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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.
- When possible, round off numbers to one or two decimal points. For example, 5.2 t/ha, *not* 5.232.
- 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; seven 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.

Genetic evaluation and utilization

OVERALL PROGRESS

Variability in daily grain production per hectare in rice

S. S. Saini and Ish Kumar, Regional Rice Research Station, Punjab Agricultural University, Kapurthala, India

In northern India the rice-growing season is limited to from mid-May to the end of October. Therefore, it is essential to develop varieties that take no more than 100 days to mature in the field to permit the timely sowing of the primary rabi crop, wheat, in November. The yield potential of such varieties should be equal to or better than that of the present commercially grown high yielding varieties.

The present concept in rice breeding is to develop a genotype that makes the best use of available nutrients and solar

Table 1. Duration and daily grain production per hectare of 218 rice varieties during 1976 kharif (wet season), Kapurthala, India.

Grain production/ha (kg)	Varieties (no.) of different growth duration						
	80-90 days	91-100 days	101-110 days	111-120 days	121-130 days	131-140 days	Total
25 – 30	–	–	–	–	–	2	2
30 – 35	–	–	–	–	–	2	2
35 – 40	–	–	–	3	3	4	10
40 – 45	–	–	3	9	12	1	25
45 – 50	–	1	6	21	7	1	36
50 – 55	–	2	7	26	15	–	50
55 – 60	–	–	6	24	14	–	44
60 – 65	–	2	7	13	12	–	34
65 – 70	–	–	3	4	1	–	8
70 – 75	–	–	2	–		–	3
75 – 80	–	–	–	–	–	–	–
80 – 85	–	1	–	–	–	–	3
85 – 90	–	1	–	–	–	–	1
	2	7	34	100	65	10	218

Table 2. Daily grain production per hectare of different groups of varieties. Kapurthala, India.

Group	Variety	Field duration (days)	Grain/day per ha (kg)
	Long duration, low yielding		
I	1728	138	28.47
	Basmati 370	131	28.40
	Short duration, high yielding		
II	PR 103	92	86.74
	IR1561-228-3-3	91	82.42
	MTU 6368-89	89	82.37
	RP 379-34-8 1-1 3	90	81.33
	Recommended high yielding		
III	Jaya	117	66.10
	PR 106	119	65.00
	Palman 579	110	53.09

PR 103 yielded 86.7 kg/ha daily in trials at Kapurthala, Punjab, India.

energy in the shortest rice-growing period to give maximum yield per unit of area and per unit of time at a low cost. To identify such efficient type , 218 newly developed, short-statured cultures from various crosses were grown in a replicated yield trial at the Regional Rice Research Station, Kapurthala. Data on duration in the field and on daily grain production per hectare were recorded.

Daily grain production per hectare varied widely. Varieties with a growth duration of 80 to 140 days produced 25 kg to 90 kg/day per ha (Table 1). The varieties that performed well are compared with the present high yielding varieties of the Punjab in Table 2.

The varieties in group II of Table 2 show promise as replacements for almost all high yielding varieties of the Punjab; they may also help to prolong the transplanting period. They would also vacate the fields from 10 to 20 days earlier than the presently grown varieties and thus allow farmers to prepare the fields for timely sowing of wheat. The higher daily grain production per hectare of those varieties seems to represent a high physiological capacity to mobilize photosynthates and to translocate these to organs having economic value. A detailed study of the morphophysiological traits of these groups can provide better selection criteria for genetic gain in paddy yield improvement. A conspicuous morphological character of PR 103, which gave the highest daily grain yield of 86.7 kg/day per ha, seems to be its very long (60–80 cm) and upright flag leaf (see photo) that intercepts maximum sunlight during the grain-filling phase in the field. Hybridization programs may use such varieties widely to transfer their desirable traits to other varieties.

Co 40 or Rajarajan — a new high yielding, long-duration monsoon rice

P. Narayanasamy, assistant professor (rice), and S. R, Rangasamy, principal, Farm Science Center, Pondicherry 605010; and A. Subramanian, director, Extension Education, Tamil Nadu Agricultural University, Coimbatore 3, India

The monsoon season in the Coromandal coastal belt and Cauvery basin of Tamil Nadu extends from August to December. The monsoon is characterized by factors not normally favorable for increased rice yields — cool temperature (from 25.1ºC to 29.7ºC), short duration of sunlight (from 5.5 to 8.3 hours/day), monsoon cloudiness, and high rain intensity (from 927 to 1,144 mm in 50–53 rainy days). Despite these unfavorable conditions, 60 to 70% of the rice area in India, particularly in Tamil Nadu (1.62 to 1.69 million ha), is grown to monsoon rice.

In spite of the. development of several high yielding varieties, the specific varietal needs for the large monsoonal rice area, including high yield potential and long growth duration, have not been met. Neither national nor international rice breeding organizations have devoted much effort to the development of rice varieties with growth duration of longer than 140 to 145 days. Varieties with a long vegetative phase and a maturation period of 160 days or more would commence flowering at the end of the monsoon. Panicle emergence would then coincide with bright, dry, cool weather and slowly increasing temperature during the postmonsoon period. Inherently photoperiod-sensitive varieties grown now are tall indicas that yield low, mainly because of poor nitrogen utilization and susceptibility to lodging and blast *Pyricularia oryzae.* The latest tall indica variety made available for monsoon cultivation is Co 25, from the cross Co 4/ADT-10. Co 25 is resistant to *Pyricularia,* is photoperiod-sensitive, and has a growth duration of 165 to 180 days. But it gives low yields of 3 to 3.5 t/ha (see table), because it lodges even at the early growth stage.

To achieve those objectives, IR8 and Co 25 were crossed in 1969 at the Paddy Breeding Station, Tamil Nadu Agricultural University (TNAU), Coimbatore. A number of derivatives were selected and tested for yield in the

Mean yield of Co 40 *Rajarajan* rice in the monsoon season (Aug. to Jan.) in Pondicherry and Tamil Nadu regions, India.

Trials	Yield (t/ha)				
	1974	1975	1976	1977	Mean
Rice research station	7.5	6.8	6.7	6.6	6.9
Adaptive trials in farmers' fields	–	5.6	6.1	6.0	5.9
Demonstration in farmers' fields	–	–	6.4	6.6	6.5
Mean	7.5	6.2	6.5	6.5	6.1
Local check (Co 25)	3.7	2.6	4.1	3.7	3.5

monsoon period. TNAU finally selected one such culture, TNAU 13493, and released it for cultivation in 1977 as Co 40 Rajarajan. This variety grows to 110 cm and matures in 165 to 170 days. Its grain is short and bold and the length:width ratio is 2.23. The vegetative period extends from 110 to 115 days.

Some significant characteristics of Rajarajan are 1) medium-tall stature with lodging resistance, 2) photoperiod sensitivity, 3) high photosynthetic ability even in cloudy monsoon weather, 4) resistance to *Pyricularia,* 5) high field tolerance for bacterial blight, 6) nitrogen utilization at moderate levels (80–120kg/ha), and 7) high yielding ability (from 6 to 7.5 t/ha vs 3 to 3.5 t/ha for the existing tall indica varieties) (see table).

Seedlings of Rajarajan can be planted after 50 to 60 days in the nursery beds so that its 110- to 115-day field duration is in the management limit of small farmers with available rainfall and a little stored water left in seasonal ponds during postmonsoonal dry periods.

The yields of Rajarajan in research stations, adaptation trials in farmers' fields, and demonstration plots from 1974 to 1977 are given in the table. Other advantages are its yield stability across seasons and locations, and its medium-tall stature that makes it a source of rice straw, a stable feed for cattle in this region. Rajarajan is well received by the local farmers.

Fifteen participants in 1978 GEU training program

Fifteen participants from Bangladesh, Indonesia, Sri Lanka, and Thailand attended the 1978 Genetic Evaluation and Utilization (GEU) training program at IRRI from February 15 to June 16 (see photo). The course includes both instruction and practical experience in the basic skills essential to the operation of successful rice improvement programs, emphasizing and demonstrating the importance of multidisciplinary cooperation.

Participants in the 1978 GEU training program checking their hybridized plants in the IRRI plant breeding screenhouse. From left to right are: S. Ponnuthurai, D. L. Wichremasingha, and G. G. Saparamadu from Sri Lanka; M. Potisurintara, A. Thaotho from Thailand; I. Hadisjaban, A. Subardjo, A. Kartohardjono, Z. A. Simanullang, Sumarno, and A. E. Kosman from Indonesia; and M. B. Alam, Q. A. Haque, Md. A. Hossain, and P. K. S. Ray from Bangladesh.

The GEU training program is basically skills oriented. Participants enhance their competence in screening to identify desirable rice characters, in combining such characters through selective plant breeding, and in evaluating the progeny.

Candidates for GEU training are carefully selected. Only highly motivated and active rice scientists of leadership potential with a knack for hard work qualify.

The diffusion of specific semidwarf rices as parents in Asian rice breeding programs over 10 years

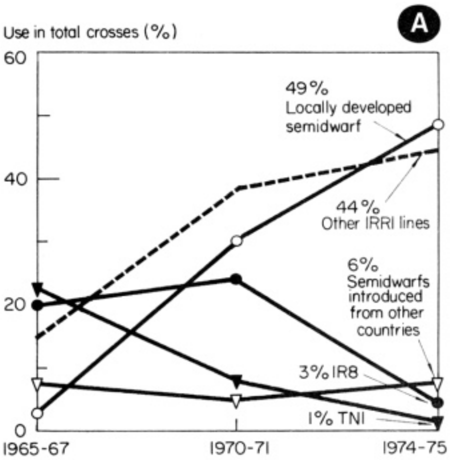
Thomas R. Hargrove, associate editor, International Rice Research Institute

Although researchers have traced the spread of the improved rice varieties onto farmers' fields, little is known about their diffusion as parent varieties into breeding programs. Through analysis of breeding records and in-depth interviews with rice breeders, the International Rice Research Institute studied changes in the rices used as parents in 355 randomly selected crosses made over a 10-year period at 14 agricultural experiment stations and universities in 7 Asian nations: Bangladesh, India, Indonesia, Korea, Philippines, Sri Lanka, and Thailand. The research project was partially funded by a grant from The Rockefeller Foundation,

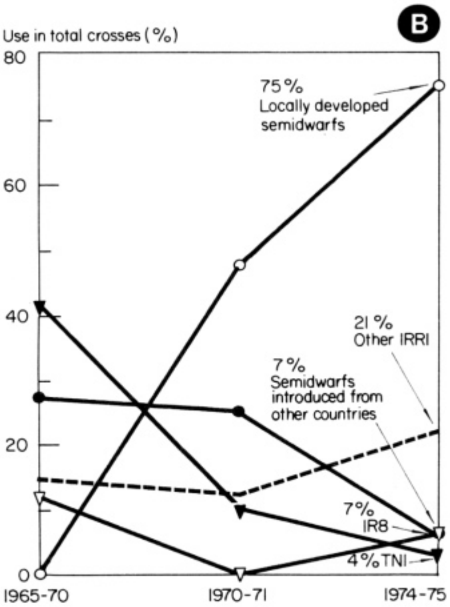
The most popular single gene source in the 1965–67 sample of crosses was Taichung Native 1 (TN1), a semidwarf variety developed in Taiwan in 1956. TN1 was used in 22% of the total crosses, IR8 in 20%, and other IRRI lines in 14% (see figure, A).

By 1970, the use of TN1 had dropped sharply: by 1974–75 TN1 was used in only 1% of the crosses. The use of IR8 increased slightly by 1970–71, but dropped to only 3% by 1974–75. The use of IRRI varieties and lines other than IR8 as parents increased to about 44% of the crosses by 1974–75; the use of semidwarfs introduced from other countries also increased slightly.

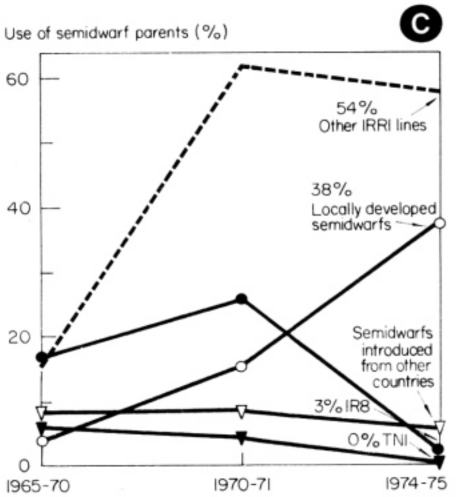
But the strongest trend was the growing use of *locally developed*



A. Use of semidwarf parents in the rice breeding programs of 7 Asian nations over a 10-year period. Eight hundred and nineteen parents used in 355 randomly selected crosses at 14 agricultural experiment stations and universities.



