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THE GENETIC CONSERVATION PROGRAM OF IRRI

An in-depth report on the
Genetic Conservation Program and the
Genetic Evaluation and Utilization (GEU) Program

and

plans for extending the
conservation operations into
the next decade

THE INTERNATIONAL RICE RESEARCH INSTITUTE
Los Baños, Laguna
Philippines

December, 1974

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1. Introduction

While the Institute was being built and staffed, the establishment of a rice germ plasm collection was conceived as one of the unique services that IRRI could perform for the rice-growing countries of the world (Chandler, 1961). With many national and international institutions extending full cooperation, a large varietal collection of 9,000 accessions was assembled within a few years and the Institute soon played a vigorous role in the exchange of rice germ plasm. While the Institute is the principal beneficiary of its seed bank, seeds drawn from its germ plasm bank lend great impetus to varietal improvement programs in many countries. The willingness of nearly every rice research institution of the world to deposit its varietal collection with IRRI reflects not only confidence in IRRI's capacity to preserve gene-pools but also satisfaction with IRRI's services in the distribution and exchange of genetic materials.

Although IRRI has become widely known as a world-wide genetic resources center for the rice crop, its physical facilities and technical personnel do not adequately meet the needs of the vastly expanded activities of the seed bank. It is time to re-examine IRRI's genetic conservation and evaluation programs, with the ultimate aim of further increasing its effectiveness in serving the diverse needs of many production areas. This report will provide the foundation for designing improvements on a decade-long basis.

2. Progress of the Genetic Conservation Program

a. Scope of germ plasm in the IRRI seed bank prior to 1972

Prior to 1972, IRRI acquired seed stocks mostly from national and state research institutions and only occasionally from plant explorers or farmers. By the end of 1971, IRRI had 19,374 cultivars of *O. sativa*, 263 strains of *O. glaberrima*, 316 genetic testers, and 1,037 strains of wild taxa. In its geographic coverage, the IRRI collection of rice cultivars represented fairly adequately the national collections of Japan, Malaysia, Philippines, Taiwan, South Vietnam, and the U.S.A. but was rather deficient in the cultivars of Bangladesh, Burma, mainland China, India, Indonesia, Laos, Nepal, Pakistan, Sri Lanka, Thailand and Vietnam. In terms of varietal diversity, the IRRI collection shared the same weakness of most national collections: it had adequate coverage of the major commercial cultivars and improved varieties but poor coverage of the minor varieties, primitive (unimproved) forms, and special types (Chang, 1972a). It was also deficient in the African rices and the wild taxa.

b. Progress in field collection during 1972-1974

The field collection programs received full cooperation from the national governments concerned and financial support from The Rockefeller Foundation, the Ford Foundation, USAID, and the ODA. Assisted by IRRI's out-reach projects, IRRI and the collaborating national centers acquired 12,837 seed samples from farmers' fields in 12 countries during the period from 1971 to the end of December 1974 (Table A). Moreover, about 1,220 seed stocks were gathered from widely scattered rice experiment stations in Bangladesh, Burma, and Khmer and deposited in the national center. The IRRI staff participated in the field collection programs in the remote areas of Bangladesh, Burma, Indonesia, Khmer, and Sri Lanka. It gave technical assistance to the collection operations in Laos, Malaysia, Nepal, Pakistan, Philippines, South Vietnam, and Thailand. Forty-six samples of wild taxa were also collected (Table B). FAO/UNDP rice experts in Liberia collaborated with IRRI on the collection of the African rices.

During the same period IRRI intensified its efforts in canvassing the existing collections of many strategically located rice experiment stations and succeeded in channelling the remnant collections into the IRRI seed bank. About 4,550 accessions were added to the Institute bank by correspondence.

In the field collection program, emphasis was given to special areas where one or more ecological factors limit rice production. The collection teams obtained more than 3,900 samples known to have resistance or tolerance to salinity problem soils, cool temperatures, drought, deep water, or prolonged submergence (Table B). The true quality of such special types need to be verified, however.

By the end of 1974 IRRI's germ plasm bank had 35,000 cultivars and a second collection of 3,000 entries, consisting of African rices, genetic testers, and wild taxa.

c. Assistance to other facets of different national conservation programs

The 32-page Manual for Field Collectors of Rice (Chang et al., 1972) was widely used in the national field collection programs. A comprehensive manual on genetic conservation, evaluation, and utilization is being prepared for the use of workers in national programs. A decimal code system for the growth stages of cereals (Zadoks, Chang and Konzak, 1973) has been published and widely reprinted in several field crop newsletters.

National rice catalogs in India and Malaysia adopted the format of the IRRI variety catalog (IRRI, 1970).

IRRI has trained genetic stock officers for Bangladesh, Malaysia, Pakistan, and Thailand and will continue the resident training program at Los Baños.

IRRI assisted Burma and Indonesia in acquiring refrigerated seed storage facilities. Its staff has also advised several national centers on the procedures and physical facilities required for genetic conservation programs.

IRRI's assistance in these areas is designed to improve the capability of the national research centers in continuing their genetic conservation efforts.

3. Progress of the Genetic Evaluation and Utilization (GEU) Program

a. Promising sources of resistance or tolerance identified at IRRI

Systematic screening for resistance to an important pest began with the screening for resistance to the blast pathogen in 1962 at IRRI. This was soon followed by testing for resistance to the stem borers, the bacterial blight, the tungro virus, and the leafhoppers. From the early 1970's, several research departments began the systematic screening for tolerance to the yield-limiting, ecologic, and edaphic factors. The present GEU program includes 32 problem traits under systematic evaluation.

Table C shows the progress in different facets of the GEU program. The magnitude of screening each problem trait, the status of the evaluation program, and the sources of resistance or tolerance that were identified are given in the Appendices.

Table C does not show the magnitude of the screening tests of the breeding lines, however. About 30,000 to 35,000 lines are annually tested under many facets of the GEU program, especially for their reactions to the diseases and insects and for quality evaluation.

The largest numbers of accessions have been screened for reaction to bacterial blight when the cultivars were grown in the seed increase and characterization plots each season. Nearly one-half of the total collection have been screened for protein and lysine contents, resistance to blast, and resistance to the striped stem borer. The tests for virus resistance, drought resistance and tolerance, hopper resistance, and tolerance to adverse problem soils can be greatly expanded when additional space and facilities are made available to IRRI. Reactions to certain diseases and insects, tolerance to adverse edaphic factors, floating ability, and tolerance to cool temperatures — factors not present at Los Baños — can be more effectively evaluated outside IRRI under the network of coordinated international variety testing programs. The newly built phytotron will add new dimensions to IRRI's search for useful genes in coping with climatic factors and their interactions with biotic or edaphic factors.

Many outstanding sources of resistance to a specific disease or insect have been found. Although the resistant varieties often are many, genetic studies indicate that non-allelic genes for resistance are rather few. For instance, only three loci are known for the resistance to the green leafhopper (Nephotettix virescens), two for the brown planthopper (Nilaparvata lugens), and two for bacterial leaf blight. In the case of the grassy stunt virus, a dominant gene for resistance in O. nivara is the only known source among 5,000 cultivars and more than 100 wild taxa included in the testing program. The recessive semidwarfing gene from Dee-geo-woo-gen of Taiwan is the only one being extensively used in rice breeding programs of many nations because more than 10 semidwarf varieties or mutants originating in India, Burma, and China share the same locus. It is therefore urgent that more diverse sources of useful genes be identified and this can be done only by expanding the collection and evaluation operations.

b. Contribution of IRRI's seed bank services and GEU findings to national rice research programs.

Although IRRI is the immediate beneficiary of its seed bank and GEU operations, many national rice research programs have also benefited from IRRI's services and findings. Table D shows the volume of seed packages being requested and sent abroad. From seeds supplied by IRRI, Taichung Native 1 and Tainan 3 spearheaded the acceptance of the new plant type in India. Two U.S. selections were tested and named varieties in the Dominican Republic. Kaohsiung 21 of Taiwan became a recommended variety in southern Brazil. Seeds drawn from the IRRI germ plasm bank have restored thousands of varieties to the national collections of Indonesia, Malaysia, Sri Lanka, South Vietnam, and Tanzania (Chang, 1972b).

The outstanding resistance of blast found in several tropical varieties and the grassy stunt resistance in a wild relative would not be available to rice breeders if these strains had not been preserved by foreign institutions.

To an even greater extent, IRRI-identified sources of disease or insect resistance were extensively utilized in several national breeding programs. The finding of outstanding sources of resistance or tolerance has prompted several national rice research centers to undertake similar evaluation activities. Such efforts, along with IRRI's, are being coordinated and systematized under the network of coordinated trials.

c. Proposed measures to improve the efficiency of GEU operations and to facilitate information retrieval

While IRRI's GEU activities have yielded many useful sources of resistance or tolerance for individual traits, several measures should be adopted to increase the effectiveness of the GEU program. Along with the accumulation of information about the geographic distribution of resistance or tolerance, newly received samples can be sorted out by place of origin and associated ecological conditions. Such information could be channelled into a specific evaluation program. This approach will reduce the number of accessions to be tested in any one program and will also lead to more speedy findings. Such a measure is being implemented for special types which are known to be tolerant to an ecologic factor (stress) or edaphic problem. It should be extended to cover a specific disease or insect whenever applicable.

Every IRRI accession that has been identified as having resistance (or tolerance) to one trait or another should be completely tested and listed for its reaction to other pests and problems so that findings from different testing programs can be collated. Although such an effort has been done for the morpho-agronomic traits, the blast, and bacterial blight reactions, and the stem borer resistance of 8,628 accessions in the first IRRI variety catalog (IRRI, 1970), a computer program should be established to cope with the multiplicity of resistances and tolerances being covered in the GEU program. Such an information recording and retrieval system would also help in reducing the number of accessions to be tested for any particular trait and in disseminating the findings to rice researchers in foreign lands. The tables in the Appendixes are preliminary steps leading to the multiple listing of reactions.

Attention shall be given to developing an efficient way of identifying and eliminating the most likely duplicate samples -- a situation arising from the collection of indigenous germ plasm by many extension workers in adjacent areas within a country or an island. IRRI will explore biochemical techniques that will facilitate the identification of duplicate accessions, possibly in cooperation with a university or universities in the U.K.

We also need to collaborate with other gene banks and data banks in improving the biological and biometrical aspects of genetic conservation. IRRI will seek the assistance of FAO/IBPGR and the cooperation of other international organizations in sharing the work load of seed rejuvenation and storage. The USDA researchers have agreed in principle to rejuvenate and maintain the temperate zone varieties in the U.S. collection. Regional rice research centers, such as IITA, CIAT, and an agency in Japan will be approached to assist IRRI on the seed increase of stocks which are not adapted to Los Baños conditions. In addition to the U.S. National Seed Storage Laboratory at which 18,780 duplicate seed samples have been deposited, other gene banks will be asked to assist in the storage of duplicate seed samples.

IRRI is willing to serve national centers in tropical Asia by storing their duplicate seed samples. Similar services may be extended to other cereals or grain legumes maintained by regional genetic resources centers in Southeast Asia.

4. Anticipated Needs for Additional Germ Plasm

By the end of 1974 various rice production areas in tropical and subtropical Asia will be systematically canvassed, except for the following:

1) Bangladesh - transplanted aman and floating varieties with special features; wild species.

2) Burma - hilly areas of the Chins, the Shans, the Kayahs, the Kashins, and the Mons for hill rices; wild species.

3) China - areas little collected in the past.

4) India - remote areas in the sub-Himalayan region (Kashmir, Jammu, H.P., W.Bengal), central India (Ranchi of Bihar, Rewa of M.P., west Orissa, north and west Andhra), Dangs and Konkan, for minor varieties tolerant to adverse ecologic or edaphic factors; wild species.

5) Indonesia - upland varieties of west Java, central Java, east Java; upland types on Kalimantan, Sulawesi, Nuga Tenggara (islands east of Bali) and West Irian; tungro-resistant lowland varieties; wild species.

6) Khmer - areas controlled by the Khmer Rouge; floating varieties planted along the shores of the Tonle Sap lake; wild species.

7) Laos - hilly areas controlled by the Pathet Lao for hill rices; wild species.

8) Nepal, Sikkim and Bhutan - high-elevation areas or special types.

9) Pakistan - Swat Valley for cold-tolerant types; Sind district for salinity--and alkalinity-tolerant types, or heat-tolerant types.

10) Thailand - hilly areas in the north and northeast for hill rices; floating varieties with special features; Khorat area for saline- and alkaline-resistant types; wild species.

11) Malaysia - mainly in the hills of Sarawak for hill rices; northern part of West Malaysia for tungro-resistant varieties.

12) North Vietnam - areas not covered in the past.

