This is why breeders tend to concentrate to adapted and improved materials, avoiding wild parents, landraces and exotics, available in germplasm banks which would require long time, high financial support besides the difficulty to identify potentially useful genes. Marshall (1989) emphasized that the difficulty to identify useful genes is the main factor responsible for the low utilization of these accessions. Evidently, there is a gap between available genetic resources and breeding program activities. While germplasm banks try to preserve as much as possible the genetic variability to be used by breeders, breeding programs do not explore efficiently the available diversity, relying almost exclusively on their working collection.

Conclusion

The importance of genetic resources is widely recognized. Activities related to genetic resources like germplasm introduction, exchange, collection, characterization, evaluation, documentation and conservation are characterized by high cost and long term return. Until recent past, conservation of rice germplasm was synonymous with repeated rejuvenation in the field. This process of maintenance subjected the germplasm to a threat of losing their identity because of random and non-random processes due to sampling. Also loss due to unforeseen natural calamity of the type of super-cyclone and flood devastating the native germplasm cannot be ruled out so far on farm ex situ conservation is concerned.

Therefore, realizing the importance of genetic diversity, Jeypore tract of Odisha, the Palakkad area of Kerala and Apatani valley of Arunachal Pradesh deserve to be protected as on farm in situ conservation sites.

Germplasm Collection, Conservation and Evaluation for Rice Improvement

NRRI Technology Bulletin - 132

Editing and layout : GAK Kumar and Sandhyarani Dalal

Photography: P Kar & B Behera

Laser typeset at the National Rice Research Institute, Indian Council of Agricultural Research, Cuttack (Odisha) 753 006, India and printed at Printech offset, BBSR. Published by the Director, for the National Rice Research Institute, Cuttack (Odisha) 753 006.

Germplasm Collection, Conservation and Evaluation for Rice Improvement

BC Patra, BC Marndi, P Sanghamitra and Pritesh Sundar Roy

Plant genetic resources (PGR) constitute the basic raw material for any crop improvement programme. They are generally referred to as germplasm or genetic resource material. The rapid yield growth in 1970s and 1980s was built on a solid foundation of systematic development of genetic resources. By 2030, the production of rice must increase by at least 25% in order to cope up with population growth and demand in the country. The enormous rice genetic diversity available in the gene banks will be the foundation for the genetic improvement of the crop through unraveling the new genes and traits that will help rice producing farmers who are facing the challenges brought about by climate change, pests and diseases, and other unfavourable conditions. It is well known that the traditional rice varieties and their wild relatives constitute an invaluable gene pool in terms of resistance/tolerance to biotic and abiotic stresses, which can be exploited for developing modern varieties having enough resilience to sustain adverse climatic changes. Rice is cultivated as far north as the banks of the Amur River (53° N) on the border between Russia and China, and as far south as central Argentina (40° S). It is grown in cool climates in the mountains of Nepal and India, and under irrigation in hot deserts of Pakistan, Iran and Egypt. It is an upland crop in parts of Asia, Africa and Latin America. At the other environmental extremes are the floating rices, which thrive in seasonally deeply flooded areas such as river deltas - the Mekong in Vietnam, the Chao Phraya in Thailand, the Irrawady in Myanmar and the Ganges-Brahmaputra in Bangladesh and eastern India. Rice can also be grown in areas with saline, alkali or acid sulphate soils.

Origin and spread of cultivated rices

The centre of origin and centers of diversity of two cultivated species *Oryza sativa* and *O. glaberrima* have been identified using genetic diversity, historical and archaeological evidences and geographical distribution.

It is generally agreed that river valleys of Yangtze, Mekong river could be the primary centre of origin of *O. sativa* while Delta of Niger river in Africa as the primary centre of origin of *O. glaberrima* (Porteres, 1956). The diversity within the Asian cultivated rice (*O. sativa*) is enormous. Some controversy exists over when and where rice was domesticated (Sweeney & Mc Couch, 2007; Huang et al., 2012). It is fairly safe to say that rice was being cultivated at least 10,000 years ago and that it was domesticated from its wild ancestor *O. rufipogon* (Khush, 1997).