B. Use of semidwarf parents in Indian rice breeding programs over a 10-year period. Three hundred parents used in 140 randomly selected crosses at 7 agricultural experiment stations and universities, India.



C. Use of semidwarf parents in rice breeding programs of 6 Asian nations (excluding India) over a 10-year period. Five hundred and nineteen parents used in 215 randomly selected crosses at 7 agricultural experiment stations and universities in 6 Asian nations, 1965-75.

semidwarfs – from almost zero to use in almost half of the crosses in 10 years. Most of such semidwarfs were progeny of earlier crosses with TN1 or IR8.

Because more than a third of the crosses analyzed were made at seven research centers in India, the data were analyzed to determine if Indian rice breeders differed from fellow rice breeders in the six other nations in the adoption of genetic materials.

By 1974–75,75% of the crosses made in the Indian sample involved a locally developed semidwarf; 21% involved an IRRI parent other than IR8; and 7%, a semidwarf introduced from another country (figure, *B*). In the six other countries, IRRI was the major source of semidwarf parents (figure, *C*). But the same strong trend toward the use of locally developed semidwarfs was found.

The 111 times that a semidwarf variety was used as a parent in 1974–75 involved 83 separate varieties or breeding lines.

Ancestry of locally developed semidwarf rices used as parents in Asian rice breeding programs in 1974–75

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

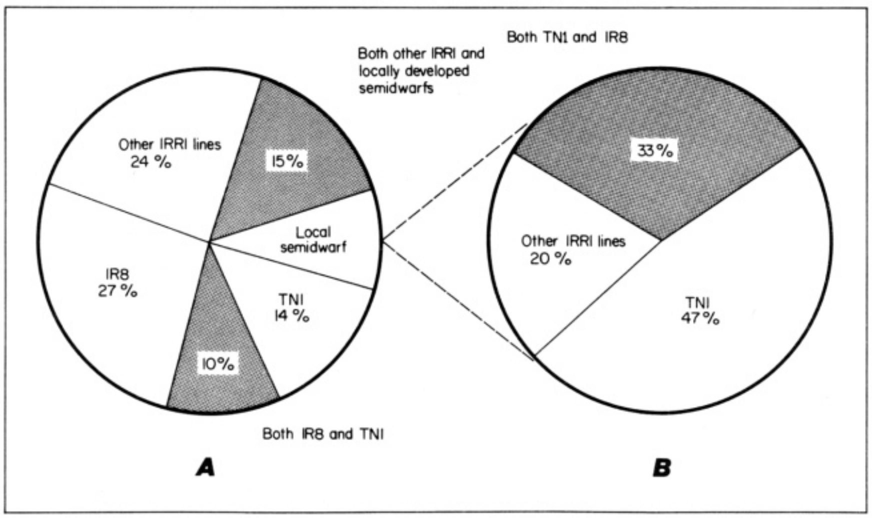
In a study of the diffusion of genetic materials among rice breeding programs in different countries of Asia, almost half of the 377 randomly selected crosses made in 1974–75 at 14 agricultural experiment stations in 7 Asian nations involved the use of at least one *locally developed* parent. The sources of the semidwarf gene were determined by analyzing the ancestry of the local semidwarfs. Genes were traced back two or three generations.

Seventy-six percent of the local semidwarf parents were progeny of IR8 or other IRRI varieties and lines (see figure, *A*). For example, the variety K35, used as a parent in India, is a progeny of the cross IR8/HR19; RD1, used in Thailand, is from Leuang Tawng/IR8.

Twenty-four percent of the local semidwarfs such as Sona (TN1 /GEB 24) and Jaya (TN1/T141) were progeny of TN1. Twenty-five percent of the rices had at least two different semidwarf parents; for example Tong-il, often used in Korean crosses, is from the cross IR8//Yukara/TNl.

But a fourth of the local semidwarf parents were themselves progenies of local semidwarfs that had been developed earlier. The genetic composition of those second-generation ancestors was determined next. Eighty percent were found to be progeny of TN1 (figure, *B),* Thirty-three percent had both TN1 and IR8 in their ancestry. For example, Pusa 33, used in three crosses, is a progeny of a cross of Ratna (TKM 6/IR8) with Improved Sabarmati (TNl*3/ Basmati 370).

Because TN1, IR8, and most other semidwarfs have Dee-geo-woo-gen (DGWG) as a common ancestor, the DGWG gene may be assumed to be in about 80% of the crosses analyzed for 1974–75.



A. Source of semidwarf gene in 59 locally developed semidwarf rices used as parents in 1974–75 crosses. B. Source of semidwarf gene in the ancestors of local semidwarfs that were used as parents in 1974–75 crosses.

Thus, although by the mid-1970's the original stiff-strawed varieties such as TN1 and IR8 were virtually phased out of breeding programs as direct parents, almost all the semidwarf parents that replaced them were their progeny.

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

Invitation to participate in an international rice genetic survey

The increasing volume of hybridizations made in national and international rice improvement programs and the accelerated exchange of genetic material necessitate the establishment of a permanent and comprehensive record bank for the use of present and future generations of rice scientists. Some hybridization records from early breeding programs have been lost; others are relatively inaccessible. The record bank could provide information on any rice variety, including its complete genetic ancestry and the extent of its use in farmers' fields or in crosses.

Such information can help scientists to identify possible sources of resistance and to avoid the inherent dangers of genetic uniformity in the world's rice crop. IRRI invites rice scientists to collaborate in an *international rice genetic survey* to systematically gather, store, and disseminate such information. The information will be made available to all rice researchers and will help IRRI scientists and collaborators from national programs focus on problem areas considered most critical.

Information on rice varieties most widely grown by farmers, on the newest varieties released by national programs, and on elite breeding lines is also needed.

By analyzing the genetic background and traits of elite breeding lines in various programs - and of parent materials used in crosses - scientists can anticipate the types of varieties that would be released within the next few years.

We request that each breeding program send to IRRI a list of the varieties and lines described (see following) and copies of hybridization records.

MOST WIDELY GROWN VARIETIES, those grown on more than 50,000 ha within a political region or, for smaller areas, the varieties most extensively grown in farmers' fields. Include the following information:

- varietal name (or names, in some cases)
- cross (if of hybrid origin) or progenitor (if pureline selection or mutant)
- origin of variety
- plant height
- state, province, or region (political)
- main season (or seasons) grown
- agroclimatic conditions or type of culture (rainfed lowland, deep water, etc.)
- growth duration (days from seed to seed)
- estimate of the area on which grown (both total number of hectares and percent of total rice land in the state, province, or region)
- major important agronomic traits (gall midge resistance, grain quality, etc.)

NEWEST RICE VARIETIES, released by each station over the past 10 years. Include the following information:

- varietal name
- source of variety
- previous line designation
- cross (if of hybrid origin) or progenitor (if pureline selection or mutant) from which the variety was selected
- plant height
- growth duration (days from seed to seed)
- agroclimatic conditions or type of culture for which recommended (rainfed lowland, deep water, etc.)
- state, province, or region (political) where released
- estimate of the area on which the variety is grown (both total number of hectares and percent of total rice land in the state, province, or region)
- important agronomic traits

ELITE BREEDING LINES, the most promising prerelease lines in advanced yield trials of the ultimate stage of testing (on-station, regional, minikit, or production trials). Will probably be no more than 10 lines/geographic region.

Please provide information on:

- line designation
- cross from which the line was selected
- plant height
- growth duration
- agroclimatic conditions or type of culture for which intended
- important agronomic traits
- state, province, or region (political)

HYBRIDIZATION OR CROSSING RECORDS, made since the initiation of crossbreeding at various stations. Anyone who has access to old crossing records from programs that no longer exist is also requested to provide a copy so that the ancestry of varieties that came from those crosses will not be lost to future generations. Include:

- name of station and country
- line designation (K, BR, etc.) and number
- cross (female parent first, then male)
- year (approx.) that cross was made

The information should be sent to:

Thomas R. Hargrove
Associate Editor
International Rice Research Institute
P. O. Box 933
Manila, Philippines

Thank you in advance for your time and consideration.

GENETIC EVALUATION & UTILIZATION

Germplasm conservation

Primitive cultivated rices and wild relatives from the Chhotanagpur region of southern Bihar, India

D. P. Srivastava, Central Rice Research Institute, Cuttack 6, Orissa, and S. C. Prasad and P. N. Sinha, Agricultural Research Institute, Rajendra Agricultural University, Kanke, Bihar, India

The hilly, rainfed Chhotanagpur region of southern Bihar is predominantly inhabited by tribal people. The terraced lands vary widely in ecological and agronomic systems, ranging from moisture-stressed upland conditions to wet lowland conditions. On the basis of moisture and water regimes the lands are classified into six groups: Tanr 1, Tanr 2, Tanr 3, Don 3, Don 2, and Don 1. The Tanr lands are subject to moisture stress, which is most severe in Tanr 1 followed by that in Tanr 2 and 3. Don 1 lands are waterlogged throughout the cropping season, while Don 3 and 2 depend on rainfall for moisture.

A rich variability of cultivated rice is found in those systems. Annual and perennial wild rices of the *O. sativa* type are also common. The Gora rices (early maturing) are grown in Tanr lands in Ranchi district. The well-known Black Gora has primitive characteristics, i.e., black hulls and red kernels. Annual wild rices (similar to *O. nivara*) are also frequently observed in the fields of Black Gora. They have black hulls, red kernels, and awned spikelets. Their grains tend to shatter. The wild rices show some similarities to Black Gora.

In Chaibasa district, annual wild rices, some with black and others with straw hulls, are found near rice fields. Semisterile annual wild rices that appear to be hybrids with *O. sativa* are also common in some regions. A few cultivated rices such as Chidikata, Koya, and Kosambaba have certain characters similar to those of annual wild rices - black hulls, awns, and red kernels. Kosambaba has both straw and black hulls. In one instance, Chidikata was observed with black as well as with golden brown hulls. A few varieties also had intravarietal variations.

Such rices as Black Gora, Chidikata, Koya, and Kosambaba that the tribal people cultivate appear to be primitive cultivars with many of the characters of their nearby wild relatives. Such varieties could be valuable in understanding genetic interrelationships; they could offer opportunities for the study of the affinity of the cultivated rices and their adjoining wild relatives.

GENETIC EVALUATION & UTILIZATION

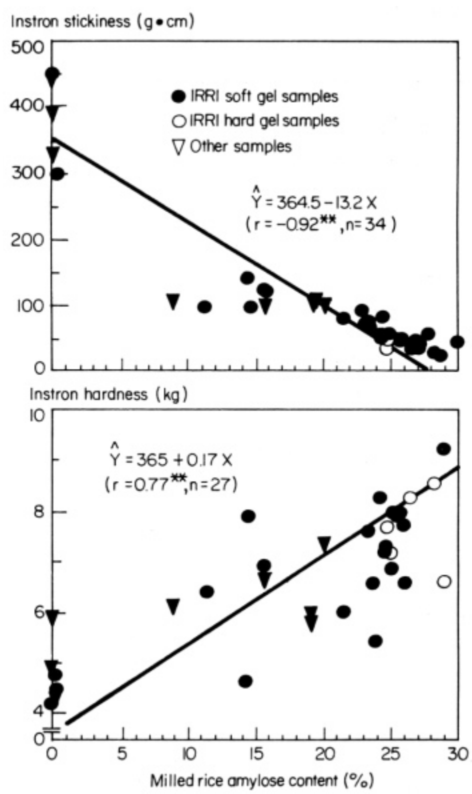
Grain quality

Hardness and stickiness of cooked rice as indicators of eating quality

C. M. Perez, senior research assistant, C. G. Pascual, research assistant, and B. O. Juliano, chemist, International Rice Research Institute

Methods of measuring stickiness and hardness of cooked rice with an Instron food tester were developed using 20 g raw milled rice cooked in an optimum amount of water based on amylose content. Stickiness was measured as the work required to separate the plunger from the platform with cooked rice pressed between them. Hardness was the maximum force required to extrude the cooked rice through a modified Ottawa Texture Measuring System extrusion cell. Both stickiness and hardness of cooked rice, mostly IRRI samples, correlated with amylose content (see figure). But the hardness values varied more than stickiness values for all amylose levels.

Among IRRI high-amylose (>25%) rices, the grain of those with soft gel consistency tends to be softer and more sticky when cooked. Varietal differences in texture among rices with low or intermediate amylose content were associated with differences in hardness of cooked rice rather than with differences in stickiness. Among Philippine and Indonesian rices of intermediate amylose content (20–25%), samples with soft gel consistency and low amylograph consistency tended to be soft when cooked. In some cases, differences in hardness of cooked rice were associated with differences in gelatinization temperature of the starch (alkali spreading value). Among South Korean and Japanese low-amylose (12–20%) rices, hardness values of cooked rice were related mainly to differences in gel and amylograph consistency. When cooked, the preferred waxy varieties from Korea, Philippines, and Thailand were soft and sticky, and tended to have low (<70°C) gelatinization temperature.

