GENETIC DIVERSITY IN RICE AND IT'S CONSERVATION

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ABSTRACT

Rice (Oryza sativa L.) the important global food crop is gifted with a lot of biodiversity both in the form of land races and wild species. This variability is scattered in many parts of the world, particularly found abundant in South east Asia and African countries. The traditional varieties / land races and wild species are the genetic wealth of a country, because they are enriched with valuable gene system. This germplasm is very much useful to breed genotypes resistant to biotic and abiotic stresses and also to improve the grain quality characters. Therefore, exploration, collection and conservation of these gene pools had been started during 1960s to study their origin, variability relationship and also being exploited for rice improvement. The responsibility of conservation and regeneration of all these germplasm is wasted in many countries. Inspite of a lot of constraints and problems, this task is in progress.

INTRODUCTION

Agricultural production depends on continuing infusions of genetic resources for yield stability and growth of crop plants. All agricultural commodities, even modern varieties, descend from an array of wild and genetic resources. The genetic resources of rice, the pioneer food crop of the world, comprising land races, modern and obsolete varieties, genetic stocks, breeding lines, and the wild rices are the basis of food security. Before the development of modern varieties, farmers cultivated land races, which are generally very diverse within species, because each cultivar was adapted to specific environment. The pace of improvement has accelerated as modern breeding techniques were developed that facilitated selection of specific desirable traits. Breeders continuously needed new and diverse germplasm from outside and utilized the stock; sometimes related wild species and land races were used to find specific traits to maintain or improve the yield. The value of conserved germplasm can, therefore, be assessed in terms of useful traits for rice breeding and the economic impact that germplasm utilization has on rice production and productivity. Therefore, the exploration and conservation of the biodiversity of rice were felt important and work commenced to conserve the germplasm, documents and utilization.

THE RELATIONSHIP BETWEEN THE GENUS *ORYZA* AND OTHER GRASSES

Botanists group plants into families; families are divided and subdivided into subfamilies, tribes, genera, species, etc. The genus *Oryza*, which consists of two cultivated rice species, *O.sativa* L. and *O.glaberrima* Steud and about 21 related species, are in the grass family Poaceae.

*Oryz*a is closely related to the bamboos (Tzvelev, 1989) and some of the forest wild rices look like miniature bamboos. Rice and its relatives are quite unrelated to other major cereals such as maize, wheat and sorghum. A comprehensive numerical taxonomical analysis of the grass family, which probably reflects evolutionary relationship, shows the association between rice and bamboos, and the divergence of rice from other cereals (Watson *et al*., 1985).

Rice belongs to the tribe *Oryzeae*, which consists of 12 genera (Table 1). Examples of potentially useful traits in genera related to *Oryza* are

- Plants adapted to cold water (*Zizania*),
- Plants adapted to salt water *(Porteresia*, an ecotype of *Leersia oryzoides*), and
- Plants with unisexual spikelets (*Zizania, Luziola, Zizanopsis*).

Table 1. Genera, number of species, chromosome number and spikelet structure in the tribe *Oryzeae* (Duistermaat 1987, Pyrah 1969, Second 1985b)

Genus	Chromosome number (2n)	Spikelet structure
Oryza	24, 48	Bisexual
Leersia	24, 48, 60, 96	Bisexual
Chikusichloa	24	Bisexual
Hygroryza	24	Bisexual
Porteresia	48	Bisexual
Zizania	30, 34	Unisexual
Luziola	24	Unisexual
Zizaniopsis	24	Unisexual
Rhynchoryza	24	Bisexual
Maltebrunia	Unknown	Bisexual
Prosphytochloa	Unknown	Bisexual
Potamophila	24	Unisexual and Bisexual

Most of the species in genera related to *Oryza* have not been studied in detail. However, two species in the genus *Zizania* are a well-known part of America and Asian cuisine. *Z. palustris* L., is the wild rice of North America commonly served during the United States thanks giving Day meal. *Z. latifolia* is eaten as a vegetable, particularly in Chinese dishes.

The genus *Oryza* consists of species adapted to a wide range of habitats. Several species grow in shady forests, others in vast strands in deep water swamps. Wild rices can be found, for example, in the Himalayan foothills, Asian river deltas, tropical Caribbean islands, the Amazon basin, and the inland swamplands of southern and western Africa as well as in temporary pools of the arid savannas of the tropics. The wild species of *Oryza* are found almost exclusively within the boundaries of the tropics. Cultivated rice, however, is grown as far as 50º N in China and 40º S in Argentina.