Varieties of same group when grown in different seasons and different cultural managements are named as different ecotypes (crop growing time) as mentioned below:

1. Boro: Nov.-Dec./April-May: In water stagnated areas or with irrigation; cold tolerant at seedling stage (spring or summer rice)
2. Aus: April-Aug.: Autumn rice, broadcast **(*aus*)** or transplanted **(*ahu*)**
3. Broadcast Aman: April-Dec: Broadcast, deepwater rice (also called ***bao*)**, shallow water rice (also called ***asra*)**
4. Transplanted Aman: July-Dec: Winter rice, transplanted, photoperiod sensitive (***sali,*** *kharif*)

The natural hybridisation between *aus* and *O.rufipogon* gives rise to aman in eastern India; whereas *japonica* and *O.rufipogon* give rise to *sali* in Brahmaputra valley, *boro* is the intermediate between *aus* and *aman*. The *aman* ecotype migrated to south-east Asia and spread there very fast. It gave rise to *tjereh* or *bulu* ecotype in Indonesia. The order of ecotypes w.r.t its mean sterility value are *aus, aman, boro, tjereh, sali* and *japonica*.

The *bulu* type of Indonesia could have been the progenitor of *javanica* rice. The closer relationships between *japonica* and *javanica* ecotypes could be attributed to the possible closer genetic relationship between the populations of *O. nivara* of south China and south-east Asia (Glaszmann, 1986; Chang, 1985). The *aman* ecotype was evolved from the *aus* ecotype as a result of introgression of *O. rufipogon* genes into the *aus* ecotype in the lower Gangetic valley. According to Ramiah & Ghose (1951) and Chang (1976), the deepwater rice cultivars are the product of introgression of *O. rufipogon* characters into *O. sativa*. Phylogenetic analyses based on SNP data confirmed differentiation of the *O. sativa* gene pool into 5 varietal groups *indica*, *aus/boro*, basmati/sadri, tropical *japonica* and temperate *japonica.*

Rice research started in India little more than one hundred years ago with the establishment of Imperial Agricultural Research Institute in Pusa, Bihar in 1905.

During early part of the 20th century and more specifically in the years between 1910 and 1920, Mr. F.R Parnell, Mr. G.P. Hector and Mr. Graham initiated collection of rice germplasm from the Madras Presidency, Bengal and the Central provinces, respectively.

Way forward

1. Germplasm is basic to crop improvement programs for sustainable agriculture. A road map depicting collection sites need to be prepared so that areas which are not covered in the map will be explored and germplasm will be collected and conserved. Future collections should also aim at trait specific collection of germplasm.

2. Wild and primitive populations are the reserves of cryptic variability and hence their capacity for adaptive response is high. Such genetic variation is as important as prevalent varietal diversity for genetic conservation. It is, therefore, important to collect and conserve the wild rice germplasm.

3. It has been estimated that even 5% of rice germplasm conserved in different gene banks have not been utilized. Our research should be oriented towards developing a core collection which represents the diversity of entire collection and removes duplicate accessions that will enhance the use of germplasm by identifying diverse source of parents and also will ease in evaluating the germplasm against biotic and abiotic stresses.

4. Identifying trait-specific genetically diverse parents i.e., salt tolerance, cold tolerance, drought tolerance, early/late heading, low chilling, tolerance/resistance to particular pests/diseases, adaptability to water logged habitats, tillering capacity, root system, leafiness, etc., apart from quality characteristics are the primary need of the plant breeder for trait enhancement. So identification of new diverse sources will help in better utilization of germplasm in the breeding programmes, aimed at producing agronomically superior cultivars with broad genetic base.

5. A rice seed file depicting photograph of individual germplasm may be prepared for identification of germplasm and avoiding misrepresentation of germplasm.

6. Future works should aim at characterizing the gene bank materials and creating a data base for better utilization in breeding programme. Morphological and molecular characterization of a core/minicore and trait specific subsets will further enhance the usefulness of the germplasm accessions.