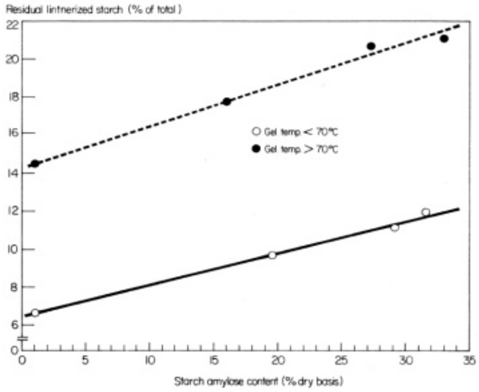


Relationship between amylose content of milled rice and Instron stickiness and hardness of rice cooked with the optimum level of water and then cooled. IRRI, 1977.

Properties of lintnerized starch granules from rices of different amylose content and gelatinization temperature

C. C. Maniñgat, research assistant, and B. O. Juliano, chemist, International Rice Research Institute

The gelatinization temperature of starch is rapidly becoming recognized as an important indicator of eating quality of both waxy (glutinous) and nonwaxy rices. Its measurement in breeding programs by



Recovery of lintnerized starch from starch granules of eight rices differing in amylose content and final gelatinization temperature.

the alkali digestibility test on whole kernels of milled rice suggests that the whole kernel also reflects this starch property. To better understand the property, the characteristics of starch granules of eight rices differing in amylose content and gelatinization temperature were studied at IRRI. The rices were lintnerized or corroded in 2.2 N HCl at 35°C for 15 days. Lintnerization of rice starch granules consisted of a fast stage of 7 to 9 days involving the amorphous portion of the granules, and of a slower stage involving the crystalline portion. The weight recovery of lintnerized starch ranged from 6.6 to 21.1% and was greater for samples with higher gelatinization temperature (>70°C) and, to a lesser extent, high amylose content (see figure). Lintnerized starch had sharper X-ray diffraction peaks (more crystalline) than native starch. At the same amylose content, rice starch granules with high gelatinization temperature had a greater crystalline fraction than those with low gelatinization temperature.

The residual starch from both waxy and nonwaxy rices consisted mainly of two fractions with about 15 and 30 glucose units. The 15-glucose-unit fraction was linear and corresponded to the size of the outer chain length of rice amylopectin. The fraction consisting of 30 glucose units was probably a mixture of singly branched and linear dextrins, as indicated by the incomplete debranching into the 15-glucose-unit fraction by pullulanase. Differences in mean molecular size of the lintnerized starch (19 to 30 glucose units) were due to differences in the ratio of those two fractions. Thus, differences in gelatinization temperature of starch granules and their accessibility to various chemicals such as HCl and KOH were verified to be related to degree of crystallinity of the granules.

GENETIC EVALUATION & UTILIZATION

Disease resistance

Occurrence of rice tungro virus in Tamil Nadu

S. Kannaiyan, V. Jayaraman, R. Jagannathan, and V. G. Palaniyandi, Plant Pathology Laboratory, Paddy Experiment Station, Ambasamudram 627401, Tamil Nadu, India

Rice tungro is caused by a virus that is known to be transmitted by leafhopper vectors. In recent years tungro has been epidemic or epiphytotic, often striking suddenly and devastating large areas of rice. The existence of tungro in India remained obscure until 1969, when a severe epidemic took a heavy toll of the rice crops in Uttar Pradesh and Bihar.

A tungro outbreak was noticed in this tract during kharif (July–Oct.) and pishanam (Nov.–Mar. 1977–78), seasons of 1977. The disease was observed in severe proportions in the southern districts of Tamil Nadu — Ramnathapuram, Madurai, Tirunelveli, and Kanyakumari. The disease incidence was severe in rice varieties ADT 31, TKM 8, TN1, IR8, IR5, ASD 11, Co 40, Co 25, and Bhavani — but IR20 was completely disease free. Ponni, Culture AS 3827, Culture AS 1391, and eight other entries — 1201, 1203, 1205, 1208, 1209, 1217, 1219, and 1230 — were found moderately resistant to tungro.

A possible source of resistance to rice ragged stunt disease

K. C. Ling, E. R. Tiongco, and G. Z. Salamat, Jr., International Rice Research Institute

Preliminary results of a search for sources of resistance to rice ragged stunt disease reveal that the variety Ptb 21 Acc. no. 11053 received from the Central Rice Research Institute of India may be resistant; it consistently had a low percentage of seedling infection after ragged stunt inoculation by viruliferous brown planthopper (BPH) Maparvatu fugens in screen cages and in a screenhouse.

The resistance of this Ptb 21 sample to BPH has not been determined, but another Ptb 21 sample Acc. no. 6113 received from the Andhra Pradesh Agricultural Research Institute in Hyderabad is known to be resistant to all three known BPH biotypes. Hence, Ptb 21 Acc. no. 11053 may also be resistant to BPH. Even so, the low percentage of seedlings of Ptb 21 Acc. no. 11053 infected with ragged

Infection of rice seedlings with ragged stunt disease after inoculation by two methods. IRRI, 1978.

Acc. no.	Variety	Seedlings infected with ragged stunt (%)		Brown planthopper resistance[a]
		Cage method	Screenhouse method	
105	TN1	92	96	S
7733	Gangala	71	84	R
6113	Ptb 21	–	–	R
11053	Ptb 21	3	12	–

[a]At IRRI Entomology Department. S = susceptible; R = resistant; – = data not available.

stunt disease may not be entirely due to BPH resistance; the rice variety Gangala is also resistant to the three known BPH biotypes, but it had a high percentage of seedlings infected with ragged stunt disease in the same inoculation test (see table). Hence, Ptb 21 Acc. no. 11053 may be resistant not only to BPH but also to ragged stunt disease.

Experiments to confirm this finding are under way.

Occurrence of water mold disease of rice seed and seedlings in Bangladesh

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A disease that caused rice seeds and seedlings to rot was found in seedbeds of the boro season this year. The causal organism is a phycomycetous fungus of the genus *Achlya,* commonly known as water mold. The species, which has not yet been identified, attacks sprouting seeds and affects germination. Even if a seed germinates, the seedling soon rots or its vigor is reduced.

A few days after infection, a brownish, cottony, hyphal growth was found around the seeds. The disease was severe when the seedbed was submerged for 3 to 4 days during seedling emergence or after the sowing of sprouted seeds. Cold weather seems to have aggravated the situation. About 10 to 50% of the seed and seedlings either rotted or showed damping-off. Dry seedbeds did not have the disease.

Reaction of some boro varieties and lines to water mold disease of rice at the Bangladesh Rice Research Institute farm.

Cultivar	Disease incidence (%)		Cultivar	Disease incidence ($6)	
	Rotten seeds	Affected seedlings		Rotten seeds	Affected seedlings
BG 902	9.5	26.7	IR747-B2-6-3	3.6	68.9
BR 3	39.7	29.5	IR910-12-3-1-3	11.6	10.9
BR 6	4.2	40.9	IR944-85-1-2-1-1-2-1	19.1	6.4
BR 7	52.1	16.7	IR1103-15-8	38.6	42.5
BR 20-29-2	5.00	11.5	IR1514-E666	4.5	48.9
BR 43-1 1-2	1.00	3.8	IR1529-430-3	5.6	12.2
BR 43-11-3	0.0	0.0	IR2003-P17-7-4-2	18.9	32.2
BR 52-315-12	0.0	4.0	IR2031-724-2-3-2	47.00	41.8
BR 167-2B-3	4.0	15.1	IR2035-117-3	1.9	18.5
BR 167-2B-9	28.5	37.2	IR2038-158-2-3	3.3	16.2
BR 167-26-2-1	27.2	12.3	IR2053-87-3-1	20.8	16.8
Chandina	25.9	47.1	IR2053-160-3	90.0	8.0
Chandina/HR29-4	0.0	0.0	IR205 3-200-4	90.0	8.0
Chandrosail I	31.4	7.6	IR2053-362-1-4-4	95.0	3.0
CR 120	90.00	8.0	IR2061-214-3-3-28	5.9	5.1
Habiganj BoroII	3.9	16.9	IR2061-214-3-3-32	4.4	1.8
Habiganj Boro IV	8.00	18.4	IR2061-423-1	16.8	19.0
Habiganj Boro VI	3.3	15.1	IR2061-465-1-5	7.1	10.0
Habiganj Boro VIII	17.5	22.6	IR2061-628-1-1-1-4-3	16.7	46.3
Hashikalmi	29.00	6.0	IR2070-423-2-5-6	1.1	22.9
IET 1444	4.6	29.9	IR2070-414-3-9	5.7	56.2
IET 2845	5.7	8.9	IR2071-625-1-252	6.5	8.9
IET 2895	0.0	0.0	IR2871-53-2	3.1	29.7
IR8	11.6	11.2	IR3403-267-1	9.1	45.5
IR20	95.0	3.0	IR4405-451	8.9	35.2
IR28	7.6	10.3	Mala/Comilla	3.1	6.4
IR29	6.6	11.0	Mala/Habiganj	4.8	7.6
IR32	8.5	12.2	Mala/J15	0.0	0.0
IR78-177-3-2-2	12.00	5.2	Ratna	1.0	5.2
IR382-4-3-2	7.5	7.5	TN1	3.0	2.0

A preliminary survey of seedbeds on the BRRI farm indicated that rice varieties differ markedly in susceptibility to the disease at one of the two stages (see table). Highly susceptible varieties were BR3, BR6, BR7, Hashikalmi, and Habiganj Boro II, IV, and VIII.

This is the first report of the occurrence of such a disease in Bangladesh. To prevent seedling loss due to this disease, seedbed submergence should be avoided.

Evaluation for sheath blight resistance in rice

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From 1975 to 1977, efforts were made at the All India Coordinated Rice Improvement Project to develop simple, rapid, and mass inoculation methods to induce sheath blight disease in rice and to evaluate germplasm and breeding lines in the field and in glasshouses. Preliminary results are reported elsewhere; this article reports screening methodology and catalogues entries that showed sheath blight tolerance in fields and glasshouses.

The pathogen *Rhizoctonia solani* was isolated from affected leaves and sheaths collected from farmers' fields in a sheath blight-endemic region of West Godavari district, A.P. The pathogen was multiplied on shoots of the water sedge *Typha angustata.* Typha shoots are preferred to rice stem pieces because *Typha* stems are strong enough to withstand mechanical handling when inoculated and are readily available the year-round in irrigation and drainage channels. *Typha* shoots measuring 7.6 to 10.2 cm (3–4 in.) in length were soaked in 1% peptone water in 1-liter Erlenmeyer flasks for 7 days. The shoot pieces having mycelium and sclerotia were placed between the tillers in the central region of the rice hills, 5 to 10 cm above the waterline.

The field layout for screening included a normal 2-row observational nursery with an appropriate check, 3 to 5 m long, spaced 20 cm within rows and 20 cm between rows. Ten hills were inoculated in each test row at about panicle initiation stage (60–70 days after seeding). Disease observations on the test entries, based on a 0 to 9 scale, were recorded at 3 weeks after inoculation and 10 days after flowering.

In greenhouse tests, the plants were grown individually in plastic pots 15.2 × 15.2 cm (6 × 6 in.) and were inoculated at around the panicle initiation stage. A minimum of three replicates were maintained for each test entry. For pathogen establishment, the inoculated plants were placed in humid chambers (RH = > 95%, maintained from 1600 to 0800 hours the next day) for 5 days, then transferred to glasshouse benches. Overhead sprinklers were used from 1000 to 1500 hours daily to facilitate further disease development. Disease observations were recorded at 14 days after inoculation at 25 to 33°C, or at 21 days after inoculation at 22 to 30°C, based on the 0–9 disease severity scale.

In the 1975–77 wet season, about 2,000 test entries in the National Screening Nursery and the International Sheath Blight Screening Nursery were screened in the field and about 500 entries of the Assam Rice Collection were evaluated in the glasshouse. Those entries found tolerant in the field were also critically reevaluated in the glasshouse.

In our 3-year study no variety or selection was resistant to the sheath blight pathogen. But certain entries had low disease incidence; they had a few restricted lesions on the lower leaf sheaths and the basal stem regions. The entries having tolerance (disease score < 5) are listed in the table. Several of the tolerant semidwarf selections derive from gall midge-resistance breeding programs (e.g., progeny belonging to the series RP974, RP975, IR2071, etc.). Out of 500 ARC entries tested in the glasshouse, 4 rices — ARC 15762, ARC 18119, ARC 18275, and ARC 18545 — were tolerant of sheath blight.

Varieties and selections that had low disease scores in field and glasshouse tests at AICRIP, India, during 1975–1977.