Rice is the world's most important staple food crop, and the rice genetic resources stored in the International Rice Gene bank (IRG) at the International Rice Research Institute (IRRI), Los Banos, Philippines, represent the largest and most diverse collection of rice in any gene bank (Bettencourt and Konopka, 1990). In fact, the collection comprises about 2% of all rice germplasm samples conserved worldwide, and donated from more than 110 countries. The collection of more than 80,000 registered samples is made up of landrace varieties nurtured by farmers for generations, modern and obsolete rice varieties, some breeding lines and special genetic stocks, the 21 wild species in the genus *Oryza*

(Vaughan, 1994) and related genera in the tribe *Oryzae* (Table 2).

Table 2 : *Oryza* species and other genera in the collection of the International Rice Gene bank at IRRI

Species complex	Species	Genome	Accession
***O. sativa* complex**	*O. glaberrima*	AA	1255
	O. barthi	AA	224
	O. longistaminata	AA	134
	O. sativa	AA	76614
	O. nivara	AA	468
	O. rufipogon	AA	712
	O. meridionalis	AA	43
	O. glumaepatula	AA	37
***O. ridleyi* complex**	*O. longiglumis*	4x	6
	O. ridleyi	4x	17
***O. meyeriana* complex**	*O. granulata*	2x	22
	O. meyeriana	2x	8
***O. officinalis* complex**	*O. officinalis*	CC	247
	O. minuta	BBCC	65
	O. eichengri	CC	23
	O.rhizomatis	CC	19
	O. punctata	BB, BBCC	54

Species complex	Species	Genome	Accession
	O.latifolia	CCDD	37
	O. alta	CCDD	10
	O. grandiglumis	CCDD	10
	O. australiensis	EE	25
***Oryza* species not assigned to any complex**	*O. schweinfurthiana*	4x	1
	O. brachyantha	FF	17
Hybrids			587
Other genera in *Oryzae*	*Chikusichloa aquatica*		1
	Hygroryza aristata		4
	Leersia hexandra		1
	L. perrieri		1
	L. tisseranti		3
	Porteresia coarctata		1
	Rhynchoryza subulata		1
Total			**80647**

Most samples in the collection are landrace varieties of *O. sativa*. Ecological differentiation involving cycles of hybridization, differentiation and selection were enhanced when ancestral forms of *O. sativa* were carried by farmers and traders to higher latitudes, higher elevations, dryland sites, seasonal deep water areas and tidal swamps (Chang, 1995). Two major ecogeographic races were differentiated as a result of isolation and selection; *indica* and *japonica* (Kato, 1930). The differentiation also involved morphological and serological characters as well as intervarietal fertility (Glaszmann, 1987). Selections made to suit cultural and socioreligious traditions added diversity, especially in grain size, shape and colour and endosperm properties. Today, thousands of varieties are grown in more than 100 countries (Jackson *et al*., 1996).

GENETIC EROSION AND GERMPLASM COLLECTION

In many areas, high yielding modern varieties were adopted by farmers and the cultivation of the landrace varieties in loss of genetic diversity and genetic erosion declined. The wild species are threatened with extinction through changes in land use, extension of agriculture into marginal areas and deforestation.

The collecting activities are closely linked to conservation and use. Farmers throughout Asia usually maintain the identity of each rice variety and enlisting their help to identify different varieties is an effective way of collecting germplasm. Using this method, more than 2,000 samples of *O. sativa* were collected during the second half of 1995 from the southern provinces of the Lao People's Democratic Republic (PDR). It is estimated that about 60% of these samples are unique varieties. Maintaining the germplasm samples as purelines also facilitates their multiplication or regeneration, conservation in the genebank, and ultimately the use by rice research workers worldwide. IRRI received almost 700 samples of *Oryza sativa* and 84 samples of different wild species from the Lao PDR, Tanzania, Philippines and Costa Rica during 2,000 and more than 24,700 samples of cultivated rice and 2,400 samples of wild rice were collected in 165 missions from 22 countries (Anon, 2000). More than 80 % of the cultivated samples and almost 70 % of the wild samples are now safely preserved in IRRI's International Rice Gene bank. Rice is believed to have originated in the South east and south Asia which includes north eastern zone of India. Therefore, a large number of indigenous varieties of cultivated rice and forms of wild species (*Oryza rufipayan, O. officinalis* and *O. granulate)* are seen in these regions.

Collecting the variability observed in indigenous rice cultivars began in India around the turn of this century. The work received special attention following establishment of the Agricultural Research Station at Dacca (Eastern India) in 1911 and the Paddy Breeding Station at Coimbatore (Southern India) in 1912. Setting up the Indian Council of Agricultural Research (ICAR) at New Delhi in 1929 and the Central Rice Research Institute (CRRI) at Cuttack in 1946 further strengthened these efforts. During the second phase of systematic explorations, the Jeypore Botanical Survey explored South Orissa and adjoining areas of Madhya Pradesh during 1955-60, which led to the collection of 1,745 cultivars. During 1965-67, 900 traditional cultivars of Manipur in far eastern India were collected.