13) South Vietnam - remote areas for varieties tolerant to acid-sulfate soil, salinity, or deep water; wild species.

14) Sri Lanka - Yala season varieties; cultivars that are tolerant to iron toxicity, drought, or salinity.

15) West Africa - O. glaberrima races; O. sativa cultivars of special ecological merit or tolerant to iron toxicity and phosphorus deficiency.

Aside from the above geographic areas, much remains to be sought from special ecologic niches in various areas for the following traits or types:

1) Tolerance to salinity;

2) Tolerance to extremely acid soils, either under flooded or mesic conditions;

3) Tolerance to soil alkalinity;

4) Tolerance to submergence;

5) Floating ability;

6) Tolerance to cool temperatures;

7) Drought resistance and tolerance;

8) Resistance to the leafhoppers and planthoppers;

9) Resistance to the virus diseases especially grassy stunt and yellow dwarf;

10) Resistance to presently minor fungus diseases, such as the brown leaf spots, stem and sheath rots, and false and kernel smuts which may gain importance in the future;

11) Resistance to presently minor insect pests, namely, several species of leafhoppers and planthoppers, rice hispa, thrips and root aphid;

12) Tolerance to iron deficiency or zinc deficiency;

13) Tolerance to pollutants;

14) Wild relatives of O. sativa and O. glaberrima.

While geographic regions and areas with specific ecologic restraints such as soil salinity and cool temperatures are largely known and can be canvassed comprehensively, sources of resistance to most of the minor pests or to some of the insect pests are not necessarily present in areas where the disease or insect is endemic. Thus both endemic and non-endemic areas shall be covered in future collections.

IRRI and the countries concerned will re-collect special types in certain area where preliminary evaluation has yielded promising sources of desired traits. Potentially promising areas are Bangladesh, Burma, India, Indonesia, Malaysia, and Vietnam.

The above plan for future collection is aimed at broadening the geographic coverage of conserved materials as well as at expanding the genetic base of the varietal collection. A wider genetic base is essential in coping with genetic changes within a pest or with shifts in the prevalence among different pests.

Moreover, the completion of the IRRI phytotron allows refined studies on cold tolerance, heat tolerance, thermoperiodicity, and interaction among physical environmental factors related to water economy.

For countries with ample technical manpower such as China and India, field collection can be executed by national research centers with IRRI collaborating at the planning phase. For most of the other countries, IRRI's direct participation will be a continuing necessity to sustain the impetus generated.

A tentative plan for IRRI's further efforts in field collection is summarized in Table E. Both the geographic areas and projected targets are expected to increase as IRRI researchers continue to identify promising materials from the collected samples.

We expect the size of IRRI's germ plasm bank to grow to a total between 60,000 and 80,000 accessions within the next decade.

5. Projected Needs for Seed Processing and Storage Facilities and for Technical Personnel

IRRI's field collection activities have outgrown its existing facilities and manpower for genetic conservation. During 1973-74 it did not have sufficient field space to plant all the collected samples. Thousands of collected samples are being temporarily stored. The medium-term cold storage room (36 sq m) -- good for 15 to 20 years of seed longevity -- is completely filled with seed samples of 22,000 accessions (250 g./accession) and 77 large cans of 4,000 breeding lines each. The short-term seed laboratory (216 sq m) -- good for 3 to 5 years of seed longevity -- is becoming so crowded that the storage of bulk samples has been shortened from 3 years to 2 years. Moreover, seeds of about 6,780 accessions in the medium-term storage room are more than 10 years old -- estimated to be 5 years away from the point of rapid deterioration in seed viability (Roberts, 1960). Seed viability is definitely deteriorating among the temperate-zone varieties (Table F). Seed rejuvenation needs to be carried out within the next few years. Fresh seed should be sealed in metal cans under vacuum and stored under sub-zero temperature (-5°C, 30-40% RH), as suggested by the FAO (1974) for base collections. Such storage conditions could preserve seed viability up to 300 years (Ito and Kumagai, 1969). Meanwhile, the 250-g seeds stocks in the medium-term storage unit will continue to serve the needs of rice researchers until the stock runs out.

The present staff of one research assistant, one research aide, two laboratory helpers, one field assistant, and three laborers (including one emergency laborer) is not large enough to cope with the overall needs of the seed bank. Additional personnel is also needed to fulfill the expanded seed requirements of the GEU program. The records system for the seed bank needs to be improved and updated. A second volume of the IRRI variety catalog of morpho-agronomic characteristics needs to be assembled and published. A recording and information retrieval system for the GEU program should be set up and integrated with the morpho-agronomic data taken on the accessions.

To meet the impending needs, the following expansions in physical facility and technical personnel are envisaged. The seed processing and storage facilities shall also include the immediate requirements of the expanded plant breeding program.

(1) A seed processing and storage building at a new site -- conveniently located with assurance of security; away from potential fire hazards; allowing an efficient flow of seeds for processing, evaluation, storage and distribution; but serviceable by the emergency generators -- be built to house the 13 essential components.

A. Seed storage rooms (continuously refrigerated)

1. Short-term seed storage -- 440 sq m; 4-m high ceiling; 21-22°C, 40-60% RH; includes area for seed drier and seed canning machinery (about 20 sq m); one exhaust fan.

2. Medium-term seed storage -- 120 sq m; 3-m high ceiling; 2-3°C; 25-40% RH; insulated door; temperature and humidity recording devices.

3. Long-term seed storage -- 40 sq m; 3-m high ceiling; -5°C; 30-40% RH; insulated door; dehumidified air circulation; temperature and humidity recording devices.

4. Buffer area (in front of the doors to 2. and 3.) -- at least 2-m clearance to the doors of 2. and 3.; wide sliding door to permit a lab cart to pass through; can be served by the dehumidifying unit when the door of 2. or 3. is open.

B. Seed processing area (air-conditioning during working hours) -- 3-m.high ceiling; 240 sq m area; with one air-exhaust.

C. Quality evaluation labs (air-conditioning during working hours).

1. Milling lab -- 3-m high ceiling; 80 sq m area; with one air-exhaust.

2. Quality lab -- 3-m high ceiling; 80 sq m area; one air-exhaust; accessible to water heater.

D. Office-lab (air-conditioning during working hours) -- 3-m high ceiling; 120 sq m area; includes data-storing space.

E. Service areas (air-conditioning during working hours)

1. Storeroom for supplies -- about 30 sq m

2. Men's toilet and lockers -- about 24 sq m

3. Women's toilet and lockers-- about 16 sq m

F. Room for the refrigerating units, dehumidifying device, and water heater -- about 80 sq m

G. Storage area for glass jars and tin cans in the attic, includes staircase.

Figure A shows the existing Plant Breeding facilities in the Service Building. The proposed seed lab is sketched in Fig. B.

Fig. A. Existing Seed Lab, Seed Storage Area, Milling Lab and Quality Lab of Plant Breeding Department, IRRI.

PB-1	112 m^2	Work area
1-a	36 m^2	Office of res. assistants
1-b	32 m^2	Storage of tools & supplies
PB-2	66 m^2	Quality Lab
2-a	72 m^2	Milling Lab
PB-3	216 m^2	Short-term seed storage
PB-4	72 m^2	Seed Processing
4-a	36 m^2	Medium-term seed storage

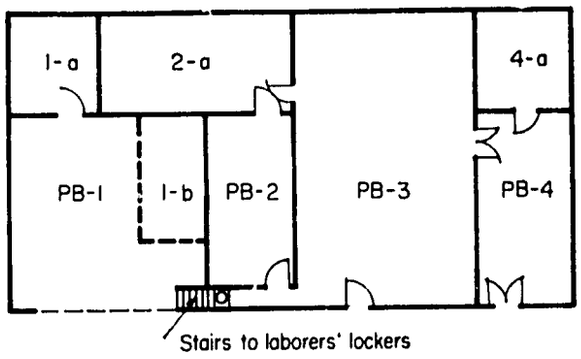
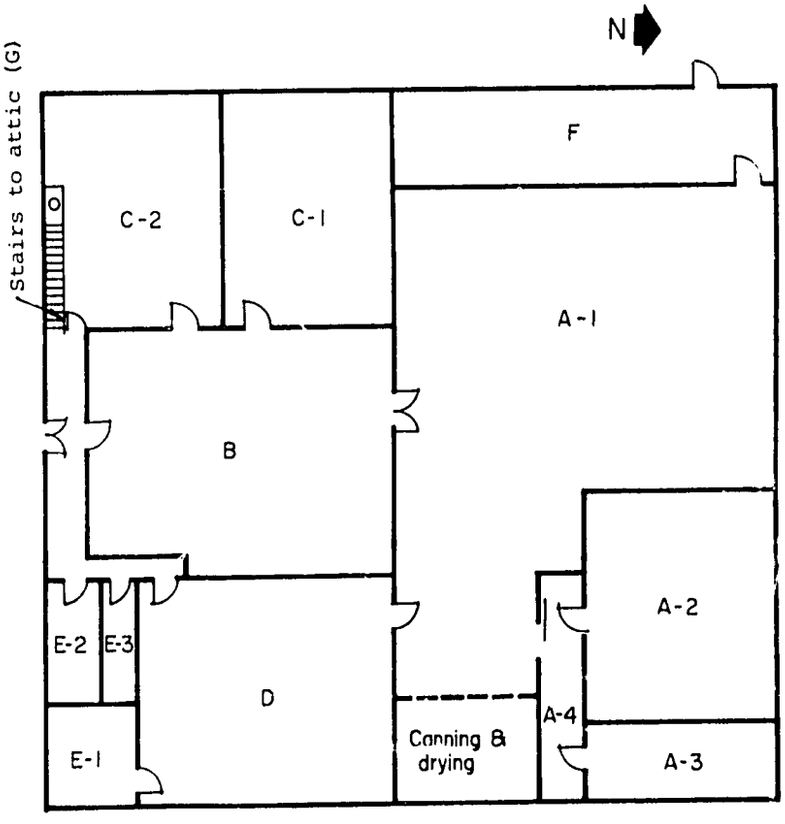


Fig. B. Proposed GEU Seed Lab

A-1	440 m^2	Short-term seed storage
A-2	120 m^2	Medium-term seed storage
A-3	40 m^2	Long-term seed storage
A-4	c20 m^2	Buffer area
B	240 m^2	Seed processing
C-1	80 m^2	Milling Lab
C-2	80 m^2	Quality Lab
D	120 m^2	Office-Lab
E-1	c30 m^2	Storeroom
E-2	c24 m^2	Men's toilet & lockers
E-3	c16 m^2	Women's toilet & lockers
F	c80 m^2	Refrigerating & dehumifying machineries
G		Storage area in attic

Total floor space: c1070 m^2



(Sketches not drawn to scale)

(2) The personnel requirements are enumerated as follows:

Position (rank)	Responsibility	Number	Old or new position
Geneticist	Overall planning and supervision	1	Old
Senior Assistant Scientist	Coordination and supervision of routine operations, also serving as field advisor on field collection to agencies outside the Philippines	1	To partly replace the temporary Field Advisor (1972-74)
Assistant Scientist or Senior Research Assistant	(1) To take morpho-agronomic notes in field and to increase seed stocks of cultivars	2	1 old
	(2) To supervise the flow of seeds into seed bank and into GEU operations		1 new
Research Assistant or Research Aide	(1) To record and multiply (if necessary) incoming seed samples from abroad and to look after African rices, mutants, and wild species	2	1 old
	(2) To implement seed increases for GEU use and to rejuvenate old seedstocks		1 new
Clerk	Record keeping	1	new
Laboratory Assistants	Lab measurements, transfer of records, preparation of seed samples for storage or distribution	3	2 old, 1 new
Field Assistant	To supervise laborers	1	old
Laborers	(a) Field operations - 6 (b) Lab operations - 1	7	3 old, 4 new

(3) Special project on the conservation of the African cultivated rices (O. glaberrima) and its weed relative (O. barthii) — These races are also facing the threat of extinction. IRRI has encouraged rice researchers in West Africa to conserve the African rices. About 940 strains are being maintained at Los Baños, of which 324 samples were recently collected in Liberia. While IRRI is perfectly willing to assume the major responsibility of conserving the African segment of rice germ plasm, inputs from IITA and WARDA are needed. Because the African rices are highly susceptible to the insects and diseases prevalent at Los Baños, it appears necessary to increase seeds at an appropriate location in West Africa which is free from such pest ravages. Perhaps the International Board for Plant Genetic Resources (IBPGR) of the Consultative Group could assist IRRI in obtaining such collaboration from an institution in Africa.

6. Budgetary requirements (to be added following consultation with architects and engineers)

Report prepared by a committee composed of:

T. T. Chang, Chairman
H. E. Kauffman
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December 1974

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Table A. Progress in field collection in twelve collaborating Asian countries with IRRI's direct or indirect participation, September 1971 to December 1974.

