AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 74

1. SUBJECT CLASSIFICATION
A. PRIMARY: Food production and nutrition — AF30-0150-G635
B. SECONDARY: Plant breeding--Cereals-- Rice--India

2. TITLE AND SUBTITLE
Genetic and sociologic aspects of rice breeding in India

3. AUTHOR(S)
Hargrove,T.R.

4. DOCUMENT DATE: 1977
5. NUMBER OF PAGES: ~~33p.~~ 34p.
6. ARC NUMBER: ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
IRRI

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(In IRRI res.paper ser.no.10)

9. ABSTRACT

The rapid increases in cereal production in LDCs during the 1960's and 1970's were spearheaded by new semidwarf varieties of wheat and rice. The new form of genetic technology was rapidly adopted across Asia, Africa, and Latin America, particularly in the irrigated regions. The flow of rice genes during a decade was traced by analyzing randomly selected crosses made at 10 Indian research stations during three periods:1965-65, 1970-71, and 1974-75. The percentage of total crosses in which a semidwarf parent was used increased to 91% by 1970-71, and remained at that level through 1974-75. As the use of locally developed, semidwarf varieties increased in India, the use of tall varieties decreased. Tropical rices are mostly of the indica type, but rice breeders have long been interested in crossing the indica with the temperate-zone japonica rices. Analysis indicated that the semidwarf indicas, such as TN1, IR8, and the locally developed semidwarfs, pushed the japonica, javanica and ponlai materials out of the programs. The overall breeding objectives included increased yield potential, improved grain quality, growth duration, disease resistance, and insect resistance. Of lesser importance were drought resistance, cold tolerance, waterlogged-soil tolerance, and deep-water tolerance. Semidwarf varieties were chosen for increased yield potential, grain quality, and disease and insect resistant crosses. The locally developed semidwarf Jaya was named as one of three most widely grown varieties. The second most popular was IR8, followed by two other semidwarfs, Ratna and IR20. Numerous data tables are included.

10. CONTROL NUMBER
PN-AAF-129

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Genetics
India
Rice
Rice breeders?
Rural sociology
Varieties
Yield

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/ta-G-1074 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

Aid/d G-1074 GB
IRRI

IRRI RESEARCH PAPER SERIES
Number 10 September 1977

GENETIC AND ECOLOGICAL ASPECTS OF RICE PLANT HOPPERS

THOMAS R. HARDY

The International Rice Research Institute
Los Baños, Laguna, Philippines

GENETIC AND SOCIOLOGIC ASPECTS OF RICE BREEDING IN INDIA[1]

ABSTRACT

The flow of rice genetic material at 10 Indian research stations was traced through three periods: 1965-67, 1970-71, and 1974-75. Breeding objectives of 1974-75 crosses were determined. The genetic makeup and traits were determined of popular farmer varieties and of new locally developed rices at 12 centers. Sociologic data were gathered on the breeders.

In 1965-67, 80% of the crosses involved at least one semidwarf; TN1 was used in 41%, IR8 in 27%. By 1974-75, 91% of the crosses involved semidwarfs. Use of TN1 and IR8 dropped sharply, but locally developed semidwarfs were used in 61% of the crosses. Of the local semidwarfs, 55% were progeny of IR8, and 39% of TN1.

Use of tall parents dropped from 77% of the crosses to 48% during the decade. Use of indica parents increased from 79% to 96% and use of japonicas and ponlais declined. Use of hybrids increased from 57% to 74%.

Yield potential was a breeding objective for 89% of the 1974-75 crosses; fertilizer response, 80%; lodging resistance, 80%; grain quality, 67%; growth duration, 59%; disease resistance, 43%; insect resistance, 37%; drought resistance, 9%; cold tolerance, 9%; waterlogged soils tolerance, 7%; and deep-water tolerance, 2%.

Half of the popular farmer varieties were semidwarfs; 65% were locally developed, the others were from IRRI. Jaya was most popular, followed by IR8. For 52% of the rices grain quality was a favored trait; 24% had poor grain. Fifty-two percent of the rices had a desired growth duration. For half of those earliness was the preferred trait and for half, intermediate or late duration. Disease resistance was a favored trait of 18% and susceptibility was a weakness for 58%. Insect resistance was a favored trait of 17% and susceptibility a weakness of 30%.

Of the newest varieties, 83% were semidwarf and 17% were intermediate in height. Of the 15 semidwarfs, 13 were progeny of IR8. Desired growth duration was a favored trait of 72% of the new rices; earliness accounted for 61%. For 61% grain quality was a favored trait while 23% had poor grain. Resistance to at least one disease was a trait of 61% and a susceptibility of 73%. Half of the new rices were resistant to insects and half were susceptible.

---

[1]by T. R. Hargrove, associate editor, International Rice Research Institute, Los Baños, Philippines. Submitted to the IRRI Research Paper Series Committee 20 January 1977.

Mean ratings of environmental and pest problems were compared with breeding objectives. Pests were a major problem in all areas; 50% of the crosses were for pest resistance. Drought was rated second, but only 9% of the crosses were for resistance to it. Of specific pests, bacterial blight was named as a major problem in 75% of the areas; 17% of the crosses aimed for resistance to it. Stem borer was cited in 69% of the areas, but only 2% of the crosses were for resistance.

About 41% of farmer's fields were considered irrigated; 67% of the breeders' work was on irrigated rice; and 54% of the newest varieties were suited to irrigation. For rainfed rice, the averages were: farmers' fields, 40%; scientists' efforts, 19%, and newest varieties, 33%.

The breeders' mean age was 42.7 years and mean professional experience, 15 years. Fifty-six percent had an agricultural background. The breeders spent 73% of their time in research and 54% in breeding activities. Forty-four percent held a Ph.D., half from highly developed nations.

GENETIC AND SOCIOLOGIC ASPECTS OF RICE BREEDING IN INDIA

The rapid increases in cereal production in the developing nations during the 1960's and 1970's were spearheaded by new semidwarf varieties of wheat and rice. Although many believed that small-scale farmers were reluctant to change, the new form of genetic technology was rapidly adopted across Asia, Africa, and Latin America, particularly in the irrigated regions. Chandler (1976) wrote,

> "Of the many factors responsible for this advance, by far the most decisive was the development, by agricultural scientists, of the short, stiff-strawed, fertilizer-responsive varieties of rice and wheat which have essentially doubled the yield potential of mankind's two important food crops."

Jennings (1974) noted two fundamental differences between the new and the old varieties: a drastic shortening of the straw of the new plants to reduce lodging and to increase the ratio of grain to straw, and a marked increase in their adaptability over latitudes, elevations, and other environmental factors.

The spread of the new varieties onto farmers' fields -- the so-called green revolution -- has been well documented, but less is known about a corresponding diffusion that may have even greater long-term effects -- their diffusion as parent varieties through national rice breeding programs. Plant breeders use such varieties as genetic building blocks; through crossbreeding, they incorporate the genes that control desired traits into new progeny, which are then fed into seed production channels and onto farmers' fields.

As a major supplier of genetic material to more than 50 nations, the International Rice Research Institute (IRRI) seeks knowledge of what parent materials are adopted by scientists in national programs, what genetic traits they are used for, and what factors influence adoption of the new varieties.

It is known, for example, that many of the semidwarf varieties now being planted were developed by national scientists. What is the genetic makeup of these varieties? Are they progeny of crosses with the first semidwarfs? Are these new varieties replacing the IRRI semidwarfs?

Knowledge of the extent of use of given varieties as parents will indicate the influence of IRRI on national programs for rice technology development. And all rice scientists need to know the genetic composition of current and potential varieties to avoid the inherent danger of a lack of genetic diversity in the world's rice crop.

Through in-depth interviews and analyses of breeding records, IRRI traced the diffusion over a 10-year period of rice genes into the programs of 41 plant breeders at 28 experiment stations and agricultural universities in 10 Asian countries. Data were also gathered on the sociologic backgrounds of the rice breeders who adopt new genetic technology. The project was partially funded by The Rockefeller Foundation and was conducted in collaboration with the Agricultural Education Department, Iowa State University, USA.

The biologic and sociologic information gathered can help those concerned with international agricultural development determine how an international agricultural research center such as IRRI can best allocate its resources to encourage and stimulate the local development of better farm technology for rice farmers.

Breeders were interviewed from Bangladesh, Korea, India, Indonesia, Iran, Nepal, Pakistan, Philippines, Sri Lanka, and Thailand.

Data compiled and analyzed for 18 of the breeders from 12 experiment station and universities in India are reported in this paper. Crossing records for 1965-67 and 1970-71 were analyzed at four state-level rice research stations and agricultural universities in Kashmir, Maharashtra, Orissa, and Punjab, and at three national centers: the Central Rice Research Institute (CRRI), Cuttack; the Indian Agricultural Research Institute (IARI), New Delhi; and the All India Coordinated Rice Improvement Project (AICRIP), Hyderabad. Crossing data for 1974-75 were compiled from the same rice research stations plus three other state-level stations in Bihar, Kerala, and Tamil Nadu.

Breeders were also interviewed, but crossing records were not analyzed, at two other state-level stations in West Bengal and Uttar Pradesh.

