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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 (glrow).
- 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 IRRI. 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

Inheritance of gamma ray-induced multipistillate mutant in rice

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F_1 seed from the cross NSJ 200/Badshah Pasand at 12% moisture content were irradiated with 25 Kr gamma rays from a 60 Co source. In M_2, four 100% male-sterile and multipistillate plants were observed. Each floret consisted of gynoecium with four ovaries and eight styles. All ovaries were fused together, leaving four conspicuous grooves. However, the number of stamens—six—was normal. Both lemma and palea were narrow and semilunar in shape and could not completely cover the androecium and gynoecium. These multipistillate plants produced a few seed that germinated by outcrossing, but the seedlings were poor. A single seed was produced by each floret, indicating that only one pistil was fertile.

In M_3,30 plant progeny, each consisting of 50 plants, were grown. Six plant progeny segregated into normal and male-sterile multipistillate plants (see table). Of the 300 plants, 16 were male-sterile and multipistillate. Statistical analysis showed that this character is probably governed by duplicate genes (X^2 = 0.4301, P > 0.50 for 15: 1 ratio). The mutation can be explained genetically as follows: Let G_1 and G_2 be duplicate genes, any of which produces normal pistils. When both are homozygous recessive, they produce male-sterile multipistillate plants. The genotype of parents in this case might be $G_1G_1G_2G_2$ and $g_1g_1G_2G_2$. The mutation took place at the G_2 locus, involving one of the two alleles.

Segregation of six rice plant progeny into male sterile multipistillate plants.[a]

Line	Mutants	Normal plants	Total
2	1	49	50
7	3	41	50
9	1	49	50
11	2	48	50
24	5	45	50
28	4	46	50
Total	16	284	300

[a] X^2 (15:1) = 0.4301, P > 0.50

Diffusion of genetic materials among Asian rice breeding programs

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

Although researchers have studied 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 the breeders who made the crosses, IRRI attempted to trace the diffusion of genetic materials used as parents over a 10-year period, from the mid-1 960's through the mid-l970's, at 14 agricultural experiment stations and universities in 7 Asian nations. The breeders represented 7 centers in India, 2 in Korea, and 1 center each in Bangladesh, Indonesia, the Philippines, Sri Lanka, and Thailand. The research project was partially funded by The Rockefeller Foundation.

Three hundred and fifty-five crosses, involving 819 parents, were randomly selected from the breeding records for 3 time periods: 1965–67,1970–71, and 1974–75.The percentages of semidwarf, intermediate-statured, tall, and deep-water or floating rices used during each period were calculated on a cross basis—the percentage of total crosses in which a variety of each plant type was used as a donor parent—and on *an individual-parent basis*—the percentage of different types of rice in the total gene pool.

Sixty-one percent of the 1965–67

Percentages of rices of different plant height used as parents in crosses over a 10-year period. Eight hundred and nineteen parents used in 355 randomly selected crosses at 14 agricultural experiment stations and universities in 7 Asian nations, 1965 through 1975.

Plant ht	Rices used (%)		
	1965–67[a]	1970–71[b]	1974–75[c]
In crosses			
Tall	74	57	45
Intermediate	51	39	35
Semidwarf	61	86	84
Floating/ deep water	2	1	2
As individual parents			
Tall	40	30	24
Intermediate	31	22	17
Semidwarf	28	48	58
Floating/ deep water	1	–	1

[a]277 rice varieties and lines used in 119 crosses.
[b]351 rices used in 147 crosses.
[c]191 rices used in 89 crosses.

crosses involved at least one semidwarf; and by 1974–75, semidwarf involvement had leveled off at 84% (see table). Crosses that involved a tall variety dropped from 74% in 1965–67 to 45% in 1974–75.

The intensity of use of semidwarfs as parents increased more than the percentage of crosses involving a semidwarf. In 1965–67, 28% of the total gene pool was semidwarf, and 40% was tall. Ten years later, the percentage of semidwarf material had almost doubled and that of tall and intermediate-statured materials had dropped sharply. That indicates that breeders were increasingly crossing semidwarf parents with other semidwarfs.

Adequacy and importance of resources among rice breeding programs in Asia

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

A plant breeder is essentially a "genetic architect." The tools that he uses to build new rice varieties include such resources as experimental land, greenhouses, scientific information, and varieties with specific genetic traits to use as parents.

To determine how rice scientists perceive the limitations of such resources, IRRI surveyed 38 rice breeders at 24 research centers in 10 countries as part of a study, initiated in late 1975, of rice breeding in Asia. The project was partial1 partially funded by a research grant from The Rockefeller Foundation.

Each breeder was asked to rate the adequacy of each of 14 resource factors – considered important to rice breeding – on a scale of from one to five (1 = very adequate, 5 = very inadequate). The resources were drawn up by plant scientists from IRRI and from national programs.

The scientists rated "personal freedom to incorporate new breeding materials, techniques, and ideas into the rice improvement program" as the most adequate, with a mean rating of 1.63 (about midway between "adequate" and "very adequate") (see table). "Availability of genetic materials" received the second highest rating (2.03 or "adequate"). "Availability of experimental land" and "availability and quality of field labor" were also rated as

Ratings of adequacy and importance of resources that influence the work of rice breeders. Thirty-eight rice breeders at 24 agricultural experiment stations and universities in 10 Asian nations, 1975.

Resources	Mean rating of adequacy[a]	Importance score	
		Total[b]	Index[c]
Opportunities for specialized training or advanced education for people who work under you	3.08	49	0.32
Availability of genetic materials with specific genetic characteristics	2.03	46	0.30
Personal freedom to incorporate new breeding materials, techniques, and ideas into the rice improvement program	1.63	45	0.30
Opportunity to have breeding lines thoroughly tested under diverse pest and environmental conditions	2.91	38	0.25
Financial support	3.00	37	0.24
Scientific information resources, such as journals, books, and contact with other scientists, to use in your breeding program	2.83	32	0.21
Availability and quality of trained technical help	2.75	32	0.21
Opportunities for specialized training or advanced education	3.27	17	0.11
Opportunity to gain scientific recognition	3.13	15	0.10
Equipment and tools to use in experiments and breeding work	3.08	12	0.08
Opportunities for professional advancement	3.07	11	0.07
Experimental land	2.11	7	0.05
Transportation	3.25	5	0.03
Availability and quality of labor	2.26	2	0.01
Others (specify)	3.43	10	0.07
Av.	2.99		

[a]On a scale of from 1 to 5: 1 = very adequate at this station; 2 = adequate; 3 = intermediate; 4 = inadequate; 5 = very inadequate.
[b]Calculated by assigning a weight of 4 to each factor rated as first in importance by each breeder; 3 to each factor rated second; 2 to each rated third; and 1 to each factor rated fourth. Totals for each factor were then summed. Maximum possible weight per factor was 152 (if all 38 respondents had rated one factor as first in importance).
[c]Calculated by dividing total importance score by maximum possible score per factor (152). 1 = most important; 0 = least important.

fairly adequate (2.11 and 2.26, respectively).

Rated as least adequate among the factors were "opportunities for specialized training or advanced education" (3.27) and "transportation" (3.25). Other resources named by the individual rice breeders were rated as least adequate by four individual breeders (3.43). Of these, "red tape and bureaucracy" was named twice.

Each breeder then ranked the top four resources in terms of importance to the success of a breeding program. Importance scores and indices were then calculated.

Rated as most important was "opportunities for specialized training or advanced education for the people who work under you." It received an importance rating of 49 and an index of 0.32 (see table). The adequacy rating for this resource was 3.08 (intermediate). Second most important was "availability of genetic materials," which breeders had rated as "adequate." Third was "personal freedom," the factor that received the highest average adequacy rating. "Opportunity to have breeding lines thoroughly tested under diverse pest and environmental conditions" was considered fourth most important.

Interestingly, "opportunity to gain scientific recognition" was rated as ninth in importance of the 14 factors, with a mean adequacy rating of 3.13. "Opportunity for professional advancement" was rated as 11 th in importance and received an adequacy rating of 3.07.

Upland rice varieties for rainfed areas of Orissa, India

A. Roy, rice breeder; P. K. Mishra, junior breeder; K. C. Das, agronomist; D. Mishra, junior pathologist; and U. K. Nanda, junior entomologist, All India Coordinated Rice Improvement Project, Chiplima, Orissa, India

A suitable drought-resistant, high yielding rice variety is needed for the rainfed region of Orissa, particularly the southwestern districts, where drought occurs regularly. A few tall, local indica varieties such as Saria (75 days maturity), N 22 (95 days), Dular (95—100 days), and Kalakeri (85 days), are planted on more than 90% of the upland rice area but their yields are low. A few cultivars in the International Upland Rice Observational Nursery (1977) with good drought resistance and resistance to diseases such as bacterial blight and *Helminthosporium* have paved the way toward solving the problem. Promising cultures identified and proposed for multilocational tests during kharif 1978 are presented in the table.

Performance of promising lines from the 1977 International Upland Rice Observational Nursery. Orissa. India.

Cultivar	Drought tolerance[a]	Maturity (days)	Yield (t/ha)	Insect and disease reactions[a]			
				GM	BB	H	SR
IR2307-217-2-3	3	108	2.2	1	3	1	1
IET 3127	1	116	2.2	3	3	1	1
IR2061-522-6-9	3	107	1.8	2	3	3	1
62-355	5	108	2.0	2	5	1	2
IR2061-465-1-5-5	5	107	1.8	2	3	1	1
Dular	3	98	1.8	3	5	3	1
DV110	1	102	1.8	2	5	5	1
IET 1444	3	99	1.8	4	5	1	3
N 22 (check)	3	95	1.5	2	7	1	0
Kalakeri (check)	3	85	1.5	2	5	3	1
Saria (check)	3	75	1.4	2	5	3	1

[a]Standard Evaluation System Scale: 1 = tolerant or resistant; 9 = susceptible. GM = gall midge; BB = bacterial blight; H = Helminthosporium; SR = sheath rot.