Designation	Disease score: Field test, Wet season 1975	Disease score: Field test, Wet season 1976	Disease score: Glasshouse test 1977
IRSHBN test entries			
B 9c-Md-3-3	3	–	5
IR789-98-2	5	–	5
IR1103-15-8	5	–	5
IR1910-472 P	5	–	5
Guyana Sel. 60-283	5	–	5
IR2071-588-4-4	5	–	5
IR2071-588-4-5-1	3	5	6
IR2798-88-32	5	5	6
IR2843-26-3-2	5	5	6
BR-4-30-51-2	5	–	6
Remadja	5	–	5
Sigadis	5	–	5
Pankaj (resistant check)	5	–	5
National screening entries			
OR 42-10	5	5	8
RP 974-25-4-3-1	5	3	3
CU1 6475	5	1	–
CR 129-120	5	5	5
PAU 21-88-5	5	5	4
CR 149-3295-4-205	5	3	–
IR2071-176-1-2-1	5	3	–
IR2071-747-6-3-2	5	3	–
RP975-109-2	5	1	5
RP975-121-6-1-1	5	–	3
RP975-25-4-3-1	5	3	3

GENETIC EVALUATION AND UTILIZATION

Insect resistance

Resurgence-inducing insecticides as a tool in field screening of rices against the brownplanthopper

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Rice varieties and selections are usually screened for resistance to the brown planthopper (BPH) in the greenhouse where 7- to 14-day-old seedlings are evaluated by the seedbox technique. This method has effectively identified highly resistant material but has been less effective in identifying strains with moderate and field resistance. At IRRI and in Sri Lanka, the reactions of some varieties have varied distinctly between the greenhouse and the field. Extensive field screening should precede the release of a variety. But several years may be required to obtain reliable data because BPH are distributed unevenly within a field and populations are often too low to evaluate. Even when screening is done in so-called *hot spots,* the pest's unpredictability can cause high expenditures in money, labor, land, and time.

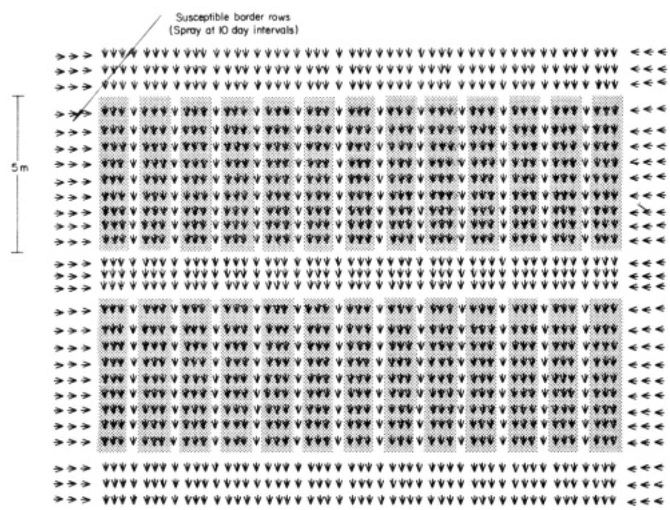
The use of insecticide application as a technique in inducing BPH resurgence was developed to provide evenly distributed and high-BPH field populations at about 80 days after transplanting. In insecticide evaluation studies we have identified insecticides that cause BPH resurgence. The synthetic pyrethroid decamethrin, as well as methyl parathion and diazinon, effectively promotes resurgences (see table). The synthetic pyrethroid cypermethrin (NRDC 149), azinphos ethyl, and carbofuran also cause resurgence (the latter may be effective only where the BPH has developed resistance to the insecticide). In India, mephosfolan, quinalphos, phorate, and the combination of dimecron + nuvan have been reported to cause resurgences. Foliar sprays induce resurgences more effectively than granular formulations.

Our field screening procedure for BPH resistance starts with the planting of three or more border rows of a line, such as IR1917-3-17, which is susceptible to BPH but resistant to tungro virus (see figure). The borders are planted across each end of the test entries. Depending on seed availability, from 1 to 4 rows — each 5 m long — of the test entries are planted with 1 row of a susceptible check variety between each entry. The border rows are sprayed at a low rate — about 100 g

Effect of foliar sprays on brown planthopper (BPH) population and damage in upland rice (variety Kinanda).[a] IRRI, 1976 wet season.

Insecticide[b]	BPH population (no./10 linear-m row) 94 DS[c]	Resurgence ratio (x:1)[d]	Hopperburn (%) 117 DS
Decamethrin	6,733 a	16.4	100
Methyl parathion	2,468 a	6.0	75
Diazinon	1,919 ab	4.1	55
BPMC	178 c	0.4	1
Perthane	29 d	0.1	0
Control	411 bc	–	4

[a] In a column means followed by a common letter are not significantly different at the 5% level.
[b] Insecticides were applied three times at 49, 72, and 94 days after seeding (DS) at 0.75 kg a.i./ha.
[c] The planthopper counts at 94 DS were made before the third application.
[d] Resurgence ratio = $\frac{\text{number of brown planthoppers in insecticide treatment}}{\text{number of brown planthoppers in untreated control}}$



Field plot layout used in the field evaluation of rice for brown planthopper resistance IRRI, 1978.

active ingredient/ha. The spray is directed at the canopy. Plants are sprayed at 10-day intervals beginning at 30 days after transplanting. Plant damage is first rated when the adjacent susceptible check variety is killed, then is rated at 1-week intervals until increase in damage ceases. The extent of damage as based on the Standard Evaluation System for Rice and the percentage of hopperburned plants are then recorded. For additional information on BPH buildup, insects are counted at regular intervals throughout the crop season. Varieties with moderate levels of field resistance are easier to detect with this technique than with the greenhouse method.

Varietal resistance to striped rice borer *Chilo suppressalis*

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One hundred and twenty-seven rice varieties and lines were evaluated to determine the correlation among percentage of infested tillers, larval number, and larval weight.

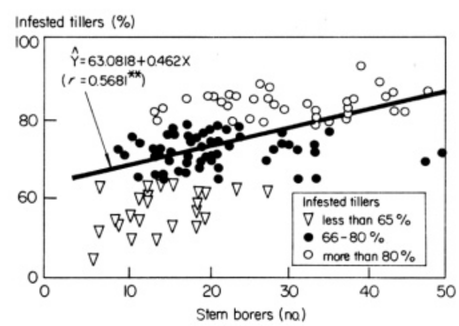
Twenty days after seeding, plants were transplanted in two replications of six hills (2 plants/hill) in a net house. Thirty 10- × 12-cm dishes containing 200 larvae on straw were placed in the middle of the net house so that moths could emerge and infest the varieties.

After 50 days, all stems of each rice were dissected, the larvae and infested tillers were counted, and larval weights were determined.

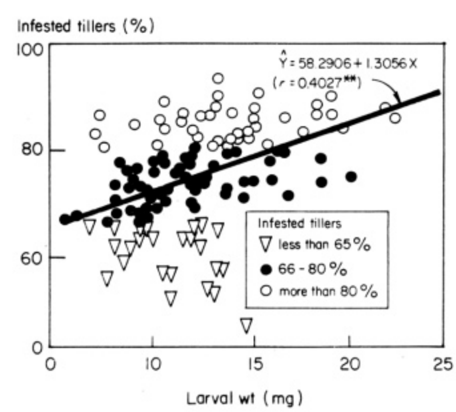
The percentage of infested tillers correlated positively with both the number of larvae and the larval weights in all rices (Fig. 1, 2).

In varieties with a low number of infested tillers, there was a high correlation between infested tillers and number of larvae, but in varieties with high infestation (more than 80%), number of infested tillers did not correlate significantly with number of larvae.

In moderately resistant varieties (less than 80% infested tillers), the percentage of infested tillers correlated significantly with larval weights. As larval numbers increased, larval lengths and body weights were reduced proportionately. The resistant check IR747 had 51% tiller infestation, but the larvae that fed on it had significantly lower body weights and numbers.



1. Relationship between percentage of infested tillers and number o striped rice borers in rices evaluated in the screenhouse. Suweon, Korea.



2. Relationship between percentage of infested tillers and larval weight of striped rice borers in rites evaluated in the screenhouse. Suweon, Korea.

Varietal resistance and chemical control of thrips in West Bengal, India

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In July 1976, a severe outbreak of thrips *Baliothrips biformis* occurred in the nurseries at the Rice Research Station, Chinsurah, West Bengal. About 90% of the seedlings showed leaf-rolling and yellowing in the upper half of the leaves. The graminaceous weed *Paspalum scorbiculatum* surrounding the nursery bunds harbored the thrips. Rainfall during seedling growth was below normal, but the nurseries were kept wet throughout the period by repeated irrigation. In a National Screening Nursery set of 394 entries, only IET 5973, IET 6003, and IET 6004 had minimum infestation (score = 3 on a 1–9 scale). Three other entries scored 9 and had considerable seedling mortality. No entry was free from attack.

The thrips problem in the 1977 nurseries was similar, although rainfall was normal. Six insecticides — phosalone, methyl demeton, fenitrothion, thiometon, Isofenphos, and phenthoate — were tested to check the infestation. Among them thiometon at 0.02% concentration was quite effective. At the tillering stage, the plants had no symptoms of thrips damage but showed a preponderance of bacterial blight.

GENETIC EVALUATION & UTILIZATION

Deep water

Algae living on deep water rice in Bangladesh

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Stem sections, including nodal roots and leaf sheaths, were removed from deep-water rice in a field at Keraniganj, central Bangladesh, in mid-August and early September 1977. The variety, Chota Bawalia, had been flooded for 3.5 months and was in the late vegetative stage. The water was 1.5 m deep. Twenty-four species of algae were identified from this material: 12 Cyanophyta, 4 Chlorophyta, and 8 Chrysophyta.

The following 5 Cyanophyta species are known as nitrogen fixing algae:

Species	Substrate	Relative abundance[a]
Anabaena unispora var. *catlingii* var. nov.	roots	X
Scytonema coactile	roots	X
Plectonema tomasinianum	stem	X
Calothrix marchica	roots	XX
Microchaeta robusta	roots, leaf sheaths	X

[a] x = rare, xx = moderate.

GENETIC EVALUATION & UTILIZATION

Temperature tolerance

Rice germplasm from the higher Himalayan hills of Uttar Pradesh, India

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More than 600 rices have been collected in a germplasm conservation project in the Himalayan hills of Uttar Pradesh. The highest altitude at which rice is grown in these hills is 1,820 m.

Nine rices were collected from altitudes higher than 1,700 m. Three — Jaulia, Swag, and Laugiri — were collected in Gwaldam, Chamoli district, at 1,819 m. Three others — Chaurdhan, Gyarsu, and Chari — were collected from Kutnaur, Uttarkashi district, at about 1,700 m. Another three — Bomki, Bhagwaunaj, and Jadkhia — were collected from Bhatwari, Uttarkashi district, also at about 1,700 m. All collections were from rainfed upland fields, which are sown around mid-March and harvested in mid- to late September. The cultivars are being further purified, tested, and multiplied. Their grain characteristics are in the table.

Grain characteristics of cultivars collected at altitudes higher than 1,700 m in the Himalayan hills of Uttar Pradesh, India.

Cultivar	Grain type	Abdominal white	Pericarp color	Aroma
Jaulia	Long, bold	Absent	Light red	None
Swag	Short, bold	Present	White	None
Laugiri	Long, bold	Absent	Mild red	None
Chaurdhan	Long, bold	Absent	Deep red	None
Gyarsu	Medium, slender	Absent	White	None
Chari	Short, bold	Absent	Light red	None
Bomki	Long, bold	Absent	White	Aromatic
Bhagwaunaj	Long, bold	Absent	Light red	None
Jadkhia	Long, bold	Absent	Light red	None

Adverse soils

Performance of promising salt-tolerant varieties in Karnataka, India

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Rice is the main cereal crop in the lowlands of Vani Vilas Sagar tract, Karnataka. A large proportion of this area is black soils; most are affected by salt. The varieties presently grown are SR26B and S317, known locally as Banku and Halubbalu, respectively. Both have fair tolerance for adverse soils, but they lodge even at preflowering stage. They are also susceptible to blast disease. Some breeding to improve SR26B was initiated at the Agricultural College, Dhanwar, in 1968. But the improvement was only in earliness and photoperiod insensitivity. The development prompted the testing of new salt-tolerant lines — from crosses involving SR26B, S317, and other rices from various rice research institutes within and outside of the state — for adaptability to the Vani Vilas tract.

During both the 1977 dry and wet seasons 17 MR lines from crosses involving Kare Kagga and SR26B, 3 IRRI varieties, and 1 culture from AICRIP, Hyderabad, were evaluated along with popular local varieties at Alur village. The experiments were in a randomized block design, replicated three times. Rice was sown on 25 January and 22 July in the 1977 dry and wet seasons, respectively. Three or four 26-day-old seedlings were transplanted at a 20- × 15-cm spacing to accommodate a plot size of 3.6 m^2.