DIFFUSION OF GENETIC MATERIAL AMONG BREEDING PROGRAMS

Each parent of an improved rice variety has its own genetic code, or its own set of inheritable genetic traits. A critical analysis of the breeding material used by rice breeders can help indicate the genetic composition of current -- and future -- modern varieties, and provide a measure of the role of the green-revolution varieties in local technology development.

The flow of rice genes during a decade was traced by analyzing randomly selected crosses made during three periods: 1965-67, 1970-71, and 1974-75. The percentages of different types of parent material used during each period were calculated on

- a cross basis, e.g., the percentage of crosses in which a semidwarf was used as one of the donor parents, and
- an individual-parent basis, e.g., the percentage od different types of rice in the total genetic pool used in each period.

Forty-four crosses were analyzed from the 1965-67 breeding records and 68 crosses from the 1970-71 records of 7 Indian rice research stations. For 1974-75, 46 crosses were analyzed at 10 stations.

Adoption of semidwarf rices as parental material

Eighty percent of the 44 crosses made in 1965-67 involved the use of at least one semidwarf parent to reduce the height of the tropical plant; 38% of the 102 individual parents used were semidwarfs (Table 1).

Table 1. Plant height of 336 rices used as parents in 158 crosses made during a 10-year period. Ten agricultural experiment stations, India, 1965

Plant height	1965-67				1970-71				1974-75			
	102 individual parents		44 crosses		102 individual parents		68 crosses		96 individual parents		46 crosses	
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%
Tall	38	37	34	77	52	38	50	74	26	27	22	48
Intermediate	25	25	20	45	13	9	12	18	5	5	5	11
Semidwarf	39	38	35	80	73	63	62	91	65	68	42	91

The most popular single gene source used in 1965-67 was the Taiwanese variety Taichung Native 1 (TN1), the first semidwarf to be widely grown in India. Probably the world's first hybrid semidwarf variety, TN1 was developed in Taiwan from the cross Dee-geo-woo-gen/Tsai-yuan-chung, made in 1949. According to Huang et al. (1972), TN1 was introduced into India in 1960. IRRI sent 1 ton of TN1 seed to India by air in 1966; the Indian government later purchased more than 50 tons. TN1 probably reached a peak production during 1968-69 when it was planted on 810,000 ha.

TN1 was used in 41% of the 1965-67 crosses at the seven Indian stations. Although IR8 was released in 1967, it was used -- often identified by its experimental line number -- in 27% of the 1965-67 crosses analyzed (Fig. 1) IRRI experimental lines other than IR8 were used in another 14% of the crosses. Semidwarf rices from China, Japan, and Taiwan were used in 7% of the crosses. No use of locally developed semidwarfs as parents for the 1965-67 period was reported.

The percentage of total crosses in which a semidwarf parent was used increased to 91% by 1970-71, and remained at that level through 1974-75 (Table 1). But the intensity of use of semidwarf rices as parents, and the genetic composition of semidwarfs, changed far more significantly than the number of crosses that involved semidwarfs. The percentage of crosses in which TN1 and IR8 were directly used as parents dropped dramatically from the mid-1960's to the early 1970's. By 1974-75, TN1 was used as a parent in only about 7% of the crosses. Through the first 5 years, the use of IR8 as a parent dropped only by 1% (27-26% of the crosses), but by 1974-75, IR8 was used in only 17%. Other IRRI materials were used in 14-15% of the crosses through 1970-71, but as newer materials became available, were used in twice as many crosses (Fig. 1).

The percentage of crosses that used semidwarf material from other countries increased slightly from 1965 to 1975 (7-11%). But a strong new trend developed after 1967. Although no locally developed semidwarfs were used as sources of the dwarf gene in 1965-67, by 1970-71 46% of the crosses involved a local semidwarf, and by 1974-75, 61% of the crosses involved at least one locally developed semidwarf.

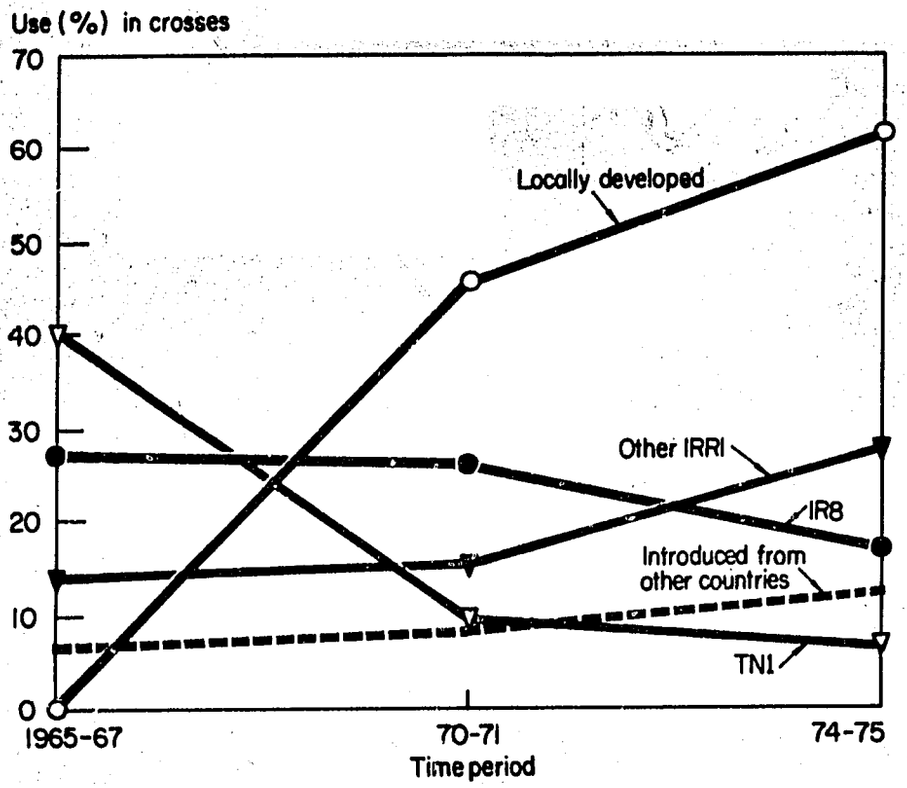

Fig. 1. Use of semidwarf parents in crosses at seven Indian rice research stations 1965-67 and 1970-71; and 10 Indian rice research stations 1974-75.

Tall and intermediate-statured parent

As the use of locally developed, semidwarf varieties increased in India, the use of tall varieties decreased. In 1965-67 37% of the parents used in crosses were tall varieties. By 1974-75, only 27% of the parents were tall. In the 1965-67 period, 77% of the crosses involved a tall parent and 80% involved a semidwarf. Only 48% of the 1974-75 crosses, however, involved tall varieties.

The percentage of crosses in which intermediate-statured parents were used followed a similar trend.

Genetic composition of local semidwarfs used as parents

Analysis of the parents and of the ancestors of the locally developed semidwarfs used in the 1974-75 crosses shows that rice breeders in India adopted the first semidwarf varieties and incorporated their plant type into newer rices better suited to local conditions. Fifty-five percent of the locally developed semidwarf parents were progeny of IR8, and another 39% were progeny of TN1 (Fig. 2). There is a 9% overlap -- rices which had both IR8 and TN1 or IR8 and Jaya in their ancestry. Jaya is a locally developed semidwarf from the cross TN1/T141.

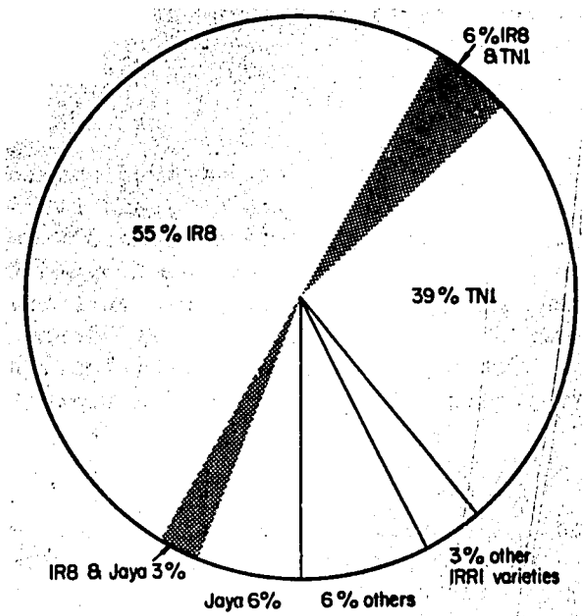

Fig. 2. Source of dwarf gene in locally developed semidwarf parents. Percentages total more than 100 because several semidwarfs were progeny of crosses involving both IR8 and TN1, or IR8 and Jaya.

Virtually all of the semidwarf materials, such as TN1 and IR8, have the Chinese rice Dee-geo-woo-gen (DGW) as a source of dwarfism, so it can be assumed that the DGW gene was in about 90% of the 1974-75 crosses analyzed.

Thus, by the mid-1970's, the original short, stiff-strawed varieties were being phased out of the breeding programs as parents, but they continued to live on through a wide range of progeny.