The plant introduction of IARI, New Delhi was converted as NBPGR in 1976. It is a nodal agency for exploration, collection, conservation, characterization, evaluation and documentation for germplasm of all crops including rice. A large number of rice collection were made by Sharma and his team (1968-1973), with the help of IARI (Sharma, 1982). These collections were known as Assam Rice Collections (ARC). The Raipur collection of 19,116 rice cultivars grown locally in Madhya Pradesh region was made during 1971-76. Additional collection of 1,938 cultivars was made through a special drive for upland varieties under cultivation in Andhra Pradesh, Karnataka, Madhya Pradesh, Uttar Pradesh, Orissa and West Bengal. Collaborative explorations by NBPGR, and state agricultural universities added nearly 7,000 cultivars during 1978-80. The Vigyan Parishad Kendra Agricultural Station at Almora collected

1,247 cultivars from hilly regions of Uttar Pradesh. NBPGR and CRRI jointly explored Sikkim, South Bihar, and parts of Orissa in 1985 and collected 447 local types. Explorations by NBPGR during 1983-89 led to further addition of 4,862 cultivars to the national germplasm collection.

WILD RICE COLLECTION IN INDIA

In addition to spectacular variability in its traditional cultivars, India is also rich in wild rice, particularly *O. nivara, O. rufipogon, O. officinalis* and *O. granulata*. These species were collected by the pioneer research workers, Subsequently, S.V.S. Shastry and his Co-workers at Indian Agricultural Research Institute (IARI) made extensive collections of wild species of *Oryza* from Northern, Western, Central and Eastern India and assembled striking variability in *O. nivara* and *O. officinalis*. Variability in *Portersia coarctata* has been collected from coastal areas.

Besides Indian scientists, the foreign scientists like Kihara in early 1960s. Watanabe in the late 1960s and 1970s, French Scientists in 1986, came to India and in collaboration with Indian Council of Agricultural Research (ICAR) and IRRI undertook more intensive exploration all over the country and collected the wild species.

WILD SPECIES CONSERVATION

The international network for rice germplasm conservation has the following components.

1. The IRGC of IRRI shall preserve a complete set of genotypes. Other national and international centers help IRRI on rejuvenation.

2. IRRI shall preserve, rejuvenate and distribute *indica*, *japonica* cultivars, *O.sativa* and *Oryza* species except those from Africa.

3. The National Institute of Agrobiological Resources in Tsukuba, Japan, shall preserve, rejuvenate and distribute *japonica* varieties of East Asia.

4. The National Plant Germplasm System (NPGS) of USA shall preserve the accessions from USA, South America and Mediterranean area. The USA also shall continue to store duplicate samples of conserved IRRI stock.

5. IITA (International Institute of Tropical Agriculture, Ibadan, Nigeria) will preserve, rejuvenate and distribute cultivars of *O. glaberrima* and wild species of Africa. Institute de Recherche Scientistique et Technique Outline -Mer-France (ORSTOM) and West African Rice Development Association, Bouake, Ivory Coast (WARDA) plan to collaborate with IITA.

The above centers shall exchange and carefully compare the accession lists to minimize the maintenance of obviously duplicate accessions. Now, it is felt the need of multi-level (National / State / lesser entities) public and private collaboration in various conservation activities.

CONSERVATION METHODS

The international efforts aiming at collection, conservation and documentation have been coordinated by IPGRI since 1974 and the national efforts by NBPGR, New Delhi, since 1976. Broadly speaking, there are two main approaches to genetic conservation, namely, *in situ* and *ex situ* conservation.

IN SITU CONSERVATION

In situ conservation is best suited for wild species, which grow in different ecological niches. There are 21 wild species and varieties reported in the genus *Oryza* in tropics and subtropics. In Western Ghat areas four wild species and one weedy form occur. Among these, two form the part of evergreen or semi-evergreen forest vegetation upto an elevation of 2,500 ft. Two species such as *O. nivara* and *O. rufipogon* being genetically closer to cultivated rice occur in marshy areas, shallow ditches and partially inundated areas both in hills and plains.

ON FARM CONSERVATION

Another method of *in situ* conservation of land races of rice is on farm conservation. This helps in conserving the diversity in its original abode itself where these land races, local cultivars and special varieties have developed through a prolonged dynamic state of complex processes of crop evolution involving origin, domestication, spread, diversification and evolution.