Year	Country	Samples collected	
		Directly	Indirectly
1971	Nepal		907
1972	Sri Lanka	412	
	Indonesia	1363	1130
	Pakistan		567
	Philippines		128
	Vietnam, S.		226
	Laos		351
1973	Khmer	280	
	Bangladesh	122	1813
	Burma	115	
	Indonesia	1526	517
	Malaysia, E.		87
	Philippines		127
	Vietnam, S.		104
	Laos		4
	Pakistan		182
	Thailand		127
1974	Bangladesh	234	548
	Burma	110	
	Indonesia	927	583
	Malaysia, E.		288
	Philippines		59
	Total	5089	7748

Table B. Special types of rice varieties and wild taxa acquired from July 1972 to December 1974.

Reported feature	Samples (No.)
Tolerance to salinity	124
Tolerance to acid soils (flooded)	150
Tolerance to alkaline soils	11
Upland types	2425
Floating types	518
High-elevation types	600
Resistance to nematodes	5
Escape from rodent damage	9
Aromatic types	89
(Total for special types)	(3931)
Wild taxa	46

Table C. Progress of systematic evaluation operations in IRRI's GEU program, 1962-74.

Problem trait and index no. in Appendix	Accessions screened to date	Projected number of accessions to be screened					Special types collected	Promising sources identified		
		1974	1975	1976	1977	1978		Accessions (no.)	Countries of origin	Non-allelic sources
/Deep water/										
1) Floating ability	248 cv.	120	400	400	400	400	404	41	Thailand, India, Italy, Bangladesh, China, Vietnam, Portugal	--
2) Submergence tolerance	1,126 cv.	1200	2000	2000	2000	2000	41	26	Sri Lanka, Thailand, Indonesia, Surinam	-
/Diseases/										
3) Bacterial blight	22,100 cv.	3500	3000	3000+	3000+	3000+	-	259	India, Indonesia, Japan, U.S.A.	2+
4) Bacterial leaf streak	2,200 cv.	3000	3000	3000	3000	3000	-	c. 1000 need confirmation	Bangladesh, India, China, Japan, U.S.A.	-
5) Blast	10,251 cv.	3000	6000	6000	3000+	3000+	-	115	Widely distributed	Probably many
6) Sheath blight	433 cv.	2000	4000	4000	4000	4000	-	None with high level of resistance	-	
7) Tungro	3,559 cv.	(16,000 total annual capacity in greenhouse; volume can be increased by field tests)					-	9 HR 21 R-MR	India, Bangladesh, China, Indonesia, Thailand	

Table C../2

Problem trait and index no. in Appendix	Accessions screened to date	Projected number of accessions to be screened					Special types collected	Promising sources identified		
		1974	1975	1976	1977	1978		Accessions (no.)	Countries of origin	Non-allelic sources
8) Grassy stunt	5,000 cv. 100 wild	(5,000 total annual capacity in greenhouse; volume can be increased by field tests)						0 1	O. nivara of India	-
/Insect pests/										
9a) Green leafhopper (N. nigropictus)	232 cv.	1000	2000	2000	2000	2000	-	4	India, Bangladesh	-
9b) Green leafhopper (N. virescens)	5,810 cv.	3000	3000	3000	3000	3000	-	123	India, Bangladesh, Ghana, Indonesia, Sri Lanka, Malaysia, Sierra Leone, Laos	3
9c) Brown planthopper (N. lugens)	9,311 cv.	4000	4000	4000	4000	4000	-	103	India, Sri Lanka, Burma, China, Indonesia, Vietnam	2
9d) White-back planthopper (S. furcifera)	2,684 cv.	3000	3000	3000	3000	3000	-	45	India, Indonesia, Vietnam, China, Sudan, Malaysia, Pakistan	-
9e) Zigzag leafhopper (R. dorsalis)	1,500 cv.	1000	2000	2000	2000	2000	-	5	India, Pakistan, Sri Lanka	-

Table C../3

Problem trait and index no. in Appendix	Accessions screened to date	Projected number of accessions to be screened					Special types collected	Promising sources identified		
		1974	1975	1976	1977	1978		Accessions (no.)	Countries of origin	Non-allelic sources
10a) Striped borer (C. suppressalis)	10,375	600	1000	1000	1000	1000	- -	26 26	China, U.S.A., Burma, India, Philippines	. -
10b) Yellow borer (T. incertulas)	741 cv.	950	1000	1000	1000	1000	-	12	Indonesia, Africa, India, Thailand, China	-
11) Whorl maggot (H. philippina)	5,000 cv.	2000	4000	4000	4000	4000		131	India, China, Japan, Laos, Sri Lanka, Egypt, Italy, Brazil, Hungary, Philippines, Spain	
12) Leaf folder (C. medinalis)	687 cv.	(No firm schedule)						6	India, Laos, E. Africa, Bangladesh	
/Nitrogen utilization/										
13a) Atmospheric N	102 cv.	102	400	800	800	800				
13b) Soil N	99 cv.	99	400	800	800	800				
/Nutritive quality/										
14) Protein	12,500 cv. 17 wild	0	(No firm schedule)				None			

Table C../4

Problem trait and index no. in Appendix	Accessions screened to date	Projected number of accessions to be screened 1974	1975	1976	1977	1978	Special types collected	Promising sources identified: Accessions (no.)	Countries of origin	Non-allelic sources
14) Lysine	12,500 cv. 17 wild	0	0	0	0	0	None			
/Drought/										
15a) Field resistance	2,118 cv.	2655	3000	5000	5000	5000	2401	114	Laos, W. Africa, Bangladesh, Philippines, Malaysia, Thailand, Colombia, Vietnam	
	112 O. glab. strains	112	200	300	300	500	939	none		
15b) Drought resistance	20 cv.	200	200	400	600	800		7	Africa, Philippines, Bangladesh	
15b) Root system in upland soil	78 cv.	120	200	400	600	800		7	Africa, Philippines, Bangladesh	
15c) Drought tolerance GH	102 cv.	226	1500	1500	1500	1500		3 cv. 12 lines	Africa, Philippines	
Field	20 cv.	1500	1500	1500	1500	1500				
/Cold tolerance/										
16) Cool air	1,000 cv.	500	(No firm schedule)				572	10+	Widely distributed	
16) Cold water	1,000 cv.	500	(No firm schedule)					6+	Widely distributed	
/Pesticide tolerance/										
Pesticide tolerance	52 cv.	52	(No firm schedule)							

Table C../5

Problem trait and index no. in Appendix	Accessions screened to date	Projected number of accessions to be screened					Special types collected	Promising sources identified		
		1974	1975	1976	1977	1978		Accessions (no.)	Countries of origin	Non-allelic sources
/Problem soils/										
17) Alkali resistance	61 cv.	150	2000	(No firm schedule)			11	1	India	
17) Aluminum and manganese toxicity	32 cv.	50	50	(" " ")				1	Philippines	
17) Iron deficiency	61 cv.	50	50	(" " ")			4	1	Philippines	
17) Iron toxicity	100 cv.	200	1000	(" " ")			148	1	India	
17) Phosphorus deficiency	65 cv.	250	100	(" " ")			3	1	Sri Lanka	
17) Salt resistance	65 cv.	50	2000	(" " ")			121	1	India	
17) Zinc deficiency	18 cv.	50	1000	(" " ")			1	2	India, Sri Lanka	

Table D. Number of seed packages sent to foreign requesting agencies and researchers from the IRRI seed bank, 1962-1974.

Year	Cultivars		Genetic testers and wild taxa	
	Packages	Requests	Packages	Requests
1962-63	400	17	111	10
1964	2,355	67	228	16
1965	1,608	56	122	6
1966	1,052	41	461	12
1967	1,764	121	789	7
1968	5,286	147	241	18
1969	5,800	101	287	19
1970	5,660	106	91	8
1971	2,300	132	325	10
1972	2,501	83	610	15
1973	9,777	96	422	22
1974	2,602	141	167	11
Total	41,105	1,108	3,854	154

Table E. Schedule of IRRI's direct role in field collection activities during the next decade (excluding indirect participation in collecting programs of China, India, Pakistan and North Vietnam).

Year and Period		Country and area	Types to be collected	Estimated collection size [a]
1975	1st half	South Vietnam	Floating rices, double-transplanted[b]; acid sulfate tolerant types; saline tolerant types; wild species	300 - 500
	2nd half	West Africa	Discussion with national centers concerned	-
		Bangladesh[b]	Floating rices (broadcast aman); transplanted aman; wild species	800 - 1000
1976	1st half	Bangladesh[b]	Aman types	
		Indonesia (Java)	Upland rices of the bulu and cere types	250 - 400
	2nd half	Laos	Hill rices; wild species	500 - 800
		Burma	Hill rices; delta varieties[c]; cool tolerant types quality rices; wild species	400 - 500
1977	1st half	Indonesia (Kalimantan)[d]	Tidal swamps; upland (ladang and gogo types); wild species	250 - 300
	2nd half	Thailand	Floating rices; hill rices; wild species	150 - 200
1978	1st half	Indonesia (Sumatra)[e]	Upland; high elevation; tidal swamp (Jambi) varieties	200 - 400
	2nd half	Khmer[b]	Floating rices; long-duration types with pest resistance; wild species	100 - 150
1979	1st half	Indonesia (small islands)[f]	Upland and lowland varieties (bulu and cere); wild species	200 - 300
	2nd half	Malaysia (Sarawak)	Hill rices; acid-sulfate tolerant types	150 - 300
1980 thru 1984		Re-collect special types in South and Southeast Asia; direct participation in field collection in West Africa		15,000

a Wild species numbering 3,000 not included in the estimated size
b Extending into the early part of the next year
c 50 to 100 cm standing water throughout the growing season
d East, west and central parts
e Aceh, Jambi, Bengkulu provinces
f Nusa Tenggara, Maluku, West Irian

Table F. Changes in the germination percentage of three control varieties stored in the medium-term storage room over an 11-year period.

Variety	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Peta	56	89	96	96	97	93	90	90	95	97	96	97
Siam 29	80	95	97	97	97	97	95	96	97	96	97	98
Chianan 8	74	72	76	80	77	74	74	84	77	63	63	54

Note: (1) Initial seed moisture content before storage was 12 percent; moisture content was reduced and stabilized at 9 percent during storage.

(2) Seed viability is tested twice a year; germination percentages given represent first-of-the-year test.

APPENDIXES

Progress of IRRI's GEU Program in Screening Rice Cultivars and Wild Taxa

The following appendixes summarize the information on magnitude of the problem trait being screened, the status of the testing programs, and promising sources of resistance or tolerance. Traits such as protein content and quality, the outstanding sources of which have yet to be identified, are described briefly.

The appendixes and tables are categorized as follows:

1) Floating ability
2) Tolerance to submergence
3) Bacterial blight
4) Bacterial leaf streak
5) Blast
6) Sheath blight
7) Tungro virus
8) Grassy stunt virus
9) Leafhoppers and planthoppers
10) Stem borers
11) Whorl maggot
12) Leaf folder
13) Nitrogen utilization
14) Nutritive quality
15) Drought resistance and tolerance
16) Tolerance to cold water and cool air
17) Problem soils

1. Floating ability via internode elongation

Deep-water rice is grown in water from 150 to 500 cm deep. Around 10,000,000 hectares or 10 percent of the rice growing area in South and Southeast Asia is planted to floating rice varieties. In Bangladesh, Thailand, India, Burma, Cambodia, Vietnam and certain parts of Africa, floating rice is the only crop that can be planted in the deep water areas so that if the crop fails, the whole planting season fails.

Grain yields in these areas are low and the prospect of improving the grain yields in the near future is not too bright since very little work is being conducted for the improvement of this particular rice culture. The high-yielding rice varieties are not adapted to these areas since the HYVs are unable to elongate and survive the deep water conditions.

The direction for the improvement of grain yield in deep-water areas has not been well defined, as it has been for lowland rice culture. However, the grain yield of floating rices can be stabilized

if certain characteristics, such as resistance to drought in the juvenile stage and a greater ability for internode elongation are incorporated into its germ plasm. In areas where the water level rises rapidly, many plants die because they are unable to keep up with the rise in water level. A greater ability to elongate is therefore needed.

IRRI is screening the germ plasm collection to identify varieties with greater ability to elongate. About 100 varieties collected from deep water areas were initially screened. Table 1 lists those varieties showing good elongation ability.

Screening of varieties from other non-floating areas might also identify those varieties which can elongate and in addition have other useful characteristics. Three European varieties included in the screening program showed good internode elongation when submerged in water (Table 1). These three varieties are not planted as floating varieties; they have a more erect tillering angle and greater number of tillers than the typical floating variety. These plant characters may be useful in improving the grain yields of floating rice, i.e., in increasing the tiller number per unit area.