Origin of parental materials

During 1965-67, 32% of the parent material used in randomly selected crosses was either local or locally developed. That figure increased to 60% by 1970-71 and to 64% by 1974-75. The percentage of plant materials introduced from other countries dropped from 50% in 1965-67 to 12% in 1974-75 as Indian breeders switched from TN1 to locally developed semidwarfs. The use of all IRRI materials increased from 18% in the mid-1960's to 24% in the mid-1970's.

Use of indicas, japonicas, javanicas, and ponlais

Tropical rices are mostly of the indica type, but rice breeders have long been interested in crossing the indica with the temperate-zone japonica rices. In fact, IRRI's 1961-62 plant breeding strategy to develop a short-statured rice plant included indica-japonica crosses (IRRI, undated).

Analysis of the type of parent materials used in Indian crosses indicates that the semidwarf indicas, such as TN1, IR8, and the locally developed semidwarfs, pushed the japonica, javanica, and ponlai materials out of the programs. In the mid-1960's, 79% of the parent materials was indica and by 1974-75, 96% was indica. In 1965-67, 7% of the parent materials was japonica. That figure dropped to 3% in 1974-75. Ponlai varieties

(japonicas from Taiwan) were used in 8% of the 1965-67 crosses, but none were found in the 1974-75 analysis.

Method of development of parents

Fifty-seven percent of the 1965-67 crosses involved hybrid materials as parents; that figure increased to 62% in 1970-71 and to 74% in 1974-75. The percentage of crosses that involved mutants decreased from 3 to 1% over the decade; that of crosses using pureline selections dropped from 30 to 18%. Interestingly the percentage of crosses that used varieties classified as *unimproved* increased from 1 to 7% over the 10-year period. That may indicate that breeders are going back to the original traditional sources of specific genetic traits as their programs become increasingly problem oriented.

Time to adoption

For 31 of the rices used in the 1974-75 Indian crosses, the breeders could recall both the year in which a particular variety or line was developed (to the fixed-line stage) and the year in which they first used it as a parent. For 18 rices, the breeders could recall the year that they first heard of a particular rice and the year it was adopted as a parent. There was an average time lag of 3.7 years from the time a variety or line was developed until it was adopted. The time lag from first awareness of a particular rice until its adoption in the breeding program was 1.7 years.

Method of acquisition

The breeders could recall how they acquired 83 of the 96 rices used in the 46 randomly selected 1974-75 crosses. Sixty-four percent were locally available -- traditional or locally developed varieties, or rices that were already in the rice collection at that station (Table 2). Most of the outside materials were acquired through AICRIP or IRRI trials. The 2% of the rices requested from the IRRI germ plasm bank were ordered on the basis of specific traits such as drought tolerance or earliness; none were requested by name.

Table 2. How rice breeders acquired 83 parents used in 46 randomly selected crosses. Ten agricultural experiment stations, India, 1975.

Source	Parents	
	no.	%
Local traditional, locally developed, or in local germ plasm collection	53	64
Sent in trials (AICRIP and IRRI)	19	23
Requested from IRRI by trait	2	2
Others	9	11
Total	83	100

OBJECTIVES OF RICE BREEDERS

To determine the overall breeding objectives at the 10 research stations, the genetic traits were compiled for which the breeders indicated they used each parent in each of the 46 crosses made in 1974-75. Also compiled were the characteristics that the breeders sought from each type of rice and each variety or line.

Increased yield potential was the objective most frequently cited -- the reason that one of the parents was used in 89% of the crosses (Fig. 3). Higher fertilizer response and resistance to lodging were each an objective of 80% of the crosses. The semidwarfs were almost invariably used as parents for the yield -- fertilizer response -- nonlodging complex (Table 3).

Improved grain quality was an objective of 67% of the crosses (Fig. 3) and because of that, the type and origin of the individual parents that were used for the trait were determined. In 19 of the 26 times (73%) that tall varieties were used, the breeders hoped to transfer a preferred type of grain from the tall donor into the progeny (Table 3). But specific grain-quality objectives varied considerably, indicating that consumer preferences varied widely. Long, slender, and aromatic grains were most popular (Fig. 3).

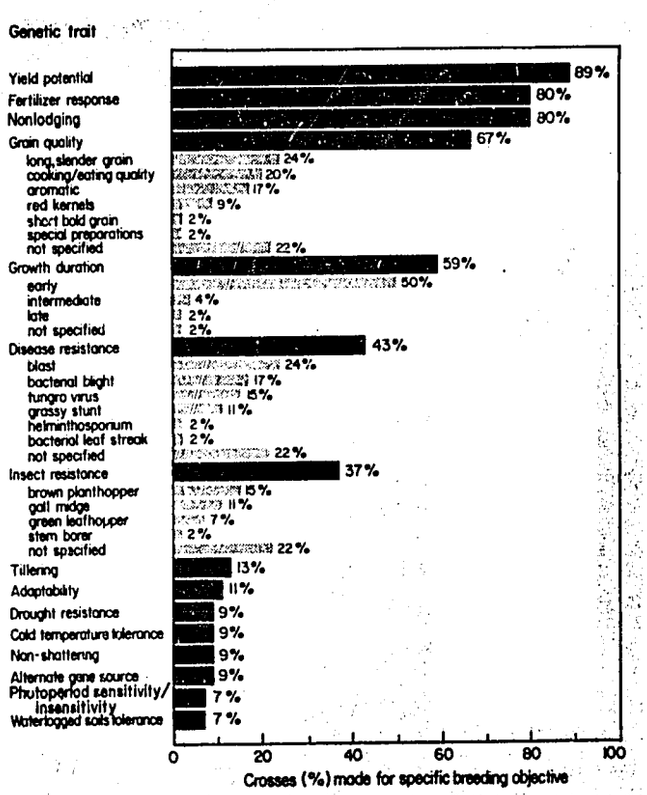

Fig. 3. The objectives of 46 randomly selected crosses made in 1974-75. Ten agricultural experiment stations, India, 1975.

Table 3. The frequency with which rice breeders sought desired genetic traits from semidwarf, intermediate, and tall parents in crosses. Ninety-six parents in 46 randomly selected crosses made in 1974-75. Ten agricultural experiment stations, India, 1975.

Breeding objective	Use (%)[a] as parents		
	Semidwarf	Intermediate	Tall
Yield potential	83		4
Fertilizer response	74		
Lodging resistance	75		4
Grain quality	43	60	73
Growth duration	31	20	50
Disease resistance	42	40	27
Insect resistance	28		12
Tillering	8		4
Adaptability	6	20	
Drought resistance	3		8
Cold temperature tolerance		20	15
Nonshattering			4
Alternate gene source	3	20	4
Photoperiod sensitivity/insensitivity	3		8
Adverse soils tolerance	5	20	8
Heavy grains/panicle	3	40	
Seed dormancy	3		4
Seedling vigor	3		
Threshability	2		
Milling recovery	3		
Deep water tolerance		20	
Yield stability	2		
Others	2	20	8

[a] Percentage of total times each type of rice was used as a genetic source for each desired trait.

Grain quality was a breeding objective 43% of the times that semidwarf parents were used. Twenty-eight individual semidwarf varieties and lines used for grain quality were examined. Although 55% of the 65 semidwarfs used as parents in the total 1974-75 gene pool were developed in India, 80% of all semidwarf used for preferred grain characteristics were locally developed (Fig. 4). These data indicate that a primary reason that breeders cross the introduced semidwarfs, such as IR8 and TN1, with local varieties is to develop high-yielding semidwarfs with a grain quality acceptable to local tastes.

Growth duration was an objective of 59% of the crosses (Fig. 3). Most of the crosses aimed at achieving earliness, but 2% was aimed at achieving long growth duration. The long-duration crosses were for single-cropped regions with a long monsoon season where farmers want varieties that will mature after the rains have ended. Tall rices were more frequently used as donors for preferred growth duration (Table 3).

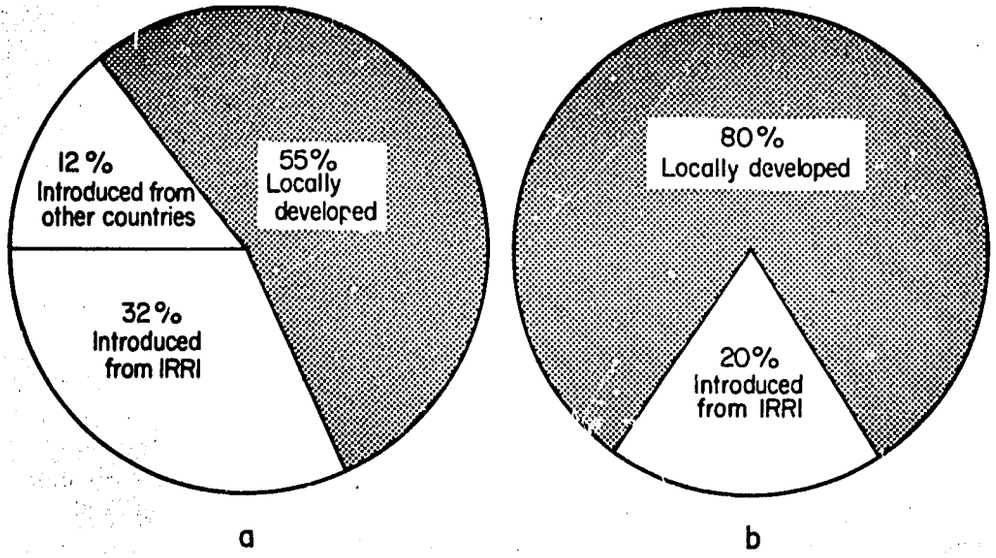

Fig. 4. a) Fifty-five percent of all 65 semidwarf parents used in 1974-75 crosses were locally developed. b) Twenty-eight of the 65 semidwarf parents were used to transfer a preferred grain type into progeny. Eighty percent of these semidwarfs with good grain quality were locally developed. Ten agricultural experiment stations, India, 1975.