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Seed treatment to maintain viability, vigor, and yield potential of stored rice seed

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Rice seed deteriorate significantly under ordinary uncontrolled storage in eastern India, especially during the warm and humid monsoon months from June to September. Studies at the Calcutta University College of Agriculture over the past 5 years have led to the development of a simple and easily practiced soaking-drying method of seed treatment to maintain vigor, viability, and productivity. Before stored seed begin to lose viability (5—10months, depending on ambient conditions), they are soaked in double their volume of water or dilute solutions of sodium phosphate (dibasic, 10^{-4}M) for 5 hours and then dried back to their original weight in the sun or in a current of hot air (36—38°C)in a drying cabinet. The treatment greatly minimized the subsequent deterioration of such seeds when restored under ambient conditions (see table).

With fresh seed, the soaking-drying treatment is ineffective and would even accelerate deterioration when seed are stored for longer periods. But the treatment would break the dormancy of freshly harvested seed of certain cultivars and give more uniform germination of seed that are immediately planted. Treatment of old, deteriorating seed is not advisable. The marginal effects of presowing treatment of stored seeds imply the necessity of maintaining a sufficient time gap between treatment and planting.

Hydration has also been achieved by spraying or dipping the stored seed in water or chemical solutions for a few minutes and then keeping them in shade 2–3 hours before drying. Even equilibrating the moisture of stored seed with a saturated atmosphere (100% RH) for 24 hours, then drying them back, would greatly reduce seed deterioration in subsequent storage. Drying back to the original weight is important; storage of partially dried seed would do more harm than good. Seed that have been treated can be re-treated several months later to further extend their storage life.

The treatments have been effective in all rice cultivars so far studied: Ratna, Jaya, IR8, Pusa 2-21, Mahsuri, Rupsail, Patnai 23, Sitabhog, Dular, and Dhairal. The method could be used to maintain germplasm collections under ordinary storage conditions for a considerable period, and eliminates the need to regrow the genetic stocks each year.

Effect of different physiochemical seed treatments on germination and yield of rice.[a] University of Calcutta, India.

Treatment[b]	Germination[c] (%)	Mean root length after 120 h (mm)	Mean shoot length after 120 h (mm)	Grain yield[d] (t/ha)
Control	68 b	52 b	15 b	4.6 c
Water	88 a	62 a	23 a	6.1 b
Sodium phosphate (dibasic, 10^{-4}M)	91 a	66 a	25 a	6.7 a

[a] In any column, means that are followed by a common letter are not significantly different at the 5% level.
[b] Nine-month-old Ratna seed, which had been stored under ambient conditions (RH 67 ± 11%, temp. 27.1 ± 4ºC), were treated on 22 Aug. 1976 and were subsequently sown in Dec. 1976.
[c] Germination tests were conducted in the laboratory at 28°C before sowing in the seedbed on 21 Dec. 1976.
[d] Yield of crop at 135 days' duration (sowing to transplanting, 40 days; transplanting to harvest, 95 days); differences in field (nursery) emergence of seedlings were eliminated during transplanting.

GENETIC EVALUATION & UTILIZATION

Disease resistance

Varietal reaction to *Podredumbre de la Vaim (Ophiobolus* sp.) in Lambayeque, Peru

Oscar Ojeda Ch. and Alberto Jimenez S. Lambayeque, Peru

Twenty-five-day-old seedlings of the varieties Nylamp, Chicama, Minabir, Inti, IR8, Siam Garden, Mochica, and Chancay were inoculated with a mycelium suspension of *Ophiobolus* sp in such a way that the mycelium was in contact with the sheaths. The plants were then kept in a greenhouse for 2 months. Adequate humidity was provided by irrigating the plants as needed. The presence or absence of typical disease symptoms and fungus structures was then evaluated.

The sheaths of Nylamp, Mochica, and Siam Garden varieties were all infected but Chicama, Minabit, and Chancay had only 25% sheath infection. Inti and IR8 were infected least, suggesting varietal resistance to the disease in Lambayeque state, Peru.

Varietal reaction to kresek infection

T. W. Mew, associate plant pathologist, C. M. Vera Cruz and R. C. Reyes, research aides, International Rice Research Institute

Kresek is normally observed 1 to 4 weeks after transplanting. Adult plants may also be infected if conditions are favorable for the disease and if the variety is susceptible. Under experimental conditions, young seedlings are infected more than older seedlings.

IR8, which has no gene for bacterial blight resistance, and IR1545, which has a recessive gene *(xa5),* were further evaluated for response to kresek infection at different ages. Plants were inoculated by dipping their roots in bacterial suspension for 5 minutes. All IR8 seedlings were infected at ages ranging from 9 to 32 days after seeding (DS). At 9 and 16 DS, IR1545 was as susceptible as IR8. But at 23 DS, 54% of the IR1545 plants were infected with kresek, and at 32 DS, 8% were infected. That indicates that kresek resistance is expressed not only between varieties but also within varieties at different ages.

When IR8, IR20, IR1545, and DV85, which differ in resistance to bacterial blight, were tested for kresek infection by the root-dipping method of inoculation with Pxo82, DV85 was infected less than the others. IR8, IR20, and IR1545 also differed in response to kresek at different inoculum concentrations.

Fourteen varieties were then evaluated in the greenhouse and in the field for kresek reaction against two isolates, Pxo61 and Pxo82. The varieties varied in reaction to the two isolates. In addition, the reactions of Ketan Lumba, Lakshini Lumba, IR8 (susceptible check), and India Dular (resistant check) to the three Philippine pathotypes of *X. oryzae* for leaf blight indicated that their kresek reactions did not correlate with their leaf blight reactions.

On the basis of overall reaction to the two isolates in the greenhouse, India Dular was ranked as most resistant; the susceptible check IR8 ranked 13th of the 14 varieties. In the field test with the same inoculation method, India Dular was most resistant and IR8, most susceptible. Plants were scored at 21 days after inoculation in the greenhouse and at 6 weeks in the field.

Scoring for varietal resistance to kresek

T. W. Mew, associate plant pathologist, C. M. Vera Cruz and R. C. Reyes, research aides, International Rice Research Institute

Because kresek is a systemic infection of bacterial blight, the scoring of infection at a certain time after inoculation should be standardized. In a preliminary greenhouse test, the percentage of kresek development was found to climax 3 to 4 weeks after inoculation by the root-dipping method. Experiments using IR8 were thus designed to determine the proper number of plants to serve as bases for varietal testing and screening, and the optimal number of days after inoculation for scoring. Obviously, the higher the number of plants, the lower the coefficient of variation obtained on the basis of estimated standard error of the means. This holds true for the prolonged duration of infection after inoculation. For practical purposes, from 60 to 80 plants scored at any time from 21 to 24 days (C.V. = 13%) after inoculation seem adequate for greenhouse tests. In the field, a proper base is 100 hills/variety scored at the 5th week after artificial inoculation and transplanting.

Reaction of wild rice species to sheath blight

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Ten strains of wild species were raised in mud pots and inoculated with the sheath blight pathogen *Rhizoctonia solani* by the straw bit method. Their disease reactions were observed and recorded. *Oryza australiensis* and *O. nivara* were highly susceptible to the disease but *O. rufipogon* and *O. barthii* were resistant. The other wild rices were susceptible.

Nira, a brown planthopper-resistant variety

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During 1976 kharif and rabi, and 1977 kharif, the resistance to brown planthopper and stem borer of 844 bulk progenies, 804 single-plant selections, 988 germplasm entries, and 62 varieties were evaluated in the laboratory and in the field.

From 30 to 40 seeds of each rice strain screened were sown in 20-cm-long rows in wooden boxes. A susceptible check, Taichung Native 1 (TN1), was planted as a border. At 1 week after sowing, the wooden boxes were transferred to a galvanized iron tray filled with water. Brown planthoppers that had been raised on TN1 were transferred to the seedlings. (The original source of the hoppers was a collection

Reaction of varieties to brown planthopper in the laboratory. Tamil Nadu Agricultural University, India.

Designation	Origin	Damage rating[a]
Nira	USA	0
Aruvatham chormali	Malabar	1
Thone-lone-lon B.20	Burma	1
Morada	South Canara	1
Co 10	Tamil Nadu	1
ASD 11	Tamil Nadu	1
Arupatham Kuruvai	Coimbatore	3
Kuruvai kalyan	Tirunelveli	3
Moshanam	Chinglepet	3
Mutha samba	South Arcot	3
Velan samba	South Arcot	3
Ptb 15	Kerala	3
Ratna chooda	Ganjam	3
Gurida Akkalu	Ganjam	3
Menthi Bayahenda	Ganjam	3
Chennagi	Bellary	3
Seera Samba wild paddy	Sri Lanka	3
Bing Yang Chao	China	3
Changalisein	China	3
Itach-huning	China	3
Talichao	China	3
Glutinous variety	Burma	3

[a] On a scale of 1 to 9: 0 = immune; 9 = very susceptible.

made at Gobichettipalayam, Coimbatore.) When all TN1 seedlings were dead, the test seedlings were rated on a scale of 0 to 9 (0 = immune; 9 = very susceptible). Those whose grades were 3 or less are listed in the table.

Nira's rating was 0; further field tests in 1977 kharif and rabi confirmed the rating. Nira was not affected at all when caged with the insects.

Discontinuous variation in virulence of *Xanthomonas oryzae*

T. W. Mew, associate plant pathologist, International Rice Research Institute

We proposed a scheme, based on host-parasite interactions, to detect continuous and discontinuous variations in virulence of *Xanthomonas oryzae* on resistant rice. Figure 1 shows continuous variation in virulence among the isolates with no specificity in infection.

Results with the Philippine isolates and selected varieties with specific genes for resistance indicate that Pxo6l causes some lesions on varieties differing in specific resistance, yet it is more compatible with IR8, i.e. it produces larger lesions on varieties that have no functional genes for resistance in the Philippines. Likewise, Pxo79 causes more lesions on varieties with no functional genes and with the dominant gene *Xa4* for resistance. But Pxo71 is more specific to varieties with no functional gene and to varieties with the recessive gene *xa5* for resistance. DV85, which has two genes for resistance, is resistant to all of those isolates; however, Pxo71 always seems to produce longer lesions than the two other isolates on that variety. (That may indicate the aggressiveness of the isolate. Analysis of variance suggested the interaction effect (V × I) was highly significant.) The relative reaction among the selected differentials varied from one isolate to another. When the differential varieties were inoculated at different ages with these isolates, differential interactions between the isolates and the varieties were observed, showing specificity in infection between isolates and compatible varieties.