In the dry season, the cultivars MR353, MR359, MR363, and SR26B-M (a photoperiod-insensitive mutant from SR26B) yielded better than Mangala, the high yielding tolerant check (see table). The three MR rices matured 5 days later than Mangala but 20 days earlier than SR26B-M. In the wet season, the yields of MR353, MR359, and the new entries MR340 and Dasal were comparable with those of SR26B. All varieties matured from 9 to 22 days earlier than SR26B. The mean yields over 2 seasons of MR353, MR359, MR362, and SR26B-M were more than 4 t/ha. The MR cultures clearly owe their tolerance to their female parent Kare Kagga, a popular cultivar on the west coast of Karnataka, India, known for its high tolerance for soil adversities.

Because of their plant stature, earliness, and photoperiod insensitivity, MR340, MR353, MR369, and MR363 have been advanced for multilocational performance testing in Vani Vilas Sagar, Tungabhadra, and Krishnarja Sagar project areas, where soil problems similar to those of Hiriyur prevail in vast areas.

Performance of rice varieties and lines in the salt-affected soils at Alur, Karnataka, India, in the 1977 dry and wet seasons.

Designation	Parentage	Days to maturity	Yield[a] (t/ha)		
			1977 DS	1977 WS	Mean
MR 338	K. Kagga/IR8	120	4.2	1.0	2.6
MR 343	SR 26B/Waner 1	145	4.0	2.5	3.2
MR 346	K. Kagga/IR8	120	3.1	3.1	3.1
MR 353	K. Kagga/IR8	120	6.1	3.3	4.7
MR 359	K. Kagga/IR8	120	6.4	3.3	4.9
MR 362	K. Kagga/IR8	130	5.4	2.8	4.1
MR 377	K. Kagga/IR8	130	5.6	1.1	3.3
C7		145	4.9	1.2	3.0
SR 26B mutant	SR 26B	140	6.1	2.8	4.4
Madhu	TN1/TKM 6	125	4.2	1.2	2.7
MR 348	K. Kagga/IR8	130	4.7		
MR 358	K. Kagga/IR8	130	5.0		
MR 363	K. Kagga/IR8	120	6.8		
MR 375	K. Kagga/IR8	130	3.8		
MR 376	K. Kagga/IR8	135	5.4		
IR20	Peta^3/TN1//TKM 6	135	3.5		
Mangala	Jaya/S 317	115	5.4		
MR 261	IRS/Waner 1	130		3.1	
MR 292 F	Jaya/S 317	133		3.1	
MR 340	K. Kagga/IR8	133		3.1	
MR 341	K. Kagga/IR8	132		3.1	
MR 342	K. Kagga/IR8	128		3.1	
IR3541-6-PN-58-5-3-1	IR442-2-58/IR1514A-E666//BRJl-l3-B-55/IR480-5-9-3	130		2.6	
IR40	IR20*2/ *O. nivara*//CR94-13	130		2.6	
Dasal		126		3.8	
Getu		128		2.7	
SR 26B		142		3.5	

[a] DS = dry season; WS = wet season.

Phosphorus-efficient varieties

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The possibility that Texas rice varieties are efficient utilizers of phosphorus (P) would explain the lack of yield increase when P fertilizer is applied to rice grown on seemingly P-deficient soil. Beaumont

Response of rice varieties to P deficiency in culture solution and in the field at Beaumont, Texas, USA.

Variety	Yield response (t/ha)		Change (%)[a]	RTR (%)[b]	IRRI P deficiency rating[c]
	0 kg P/ha	20 kg P/ha			
Labelle	4.4	4.7	+6	0[d]	–
Lebonnet	4.3	4.5	+4	0	–
Brazos	5.9	5.8	–3	500	–
IR20	2.0	2.2	–	0	R
IR28	5.3	5.4	+2	88	R
Starbonnet	4.3	4.4	+2	0	–
Caloro	2.0	2.2	–	100	–
Nato	4.1	4.3	+5	0	–
Bonnet 73				0	–
Vista				0	–
MI48				0	S
IR2061-464-2				175	R
IR442-2-58				68	S
Dawn				0	–
Mars				0	–
Nova 76				0	–
Calrose 76				0	–

[a] Yields of IR20 and Caloro were so low that no evaluation was made.
[b] Relative tillering ratio = no. of tillers in 1 ppm P nutrient solution divided by no. of those in 10 ppm P and multiplied by 100. The tiller count is made after 4 weeks of growth.
[c] R = resistant; S = susceptible to P deficiency; – = information not available.
[d] 0 means plants failed to tiller in either 1 or 10 ppm P solution. There is no clear explanation why IR20 or some other varieties had no tillers.

clay, an important Texas rice soil, generally contains less than 1 ppm P (extractable with ammonium acetate of pH 4.2). Yet rice yields on this soil are substantial and are seldom increased by application of P fertilizer. To test the hypothesis that certain Texas varieties are efficient utilizers of P (i.e. resistant to P deficiency), their yield responses to P fertilizer were compared with those of IR20 and IR28, which the 1974 IRRI Annual Report had reported as resistant to P deficiency. The first eight varieties in the table were planted on a Beaumont clay containing 1 ppm extractable P. Each variety was fertilized with adequate nitrogen and 0 or 20 kg P/ha.

The poor yields of the late-maturing varieties IR20 and Caloro made evaluation of their P efficiency impossible. The six other varieties' yield response to P fertilizer suggests two possibilities: 1) the soil was not so deficient in P as to cause a P stress or, 2) Nato, Starbonnet, Labelle, Lebonnet, and Brazos are as resistant as IR28 to P deficiency, which means that they are unrecognized sources of resistance to P stress.

A technique described in the 1975 IRRI Annual Report was used to further evaluate the P efficiency of selected varieties. It provides a measure of P efficiency by determining the relative tillering ratio (RTR) (see footnote in table for RTR formula). The pH of the nutrient solution was adjusted to 5.0 and the RTR of the resistant rices IR20 and IR28 and of the susceptible MI-48 were compared with that of selected US varieties in the greenhouse where temperatures averaged about 20°C (see col. 4 of table). The data indicate that Brazos and Caloro are possible new sources of tolerance for P stress and suggest that 10 ppm P may be toxic to Brazos.

The relatively high RTR values for IR2061-464-2 and IR28 agreed with their resistance rating to P deficiency based on field tests at IRRI. But the values for IR20 and IR442-2-58 did not agree with the resistant and susceptible RTR ratings, respectively, given in the 1974 IRRI Annual Report. Similarly, the RTR values in this study do not agree with field results. For instance, the RTR values of Labelle, Lebonnet, Starbonnet, and Nato in nutrient solution were very low, but their yields without P fertilizer in the field were as good as those with P fertilizer. Further evidence that RTR may not reflect P efficiency in the field is in the 1975 IRRI Annual Report. Nevertheless, according to data collected in this study (not reported here) the RTR technique appears to indicate P efficiency better than measurements of shoot weight, root weight, and/or root: shoot ratio — but it is not as reliable as field evaluation.

Although both the field and the RTR technique identified IR28 and Brazos as tolerant of P stress, additional studies are planned to characterize the P efficiency of selected US varieties more precisely.

Corrections

The authorship of the article *Genetic potential and utilization of rice in northeastern India,* IRRN 2:6 (December 1977) should read:

M. L. H. Kaul and R. Garg, Botany Department, Kurukshetra University, Kurukshetra, Haryana, India

The authorship of the article *A study of vein-swellings of rice plants infected with ragged stunt,* IRRN 3:2 (May 1978) should read:

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Pest management and control
DISEASES

The distribution of ragged stunt disease and its resulting rice yield reduction in Indonesia

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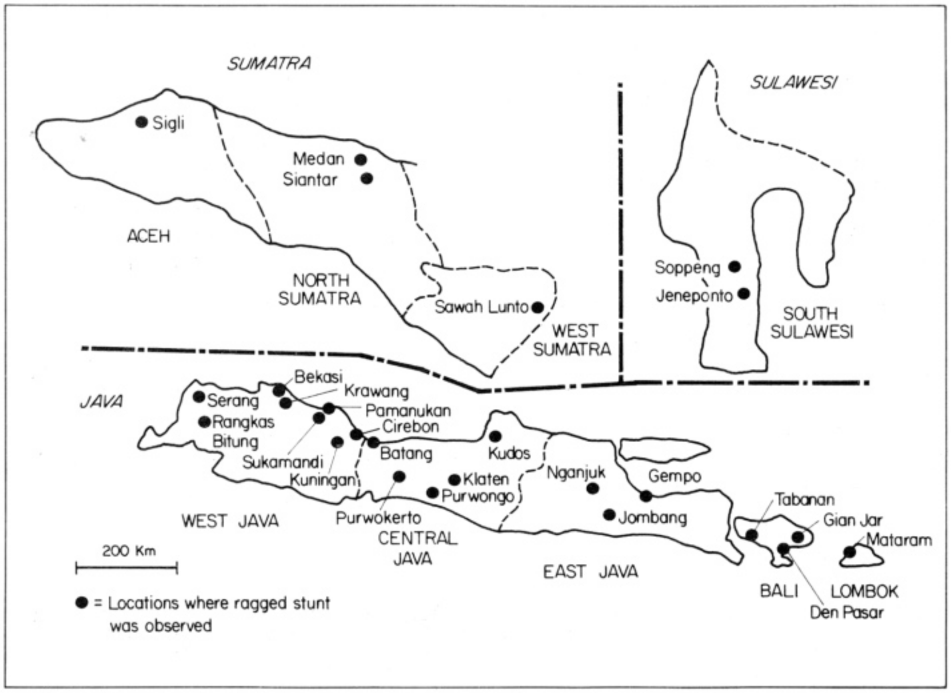
Ragged stunt, a new rice disease, was observed at the Sukamandi Experimental Station, Sukamandi, West Java, in May 1977. A similar disease had been reported earlier from the Philippines and at another location in Indonesia. Ragged stunt was reported in Thailand in 1977, and in Sri Lanka and India in 1978. Investigations by several scientists demonstrated that the disease is transmitted by the brown planthopper *Nilaparvata lugens.*

Plant pathologists and entomologists of the Central Research Institute for Agriculture, Sukamandi Branch, surveyed the spread of the disease. Random stops were made along major highways and plants were examined for ragged stunt symptoms.

Ragged stunt appears to be widely distributed in the rice-growing areas of Java as well as Sumatra, Sulawesi, Bali, and Lobak (see figure).

Yield losses were studied in commercial seed production fields at the Sukamandi station. Plants with symptoms of ragged stunt were harvested in an area of 100 m^2, replicated three times. In a second experiment only two replications were made. Checks were selected among 1,600 apparently healthy plants. The plants were randomly selected and were equal to 100 m^2 planted at 25 × 25 cm. Harvested grain was dried to about 13% moisture content before weighing.

The incidence of ragged stunt was very high in 5 ha each of Pelita I-1, Pelita I-2, and PB5 (IR5) that were being grown for seed production. Although brown planthoppers were present there was no hopperburn. Yield data were taken in those fields to estimate the losses due to ragged stunt. Yield losses in the three varieties ranged from 53 to 82%, with ragged stunt infection ranging from 48



Distribution of ragged stunt disease. of rice in Indonesia, 1978.

Yield loss due to ragged stunt in three varieties and three promising Lies. Central Research Institute for Agriculture, Sukamandi Branch, Sukamandi, West Java, Indonesia.

Variety/line	Ragged stunt[a] (%)	Av. yield (t/ha)	Yield loss (%)
Pelita I-1[b]	48	1.6	53
	0	3.5	
Pelita I-2[b]	76	0.6	82
	0	3.6	
PB5[b]	61	0.6	81
	0	3.4	
B2360-11-3-2-9[c]	67	1.0	66
	0	3.1	
B3753-7-Pn-4-1[c]	74	0.6	83
	0	3.8	
B2540b-Pn-30-2-Mr-4[c]	34	1.3	68
	0	4.4	

[a]1,600 hills = 100 m^2 were selected to obtain yields for checks.
[b]Av. yield, 3 replications.
[c]Av. yield, 2 replications.

to 76% (see table). In a second observation of three promising lines, yield losses ranged from 66 to 83% and ragged stunt infection ranged from 34 to 74%.

The observations indicate that the disease has the potential to cause severe losses. Further research is needed to identify resistant sources that can be incorporated into commercial varieties.

