Appendix 4

State of diversity of major and minor crops

A4.1 Introduction

In Annex 2 of the first SoW report, a number of crops of major and minor importance for food security in one or more global subregions were surveyed for the state of their diversity. Similarly in this Appendix, major crops (wheat, rice, maize, sorghum, cassava, potato, sweet potato, beans (*Phaseolus*), soybean, sugar crops, and banana/plantain) and a number of globally minor, but subregionally or nationally major, crops (millets, roots and tubers other than the ones listed above, pulse crops other than species of *Phaseolus*, grapes, tree nuts, and vegetables and melons) are surveyed. While this range of crops is not a definitive list of staple or important food and oil crops, it does include examples of different crop groups (cereals, food legumes, roots and tubers, tree crops), species with different breeding systems (cross-pollinating, self-pollinating, clonally propagated), and crops of temperate and tropical origins. It also includes crops for which there has been great investment in conservation and improvement, notably wheat, rice and maize, as well as crops for which there has been relatively less investment, such as cassava, sweet potato, and plantain. This list of major and minor crops also provides a good sampling of the crops listed in Annex 1 of the ITPGRFA,[1] although not all crops surveyed here are in Annex 1 (e.g. soybean, groundnut, sugar cane, grape and some millets).

The purpose of this Appendix is not simply to repeat information presented in Chapters 1, 2, and 3 of the main report, but to highlight some of that information in a crop-oriented context. General information is provided here on the major patterns of production and on the area harvested of the major and minor crops over the years 1995 through 2008;[2] the composition of their genepools; the state of *in situ* diversity for crop species, if wild forms exist, and of CWR and *in situ* conservation programmes (more details are given in Chapter 2); specific reports of genetic erosion; summaries of the status of major *ex situ* collections (more details are given in Chapter 3 and Appendix 2); the status of safety duplication of *ex situ* collections, gaps, opportunities and priorities in the extent of coverage of the genepool diversity in *ex situ* collections; the extent of documentation, characterization and evaluation of collections; issues related to utilization of collections; the impact of climate change on priorities and concerns for both *in situ* and *ex situ* conservation; and the role of specific crops for sustainable production systems, organic production systems, and farmer opportunities. In the individual crop sections that follow, specific concerns are highlighted.[3]

Diversity status

Since 1995, more than 1 million germplasm samples have been added to *ex situ* collections and at least a quarter of these accessions are the result of new collecting missions (from fields, markets, and nature).[4] The remainder are probably a result of increased exchange of accessions among collections. The number of accessions is not a direct measure of diversity. There are many germplasm descriptors from which the diversity status of a collection can be inferred (for example, passport information, phenotype information for many characters, genotype information from many possible markers and assays, and basic taxon biology). The assessment of diversity thus depends upon the uniform availability of such information for the collections to be studied. As pointed out by many sources, uneven documentation of crop germplasm is a major shortcoming for most collections.

Even less is known about the state of diversity represented in genebank accessions of wild species related to crops or about the status of diversity in taxa growing in any sort of natural reserve or other *in situ* conservation areas. As pointed out in Chapter 2, very few (<50) CWR have been assessed for their diversity status compared to the hundreds of known CWR. Many country reports have stressed concern for the lack of attention paid to both *in situ* and *ex situ* conservation of CWR. Chapter 2 also reports on the CGRFA-commissioned study to identify conservation priorities and specific locations for critical *in situ* conservation of CWRs of the major food crops in almost all continents.[5]

The negative impact on biological diversity and efforts at germplasm conservation and utilization caused by armed conflicts and outright war was noted in Chapter 2, but was also strongly emphasized by some country reports.[6] Political instability, changes in political systems, economic disparities and uneven development across national landscapes have also negative repercussions on biological diversity and both precede and follow outright conflicts. Specific impacts include destruction of habitat, basic infrastructure and the collections themselves.[7]

Even as studies and reports have been identifying gaps and deficiencies and raising alarms, there has been progress in diversity assessments since the first SoW report, motivated by many factors, actors, and initiatives:

- increasing country compliance with mandates of the 1992 CBD (*in situ* and *ex situ* conservation and access and sustainable use of biodiversity) as well as national biodiversity strategies and action plans for carrying them out;
- the coming into force of the ITPGRFA and steps taken by countries for its implementation;
- the FAO Commission on Genetic Resources for Food and Agriculture, the first SoW report, and the subsequent GPA;
- the international research organization IPBGR/IPGRI/Bioversity International and its efforts at research, documentation, and training dedicated to conservation of agrobiodiversity;
- the efforts of the international centres of the CGIAR with their various mandated crops;
- national and regional efforts (for example, the United States Department of Agriculture [USDA], the United States Agency for International Development [USAID], the Swedish International Development Cooperation Agency [Sida], the European Commissions) at training and capacity building for conservation and utilization in countries with priority crops;
- the establishment of the GCDT and its efforts to motivate assessments and conservation strategies and to provide funding to carry out the priorities thus established.