Rice varieties tolerant of root-knot nematode in rainfed areas

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Root-knot nematodes were observed on rainfed rice at the Ubon Rice Experiment Station, northeastern Thailand. The major soil texture of this predominantly rainfed rice region is sandy loam. Average annual rainfall is 1,500 mm. Five genera of nematodes were identified; *Meloidogyne,* which was very active in the rice field, was the major genus.

Of 64 varieties screened for tolerance, 22 were found promising (from 4 to 25% root-knot infestation) (see table). Crop growth on those rices was normal.

Varieties will be inoculated with nematode egg mass in further trials, both in fields and in pots.

Promising varieties with tolerance for root-knot nematode. Ubon Rice Experiment Station, Thailand.

Variety	Knot-formation (%)	Maturity (days)	Origin
RD6	4	144	Thailand
Burma Acc. 24161	5	not harvested	Burma
RD69 NF U-G-25	5	111	Thailand
Burma Acc. 24160	7	not harvested	Burma
Hawm Dong PMI 72–22	9	144	Thailand
147/54	10	111	Egypt
IR2071-636-5-5	15	111	IRRI
Hawm Dong PMI 72–40	15	144	Thailand
Amo1/1–82	16		Egypt
KDML'65 G_1 U-45	18	144	Thailand
RD2	18	125	Thailand
219/54	18	111	Egypt
IAC 1246	19	112	Brazil
RD7	20	111	Thailand
RD4	21	125	Thailand
158/54	21	111	Egypt
IR36	22	111	IRRI
IET4094	24	111	India
RD9	24	111	Thailand
Amol 1–78	25	111	Egypt
IR2061-465-1-5-5	25	112	IRRI
IR2071-625-1-252	25	112	IRRI

Effect of plant and leaf age on susceptibility to bacterial blight

T. W. Mew, associate plant pathologist, C. M. Vera Cruz and R. C. Reyes, research aides, International Rice Research Institute

Rice plants are generally thought to be more susceptible to bacterial blight infection at the seedling than at the adult stage, and also to vary in resistance at different leaf ages. A variety's resistance or susceptibility to specific isolates appears independent of plant age but dependent on compatibility of host variety and isolate. Four varieties, IR8, IR20, IR1545, and DV85, were tested for resistance to the isolate Pxo82 at 9 to 37 days after seeding (DS). Pxo82 overcame the resistance of IR20 (Xa4) and IR8; the two varieties had long lesions that resulted in more infection at the seedling stage than IR1545 and DV85, which are resistant to Pxo82. Although lesions on those two varieties were longer at 9 than at 16 DS, their overall disease reactions at 9 DS were moderately resistant to resistant.

When individual leaves ranging from young to old were analyzed, significant interactions were noted among varieties but not among isolates. The interactions between varieties and isolates, however, were significant. When varietal resistance is evaluated with specific isolates, the leaf position at scoring may affect the reaction. On this basis, the varieties IR8, IR1545, DV85, and RP291-20 were consistently resistant or susceptible to bacterial blight, while IR20 and Cempo Selak varied in reaction. There was no longer any significant interaction with leaf positions within each group. Larger differences in leaf position were detected among varieties of the latter than among those of the former group.

Pest management and control

DISEASES

Transmission of rice ragged stunt disease by *Nilaparvata lugens* in Japan

T. Senboku and E. Shikata, University of Hokkaido, Japan, and E. R. Tiongco and K. C. Ling, International Rice Research Institute

The transmission of rice ragged stunt disease by the brown planthopper *Nilaparvata lugens* that had been reared on rice plants in Sapporo, Japan, for 4 years was studied. After 1-day acquisition feeding on diseased plants of the line IR3839-1, infected in the Philippines, 50 brown planthoppers (BPH) were tested for infectivity by daily serial transmission to 1,270 seedlings of the variety Mihonishiki for 40 consecutive days (except when insects died earlier). The experiment was carried out in a temperature-controlled greenhouse (25–28°C) at the University of Hokkaido, Japan.

Twenty-eight percent of the tested BPH were active transmitters. Both female and male adults and both brachypterous and macropterous forms were able to transmit the disease. The latent period ranged from 5 to 11 days after acquisition feeding, averaging 8.6 days. The infective insects transmitted the disease to 1 to 31 or more seedlings during their life spans. The retention period ranged from 9 to 41 days or more, after acquisition feeding (some insects did not die on the last day of the transmission test, 41 days after acquisition feeding). The disease-transmitting days were from 33 to 100% (av. 81%) of the period from the time the insects became infective until the end of the transmission test.

The BPH in Japan did not differ strikingly from the BPH in the Philippines in either percentage of active transmitters or latent period. But they infected more rice seedlings during their life spans, had longer retention periods, and had higher percentages of disease-transmitting days than the Philippine BPH tested at IRRI.

Further studies will be conducted to determine if the differences are due to ecotype of the insect or conditions of the transmission test.

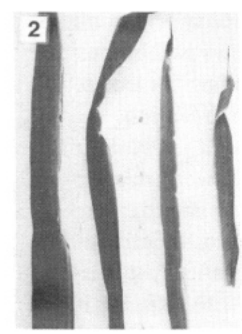
Host range of rice ragged stunt virus

K. C. Ling, plant pathologist, E. R. Tiongco, senior research assistant, and V. M. Aguiero, research assistant, International Rice Research Institute

Plants of several rice species were inoculated by brown planthopper *Nilaparvata lugens* that were viruliferous for ragged stunt disease. Most of the plants did not become infected. Among *Oryza* species, however, *O. sativa, O. latifolia,* and *O. nivara* were all infected. The infected plants of *O. latifolia* (Fig. 1, 2) and *O. nivara* (Fig. 3) showed symptoms of stunting, ragged leaves, vein swellings, and nodal branches. Those symptoms are similar to the ones on infected *O. sativa.*

Brown planthoppers recovered the virus from the diseased plants of *O. latifolia* and *O. nivara* and transmitted it successfully to rice plants.

Consequently, *O. sativa* is not the only host of ragged stunt.



1. An *O. latifolia* plant infected with ragged stunt.

2. Ragged leaves of a diseased *O. latifolia* plant.

3. Healthy plants of *O. nivara* (left) and plants infected with ragged stunt (right).

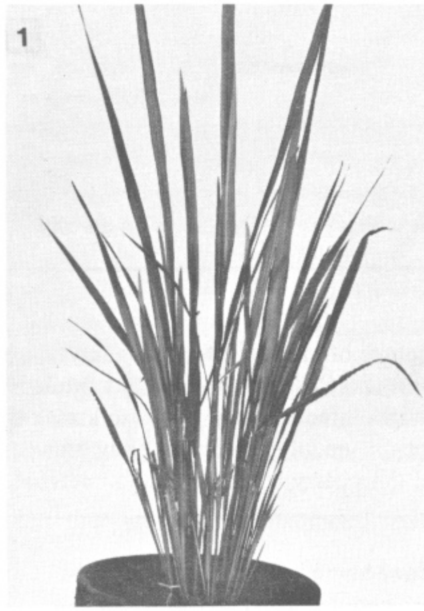
Dual infection of plants with ragged stunt and other virus diseases

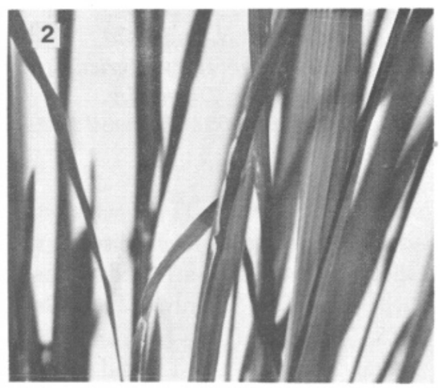
K. C. Ling, plant pathologist, E. R. Tiongco, senior research assistant, and V. M. Aguiero, research assistant, International Rice Research Institute

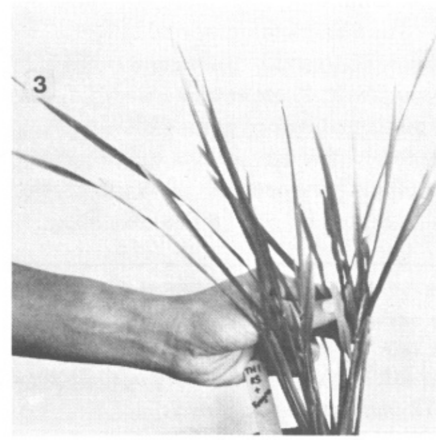
In the Philippines, there are five virus and virus-like diseases of rice plants – grassy stunt, orange leaf, ragged stunt, tungro, and yellow dwarf (orange leaf and yellow dwarf are of minor importance). Rice plants can be infected with both tungro and grassy stunt. Therefore, dual infection of ragged stunt and grassy stunt or ragged stunt and tungro was studied by inoculating seedlings of TN1 with the respective viruliferous insects in the greenhouse.

Rice plants were infected with both grassy stunt and ragged stunt (Fig. 1, 2). The dually infected plants had the symptoms of both grassy stunt (profuse tillering and narrow leaf blades) and ragged stunt (ragged leaves). They were much more stunted, particularly at later growth stages. The tips of some leaves were twisted.

Rice plants were also infected with both tungro and ragged stunt (Fig. 3). The infected plants showed stunting, yellowing of leaves (a tungro symptom), and ragged leaves (ragged stunt symptom).







1. A rice plant infected with both ragged stunt and grassy stunt.

2. Close-up of the dually infected plant, showing ragged leaves.

3. A rice plant infected with both ragged stunt and tungro.

The dual infection indicates absence of cross protection either between ragged stunt and grassy stunt or between ragged stunt and tungro. Hence, the causal agent of ragged stunt is not closely related to the causal agent of grassy stunt or of tungro.