The three European varieties indicate the importance of screening varieties from areas where the water is not deep. If several non-allelic genes are involved in the ability to elongate, it is important to screen and identify diverse sources which have different plant characteristics and have the ability to elongate.

There are about 1,000 floating rice varieties. IRRI has more than 400 floating varieties. Further collections are needed, especially from African countries and the tidal swamp areas.

Table 1. Varieties with rapid rate of internode elongation when submerged in deep water.

Variety	Acc. No.	Origin
Baishbish	5811	Bangladesh
Banor Jhota	26297	Bangladesh
Bhawalia Digha	1246	Bangladesh
Bhoro Digha	1269	Bangladesh
Bhoro Nepa	1160	Bangladesh
Boon Nahk	24220	Thailand
Cheng Chang	1630	China
Choto Digha	1159	Bangladesh
Digha	1033	Bangladesh
DM 53	8735	Pakistan
Dol Kochu	1196	Bangladesh
DW 6255	24132	India
Goda Laki (HBJ Aman II)	5912	Bangladesh
Gourkajol	1277	Bangladesh
Habiganj Deep Water 1	11749	Bangladesh
Habiganj Deep Water 2	11750	Bangladesh
Habiganj Deep Water 8	11751	Bangladesh
Hawn Chahng	24222	Thailand
Hijli Digha	1263	Bangladesh
Jabra	1254	Bangladesh
Jhota	1175	Bangladesh
Kala Digha	1272	Bangladesh
Katia Bagder 13/20	6498	Bangladesh
Kekowa Bao	21324	India
Khao Hawn	24225	Thailand
Leb Mue Naling	7819	Thailand
Mal Bhog	1034	Bangladesh
Maliabhangar	5810	Bangladesh
Manik Digha	1268	Bangladesh
Nak Neva	24227	Thailand
Nam Sagui 19	11462	Thailand
Nang Dum To*	231	Vietnam
Ponta Rubra**	3187	Portugal
Rajamoral	1279	Bangladesh
Rosa Marchetti**	17017	Italy
Royna	1152	Bangladesh
Saibur	24229	Thailand
Srau Kraham	23258	Khmer
Suna Digha	1169	Bangladesh
TD 72	8297	Thailand
Vialone**	3134	Italy

* Also resistant to submergence or flooding.
** Japonica type with ability to elongate.

2. Tolerance to submergence

The area that is flooded or submerged varies from year to year and is therefore difficult to estimate. However, more than 35,000,000 hectares of rice are annually flooded -- these are the deep-water areas, the tidal land along sea coasts and tidal swamps.

The grain yields lost annually as a result of flooding could be minimized by increasing the resistance of rice plants to submergence.

IRRI has screened more than 600 varieties. Table 2 shows the most resistant varieties identified so far. Most of the resistant varieties came from areas in Sri Lanka where rice is annually submerged for short periods of time.

Two types of tolerance are needed for rice. The first is tolerance to submergence in flood water from one day to a few weeks. The second is tolerance to submergence in flood waters remaining in the field for 2 to 5 months. The first type of tolerance enables the varieties to withstand submergence without elongating so that the plants do not lodge when the water recedes. The second type prompts the varieties to elongate enabling them to grow above the water level.

Screening for resistance to submergence is relatively rapid even without limited facilities. The germ plasm collection will eventually be screened systematically.

Table 2. Varieties tolerant to submergence.

Variety	Acc. No.	Origin
Buruma Thavalu	15335	Sri Lanka
Goda Heenati	15419	Sri Lanka
Jamis Wee	15294	Sri Lanka
Kaharamana	15479	Sri Lanka
Kalu Gires	15330	Sri Lanka
Kalu Kanda	15430	Sri Lanka
Kaluwee	15425	Sri Lanka
Kanni Murunga	15432	Sri Lanka
Kottamalli	15435	Sri Lanka
Kurkaruppan	15449	Sri Lanka
Lumbini	15319	Sri Lanka
Madabaru	15333	Sri Lanka
Madael	15426	Sri Lanka
Nang Dum To	231	Vietnam
Nam Sagui 19	11462	Thailand
Padi Ewang Janggut	24758	Indonesia
Periya Karuppan	15460	Sri Lanka
Pokuru Samba	15337	Sri Lanka
Ratawee	15185	Sri Lanka
SML Temerin	10870	Surinam
Sudu Gires	15331	Sri Lanka
T442-57	13016	Thailand
Thavalu	15314	Sri Lanka
Thavalu	15325	Sri Lanka
Venan Vellai	15464	Sri Lanka
Weli Handiran	15433	Sri Lanka

3. Bacterial blight

In Asia, during the monsoon season, on up to 15 million hectares where intensive cultivation practices are followed bacterial blight is a major disease. Losses in grain yield frequently range from 5 to 10 percent but occasionally reach 50 percent.

Out of approximately 22,000 cultivars screened for bacterial blight resistance, 259 have shown moderate to strong resistance. Genetic studies on approximately 25 cultivars have so far identified two distinct sources: a single dominant gene and a single recessive gene. Several other cultivars have intermediate field resistance.

Field collections for cultivars resistant to bacterial blight should continue in northeast India, Bangladesh and Burma. Cultivars from the People's Republic of China could add new resistant sources.

4. Bacterial leaf streak

Bacterial leaf streak is found only in tropical Asia, primarily in the monsoon season following strong winds. Yield losses are generally much less than for bacterial blight.

Many cultivars have shown resistance to bacterial leaf streak but no genetic studies have been conducted to determine the mode of inheritance or the non-allelic sources. A high proportion of the cultivars so far identified have originated in Bangladesh, northeast India, China, Japan, and U.S.A. Several strains of O. rufipogon, O. sativa f. spontanea, and O. glaberrima were also resistant.

No special area of collection is recommended.

Table 3a. Promising sources for resistance to bacterial blight.
- Screened at least 3 times against Philippine isolates.
- December 1974.

Variety	Acc. No.	Origin	Variety	Acc. No.	Origin
ADT 25	5151	India	ARC 7406	20617	India
Andel	17153	Indonesia	ARC 7416	20625	India
ARC 5756	20220	India	ARC 7423	20627	India
ARC 5758	12122	India	ARC 10025	20653	India
ARC 5793	12133	India	ARC 10027	20655	India
ARC 5955	20288	India	ARC 10068	20685	India
ARC 6003	12174	India	ARC 10070	21184	India
ARC 6018	12180	India	ARC 10313	20845	India
ARC 6068	20325	India	ARC 10372	20884	India
ARC 6079	20335	India	ARC 10376	20887	India
ARC 6125	20349	India	ARC 10520	20967	India
ARC 6230	12259	India	ARC 10674	12567	India
ARC 6231	12260	India	ARC 10945	12678	India
ARC 6565	20400	India	ARC 10952	12682	India
ARC 6608	12293	India	ARC 10957	21157	India
ARC 7001	20436	India	ARC 10959	12686	India
ARC 7013	20437	India	ARC 10968	12690	India
ARC 7043	20458	India	ARC 11069	21183	India
ARC 7045	20460	India	ARC 11070	21184	India
ARC 7046	20461	India	ARC 11071	21185	India
ARC 7055	20468	India	ARC 11072	21186	India
ARC 7060	20471	India	ARC 11075	21188	India
ARC 7090	20490	India	ARC 11083	21199	India
ARC 7098	20498	India	ARC 11092	21192	India
ARC 7102	20501	India	ARC 11104	21196	India
ARC 7128	20524	India	ARC 11109	21199	India
ARC 7132	19679	India	ARC 11118	21205	India
ARC 7207	20545	India	ARC 11121	21207	India
ARC 7260	12346	India	ARC 11124	21209	India
ARC 7286	20580	India	ARC 11204	21223	India
ARC 7291	12356	India	ARC 11219	21236	India
ARC 7303	12359	India	ARC 11226	21241	India
ARC 7320	20599	India	ARC 11252	21256	India
ARC 7323	20602	India	ARC 11255	21259	India
ARC 7323	20602	India	ARC 11287	21289	India
ARC 7327	12368	India	ARC 11295	21297	India
ARC 7328	12369	India	ARC 11311	21308	India
ARC 7334	20605	India	ARC 11322	21315	India
ARC 7336	20606	India	ARC 11328	21320	India
ARC 7347	12376	India	ARC 11332	21324	India

..... more

Table 3a ....

Variety	Acc. No.	Origin	Variety	Acc. No.	Origin
ARC 11351	21340	India	DL-5	8593	Bangladesh
ARC 11558	21476	India	DNJ 142	8426	"
ARC 12162	21952	India	Dudhi	16256	Nepal
ARC 12172	21960	India	Dular (R)	636	India
A-kuk-do	19682	India	DV 29	8816	Bangladesh
Bacon		Vietnam	DV 32	8818	"
Bageri	16193	Nepal	DV 52	8828	"
Bajang	17183	Indonesia	DV 85	8839	"
Bakai	23806	Nepal	DV 86	8840	"
Balacung	19232	Indonesia	DV 139	8870	"
Balik Semah	17201	Indonesia	DZ 78	8555	"
Bandja Ili	17216	Indonesia	DZ 192	8518	India
Bangaluwa	16268	Nepal	Gaja Baru	17586	Indonesia
Bathkiriel	15212	Sri Lanka	Gewal Bangoran	17651	"
Beak Ganggas	17253	Indonesia	Gokhue Saier	16195	Nepal
Belanok Kesambi Barak	17264	Indonesia	Gropak Gede	17687	Indonesia
Bendjah Urang	17639	Indonesia	Halsudu Heenati	15599	Sri Lanka
Benong	13530	Indonesia	Halsuduwee	15723	"
Bilekagga	19927	India	Hashikalmi	3397	Surinam
BJ1	3711	India	Hegar Manah	17733	Indonesia
Boder	17315	Indonesia	Hom Thong	12969	Laos
Bulu Baselijan	17341	Indonesia	Ikogan	19502	Philippines
Bulu Djambu	17343	Indonesia	Indel	17748	Indonesia
Bulu Manggali	17348	Indonesia	Jawa Renges II	17763	"
Bulu Putih	17350	Indonesia	Kalimadu 50	19338	Sierra Leone
Bulu Sampang	17352	Indonesia	Kentjana	922	Indonesia
Buntak Tuwungbatu	17356	"	Ketan Bajong	17830	"
Camor	17366	"	Ketan Bas	17834	"
Chinsurah Boro I	11483	Japan	Ketan Bedug	17837	"
Chinsurah Boro II	11484	Japan	Ketan Bendu	17838	"
Dayaggot qan bunuggon	9134	Philippines	Ketan Gabel	17851	"
DB-3	8361	Bangladesh	Ketan Gadjih	13512	"
DD-48	8620	"	Ketan Gondel	17857	"
DD 100	8649	"	Ketan Gondopuro	17859	"
Devarasi	16173	Nepal	Ketan Gundel	17865	"
DF-1	8365	Bangladesh	Ketan Kunir	17887	"
Djalawara	17471	Indonesia	Ketan Kutuk	17894	"
Djawa Sredek	17517	"	Ketan Laler	17897	"
Djelita	13714	"	Ketan Lumbu	16461	"
Djarabang	17543	"	Ketan Mari Kangen	17910	"

..... more

Table 3a ....