Limitations in germplasm use

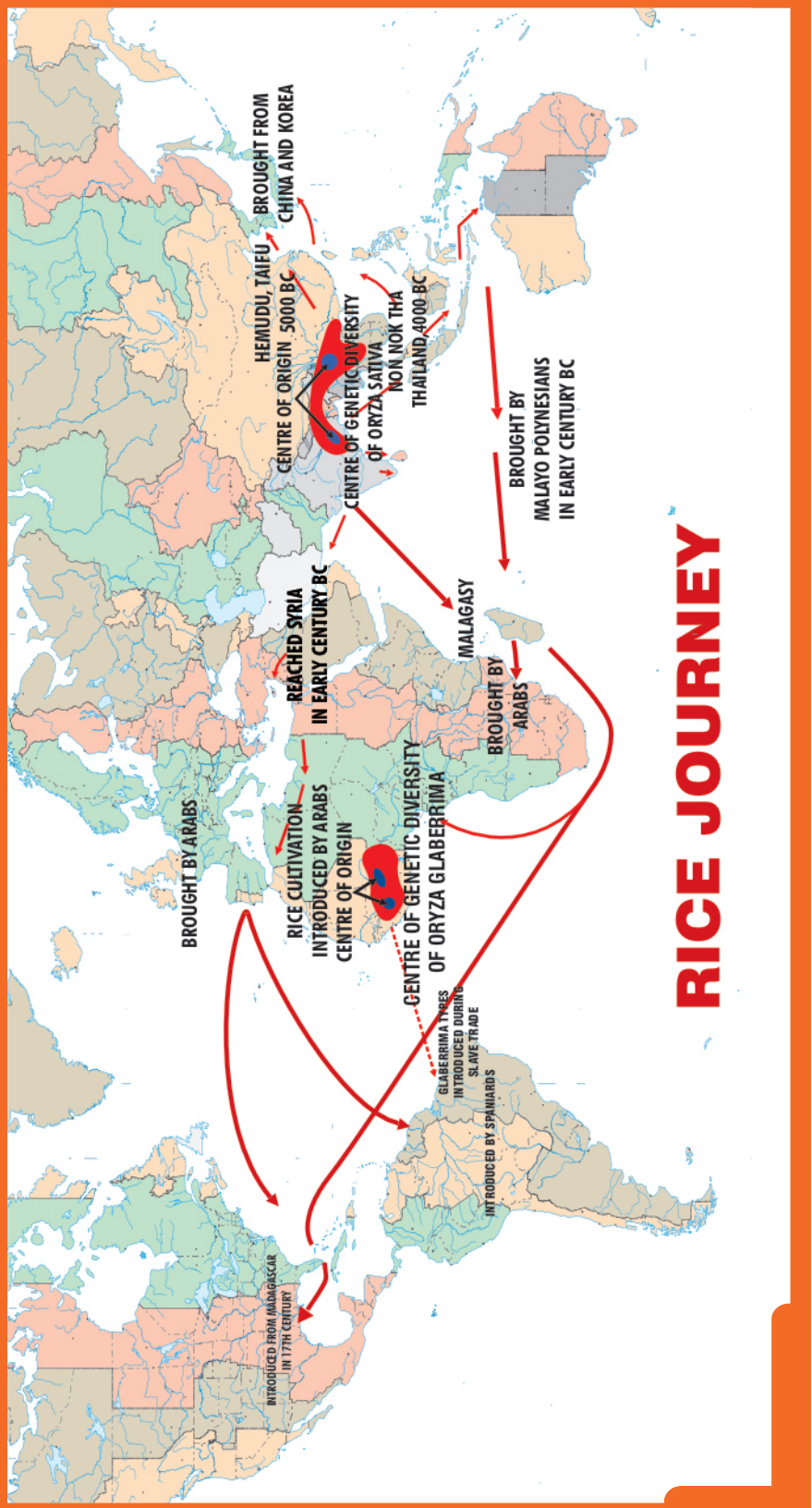
The low utilization of plant genetic resources conserved in the National Gene bank of India (about 109,000) is due to lack of documentation and adequate description of collections, accessions with restricted adaptability and insufficient rice breeders in the country. There is also a gap between available genetic resources and breeding program activities. While germplasm banks try to conserve as much as possible the genetic variability to be used by breeders, breeding programs do not explore efficiently the available diversity, relying almost exclusively on their working collection.

The search for superior genotypes regarding yielding ability, disease and pest resistance, stress tolerance or better nutritional quality is very hard, competitive and expensive.