A study of vein-swellings of rice plants infected with ragged stunt

P. Q. Cabauatan, research aide, and K. C. Ling, plant pathologist, International Rice Research Institute

One symptom of rice ragged stunt disease is the appearance of narrow, elongated swellings of veins, a result of proliferation of phloem cells in vascular bundles. *Vein-swelling* seems to be a more appropriate term than *gall* to describe that symptom. Galls have been defined as large swellings on plant tissues caused by the invasion of parasites such as fungi and bacteria, or as excrescences of plants caused by fungi, mites, or insects. The definitions imply that the causal agent or parasite is localized in or restricted to the galls. That does not hold true for malformations due to the systemic infection of a virus, because the virus also spreads to other plant parts. Therefore, it has been suggested that virus-induced abnormalities be classified as enations or tumors rather than as galls. For ragged stunt disease, vein-swelling is preferred because it is both specific and descriptive.

When 60 rice varieties and lines that had been naturally infected with ragged stunt were examined at or after the late tillering stage, all had vein-swellings. Of the 170 diseased hills examined, 96% had vein-swellings. Not every diseased hill of some rices had vein-swellings. For instance, only about 50% of diseased hills of Raminad strain 3 had them. Nor did every tiller in a diseased hill have vein-swellings. Of the 794 tillers of diseased plants of 18 rices examined, 66% had them. The percentage of tillers with vein-swellings seemed to increase as the plants grew older.

The vein-swellings appeared on leaf sheaths, blades, and culms at varying frequencies. Of the 1,006 vein swellings examined, 72% appeared on the leaf sheath, 21% on the blades, and 7% on the culms. The vein-swellings were not distributed evenly on the leaf sheaths, nor on the blades. About 90% of those on the leaf sheaths appeared on the upper half. About 60% of those on the leaf blades were on the lower half, most near the collar.

The vein-swellings were on the outer surfaces of leaf sheaths or on the lower surfaces of blades. None were observed on the opposite sides, possibly because of the location of phloem cells in the tissue and of the swelling due to their proliferation.

The vein-swellings varied in width from 0.2 to about 1 mm, and in length from about 1 mm to more than 10 cm. The number varied among tillers and varieties. The average was 4.3 vein-swellings/tiller among the 794 tillers of 42 diseased hills of 18 rices examined.

Of the 1,099 vein-swellings examined, 82% were white or pale yellow; 2%, light brown; 6%, dark brown; and 10%, mixed (one portion pale yellow, the other, brown). The colors seemed to remain unchanged until the death of the rice plants.

The vein-swellings appeared on both leaf sheaths and blades of artificially infected plants at about 3 weeks after inoculation.

Although vein-swellings are less conspicuous than other symptoms of ragged stunt disease – ragged or twisted leaves and malformed or twisted flag leaves – they appeared fairly consistently on the diseased plants, particularly during later growth.

A new medium for multiplication of sheath blight pathogen *Rhizoctonia solani (Thanatephorus cucumeris)*

S. Kannaiyan and N. N. Prasad, Microbiology Laboratory, Agriculture College, Annamalai University, Annamalai nagar 608101, Tamil Nadu, India

A new rice sand medium was developed for multiplication of *R. solani* to infect rice through soil inoculation at the seedling stage. Two hundred grams of well-sieved river sand was put in 250-ml Erlenmeyer flasks and 40 ml of tap water was added. Rice grains at 1 to 5% levels were added, sterilized at 15 psi for 1 hour, and inoculated with a single *R. solani* sclerotium. The incorporation of rice grains at 5% level was optimum to obtain maximum mycelial growth and sclerotial production. By the 7th day maximum mycelial growth and sclerotial production had been attained. The rice sand medium was used at an inoculum level of 25% to artificially induce rice seedling infection.

Relationships involved in the bacterial blight syndrome

T. W. Mew, associate plant pathologist, International Rice Research Institute

The bacterial blight syndrome in the tropics has three types of symptoms: leaf blight, kresek, and pale yellow symptoms. The kresek and leaf blight symptoms are distinct and independent of each other (i.e. individual plants may be infected by either kresek or leaf blight). The kresek-infected plants may serve as a source of inoculum for secondary infection leading to leaf blight, while leaf blight infection may turn into kresek if plants are infected during early growth or if the variety is susceptible to bacterial blight. That indicates that kresek and leaf blight result from the primary effect of infection. Pale yellow is a secondary effect that results from either leaf blight or kresek infection.

Seed-borne nature of sheath blight pathogen *Rhizoctonia solani* in rice

S. Kannaiyan and N. N. Prasad, Microbiology Laboratory, Agriculture College, Annamalai University, Annamalai nagar 608101, Tamil Nadu, India

Seed of the variety ADT 3 1, which is susceptible to sheath blight disease, were collected from a crop affected by sheath blight during 1975 kuruvai (June-Sept), 1975–76 thaladi (Oct–Jan), and 1976 navarai (Feb–May), and tested for the presence of *R. solani.* The presence of the pathogen in seed planted in Dixon Agar medium indicated its seed-borne nature. Isolation of the fungus from seeds ranged from 4 to 6.6%. Seed collected in the thaladi had the highest infection (6.6%) followed by those in navarai (5%) and kuruvai (4%).

Effect of different soil types on rice seedling infection caused by *Rhizoctonia solani*

S. Kannaiyan and N. N. Prasad, Microbiology Laboratory, Agriculture College, Annamalai University, Annamalai nagar 6081 01, Tamil Nadu, India

Seedlings of ADT 31, which is susceptible to sheath blight infection caused by *Rhizoctonia solani,* were raised in pots filled with soils of various types: red, clay, sandy loam, laterite, alluvial, black, and sandy. The sheath blight pathogen was multiplied in a rice sand medium and inoculated at the 25% level.

Seedling infection was less in sandy soil (29.3%) and black soil (40%). The maximum seedling infection was recorded in clay soil (78.6%) followed by that in red, alluvial, laterite, and sandy loam soils.

Preliminary observations of brown spot and its control in rice in Peru

Alberto Jimenez S., Carlos Panizo S., Victorio Garcia V., and Jose Senmache S., Lambayeque, Peru

During the 1976-77 rice season severe brown spot symptoms, similar to those caused by *Helminthosporium oryzae,* were observed in the variety Nylamp planted at several sites in Lambayeque.

A fungus was isolated from diseased leaves. The mycelium was cream-colored and produced spore-like structures. The isolate failed to sporulate in a medium that was appropriate for *H. oryzae.*

From the nature of lesions and the failure of the mycelium to sporulate, the symptoms observed on Nylamp seem to have been caused by a fungus belonging to the *Dematracea* group, similar to *H. oryzae.*

Pest management and control
INSECTS

Natural enemies of brown planthopper and green leafhopper in India

T. M. Manjunath, P. S. Rai, and Gavi Gowda, University of Agricultural Sciences, Regional Research Station, V.C. Farm, Mandya, Karnataka, India

Severe infestations of the rice brown planthopper (BPH) *Nilaparvata lugens* and green leafhopper (GLH) *Nephotettix nigropictus* occurred in several localities in Mandya, Karnataka, during the summer (Jan.–May) and kharif (May–Dec.) paddy seasons of 1976. Hoppers at all growth stages were collected and separated into cages. The predators found in association with them were placed in cages with the hoppers and their feeding on them was observed. The natural enemies listed below were common to the BPH and GLH.

EGG PARASITES

- Hymenoptera
  - Trichogrammatidae — *Oligosita* sp.

NYMPHAL/ADULT PARASITES

- Hymenoptera
  - Dryinidae — *Echthrodelphax fairchildii* Fallen; *Haplogonatopus* sp.

PREDATORS

- Coleoptera
  - Coccinellidae — *Coccinella arcuata* F.
- Hemiptera
  - Anthocoridae — *Amphiaraeus constrictus* Stal. *(hulvescens Walk.)*
  - Miridae — *Cyrtorhinus lividipennis Reuter*; *Tytthus parviceps Reuter*
- Hymenoptera
  - Formicidae — *Camponotus* sp. 1; *Camponotus* sp. 2 *(fulvomarginatus group)*

PATHOGEN

- Entomopthorales
  - Entomopthoraceae — *Entomopthora sp.*
- Amphibia
  - Anura, Ranidae — *Rana limnocaris limnocaris Wieg.*

A few individuals of three Scelionid species, *Baeus, Gryon,* and *Oxyscelio* sp., also emerged in the tubes containing portions of leafsheaths bearing BPH and GLH eggs, but their exact status will have to be confirmed. Three unidentified species of spiders were also common in rice fields.

C. lividipennis was the most important predator. The dryinids gave up to 51 % parasitism of BPH. Studies on the bioecology of these natural enemies are in progress.

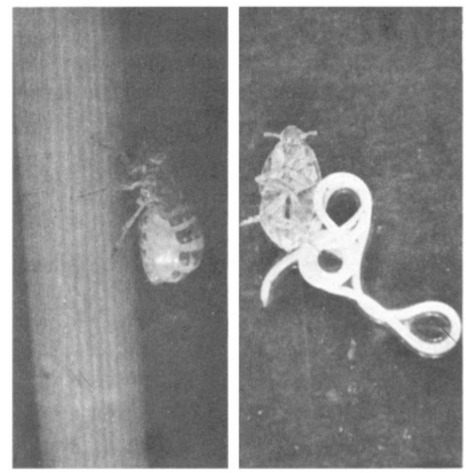
The authors are grateful to the Director, Commonwealth Institute of Entomology, London, for identification of the specimens.

Two nematode parasites of rice brown Planthopper in India

T. M. Manjunath, junior entomologist, All India Coordinated Rice Improvement Project (AICRIP), University of Agricultural Sciences, Regional Research Station, C.D. Farm, Mandya, Karnataka, India

Several natural enemies of the rice brown planthopper (BPH) *Nilaparvata lugens* have recently been reported in India. While continuing the survey, the author recorded two more nematode species as parasites. Both belong to the genus *Hexamermis* of the family *Mermithidae.*

One nematode was minute (about 0.50 mm long) and scarce; it was reared on only three planthopper adults. More than 100 juveniles emerged from a single host. The other nematode, a Mermithid, was fairly large and common. The parasitized host had a greatly distended abdomen (Fig. 1) and fell on the ground before the parasite emerged. Only one nematode emerged from a single host (Fig. 2). Fifteen freshly emerged juvenile nematodes had an average length of 4.84 mm (range, 4.20 to 5.90 mm) and an average width of 0.308 mm (0.286 to 0.315 mm). The nematode was reared from both brachypterous and macropterous males and females, but field parasitism of brachypterous females was consistently higher than that of other forms (see table).



