0.24
	IR262	
3d	0	–
4th	0	–
5th	31	0.24

[a]From top of plant.



Provisional mechanism for *sudden wilting* of the rice variety Yushin.

unfavorable weather and soil conditions. We describe a provisional mechanism for *sudden wilting* of Yushin in the figure. Further investigations into air space and oxygen transport ability of rice varieties are under way. They may throw light on varietal differences in tolerance for some known physiological disorders.

Increased productivity in tall and dwarf rice varieties through benzimidazole and zinc sulfate sprays

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We previously reported that spraying Jaya rice with cytokinins and zinc salt ($ZnSO_4$) at a particular developmental stage was effective in increasing yield. In this experiment, the effectiveness of benzimidazole (Bzi) and zinc sulfate as foliar sprays was observed on yield and yield components of the photoperiod-sensitive tall rice variety NC1281 and the photoperiod-insensitive dwarf Jaya. Aqueous solutions (100 µg/ml) of Bzi and zinc sulfate were sprayed on the rice plant at seedling, preflowering, and postflowering stages. The growth and yield parameters considered were plant height, straw weight, number of panicles, percentage of ripened grains, grain:straw ratio, yield per plant, and protein content of the seeds.

Effect of benzimidazole and zinc on some yield parameters of tall (NC1281) and dwarf (Jaya) rice varieties, West Bengal, India.

Variety	Treat-merit	Yield parameters at harvest						
		Plant height (cm)	Straw wt (g/plant)	Panicles (no./plant)	Grain wt (no./plant)	Grain: straw ratio	Ripened grains (%)	Protein content (mg/g)
Seedling stage (48 days old)								
NC1281	Bzi	146.5	74.4	10.2	23.1	0.311	89.4	75.3
	Zn	145.4	63.4	8.8	23.5	0.370	90.6	74.1
Jaya	Bzi	89.0	32.0	10.0	18.3	0.572	72.9	79.0
	Zn	85.8	30.8	13.4	21.5	0.699	65.4	86.6
Preflowering stage (80 days old)								
NC1281	Bzi	152.6	81.8	10.0	27.8	0.340	93.3	74.8
	Zn	146.6	81.0	12.2	28.7	0.353	90.2	80.6
Jaya	Bzi	94.6	48.4	10.8	19.3	0.396	69.8	91.4
	Zn	92.7	42.7	10.0	16.5	0.306	67.9	84.6
Postflowering stage (96 days old)								
NC1281	Bzi	147.0	78.2	11.4	28.4	0.363	91.6	80.6
	Zn	144.8	76.4	14.2	31.4	0.401	89.6	80.6
Jaya	Bzi	94.3	51.0	11.2	20.9	0.410	74.0	85.0
	Zn	90.8	46.0	15.6	23.2	0.504	69.6	85.5
Control								
NC1281		149.6	76.4	10.6	24.0	0.314	91.8	90.7
Jaya		92.2	40.6	10.0	16.2	0.398	70.4	84.6

When sprayed at the seedling stage, both Bzi and zinc sulfate were ineffective on NC1281 but increased yield in Jaya (see table). The two chemicals significantly increased yield components as well as yield per plant in both varieties when they were sprayed at preflowering and postflowering stages. The effect was greatest when the chemicals were applied at a later stage of growth. Plant growth was found related directly to yield. Sprayed at the preflowering stage, both Bzi and zinc sulfate were more effective in increasing yield in NC1281 than in Jaya; when sprayed at postflowering the two chemicals were equally effective in increasing the yield parameters of both varieties. Higher yield at the later stages might be due to efficient preflowering translocation as shown by the higher grain:straw ratio.

The two chemicals did not increase seed protein content; however, a slight increase in protein content was observed in Jaya sprayed with Bzi at preflowering stage.

Machinery development & testing

Paddy harvester developed in Tamil Nadu, India

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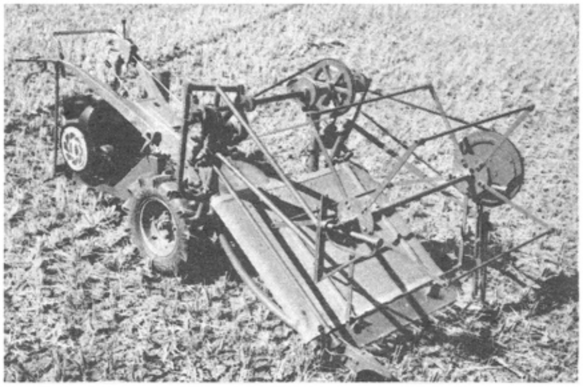
A paddy harvester has been developed at the Zonal Research Center of Tamil Nadu Agricultural University. The harvester is mounted on the front of a power tiller, with the tiller engine shifted to the rear for effective balancing, thereby reducing operator fatigue (see photo).