NATURE AND OBJECTIVES OF ON-FARM CONSERVATION

It has often been assumed that on-farm conservation is complementary to other methods of genetic conservation. Objectives of on-farm conservation are:

- The maintenance and enhancement of allelic diversity at the farm level.

- Access to and control over diversity at the local level.
- Promotion of genetic diversity conservation is an option for household security.

APPROACHES FOR ON-FARM CONSERVATION

On-farm conservation strategies can be categorized under two main principles.

1. Make diversity a viable option to farmers

There is general consensus that farmers are not conservationists in nature, but are conservationists through use. In other words, farmers have to be provided with the right technical and economical options, so that they see the advantages for growing the varieties targeted by the conservationists.

Promoting long-duration varieties

Although difference in agroecological and socioeconomic conditions can be met where traditional and modern varieties coexist, changes in those conditions increase the tension between traditional and modern varieties. The competition between traditional and modern varieties is aggravated when their respective niches are modified. For example, the predominance of high-quality traditional varieties may be affected by the increased adoption of high-yielding varieties due to the development of irrigation. The higher market price for traditional varieties does not compensate their lower yield and longer duration. Farmers will continue to grow these traditional varieties if their cultivation does not penalize them.

2. Strengthen farmers' access to diversity

Understanding the external factors of genetic erosion

Various studies demonstrated how fast genetic erosion can occur at the local level. In 1997, El Nino caused a severe drought that affected the Cagayan Valley and much of the Philippines.

The drought and the rain affect the rice, when the rice plants are at seedling stage, a stage when the tolerance to these factors is negligible. Some farmers who had decided to wait for more rains could never plant. The typhoons also hit and cause severe infrastructure damage, during early season flooding, level and intensity increase it is devastating. Again, rice seedlings will be lost, even plants at later growth stages were badly affected.

Deficient household seed storage technology

Due to the humid climate conditions, the normal seed storage conditions in farming households do not permit farmers to conserve the germination ability of seeds more than 6-9 months. This means that farmers cannot jump a production season; if they do not produce seeds for a given variety during season they will have to find an external source to get seeds to plant the variety in season. Obviously, another option for them would be not to plant the variety.

Lack of infrastructure for seeds of traditional varieties

In a situation where seed stocks of most farmers were affected, farmers have to rely on external sources to obtain seeds for the next planting season. The seed stores generally carry only modern varieties and certified seed growers, a part of the Department of Agriculture's system of seed procurement strategy, grow only modern varieties.

Support to the use of modern varieties

In a programme (1997 and 1998) farmers are given seeds at no cost, but upon harvest are expected to pay for them. The seeds given in the scheme are from the certified seed growers and are always modern varieties, and sometimes only the recommended varieties. Traditional varieties are not planted by certified seed growers and were not included in the scheme.

Resilience of irrigated plots

The varieties that were planted in irrigated plots were obviously less affected by the drought than the varieties planted on rainfed plots. Therefore, irrigation sustained the use of the modern varieties, as farmers plant only modern varieties in irrigated plots (Morin *et al*., 1998).

What is remarkable here is that genetic erosion was caused by factors that 1) are external to the farmers' decision-making process, and 2) accompany the release of improved varieties, but are not related to the intrinsic qualities of improved varieties.

Improving on-farm storage

A simple and cheap seed drying and storage device that farmers could use to store the seeds for several years is needed. With a simple plastic drum as a container, and toasted rice seeds in a drying medium, preliminary tests show the moisture content of fresh-harvested seeds can be brought down to 10%, i.e., to a level that would permit the conservation of seeds in the closed drum for several years.

CONSTRAINTS AND INSTITUTIONAL SUPPORT NEEDS OF ON-FARM CONSERVATION

There are several factors, which determine why farmers continue to grow or cease to grow their local varieties. The decrease in diversity is affected through biases towards uniformity by the formal sector, and market systems for local products may not favor the retention of a broad spectrum of crops or varieties at the farm level.

Changing land use patterns may have an influence on diversity. It was suggested that land fragmentation may permit farmers to grow landraces on one plot of land, and commercial varieties on others. Since the development of on-farm conservation approaches beyond current practices have hardly been started, and the mechanisms poorly understood, the group felt the need to increase awareness of the potential of on-farm conservation through dialogues, training, and education at all levels. Interaction with farmers to enhance their understanding of the broader issues of plant genetic conservation would be one approach.

EX SITU CONSERVATION

Active collections / Field gene banks

Storage of seeds for long term in the case of orthodox species is done based on the Harington's 'rules of thumb' which define the relative influence of temperature and seed moisture content on seed longevity or viability. Both these factors are reported to act independently on the seed viability. The first rule says that for every 1% reduction in seed moisture content, the longevity of seed viability is doubled. Similarly, the second rule says that for reduction of every 10° F or 5.56° C, seed longevity is doubled.