1. A brown planthopper (brachypterous female) parasitized by a Mermithid.
2. The nematode that has just emerged from brown planthopper.

Parasitism of brown planthopper[a] (BPH) by a Mermithid. Karnataka, India, 1977.

Month	BPH examined (no.)					Parasitism (%)				
	Females		Males		Total	Females		Males		Total
	B	M	B	M		B	M	B	M	
October (2nd half)	70	43	6	32	151	12.9	4.6	0	3.1	8.0
November	94	115	20	53	282	33.0	10.4	15.0	9.4	18.1
December (1 st week)	15	25	0	20	60	33.3	12.0	0	10.0	16.7

[a]B = Brachypterous form; m = macropterous form.

To estimate field parasitism by the nematode, weekly collections of BPH infesting paddy were made. About half of the BPH collected were dissected; the others were reared in the laboratory. The table shows parasitism.

This Mermithid was also reared from field collected *Sogatella furcifera* and *Nephotettix nigropictus.*

The Mirid *Cyrtorhinus lividipennis,* an important predator of the BPH, was parasitized by another Mermithid which may represent a new genus. However, it was scarce.

The author is grateful to Dr. G. O. Poiner, Jr., Invertebrate Pathologist, University of California, Berkeley, California, U.S.A., for identifying the nematodes. Specific identification was not possible as only juvenile, no adult, nematodes were obtained.

Occurrence of brown planthopper on rice in West Bengal, India

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

In West Bengal, the brown planthopper (BPH) *Nilapavata lugens* was first noted as a serious pest of summer (boro) rice in 1973 at Khanakul, Hooghly district. Epidemics of the pest have since appeared regularly in ever-larger areas. Recently the infestation has spread to other rice-growing areas of West Bengal, particularly river and coastal belts. The BPH has also been recorded on main winter (kharif or aman) rice, but there damage is less.

The main rice-growing area of Khanakul is low-lying and basinlike; water from two rivers and a number of drainage channels are impounded there. Summer rice is the main crop because land is submerged from July to November. The initial attack is by immigrant macropterous insects, which produce both macropterous and brachypterous forms, during late February and March. Hopperburn is noticed in April. The pest disappears in mid-May, at the time of rice harvest. All the high yielding photoperiod-insensitive rice varieties are attacked. But some local rice varieties of lower yield potential that are transplanted earlier escape damage.

Populations of leafhoppers and planthoppers in Egypt from 1973 to 1975, as indicated by sweep-net samples

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Samples of leafhoppers and planthoppers were taken weekly with a sweep net (1 00 double strokes/sample) throughout the April to November rice-growing seasons from 1973 to 1975 at Kafr-el-Sheikh, Egypt. Eight cicadellid species, six delphacids, and only one cixiid were found. But two dominant species were caught in great numbers - *Balclutha hortensis* and *SogateIla vibix.* Next in abundance were *Nephotettix modulatus* and *Sogatella furcifera* (see table).

The number of leafhoppers and planthoppers increased gradually from year to year. In the three successive seasons of 1973, 1974, and 1975, cicadellids averaged 44.5, 258.6, and 929.5 insects/100 strokes, respectively; delphacids, 17.3, 271.4, and 623.1/100 strokes. In 1973, populations of most cicadellids peaked in July and August; in 1974 and 1975, they peaked in October and November. Populations of all the delphacid species, however, peaked in October and November in the 3 sampling years.

The average sex ratio of various species from 1973 to 1975 was near equality

Population density and sex ratio of leafhoppers and planthoppers in sweep-net samples taken weekly throughout the rice-growing season (Apr.–Nov.)at Kafr-el-Sheikh, Egypt, 1973 to 1975.

Family and species	Mean no./100 strokes			Peak no./100 strokes[a]			Males
	1973	1974	1975	1973	1974	1975	(av %)
FAMILY CICADELLIDAE							
Balclutha hortensis	18.7	238.7	875.4	32.8	807.0	2955.2	46.3
Nephotettix modulatus	6.3	3.2	42.0	14.4	13.8	166.4	54.1
Cicadulina bipunctella zeae	9.5	14.7	6.5	19.5	43.3	19.3	46.8
Empoasca decipiens	3.6	0.8	2.8	10.3	3.0	13.8	43.7
Macrosteles sexnotatus	5.5	0.7	1.0	16.0	2.0	3.8	28.7
Exitianus taeniaticeps	0.9	0.5	1.3	2.8	1.5	7.3	62.8
Recilia schmidtgeni	0.0	0.0	0.6	–	–	2.7	–
Neoaliturus haematoceps	0.0	0.1	0.0	0.0	0.2	0.0	–
Total	44.5	258.6	929.5	86.0	853.0	3136.8	–
FAMILY DELPHACIDAE							
Sogatella vibix	12.8	250.0	593.5	24.0	1400.0	2507.2	54.5
Sogatella furcifera	3.1	19.3	26.6	9.5	116.0	124.4	55.2
Toya nigeriensis	0.9	0.8	2.0	5.0	4.0	5.3	47.9
Falctoya aglauros	0.4	1.3	0.8	3.0	6.0	2.0	75.4
Matutinus iphias	0.0	0.1	0.2	–	–	–	–
Dopidocephala elegans	0.0	0.0	0.2	–	–	–	–
Total	17.3	271.4	623.1	41.5	1526.0	2638.0	–
FAMILY CIXIIDAE							
Oliarus frontalis	0.0	0.1	0.1	0.0	2.0	3.0	75.0

[a]Monthly average.

(44–55% males) in most species, but it was far from equality in *Macrosteles sexnotatus* (29% males), *Exitianus taeniaticeps* (63% males), and *Falctoya aglauros,* and *Oliarus frontalis* (75% males each).

Control of rice thrips *Baliothrips biformis* with seedling root dip treatments

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An experiment conducted at the Paddy Breeding Station, Coimbatore, in kharif 1976 evaluated the effectiveness of selected insecticides as root-dip treatment for controlling pests in newly transplanted rice. The trial was laid out with four insecticides – chlorpyriphos, chlorfenvinphos, dimethoate, and leptophos – at different concentrations and exposure times in a randomized design replicated four times, and compared with an untreated control. The seedling roots were kept in the insecticide solutions for specified times before transplanting. Pests such as thrips, whorl maggots, and stem borers on five random plants per replication were recorded at 15,30, and 45 days after transplanting (DT).

All the insecticides significantly reduced thrip incidence at 15 DT. Chlorpyriphos at 0.04% for 4 hours was best, followed by dimethoate at 0.02% for 4 hours, and chlorfenvinphos at 0.02% for 4 hours. The whorl maggot was noticed only at 30 DT, but the incidence was low. However, the incidence was minimum in the chlorfenvinphos 0.02% treatment for 4 hours. In all treatments, stem borer incidence was less than that in the control at 30 DT, but increased by 45 DT. Although not extremely effective, seedling root dip with chlorpyriphos 0.04% or dimethoate 0.02% for 4 hours can be used to control thrips in the early transplanted crop.

Percentage of leaves affected by thrips at 15 days after transplanting. Coimbatore, India.

Chemical concn (%)	Exposure time (h)	Leaves (%) affected[a]
Chlorpyriphos 20 EC		
0.02	2	14.6
0.02	4	13.9
0.02	12	13.9
0.04	2	12.1
0.4	4	9.6
Chlorfenvinphos 24 EC		
0.02	2	17.3
0.02	4	10.1
0.02	12	14.9
0.04	2	15.2
0.04	4	17.5
Dimethoate 30 EC		
0.02	2	21.5
0.02	4	7.8
0.02	12	13.1
0.04	2	12.8
0.4	4	11.2
Leptophos 35 EC		
0.02	2	10.4
0.02	4	13.0
0.02	12	20.2
0.4	2	17.2
0.04	4	14.9
Control		36.1

[a]S.E. = 2.93%; C.D. = 8.64%. Average of four replications.

Ragged stunt virus disease in India and Sri Lanka

E. A. Heinrichs, entomologist, and G. S. Khush, plant breeder, International Rice Research Institute

During the International Rice Testing Program monitoring tour to South India and Sri Lanka in February 1978, rice plants with symptoms of ragged stunt virus disease—identical to those previously observed in the Philippines, Indonesia, and Thailand—were observed. Numerous TNAU breeding lines at the Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore, India, were infected. At the Batalagoda Central Rice Breeding Station, Sri Lanka; only one plant of the variety BG 34-8 was observed to he infected. Transmission studies will be conducted by Indian and Sri Lankan scientists to confirm the reports.

Recent epidemics in Indonesia and the Philippines have brought ragged stunt to the attention of rice scientists. The presence of the disease in such widely separated geographical regions as Sri Lanka, India, the Philippines, Indonesia, and Thailand indicates that it has probably been endemic in Asia for years.

Pest management and control

WEEDS

Effects of herbicides on rice seed coated with activated carbon and direct seeded

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The performance of five granular herbicides in broadcast-flooded rice was evaluated in the second crop of 1977 at the Chiayi Station. Seed of the modem indica selection, Chianung-sen-yu 13 were coated with 8 kg activated carbon/ha before broadcasting on a flooded soil at the rate of 100 kg/ha. Mixed seeds of *Echinochloa crus-galli, Monochoria vaginalis,* and *Cyperus difformis* were also sown at 3 kg/ha immediately after the rice seed were broadcast. Herbicides were applied at 6 days after seeding, when most of the rice and weeds were at the one- to two-1eaf stage.

Of the five granular herbicides (see table), Perfluidone/2,4-D IPE gave the best weed control. Benzglycereth (WL29226) gave the poorest control; the others controlled weeds satisfactorily. Coating rice seeds with activated carbon did not affect the effectiveness of herbicides, but it improved their selectivity to direct-seeded rice considerably. When activated carbon was used, rice toxicity ratings were reduced by almost a third in the less selective granular herbicides terbuchlor,

Effects of herbicides on rice seed coated with activated carbon and direct seeded. Second crop, 1977, Chiayi, Taiwan.

