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INTERNATIONAL CITRUS GENETIC RESOURCES

THE CENTER OF ORIGIN and diversity of citrus is in southeast Asia. Consequently, this is where the greatest amount and diversity of citrus genetic resources may be expected to be found, particularly *in situ* (REUTHER 1977, IBPGR 1982). Assessment of the genetic vulnerability of any species requires knowledge of the extent and distribution of genetic diversity. Unfortunately, information on natural and semi-natural citrus genetic resources is limited. The information that is available is often simply a catalog of plants present in an area, with little more than names and phenotypic descriptions. Often even information on the frequency of occurrence is lacking. More detailed characterization and evaluation data are needed to assess adequately the actual amount of genetic diversity present. These data should include both descriptive information and molecular level genetic analyses.

The report, The State of the World's Plant Genetic Resources for Food and Agriculture (accessible at http://web.icppgr.fao.org/wrlmap_e.htm), was prepared for the International Technical Conferences on Plant Genetic Resources in Leipzig Germany in 1996. In this report the number of citrus accessions worldwide were listed at 6,000 which included a mixture of wild species, old cultivars, and advanced cultivars and breeding lines. In an effort to better understand the nature of these collections and promote conservation of citrus and related genera, a global network on citrus genetic resources conservation and utilization was formally constituted under the aegis of the FAO in 1997. The Global Citrus Germplasm Network (GCGN) will function on a voluntary basis and will involve national institutions and existing regional and inter-regional citrus networks. The purpose of the network is to link different initiatives in different parts of the world that deal with genetic resources exploration, conservation, and utilization. The GCGN is chaired by a General Coordinator and guided by Coordinating Board. Within the GCGN four working groups were defined to conduct the scientific and technical work of the global network focused on genetic resource characterization; establishment of a global computerized citrus genetic resource information system; conservation strategies; and utilization of citrus genetic resources.

In the southern and southeastern Asian countries to which *Citrus* and related genera are indigenous, development and consequent habitat loss is occurring due to deforestation, population pressure, fire, and hydroelectric, agricultural, and other development pressures. Habitat loss results in a loss of genetic diversity. Efforts are being made at habitat preservation in these areas, however, *ex situ* preservation of genetic resources has become imperative due to the rapidity of habitat loss. *Ex situ* collections also make genetic resources more readily available to users and facilitate characterization and evaluation. What follows are brief descriptions of the status of *in situ* and *ex situ* collections of citrus and citrus relatives in selected countries and regions.

China. Southern China is one of the centers of diversity for *Citrus* and related genera, and a wide range of genetic diversity is apparently still present *in situ* (GMITTER and HU 1990, ZHENG 1995, DENG et al. 1997, CHEN 1997). However, some, although not all, areas are threatened with habitat degradation or lack of proper management that could result in decreases in genetic diversity. Chinese governmental surveys during the 1970s uncovered a number of putative new species, including *C. honghensis*, *C. mangshanensis*, *C. daoxianensis*, and *Poncirus polyandra*. These putative species are mostly unknown outside of China and some may be endemic. There is use of indigenous genetic resources in China, and some attempts at *in situ* preservation have been made. However, conservation of citrus genetic resources in China consists mostly of *ex situ* collections at present. Beginning in the early 1960s, a National Citrus Germplasm Repository was established at Chongqing, Sichuan province, and regional citrus genetic resources repositories were established in Huangyan, Zhejiang province; Guiling, Guangxi province; Zhangsa, Hunan province; and Guangzhou, Guangdong province. As of 1996, the National Citrus Germplasm Repository had 1,041 accessions, while the Huangyan, Guiling, Zhangsa, and Guangzhou regional repositories had 128, 216, 40, and 140 accessions, respectively. These current numbers represent substantial reductions in accessions since the repositories were established. The reductions were due to such factors as lack of funds, disease, and freezing weather. The exact contents

of these collections is unknown, but a high percentage is indigenous, and undoubtedly represents a substantial amount of diversity not present in collections elsewhere in the world. Some of the accessions, indigenous and otherwise, consist of advanced lines or selections. The collections in the repositories have had received only a limited amount of characterization and evaluation.

India. Northeast India is a center of origin and diversity for *Citrus* and related genera. Genetic diversity of indigenous *Citrus* species in this region is gradually eroding (RAI et al. 1997) and the area is experiencing civil unrest, making evaluation of genetic diversity and plant exploration difficult. There are apparently a few stands of wild citrus in these areas, but many of the wild populations consist of dooryard plantings. A long history of cultivation and selection have produced many genotypes and landraces, which are difficult to distinguish from wild citrus populations. Still, a wide range of genetic diversity undoubtedly exists in these areas (SINGH 1981, CHADHA 1995, SINGH and UMA 1995, RAI et al. 1997). There is an *in situ* gene sanctuary for citrus in the Garo Hills in the northeast of the state of Assam, which is a field genebank with 627 accessions (SINGH 1981). Other regions of diversity include the central and northwest Himalayas, Maharashtra, and the southern peninsula. *Ex situ* conservation of citrus genetic resources began in the 1950s in India, but the number of accessions maintained has declined due to lack of maintenance and disease. *Ex situ* collections consist of 451 or 521 accessions (depending on the source of the estimate) at eight sites (Chetalli, Bangalore, Rahuri, Tirupati, Abohar, Bhatinda, Yercaud, and Delhi). The *ex situ* collections in India are mostly of rootstock varieties and a few local cultivars, with not much diversity represented. There is a plan to concentrate the various collections at the National Research Centre for Citrus in Nagpur. However, as of January 1996, there were only a small number of accessions planted at Nagpur.