Seed Stores

	Short term	Medium term	Long term
Temp.	10 – 20ºC	10ºC	–10 to –20ºC
Seed moisture	4% ± 1	4%	4%

Seeds maintaining their viability even after drying to 12% moisture under low temperature are called orthodox seeds. These can be stored in long term storage between –10 and –30°C. Such seeds with 5+1 or 5-1% moisture content can be stored in hermatically sealed containers in long term storage for over 100 years at –20ºC. The world's one of the largest seed stores is at Fort Collins in US. In IRRI, both a long term seed store keeping about 80,000 accessions and a short or medium term store for similar number of working collections are established for rice. In India such a big store for accommodating several lakhs of seed samples is now available in NBPGR at New Delhi. The minimum quality requirements of the seeds are the following:

- The seeds should not be treated with any chemicals or pesticides
- The seeds should have a minimum germination percentage of 85
- It should be free from seed borne pathogens and pests

A total of 4,000 seeds per sample in the case of self pollinated crops (eg. Rice) and approximately double for cross pollinated crops (eg. Chillies) should be kept in the store to maintain the variability as per the gene pool concept.

Periodical regeneration and rejuvenation of collections kept in the short/medium/long term storages and in *in vitro* are either done in the field, in suitable condition or in special situations such as green houses, grow houses, screen houses etc. In the case of rice in IRRI, about 500 accessions are grown every season in such a way as to characterize them and rejuvenate them. NBPGR now keeps its field collections numbering about 5,000 in three centres in the field as well as in the store. A long term seed store also caters to the need of safer storage of collections immediately after field characterization and evaluation.

IN VITRO CONSERVATION

In rice, biotechnological tools such as *in vitro* and cryo techniques have been mainly used for crop improvement. Their application in storage is very much restricted. Since rice produces orthodox seeds, it is rather convenient and practical to store seeds making use of long term, medium term and short term storage and hence put a limit to the use of biotechnological tools in its germplasm storage. In NBPGR New Delhi over 33,000 accessions of rice have been kept in long term storage.

Mainly anther culture and embryo culture are the two areas in which early workers have been concentrating. In China induction of haploids through anther culture was followed and further attempts on improvement of anther culture techniques are also being attempted. In 1979, it was proved that cold pretreatment of flower buds / panicles at 9-

11ºC for 14 days promoted induction of more number of green plantlets. It is an approved fact that various durations and different temperatures of cold pretreatment of rice in anther culture had differential effect on induction of callus and regeneration of plantlets. In anther culture, anther cell walls are used in MS, modified LS, modified Whites and N6 media. Further work on these aspects showed varied responses by different varieties, genotypes and species of *Oryza*. Establishment of embryogenic cell suspension cultures and plantlet regeneration from protoplast of *O.rufipogon* following a preheat treatment in 54ºC for 5 days to break down dormancy of seeds of rice. Induction of plantlets directly from anther culture was also successful. Meanwhile, culture of isolated pollen was also carried out to study on the stage on pollen development that triggers embryogenesis and also to study the effect of cold shock in improving the efficiency of pollen grains going through embryogenic process were also attempted.

Molecular biology, by generating new technologies and methods of analysis that either provide new approaches or supplement classical methods of analysis, has contributed significantly to increased understanding of many aspects of plant biology. Promising areas of biotechnology that may serve plant genetic resources activities and research are shown in Table 3.

Table 3: Biotechnological tools and their potential applications in plant genetic resources activities.

Activities or research	Helpful new technologies
Collecting or acquisition	*In vitro* technology, recombinant DNA technology (gene/DNA library and cloned genes)
Characterization	RFLP technology, protein/isozyme

Biosystematics Genetic diversity Identifying duplicates Genetic stability	electrophoresis
Maintenance and preservation	*In vitro* technology, cryopreservation, recombinant DNA technology (gene/DNA library)
Dissemination and exchange	*In vitro* technology, recombinant DNA technology (disease indexing, gene/DNA library, and cloned genes)

THE INTERNATIONAL RICE GENEBANK (IRG)

The long-term preservation of rice genetic resources is the principal aim of the IRG. Formerly known as the International Rice Germplasm Center, the gene bank has operated since 1977, although genetic conservation activities started in the early 1960s, just after the Institute was founded.