Herbicide	Rate (kg a.i./ha)	Weed control[a]		Rice toxicity[b]		Yield (t/ha)[c]	
		With carbon	Without carbon	With carbon	Without carbon	With carbon	Without carbon
Terbuchlor	0.3	1.7	1.1	5.8	8.3	5.2 ab	3.1 c
Benzglycereth (WL29226)	0.5	4.3	4.3	2.0	2.1	5.7 a	5.1 ab
Piperophos/ dimethametryn	0.5/ 0.5	1.9	1.7	3.4	5.6	5.4 ab	4.5 bc
Piperophos/ 2,4-D IPE	0.5/ 0.5	8.0	8.2	3.3	4.4	5.6 ab	5.2 ab
Perfluidone/ 2,4-D IPE	1.0/ 0.25	8.6	8.8	4.8	5.1	5.3 ab	5.5 ab
Untreated control	–	1.0	1.0	1 .0	1 .0	4.9 ab	4.8 ab

[a] Rated at 15 days after herbicide application: 1 = no control, 10 = excellent weed control.
[b] Rated at 15 days after herbicide application: 1 = no control, 10 = complete kill of rice.
[c] Any two means with a common letter are not significantly different at the 5% level.

piperophos/dimethametryn, and piperophos/2,4-D IPE. Herbicides with protectant gave higher yields than those without; the degree of yield increase was more pronounced in herbicides that are more toxic to rice. Without protectant, plots treated with the highly toxic terbuchlor and piperophos/dimethametryn gave lower yields than the untreated control; the difference for terbuchlor was significant at the 0.05% level. The untreated control with carbon-coated seeds also yielded higher than that without carbon coating, suggesting that activated carbon has beneficial effects other than as a herbicide protectant.

Soil and crop management

Effect of levels and sources of nitrogen on Jaya

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Nitrogen fertilization, one of the most effective production inputs for rice, is expensive in Asia. To increase rice yields, not only is the optimum quantity of nitrogen important; suitable sources must also be considered. A field experiment was designed through the European Nitrogen Service program at J. N. Agricultural University, Jabalpur, M. P., India, to determine optimum and profitable doses of nitrogen supplied through suitable sources to Jaya, a high yielding dwarf indica variety.

The soil of the experimental area was sandy clay loam, low in available nitrogen (156 kg/ha), medium in available P_2O_5 (44 kg/ha), and high in available K_2O (300 kg/ha). The soil's pH was 7.0. Four levels of nitrogen (0, 60, 120, and 180 kg N/ha) and three sources (urea, calcium ammonium nitrate [CAN], and urea as basal with CAN topdressed) were used. The nitrogen was applied in 3 split doses: 50% as basal, 25% at active tillering stage, and the remaining 25% at panicle initiation. Among the data determined were ancillary characters; nitrogen, phosphorus, and potassium content in plants; and protein content of the grain.

Nitrogen application as high as 180 kg N/ha resulted in a positive yield response and improved all characters observed (effective tillers, panicle length, test weight, and flag leaf area). The uptake of nitrogen, phosphorus, and potassium in plants increased as nitrogen level increased; uptake of all nutrients was maximum at 180 kg N/ha. The protein in grain increased with increasing nitrogen level; it ranged from 8.97 to 11.20%.

With every increase in nitrogen level, grain yield increased significantly. At 0, 60, 120, and 180 kg N/ha levels the mean yields were 4.3, 5.5, 6.2, and 6.7 t/ha, respectively. The percentage increases in yield over the control for 60, 120, and 180 kg N/ha were 28, 46, and 57, respectively. The responses per kilogram of nitrogen at 60, 120, and 180 kg/ha were 21, 16, and 14 kg of paddy grain, respectively.

Nitrogen applied through urea gave the maximum grain yield (6.3 t/ha), followed by the urea + CAN combination (6.1 t/ha) and CAN (6.0 t/ha). Although the forms of nitrogen did not produce significant differences in grain yield, urea returned a higher net profit per hectare and was most economical.

The pinch method of dibbling rice in a paste of cow dung under wet conditions in southern Kerala, India

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A peculiar system of sowing rice - dibbling seeds in a paste of cow dung under wet conditions - has long been practiced in parts of southern Kerala.

After the final puddling, the farmer levels the field with a leveling board, leaving only a minimum amount of water. The field is left that way overnight (15–18 hours) to allow the sediments to settle. The next morning the standing water is drained. Raised beds about 2 to 2.5 m wide are then made by opening small furrows 10-cm deep with spades to allow the inlet and drainage of irrigation water during crop growth. The individual beds are then leveled with a device made of coconut frond or by foot. The field is then ready for dibbling.

Cow dung is cleaned of undigested grass or straw and trampled by foot into a paste. Water is added if required. The paste is leveled to a circle about 10 cm thick. Sprouted paddy seeds are then sprinkled over the paste. The seeds are mixed with the cow dung paste by foot. Then the cow dung paste is heaped with a spade and again leveled to a circle. The process is repeated three or four times. To determine if the seeds have been mixed uniformly, the farmer takes a pinch of the paste and examines it in a bowl of water. The mixture is considered uniform when it shows 3–5 seeds/pinch.

The paste is then dibbled in the prepared beds by throwing it pinch by pinch, maintaining a uniform distance (40 to 45 hills/sq m) between hills.

If adequate cow dung is not available, fine tank silt is used for part of the paste. In 3 or 4 days, vigorous green sprouts emerge from the paste, giving the fields a green, carpety appearance. After 8 to 10 days, water is let in and allowed to stand in the furrows on either side of the beds. After about 2 weeks, water in the beds is increased to about 2 cm if there are signs of weed growth or of white ant or cricket attack.

This sowing method is usually used for short-duration varieties that were not customarily transplanted in the past. It results in vigorous seedling emergence, better nutrient absorption in early stages, and survival during periods of water scarcity. Irrigation and drainage are more efficient because the furrows on both sides of the beds allow uniform moisture control. The method also allows freedom of movement for field operations.

The relationship of *khaira* incidence in rice to phosphorus levels and farmyard manure applications

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Khaira, an ailment attributed to zinc deficiency in plants, is common in the Mollisols of the *tarai* region of northern India. Phosphorus becomes more soluble on submergence. At high levels, it has reportedly reduced drastically the uptake and translocation of zinc to the shoots of rice plants.

In a field trial, the response of rice (variety IR24) to nitrogen, phosphorus, and potassium fertilizers under artificially created soil fertility levels was studied. The levels were different amounts of the three nutrients and farmyard manure that had been applied to four plots (each consisting of 0.2 ha of an 0.8-ha experimental plot) during previous crop seasons. One plot received farmyard manure and fertilizer phosphorus, the second received high levels of phosphorus only, the third was rich in inorganic residual nitrogen, and the fourth received no fertilizer or manure during the previous years. Thus the experimental plots varied widely in available soil phosphorus. Each of the four plots was subdivided into 43 plots of equal size and response of rice to soil and fertilizer nutrients was studied.

Effect of levels of soil and fertilizer phosphate and farmyard manure on the incidence of khaira G. B. Pant University of Agriculture and Technology. Pantnagar. India.

Phosphorus levels [a] (kg P/ha)	Plots affected by khaira (no.)			
	No plants affected	Fewer than 25% plants affected	Fewer than 50% plants affected	Almost all plants affected
0– 25	44	3	0	0
26– 50	20	15	8	1
51– 75	7	4	5	3
76– 100	2	1	8	3
101– 125	0	0	0	5
Farmyard manure applied in previous years	43	0	0	0

[a] (Olsen’s soil P + fertilizer P).

Interesting trends were noted in the incidence of *khaira* and levels of soil and fertilizer phosphorus (Olsen’s P and single superphosphate, respectively) on the one hand, and in the previous year’s application of farmyard manure on the other (see table).

The plot where farmyard manure had been applied in previous years had no incidence of *khaira* even at high levels of soil and fertilizer phosphorus. But in the plots with no farmyard manure, the relationship between *khaira* incidence and phosphorus levels was positive. At phosphate levels below 25 kg P/ha, there was almost no incidence of *khaira.* The few plots where it occurred were only mildly affected. As the phosphate level increased, the number of cases and the severity increased. At the highest phosphate level (100 to 125 kg P/ha), all plots were severely affected.

Farmyard manure seems to have increased the availability or translocation, or both, of zinc to rice plants. Even at phosphate levels as high as 100 to 125 kg P/ha, no incidence of *khaira* was observed. Possible reasons are being investigated.

Invitation to authors

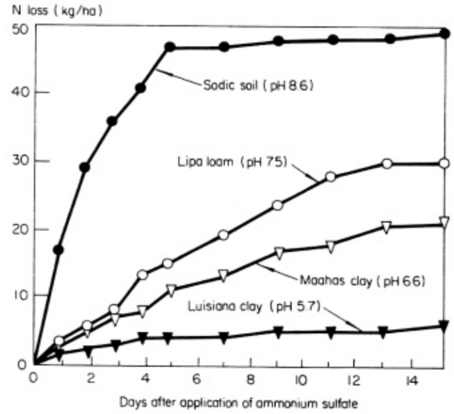
The International Rice Research Newsletter (IRRN) invites all scientists to contribute concise summaries of significant rice research for publication. Contributions should be limited to one or two paragraphs and a table, figure, or photograph. They are subject to editing and abridgement to meet space limitations. Authors will be identified by name, title, and research organization.

Ammonia volatilization losses from flooded rice soils

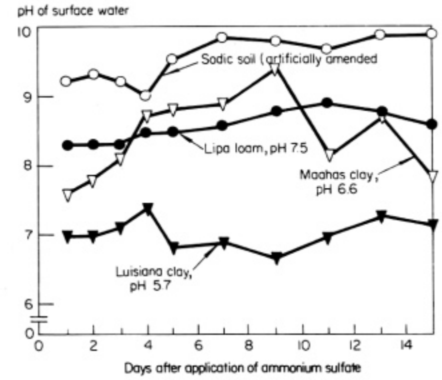
K. L. Sahrawat, postdoctoral research fellow, Soil Chemistry Department, International Rice Research Institute

Ammonium (NH_4^+) may be lost by volatilization from surface-applied fertilizers, from ammonium-forming fertilizers such as urea, and through diffusion from the soil to the surface. Some recent reports suggest that the losses could be as high as 50%. The loss has been attributed largely to the increased pH of the surface water caused by CO_2, depletion due to photosynthesis by aquatic organisms, mainly algae.