As reported in Chapter 2, since 1995 many countries have carried out specific surveys and inventories at least at the level of species, either as part of their National Biodiversity Strategy and Action Plans or within the framework of individual projects. Most have been limited to single crops, small groups of species, or limited areas within the national territory. ICARDA has assisted countries in North Africa, the Near East and Central Asia in surveys to assess density, frequency, and threats to CWR. Academic research undertakings have surveyed active farms in several countries to assess the extent of traditional varieties still grown in spite of the availability of modern, high-yielding varieties of many crops and report that a significant amount of crop genetic diversity in the form of traditional varieties continues to be maintained on-farm (Chapter 2 and country reports from Bosnia Herzegovina, Iceland, the Niger, Poland, Switzerland and the Former Yugoslav Republic of Macedonia, which affirm that crop diversity is still high and that special efforts are made to keep it that way). For example, in the Niger, no genetic erosion was observed during recent collecting missions and many traditional cultivars still prevailed in farmers' fields. No losses of millets and sorghum varieties could be detected in comparing collecting missions in 1973 and 2003, however, improved varieties of millet had increased.[8]

On the other hand, there continue to be recurring reports and alerts about the dwindling diversity of landraces and traditional varieties in production and in conservation.[9] Among the country reports, the majority pointed to decreases in cultivation of traditional varieties and landraces due to replacement by modern varieties.[10] Along with this conclusion, however, most of these country reports also stated that the detailed surveys and inventories that could document these decreases have not been done. The strongest conclusion that can be made from these country reports is that the extent of diversity maintained in crop production systems or in the wild either is not known or varies greatly with crop or ecosystem and country.

Among the strategies countries have reported for preventing genetic erosion caused by pressures for variety replacement are:

- on-going collection of wild and on-farm germplasm and diversification of production with traditional cultivars to allow farmers to produce for local markets and traditional use;[11]
- adequate conservation of landraces and traditional grass varieties by the Nordic Gene Bank;[12]
- collection, identification and *ex situ* conservation of crop landraces by public and private institutions;[13]

- absence of intensification of agriculture in many areas so that there is a continuing high number of varieties and species in cultivation;[14]
- since the late 1990s measures have been in place to protect habitat, promote continued landrace cultivation through farmer-participation projects, reintroduce landraces and old cultivars for organic production, and on-going collection missions;[15] and
- on-going collection missions and promotion of on-farm conservation of heritage pasture, vegetable and fruit tree varieties.[16]

Many country reports have indicated that "informal" seed systems remain a key element in the maintenance of crop diversity on farms (Chapter 4). It was noted in the United Republic of Tanzania that such an informal system accounts for up to 90 percent of seed movement.[17] The country reports of both Finland and Germany called attention to EU Council Regulation No. 1698/2005, which came into force in 2006 on the national and state levels. Under these regulations, payments can be made (premiums per hectare) for the cultivation of crop varieties threatened by genetic erosion, as well as for specific actions supporting the conservation and sustainable use of these varieties.

Following the adoption of the ITPGRFA, the GCDT was established in 2004. Among its goals is the identification and addressing of the highest priority diversity conservation issues which involve *ex situ* conservation of the ITPGRFA mandate crops (listed in Annex 1 of the Treaty).[18] The Svalbard Global Seed Vault opened in 2008 and provides the ultimate global security backup collection of crop diversity held in genebanks around the world, for insurance against both incremental and catastrophic loss. Since its opening, there has been a concerted effort at depositing duplicate accessions from the CGIAR global collections and many national and regional collections.