Sources of resistance/tolerance for some important traits from wild spp

	Species	Useful traits
i	*O. alta*	Resistance to stem borer, high biomass production
ii	*O. australiensis*	Resistance to BPH & tolerance for drought
iii	*O. brachyantha*	Resistance to YSB, leaf folder and whole maggot
iv	*O. breviligulata*	Resistance to GLH and BLB
v	*O. eichingeri*	Resistance to BPH, WBPH & GLH
vi	*O. glaberrima*	Tolerance to drought, acidity, iron toxicity, African gall midge, nematodes & weed competitiveness
vii	*O. glumaepatula*	Elongation ability, source of CMS
viii	*O. grandiglumis*	High biomass production
ix	*O. granulata*	Shade tolerance, adaptation to aerobic soil
x	*O. latifolia*	Resistance to BPH and high biomass production
xi	*O. longiglumis*	Resistance to BLB, BL
xii	*O. longistaminata*	Source of *Xa 21* gene for BLB resistance
xiii	*O. meridionalis*	Elongation ability
xiv	*O. meyeriana*	Adaptation to aerobic soil
xv	*O. minuta*	Resistant to BPH, WBPH, source of Pi-9 (t) gene resistant to blast
xvi	*O. nivara*	Resistance to grassy stunt virus and BLB
xvii	*O. officinalis*	Resistant to BPH, WBPH
xviii	*O. punctata*	Resistant to BPH, GLH, BLB & bacterial leaf streak
xix	*O. rhizomatis*	Drought resistance
xx	*O. ridleyi*	Resistance to Stem borer, BLB and BL
xxi	*O. rufipogon*	Elongation ability, resistance to BLB, source of CMS
xxii	*Porteresia coarctata*	Resistance to YSB and salinity

Origin and spread of cultivated rices



At the same time, in 1911 the first Agricultural Research Station devoted exclusively to rice research was established in Dacca (now Dhaka in Bangladesh) and the Paddy breeding station was established at Coimbatore in 1912. Subsequently Karimganj (1913) and Titabar (1923) in Assam; Pattambi in Kerala and Nagina in Uttar Pradesh in 1927; Chinsurah, West Bengal in 1932; Habiganj (now in Bangladesh) in 1934; Sabour, Bihar in 1936; and many more research stations were established in different agro-climatic zones of the country. All these rice research stations collected traditional rice varieties from their respective regions/localities, practiced pure line selection to identify higher yield potential lines and recommended them for general cultivation by the farmers. This led to recommendation of 394 varieties for general cultivation.

Germplasm Collection

Rice research was further geared up when the country was facing widespread drought and famine. Several million people suffered a setback due to Bengal famine in 1943 which was caused due to the brown spot disease of rice in an epidemic form. The Govt. of India, with the help of the then premier of Odisha, the Maharaja of Paralakhemundi and Dr. P.K. Parija, the then Director of Agriculture, Govt. of Odisha established the Central Rice Research Institute (now NRRI) at Cuttack in April 23, 1946 with Dr. K. Ramiah as its founder Director. Dr. Ramiah brought with him a nucleus set of about 2,400 accessions of rice germplasm from Coimbatore, which was being maintained at the Paddy breeding station. This became the starting point of the building up National Germplasm Collection for rice at NRRI, Cuttack. Subsequently many exploration and collection programmes, introduction and acquisition through exchange activities have helped to enrich the Gene Pool of the Institute.

In 1955, when Dr. N. Parthasarathy was Director, the NRRI undertook its first planned exploration and collection mission of rice germplasm in the Jeypore tract (now Koraput district of Odisha).

The collection programme continued for five years (1955-59) by a team of scientists led by Dr. S. Govindaswami and supported by a scheme sanctioned by the ICAR. This mission was popularly known as Jeypore Botanical Survey (JBS) and was the first of its kind, ever organized in the world to collect rice germplasm (Chang, 1989).The team explored about 27,000 sq. kms. and collected a total of 1,745 cultivated rice and 150 wild rice accessions (Govindaswami & Krishnamurty, 1959). Later, when Dr. R.H. Richharia became Director of NRRI, he initiated the exploration and collection of rice germplasm from Manipur and Nagaland during 1965-69. This mission was also spread over a period of five years and a total of 874 accessions were collected.

Unique Rice germplasm registered at ICAR-NBPGR

Name of Germplasm	Year of Registration	Important Trait
Khoda (PD 27)	2004	Tolerance to complete submergence
T-1471(Kodiyan)	2005	Tolerance to anaerobic seeding
Khadara (PD 33)	2008	Tolerance to complete submergence
Atiranga (RM5/232)	2008	Tolerance to complete submergence
Kalaputia (PCP 01)	2008	Tolerance to complete submergence
Gangasiuli (PB 265)	2008	Tolerance to complete submergence
Kusuma (PD 75)	2008	Tolerance to complete submergence
Mahulata (PB 294)	2008	Tolerance to Vegetative stage drought
Medinapore (RM5/AK-225; IC 0258990)	2010	Tolerance to complete submergence
Andekarma (JBS-420; IC 0256801)	2010	Tolerance to complete submergence
Champakali (IC 0258830)	2010	Tolerance to complete submergence
Brahman Nakhi (DPS 3)	2010	Tolerance to Vegetative stage drought stress
Sal kaiin (PB 78; IC 0256590)	2010	Tolerance to Vegetative stage drought stress
Bhundi (JRS 9; IC 0575277; AC42091)	2014	Tolerance to complete Submergence and having shoot elongation ability
Kalaketki (JRS 4; IC 0575273; AC42087)	2014	Tolerance to 20 days complete submergence
CR 143-2-2 (IC 0513420)	2017	Tolerance to both vegetative and reproductive stage drought stress
Salkathi (AC 35181; PB 289)	2018	Resistance to brown plant hopper (BPH)