For several countries, including Sri Lanka, Cambodia, Lao PDR and the Philippines, the germplasm conserved in the IRG represents a more or less complete duplicate of their national collections. For other countries, such as India and the People's Republic of China, only parts of their national collections are duplicated at IRRI. Nevertheless, the IRG has provided an important safety net for national conservation efforts. On several occasions, it has been possible to restore rice germplasm that had been lost in national gene banks with accessions already conserved at IRRI. Such germplasm restoration has had a significant impact on national conservation efforts (Jackson, 1994; 1995).

Considerable attention has been paid to postharvest management standards of orthodox seeds. In the IRG, all cultivated rice germplasm accessions are multiplied or regenerated for long-term conservation in the field on IRRI's

Central Research Farm in Los Bonos (14º 13′ N, 121º 15′ E) between the beginning of November and May. A significant number of accessions in the collection are temperate adapted *japonica* varieties, or photoperiod-sensitive varieties.

In recent research, the environmental factors which affect seed quality and therefore potential longevity in storage, of the different types of rice have been identified, (Kameswara Rao and Jackson, 1996). Change in seed quality during the ripening stage were studied in 16 rice cultivars representing the two main types of *O. sativa, indica, japonica* and *O. glaberrima*; also changes in seed quality during development and maturation in three *japonica* cultivars and one *indica* cultivar planted on three different dates between October and early January were also studied (FAO, 1996). This research has permitted the introduction of new germplasm regeneration procedures, and seed production during this period which has several important advantages.

THE VALUE OF CONSERVED GERMPLASM

The rice varieties nurtured by farmers for generations have an inherent genetic value because of their adaptation to different farming conditions and resistance to pests and diseases. Knowledge of these traits, their adaptation to different farming conditions and resistance to pests and diseases, their genetic and molecular control and stability under different conditions enhances the value of the conserved germplasm.

Over three decades, the germplasm collection at IRRI has been systematically characterized for a range of morphological and agronomic traits that facilitate conservation, as well as selection of suitable phenotypes by breeders (Table 4). Thousands of individual rice accessions have been evaluated for their resistance to, or tolerance for a wide range of pests, diseases and abiotic stresses, such as brown planthopper, rice blast and bacterial leaf blight and adaptation to cold temperatures or saline soils (Jackson *et al.,* 1996).

Table 4: Number of *O.sativa* accessions in the International Rice Gene bank collection evaluated at IRRI for their reaction to insect pests and diseases (Jackson, 1997).

Stress	***O.sativa* accessions screened**	
	Number	**% Resistant**
Insect pests		
Brown plant hopper biotype 1	44335	15.4
Brown plant hopper biotype 2	10053	1.9
Brown plant hopper biotype 3	13021	1.8
Green leaf hopper	50137	2.8
Rice whorl maggot	22949	3.0
White backed plant hopper	52042	1.7
Zigzag leaf hopper	2756	10.1
Rice leaf folder	8115	0.6
Yellow stem borer	15656	3.8
Striped stem borer	6881	<0.02
Disease		
Blast	36634	26.2
Sheath blight	23088	9.3
Bacterial blight	49752	11.1
Rice tungro disease	15795	3.5

The Genetic Evaluation and Utilization (GEU) Program has made successful use of the following genepools:

Chinese semi-dwarfing source, vertical resistance to several diseases and insects, early maturity and photoperiod – insensitivity, drought resistance and recovery, and tolerance to certain adverse soil factors. For instance, the recent IR varieties are highly resistant to bacterial leaf blight, the tungro virus, grassy stunt virus, biotypes 1 and 2 of the brown planthopper, leafhopper resistance and tolerance to one or more adverse soil factors. The genes for grassy stunt resistance were derived from the wild relative, *Oryza nivara*. Nearly all of the national centres have made profitable use of the semi dwarfing gene (sd_1) contributed by Dee-geo-woo-gen and a varying number of the pest resistance genes derived for IRRI lines or IR varieties. Moreover, through local screening and selection, several national centres have incorporated additional resistance or tolerance genes from other sources into their improved varieties.

Assam rice collection (ARC) had many valuable genes for resistance to various pests and diseases, viz., gall midge, stem borer, green leaf hopper and diseases like leaf and neck blast BLB, RTD and bacterial leaf streak (Sastry *et al.,* 1971, Chatterjee *et al.,* 1977), tolerance to cold drought (Hakkim and Sharma, 1974) flood, high protein (Srivastava and Nanda, 1977), amylase content for the stature, Seetharaman *et al.* (1974) and also for the genes for the dwarf stage. Seetharaman, 1974 found that whole assemblage of Japonica characters such as thin culm, shy tillering, short panicle, etc., in ARC, therefore, opined that racial differentiation in *O. sativa* might have taken place in this region. Rao and Srinivasan (1978) found that ARC also had high yield potential and under low level ‘P’ in the soil. Seetharaman and Ghorain (1976) also recorded land races with *glaberrima* like characters, viz., truncated ligule, red kernel, etc., The Assam rice collections have also possessed diversity for glutinous or waxy traits in rice. This is a special class of rice for preparation of confectionaries (Pithus hurum), rice bear (apong, haj)., and breakfast food (Salpan) and industrial use. Besides, aromatic rices (Jolia) for the preparation of Kheer, Poloa) and Chokuwa and soft rice, and rices used for preparation of flaked, popped rice, puffed rice and bar boiled rice were also found (Ahmed *et al.,* 2000 a, b). Besides, high degree of variability for many characters has been observed by Pandey and Gupta (1995) in the germplasm of rice collection from NEH (Table).