Variety	Acc. No.	Origin	Variety	Acc. No.	Origin
Ketan Pandang	17832	Indonesia	Patchaiperumal	15681	Sri Lanka
Ketan Seponjono	17959	"	Patong 32	13843	Malaysia
Ketan Simbukan	19965	"	Perum Karuppan	15513	Sri Lanka
Ketan Temon	17967	"	Perunel O. 69-18	19581	India
Ketan Tjendani	17970		Peuteuj	18484	Indonesia
Ketan Tjrumik	17973	Indonesia	P.I. 18006-1	3687	India
Ketan Tolc	17975	"	PI 231129	11114	America
Khao Lo	12904	Laos	PI 346824	16820	
Kirikunda	15558	Sri Lanka	Plampeyan	18494	Indonesia
Kolongi Bao	24135	India	Pulo	18519	"
Krawang Hadji	18024	Indonesia	Pulu Banrakaja	20073	Indonesia
Lal Ahu	16121	Nepal	Pusur	8350	Bangladesh
Lalaka Gadur	16255	"	Race	15706	Sri Lanka
Lal Sar	16185	"	Randjani	18596	Indonesia
Latu	18093	Indonesia	Rangun Serta	18600	"
Lenggang Genuk Bulu	18119	Indonesia	Rante	18608	Indonesia
Lua Ngu	16852	Vietnam	Rante	18609	"
Madhukan	14781	India	Rathu Heenati	15609	Sri Lanka
Mahamawee	15213	Sri Lanka	Remadja	679	Indonesia
Malagkit Sungsong	755	Philippines	Remadja Bulu	18620	"
Malalwariyan	15203	Sri Lanka	Rengesi	18628	Indonesia
Maturi	16187	Nepal	Rerm Bilash	16273	Nepal
Matury	16190	"	Rodjolele	9909	Indonesia
M.C.M.-2	19301	India	Sajani	16177	Nepal
Meritam	18267	Indonesia	Sampang Kuning	18678	Indonesia
Mond-Ba	15813	Senegal	Sampang Lempuyang	18679	Indonesia
Mujaer	18296	Indonesia	Sampangan Perak	18677	"
Murunga Balawee	15725	Sri Lanka	Seksrek	18740	"
Murungawee	15498	"	Semora Mangga	4181	"
Nagir	23984	Nepal	Sereh	16566	"
Nagkayat	584	Philippines	Sidjangguk	18826	Indonesia
Nakhi	16254	Nepal	Sidjero Gundil	18829	
Ngane Tia	13010	Laos	Sigadis	4095	"
No. 20	15606	Sri Lanka	Sintawati	18863	"
Olek Bandung	18337	Indonesia	Slendoran	18962	"
Padi Ireng	18373	Indonesia	Soal byeo #2	19868	
Padi Tomat	18408	"	Sogol	18905	Indonesia
Palotan Melati	18426	"	Sokan Dhan	16250	"
Pare Buwun	18456	"	Soponjono	18913	"
Pare Djerah	18458	"	Sri Kuning	14622	"

Table 3a .....

Variety	Acc. No.	Origin	Variety	Acc. No.	Origin
Sudumalawee	15218	Sri Lanka	Walen	16685	Indonesia
Sukonandi	18937	Indonesia	Wanni Dahanala	15721	Sri Lanka
Syntha	10307	"	Wase Aikoku	525	Japan
Tally	16146	Nepal	W 1263	11057	India
Taothabi (M-163)	13146	India	Yakadawee	15293	Sri Lanka
Tjempo Manggi	19034	Indonesia	Zenith	131	America
TKM 6	237	India			
Tolil 14	13836	Malaysia			
UCP 28	8728	Bangladesh			
Vella Peruvazha O. 68-12	19588	India			

Table 3b. Origin of varieties resistant to bacterial blight.

ASIA			
East	-	Japan	3
		Korea	1
Southeast	-	Indonesia	87
		Laos	3
		Malaysia	2
		Philippines	4
		Vietnam	2
South	-	Bangladesh	16
		India	98
		Nepal	17
		Sri Lanka	16
AFRICA		Senegal	1
		Sierra Leone	1
N. AMERICA		U.S.A.	2

5. Blast

Blast is the most widespread disease of rice since it occurs in all countries where rice is grown. Losses are generally most severe in areas at high elevation in the tropics or in lowland areas during the cool season.

Because of the variability of the pathogen, limited work has been done on the inheritance of resistance or on the non-allelic sources. Varieties that have been identified in the International Blast Nurseries are resistant at nearly all test locations, however.

Future collections should concentrate in highland areas of tropical Asia, upland rice areas, and in endemic areas of Africa and Latin America.

Table 5a. Promising sources for blast resistance.
- Screened in IBN: 1964-1973.
- December 1974.

Variety	IRRI Acc. No.	Origin	International Blast Nursery		
			No.a/	SIb/	Rc/
Ahmee Puthe	5735	Burma	172	1.48	97.1
Amritsari HR 22	6394	India	203	1.81	92.8
Andi from N. Pokhara	3707	U.S.A.	150	1.98	90.1
Badshabhog	5753	India	173	1.64	94.1
Badshabhog (scented)	4804	India	166	1.77	91.1
Basmati (C-5888)	9035	Pakistan	345	2.09	88.7
Basmati T3	6447	India	208	1.74	93.4
BMT 53R 3540	4132	Thailand	161	1.85	93.0
C46-15	6785	Burma	217	1.51	97.3
C-46-15	6786	Burma	41	1.56	93.1
Ca 435/b/5/1	6350	Indonesia	196	1.56	97.1
Ca 902/b/2/1	6349	Chad, Af.	195	1.54	94.9
Ca 902/b/2/2	6382	India	201	1.60	94.5
Ca 902/b/3/3	6347	Chad, Af.	194	1.60	94.7
Carreon	5993	Phil.	180	1.38	97.4
CI 2011-1	3311	U.S.A.	132	1.61	94.6
CI 6037-4	3667	India	144	2.01	92.2
CI 6914	4098	U.S.A.	160	1.79	90.6
CI 7338-5	3990	Phil.	156	1.84	91.6
CI 7787	11108	U.S.A.	1	1.83	91.7
Ptb 26 (Cheu Kayama)	6301	India	192	2.05	90.9
Chugoku 31		Japan	351	2.14	84.1
Ptb 30 (Chuvannam Modan)	6304	India	193	1.86	91.5
Colombia 1	19293	Colombia	353	2.11	89.5
Colombia 2	19294	Colombia	353	2.20	88.3
Colombia 3	19295	Colombia	355	2.11	90.2
CP 231 x HO 12	6741	U.S.A.	215	1.70	90.9
CP 231 x HO 12	6764	U.S.A.	216	1.65	91.2
Ctg 1516	8704	Bangladesh	312	1.87	92.0
D-25-4	6806	Burma	42	1.73	90.4
D-44-1	6804	Burma	218	2.05	89.1
DB-3	8361	B'desh	255	1.81	92.4
DD-6	8608	B'desh	294	1.99	90.9
DD 48	8620	B'desh	297	1.77	91.6
DD-89	8644	B'desh	301	2.01	90.6

a/ Number of tests.
b/ Susceptibility index = average disease score over all locations.
c/ % R = Proportion of tests with R reaction.

Table 5a .....

Variety	IRRI Acc. No.	Origin	International Blast Nursery		
			No.	SI	% R
DD-91	8645	Bangladesh	302	2.05	92.6
Dissi Hatif	7802	Senegal	244	1.51	97.3
DL-2	8591	Bangladesh	287	2.26	90.9
DL-5	8053	Bangladesh	288	1.64	94.1
DL-9	8596	Bangladesh	290	2.02	88.4
DL-10	8597	Bangladesh	291	1.91	91.8
DL-12	8599	Bangladesh	293	1.77	93.3
DM-59	8779	Bangladesh	321	1.97	91.4
DNJ-60	8375	Bangladesh	257	1.93	93.7
DNJ-129	8463	Bangladesh	270	1.77	92.1
DNJ 131	8435	India	269	2.00	87.6
DNJ 142	8426	Bangladesh	266	1.91	89.0
DNJ 146	8425	Bangladesh	265	1.97	89.0
Dondoni Kunluz	7535	Afghanistan	232	1.93	89.0
DZ 193	8517	Bangladesh	278	1.79	94.4
El Gopher	6951	U.S.A.	224	1.68	93.7
H-5	156	Sri Lanka	46	1.71	92.7
Huan-sen-go	4619	China	164	1.35	96.3
J-519	4089	U.S.A.	158	1.88	92.8
Jhung Paddy 7	5796	India	174	1.78	91.8
Slo 16 (Kasipchodi)	6378	India	200	1.86	92.6
Laka	4217	Indonesia	162	1.88	89.2
Leter 08	6062	India	182	1.93	93.0
M-302	154	Sri Lanka	44	1.86	90.3
M-302	154	Sri Lanka	125	1.67	94.9
Macan Tago	5827	Philippines	176	1.79	95.5
Mamoriaka	3441	Malagasy	137	1.48	97.9
Mekeo White	11146	Papua, N. G.	81	1.94	92.8
Milketan 20	4033	Philippines	157	2.05	89.7
N-12	3716	Japan	151	1.80	93.8
N32	3717	India	152	1.89	93.8
Nang chet cuc	199	Vietnam	105	1.64	95.9
No. 79	3390	India	134	1.77	92.0
NP-97	3700	India	148	1.87	94.6
NP-130	3702	India	149	2.08	93.8
Padang Trengganu 22	11139	Malaysia	76	1.93	86.4
Pah Leuad 29-8-11	175	Thailand	126	1.65	95.5
Pah Leuad	24443	Thailand	122	1.57	94.2
Pi 3	6734	Japan	214	1.66	93.6
Pi 4	6733	Japan	213	1.54	94.0

..... more

Table 5a .....

Variety	IRRI Acc. No.	Origin	International Blast Nursery		
			No.	SI	% R
PI 184675-2	7366	Iran	226	1.82	92.5
PI 184675-4	7368	Iran	227	1.76	93.8
Pusur	8350	Bangladesh	254	1.81	93.7
R-67	8350	Senegal	88	1.85	92.4
R-67	9011	Senegal	341	1.64	94.6
Rajbhog N22	6264	India	188	2.01	91.4
Ramgarh	3643	India	143	1.82	92.1
Ram Tulasi	181	India	128	1.41	97.2
Ram Tulasi (sel)	178	India	56	1.70	92.0
Ram Tulasi (sel)	178	India	127	1.42	97.4
S · 1		Japan	352	2.36	86.4
S12 DZK	6827	India	221	1.92	93.0
S12 O.Z.K.	3747	India	155	2.07	90.7
S20 J.K.W.	6822	Pakistan	219	1.63	92.9
S39 J.K.W.	6836	Pakistan	222	1.68	93.9
Samba	8916	Sri Lanka	339	1.68	92.8
Secano do Brazil	3375	El Salvador	133	1.75	94.1
Simpangan Kuning	5472	Malaysia	168	1.74	92.0
Sitasail	3739	India	154	2.29	90.9
Soavina	9012	Gambia, Africa	342	2.22	89.6
Sornavari	8443	French Sudan Africa	138	1.73	92.9
Surjamkuhi	8256	India	247	1.91	92.7
T1	3392	India	135	1.89	93.9
T1	6294	India	191	1.93	93.7
T3	3694	India	147	1.82	93.6
T9	3719	India	153	1.85	92.3
T23	6433	India	207	1.74	94.10
Tadukan	9804	Philippines	12	1.50	94.5
Ta-poo-cho-z	4285	China	121	1.61	91.34
TD 58	8288	Thailand	251	1.82	91.2
TD 68	8294	Thailand	252	1.74	92.6
Tetep	11115	Vietnam	11	1.24	98.0
Ptb 9 (Thava Lakkanan)	6274	India	189	1.52	96.8
Trang Cut L. 11	200	Vietnam	106	1.70	94.3
Unblatuzi Valley Sugar Co.	3440	India	136	1.82	93.7
W.R.C. 4	5801	India	175	1.67	93.2
41 Mushkan	6418	Bangladesh	204	1.85	90.9
268b/Pr/8/1/1	7623	Indonesia	233	1.76	91.5
370 Basmati	6426	Pakistan	205	1.82	92.5
818-3 BR9	5881	India	178	1.78	89.4

Table 5b. Origin of blast resistant entries.

		No. of resistant varieties	% of Total
ASIA			
East	Japan	5	4.38
	China	2	1.75
Southeast	Burma	5	4.38
	Indonesia	3	2.63
	Malaysia	1	0.87
	Papua New Guinea	1	0.87
	Philippines	5	4.38
	Thailand	5	4.38
	Vietnam	3	2.63
South	Afghanistan	1	0.87
	Bangladesh	20	17.50
	India	32	28.05
	Iran	2	1.75
	Pakistan	4	3.50
	Sri Lanka	4	3.50
AFRICA			
	Chad	2	1.75
	Gambia	1	0.85
	Malagasy	2	1.75
	Senegal	1	0.85
	Sudan	1	0.85
SOUTH & CENTRAL AMERICA			
	Colombia	3	2.63
	El Salvador	1	0.87
NORTH AMERICA			
	U.S.A.	8	7.02

6. Sheath blight

In recent years, the occurrence of sheath blight has increased considerably in Asia as more intensive cultural practices have been adopted. Although studies on yield losses are few, moderately severe losses in the monsoon season have been reported.

No resistant cultivars have been identified, although a few appear to be less susceptible than others.

Systematic screening will continue although highly resistant varieties may not be found.

7. Tungro virus

Tungro virus continues to be the major disease threatening rice production in tropical Asia. Past experience has shown that when epidemics occur, production is cut drastically.

Many cultivars, mostly from India, have been found to be resistant to tungro. Although the inheritance of resistance has not been studied, there is a high level (Gam Pai, Pankhari 203) and an intermediate level (Peta, Sigadis, TKM 6) of resistance, which would indicate at least two distinct sources (Tables 7a and 7b).

Future collections should be concentrated in Indonesia, Malaysia, and the Philippines where the virus has been endemic for many years.