The harvester consists of a reel to bend the crop for cutting, a cutter bar to harvest the paddy, and a conveyor to windrow the cut crop for easy collection by laborers. The power from the tiller is taken from the clutch pulley to a main shaft, then fed to the different working parts (see diagram). The harvester's short turning radius (3 m) allows it to be operated even in small paddy fields. The only prerequisite is that a small plot of 4 × 1 m at a corner of the field must be harvested by hand to accommodate the unit before machine harvest starts.

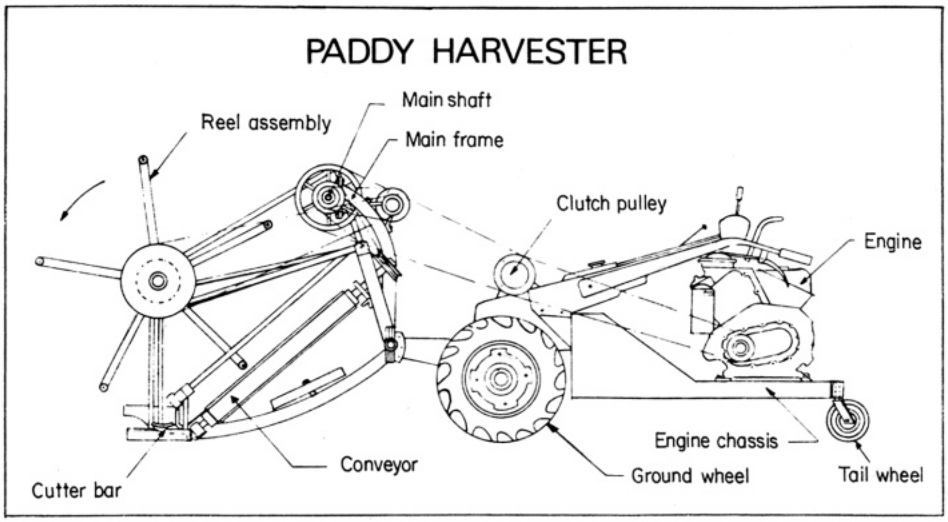
A single person operating the machine can cover 0.7 ha/8-hour day. The shattering loss is less than 1% for all paddy varieties except for CO 37 (1.7%). When reaped manually the same varieties suffer shattering losses ranging from 0.3 to 0.5%. The cost of harvesting 1 ha with the machine, including manual collection of the crop, is US$13.75/ha; with manual labor it is $17.50. The savings in harvest costs with use of the machine are $3.75/ha — or 21.5%. The cost of the unit is around $437 excluding the cost of the power tiller, and about $2,250 including the power tiller's cost. In fields where the machine is to be used, irrigation is generally stopped 10 to 15 days before the proposed harvest date so that the field will be dry and the machine's wheels will not skid.

The unit is operated at a speed of 1.5 to 1.6 km/hour during harvest. The power tiller must run in the first or low gear to operate the unit at this speed.



Paddy harvester attached to front of a power tiller.

Diagram of a paddy harvester.



To move the unit from one plot to another, small earthen ramps made of soil excavated from the field will allow the unit to easily climb over the bunds.

Design details are available from Tamil Nadu Agricultural University.

Specifications

Overall dimensions: 3.85 × 1.35 × 1.30 m

Power: 8 to 10 hp (power tiller)

Manpower required: 1 operator

Output: 0.7 ha/day

Cutter bar:
- Speed: 300 cycles/minute
- Stroke length: 8 cm
- Linear speed: 48 m/minute
- Cutting width: 90 cm
- Fingers (no.): 13
- Cutting blades (no.): 12

Conveyor:
- Speed of roller: 235 rpm
- Diameter of the roller: 6 cm
- Peripheral speed: 44.3 m/minute
- Width: 90 cm

Reel:
- Diameter: 1.05 m
- Speed: 20 rpm
- Peripheral speed: 66 m/minute
- Bats (no.): 5

Forward speed of the tiller: 1.6 km/hour in 1st or low gear

Other details:
- Min. ht of cut above ground level: 5 cm
- Shattering loss: 50 kg/ha, or 1% of yield
- Condition of the crop and soil: Crop should be nonlodging. The soil should be dry so that the power tiller wheel will not bog or spin.

Cost of unit:
- Excluding power tiller: $437
- Including power tiller: $2,250.

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