Nematode	AC-26594 (TKM-6), AC-40083 (MTU-17), AC-467 (Lalnakanda-41), Hasma, Bahagia, AC-40509 (Manoharsali), Amla, AC-17134 (Sathia), AC-22899 (Anang), AC-23652 (Kalakeri), Kanyakaprashant
Drought	AC-254, AC-263, AC-304, AC-511, AC-2298, AC-3035, AC-3111, AC-3577,AC-9066, AC-9387, ARC-7063, AC-45 (CH-45), AC-40083 (MTU-17), W-691, AC-467 (Lalnakanda-41), AC-35207 (Dular), AC-37077 (Dhan gora), AC-37127 (Black gora), AC-37291 (Kalakeri), AC-8205 (Surjamukhi), AC-34440 (Salumpikit), AC- 34256 (Kabiraj Sal), AC-34296 (Bombay murgi), AC-34992 (Salkain), AC-35021 (Kalon dani) AC-35038 (Godhi akhi), AC-35046 (Nadi tikar), AC-35059, (Phutki bari), AC-35060 (Bhuska), AC- 35143 (Baihunda), AC-35452 (Karama), CR 143-2-2, AC- 100374 (Oryza nivara), AC-100476 (Oryza nivara)
Submergence	AC-24682 (FR-13A), AC-35741(Telgri), AC-35323(Chaula pakhia), AC-35675(Biesik), AC-36107(SL276), AC-36470(Khoda),Khadara, Kalaputia, AC-26670(Janki), AC-40844 (Manasarovar), Sarumuli, AC-40916(Jalamagna), AC-40604 (Jaladhi-1), Kanawar, Atirang, Gangasiuli, Bhundi, Kusuma, Medinapore, Andekarma, Champakali, Kalaketki
Salinity	AC-2405 (SR-26B), AC-8532(Pokkali), Pateni-2, AC-41360 (Nonabokra), AC-35255(Rahaspanjar), Canning-7, Ravana

Simultaneously, a PL-480 project on collection of rice germplasm was operative during 1967-72 with Dr. M.S. Swaminathan and Dr. S.V.S. Shastry at IARI, New Delhi. In this programme, during a period of five years, Dr. S.D. Sharma and his associates collected a total of 6,630 accessions from all the districts of Arunachal Pradesh, Nagaland, Manipur, Tripura, Meghalaya, and North Lakhimpur, Guwahati and Goalpara districts of Assam. This mission was popularly known as Assam Rice Collection (ARC). During 1970-79, a special programme was undertaken to collect rice germplasm from all the rice growing districts of Madhya Pradesh by Dr. R.H. Richharia after he left NRRI in 1969. He explored 42 districts and collected a total of 19,226 accessions which formed the Raipur Collection. In 1975, under the leadership of Dr. J.K. Roy, a comprehensive exploration and collection programme was drawn for the whole country especially for the traditional rice growing areas of Karnataka, Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal and Odisha covering 30 districts of 7 states. This programme was popularly known as National Collection from States (NCS) and resulted in collection of 1,038 accessions.

The perennial wild species was known earlier as *O. perennis* by all rice workers until Bor (1960) identified it as *O. rufipogon*. The annual wild species was earlier known as *O. fatua* Koenig (a *nomen nudum*). Sharma & Shastry (1965) assigned it a new name (*O. nivara*) as *O. fatua* was not a validly published name for the annual wild species (Fig.1).