Resistance to at least one disease was an objective of 43% of the crosses; resistance to insects, an objective of 37% (Fig. 3). The breeders tended to use semidwarf rices for both characters (Table 3). The most frequent disease-resistance objectives included blast, bacterial blight, tungro virus and grassy stunt virus. Insect resistance was most commonly sought for brown planthopper and gall midge.

Among other biological stresses, drought resistance was sought in 9% of the crosses; cold tolerance in 9%; waterlogged-soil tolerance, in 7%; and deep-water tolerance, in 2%. Tall or intermediate-statured parents were used as donors for most of those characteristics. High tillering ability was an objective of 13% of the crosses (Fig. 3).

GENETIC COMPOSITION AND CHARACTERISTICS OF MOST WIDELY GROWN VARIETIES

Genetic composition

The flow of rice genes into varieties and onto farmers' fields was traced by analyzing the genetic composition of the most popular varieties in each region. Each of the 16 breeders at 12 research centers named the three main varieties grown on farmers' fields within the area served by his experiment station. For each rice named, a standardized "genetic data sheet" was completed on plant type, height, method of development, genetic composition, and the breeder's perceptions of the variety's genetic

strengths and weaknesses -- the traits that farmers considered good or bad about each rice.

Each hybrid's ancestry was traced. If a parent of a hybrid were itself a hybrid, its ancestors were identified and the incorporation of genes into the varieties was traced back several generations. At stations where more than one breeder were interviewed, each breeder named the three most popular varieties within a major subregion of the station.

The breeders cited 46 rices, which comprised 32 different varieties, as the most widely grown in 14 regions. Half of the rices cited were of the semidwarf plant type, 17% were intermediate-statured rices, and 33% were tall varieties (Fig. 5).

For eight of the 15 regions (53%), the locally developed semidwarf Jaya was named as one of three most widely grown varieties (Table 4). The second most popular variety was IR8, followed by two other semidwarfs, Ratna and IR20, and two intermediate-statured rices, Pankaj and Mahsuri.

Ninety-four percent of all varieties cited as most widely grown in the 15 regions were indicas (Table 5). Sixty-six percent were locally developed; 22% were introduced from IRRI; and 8% were introduced from another country. Sixty-three percent were hybrids, 19% were pureline selections, and 9% were unimproved.

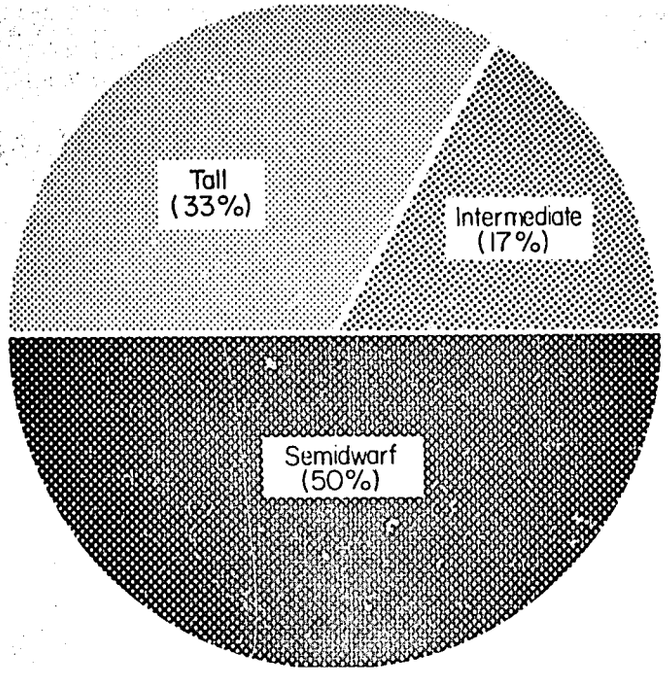

Fig. 5. When 16 rice breeders were asked to name the three varieties most widely grown on farmers' fields in the areas served by their experiment stations, half of the 46 citations were for semidwarf varieties. Twelve agriculture experiment stations, India, 1975.

Table 4. The 32 rice varieties cited by 16 Indian rice breeders as among 3 most widely grown by farmers in 15 regions of India, 1975.

Variety	Locations[a]	Genetic makeup	Origin	Regions where widely grown (%)
		Semidwarf varieties		
Jaya	Ker, Bih, Pun, W.B., U.P., I, NWI, I-irrig.	TN1/T141	Local	53
IR8	I-irrig., NWI, Bih, Pun	Dee-geo-woo-gen/Peta	IRRI	27
Ratna	U.P., NWI	TKM6/IR8	Local	13
IR20	T.N., W.B.	Peta[3]/TN1//TKM6	IRRI	13
IR24	U.P.	IR8///CP231/SLO-17// Sigadis	IRRI	6
Jyothi	Ker	Ptb 10/IR8	Local	6
Palman 579	Pun	IR579 (IR8/Tadukan)	IRRI	6
Pusa 2-21	W.B.	IR8/TKM6	Local	6
Triveni	Ker	Annapoorna[b]/Ptb 15	Local	6
Vaigai	T.N.	TN1/CO29	Local	6
Jagannath	Or.	Mutant from T141	Local	6
		Intermediate-statured varieti		
Pankaj	W.B., I-irrig.	IR5 (Peta/T. Rotan)	IRRI	13
Mahsuri	Or., I	Taichung 65/Mayang Ebos	Int. Rice Comm.	13
Bhavani	T.N.	C4-63 (Peta/BPI-76)	Phil.	6
China 972	Kas.	----[c]	China	6
China 988	Kas.	----	China	6
China 1039	Kas.	----	China	6
		Tall varieties		
BR34	Bih.	Pureline selection	Local	6
CO25	T.N.	CO4/ADT10	Local	6
CR10	Or.	T90/W 113	Local	6
EB17	Mah.	Pureline selection	Local	6
Kolamba 42	Mah.	Pureline selection	Local	6
Larbeoul	Kas.	Traditional	Local	6
Madew 3	Kas.	Unimproved	Local	6
Niver	Kas.	Unimproved	Local	6
NC1281	Or.	Pureline selection	Local	6
Patni	Mah.	Pureline selection	Local	6
Siga	Kas.	Unimproved	Local	6
T141	Or.	Pureline selection	Local	6
T1242	Or.	Pureline selection	Local	6
White Luchai	Mah.	Pureline selection	Local	6
Ziniya 149	Mah.	Pureline selection	Local	6

[a] I = grown across all India; I-irrig. = irrigated regions of India; NWI = Northeast India; Ker = Kerala state; Kas = Kashmir (2 regions); Mah = Maharashtra (2 regions); T.N. = Tamil Nadu; Or. = Orissa (2 regions); Pun = Punjab; Bih = Bihar; U.P. = Uttar Pradesh; W. B. = West Bengal.

[b] Annapoorna is from the cross TN1/Ptb 10.

[c] Neither the genetic makeup nor the method of development of China 972, China 988, and China 1039 could be determined.

Ninety-three percent of the 15 tall varieties were indicas. All originated in India. Sixty percent were pureline selections, 27% were unimproved, and 13% were hybrids (Table 5). None of the tall varieties were widely grown in more than one region, which indicates their high degree of location specificity (Table 4).

Table 5. Characteristics of 46 rices cited as among the 3 most widely grown varieties in farmers' fields in 15 regions of India. Sixteen breeders at 12 agricultural experiment stations, India, 1965.

	Varieties (%) widely grown			
	Tall	Intermediate	Semidwarf	All
Plant type				
Indica	93	75	100	94
Japonica	-	-	-	-
Indica/japonica	-	25	-	4
Indica/japonica	7	-	-	2
Origin				
Locally developed	100	-	65	66
Introduced from IRRI	-	25	35	22
Introduced from other country	-	50	-	8
International Rice Commission	-	25	-	4
Method of development[a]				
Unimproved	27	-	-	9
Pureline selection	[illegible]	-	-	19
Mutant	-	-	4	2
Hybrid	13	63	96	63

[a] The method of development of three introduced varieties (China 972, China 988, and China 1039) could not be determined, so the total percent for all varieties does not equal 100.

The eight citations for intermediate-statured rices were for six varieties (Table 4). Pankaj, a selection from IR5, and Mahsuri[1] were each cited in two regions. Bhavani, which is widely grown in Tamil Nadu state, southern India, is a selection of the Philippine variety C4-63.

[1] Mahsuri was developed with support from the International Rice Commission, an international cooperative rice improvement association established by the Food and Agricultural Organization (FAO) in 1949. During the 1940's several countries in tropical Asia sent seed of their best indica varieties for crossing with japonicas at the Central Rice Research Institute (CRRI), Cuttack, India. The F_1 were grown at CRRI and F_2 seed from each populations cross were sent to participating countries for further selection. Mahsuri was selected in Malaysia from such a cross.

