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STRATEGY FOR CONSERVATION AND ENHANCED USE OF CROP GENETIC RESOURCES

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Introduction

The plant genetic resources (PGR) are finite and vulnerable for loss due to introduction of new crop cultivars in agriculture, urbanization, and natural hazards, etc. The realization of this fact led to the drafting of Convention on Biological Diversity at the Earth Summit in Rio in 1992. The PGR contribute enormously towards achieving the Millennium Development Goals of food security, poverty alleviation, environmental protection, and sustainable development. PGR are critical components of crop improvement efforts aimed at increasing food security - both for short-term gains as well as for long-term increase in productivity. Over the years, genebanks have been established in a number of countries and the number of accessions conserved in genebanks now exceeds the six million mark (FAO 1998).

The mission of the Consultative Group on International Agricultural Research (CGIAR) is to achieve sustainable food security and reduce poverty in developing countries through research and development in the fields of agriculture, forestry, fisheries, policy, and environment. Exploration, exchange, and conservation of PGR is one of the main objectives of the CGIAR. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT – one of the 15 CGIAR centers) has responded to this need by establishing a Genetic Resources Unit for assembly, characterization, evaluation, maintenance, conservation, documentation and distribution of germplasm of the sorghum, pearl millet, chickpea, pigeonpea, groundnut, finger millet, foxtail millet, barnyard millet, kodo millet, little millet and proso millet, and their wild relatives. In this paper we present a brief account of (i) ex situ germplasm assembly efforts, (ii) germplasm management in ICRISAT genebank (iii) germplasm utilization status and (iv) means to enhance use of germplasm in research and development.

1. Germplasm assembly in the ICRISAT genebank

Since the inception of ICRISAT in 1972, efforts were initiated to assemble the germplasm of the mandate crops from various research institutes around the world. The Rockefeller Foundation donated 11961 accessions of sorghum and 2000 accessions of pearl millet to ICRISAT. ICRISAT also obtained 2000 accessions of pearl millet collected by the Institut Francais de recherché Scientifique pour le Development en Cooperation (ORSTOM) in francophone West Africa. A chunk of chickpea and pigeonpea germplasm were the donations by the (former) Regional Pulse Improvement Project (RPIP). We also acquired over 1,200 chickpea accessions from the Arid Lands Agricultural Development (ALAD) program in Lebanon. Similarly, much of the groundnut germplasm was received from the Indian groundnut research programs and the USDA.

New germplasm of mandate crops was also collected from the priority areas. From 1975 to 2003, a total of 213 joint missions were launched in 62 countries securing 33,194 accessions of ICRISAT mandate crops. Besides genebank activities, ICRISAT also works on the genetic improvement of the mandate crops. A large number of improved breeding lines, stress resistant sources or the cultivars were developed, and 3905 such lines have been registered in the genebank for

future utilization. At present, a collection of 114,870 accessions of eleven crops is conserved in the ICRISAT genebank (Table 1).

2. Germplasm management in the ICRISAT Genebank

2.1. Phenotypic characterization and evaluation: Adequate characterization for agronomic and morphological traits is necessary to facilitate the utilization of germplasm by researchers. To achieve this, germplasm accessions of all the crops were sown in batches over the years and characterized for morphological and agronomic traits. Germplasm screening against biotic and abiotic stresses, and the estimations of grain food quality were conducted jointly with various disciplinary scientists. Germplasm sets were evaluated for agronomic performance over locations jointly with NARS scientists in India, Nepal, Thailand, Indonesia, Ethiopia, and Kenya and more intensively with the National Bureau of Plant Genetic Resources (NBPGR), India. The results of joint evaluations have led to better understanding of the germplasm material.

2.2. Regeneration: Regenerations were carried out to meet the seed increase requirements of (i) accessions that had reached a critical level of seed stock/viability; (ii) accessions required for medium-term storage (MTS) and/or long-term storage (LTS); and (iii) germplasm repatriation. During regeneration, all possible efforts are made to grow the accessions under healthy conditions and following the appropriate pollination control measures.

2.3. Conservation: Germplasm conservation requires cleaning the seed material, drying to minimal seed moisture content, storing in cool and dry conditions, and regular monitoring of seed health during storage. In the ICRISAT genebank, the seeds of the entire collection are stored in MTS (4^0C, 20–30% RH) in aluminum cans. The germplasm accessions are also conserved in LTS (-20^0C) after packing in vacuum-sealed aluminum foil pouches.