Other Southeast Asian countries. The area is rich in indigenous Aurantioideae genetic resources, with chance seedlings, semi-wild, and wild types. There are three collections in Malaysia (JONES 1991, SAAMIN and KO 1996), the main one being the Malaysia Botanical Garden (over 100 accessions), three in Indonesia (498 accessions), three in Thailand (585 accessions), and two in the Philippines (107 accessions). There are also some *in situ* conservation efforts. In the period 1983 to 1988, the International Plant Genetic Resources Institute (IPGRI, then the International Board for Plant Genetic Resources) coordinated four collecting missions to Thailand, Malaysia, Indonesia, and Brunei resulting in the addition of 391 new accessions (these are maintained in Japan, the organizer of the missions). In 1986, IPGRI invited Malaysia to accept responsibility for maintaining a field collection of Southeast Asian species of Aurantioideae. Although not as large as some collections, these Southeast Asian collections have notable genetic diversity, particularly in the pummelos and some of the related non-*Citrus* genera, and appear to be fairly well maintained and curated.

Asia's largest collections, outside of the centers of origin discussed above, are in Japan (OMURA 1997). Citrus entered Japan in ancient times and some types became semi-naturalized. The federal Fruit Tree Research Station in Tsukuba has a large collection maintaining a number of citrus relatives. This station has been active in collecting in Nepal (1983–1985) and Vietnam (1996) in IPGRI-coordinated cooperative programs. Accessions collected from these ventures are maintained in Japan. The accessions at Tsukuba and in various other, smaller collections total approximately 1,200 (OMURA 1997).

Australia. Indigenous citrus relatives include taxa in the genera *Eremocitrus* and *Microcitrus*, for which Australia is the center of origin. These taxa probably served as aboriginal foods. Organized *ex situ* citrus genetic resource maintenance and utilization is conducted today by state government departments of agriculture and primary industries, the federal Commonwealth Scientific and Industrial Research Organization (CSIRO), and various arboreta, botanical gardens, and university plant collections (SYKES 1997). In total, these collections include about 500 accessions and are rich in diversity of cultivated types. Most accessions are backed up by duplication in different sites. Acquisition of new material by budwood is limited due to quarantine concerns, but seed importation and subsequent characterization and evaluation of *Citrus* relatives from other Southeast Asian countries and materials with rootstock potential has been an ongoing activity, especially of CSIRO as part of a program of genetic resources enhancement.

Elsewhere. Outside of the centers of origin and diversity, collections consist mostly of advanced lines and commercial varieties in countries with citrus production and citrus breeding programs. ROUSE (1988) and BETTENCOURT et al. (1992) have summarized the world citrus collection situation identifying major and minor *ex situ* citrus collections. Large *ex situ* collections of citrus are found in Argentina, Brazil, Corsica, Morocco, New Zealand, South Africa, Spain, and Turkey. Although the number of accessions reported for some of these collections exceeds the number maintained by the CVC in California, the amount of genetic diversity present is generally less than in the CVC. For example, some of the larger collections contain many selections of the same variety, and so the genetic diversity is less than might be expected from the number of accessions. Representatives of genera related to *Citrus* are particularly lacking in most of these collections. On the other hand, some of the smaller collections worldwide may not offer a large number of varieties or much diversity, but may be

important for indigenous local variation in *Citrus* or for endemic species. For instance, BETTENCOURT et al. (1992) list Cameroon as having some indigenous *Citropsis* species in their collection.

These collections vary as to the purposes they serve. Most of the collections are located in countries where citrus is not native, so they serve a multiplicity of functions including limited genetic resources maintenance for crop enhancement and breeding and as mother trees for the production of trees for a commercial fruit industry. Large genetic resources collections intended for the preservation of diverse species encompassing the genus *Citrus* as well as related genera exist in only a few places in the world besides the CVC. Most collections in other countries consist of field plantings, and, with a few notable exceptions, virus-free budwood is not available. The Citrus Germplasm Bank, Instituto Valenciano de Investigaciones Agrarias in Valencia, Spain is one of those exceptions and virus-free material is available. Spain's quarantine and certification programs are among the world's best and most respected (NAVARRO et al. 1988).