The loss of NH_4^+ through volatilization from four soils of varying pH was assessed by the open- and closed-bottle technique. Nitrogen was broadcast at 100 kg N/ha as ammonium sulfate at 2 weeks after transplanting. The pH of the flood water of those soils was monitored during 15 days of study.



1. Influence of soil properties on cumulative loss of N as NH_3 gas. IRRI.



2. pH of the flood water of four tropical soils after application of ammonium sulfate. IRRI.

The total nitrogen loss through ammonia volatilization during the first 15 days was highest in alkalized Maahas clay and lowest in Luisiana clay (Fig.1).

Figure 2 shows a striking relationship between changes in pH and ammonia losses through volatilization. In alkali soil, the pH of the flood water ranged from 9 to 9.9 during the 15 days; in other soils it was lower. In Luisiana clay, where pH was lowest, ammonia volatilization losses were also lowest.

Environment and its influence

Mechanism of the effect of gibberellin on rice

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Treating rice with gibberellins causes the stems to elongate and become more slender, and thus to lodge. The silica of the cell walls of the treated plants was found to be similar to that of untreated plants. In treated plants, tillering was depressed, branching increased, the incidence of sterile panicles was marked, and yield was reduced.

Application of gibberellic acid (GA) to rice plants decreased the riboflavin and endogenous thiamine contents of the leaf and increased the level of leaf thiamine and thiamine diphosphoric acid cocarboxylase. GA inhibited flavin oxidase markedly, causing indole-3-acetic acid (IAA) to accumulate. The RNA:DNA ratio in the growth apex of GA-treated rice increased. Although the total protein content of the rice plants remained constant, the amount of the electrophoretically mobile fraction of acid albumins declined. The total content of free amino acids decreased, but the levels of the different amino acids varied. The content of free proline decreased markedly and the histone content increased; the flow of the messenger system from the nuclei into the cytoplasm was shortened. GA probably affected the messenger system.

In summary, the mechanism of the effect of GA may be described as: GA decreases the content of the flower-initiating regulator (proline); promotes the accumulation of the repressor-blocking group of genes for reproduction (histone); and promotes IAA accumulation.

Rice-based cropping systems

Insects in an introduced double-cropping pattern of rainfed lowland rice

M. D. Lumaban and J. A. Litsinger, Department of Entomology, Cropping Systems Program, International Rice Research Institute

A single rice crop transplanted in July is the traditional cropping pattern at the research site of the IRRI-Philippine Bureau of Plant Industry Cropping Systems Program in Oton and Tigbauan, Iloilo, Philippines. The IRRI-BPI team is testing the feasibility of double-cropping of rice by establishing the first crop with the onset of the rainy season (usually in May) after a 3-month dry fallow period. If farmers grow early maturing varieties, there is sufficient rainfall in this nonirrigated area to plant a second rice crop.

Insect pests were monitored in plots that had been treated with insecticide and in untreated plots in six farmers' fields where two crops of IR28 were grown in the introduced pattern. The first crop was wet-seeded in May and the second was transplanted in October.

The first crop was essentially insect free; both protected and unprotected plots yielded 5.1 t/ha (see table). Because the crop was established early with the first rains, it escaped pest buildup.

The second crop was attacked by the same insect complex that normally attacks the single rice crop. The key insects were rice caseworm *Nymphula depunctalis* (whose larvae defoliate the crop), rice green-homed caterpillar *Melanitis leda ismene,* and rice skipper *Pelopidas mathias.* Minor insects were stem borers (predominantly white rice borer *Tryporyza innotata*) and rice bug *Leptocorisa acuta.* The pests increased on the first rice crop as well as on the grassy weeds that proliferated in fallow fields with the onset of rains before the July puddling of the single crop. The yield difference between the insecticide-protected and unprotected plots (5.0 vs 3.9 t/ha) was significant in the second crop.

The fact that the first crop requires no insect control makes the double-rice pattern attractive to farmers whose cash resources to purchase insecticides are limited.

Insect occurrence and benefit from insecticide protection on the first (wet-seeded IR28) and second (transplanted IR28) crops of an introduced rice double-cropping pattern in a rainfed lowland environment. Oton and Tigbauan, Iloilo, Philippines, 1976.

Crop	Untreated				Yield (t/ha)	
	Defoliation (%)	Stem borer (%)		Rice bugs (no./sq m)	Untreated plots	Treated[a] plots
		Deadhearts	Whiteheads			
First[b]	4	2.6	2.3	1.2	5.1	5.1
Second[c]	22	5.4	7.4	3.7	3.9	5.0

[a] 2 kg a.i. carbofuran (Furadan 3 G)/ha incorporated in the soil before planting, followed by 4 spray applications of 0.75 kg a.i. monocrotophos (Azodrin 16.8 EC)/ha.
[b] Av. of 6 fields planted in May.
[c] Av. of 6 fields planted in October.

A boro and deep-water rice relay cropping pattern in Bangladesh

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Farmers in Bangladesh, encouraged by high yielding varieties, better irrigation, higher boro yields, and less risk of flood damage, have shifted 0.5 million of the estimated 2 million ha of deep-water rice to boro cultivation. A cropping pattern in which a boro crop is followed by deep-water rice is not possible for most farmers because the late boro harvest (late April to May) interferes with the establishment of the deep-water rice crop. A study to determine the feasibility of growing deep-water rice in addition to modern boro rice on the same land in 1 year by relay cropping was conducted. Boro rice was planted in the dry season (late December) in a deep-water field near the Bangladesh Rice Research Institute (BRRI). The flood water rose to 1.5 m deep and lasted from mid-June to October in 1977.

The effect of different plant and row spacings on boro rice yield and on the establishment of deep-water rice seedlings was studied. The effect of different relay planting methods and nitrogen applications on yields of deep-water rice after boro harvest was also investigated.

Boro yield did not significantly differ between traditional 20 × 20-cm spacing and paired-row spacing (15 cm between hills and rows, 45 cm between paired rows). But paired-row spacing made the broadcast aman crop easier to plant at the boro crop's flowering stage, resulted in less damage to the boro crop at harvest, and increased broadcast aman yields (see table). Topdressing of 40 kg N/ha increased deep-water rice yields by 100% in all boro spacing plots. The yields of broadcast aman rice were low because the exceptionally heavy rains in May and June flooded the sprouted deep-water rice

The effect of plant spacing, row spacing, and nitrogen application on the yields of boro rice and of a relay crop of deep-water rice, Bangladesh.

Spacing (cm)	Boro rice yield (t/ha)		N application (kg/ha)	Deep water rice (Hbj. Aman IV) (t/ha)
	BR6	BR3		
20 × 20	3.2	5.1	0	0.3
			40	0.7
30 × 15	3.0	4.9	0	0.5
			40	1.0
15 × 15 × 49[a]	3.0	5.0	0	0.6
			40	1.2

[a]15 cm between hills and rows, 45 cm between paired rows.

seeds and reduced the plant stand.

In another study, no significant difference was found between using sprouted seeds and transplanting 30-day-old seedlings of deep-water rice. The plot was not deeply flooded, however, and deep-water rice yields averaged a respectable 1.4 t/ha.

The experiment‘s indicate that relay cropping of boro and deep-water rice has a definite potential for increasing rice production in some areas of Bangladesh.

But the choice of boro variety and spacing, the timing and method of planting of deep-water rice, and the amount of fertilizer needed for good stands and yields require more study. Major factors that determine the success of the cropping pattern and that vary from site to site include the timing of the flood, the moisture status during establishment of deep-water rice, and nutrient availability.

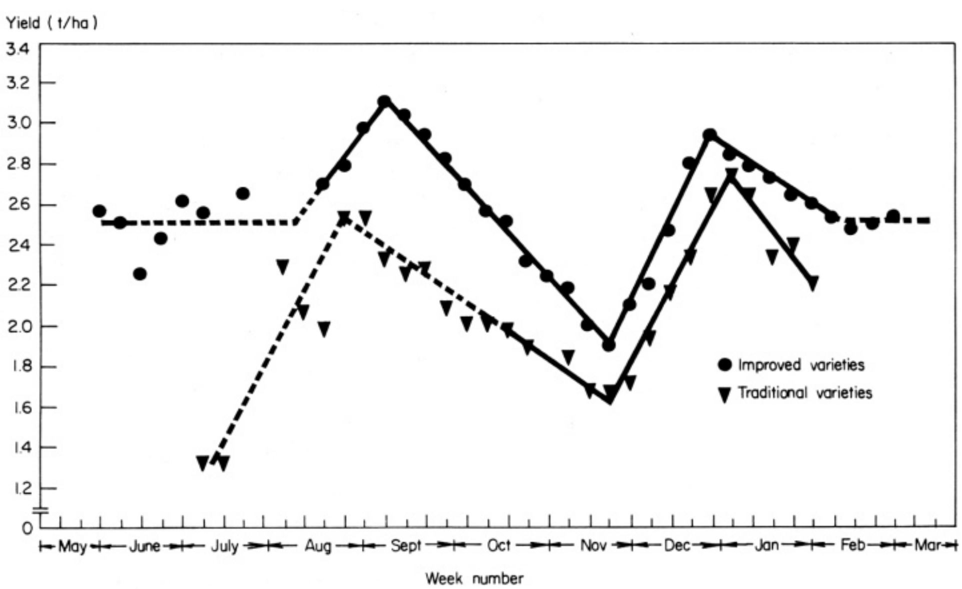
Expected rice yields in rainfed systems

E. C. Price, R. L. Tinsley, and H. G. Zandstra, International Rice Research Institute

The IRRI cropping systems program is investigating strategies for multiple cropping of rice in rainfed and partially irrigated systems through appropriate choice of variety and cultural practices. Major considerations are planting dates, growth duration of rice varieties, tillage methods, planting methods (direct seeding or transplanting), and rainfall distribution. To assess farmers' yield expectations with their present technology, yields of more than 900 farmer-managed plots of rainfed and partially irrigated rice, including 556 plots of improved and 422 plots of traditional varieties, were examined by date of harvest. The data were obtained from daily farm records kept in 1975–76 and 1976–77 by 130 farmers in Batangas, Iloilo, and Pangasinan provinces, Philippines. The times of onset and decline of bimodal rainfall patterns are similar at all the sites. The improved varieties were planted in lowland fields; most were single crops. Most traditional varieties were also single crops, but some were grown on upland fields.