2.4. Safety back up: ICRISAT's agreement with FAO places the germplasm collections under the auspices of FAO, and requires safety back-up for long-term conservation in countries out side India. We have initiated efforts conserving 2000 chickpea at ICARDA (Syria) and 2006 groundnut and 4580 finger millet accessions at ICRISAT Regional Genbank at Niamey in Niger.

2.5. Documentation: The vast germplasm data gathered on chickpea and pigeonpea germplasm has been summarized and presented to the users in the form of catalogs (Pundir et al. 1988, Remanandan et al. 1988). During the last 15 years, we had a very purposeful collaboration with the NBPGR, India, on germplasm exploration, and evaluation at a number of locations, and the outcome were reviewed and discussed in a workshop 'Collaboration on Genetic Resources' held in 1988 at ICRISAT, Patancheru (ICRISAT 1989). Core and mini-core collections of ICRISAT mandate crops were established and the information was published through journal articles (Grenier et al. 2001; Bhattacharjee 2000; Upadhyaya and Ortiz 2001; Upadhyaya et al. 2001a; Upadhyaya et al. 2002; Upadhyaya et al. 2003; Upadhyaya et al. 2005; and Reddy et al. 2005) for the benefit of fellow research workers. A 'Manual of Genebank Operations and Procedures' has also been published (Rao and Bramel 2000) documenting the history of the collections, procedures for germplasm acquisition, maintenance, documentation, conservation, and distribution.

3. Germplasm utilization

3.1. Germplasm supply to users: ICRISAT Genebank supplies healthy, viable, and genetically pure seeds of genetic resources to the research workers. Scientists at ICRISAT are the largest users of the germplasm followed by the scientists in India. During 1973 to 2004, we have supplied over 660,000 seed samples to the scientists outside ICRISAT representing 143 countries.

3.2. Germplasm repatriation: The global collections held at ICRISAT serve an important purpose in restoration of germplasm to the source countries when national collections are lost due to some reasons. For example, we repatriated 362 sorghum accessions to Botswana, 1827 sorghum and 922 pearl millet to Cameroon, 1723 sorghum and 931 chickpea to Ethiopia, 838 sorghum, and 332 pigeonpea to Kenya, 1436 and 445 sorghum accessions respectively to Nigeria and Somalia and 71 pigeonpea accessions to Sri Lanka. The ICRISAT germplasm collections include 44,822 accessions received from or jointly collected with the Indian NARS. On request, these accessions have been restored to the NBPGR Genebank, New Delhi, India.

3.3. Impact of germplasm supplied to the NARS, worldwide: Besides the utilization of germplasm in ongoing research at other institutes, 66 germplasm accessions of seven crops from the ICRISAT supplied samples have been directly released as cultivars in 44 countries. These cultivars have greatly benefited countries where released.

4. Strategies to enhance germplasm utilization

ICRISAT genebank has supplied more than 660,000 germplasm samples to users outside the ICRISAT from 1975 to 2004. This figure could be considered as satisfactory use of germplasm. However, the use of basic germplasm in various breeding programs is scanty. We have adopted the following strategies to enhance utilization of the germplasm in research:

4.1. Germplasm evaluation for specific traits: Germplasm accessions are evaluated for traits of agronomic importance such as yellow endosperm trait in sorghum and pearl millet and large-seeded trait in chickpea and groundnut. Based on the emergence of new priorities, future plans will be worked out.

4.2. Developing core collections: One of the reasons that plant breeders are using less of basic germplasm in research is the lack of information on traits of economic importance, which often shows high genotype x environment interactions and requires replicated multilocational evaluations. This is a very costly and resource-demanding task owing to the large size of the germplasm collection. To overcome this, our research now focuses on studying the diversity of germplasm collection and developing "core collections," which are about 10% of the entire collection, but represent almost full diversity of the species. From the germplasm collection in the ICRISAT genebank, we have already developed core collection of seven of the 11 ICRISAT related crops.

4.3. Developing mini-core collection: When the size of entire collection is large, even a core collection size becomes unwieldy for evaluation by breeders. To overcome this, we developed a two-stage strategy to develop a mini-core collection that would consist of 10% accessions of the core collection (or 1% of entire collection). (Upadhyaya and Ortiz 2001). At ICRISAT, we have already developed mini-core collections of chickpea (211 accessions) (Upadhyaya and Ortiz

2001), groundnut (184 accessions) (Upadhyaya et al. 2002), pigeonpea (146 accessions) and finger millet (65 accessions).