Table 5: Variability in characters of rice germplasm from NEH region

Sl. No.	Characters	Range
1	Plant height (cm)	56-220
2	Flagleaf length (cm)	16.8-56
3	Flagleaf width (cm)	1.1- 2.8
4	Leaf area /per plant $(cm)^2$	180-6433
5	Days to flower	94-163
6	No. of ear bearing tillers	2.0- 20
7	Panicle length (cm)	14.3-31.1
8	Branches / panicle	3-16
9	Percentage of sound grain per panicle	3-99
10	Grain for panicle	31-321
11	Grain tenacity	1.7 –15.7
12	1000 grain weight (g)	11.6- 34.6
13	Seed yield plant (g)	.4-24.0

14	Leaf blast (1-10score)	3-9
15	Neck plast (1-10 score)	3-9

Indian rice breeders have made effective use of the indigenous genepools, which provide resistance to pests or tolerance to eco-edaphic stresses. The drought-resistant N22 was used in breeding Bala. TKM 6, which has multiple resistance to insects and disease, became a parent of Ratna, Saket 4, Parjat, CR44-1 and other improved varieties. The gall midge-resistant Eswarkorra was used to breed W 1251, W 1256 and W 1263; the latter lines were widely used inside India as well as in Sri Lanka and Thailand. The tungro virus-resistant' PTB 10 has been bred into improved varieties such as Aswini, Bharathi, Jyothi, Rohini, Sabari and Triveni. Similarly, PTB 18 possessing multiple resistance has been widely used in India. For tolerance to submergence by floodwaters, FR13A is an outstanding source. Indian breeders were also developing saline-tolerant varieties from indigenous sources such as Pokkali, Getu and Dasal. R 575, a local variety of H.P. State, was used to breed Himdhan, which is adapted to altitudes above 1,000 meters.

The use of wild rice species in breeding programme for various stress situations and hybrid rice development has been described by Siddiq (1991) (Table 5). Under IRRI - genetic evaluation and utilization programme, Villegas (1991) has enlisted certain wild species used to enhance the value of agronomical traits in cultivars by way of transferring the insect resistant genes (Table 6).

For example, one accession of the wild species *O. nivara* was used to introduce grassy stunt virus resistance in IR 36. New hybrids between *O. sativa* and in any wild species have been obtained with desirable traits (Khush *et al.,* 1993). In Tamil Nadu, CO 31 (*O. perennis* / GEB 24) and MDU 5 (*O. glaberimma* / *O. sativa*) (Pokkali) were the two rice varieties released by interspecific hybridization. (Subramaniam and W.W. Mannual 1998).

Table 6: Distribution of useful genes among wild rice.

Character	**Species**
(A) Biological stress **Diseases** Grassy stunt virus Rice Tungro virus	 *O. nivara* *O. grandiglumis* *O. latifolia* *O. malampuzhensis* *O. minuta* *O. officinalis*
Bacterial leaf blight	*O. longistaminata* *O. officinalis*
Insect pests Brown plant hopper (All 3 biotypes)	 *O. oficinalis* *O. nivara* *O. minuta*
Striped borer	*O. officinalis* *O. minuta* *O. eichengiri* *O. brachyantha*
Yellow borer	*O. ridleyii* *O. resseranti* *O. perieri*
Gall midge	*O. brachyantha* *O. coaractata* *O. eichengiri* *O. granulata*
(B) Physical stress Salinity Drought	 *O. coaractata* *O. perennis*
(C) Physiological features High photosynthetic efficiency Under low light conditions	 *O. granulata*

	O. malampuzhensis
(D) Hybrid rice Cytoplasmic sterility	*O. f. spontanea* *O. rufipogon* *O. nivara*
Floral characteristics	*O. officinalis* *O. perennis*