Sixty-three percent of the intermediate-statured rices cited were hybrids (Table 5). The method of development was not determined for three intermediate-statured indicas -- China 972, China 988, and China 1039 -- introduced into Kashmir from China during the late 1940's. Seventy-five percent of the intermediate-statured rices were indicas and 25% were indica-japonica hybrids.

The 23 citations for semidwarfs represented 11 different varieties (Table 4) All were indicas, 96% were hybrids, and 4% were mutants. Sixty-five percent of the semidwarf rices were locally developed; the others were introduced from IRRI (Table 5). Of the seven locally developed rices, four were progeny of IR8 (Ratna, Jodhi, Pusa 2-21, and Palman 579); and three were progeny of TN1 (Jaya, Vaigai, and Triveni) (Table 4). Interestingly, Triveni, developed in Kerala state, southern India, was the only variety for which a locally developed semidwarf (Annapoorna) was used as the dwarf gene source. Annapoorna is a progeny of the cross TN1/Ptb 10. The only mutant cited was Jagganath. It is an induced mutant of the tall variety T141 (which is also a parent of Jaya). Jagganath is the only semidwarf variety that has neither TN1 nor IR8 in its ancestry.

On the basis of the total citations, TN1 appears in the ancestry of 62% of the semidwarfs. The reason may be the popularity of its progeny Jaya. But interestingly, despite its popularity in farmers' fields, Jaya does not seem to have been extensively used in the breeding programs (Fig. 2).

Genetic strengths and weaknesses

The reasons given by the breeders for the popularity of each of the 46 widely grown varieties were compiled and analyzed as their genetic strengths. The unfavorable traits of the varieties were compiled as their genetic weaknesses.

Yield potential was cited as a genetic strength, or a major reason for the popularity of 65% of the rices most widely grown across all of the areas (Fig. 6) Yield potential was cited as a genetic strength of 20% of the rices grown -- low yields were a major fault, but farmers grew the varieties for other reasons. Susceptibility to lodging was cited as a weakness of 33% of the rices.

Grain quality was considered a major reason for the popularity of 52% of the widely grown varieties; inferior grain quality was a genetic weakness of 24%.

Fifty-two percent of the popular rices had desirable growth duration. For half of those varieties, earliness was the preferred trait, but late and intermediate duration were preferred for the other half. For 11%, late growth duration was cited as a weakness.

Resistance to at least one disease was listed as a favorable trait for only 18% of the farmers' preferred varieties; susceptibility to disease was cited for 58%. The only specific diseases for which any of the varieties were cited as having resistance were blast (7%) and bacterial blight (4%). For 24%, blast susceptibility was cited as a weakness. Sheath blight, bacterial blight, helminthosporium, tungro, bacterial leaf streak, and grain smut were weaknesses in localized areas.

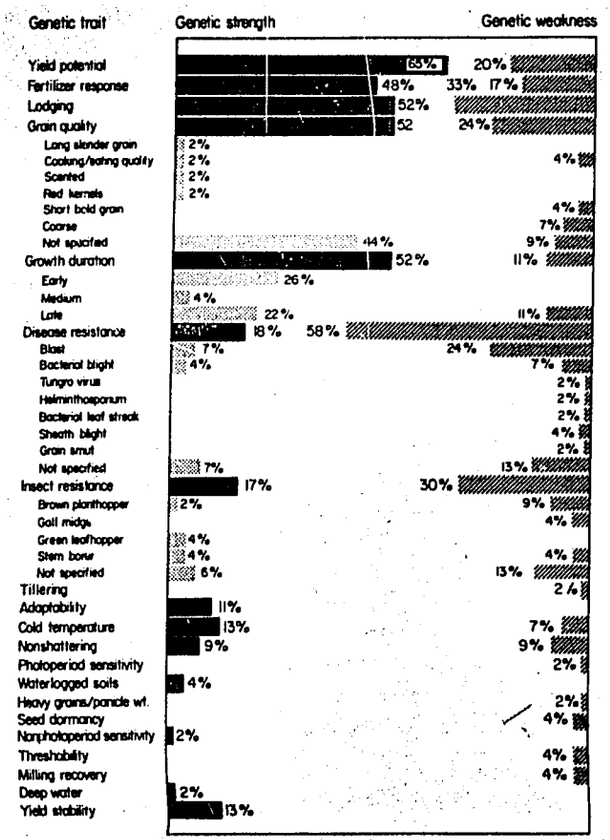

Fig. 6. The genetic strengths and genetic weaknesses of the 46 rices cited by 16 rice breeders as the most widely grown varieties in 15 regions of India, 1975.

Insect resistance was a favorable trait of 17% of the varieties; susceptibility was a weakness of 30%. Although susceptibility to gall midge was a weakness of 4% of the rices, none had resistance to it. Four percent had resistance to stem borers, 4% to green leafhoppers, and 2% to brown planthoppers.

Wide adaptability was a favorable trait of 11% of the varieties, and cold tolerance of 13%.

Genetic traits and plant height

To determine if specific genetic traits were more likely to be found among tall, intermediate, or semidwarf rices, the genetic strengths, or the favorable farmer characters, were analyzed on the basis of plant height.

Only 27% of the tall varieties were cited for high yield potential and none for good fertilizer response or lodging resistance (Table 6). But 87% of the semidwarfs were cited as having all three traits.

Sixty-seven percent of the tall varieties had good (locally preferred) grain quality. Only 47% of the semidwarfs and 38% of the intermediate-statured plants had good grain quality.

Eighty percent of the most widely grown tall varieties had favorable growth characteristics: 47% for lateness[1/] and 33% for earliness. Fifty-one percent

Table 6. Genetic strengths of the tall, intermediate-statured, and semidwarf rices cited as most widely grown on farmers' fields in 15 regions of India. Sixteen rice breeders at 12 agricultural experiment stations, India, 1975.

Genetic strength	Varieties (%) cited for genetic strength		
	Tall	Intermediate	Semidwarf
Yield potential	27	75	87
Fertilizer response	0	25	87
Lodging resistance	0	50	87
Grain quality	57	38	47
Long, slender	7	0	
Cooking/eating quality	0	0	4
Scented	7	0	0
Red kernel	0	0	4
Not specified	53	38	39
Growth duration	80	51	35
Early	33	13	26
Intermediate	0	0	9
Late	47	38	0
Disease resistance	20	13	18
Blast	7	0	9
Bacterial blight	0	0	9
Not specified	13	13	0
Insect resistance	13	0	26
Brown planthopper	0	0	4
Green leafhopper	0	0	9
Stem borer	0	0	9
Not specified	13	0	4
Waterlogged soils suitability	0	25	0
Adaptability	20	13	4
Cold tolerance	20	38	0
Nonshattering	13	25	0
Insensitivity to photoperiod	0	13	0
Deep water tolerance	0	13	0
Yield stability	0	0	26
Others	0	13	0

[1/] Seven of the 10 widely grown varieties that farmers preferred because of late maturity were tall; the others were of intermediate stature. Lateness was preferred in single-cropped monsoon areas where farmers do not want to harvest their crops until the rains end.

of the intermediate-statured rices had favorable growth duration: 38% for lateness and 13% for earliness. Of the 35% of the semidwarfs that had favorable growth duration, 26% had early, and 9% had intermediate duration.

Disease resistance was found in 20% of the tall varieties, 13% of the intermediates, and 18% of the semidwarfs. Blast and bacterial blight were the only diseases specified.

Insect resistance was cited for 13% of the tall varieties and for 26% of the semidwarfs.

Twenty-five percent of the intermediate-statured rices were considered good for waterlogged soils; none of the talls or semidwarfs were cited for this trait.

Cold tolerance was found in 20% of the tall varieties and 38% of the intermediate-statured rices. Thirteen percent of the tall rices and 25% of the intermediates were cited for nonshattering. No semidwarf was considered cold tolerant or nonshattering. Thirteen percent of the intermediates were suited to deep-water. Yield stability was cited for 26% of the semidwarfs, but for none of the tall or intermediate varieties.

THE GENETIC COMPOSITION AND CHARACTERISTICS OF NEWEST VARIETIES

To determine what types of rices are currently coming from India's rice breeding programs and becoming available to farmers, 14 breeders at 12 experiment stations were asked to name the newest variety released at each experiment station.

Genetic composition

For each variety named, genetic data were compiled similar to those for the crosses and for the most widely grown varieties. Eighteen new varieties were cited; 83% were semidwarfs and 17% intermediate-statured. Eighty-nine percent of the newest varieties were indicas (Table 7).

One variety from Kashmir, K78-13, was a japonica, and one, K-84, was a mutant of a Taiwanese ponlai variety. Two of the latest varieties were introduced from IRRI: IR24 was named locally as a variety in Uttar Pradesh and Palman 579 (the IRRI line IR579) was named in the Punjab (Table 8).

Eighty-nine percent were hybrids and 11% were mutants. CNM 25, developed in West Bengal, was a mutant of IR8, and K-84, from Kashmir, was a mutant of T65. One variety from Punjab, HM95, was classified both as a hybrid and as a mutant; it was selected from irradiated progeny of the cross Johna 349/TN1.