The solid portions of free-hand curves in Figure 1 represent the 5-week moving averages of rice yields by week of harvest. The first peaks of the improved and traditional variety curves are the moving averages of 83 and 35 plots, respectively. The second peaks are based on 65 observations of improved varieties and 73 of traditional ones, and the intervening troughs are based on 117 and 78 observations, respectively. The lowest number of observations in any 5-week period was 22, which constitutes the moving average centered on week 33 on the improved variety curve. A maximum of 154 points are averaged for week 39, also lying on the improved variety curve. Points on the dashed portion of the improved variety curve are based on a low number of observations and mainly represent the few relatively better irrigated plots in the sample. The dashed portion of the traditional rice curve mainly represents the yields of 153 upland rice plots at the Batangas site.

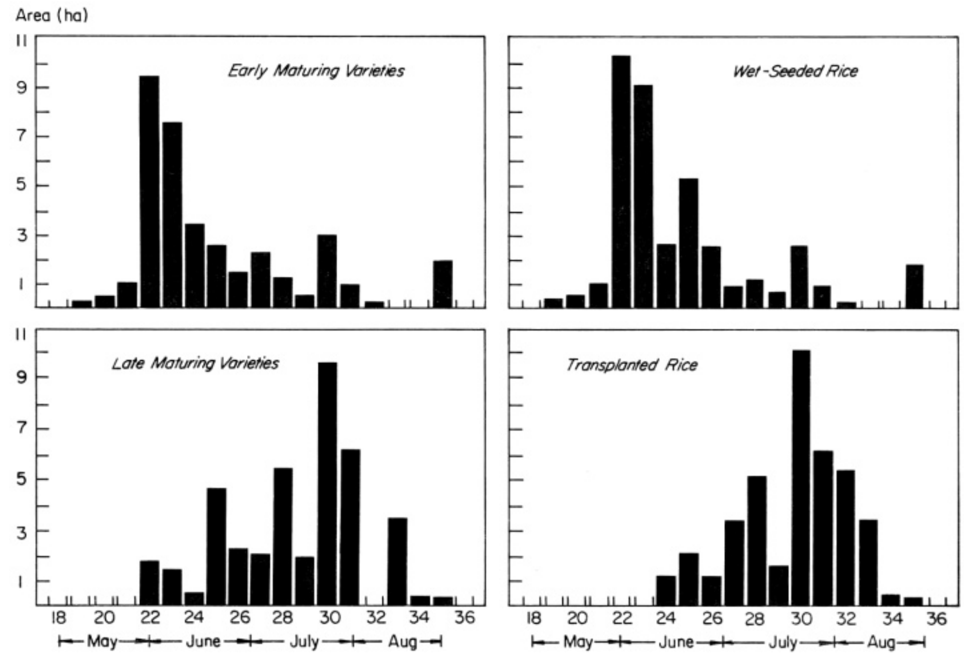
While the actual rainfall pattern shifts from year to year, it generally follows a bimodal distribution with a major peak in July and a minor peak in October. We have not attempted, however, to rigorously identify possible relationships between climate and yield. The data suggest that highest total production on lowland can be expected by direct-seeding an early maturing improved variety in mid-May for harvest in early September, then transplanting a second crop for harvest in late December. Ongoing studies indicate that the availability of power and labor, and the timing of the actual onset



1. Five-week moving average of yields of improved and traditional rice varieties by date of harvest. One hundred and thirty farmers' fields in Batangas, Pangasinan, and Iloilo Provinces, Philippines, 1975–76 and 1976–77.

of rain limit farmers' opportunities to follow the high-production pattern on an entire farm. On those plots not planted by week 26, it appears advisable to plant a single, later maturing crop to harvest around the first of the year. A corroborative study in Iloilo indeed showed that in 1976 farmers shifted from early maturing varieties and direct-seeding to later maturing varieties and transplant transplanting at about the end of June (Fig. 2).

All upland rice plots were harvested between week 34 and 41 and constitute 80% of the observations plotted on that portion of the traditional rice curve. During this period upland rice yields followed the same declining trend as yields of rainfed improved and traditional lowland rice, and compared very favorably with yields of the latter harvested in succeeding weeks.



2. Area of rice planted by 46 Iloilo farmers, by week of planting, varietal maturity period, and method of planting. Iloilo province, Philippines, 1976.

Populations of parasitic nematodes of grain legumes in rice-based cropping patterns in four environments and flooding regimes in the Philippines

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Plant parasitic nematodes of the genera *Rotylenchulus* and *Meloidogyne* are important grain legume pests in the Philippines. Those genera do not attack graminaceous crops such as rice and corn in rice cropping patterns. A study was undertaken at the target area of the IRRI-Bureau of Plant Industry Cropping Systems Program in Manaoag, Pangasinan, Philippines, to determine the nematode incidence in four common rice-growing environments, each distinguished by duration of flooding:

1. well-drained, nonpuddled fields planted to upland rice (nonflooded);
2. isolated rice paddies in drainageways among upland fields, where a crop of transplanted rice is flooded from 2 to 3 months during the rainy season;
3. paddies in lowland areas of alkaline soil that are flooded highly intermittently. Alternate flooding (no more than 1–2 weeks) and draining of such paddies alleviates iron and zinc deficiencies; and
4. normal lowland rainfed paddies with good water retention during rice cultivation (flooded for 2–3 months).

Plant parasitic nematode populations in mung beans and cowpeas following rice in four environments.[a] Pangasinan, Philippines, 1976.

Environment	Nematodes (no./250 cc soil and 1 g roots)		
	Rotylenchulus	*Meloidogyne*	Totalof 7 genera[b]
Upland fields	56	431	551
Isolated paddies in drainageways among upland fields	2	0	17
Highly intermittently flooded fields	2	5	35
Normal rainfed paddies	1	0	3

[a]Av. of 4 fields in each environmental condition having a similar cropping pattern during the previous 3 years.
[b]*Criconemoides, Helicotylenchus, Hoplolaimus, Pratylenchus, Tylenchorhynchus.*

Soil and root samples were taken from mung beans or cowpeas planted after the single rice crop in four replicated fields for each environment. Soil samples from each field were pooled and nematodes were extracted by the Baermann funnel technique. Roots were stained with acid fuchsin-lactophenol and examined under a microscope.

The results indicated that flooding during rice culture, even intermittently, is an effective cultural method for controlling plant parasitic nematodes (see table). Only in the well-drained, nonflooded, upland environment did we find very high nematode populations capable of reducing yields of legumes planted after rice.

Survev of IRRN subscribers

Who reads the IRRN?

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

Rice scientists, educators, and extension specialists can have their names placed on the International Rice Research Newsletter (IRRN) mailing list by filling out a response card and returning it to IRRI. Since the IRRN was initiatedin late 1976, more than 8,000 response cards have been returned. Certain biographic data are on the cards. A random sample of 1,000 cards was recently drawn and the data on them were analyzed.

Eighty percent of the sample are from developing nations; more than 70% are from Asia. Eighteen percent of the subscribers are from the Philippines; about 14% from India; about 5% from Latin America; 4%, from Africa; and 20%, from highly developed nations.

Twenty-two percent of the sample are agronomists; about 15%, plant breeders; 12%, entomologists; 9% pathologists; 7%, engineers; 6%, soil scientists; 5%, economists; and 3%, physiologists.

Thirty-three percent of the subscribers hold doctoral degrees; the master's degree is the highest educational attainment for 28%; the bachelor's or engineer's, for 34%; and diploma or high school, for 5%.

Thirty-seven percent of the subscribers work for government research organizations; 28%, for colleges, or universities; 13%, for extension offices; 9%, for nonprofit international organizations, and 9%, for private business or industry.

Pest management and control is the area of greatest interest — 44% of the IRRN subscribers indicated it as one of three major research interests. Next is soil and crop management (33%); followed by genetic evaluation and utilization (29%), rice and the environment (17%), irrigation water management (13%), constraints on rice yields, consequences of new rice technology and rice-based cropping systems (12% each), machinery development and testing (3%), and postharvest management (5%).

Three-fourths of the subscribers work with both rice and other crops.

Each subscriber indicated on the response card the percentage of his time spent in various professional areas. The mean percentages were then calculated. Forty-nine percent of the subscribers' time is spent in research, 16% each in teaching/training and administration, and 13% in extension.

Of the 184 items published in the IRRN during 1977, half were in the last two issues. Forty-two percent of the IRRN items were on pest management and control, 41% on genetic evaluation and utilization, and 15% on soil and crop management (see table).

Indian scientists submitted 43.5% of the 1977 articles published in the IRRN, followed by scientists in the Philippines (12.6%), Thailand (7.1%), Indonesia (6%), and Bangladesh (5.4%).

Problem areas on which items were published in the International Rice Research Newsletter (IRRN) (184 contributions in 6 issues, 1977).

Problem area	Items published			
	No.		%	
Genetic evaluation and utilization		76		41
Overall progress	18		10	
Disease resistance	25		14	
Insect resistance	15		8	
Deep water	4		2	
Temperature tolerance	1		*a*	
Adverse soils	3		2	
Agronomic characteristics	7		4	
Drought resistance	2		1	
Grain quality	1		*a*	
Pest management and control		77		42
Diseases	40		22	
Insects	34		18	
Weeds	3		2	
Soil and crop management		22		12
Constraints to rice yields		1		*a*
Machinery development and testing		2		1
Rice-based cropping systems		6		4
Total		184		100

[a]Less than 1%.

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