In 2006, the GCDT initiated the development of crop-based conservation and utilization strategies, convening teams of curators, breeders, and crop experts. The priorities that have emerged from this process were the next targets for the Trust, which now offers a grant process to fund work to address the priorities. The Trust's achievements in 2008 included signing over 50 grant agreements with partner organizations around the world to rescue, regenerate, characterize, evaluate, and ensure that the existing diversity, once better conserved and better understood, is quickly and easily available to plant breeders.[19]

In situ conservation status

The wild forms of many crops (especially cereals and legumes), and most of the species in their primary and secondary genepools, are usually annual species and thus populations are dynamic, and possibly transient, from year to year making it difficult for natural areas to be defined based specifically on the conservation of CWR. Most protected natural areas in the world are defined on the basis of geographic and ecological features and the presence of some dominant perennial plant taxa. Therefore the success of protected areas in maintaining annual CWR taxa is haphazard at best. An effort to support CWR conservation has been led by Bioversity International and partners with projects in five countries (see Box 2.1 in Chapter 2).[20]

On-farm conservation of old and heirloom varieties and landraces has been given impetus by many crop or food specific projects led by NGOs, public advocacy groups, and academic institutions. Several country reports have documented on-farm and participatory conservation efforts in those countries.[21] A major advance since the first SoW report was published has been increasing numbers of national surveys and inventories supported by a wide range of organizations (see Chapter 2) that have documented the status of conservation efforts and priorities for further action.

Gaps

There are still gaps in the coverage of cultivars, traditional varieties, landraces, and CWR in the *ex situ* collections of many major crops.[22] Similar, and in some cases even more extensive gaps, are found for collections of minor crops. There is a better understanding of the extent and nature of gaps in *ex situ* collections today than was the case at the time of the first SoW report. Some gaps arise by loss of once collected material. Others are due to lack of collection. Perennial taxa present special problems in regeneration, leading to loss and the need to recollect. *In situ* maintenance is often the better conservation option for perennial taxa from a genetic diversity standpoint.

The identification of gaps and recommendations for addressing them is a key component of the GCDT crop strategies. The CGIAR centres pursue these issues for their mandated crops. National PGRFA conservation programs in their country reports have documented needs in addressing gaps as well. Almost uniformly, the country reports cite needs for increased monitoring and establishment of early warning systems as a means to identify gaps in coverage and status of conservation.

Documentation, characterization and evaluation

Information systems vary greatly in type and sophistication from one collection to another. GIS and molecular data are used in the most sophisticated collections. Standardization and training are needed.[23] More detailed discussion of the trends in documentation and characterization of PGRFA and the priorities for the near future are reported in Chapter 3.

Utilization

Constraints to utilization of germplasm accessions include lack of accession data, especially evaluation data, unavailability of useful material, and concern over IPR. Priorities to increase utilization include wider use of diverse mapping populations, enhanced use of mutant and genetic stocks and wild relatives, and deployment of newer technologies such as increasingly cost effective high-throughput marker detection and DNA sequencing technology.[24]

Participatory breeding approaches have increasingly emerged as a means to target production of cultivars tailored more specifically to farmers' needs, as noted by many country reports and summarized in Chapter 4. More specific discussion of the trends in utilization of PGRFA and the priorities for the near future is also included in Chapter 4. Examples of priority needs include capacity building in both the crop improvement areas and the germplasm conservation areas and strengthened cooperation among those involved in the conservation and sustainable use of PGRFA at all stages of the seed and food chains.