Four of the varieties had locally developed semidwarf parents (Table 8): Sabari was developed from a cross of IR8 with Annapoorna (which was developed from the cross TN1/Ptb 10); Vani and IET 1039 are both from crosses that involved both IR8 and semidwarf lines from the CR10 cross (T90/IR8); CO 39 had as a parent Kannagi, which is the varietal name in Tami Nadu state for Pusa 2-21 (IR8/TKM6).

Table 7. Characteristics of 18 newest varieties released by 12 agricultural experiment stations, India, 1975.

Characteristic	Plant height[a] (%)		All rices (%)
	Intermediate	Semidwarf	
	Plant type		
Indica	33	100	89
Indica/japonica	33		5.5
Ponlai	33		5.5
	Origin		
Locally developed	100	87	89
Introduced from IRR		13	11
	Method of Development		
Unimproved	-	-	-
Pureline selection	-	-	-
Mutant	33	7	11
Hybrid	67	93	89

[a] None of the newest varieties were tall.

Table 8. The 18 newest rice varieties developed at 12 agricultural experiment stations, India, 1975.

Variety	Region where named	Genetic makeup
		Semidwarf
CNM 25	West Bengal	IR8 mutant
Jyothi	Kerala	Ptb 10/IR8
Bharathi	Kerala	Ptb 10/IR8
Sabari	Kerala	IR8/Annapoorna[a]
OR 34-16	Orissa	TN1/TKM6
IR24	Uttar Pradesh[b]	IR8///CP231/SLO-17//Sigadis
Vani	CRRI	IR8/CR10-14[c]
IET 1039	Bihar	CR10-4103[c] //T90/IR8
Kalinga 1	CRRI	Dunghanshali/IR8
Kalinga 2	CRRI	Dunghanshali/IR8
Palman 579	Punjab[d]	IR579 (IR8/Tadukan)
HM 95	Punjab	Jhona 349/TN1 (hybrid mutant)
RP 4-14	AICRIP	T90/IR8
Pusa 2-21	IARI	IR8/TKM6
CO 39	Tamil Nadu	Culture 340/Kannagi[e]
		Intermediate-statured
K-78-13	Kashmir	Shi-ei/China 971
K-84	Kashmir	Mutant of T65
Karjat 14-7	Maharashtra	IR8/Ziniya 149

[a] Annapoorna is a semidwarf developed in Kerala state from the cross TN1/Ptb 10. [b] IRRI variety named locally. [c] The CR10 cross was T90/IR8, made at the Central Rice Research Institute. [d] IRRI line named locally as a variety. [e] Kannagi from the cross IR8/TKM6 is the varietal name in Tamil Nadu state for Pusa 2-21.

Thirteen of the 15 newest semidwarf varieties had IR8 in their ancestry and three had TN1. IR8 was a direct parent of 12 of the rices and an ancestor of three. TN1 was a direct parent of two of the newest varieties and was an ancestor of one (Table 9).

Table 9. The source of dwarf genes in 15 newest semidwarf varieties released in 12 agricultural experiment stations. India, 1975.

	Source of dwarf gene	
	Parent	Ancestor
CNM 25	IR8	
Jyothi	IR8	
Bharathi	IR8	
Sabari	IR8	TN1
IR24	IR8	
Vani	IR8	IR8
IET 1039	IR8	IR8
Kalinga 1	IR8	
Kalinga 2	IR8	
Palman 579	IR8	
HM 95	TN1	
RP 4-14	IR8	
Pusa 2-21	IR8	
CO 39		IR8
OR 34-16	TN1	

Genetic strengths and weaknesses

For all of the 18 newest varieties released at the 12 Indian research centers, yield potential, fertilizer response, and resistance to lodging were cited as genetic strengths or favored characteristics (Fig. 7).

A desired growth duration was a favored trait for 72% of the varieties; earliness for 61%, and intermediate duration for 11%. For 6%, late duration was cited as a weakness.

Grain quality was cited as a genetic strength of 61% of the new semidwarfs, and as a weakness of 23%. Red kernels were a favorable trait for 16%, all of which were from Southern India. Eleven percent had long, slender grain, and 6% had preferred cooking and eating characteristics. Short, bold grain was cited as a weakness of only 6%.

The breeders cited resistance to at least one disease as a favorable trait of 61% of the new rices, and disease susceptibility as a weakness of 73%. They

cited 22% of the rices as resistant to blast; 22% to bacterial blight; and 6% each to tungro and sheath blight. Blast and sheath blight susceptibility were each cited as a weakness of 22%; bacterial blight, tungro, bacterial leaf streak, and stem rot each as a weakness of 6%.

Fifty percent of the new varieties were resistant to at least one insect; 50% were susceptible. Although 22% of the varieties were resistant to green leafhoppers, leafhopper susceptibility was never cited as a weakness.

Seventeen percent were cited as resistant to stem borers and 22% as susceptible. Brown planthopper resistance was cited as a favorable trait of 6% and hopper susceptibility was a weakness of 17%. None of the new varieties had resistance to gall midge, although 11% were cited as susceptible.

Profuse tillering was cited as a strength of 39% of the new varieties, cold tolerance of 28%, good seedling vigor of 22%. Eleven percent each were cited as having drought resistance, adverse soils tolerance, high levels of protein, and wide adaptability.

Poor threshability was cited as a weakness of 11% of the new rices.

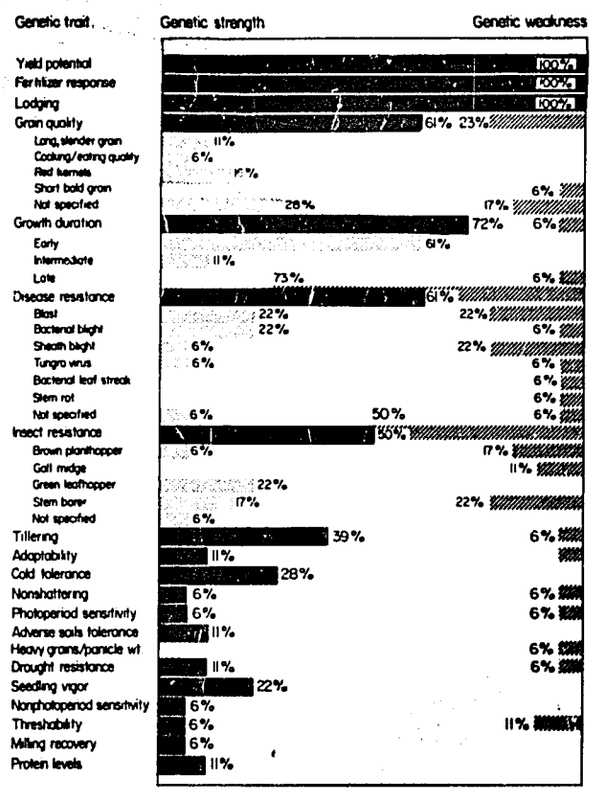

Fig. 7. The genetic strengths and weaknesses of 18 newest rice varieties released at 12 agricultural experiment stations in India, 1975.

COMPARISON OF WIDELY GROWN VARIETIES, NEWEST VARIETIES, AND BREEDING OBJECTIVES

The genetic strengths and weaknesses of the varieties that the breeders considered most widely grown by farmers were compared with those of the newest varieties released by the experiment stations and with the breeding objectives or the genetic traits that the breeders sought to incorporate into future varieties through their 1974-75 crosses.

Widely grown vs. new varieties

The breeders considered late growth duration as a favorable characteristic of 22% of the varieties widely grown by farmers, and earliness as a genetic strength of 26% (Table 10). Intermediate duration accounted for 4%. But earliness was by far the preferred growth-duration trait of the newest varieties -- earliness was a genetic strength of 61% and intermediate duration, of 11%. None considered late growth duration as a favorable trait, although lateness was cited as a weakness of 6%. Half of all of the 1974-75 crosses involved earliness as a breeding objective; 4% involved intermediate duration, and only 2% involved lateness.

Table 10. A comparison of the favored growth-duration, characteristics of the varieties cited as most widely grown by farmers, of the newest varieties released by experiment stations, and of the objectives of 1974-75 crosses. Sixteen breeders at 12 agricultural experiment stations, India, 1975.

	Varieties (%) preferred by farmers for			
	Earliness	Intermediate duration	Late duration	Total
Farmers'[a]	26	4	22[b]	52
Newest[c]	61	11	0[d]	72
Future[e]	50	4	2	56

[a] Varieties perceived by the breeders as most widely grown on farmers' fields within the areas served by their experiment stations (see Fig. 6). [b] Eleven percent cited lateness as a weakness. [c] See Fig. 7. [d] Six percent cited lateness as a weakness. [e] Objectives of the 1974-75 crosses (See Fig. 3).

There was a clear trend toward higher levels of disease resistance (Table 11). Only 18% of the farmers' varieties were considered resistant to at least one disease, while 58% were considered susceptible. Of the newest varieties, 61% were resistant to at least one disease, but susceptibility was a weakness of 73%. Forty-three percent of the 1974-75 crosses involved disease resistance. The greatest concern was with blast disease.