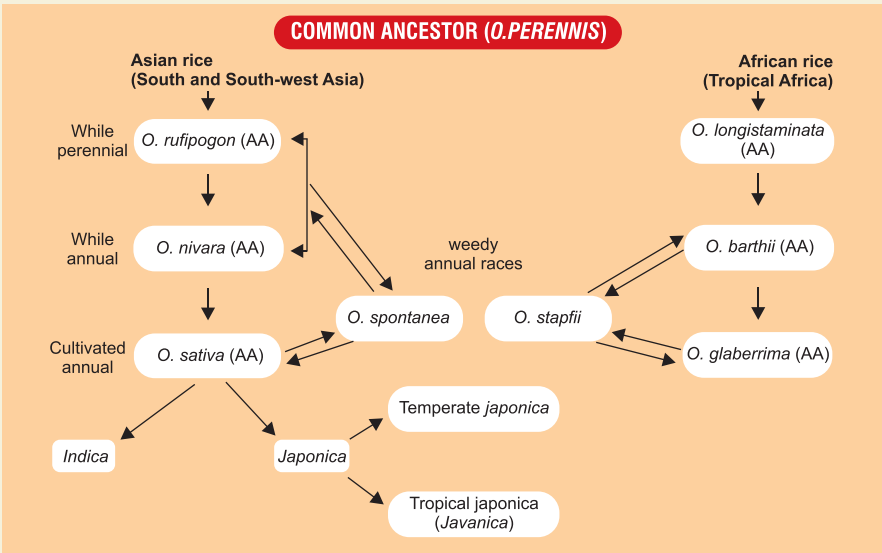


Fig. 1: Schematic representation of the evolutionary pathways of Asian and African cultivated rice

Nomenclature clarifications

1. *O. barthii* (syn.*O. breviligulata)*
2. *O. eichingeri (syn.O. collina, O. schweinfurthiana)*
3. *O. fatua* wrongly used for
   - i. *O. nivara* by Ramiah & Ghose
   - ii. *O. rufipogon* by Chevalier & Backer
   - iii. *O. spontanea* by Burkill
   - iv. *O. officinalis* by Koenig ex Ridley
4. *(syn.O. malampuzhaensis) O. officinalis*
5. *(syn.O. perennis with 3 sub species balunga, barthii, cubensis)* wrongly used for
   - i. *O. rufipogon* (in Asia)
   - ii. *O. longistaminata* (in Africa)
   - iii. *O. glumaepatula* (in S. America)
6. *O. indandamanica* syn. of *O. granulata*
7. *O. jeyporensis* misnamed, it is a variant of *O. sativa*

Germplasm conservation

There are about 127,916 (*Oryza sativa*), 1651 (*Oryza glaberrima*) and 4647 (wild relatives) accessions of rice germplasm conserved at the International Rice Research Institute (IRRI) in the Philippines as on January 2017. China has several rice germplasm collections but the collection at Beijing has over 50,000 accessions. The Japanese national rice collection contains about 26,000 accessions. The USDA-ARS rice collection has 17,279 accessions from 110 countries. The IRRI collection is probably the most genetically diverse rice collection in the world because the acquisition and field collection efforts were implemented in the appropriate places and at opportune time before advanced genetic erosion occurred (Chang,1989). In India alone, there are 109,153 accessions of rice germplasm conserved at -18^0 C and with 3-4% RH in National gene bank of NBPGR, New Delhi as on September, 2018. Therefore, the collection and acquisition of rice germplasm must be a continuous effort. Moreover, the important point is that only a small proportion of the total genetic diversity of rice has been utilized (Chang, 1989).

Several categories of germplasm are conserved for different purposes.They are as follows-

a) ***Working collection***: A collection of germplasm maintained and used by a breeder or other scientist for their own breeding or research, without taking any specific measures to conserve. The collection may have a short life span and the composition of the collection may vary greatly during its lifetime.

Utilization of Rice Germplasm (Identification of Donors)