8. Grassy stunt virus

The grassy stunt virus has developed into a major disease in localized areas of the Philippines, Indonesia, South Vietnam and India. It poses a threat to all tropical Asian countries because of the general buildup of the vector, the brown planthopper, under intensive practices of rice cultivation.

The only source of strong resistance has been found in an accession of Oryza nivara and it is controlled by one dominant gene. Field resistance has been observed in several cultivars of Oryza sativa but no inheritance studies have been conducted. Field resistance is suspected to be multigenic.

Future collections should focus on wild species from various continents. More collections of Oryza sativa should be made in south India where most of the cultivars have field resistance.

Table 7a. Varieties highly resistant to tungro virus (seedling screening).

Variety	Acc. No.	Origin
Adday Local Sel.	180	India
Andi	3707	"
ARC 6064	12203	"
Habiganj DW 8	11751	Bangladesh
HR 21	663	India
JW 47	9121	India
Pankhari 203	5999	"
T 412	5894	"
Yi Shih Hsing*	1113	China

* Tested once only.

Table 7b. Varieties moderately resistant to tungro virus (field screening).

Variety	Acc. No.	Origin
ADT 25	5151	India
Ambemohor 159	5896	"
ARC 7010	12313	"
ARC 10531	20976	"
ARC 11254	21258	"
CO 10	6261	India
CO 20	6035, 8883	"
BJ 1	3711	"
Gam Pai 30-12-15	831	Thailand
Hashikalmi	3397	Bangladesh via Surinam
Kamod 253	23317	India
Kataribhog	12765	"
Latisail	8340	Bangladesh
Malagkit Sungsong	599	Philippines
Peta	35	Indonesia
PTB 18	19312 & 11052	India
Ram Tulasi	181	"
Sigadis	5324	Indonesia
TKM 6	237	India
Tjeremas	34	Indonesia
Warangal Culture 1263 (W1263)	11057	India

9. Leafhoppers and planthoppers

Rice green leafhoppers although extremely common in tropical and temperate Asia seldom appear to cause serious direct damage because of their low density. However, because they carry virus diseases, their control is of critical importance. The two leafhoppers, Nephotettix virescens and N. nigropictus, are capable of transmitting the yellow dwarf, tungro, penyakit merah, yellow orange leaf, and leaf-yellowing viruses.

A larger number of accessions have been tested against N. virescens than against N. nigropictus. Although a fairly large number of resistant sources have been identified (Tables 9a and 9b), genetically diverse sources are probably limited to a few because of the common geographic areas involved. Varieties do not always have the same response to both species of Nephotettix. We expect that resistance to both species will have to be considered in breeding for commercial varieties.

Nymphs and adults of the brown planthopper (Nilaparvata lugens) damages the rice plant through direct feeding and by transmitting the grassy stunt virus disease. When present in large numbers the insect causes complete drying of the plant, a condition called "hopperburn." The brown planthopper occurs in Japan, Korea, Khmer, Taiwan, south China, Malaysia, India, Vietnam, Sri Lanka, Indonesia, Philippines, Guam, Fiji, Solomon Islands, Bangladesh, and Thailand. The planthoppers are rapidly gaining importance in those areas where the HYVs are planted. The number of resistant varieties is quite large (Table 9c), but only two genetically distinct sources have been identified: Bph-1 in Mudgo and bph-2 in ASD-7, underscoring the need for a broader base of genetic resistance.

The white-backed planthopper (Sogatella furcifera) occurs throughout the rice producing areas of the world. It is considered a major pest in Japan, Taiwan, Korea, Punjab (India), central Vietnam, Thailand, Fiji and the Philippines. Under favorable conditions, they multiply rapidly and cause hopperburn. In Fiji, the white-backed planthopper is associated with "rice yellows." In the Philippines it appears a dominant pest in upland rice fields. The resistant sources are given in Table 9c.

The zigzag leafhopper (Recilia dorsalis) is a common pest of rice in South and Southeast Asia, Japan, Taiwan, and the northern areas of Thailand. It damages the plant by sucking the plant sap from the leaf blades. It has been reported to transmit rice dwarf virus in Japan. In the Philippines and Thailand, this insect was reported as a vector of the orange leaf virus. Several resistant sources are shown in Table 9d. Fortunately some of these varieties are also resistant to other insects, and so the resistance to zigzag leafhopper may already be present in some promising breeding lines.

Table 9a. Varieties resistant to green leafhopper, *Nephotettix nigropictus*.

Variety	Acc. No.	Origin
ASD 7	6303	India
D204-1	6445	India
Hashikalmi	3397	Bangladesh via Surinam
PTB 18	6105	India

Table 9b. Varieties resistant to green leafhopper, *Nephotettix virescens*.

Variety	Acc. No.	Origin
Abon*	17137	Indonesia
Akung*	17149	"
Andi N. Pokhara*	3707	India
ARC 5752	12119	"
ARC 6102	12216	"
ARC 7059	12316	"
ARC 10656	12559	"
ARC 10746*	12599	"
ARC 10826	12646	"
ASD 7 (Karsamba Red)	6303	"
ASD 8 (Thuyamalli)	6393	"
B 1*	17365	Indonesia
Bageri	16193	Nepal
Bagiamon 202	6611	Bangladesh
Baguamon 14	6590	"

* Not yet retested.

Table 9b. Cont'd.

Baishbish	5811	Bangladesh
Balap Bureum*	17193	Indonesia
Balap Merah*	17194	"
Balap Putih*	17195	"
Bandja Ili*	17216	"
Bengawan Omas*	17273	"
Berondol*	17285	"
Beton*	17289	"
Bir-co-ru-mao	4348	China
Blaster Gunung*	17308	Indonesia
Bongkar Utang*	17321	"
Brengut*	17328	"
C 8461*	13473	North Borneo
C 8481*	13478	Brunei
Ca 902/b/2/2*	6382	Tchad
Chinsurah 2	6288	India
CI 7338-5*	3990	Philippines
CO 13 x CO 4 6522 B4	19333	Sierra Leone
D 204-1	6445	India
D. I 7*	8589	Bangladesh
DJ 9	8511	"
DJ 90	8479	"
DK 1	8574	"
DM 77	8796	"
DNJ 9	8403	"
DNJ 85	8368	"
Donduni Kunluz*	7535	Afghanistan
Do Khao	11533	Laos
DS 1	8573	Bangladesh
DV 29	8816	"
DV 85*	8639	"
DZ 84	8553	"
DZ 104	8548	"
Eden*	17728	Indonesia
Fatehpur 3	13387	West Pakistan
Gadis Ciamis*	17575	Indonesia
Gaja Baru*	17586	"
Gandasari*	17595	"
Gedi*	17614	"
Gendjah Bang*	17630	"

*Not yet retested.

Table 9b. Cont'd.

Hathiel*	7730	Sri Lanka
Heenati	15679	"
Hegar Manah*	17733	Indonesia
Indian Pa Lil-46*	19337	Sierra Leone
Idna*	17740	Indonesia
Indel*	17748	"
Inten*	17751	"
Japita*	17759	"
Kalimekri 77/5*	6613	Malaysia
Kuruhondarawala*	7731	Sri Lanka
Laki 383	6576	Bangladesh
Laki 396	6621	"
Laki 462	6607	"
Laki 495	6497	"
Laki 659	6622	"
Lasaw	11184	Philippines
Mango	14749	Ghana
Murungawee	15498	Sri Lanka
Padi Jiongkok*	13430	Malaysia
Pankhari 203	5999	India
PI 184675-2*	7366	Iran
PI 184676*	3511	Iran
Pla Thoneng*	11681	Laos
PTB 18*	6105	India
PTB 18	19312	"
PTB 19 (Athikraya)*	6107	India
PTB 20	19313	India
PTB 21	19314	"
PTB 24*	19317	"
PTB 27 (Kadian)	6101	"
Pulliwi	12067	Sri Lanka
Ram Tulasi*	181	India
Rangun Serta*	18600	Indonesia
Rantai Mas*	18604	"
Red Rice*	3513	Iran
Remadja*	679	Indonesia
Retant*	18632	"
Rondo Jeblot*	18645	"
Roti*	18646	"
Sakotji*	18664	"

*Not yet retested.

Table 9b. Cont'd.

Sedan Mundur*	18712	Indonesia
Segon Emas*	18727	"
Segon Mega*	18730	"
Segon Omas*	18731	"
Segon Perak*	18736	"
Sempol*	18757	"
Sempor*	18761	"
Seraju*	18775	"
Serang*	18777	"
Sero*	18786	"
Setra*	18793	"
Shanghai*	18798	"
Siam Puteh*	13466	Malaysia
Sidara*	18824	Indonesia
Siem	18832	"
Sigadis	15555	Sri Lanka
Sintawati	18863	Indonesia
Skaro*	20172	"
Sulai	15239	Sri Lanka
T 23*	6433	India
T 142 (Badshabog)*	5894	"
Tilakkachray*	681	Indonesia
Tjeremas*	34	Indonesia via Philippines
UCP 122	8794	Bangladesh
UCP 195	8802	"
# 79*	3390	Africa

* Not yet retested.

Table 9c. Varieties resistant to brown planthopper, Nilaparvata lugens.

Variety	Acc. No.	Origin
ARC 12479	22085	India
ARC 5929*	19676	"
ARC 6610*	20419	"
ARC 6626*	20427	"
ARC 6649*	20435	"
Anbaw C7	6069	Burma
Andaragahawewa	11974	Sri Lanka
ASD 7 (Karsamba Red)	6303	India
Babawee	8978	Sri Lanka
Balamawee	7752	"
Balamawee	8919	"
Balamawee	12078	"
Berawee	8967	"
Ca 902/b/2/2*	6382	Tchad
CO.9 (PI 193176)	3690	India
CO.10 (PI 193177)	3691	"
CO13*	3736	"
CO 13*	4897	"
CO 13	10633	"
CO 18*	6331	"
CO 22 (Manavari)	6400	"
D25-42*	13728	"
Dikwee	7814	Sri Lanka via Nigeria
Dikwee 328	12087	Sri Lanka
Gangala	7733	"
H105	158	"
Hamsa*	11489	India
Hathiel	7730	Sri Lanka
Heenukkulama B	11978	"
Hondarawala 378 B	12076	"
Hondarawala 502 B	12075	"
HR-12	19229	India

* Not yet retested.

Table 9c. Cont'd.

IR26	24154	IRRI
Japan Heenati C	15604	Sri Lanka
Japan Wee	15605	"
Kaluheenati*	7735	"
Kirikunda	15558	"
Kosatawee	11677	"
Kuruhondarawala	7731	"
M 302*	154	"
M 302 x Mas 24	7833	"
M.C.M. 1	19300	India
M.C.M. 2	19301	"
Maha, Murungan, Badulla	12094	Sri Lanka
Malalwariyan	15203	"
Mawee*	12854	"
M. I. 329	12089	"
Madayal B	12001	"
Mahadikwee	11956	"
Malkora A	11716	"
Mathumanhikam	8957	Sri Lanka
MTU 15	233	India
Mudgo	6663	Goa of India
Murunga 307*	3472	Sri Lanka
Murunga 308	3473	"
Murunga Balawee	15725	"
Murungakayan	8955	"
Murungakayan 3	12071	"
Murungakayan 101 B	12072	"
Murungakayan 304 B	12073	"
Murungakayan 303 B	12074	"
Murungakayan 302	11097	"
Murungakayan 307	11096	"
Murungakayan 308	11107	"
Ovarkaruppan B	11963	"
Pai-shien	11051	Taiwan
Palasithari 601	12069	Sri Lanka
Pawakkulama B	11983	"
Pannetti	8937	"
Periamorungan B	11935	"
Pirum Karuppan	15513	"
PK 1	11703	"

*Not yet retested.

Table 9c. Cont'd.

Podimawee	7728	Sri Lanka
Podiwee	11938	"
PTB 18	11052	India
PTB 18*	19312	"
PTB 19 (Athikraya)	6107	"
PTB 20*	19313	"
PTB 20*	19319	"
PTB 21 (Tekkan)	6113	"
PTB 21	11053	"
PTB 21*	19314	"
Rathu Heenati	11730	Sri Lanka
Seruvellai	8990	"
Sinnakayam B	11687	"
Sinnanayan 398	12079	"
Sinnasuappu	11697	"
Sinna Karuppan	11731	"
Sinnavellai A	11946	"
SLO 12 (Thella Garikasanavari)	6300	India
Suduwi 306	11098	Sri Lanka
Sudhubalawee	8900	"
Sudurvi 305*	3475	"
Su-yai 20*	7299	China
Thirissa	7734	Sri Lanka
Tibirewewa B	11969	"
Vellailangayan	8956	
Vellailangalayan	8958	"
Vella Kayan*	15219	"
V 1	7815	"
Warangal Culture 1252	13743	India
Warangal Culture 1253*	11055	"
Warangal Culture 1259 (EK 1259)*	13745	"

*Not yet retested.