Occurrence of ufra disease in transplanted rice

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Ufra disease of rice, caused by *Ditylenchus angustus,* had occurred only in deepwater rice in Bangladesh since Butler first reported it in 1913. During the 1977 aman season, however, ufra was found in transplanted aman rice on the BRRI farm, Joydebpur. The disease appeared in only one experimental field and affected four rice varieties. IR20, Nizersail, and BR4 were severely infested with 70, 80, and 90% affected tillers, respectively. Severe stunting, incomplete panicle emergence, and brown discoloration of boot and flag-leaf bases were observed. The occurrence disproves the previous observation that ufra disease is confined to deepwater rice. Under favorable conditions it may affect other rice crops.

Monthly fluctuation in number of conidia of rice blast fungus trapped by spore sampler

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In 1976 and 1977, a disease nursery was established for epidemiologic studies of rice blast in the field in the first and second rice crops. The rice varieties Tainan 5 (moderately resistant to neck blast) and Chianon shen 8 (susceptible) were grown at a 20- × 25-cm spacing in four equal plots of 6 × 8 m divided by crossing lines. The varieties were alternated; each variety occupied two nonadjoining plots. The experimental field was given a standard fertilizer treatment — 120-60-50kg/ha of N, P_2O_5, and K_2O, respectively. An automatic Kramar-Collins spore sampler was placed at the center of the experimental field to collect conidia the year round. Samples were taken 4 times/hour for a total of 6 minutes; the total air volume was 120 liters. The first crop was transplanted in late January and harvested in early June; the second crop was transplanted in late July and harvested in early November.

In both years, the number of trapped conidia was highest in April and August, in the first and second crops (see table). The peaks in trapped conidia coincided with the peaks of leaf blast in 1976 and 1977. But no conidia were trapped in January, February, or November 1977, or in December of 1976 or 1977. That probably indicates that the rice blast fungus overwintered for 3 to 4 months in Taiwan.

Number of conidia of rice blast fungus trapped monthly in 1976 and 1977 in the field. Chia-yi Agricultural Experiment Station, Taiwan.

Month	Conidia (no.) trapped in	
	1976	1977
January	0	0
February	0	0
March	651	13
April	4,544	818
May	695	162
June	111	19
July	43	103
August	749	497
September	45	303
October	39	15
November	14	0
December	0	0

Pest management and control
INSECTS

Brachmia arotrae, a leaf folder of rice in India

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Caterpillars of *Brachmia arotrae* sp. were observed folding and damaging rice leaves at the Central Rice Research Institute farm, Cuttack, in November and December 1977. The adult is smaller than C. *medinalis* and pale straw in color. Eggs are light yellow, flat, and oval, laid singly on the leaves or, occasionally, in rows. The incubation period is 4 to 5 days. The fully grown larva has a black head and phothoracic shield and is about l0 mm long. It fo1ds the leaves and feeds on the epidermis from inside the folded leaf. About a month is required to complete one generation. The pest, along with *C. medinalis,* was abundant in late-planted crops and accounted for 30 to 40% of the leaf folder population during the first week of December at Cuttack. Both *C. medinalis* and *B. arotrae* were also found infesting the weed *Leersia hexandra. C. medinalis* and *B. arotrae* were found to be parasitized by *Apanteles* sp. and *Brachmeria* sp.

Brachmia arotrae is becoming increasingly important. It was also observed in certain parts of Madurai district of Tamil Nadu; it may now be fairly well distributed in India. It appears to have missed the attention of rice researchers in India, perhaps because its damage closely resembles that from *C. medinalis.*

Nematodes in paddy fields of Pakistan

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Nematodes damage the paddy crop in many rice-growing areas of the world. Nematode species found in Pakistan are *Aphelenchoides* sp., *Criconemoides* sp., *Ditylenchus* sp., *Helicotylenchus* *erythrinae, Hemicycliophora* sp., *Hemicriconemoides* spp., *Hirschmanniella oryzeae, Hoplolaimus* sp., *Pratylenchus* sp., and *Tylenchorhynchus* spp. The most important are *H. erythrinae, H. oryzeae, Hoplolaimus,* and *Tylenchorhynchus. H. oryzeae* is widely distributed and abundant. During feeding it moves in the root system of the host plant and dissolves its cell walls, forming large cavities that affect the efficient functioning of the root system during heavy infestations. The population of this nematode increases with increasing age of the standing crop.

Hoplolaimus sp. occurs in comparatively low numbers. It damages the parenchymatous cells, which retards plant growth. *Tylenchorhynchus* spp., and *H. erythrinae* are widely distributed in Pakistan but have variable populations. They damage mostly the cortex, therefore their feeding has less impact than that of other species. White tip disease of rice caused by *Aphelenchoides besseyi* has not been recorded in Pakistan, but it is widespread elsewhere.

Nematode damage seems to depend on the population, intra- and inter-specific competition, reproductive rates, and environmental factors. Exact losses caused by nematodes in Pakistan's paddy crop are not known.

Rice hispa found on wheat in the Punjab, India

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The rice hispa *Dicladispa armigera* causes considerable damage to rice in parts of Gurdaspur, Amritsar, Hoshiarpur, and Kapurthala districts in Punjab state, India. The insect breeds actively from May to October, then overwinters, probably in the adult stage.

In early March 1978, rice hispa attacked the wheat cultivar WG 357 at the Regional Rice Research Station, Kapurthala. The overall damage was not serious; from 3 to 6 adults/l0 m^2 were recorded. By the end of March, the insect also appeared in the summer rice nursery; 2 to 4 adults/seedling were observed. During the off-season, a limited survey of wild grasses and weeds at the research station showed no rice hispa. A more detailed and extensive survey is needed to establish the insect's overwintering habits.

The finding of rice hispa on wheat is especially significant in the Punjab, where rice and wheat are generally rotated. If the insect can establish on wheat as well as on rice, it may become more serious because food material will be available to it year round. Efforts to grow two crops of rice per year may further accentuate the hispa problem.

A new enemy of *Azolla*

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The aquatic fern *Azolla pinnata* is being recommended for incorporation into rice fields as a natural source of fertilizer. Its cultivation is gaining momentum among rice farmers because of its ability to fix atmospheric nitrogen symbiotically with blue-green algae. *Azolla* is estimated to fix from 30 to 35 kg N/ha within 20 days.

Studies at the College of Agriculture, Vellayani, show that such pests as lepidopterous larvae and snails (gastropoda) are major factors limiting *Azolla* propagation. The phytophagous gastropods damage the fern more severely than the caterpillars do.

The snails feed voraciously on the fern at the edge of the paddy, close to the water surface. They sometimes move to the water just below the floating *Azolla* and devour the fern, but do not feed on rice plants. The pest spreads fairly rapidly.

Phorate (10 G) applied at the recommended dosage of 12.5 kg/ha for insect control also controlled the snails.

Outbreak of rice caseworm and brown planthopper in Madurai, Tamil Nadu, India

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The rice caseworm *Nymphula depunctalis,* previously a minor rice pest in the Periyar Vaigai River Project of Tamil Nadu, assumed major importance in single-cropped areas of Madurai district in December 1977. The high yielding variety IR20 is widely grown in those tracts. The planting season usually begins in September and October. lnfestation was severe in rice that was transplanted later. Patches of cut and scraped leaf surfaces and withered plants were prominent.

The brown planthopper *Nilaparvata lugens,* which was earlier considered a minor pest in that area, has become serious since the introduction of high yielding dwarf varieties such as IR8 and IR20. Infestation was heavy in 1973 and 1974. It was also severe in several parts of Melur and Vellalore in December 1977. The varieties IR20 and Bhavani were infested in the flowering and maturity stages and severely hopperburned. The outbreak may have been caused by the introduction of fertilizer-responsive, high-tillering rice varieties; heavy fertilizer applications; closer plant spacings; and indiscriminate use of pesticides.

A light-trap survey of the abundance and sex ratio of leafhoppers and planthoppers in Egypt

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Leafhoppers and planthoppers were surveyed in rice fields at Kafr-el-Sheikh, northern Egypt, with a light trap operated 2 nights/week throughout 1974–1975. Twelve species of the *Clcadellidae* family, six of *Delphacidae,* and one species each of *Cixiidae* and *Meenoplidae* families were trapped. Considerably more insects were caught in 1975 than in 1974 — 129.4 vs 83.2 *Cicadellidae/* night and 134.6 vs 121.2 *Delphacidae* /night. The highest monthly averages were in June and July for *Empoasca decipiens* and *Macrosteles sexnotatus;* August and September for *Balclutha hortensis, Cicadulina bipunctella zeae, Exitianus taeniaticeps, Balclutha rufofasciata, Neolimnus aegyptiacus,* and *Orosius albicinctus;* and October for *Nephotettix modulatus* and *Recilia schmidtgeni.* The monthly averages for delphacids were highest in September and October.

The sex ratio in the light-trap catches was near equality (44–54% males) in *N. aegyptiacus, Sogatella furcifera, Falctoya aglauros, Matutinus iphias, Perkinsiella insignis,* and *Oliarus frontalis.* But males were more prominent (57–70%) in *E. taeniaticeps, Sogatella vibix,* and *Nisia atrovenosa.* The male catch was much lower (< 40%) in the other species.

The relative abundance and sex ratio of leafhoppers and planthoppers caught in lit trap in rice fields, Kafr-el Sheikh, Egypt, 1974–75.

Family and species	Av. no./night		Peak no./night [a]		Females (av. %) 1974–75
	1974	1975	1974	1975	
Family Cicadellidae					
Balclutha hortensis	40.5	50.6	308.3	258.6	37.6
Cicadulina bipunctella zeae	20.0	36.2	162.3	176.8	34.8
Empoasca decipiens	12.3	30.1	83.3	211.8	23.5
Nephotettix modulatus	6.4	6.6	38.9	46.6	30.2
Macrosteles sexnotatus	1.2	3.1	5.7	21.9	20.0
Exitianus taeniaticeps	1.4	1.6	3.4	6.8	57.3
Recilia schmidtgeni	0.8	0.6	5.0	2.4	34.2
Balclutha rufofasciata	0.3	0.3	1.3	1.3	39.7
Neolimnus aegyptiacus	0.2	0.2	1.0	0.9	43.8
Orosius albicinctus	0.1	0.0	1.0	0.4	14.3
Batrachomorphus signatus	0.0	0.1	0.4	0.7	–
Neoaliturus haematoceps	0.0	0.01	0.0	0.1	–
Total	83.2	129.4	522.7	457.0	–
Family Delphacidae					
Sogatella vibix	108.7	120.7	1,009.1	908.0	64.8
Sogatella furcifera	6.1	7.2	37.1	41.1	53.8
Toya nigeriensis	3.3	3.0	22.1	20.1	38.7
Falctoya aglauros	2.4	2.9	17.5	22.2	49.5
Matutinus iphias	0.4	0.5	2.2	3.7	54.4
Perkinsiella insignis	0.3	0.3	1.6	2.1	46.7
Total	121.2	134.6	1,088.5	997.2	
Family Cixiidae					
Oliarus frontalis	0.7	0.5	2.9	2.7	5 1.6
Family Meenoplidae					
Nisia atrovenosa	0.2	0.2	1.1	0.8	70.2

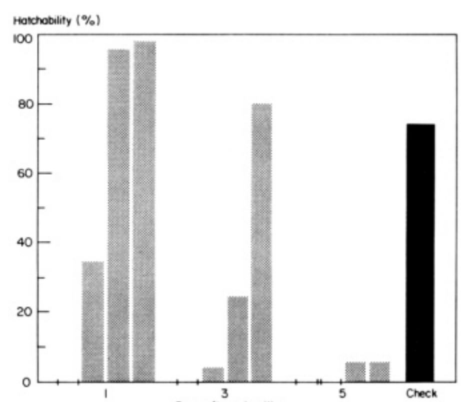
[a]Monthly average.

Ovicidal activity of insecticides for brown planthopper control

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

The brown planthopper (BPH) *Nilaparvata lugens* injects its eggs into the tissues of rice leaf sheaths, making contact with insecticides difficult. Because most insecticides have short residual activity, control of the nymphs that hatch a few days after application is poor. Such nymphs may increase BPH populations after spraying. Consequently, the proper timing of insecticide application is of utmost importance. But before growers can achieve it, they must be trained to monitor BPH populations. Application timing would be less critical if insecticides that act as ovicides (i.e. that cause egg mortality) as well as kill BPH nymphs and adults are used.

The ovicidal activity of several insecticides commonly used for rice pest control was studied at IRRI. BPH were allowed to oviposit on plants for 24 hours. At 1 day after oviposition the plants were sprayed with a 0.04% concentration of the insecticides BPMC,



Comparative hatchability of brown planthopper eggs at different ages when different concentrations of carbofuran are used. IRRI, 1976.

carbofuran, dimethoate, metalkamate, methyl parathion, MIPC, propoxur, and triazophos. Nymphs were removed daily and counted. At 14 days after oviposition, the plants were dissected and the unhatched eggs counted. Carbofuran, triazophos, and methyl parathion reduced egg hatches significantly. No eggs hatched in the carbofuran treatment. Egg hatch was 37% in the triazophos treatment and 61% in methyl parathion. Further studies indicated that insecticide concentration and age of egg at time of application influenced ovicidal activity (see figure). Five-day-old eggs were more susceptible than 1- and 3-day-old eggs. Concentrations of 0.04 and 0.02% had ovicidal activity on 1-day-old eggs, but concentrations of 0.01 and 0.005% had none.