4.4. Identification of sources for traits of economic importance using core and mini-core collections: Due to reduced size, the core collection can be evaluated extensively to identify useful parents for crop improvement. By evaluating core collection of chickpea, we identified new sources of early maturity (28 accessions), and large seeded kabuli (16 accessions) types. By evaluating groundnut core collection we found new sources of early maturity in 21 accessions, and tolerance to low temperature at germination in 158 accessions (Upadhyaya et al. 2001b). Also were found 15 Valencia, 20 Spanish, and 25 Virginia type germplasm lines in groundnut with high-yield, good shelling percentage and 100-seed weight through multilocational evaluation of the 'Asia region core collection' (Upadhyaya et al. 2005). These new sources performed better than or similar to the best control cultivars for particular trait (s) but were diverse from them. We have also identified 10 drought- and five salinity-tolerant accessions from the chickpea mini-core and 18 diverse accessions with high water use efficiency from the groundnut mini-core collection (Upadhyaya 2005) (Figure 1).

4.5. Multilocational evalutions of mini-core collections: The chickpea mini-core was evaluated at the Indian Institute of Pulses Research (IIPR), Kanpur, India during the 2002/03 and 2003/04. IIPR scientists were particularly excited with the large-seeded kabuli accessions. They selected 12 accessions for subsequent large plot evaluation and their use in the breeding program. Similarly, scientists in China, Vietnam, and Thailand have identified 8, 10 and 12 germplasm lines, respectively from evaluation of groundnut mini-core in their country.

5. Future outlook

- In future, we will have increased focus on assessment of the germplasm for their usefulness for crop improvement. The core and mini-core subsets of the germplasm will be evaluated at diverse locations to identify trait specific diverse parents.
- We have initiated developing composite sets of ICRISAT mandate crops under the Generation Challenge Program. Phenotypic and genotypic characterization of these sets will provide vast scope of identifying useful and unique germplasm resources for utilization in the crop improvement.
- Search for new and useful crop germplasm and try to secure and conserve them in the genebank.
- We need to secure new germplasm of wild *Arachis* from Peru, wild *Cicer* from Iran and pigeonpea from Myanmar and Uganda to fill the genetic gaps in the collections.

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Table 1. Germplasm holdings in the Rajendra S Paroda Genebank, ICRISAT, Patancheru, December 2004.

Crop	Active collection	Base collection	Accessions held in-trust
Sorghum	36,774	31,669	35,780
Pearl millet	21,594	15,150	21,250
Chickpea	17,258	15,984	16,961
Pigeonpea	13,632	10,266	12,698
Groundnut	15,419	6,820	14,357
Finger millet	5,949	4,620	4,931
Foxtail millet	1,535	1,054	1,534
Proso millet	842	576	835
Little millet	466	384	460
Kodo millet	658	630	547
Barnyard millet	743	487	743
Total	114, 870	87,640	110,096

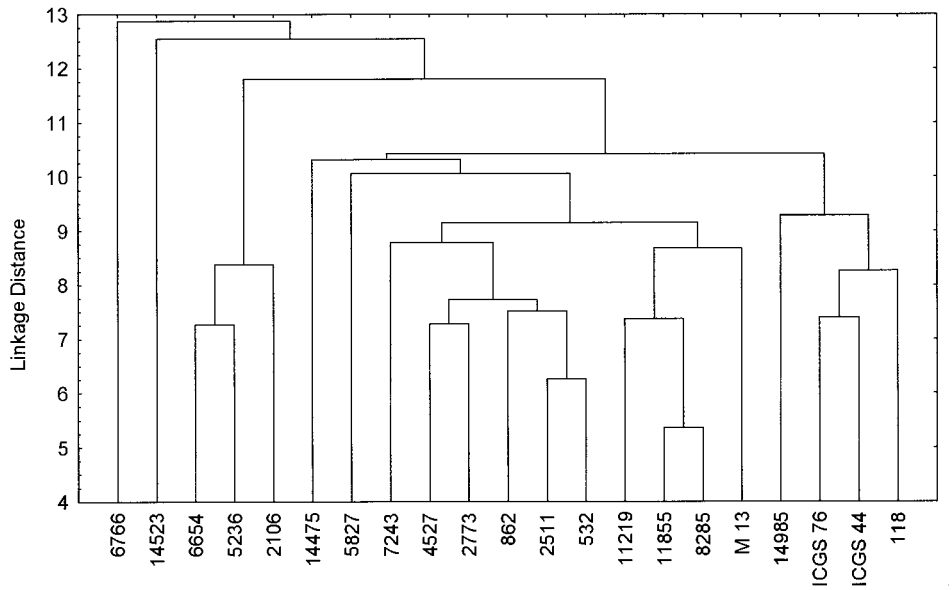

Figure. 1. Dendogram of 18 selected drought tolerant germplasm accessions and control cultivars of groundnut based on scores of first 12 principal components