Table 9d. Varieties resistant to white-backed planthopper, *Sogatella furcifera*.

Variety	Acc. No.	Origin
ADT 19 (Sarapalli)	6379	India
ARC 5752	12119	"
ARC 6248	12268	"
ARC 6563	12276	"
ARC 6601	12289	"
ARC 6611	12294	"
ARC 6624	12299	"
ARC 6634	12302	"
ARC 6650	12308	"
ARC 7331	12371	"
ARC 10214	12392	"
ARC 10595	12525	"
ARC 10600	12527	"
ARC 10651	12556	"
BJ 1	3711	"
C 5-17	3746	"
C-20	12869	"
Colombo	6662	Goa of India
Dahanala 2014	3469	Sri Lanka
Djambon	13603	Indonesia
J. B. S. 34	3732	India
Kondinga	13417	Malaysia
Manggar	13605	Indonesia
3-month variety	6716	Guyana
Mudgo	6663	Goa of India
Murungakayan	8955	Sri Lanka
Nang-lee	16739	Vietnam
Padi Budong	13423	Malaysia
Pankhari 203	5999	India
Renda Serah	18627	Indonesia
Ridjah	13613	Indonesia
Saraya	6715	Guyana
Sedan Mundur	18712	Indonesia
Segon	18719	"
Segon Mega	18730	"
Sempor	18760	"

Table 9d. Cont'd.

Sentral Merah	18770	Indonesia
SLO 12 (Thella Garikasanavari)	6300	India
Ta-lee	4267	China
Tau Binho	12871	Sudan
Ubot	19165	Indonesia
Unar	19167	"
Warangal Culture 1240	13742	India
Warangal Culture 1252	13743	"

Table 9e. Varieties resistant to zigzag leafhopper, Recilia dorsalis.

Variety	Acc. No.	Origin
Balamawee	7752	Sri Lanka
DS 1	8573	Pakistan
PTB 21	11053	India
PTB 27	6101	India
Rathu Heenati	11730	Sri Lanka

10. Stem borers

The stem borers occur every year and infest the rice plant from seedling stage to maturity. Damage to the seedlings results in dead leaves (the so-called "dead hearts"). The larvae bore into the stem usually at the nodal region. They feed and develop within the stem and cause the 'white heads.' These insects are extensively distributed over all rice-growing countries.

Borers will continue to be the most important persistent and widespread insect pests of rice. As such they are the pests that most commonly require control. Management of borers is a priority in most pest control recommendations. Currently we are largely dependent on insecticides to minimize borer damage.

Thousands of cultivars have been screened for resistance to two major species: the striped borer (Chilo suppressalis) and the yellow borer (Tryporyza incertulas). The moderately resistant sources are enumerated in Tables 10a and 10b, respectively. Resistance appears to be primarily the antibiosis type and to a certain extent the non-preference type. The mode of inheritance appears to be multi-genic and complex.

Some of the moderately resistant accessions have been used in the breeding program, and IR26 and IR20 are products of the variety TKM 6, first noticed because of its moderate borer resistance. We are attempting to increase the level of resistance by crossing varieties that each show some resistance. The progeny are screened under severe infestations to find strains with higher levels of resistance.

Because resistance is not the same for all species of borers, we are screening varieties as well as breeding lines under artificial and natural conditions for resistance to two different species. Wide field adaptability depends on the resistance to several borer species. A high level of stable borer resistance could contribute more to rice insect control in the field than any other insect control measure.

Table 10a. Varieties resistant to striped borer, *Chilo suppressalis*.

Variety	Acc. No.	Origin
Bir-co 884	4346	China
BMT 53R 3536	1863	U.S.A.
C 409	6785	Burma
Chianan 2	89	Taiwan
Chiang An Tsao Pai Ku	1577	China
Chua-dau	4785	China
CI 5339*	958	China
CO 13*	4897	India
CO 21	6396	India
DD 48	8620	Bangladesh
DNJ 97	8454	Bangladesh
DV 88	8841	Bangladesh
DZ 41	8563	Bangladesh
Lenkan-mi-thou-goo	4537	China
Patnai 6*	3726	India
PI 160638	1239	China
Su-yai 20	7299	China
Szu Miao	7300	China
Ta-poo-cho-z	4285	China
Taitung 16	99	Taiwan
Ti Ho Hung	1226	China

* With more than one Acc. No.

Table 10b. Varieties resistant to yellow stem borer, *Tryporyza incertulas*.

Variety	Acc. No.	Origin
Bali	17197	Indonesia
Bali Gropak	17179	Indonesia
Bandjara	17219	Indonesia
C4-63 (green base)	16331	Philippines
Kipusa	5467	Africa
Pai Chung Shih Pa	1268	China
RD-5	24141	Thailand
Thailand x Norin	803	India
TKM6	237	India
WC 1251	11054	India
WC 1253	11055	India
WC 1263	11057	India

11. Whorl maggot

The rice whorl maggot (Hydrellia philippina) is widely distributed in Southeast Asia. It feeds on the inner margin within the whorl of the still unopened youngest leaves and scrapesoff the tissues, leaving only the two epidermal layers. The damaged leaves are shrivelled and whitish. The damage appears to be increasing and spreading over a wider area.

About 5,000 accessions have been tested in the field for maggot resistance. A few have been screened in the greenhouse under artificial conditions. However, only moderate levels of resistance have been found (Table 11).

Moderate levels of resistance may well be adequate to prevent yield loss. Since the greenhouse screening technique is not yet very efficient, field screening might be adequate.

Table 11. Varieties moderately resistant to whorl maggot, *Hydrellia philippina*.*

Variety	Acc. No.	Origin
ADT 15 (Senkuruvai)	6221	India
Akibae	9216	Japan
ARC 6064	12203	India
ARC 6089	12212	"
ARC 6231	12260	"
ARC 10174	12385	"
ARC 10214	12392	"
ARC 10281	12420	"
ARC 10296	12421	"
ARC 10297	12422	"
ARC 10299	12423	"
ARC 10301	12424	"
ARC 10696	12580	"
ARC 10952	12682	"
ARC 11094	12712	"
ARC 11097	12713	"
ARC 11098	12714	"
Balilla x Sollana	9527	Spain
Bakong	17190	Indonesia
Bangka	17255	"
Binagacay	19389	Philippines
Biuluk	16359	Indonesia
Bulu Sampang	17352	"
California	9279	Hungary
Chen-Tsan-Co	4365	China
Cicih Selem	17434	Indonesia
CO 1	6025	India
CO.9	3690	"
CO 20 (Thella Sannavadlu)	6035	"
Csornuj	9281	Hungary
DA 18 (Pusur)	6045	Pakistan
Dendek	17461	Indonesia
Dete	17463	"

*All of the listed accessions are MR, only HR-102 is resistant.

Table 11. Cont'd.

Dete	17464	Indonesia
DH 1	9533	Spain
Fuzisaka 2	9282	Japan via Hungary
Genya Rawe	17643	Indonesia
Gin-Shan-Tsan 18	4444	China
Gondang	19278	Indonesia
Haya Norin	9402	Hungary
H. R. 102*	3753	India
H. R. 106	642	"
Hsin Hsin Bir Goo	4657	China
Hsin Huan Thou	4716	"
Ibuki	12749	Japan
Irradiated Taichung 65	9434	Taiwan
JC 198	9200	India
Kendzo	9315	Hungary
Ketan Djinggo	16445	Indonesia
Ketan Gondel	17858	"
Ketan Gropak	17862	"
Ketan Gubat	17863	"
Ketan Gundil	17866	"
Ketan Kasturi	17881	"
Ketan Kopros	17886	"
Ketan Kutuk	17894	"
Ketan Mambang	17908	"
Ketan Odeng	17926	"
Ketan Opjor	17928	"
Ketan Rantai Mas	17945	"
Ketan Rapi Djali	17946	"
Ketan Selandjana	17956	"
Ketan Sundo	17966	Indonesia
Ketan Uci	17977	"
Ketan Untup	17980	"
Kopo	18017	"
Krawang Hadji	18024	"
Koshijiwase	9262	Japan via Hungary
Kuntulan	16489	Indonesia
Lien-Chan-Bir-Gan-Wo-Mau	4542	China
Luang Ray	11511	Laos
Mae Cuoi	12017	Egypt
Mak-bit Khao	11554	Laos

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* Resistant

Table 11. Cont'd.

Ma-li-bin 2	4561	China
MGL 2 (Kayama)	6218	India
Nandi 3	18316	Indonesia
Nandi Batu	18317	"
Nano de Alcantara	9317	Hungary
Norin 19	9396	Japan via Hungary
Norin 33	9377	Japan via Hungary
Oku-masuri	12760	Japan
Originario	9376	Hungary
Oshikari Shiroque	9485	Brazil
Padi Gundil	18366	Indonesia
Padi Hitam	18371	"
Padi Krawing	18377	"
Padi Putih	18393	"
Pare Beureum 1	18452	"
Pare Beureum 1	18453	"
Parambacheera 0.6706	12014	India
Patro	9528	Spain
Perillanel 26014	6117	Sri Lanka
PTB 9 (Thavalakkannan)	6274	India
PTB 21	19314	India
Pulut Masribut	18527	Indonesia
RDR 2	613	India
Sampangan Perak	18677	Indonesia
Sanggul	18683	"
Sanpuku	12724	Japan
Sasak Barak	18704	Indonesia
Satrijo	18705	"
Sawanohana	12720	Japan
Secano	9311	Hungary
Segli	18717	Indonesia
Se-Yua-Toon-Yuanpze	4247	China
Sewu	18796	Indonesia
Shua-Nan-Tsan	4587	China
Sir Kuning Gedangan	18886	Indonesia
Si-Sou-Baj-Tao	9318	China via Hungary
Slendora	18902	Indonesia
Slobok	16571	"
Solo	18906	"
Sontok Bogo	18911	"
Sornavari	3443	Africa
Sri Kuning	18921	Indonesia

Table 11. Cont'd.

Sueca x Sollana	9531	Spain
Sushu-roku	12725	Japan
T.3	3705	India
T 1145	6270	"
Teine	12719	Japan
Teluk Bajur	18970	Indonesia
Thailand x Norin	803	India
Tj. Mudja	19140	Indonesia
Tjempo Beton	16583	"
Tjempo Sungut	16634	"
Tjempo Tambak Urang	16635	"
TKM 6	237	India
Toyochikara	12721	Japan
Tsao Wan Ching	1034	China
Vercelli	9467	Italy via Brazil
Woo-Co-Tsan	4545	China

12. Leaf folder

The leaf folder (Cnaphalocrosis medinalis) occurs extensively in all rice growing areas of the tropics. The caterpillars feed on the newly emerged leaves and fold the leaf blades into tubes. White streaks on the leaves indicate areas damaged by feeding. Several leaves on a plant may be damaged.

The leaf folder appears to be an increasingly severe pest. Although we do not know the extent of yield loss it causes, but we anticipate that this insect will soon require control over a wide area if good yields are to be maintained.

Limited testing led to the identification of six accessions as promising sources of resistance (Table 12). The testing work needs to be continued when technical help becomes available. Even moderate resistance would be very helpful to keep this pest from becoming serious and requiring pesticide treatment.

Table 12. Varieties resistant to rice leaf folder, Cnaphalocrosis medinalis.

Variety	Acc. No.	Origin
ARC 5752	12119	India
Hashikalmi	3397	Bangladesh via Surinam
Hom Thong	12969	Laos
Kipusa	5467	Africa
Mudgo	6663	Goa of India
Warangal Culture 1263	11057	India

13. Nitrogen utilization

A. Atmospheric nitrogen fixation in rice rhizosphere - The objective is to identify varieties and lines which could potentially fix more atmospheric nitrogen in the rice rhizosphere. A new assay technique is being carried out on 42 varieties in the greenhouse. Field testing will cover 102 varieties. The nitrogen fixation in situ will be assayed.

B. Utilization of soil nitrogen - The objective is to compare varietal differences in the uptake of soil nitrogen. In the greenhouse 99 varieties were tested with and without nitrogenous fertilizer (labelled with N^{15}). Field testing will include 99 varieties.

14. Nutritive quality of rice — protein and lysine

Between 1966 to 1973, about 12,500 entries from the IRRI rice collection were screened for brown rice protein. Samples were obtained from crops grown on the IRRI farm. Most of the high protein entries were low yielding and some were japonica type. Since environment is known to affect the protein content of the rice grain, the goal was to improve the protein content of milled rice from 7% to 9%, which would increase protein intake at least 10% in the Asian rice diet.