Another study indicated that granular carbofuran, metalkamate, triazophos, and diazinon at 1 kg a.i./ha in paddy water applied to potted plants containing 1-day-old eggs had ovicidal activity. Carbofuran, metalkamate, and triazophos caused 100% egg mortality.

Base vs canopy insecticide spray for brown planthopper control

G. B. Aquino, senior research assistant, and E. A. Heinrichs, entomologist, International Rice Research Institute

Foliar spray is the most common method of applying insecticide for the control of the brown planthopper (BPH) *Nilaparvata lugens* in the tropics. Because the BPH feeds at the base of the plant, Philippine control recommendations specify that the spray be directed toward the base of the plant—a time-consuming and laborious application method for spraying large areas.

Sprays directed to the base and to the canopy of the plant were compared in three IRRI experiments in 1977. In the first 2 experiments, Perthane was 10 to 20% more effective as a base spray than as a canopy spray. In a third experiment, the two methods were compared using metalkamate, monocrotophos, and Perthane. Perthane sprayed at the base of plants controlled BPH significantly better than when sprayed above the canopy (95 vs 63% control) (see table).

Foliar application of insecticides applied above and below the rice canopy for brown planthopper (BPH) control. IRRI, 1977.

Insecticide[a]	BPH (no./4linear-m row)[b] sampled with D-Vac suction machine		
	Before insecticide application (no.)	2 days after application (no.)	Control[c] (%)
		Applied above the rice canopy	
Metalkamate	4,766 a	1,183 a	74
Monocrotophos	8,213 a	3,168 b	60
Perthane	7,342 a	2,589 b	63
No insecticide	6,190 a	5,893 b	5
		Applied below the rice canopy	
Metalkamate	11,241 a	947 a	92
Monocrotophos	6,723 a	2,074 b	69
Perthane	7,521 a	335 a	96
No insecticide	7,805 a	8,811 c	0

[a]Hopper development was induced by foliar application of 30 g a.i. decamethrin/ha starting at 15 days after transplanting. Three applications were made at 750 g a.i./ha. The volume of spray material for both methods was 1,444 liters/ha.
[b]In each column, means followed by a common letter are not significantly different at the 5% level.
[c]Values shown were adjusted using Abbott's formula.

Metalkamate and monocrotophos sprayed at the base controlled BPH slightly—but not significantly—better than when sprayed above the canopy.

In other 1977 IRRI studies, monocrotophos sprayed only on the leaves controlled BPH feeding on the leaf sheaths at the base of the plant. That indicates that some insecticides move downward from the upper leaf area to the leaf sheath. The desirability of spraying below the canopy may depend on the insecticide applied.

Contact toxicity of insecticides to the three biotypes of brown planthopper

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

In recent years the population of biotype 2 of the brown planthopper (BPH) *Nilaparvata lugens* has increased in farmers' fields in Indonesia and the Philippines. Biotype 2 destroys IR26, which carries the *Bph 1* gene for resistance. In IRRI greenhouse experiments another biotype, biotype 3, emerged when BPH were forced to feed on such varieties as IR32 that carry the *bph 2* gene for resistance derived from ASD 7. So far biotype 3 has not become abundant in farmers' fields. It is important to know whether a change in biotype predominance in the natural population will also result in a change in susceptibility to the various insecticides.

Previous studies indicated that of the three biotypes, biotype 1 was generally most susceptible to various insecticides when feeding on rice plants in paddy water treated with granular formulations. In this study the contact toxicity of insecticides to the three biotypes was determined. The insecticides were applied as sprays to the insects using Potter's spray tower.

Results indicated that biotype 1 was least susceptible to the commonly used insecticides carbofuran, metalkamate, diazinon, and methyl parathion (see table). There was no significant difference among biotypes in the decamethrin and acephate treatments. The differences in results from the cited paddy-water study and from the contact toxicity study reported here may be due to different modes of action of the insecticide in the two application methods. Insecticides applied in the paddy water may have acted primarily as a stomach poison, but the insecticides in this study acted as contact poisons, entering through the cuticle rather than the mouthparts. At any rate, knowing that BPH biotypes differ in their susceptibility to insecticides is important and should be considered when developing strategies for BPH control.

Contact toxicity of insecticides applied with Potter's spray tower at 0.04% concentration against three brown planthopper biotypes. IRRI greenhouse, 1977.

Insecticide	Formulation	Mortality[a] (%)		
		Biotype 1	Biotype 2	Biotype 3
Decamethrin	2.5 EC	93 a	97 a	90 a
Carbofuran	2 F	68 b	98 a.	97 a
Metalkamate	30 EC	64 b	99 a	97 a
Acephate	75 SP	37 a	47 a	37 a
Diazinon	20 EC	24 b	49 a	43 a
Methyl parathion	50 EC	11 b	47 a	35 a
Control		6 a	6 a	4 a

[a]Mortality reading taken 48 hours after treatment. Average of 4 replications, each consisting of 25 adult insects. Any means for each biotype followed by a common letter are not significantly different at the 5% level.

Resistance of brown planthopper to various insecticides at IRRI

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

In 1977 carbofuran failed to control the brown planthopper (BPH) *Nilaparvata lugens* at IRRI. Studies using Potter's spray tower and paddy water broadcast methods of application indicated that the strain of BPH that had been exposed to carbofuran for several years (field strain) was resistant (see article, this issue). Further studies using the microapplicator were conducted to compare the field strain's level of resistance to carbofuran and to other insecticides with that of a greenhouse strain that had not been exposed to insecticides.

Both sexes of the field strain had seven times more resistance to carbofuran than the greenhouse strain (see table). The field strain had two to five times more resistance to other insecticides that had been used to varying extents at the IRRI farm. Monocrotophos and MIPC have been most commonly used for about 5 years. There was no resistance to newly developed coded compounds, such as N 3727 and A 47171, that had never been used on the farm.

The LD„ value of insecticides applied topically to greenhouse and field strains[a] of female and maIq brown planthoppers. IRRI laboratory, 1977.

Insecticide	Female			Male		
	LD_{50} (µg/g)		ERR[b]	LD_{50} (dg)		ERR[b]
	Greenhouse strain	Field strain		Greenhouse strain	Field strain	
Carbofuran	0.14	1.05	7.50	0.25	1.78	7.12
Monocrotophos	0.65	3.50	5.38	0.49	2.00	4.08
Metalkamate	1.46	5.37	3.67	2.00	8.68	4.34
Methyl parathion	7.67	23.19	3.02	10.52	13.90	1.32
BPMC	1.95	5.29	2.71	2.89	11.80	4.08
MIPC	1.42	3.29	2.30	5.23	5.59	1.06
Endosulfan	3.09	5.94	1.92	5.12	12.46	2.43
Acephate	2.93	4.96	1.69	3.56	7.79	2.18
N 3727	28.90	32.43	1.12	41.46	43.41	1.04
Perthane	5.13	5.70	1.11	4.45	10.46	2.35
A47171	4.07	4.07	1.00	6.66	5.81	0.87

[a]The greenhouse strain had not been exposed to insecticide and was reared in the greenhouse for about 30 generations. The field strain was reared in the greenhouse for about 4 generations.
[b]Estimated resistance ratio = LD_{50} of field strain divided by LD_{50} of greenhouse strain.

Heavy brown planthopper reinfestations nullify effectiveness of insecticides

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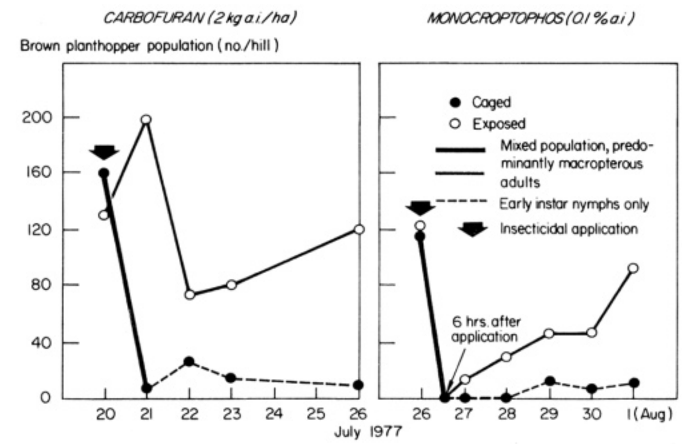
Insecticidal control has often been insufficiently effective against the brown planthopper (BPH) during massive outbreaks over extensive areas. Rapid and heavy reinfestations from unaffected BPH populations probably are a significant reason, particularly where the entire affected area cannot be treated effectively, uniformly, and simultaneously, as is common under normal field conditions. This was especially evident in recent insecticide trials in Sekinchan, Malaysia, during a BPH outbreak on the rice variety MR 7 at 20 to 26 days after transplanting.

Two fields of 2 ha each were treated with *2* kg a.i. carbofuran/ha (granular broadcast) and 0.1% a.i. monocrotophos (foliar), respectively. Immediately after treatment, 10 plants spaced over each field were randomly selected; each plant was individually enclosed with cylindrical wire and nylon screen cages. The BPH populations on these plants were determined just before treatment and periodically afterwards. Similar BPH counts were made on 26 uncaged plants randomly selected in each field.

Except on the uncaged plants treated with carbofuran, the BPH populations on all plants examined were drastically reduced soon after treatment (see figure). That confirms earlier glasshouse findings that both chemicals were highly effective. Monocrotophos acted very rapidly, causing 100% BPH mortality 6 hours after treatment. But 3.6 BPH/hill were still alive on carbofuran-treated plants at 1 day after broadcasting. On plants of both cage treatments, however, 1st-instar nymphs emerged 2 days after treatment, suggesting that BPH eggs were already present and were not affected. Macropterous adults soon reappeared on exposed monocrotophos-treated plants and, like those on exposed carbofuran-treated plants, rapidly increased. The buildups were undoubtedly due to immigrants, as the populations consisted largely of macropterous adults from nearby fields of mature plants. Under such a situation, the fresh BPH influx not only nullifies the potential effectiveness of the applied insecticides but also leads to serious hopperburn (see table).

The findings revealed that 1) heavy immigration of BPH can render potentially effective chemicals ineffective, and 2) hopperburn will ensue when the reinfestation rate exceeds the rate of insecticidal kill, leaving a BPH population that exceeds the economic injury level. Those factors probably contribute to or account for the numerous unsuccessful attempts to control large-scale BPH outbreaks by chemicals in many countries.



Effectiveness of carbofuran and monocrotophos in the control of the brown planthoppers under outbreak condition in Sekinchan, Malaysia.

Plant conditions in a 2-ha rice field (variety MR 7) treated with 2 kg a.i. carbofuran/ha during a brown planthopper outbreak in Sekinchan, Malaysia, 1977.

Date	Plants (%)			
	Green	Slight yellowing	Intense yellowing	Hopperburn
July 1977				
20 [a]	100	0	–	–
21	95	5	–	–
22	95	5	–	–
23	90	10	–	–
26	75	25	–	–
28	70	30	–	–
29	60	40	–	–
30	40	30	30	–
August 1977				
1	15	40	40	5

[a]Broadcast of carbofuran granules.

Spray volumes in relation to brown planthopper control

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The Philippine recommendations for brown planthopper (BPH) *Nilaparvata lugens* control in rice state that 333, 500, and 1,000 liters water/ha are required to spray crops at 15, 35, and 60 days after transplanting (DT), respectively. It is extremely difficult for the applicator to carry this much water over 1 ha of lowland rice. An IRRI Cropping Systems Program survey indicated that most farmers apply only about 135 liters/ha.

Studies were conducted in 1977 to determine the relationship between volume of spray solution applied and BPH control. Perthane was applied at 60 DT. The percentage of BPH control was equal for all volumes from 200 to 1,000 liters/ha (see table). Results in a repeated experiment were similar. Further studies with other insecticides will be conducted before current recommendations are reevaluated.

Effect of spray volumes on the control of the brown planthopper (BPH) on variety IR22. IRRI, 1977 wet season[a]

Treatment 0.75 kg a.i. Perthane/ha at indicated volumes (liters)	Concn (%)	BPH[b] (no./hill)		Control (%)
		Before spraying	4 days after spraying	
200	0.38	911 a	112 a	88
400	0.19	750 a	98 a	87
600	0.13	867 a	66 a	92
800	0.09	673 a	52 a	92
1,000	0.08	820 a	80 a	90
Control (300 liters water)	0.00	908 a	694 b	24

[a]To induce buildup of BPH population, the field was sprayed six times with 25 g a.i. cypermethrin/ha at 10-day intervals.
[b]In a column, any means followed by a common letter are not significantly different at the 5% level.