Seventeen percent of the farmers' varieties were cited as resistant to at least one insect, and 30% as susceptible (Table 12). Half of the latest varieties were cited as insect resistant and half as susceptible. Thirty-seven percent of the 1974-75 crosses were made for insect resistance.

Table 11. A comparison of the disease reactions of the varieties cited as most widely grown by farmers, of the newest varieties released by experiment stations, and of the objectives of 1974-75 crosses. Twelve agricultural experiment stations, India, 1975.

Disease	Varieties (%)				1974-75 crosses made for resistance[c]
	Farmers'[a]		Newest[b]		
	Resistant	Susceptible	Resistant	Susceptible	
Blast disease	7	24	22	22	24
Bacterial blight	4	7	22	6	17
Sheath blight	-	4	6	22	-
Bacterial leaf streak	-	2	-	6	2
Grassy stunt virus	-	-	-	-	11
Tungro virus disease	-	2	6	6	15
Helminthosporium	-	2	-	-	2
Grain smut	-	2	-	-	-
Stem rot	-	-	-	6	-
Not specified	7	13	6	6	22
Percentage of total rices[d]	18	58	61	73	43

[a] Varieties perceived by the breeders as most widely grown on farmers' fields within the areas served by their experiment stations (see Fig. 6). [b] See Fig. 7. [c] Breeding objectives (see Fig. 3). [d] Refers to the percentage of each category that is resistant or susceptible to at least one disease.

Table 12. A comparison of the insect reactions of the varieties cited by 16 rice breeders as most widely grown by farmers, of the newest varieties released by experiment stations, and of the objectives of 1974-75 crosses. Twelve agricultural experiment stations, India, 1975.

Insect	Varieties (%)				1974-75 crosses made for resistance[c]
	Farmer's[a]		Newest[b]		
	Resistant	Susceptible	Resistant	Susceptible	
Green leafhopper	4	-	22	-	7
Stem borer	4	4	17	22	2
Brown planthopper	2	9	6	17	15
Gall midge	-	4	-	11	11
Not specified	7	13	6	-	22
Percent of total rice[d]	17	30	50	50	37

[a] Perceived by the breeders as the most widely grown on farmers' fields within the areas served by their experiment stations (see Fig. 6). [b] See Fig. 7. [c] Breeding objectives (see Fig. 3). [d] Refers to the percentage of each category that is resistant or susceptible to at least one insect.

The fact that the breeders tended to cite disease and insect susceptibility as a weakness of a variety more than to cite resistance as a strength seems to indicate a strong concern with the incorporation of pest resistance into varieties.

The percentage of the latest varieties that were rated as resistant to specific diseases or insects was often higher than the percentage of the 1974-75 crosses that were made for resistance to that pest. That may illustrate a weakness of the method of comparison: the newest varieties represent the best material selected from the crosses of at least 5 years ago. But the objectives of the 1974-75 crosses represent an average of the total. Thus, although only 37% of the 1974-75 crosses were made for insect resistance, the best progeny lines may be selected partly on the basis of their resistance, so a higher percentage of the varieties released around 1980 could have insect resistance.

Breeding objectives and breeders' perceptions of environment and pest problems

The breeders' perceptions of the extent and severity of environmental and pest problems that face farmers in their fields were measured and compared with the breeding objectives. First, each breeder rated, in the order of severity, the four most serious environmental or biological problems (drought, cold, injurious soils, diseases and insects, etc) that limit farmers' rice yields within the area served by each experiment station. Following that, each breeder rated, in the order of severity, specific insect and disease pests.

The comparison gives an idea of the degree to which the breeding programs are oriented to overcoming production constraints through genetic manipulation, or the developement of specially adapted varieties. It may also indicate the areas for which the scientists most need improved breeding materials.

Every breeder rated diseases and insects as being among his four major environmental problems (Table 13). Pests received a mean severity rating of 3.1 on a scale where 4 was the most serious factor and 1 was the fourth most serious. In making half of the crosses, the breeders hoped to incorporate into future varieties genetic resistance to at least one disease or insect.

In 75% of the regions, drought was considered one of the major biological or environmental problems. Drought received a mean severity rating of 2.4 out of a possible 4. But only 9% of the randomly selected crosses involved the incorporation of drought resistance.

Excessive monsoon cloudiness and injurious soils were both rated as major constraints in 69% of the areas, but none of the crosses analyzed were made to confer tolerance to these factors into future varieties.

Cold temperature was rated as a problem in 31% of the areas, and received the second highest severity rating, 2.8. That indicates that cold was considered quite serious in those areas where it was a problem. Nine percent of the crosses were for cold tolerance.

Waterlogged soils are an interesting problem. Also called "ill-drained

Table 13. A comparison of rice breeders' perceptions of the biological or environmental factors that most limit rice production on farmers' fields within the areas served by their experiment stations and the percentages of crosses for resistance to each problem area (breeding objectives). Sixteen breeders at 12 experiment stations, India, 1975.

Biological/environmental factor	Areas (%) where factor was a major constraint[a]	Mean severity rating[b]	Crosses (%) made for resistance[c]
Diseases and insects	100	3.1	50[d]
Drought	75	2.4	9
Deep water	6	2	2
Floods	19	2	0
Cold temperature	31	2.8	9
Hot temperature	0	0	0
Waterlogged soils	13	2.5	7
Excessive monsoon cloudiness	69	2.5	0
Injurious soils	69	2.1	0

[a] Percent of 16 rice breeders that rated each stress as one of the four most serious problems limiting production on farmers' fields in the regions served by each experiment station. [b] On a scale of 1-4: 4 = most serious stress, 1 = fourth most serious stress. [c] Determined by analyzing genetic traits that breeders at 10 experiment station sought to incorporate into future varieties through 46 randomly selected crosses made in 1974-75 (see Fig. 3). [d] Refers to the 20% of crosses in which at least one parent was used to transfer resistance to at least one disease or insect into progeny, plus the 30% that involved both disease and insect resistance.

soils" or "stagnant soils," the term refers to regions, mostly in the coastal areas of the Indian subcontinent, where stagnant water up to 1 m in depth stands throughout the monsoon season. Although not in the list of environmental stresses, waterlogged soils were indicated under the category *other stresses* in 13% of the regions. Seven percent of the crosses were made for suitability to waterlogged soil conditions.

The breeders' perceptions of the major disease and insect problems within the areas served by the experiment stations are compared with their breeding objectives in Table 14. The most widespread field pest was bacterial blight -- the disease was named as one of the four major pests on farmers' fields in 75% of the areas. It received a severity rating of 2.8 out of a possible 4. Seventeen percent of the crosses involved bacterial blight resistance as an objective.

Stem borers were the next most widespread pest problem. Sixty-nine percent of the breeders cited stem borers as a major problem, with a mean severity rating of 2.8. But only 2% of the crosses were made for stem borer resistance (the low rate emphasizes the fact that virtually no truly resistant germ plasm is available to breeders for stem borer resistance).

Table 14. A comparison of rice breeders' perceptions of the major diseases and insects that limit rice production on farmers' fields and the percentages of crosses made for resistance to each pest. Sixteen breeders at 12 experiment stations, India, 1975.

Pest	Areas (%) where pest was a major constraint[a]	Mean severity rating[b]	Crosses (%) made for resistance[c]
Green leafhopper	-	-	7
Stem borer	69	2.8	2
Brown planthopper	44	2.4	15
Army worm	6	1.0	0
Gall midge	44	3.4	11
Gandhi bug	6	2.0	0
Blast disease	50	2.9	24
Bacterial blight	75	2.8	17
Tungro	25	2.2	15
Grassy stunt virus	6	1	11
Sheath blight	13	3.5	0
Helminthosporium	13	1	2
Glume blotch	6	3	0
Stem rot	6	3	0
Sheath rot	6	2	0
Bacterial leaf streak	0	0	2

[a] Percent of 16 rice breeders that rated each pest as one of four most serious pest problems limiting production on farmers' fields in the regions served by each experiment stations. [b] On a scale of 1-4; 4 = most serious insect or disease pest, 1 = fourth most serious pest. [c] Determined by analyzing genetic traits that breeders sought to incorporate into future varieties through 46 crosses at 10 experiment stations.

Blast, cited as a problem in half of the regions, received a 2.9 severity rating and resistance to it was the most frequent pest-resistance objective; 24% of the crosses involved blast resistance.

Gall midge was cited as a serious problem in 44% of the regions. It received a high severity rating (3.4), which indicates that although it is not serious in all parts of India, it is considered one of the worst problems in the regions where it prevails. Eleven percent of the crosses were made for gall midge resistance.

The brown planthopper was a problem in 44% of the areas, received a 2.4 severity rating, and was an objective of 15% of the crosses.

Although sheath blight received the highest severity rating (3.5), it was reported in only 13% of the regions. None of the crosses analyzed involved sheath blight resistance.

Comparison of rice-growing conditions, breeding efforts, and latest varieties

To obtain another measurement of the relevance of the overall breeding programs in providing the genetic technology that farmers need, each breeder was asked three questions about local rice-growing conditions.

1. What percentage of the rice grown on farmers' fields within the area served by your experiment station is irrigated, rainfed lowland, upland, and deep-water or floating?

2. What percentage of your professional time is spent in the improvement of irrigated, rainfed lowland, upland, and deep-water or floating rice?