Bacterial blight	AC-33523 (Tarical), AC-33557 (Dulla karma), AC-33562 (Kangpui), AC-3094 (TKM-6), AC-8368 (BJ)-1, AC-26903 (DV-85), Chinsurah boro-II, Somera mangga etc. A strain of wild rice *Oryza longistaminata* was identified at NRRI as highly resistant to bacterial blight pathogen. This has led to the identification of a new and valuable gene (*Xa* 21) for resistance to pathogenic bacterium.
Blast	AC-55 (CH-55) AC-8368 (BJ-1), AC-8369 (S-67), SM-6, SM-8, SM-9, CP-6, AC-293 (AKP-8), AC-294 (AKP-9), AC-360 (PTB-10), AC-26904 (Tetep) and Fukunishike
Tungro virus	ARC-7125, ARC-7149, DW-8, AC-368 (PTB-18), AC- 5079 (Kataribhog), Bhagirathi, Boitalpakhia, AC-34558 (Nalini) AC- 17933 (Kamod-153), AC- 34650 (Usha), AC-273 (ADT-20), AC- 297 (ASD-1), AC-304 (CO-1), AC-315 (CO-12), AC-351 (PTB-1), AC-360 (PTB-10) AC- 3094 (TKM-6), AC-8396 (CB-1)
False smut	AC-26570 (ADT-33), AC- 40119 (PTB-23), AC-40124 (PTB-26), AC-3070 (PTB-32)
Sheath rot	AC- 26904 (Tetep), Ram tulasi
Gall midge	AC-35(Ningar small), AC-39(CNAB white rice), AC-210(Bhadas-79), AC-391(Bikiri) sannam), ARC-5984(Suto syamara), ARC-10660, ARC-12508(Khauji), ARC-12586(Vale matse), ARC-12588(Amamma matse), ARC-12670(Nien sah), ARC-13166(Jaksa), ARC-13210(Yangbelok), ARC-14915(Maich dol), ARC-14967(Galong), AC- 352 (PTB-2), AC- 362 (PTB-12), AC- (PTB-18), AC- 371 (PTB-21), PTB-24, AC-26704 (Phalguna) and Leaung-152
Brown plant hopper	ARC-6650(Gomiri bora), AC-34969(Baidya raj), AC-34993(Ghusuri), AC-34997(Jhupjhupa), AC-35014(Nal dhan), AC-371 (PTB-21), AC-40634 (PTB-33), AC-30300 (MR-1523), AC-35181 (Salkathi), AC-35184 (Dhoba numberi), AC-35228 (Jalakanthi), AC-35066 (Banspati), AC-35070 (Panidubi), AC-35108 (China bali), AC-17912 (Ganga sagar), AC-20363 (Kalachudi), Tarapith, Haldi ganthi
Leaf folder	AC-33849 (Bundei), AC-35034 (Hari sankar), AC-33831 (Sunakathi), AC-33832 (Surjana), Juli, AC-35338 (Saru chinamali)
Yellow stem borer	AC-33515, AC-33526, AC-33538, AC-33563, ARC-5984, AC-30300 (MR-1523) and AC-30349 (Aganni)

Since then, more than 33,000 rice germplasm accessions have been deposited in the long term storage (LTS) of NBPGR.

Under the aegis of the Indo-USAID collaborative project, a cold module was gifted to NRRI. The facility became operative in 1998 with a controlled temperature of 4° ± 2° C & 33 % ± 5 % RH and found to be rather dependable. The Gene Bank facility thus created is meant for medium term storage (MTS) and the seeds are kept viable for 6-8 years. When accessions in the MTS working collection drops below 50 g or if seed viability falls below 85%, then the accession is increased (rejuvenated). The *japonica* varieties are monitored more frequently than *indica* rices as they have an inherently shorter storage life than *indica* varieties.

The seeds of each of the accessions were dried for reducing the moisture content up to 10-12% and kept in 3-layered aluminium foil pouches for medium term storage.

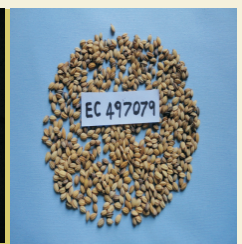
The outer layer of the pouch is polyester of 12 micron; intermediate layer is aluminium of 12 micron and the innermost layer is polythene of 250 gauges. These aluminium foil pouches have been stored in cold module at a regulated temperature of 40°C and 33 % relative humidity (RH).

Germplasm evaluation and utilization

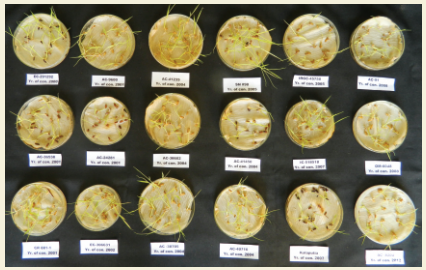
The genetic erosion has been very fast in recent years due to rapid modernization of the society and genetic diversity has been replaced by introduction of few high yielding varieties. Farmers are leaving their own traditional varieties and growing the improved cultures thereby many of the landraces have become extinct. The need for both *in situ* and *ex situ* conservation is now felt as the paddy cultivation in the country is largely affected by extreme natural calamities after rapid climate change, through an erratic monsoon. Earlier the biggest challenge was flood, but subsequently other factors like salinity after frequent cyclones and sea water surge, temperature rise and drought like situation in many parts of the country have put the challenge before rice researchers to incorporate these genetic factors in the plant.

Activities related to genetic resources are characterized by high cost and long term return. Introduction and germplasm exchange, collection, characterization, evaluation, documentation and conservation are essential steps that cannot be overemphasized. An appropriate synchronism among these activities is required for the bank to be effective in maintaining genetic variability and to assure germplasm utilization.