Pest management and control
WEEDS

Striga root parasite – a problem of dryland rice in the African savanna environment

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Striga species destroyed large tracts of rice in a commercial mechanized scheme for dryland rice at Sirasso, northern Ivory Coast, in October 1976. The most frequent species was *Striga forbesii,* with pink flowers; the least frequent was *S. hermonthica,* with violet flowers.

Large areas of rice were killed by flowering time. There was a gradient where plants were progressively less affected between the killed areas and remnant areas of healthy rice. At the time of rice maturity, the *Striga* was flowering and vigorous in the fringe areas of stunted rice but it had already matured and died in the areas where the rice was destroyed earlier in the season. *Striga* plants beyond affected areas were rare.

All varieties being grown – Moroberekan, Iguape Cateto, IRAT 13 (irradiated short mutant of 63-83), IRAT 8 (Moroberekan 63-105), IRAT 10 (Lung-Sheng 63-104), and a sister line of IRAT 10 - were affected equally.

Striga is a common problem on maize and sorghum in the savanna areas of Africa, and it has previously been casually noted on rice. It now appears that *Striga* is more than just a curiosity in rice and that it can destroy large areas if dryland rice cultivation expands in the savanna.

Mechanized cultivation with combine harvesters might extensively spread the parasite's very small seeds. Experiments are required to determine if control is possible through land management, crop rotation, or herbicides. The extensive area of severe infestation offers the possibility of screening for varietal differences in reaction to *Striga* to determine if rice resistance could be a means of control.

Soil and crop management

Effect of *Azolla* as a green manure crop on rice yields in northeastern Thailand

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Plants of *Azolla pinnata* were collected from a natural habitat in a swampy area in northeast Thailand in the 1977 wet season. They were multiplied in tanks until sufficient stock was produced to seed the experimental plots at an inoculation rate of 312 kg/ha before rice is transplanted. Several treatments were applied to accelerate the growth of *Azolla* in the experimental lots (see table).

Azolla was incorporated into the soil as a green manure at 29 days after inoculation. No *Azolla* was incorporated in the check treatment. The objectives were to find the best method of multiplying *Azolla* in rice fields and to compare the effects of *Azolla* as a green manure with those of chemical fertilizers on the yield of the variety RD 1.

Azolla was remarkably effective; RD1's yield response to it was greater than its response to 37.5 kg inorganic N/ha (see table, treatments 5 and 6).

The extremely sandy soil at the

Effect of *Azolla* on rice yields.

Treatment no.	Treatments		Fresh wt of *Azolla* before planting (kg/ha)	Paddy yield[b] (t/ ha)
	Azolla	Fertilizer[a] (kg/ha)		
1	None	0–30–25	–	2.6 c
2	None	18.75–30–25	–	2.8 c
3	None	37.5–30–25[c]	–	2.9 bc
4	*Azolla* grown without fertilizer, and incorporated before transplanting	0–30–25	794	2.9 bc
5	*Azolla* grown with 30 and 25 kg/ha P_2O_5 and K_2O fertilizer as basal application and incorporated in soil	0–0–0	11,450	3.5 a
6	*Azolla* grown with 30 kg/ha, P_2O_5 split 3 times at 10-day intervals then incorporated in soil	0–0–25	18,919	3.5 a
7	*Azolla* not incorporated in soil but 30 kg/ha P_2O_5, split 3 times at 10-day intervals	0–0–25	18,606	2.6 c

[a]Fertilizer applied to plot on day before transplanting.
[b]Values followed by the same letter are not significantly different at 5% level.
[c]Nitrogen split equally between transplanting and panicle initiation stage.

experimental site seems to favor *Azolla* in two ways. First, fixation of soil phosphorus is negligible, which favors *Azolla* growth, because of low cation exchange capacity. Second, the soil's coarse texture causes rapid nitrogen loss, whereas *Azolla* releases nitrogen slowly. The results suggest that the effect of *Azolla* was more favorable than that of a basal and topdressing nitrogen treatment (which is ordinarily needed when chemical fertilizers are used).

Azotobacter inoculation on rice crop

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Seed or soil inoculation with *Azotobacter* is increasingly being used for higher crop production. Under certain ecological conditions, *Azotobacter* fixes atmospheric nitrogen and makes it available for plant growth. The yield performance of rice inoculated with *Azotobacter* was studied.

A field trial conducted from July to October 1976 used ADT 31; from November 1976 to February 1977 IR20 was used. The treatments were 1) 25:50:50 kg NPK/ha, 2) 25:50:50 kg NPK/ha + *Azotobacter* treatment, 3) 50:50:50 kg NPK/ha, 4) 50:50:50 kg NPK/ha + *Azotobacter* treatment, 5) 75:50:50 kg NPK/ha, 6) 75:50:50 kg NPK/ha +*Azotobacter* treatment, 7) 100:50:50 kg NPK/ha, 8) 100:50:50 kg NPK/ha + *Azotobacter* treatment, 9) *Azotobacter* treatment alone, and 10) the control (no nitrogen or *Azotobacter)*. The paddy seed were treated at the rate of 600 g of *Azotobacter* culture/50 kg of seed, and the seedlings and soil were treated with 1.4 kg and 2.4 kg of *Azotobacter/ha.*

In the first trial, using ADT 31, the grain yield was significantly higher (5.6 t/ha) in the *Azotobacter* inoculation treatment with 75 kg N/ha. The *Azotobacter* application alone gave a yield of 5 t/ha, which is not statistically different from that of 25 kg N alone. During the pishanam season, the maximum grain yield, 5.2 t/ha, was recorded in the plots that received 100:50:50 kg NPK/ha with Azotobacter treatment. The results from both seasons show that *Azotobacter* inoculation will supplement 25 kg N/ha and thus reduce chemical fertilizer application by 25 kg N/ha.

Rice-based cropping systems

Relative abundance of five rice stem borer species on each crop of a triple-rice pattern in Iloilo, Philippines

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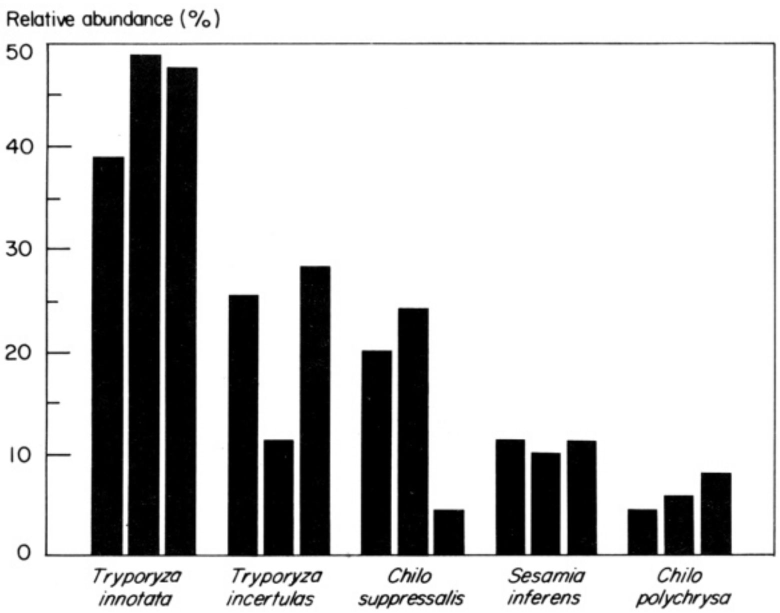
With supplemental irrigation, three rice crops are being grown in low-lying fields of Iloilo, a rainfed-lowland rice area. Stem borer populations for the crop year 1975–76were monitored on each crop (IR28) by dissecting deadhearts and whiteheads. Five species were recorded; the predominant species was the white stem borer *Tryporyza innotata* (see figure). The yellow stem borer *Typolyza incertulas,* second in abundance, was prominent on the first and third crops. The striped stem borer *Chilo suppressalis* was the third most abundant; its numbers declined, however, during the third rice crop. The pink stem borer *Sesamia inferens* was fourth most abundant and the dark-headed stem borer *Chilo polychrysa* was fifth. As current IR rice varieties are only moderately resistant to *C. suppressalis,* stem borer control in Iloilo will have to be based on insecticides.



Relative abundance of five stem borer species on each crop of a triple-rice pattern in Iloilo, Philippines, 1976.

Agronomic evaluation of dry-seeded rice varieties under rainfed-bunded conditions

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The direct or dry-seeding technique of establishing a rice crop increases the production potential of rainfed-bunded rice-based cropping systems. The technology has had a great impact in areas where the rainfall duration is limited and the supply is sufficient to establish only one regular transplanted rice crop for about 2 months after initial wet season rains. A dry-seeded rice crop established during initial rains can still be followed by either an early maturing rice crop or upland crops such as legumes and other cereals. This study was conducted to identify improved rice varieties that are suitable for dry seeding.

Twenty-six IRRI rice cultivars were direct seeded in thoroughly prepared, dry, bunded fields after initial light rains at IRRI on 25 May 1977. Rice seeds at 100 kg/ha were drilled in small furrows made with a lithao (wooden-type furrow opener), spaced at 25 × 25 cm, and covered with soil from the ridges. Soil fertility was maintained by a basal furrow application before seeding of 45-45-45 kg/ha of N, P_2O_5, and K_2O and a side-dressing of 55-0-0 kg/ha at 55 days after seeding (DS). Weeds were adequately controlled by a butachlor spray immediately after planting and two later hand weedings. Azodrin 168 and Gamma Hytox were periodically sprayed and carbofuran granules were broadcast at 65 DS to preclude or minimize insect damage. Hinosan was sprayed at 65 DS to control fungus diseases. There was no supplemental irrigation. Rainwater accumulated in the fields for only a few days after heavy rains during the late vegetative stage and after the heading stage. Thus, prevailing conditions were semi lowland.

IR36 yielded highest (5 t/ha), followed by IR28 and IR2823-399-5-6 (both more than 4 t/ha) (see table). The outstanding cultivars generally tended to be early maturing and to have other good agronomic characteristics: they are relatively short (90–116 cm), nonlodging to slightly lodging, with high tillering ability (at least 400 tillers/sq m), high panicle production (about 400 panicles/sq m), prolific grain production (83 to 130 grains/panicle, at least 70% filled), and dry-grain weight of about 18 to 26 g/1,000 seeds. Lodging appeared to be the factor most difficult to control; lodging due to strong typhoons that occurred during the vegetative stage limited the yields of most rices. Yields would probably have been higher if the relatively late-maturing rices had not lodged.

Yield and agronomic characteristics of 26 dry-seeded rices under rainfed-bunded conditions. IRRI, 1977 wet season.

Designation	Yield[a] (t/ha)	Days[b] to Heading	Days[b] to Maturity	Plant ht (cm)	Lodging rating[c]	Tillers (no./sq m)
IR36	5.01	83	111	90	2	610
IR28	4.38	74	99	100	1	481
IR2823-399-5-6	4.22	95	132	106	3	490
IR4432-52-6-4	3.88	93	121	106	4	462
IR2058-78-1-3-2-3	3.84	90	121	113	4	514
IR4427-119-6-1	3.77	88	115	102	4	483
IR42	3.69	110	134	116	3	531
IR38	3.60	92	120	100	4	582
IR4722-36-1	3.60	93	117	108	4	541
IR1561-228-33	3.54	82	115	93	1	611
IR4432-38-6	3.41	93	120	107	6	440
IR4442-143-2-1	3.27	90	118	116	8	411
IR3941-25-1	3.22	78	106	101	1	655
IR4707-123-3	3.21	85	118	95	4	594
IR4440-165-2-4	3.04	87	124	96	2	517
IR4442-45-2-1	2.98	85	117	98	2	503
IR4227-107-1-3	2.89	94	123	119	6	376
IR2307-217-2-3	2.81	77	103	91	1	593
IR40	2.74	92	118	109	9	569
IR4422-164-3-6	2.74	94	122	116	2	493
IR5201-122-2	2.48	99	130	106	4	386
IR4227-18-3-2	1.93	108	140	138	5	333
IR4613-54-5	1.69	108	139	136	6	2a4
IR4816-70-1	1.47	100	131	127	8	263
IR4608-6-2	0.87	104	132	141	7	285
Mean	3.15	92	122	109	4	478
LSD (.05)	1.26	3	5	7	4	94
CV (%)	24.4	2.0	2.8	3.9	54.9	12

[a] Mean of 3 replications. [b] From seeding. [c] 1 = no lodging; 9 = completely lodging.

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