3. What percentage of all varieties released by your station over the past 5 years is suited for each of the four rice-growing conditions?

To eliminate bias, the three questions were dispersed in the questionnaire.

Responses to the questions were then compiled, averaged, and compared. Time spent on rice improvement and the new varieties released by the stations matched fairly well except for the closely related irrigated and rainfed rice (Table 15).

Table 15. A comparison of the breeders' perceptions of the rice-growing conditions of farmers in the regions served by experiment stations; the percentages of research efforts that rice breeders devote to the same categories of rice-growing conditions; and the varieties released over the past 5 years. Sixteen rice breeders at 12 experiment stations, India, 1975.

Item compared	Rice-growing conditions (%)			
	Irrigated	Rainfed lowland	Upland	Deep water/ floating
Farmers' fields	41	40	14	5
Scientists' research efforts	67	19	10	4
Newest varieties[a]	54	33	11	2

[a] Released over the past 5 years.

SOCIOLOGICAL AND EDUCATIONAL CHARACTERISTICS OF RICE BREEDERS

The mean age of the 16 Indian rice breeders interviewed was 42.7 years. They had an average of 15 years of professional experience, not counting academic training.

Fifty-six percent of the breeders came from agricultural backgrounds, i.e., they grew up in families that derived more than half of their total income

from agricultural sources. Of those families, 60% owned their own land and rented at least part of it to tenant farmers. Forty percent owned and cultivated their own land. None of the breeders came from tenant-farmer or agricultural-laborer families (Table 16).

Eighty-nine percent of the breeders worked only with rice; 11% worked both with rice and with other crops.

Each breeder indicated the percentage of his professional work time spent in several areas. They spent 73% of their work time in research; at least 54% was in breeding-related activities, and 10% in administrative work (Fig.

To determine professional work orientations, 11 breeders were asked to indicat their first and second preferences for the types of work that they would prefe to be doing in 10 years, considering their educational backgrounds, work experience, and career interests. All of the breeders indicated remaining in rice breeding as a preference; 36% listed fundamental or basic research as a preference. Only 18% wanted to become administrators; 18% wanted to go into extension work, and 18% into applied or adaptive research other than plant breeding. Nine percent indicated teaching or training as a preference.

Similarly, the breeders were asked the types of organizations with which they would pefer to be working in 10 years. Sixty-seven percent indicated a government research organizatin as one of their two preferences; 58% listed a nonprofit international research organization; 48%, an agricultural college or university; 8%, a private company, business or industry; and 8%, a government

Table 16. Sociological characteristics of rice breeders in India. Eighteen scientists at 12 agricultural experiment stations, India, 1975.

Characteristics	Average measurement
Age	42.7 yr
Professional experience[a]	15 yr
Background[b] (%)	
Agricultural	56%
Nonagricultural	44%
Source of family's agricultural income[c] (%)	
Owned land and rented all or part to tenants	60%
Owned and farmed their own land	40%
Rented farmland from landlord	0%
Worked as agricultural laborers	0%

[a] Excludes experience gained during academic training. [b] If during each scientist's youth, more than half of his family's income derived from agricultural sources, his background was considered agricultural. [c] Refers only to the families of the 10 breeders from agricultural backgrounds.

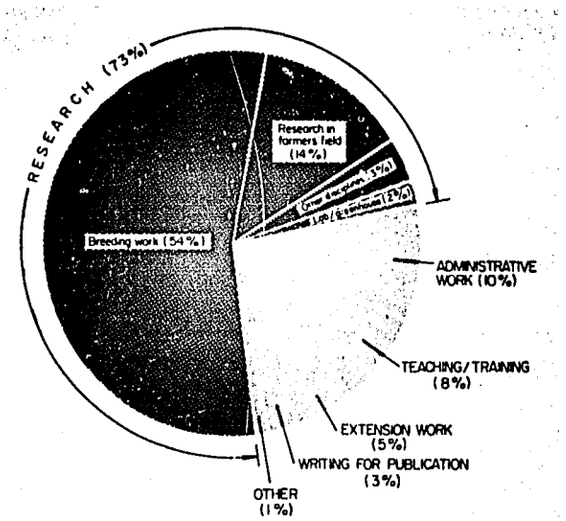

Fig. 8. Allocation of professional time of rice breeders among different types of work. Sixteen rice breeders at 12 agricultural research centers, India, 1975.

extension service. Interestingly, none of the breeders listed farming as one of their two preferences.

Education and travel

All of the breeders interviewed had at least B.S. degrees, 94% had M.S. degrees, and 44% had Ph.D.'s (Table 17). All of those whose highest level of education was a B.S. or M.S. had acquired their degrees from universities or colleges in India. But half of the Ph.D.'s held doctoral degrees from universities in Japan, Canada, England, or the U.S. Eighty-eight percent of the Ph.D.'s had degrees in plant breeding or genetics.

Table 17. The academic degrees, place of training, and disciplines of Indian rice breeders. Eighteen rice breeders, 12 agricultural experiment stations, India, 1975.

		Indian rice breeders (%)			
		Country where educated		Discipline	
Academic degrees	Highest degree attained	Locally	Highly developed nations[a]	Plant breeding/ genetics	Other scientific discipline
B.S.	100	100	0	11	89
M.S.	94	100	0	47	53
Ph.D.	44	50	50	88	12

[a] Japan, Canada, England, and the U.S.A.

Sixty-seven percent of the breeders had participated in at least one nondegree training course related to rice. Those who had participated in such courses had attended an average of 1.75 courses.

Sixty-seven percent of the breeders who had taken nondegree training had attended courses at IRRI or both at IRRI and at other institutions; 33% had attended training courses in India or other nations.

Fifty-five percent of the breeders had traveled outside India for professional purposes at least once during the previous 5 years (Table 18). Those who had traveled averaged two trips each. Most of their travel was to attend professional conferences, educational or training programs, or to confer with professional colleagues.

Table 18. The cosmopolitanism of Indian rice breeders as determined by their international travel. Eighteen rice breeders at 12 agricultural experiment stations, India, 1975.

	Trips abroad	
	no.	%
Traveled abroad[a]	10	55
Trips (av. no./scientist)	2[b]	
Purpose of last trip abroad[a]		
Professional conference	3	30
Education/training	3	30
To acquire new genetic materials	1	10
To confer with professional colleagues	3	30
Basis of selection[c]		
Selected by administrator	5	56
Direct invitation from professional conference	1	11
Direct invitation from international research center	2	22
Other	1	11

[a] During the past 5 years. [b] Average number of trips computed for the 10 breeders who had traveled abroad over the past 5 years. [c] Nine respondents.

Attitudes toward IRRI naming of rice varieties

In general, the rice breeders in India were opposed to the naming of rice varieties by IRRI (such as IR8 and IR26). Sixty-seven percent felt that IRRI should stop naming varieties and only send out genetic materials for local scientists to test or use as parents in crosses and, if they desire, to name as varieties[1] (Table 19). All of the 22% who felt that IRRI should continue to name varieties were at state-level stations.

[1] In late 1975, IRRI announced that it would discontinue its policy of naming rice varieties and would concentrate instead on sending out experimental lines for scientists in the national programs to use as parent materials or to test and name locally as varieties.

Table 19. Attitudes of Indian scientists toward the naming of rice varieties by the International Rice Research Institute. Eighteen rice breeders at 12 experiment stations, India, 1975.

Opinion	Indian scientists	
	no.	%
IRRI should stop naming varieties and only send genetic material for testing/naming to the national programs	12	67
IRRI should continue to name varieties as well as to send material to the national programs	4	22
No opinion	2	11

REFERENCES

Chandler, R.F. 1976. The physical and biological potentials and constraints in meeting world food needs. Paper presented at the World Food Conference, World Food Institute, Iowa State University, Ames, Iowa.

Huang, C.H., W.L. Chang, and T.T. Chang. 1972. Ponlai varieties and Taichung Native 1. Pages 31-46 *in* International Rice Research Institute, Rice Breeding. Los Baños, Philippines.

International Rice Research Institute. /n.d./ Annual report 1961-62. Los Baños, Philippines. 55 p.

International Rice Research Institute. 1974. Research highlights for 1973. Los Baños, Philippines. 62 p.

International Rice Research Institute. 1975. Changes in rice farming in selected areas of Asia. Los Baños, Philippines. 377 p.

Jennings, P.R. 1974. Rice breeding and world food population. Science 186 1085-1088.

Other papers in this series

No. 1	Recent studies on rice tungro disease at IRRI
No. 2	Specific soil chemical characteristics for rice production in Asia
No. 3	Biological nitrogen fixation in paddy field studies by in situ acetylene-reduction assays
No. 4	Transmission of rice tungro virus at various temperatures: A transitory virus-vector interaction
No. 5	Physicochemical properties of submerged soils in relation to fertility
No. 6	Screening rice for tolerance to mineral stresses
No. 7	Multi-site tests environments and breeding strategies for new rice technology
No. 8	Behavior of minor elements in paddy soils
No. 9	Zinc deficiency in rice: A review of research at the International Rice Research Institute

The International Rice Research Institute
P.O. Box 933, Manila, Philippines

Stamp

ISSN 0115-3862