The ratio of protein (mg) to brown rice (based on % protein and 100-grain weight) is being studied as a criterion of high protein content in rice. If it turns out to be a useful criterion, the IRRI collection will be screened for 100-grain weight and percent protein of brown rice in the future. Analysis for protein content alone has little meaning since the high protein entries are very poor in plant type and yield potential.

About 12,500 entries have been screened for lysine content (dye-binding capacity) and the graph of dye binding capacity vs. protein indicated the presence of a few higher lysine lines. Actual lysine analysis by ion-exchange chromatography and replanting of the promising entries showed that the lysine content of protein only varies by ± 0.5 percentage point at any protein level. Since the lysine content of rice protein is already high (about 4%), the increase involved is only about 12%. Hence, breeding for high protein content has more potential for raising nutritive value than breeding for higher lysine content. Only two higher lysine varieties, ARC 10525 and Kolamba 540 from India, were identified.

15. Drought resistance

Drought affects both the level of yield and the stability of yield in upland, rainfed-lowland, and deep-water cultures. The three types of culture make up 60 percent of the rice acreage in South and Southeast Asia. Upland rice occupies 80 percent of the rice acreage in Latin America and 75 percent in West Africa.

Drought resistance is a complex trait consisting of the escape, avoidance, and tolerance mechanisms. The ability to recover quickly after drought is another essential character.

Field testing in the dry season under a simulated upland culture makes possible the evaluation of thousands of cultivars and breeding lines in one season. About 80 outstanding sources of field resistance to drought have been identified from more than 2,000 cultivars screened to date (Table 15a) and utilized in IRRI's breeding program for upland rice. The component traits involved in field resistance appear to be largely of the avoidance type: deep and thick roots, plasticity in leaf rolling and unrolling as an indication of quick stomatal response to internal water stress, and heat tolerance. Varietal differences in recovery are also evaluated in the field experiments. Systematic field testing will eventually cover the bulk of the entire collection. The African rices (O. glaberrima) included.

Plant physiologists are also studying drought resistance in the greenhouse using large boxes of soil which represent different levels of constant water table. The findings (Table 15b) agree with field tests (Table 15a).

Root systems of resistant and susceptible cultivars are compared in boxes or tubes of soil. Extensive root systems, consisting of many long and thick roots, are associated with drought resistance.

Tolerance to and recovery from constant levels of water stress at different stages of plant growth are investigated by agronomists in the greenhouse. A number of varieties and lines have been found promising as tolerant genotypes (Table 15c). Testing techniques are being improved.

Efforts are being continued to further collect drought-resistant varieties from areas where drought frequently occurs or where upland rice is extensively cultivated. Such a segment of the germ plasm collection showed the greatest increase in size -- more than a ten-fold since field collections began in 1971.

Table 15a. Varieties resistant to drought in field tests.

Variety	Acc. No.	Origin
Ba Djang Nhu	19599	Vietnam
Ba Djang Ploi	19600	Vietnam
Bantia	6454	Liberia
Binirhen Str. 366	5427	Philippines
Chao Meth Nhay	11795	Laos
Dam Boung	11811	Laos
Dam Ngo	11632	Laos
Deng Mak Fay	12910	Laos
Deng Ngoua	11823	Laos
Dular*	636	India/Bangladesh
Elliot	6457	Liberia
Gamanpou	16082	Ivory Coast
Gbante	16081	Ivory Coast
Khao Kieng	11622	Laos
Hao Khao	11914	Laos
Kap Nhay	11640	Laos
Khao Deng	12927	Laos
Khao Eo	11639	Laos
Khao Hay	11788	Laos
Khao Luong	11832	Laos
Khao Nok	12902	Laos
Khao Tam	11631	Laos
Khaotong	11652	Laos
Khao Pane	12928	Laos
Khao Phoi	11623	Laos
Khao Sam Deuane	11661	Laos
Khao Tong	11621	Laos
Khao Vay	11913	Laos
Khao Xiou	11925	Laos
Khao Y Tam	11650	Laos
KH. Chepheum	11802	Laos
KH. Malenh	11812	Laos
Kinampupoy	5995	Philippines
Kouimlipou	16092	Ivory Coast
Kumayat	5428	Philippines
KU 78	15020	Thailand
KU 86	15027	Thailand
LAC 5	14948	Liberia
Lay Ngenh	11625	Laos
Lay Sort	12906	Laos
Ligerito	19918	Colombia
Ligerito	19919	Colombia
Ligerito	19920	Colombia
Mack Bouap	11653	Laos
Mack Bouap	11655	Laos

* Also rated as drought-resistant by plant physiologists.

Table 15a (continued)

Variety	Acc. No.	Origin
Mack Hing Hom	11658	Laos
Mack O	11646	Laos
Mack Tay Deng	11659	Laos
Mah Nam Pai	23756	Thailand
Mah Reng	23757	Thailand
Mai Kai	23758	Thailand
Mak Kheua	12917	Laos
Malandi II	19454	Philippines
Maligaya 5	759	Philippines
Ma Nam 276-3-1	23759	Thailand
Ma Wai	23761	Thailand
Meth Nai	11636	Laos
M1-48*	359	Philippines
Nam Mack	11635	Laos
Nga Xang Khao	11649	Laos
Nga Xang Lay	11791	Laos
N 22	4819	India
OS4*	11335	West Africa
Padi Ansisiyuk	14386	Malaysia
Padi Pupurong	14387	Malaysia
Padi Sinilop	14384	Malaysia
Padi Tambayungan	14382	Malaysia
Padi Tatakin	14390	Malaysia
Pho Kha	11626	Laos
Pinortuna	19475	Philippines
Pulot	19476	Philippines
R 75	15076	Congo Leop.
Sankok	12103	Vietnam
Seratus Malam	14415	Indonesia
Sran Kraham	16959	Cambodia
Susono-mochi	7689	Japan
Tosahata-mochi	7693	Japan
Tiale	19492	Philippines
Tres Marias	19495	Philippines
Xiou Kao	11634	Laos
1-EB	14854	Liberia
1-G	14856	Liberia
1-K	14857	Liberia
7-AA	14808	Liberia
7-B	14862	Liberia
8-A	14863	Liberia
8-CD	14866	Liberia
9-BB	14830	Liberia
9-D	14811	Liberia
10-A1	14867	Liberia
10-C	14868	Liberia

* Also rated as drought-resistant by plant physiologists.

Table 15a (continued)

Variety	Acc. No.	Origin
11-B	14869	Liberia
13-A	14833	Liberia
18-A	14836	Liberia
19-C	14837	Liberia
20-A	14838	Liberia
28-A	14844	Liberia
30-C	14846	Liberia
30-E	14848	Liberia
31-E	14849	Liberia
63-83	14725	Ivory Coast
142	14882	Liberia
270	14914	Liberia
279	14916	Liberia
280	14917	Liberia
421	14918	Liberia
428	14919	Liberia
462	14921	Liberia
551	14935	Liberia
553	14937	Liberia
558	L4941	Liberia
560	14942	Liberia
562	14943	Liberia
610	14944	Liberia

Table 15b. Drought-resistant varieties.

Variety	Acc. No.	Origin	Rating in Field test*	Rating in Constant water-table box**
Azmil	11375	Philippines	MR	R
E425	11334	West Africa	MR	R
Miltex	291	Philippines	I	R
Palawan	353	Philippines	MR	R

* Rated by plant breeders.
** Rated by plant physiologists.

Table 15c. Varieties and lines having promise in drought tolerance tests*.

Variety or line	Acc. No.	Origin (for variety) or parentage (for line)
E425	11334	Africa
MRC 172-9	26273	Philippines
IR5	9926	Peta/Tangkai Rotan
IR442-2-58		IR95-31-4/Leb Mue Nahng
IR879-314-2		IR8^{2}//Peta^{3}/Dawn
IR937-55-3		IR8^{2}//Dawn/TN1
IR1416-131-5		IR400-28-4-5/Tetep
IR1480-147-3		IR790-28-1-3/IR825-28-4-3
IR1529-72-5		IR305-3-17-1-3/IR661-1-140-3
IR1529-430-3		"
IR1529-677-2		"
IR1531-86-2		IR332-2-10-1-2-1/IR127-80-1-10
IR1545-339		IR24/DZ 192
IR1646-623-3		IR930-33-1/IR441-19-1-3-2-2
IR1721-11-6		IR24^{3}/O. nivara

* Identified by agronomists.

16. Cold tolerance

Approximately 7 million hectares are under rice in South and Southeast Asia where the HYVs can not be cultivated because of low temperature. These include the high elevation tropical areas where rice may be cultivated throughout the year; high elevation subtropical areas where rice is cultivated during the summer months only; and low elevation subtropical areas where rice is grown throughout the year but cool temperatures are a restraint only during the winter months. Because such areas are relatively small and widely scattered, cold tolerance is a relatively low priority breeding project at IRRI.

Systematic screening has not been greatly increased in size because of the low priority of the problem and the knowledge that varieties collected from cool-temperature areas should be cold tolerant. If and when more information becomes available on the specific facets of cold tolerance, systematic screening may prove more worthwhile.

Attention has been given to the collection of germ plasm from high elevation areas in the tropics, though there is not great urgency in covering all areas at once. The tolerant types are not being rapidly replaced by HYVs and this is not likely to happen within the next 5 years. However, there should be a contingency plan for making a thorough collection of these materials should improved varieties gain a foothold in the cooler areas.

Table 16. Varieties tolerant to cold water or to cool air.

Variety	Acc. no.	Origin
	Cold Water	
JP 5	13382	Pakistan
Jumula 2	13375	Nepal
Raja Imut	24171	Indonesia
Sug	24172	Kashmir
Remei	10903	Japan
Caloro	150	U.S.A.
	Cold Air	
China 1039	24168	China via Kashmi
Jumula 2	13375	Nepal
Jarak	24942	Indonesia
Kulu	11337	Australia
Sug	24172	Kashmir
Remei	10903	Japan
Boro varieties (many)		Bangladesh
Szegedi-szalchalus	16294	Hungary
Mountain Province varieties (many)		Philippines
Shirkati	14528	Afghanistan

17. Problem rice soils

Soil problems are among the main obstacles to increasing the productivity of rice lands and to extending the area under rice. They affect millions of hectares in the tropics which are climatically well suited to rice cultivation.

The main problems are salinity/alkalinity (10 m ha), salinity of coastal soils (26 m ha), iron toxicity (8 to 15 m ha), zinc deficiency (10 m ha), phosphorus deficiency (10 to 15 m ha), and iron deficiency in upland rice (10 m ha). Since poor countries cannot afford the reclamation of these soils, alternative methods of using them efficiently must be explored. One method is selecting and breeding varieties suited to adverse soil conditions.

During the past two years we have screened over 100 varieties and selections for resistance to salinity, alkalinity, iron toxicity, and deficiencies of phosphorus, iron, or zinc, and noted striking varietal differences. A more extensive and systematic program of screening is planned in the GEU program. The first step is the collection of varieties from the problem soil areas. The geographical areas are as follows:

Soil problem	Geographical area
Salinity/alkalinity	Pakistan, Punjab, Haryana, Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Andhra Pradesh in India; Khorat in Thailand; Mandalay in Burma; Iran; Iraq; Egypt; Chad; Peru.
Coastal salinity	Maharastra, Karnataka, Tamilnadu, Andhra Pradesh, Orissa and West Bengal in India; the Irrawaddy delta in Burma; southwest Thailand; western Malaysia; eastern Sumatra, Kalimantan and south Sulawesi in Indonesia; the coastal fringes of the Indo-China peninsula; the western coast of Africa; the northern coast of South America; the coastal plains of Malagasy; and the coastal soils of Luzon, Bicol, Visayas, and Mindanao in the Philippines.
Iron toxicity	The Mekong delta in Indo-China; Ongkarak (Thailand); eastern Malaysia; western Sumatra, and Kalimantan (Indonesia); Sierra Leone; Senegal; Liberia; Nigeria; Malagasy; Karnataka, Orissa, and Manipur in India; and southwest Sri Lanka.

Soil problem	Geographical area
Zinc deficiency	Most sodic, calcareous, and fresh water marshy soils. (Map in preparation).
Phosphorus deficiency	More or less the same as the iron-toxic areas.
Iron deficiency	Upland rice areas especially where the soils are neutral or slightly acid.

Table 17. Varieties highly resistant to different adverse factors in the soil.

Adverse factor	Resistant variety	Acc. no.	Origin
Alkalinity	Pokkali	8948	India via Sri Lanka
Aluminum and manganese toxicity	M1-48	359	Philippines
Iron deficiency	M1-48	359	Philippines
Iron toxicity	Pokkali	8948	India via Sri Lanka
Phosphorus deficiency	H-4	155	Sri Lanka
Salinity	Pokkali	8948	India via Sri Lanka
Zinc deficiency	H-4	155	Sri Lanka
	Pokkali	8948	India via Sri Lanka