Table 7: Use of wild rice to transfer useful traits

Species	Useful traits
O. eichengeri	Resistance to BPH Resistance to WBPH Resistance to GLH
O. australinesis	Resistance to BPH Tolerance to drought
O. minuta	Resistance to BPH Resistance to WBPH
O. officinalis	Resistance to BPH Resistance to WBPH
O. punctata	Resistance to BPH Resistance to GLH Resistance to BLB Resistance to Bacterial leaf streak
O. latifolia	Increased biomass

The use of landraces and wild species in rice breeding has had an enormous impact on rice productivity in many countries. For example, one accession of the wild species *O.*

nivara (RGC 101508) was used to introduce resistance to grassy stunt virus into cultivated rice, which led to the release of IR 36. This variety also had 15 land race varieties in its pedigree (Plucknet *et al*., 1987) and at one time was planted on more than 11 million ha, making it the world's most widely cultivated cereal crop variety (Swaminathan, 1982). Now, hybrids between *O. sativa* and many wild species have been achieved through the use of various biotechnological tools (Khush *et al*., 1993).

ASSESSING THE RISK OF FUTURE GENETIC EROSION

The current decline in biodiversity is largely the result of human activity and represents a serious threat to human development. Various attempts have been made to list the threats faced by plant diversity, both wild and cultivated, at the local, national and global level. These include WRI, IUCN and UNEP (1992), WCMC (1992), UNEP (1993) and Dahl and Nabhan (1992). The country reports which provided the raw data for the State of the World's Plant Genetic Resources also listed a number of putative cause of genetic erosion. These included the introduction of new varieties of crops and civil strife for cultivated species and deforestation, overgrazing and urbanization for wild species. Such lists "can be used as an evaluation tool for any local community wishing to impede genetic erosion" (Dahl and Nabhan, 1992) as well as to assess the danger of erosion taking place in the future.

Monitoring various putative causative factors is clearly one possible approach to assessing the risk of future genetic erosion within a genepool in a given area.

GENEBANK MANAGEMENT

In theory and in practice at many locations, the production or collecting of high viability seed lots of *Oryza sativa* and *O. glaberrima* is less a problem than is the case for many other crops. There are many potential causes of poor viability, especially under hot and humid tropical environments. Seed processing problems (particularly inadequate seed drying procedures) and delays in receiving accessions at national centers are two of the more likely causes.

The single most important factor in the successful maintenance of rice seed stocks in genebanks is the control of seed moisture content. Accordingly, it is necessary to improve seed drying procedures and the capability of genebanks to approach this target. A moisture content of 6-8% is acceptable, however, for centres that can provide subzero storage conditions (typically -10ºC).

Seed viability monitoring is the second most widespread concern. In collections held under poor storage conditions, it is necessary to monitor and regenerate accessions frequently, a heavy workload in addition to the risks inherent in frequent generation.

CONCLUSION

Many rice growing and consuming countries continued to explore rice biodiversity and conserve them ever. It is to be strengthened at regional level and mutually benefitted with exchange of germplasm.

Conservation of germplasm, the important and challenging task, needs more attention and concentration.

Though research institutes all over the world grow and regenerate the germplasm, *in situ* conservation, through on-farm cultivation in farmers field is most effective, because it maintains more allelic diversity, very accessable and provides high security. This approach should be activated more intensively by supporting the farmers, in terms of quality seed supply at affordable seed cost, procurement of seed at reasonable price, and providing simple effective seed storage facilities. The farmers should also be trained in seed production and conservation. The farmers should be often discussed to solve the problems and constraints encountered then and there. This is a novel way not only to conserve more gene pools but also to prohibit the genetic erosion of valuable germplasm.

In situ conservation is another method of conserving the wild species and related genera of the genus *Oryza*. These germplasm need specific location and environment to grow well and attain maturity. These regions need to be brought under the control of plant biodiversity authority to prevent the loss of these species and genera and the seeds collected from them should be spared to the needy countries freely.

Use of biotechnological tools such as *in vitro* and cryotechniques have to be further strengthened. Very large number of rice accessions are being maintained in many research stations for a very long time; their regeneration is very much essential to prevent the loss of viability. Growing all these germplasm every year for the aforesaid purposes is very difficult and expensive. Therefore, biotechnological approach through anther culture, cell suspension culture, pollen culture, etc., may ease the regeneration of large number of germplasm.

Research on seed technology is yet another attempt to study the quality of seeds, viability, dormancy and storability to raise the healthy plants ever as germplasm.

Documentation on the details of biodiversity of the germplasm and their characteristics is the most useful approach for the researchers choice of useful germplasm to achieve their goal in rice improvement, besides it serves as a basic compendium for the plant science students.

Policy on intellectual property right should be well implemented to protect the property right of the germplasm of every country and also to exchange materials freely to breed desirable rice plants by the rice growing countries in the globe.

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