Gw- 50. 4 g
(IC- 301206)



Gw- 8.0 g
(IC 343465)



b) ***Active collection***: A collection maintained by a gene bank and used as the source of seeds for active use, including distribution, characterization and regeneration. It is usually conserved under short- or medium-term storage conditions.

c) ***Base collection***: A collection of seed ideally prepared and held in ideal conditions for long-term conservation. The seed should be conserved and never used except for

i. periodic germination tests
ii. regeneration of samples conserved in long-term storage when their viability decreases below threshold.
iii. regeneration to replace stocks in an active collection after accumulating 3-successive generations of regeneration from active collection.
iv. as the primary point of rescue when the accession is accidentally lost from all active collections.

d) ***Seed file***: A small sample of original seed, set aside when a seed sample first arrives at the gene bank, to serve as the definitive reference sample.
The seed file should be maintained under dry conditions preventing disease or pest damage, although not necessarily alive. Other seed samples of the same accession, *e.g.* for every new harvest, should be visually cross-checked with the seed file.

e) ***Safety back-up***: Duplicate samples of the base collection, stored in a different gene bank, preferably in a different continent. The storage conditions in the safety back-up should be at least as good as those in the corresponding long-term collection. The holder of the safety back-up has no rights to use or distribute the seed in any way or to monitor seed health or viability. Additional duplication of the base collection to the Svalbard Global Seed Vault provides definitive safety back-up in case of large scale loss of crop diversity. Svalbard Global Seed Vault (SGSV) commissioned at Arctic island of Svalbard in North Pole in 2008 conserves about 0.8 million germplasm. It is managed by Norway's Dept of Agriculture and the Global Crop Diversity Trust (GCDT) under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and supported by Bill & Melinda Gates Foundation. Recently, India has deposited 25 accessions of pigeon pea in April, 2014 as the 59th Nation.

Due to the danger of unforeseen genetic erosion, the effort of developing a cold storage system for rice germplasm was initiated at NRRI in 1984. Meanwhile, during 1986, it was decided to conserve all the germplasm of NRRI at the National Gene Bank which is maintained at - 20° C for longer years.

Major Rice Germplasm Explorations

Year	Collectors / Institute	Region	No. of accessions
1910	Parnell	Madras Presidency	*
1914	Hector	Bengal Province	*
1920	Graham	Central Province	*
1946	Ramaiah (NRRI)	Coimbatore	2400
1955-59	Govindaswami, Krishnamurty & Chyaupatnaik (NRRI)	Jeypore Botanical Survey (JBS)	1895
1965	Richharia (IGKV)	Manipur	874
1967-72	Sharma, Swaminathan & Sastry (IARI)	Assam Rice Collection (ARC)	6630
1970-79	Richharia (IGKV)	Madhya Pradesh (42 dist)	19226
1975	Roy (NRRI)	National Collection from States (30 dist; 7 states)	1038
1978-80	Roy (NRRI, SAUs)	100 dist; 14 states	6349
1984-89	Sharma et al. (NRRI)	9 states	3697
1991	Patra & Duhoon (NRRI & NBPGR)	Western UP & Haryana (Basmati)	88
1992	Patra & Tomar (NRRI & NBPGR)	Chotanagpur region (upland)	80
1994-98	Patra et al. (NRRI)	Odisha	921
1999-03	Dhua et al. (NRRI)	Eastern India (wild rice; NATP)	483
1999-00	Pareek et al. (NBPGR & NRRI)	Rescue mission to super cyclone devastated areas of Odisha	857
2000	Marndi & Pande (NRRI)	Bao (deep water) rice from Assam	126
2000-02	Patra et al. (NRRI)	Boro rice from Eastern India	208
2001	Marndi (NRRI)	Aman rice from West Bengal	69
2003	Patra & Marndi (NRRI)	Medicinal rice from Chhattisgarh	71
2004	Patra & Marndi (NRRI)	Saline tolerant rice from Kerala	51
2005	Patra & Marndi (NRRI)	Traditional rice from Maharashtra & Sikkim	113
2006	Patra & Marndi (NRRI)	Traditional rice from Gujarat & Tripura	109
2007	Patra *et* al	Scented rice from UP and Odisha	57
2008-17	Patra *et* al	Trait specific rice and wild/weedy rice from Arunachal Pradesh, Assam, Chhattisgarh, Odisha, Jharkhand and Andaman & Nicobar	615

* Not available