Climate change

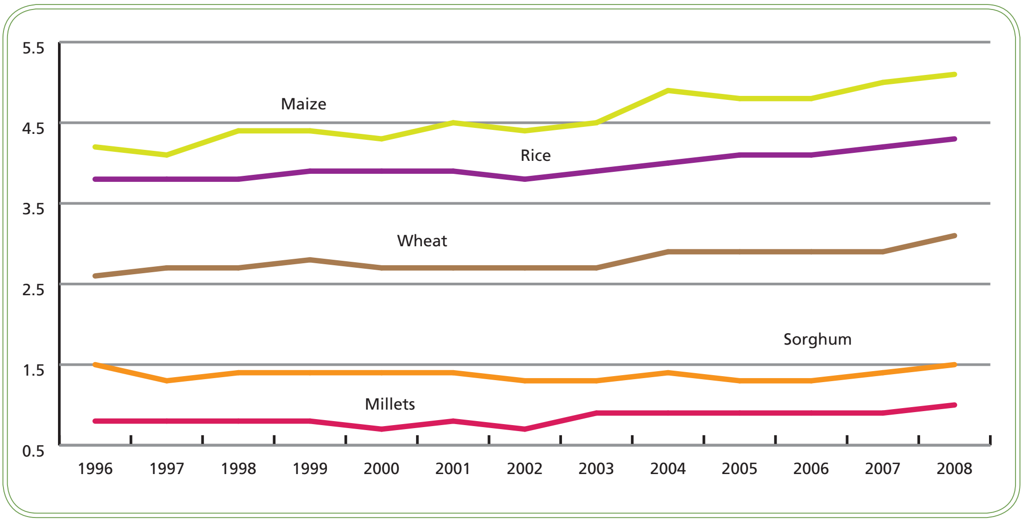
Many country reports document loss of diversity over the past decade from collections and farms due to the impacts of pest and disease outbreaks or to absence of tolerance to abiotic stresses, such as heat, drought or frost, leading to loss of accessions during regeneration and in field collections, as well as to loss of cultivars and landraces during crop production. These kinds of diversity losses are expected to grow with increasing manifestations of global climate change. Many country reports point to the threats of climate change for genetic resources. All the scenarios predicted by the IPCC[25] will have major consequences for the adaptation and geographic distribution of crops, specific varieties, and CWR. In China, for example, projections indicate shortages of water supplies for agriculture in the coming decades.[26] Systems of protected areas and reserves will be impacted in ways that will require changes in scale, size, and management plans.[27] Regeneration and grow-out issues for *ex situ* collections will be even more critical to resolve because demand for accessions will increase if breeders are to be successful in finding and incorporating new sources of disease and pest resistance and stress tolerance into cultivars to facilitate crop adaptation to impacts of increasing climate diversity. However, as the country reports document and Chapter 4 summarizes, overall, plant breeding capacity has not changed significantly since the first SoW report was first published. There is thus an urgent need to increase this capacity worldwide to address the climate change crisis.

A4.2 State of diversity of major crops

A4.2.1 State of wheat genetic resources

The yield of wheat has increased from 2.6 t/ha in 1996 to 3.1 t/ha in 2008 (Figure A4.1). Wheat continued to be the most widely cultivated crop, harvested from 224 million hectares in 2008,[28] down from the 227 million hectares in 1996. Total world production in 2008 was 690 million tonnes,[29] up from the 585 million tonnes

FIGURE A4.1
Global yields of selected cereal crops (tonnes per hectare)



Source: FAOSTAT 1996/2008

reported for 1996. The five largest producers in 2008 were still China (16 percent of global production), India (11 percent), the United States of America (10 percent), the Russian Federation (9 percent), and France (6 percent).

World wheat production is based almost entirely on two species: common or bread wheat (*Triticum aestivum*, almost 95 percent of production) and *durum* or macaroni wheat (*T. turgidum* subsp. *durum*, about 5 percent of production).[30] The former is a hexaploid species ($2n=2x=42$) and the latter tetraploid ($2n=2x=28$). Very minor, extremely local production may still be found with diploid wheats and tetraploid subsp. besides durum.

The genepool for wheats consists of modern and obsolete cultivars and breeding lines, landraces, related species (both wild and domesticated) in the *Triticeae* tribe, and genetic and cytogenetic stocks. Details of the genepool composition are described in the GCDT strategy plan:[31] The primary pool consists of the biological species, including cultivated, wild, and weedy forms of the crop species which can be easily hybridized. In the secondary genepool are species from which gene transfer is possible but with greater difficulty, typically species of *Triticum* and *Aegilops*. The tertiary genepool is composed of other species of the tribe (primarily annual species) from which gene transfer is possible only with great difficulty. 'Ease' of gene transfer is a technology-dependent concept and subject to change as are the taxonomic delimitations within the tribe. Wild relatives of wheat have proven to be highly useful sources of resistance to biotic and abiotic stresses in wheat breeding over the last two decades and this trend is expected to accelerate in the future. Similarly, genetic stocks are finding increasing use as tools in the sophisticated application of modern biotechnologies in wheat improvement.[32]

In situ conservation status

One of the few global examples of a protected area created specifically for conservation of annual cereal CWR is the "Erebuni" State Reserve in Armenia, an 89 hectare region in the transition area between semi-desert and mountain-steppe zones. Three out of the four known species of wild-growing wheat occur here (wild one-grain wheat, *T. boeticum*, wild two-grain Ararat wheat, *T. araraticum*, and wild urartu wheat, *T. urartu*) along with several species of *Aegilops*, in addition to a number of CWR of other cereal species (barley and rye).[33] Succession with other indigenous species and invasive species (both plants and animals) are threats to the integrity of the CWR species in this reserve as well as in any other in which cereal CWR may be found. In general, any protected areas in countries with Mediterranean climates are likely to include some wheat CWR taxa. Whether the genetic integrity of such populations are being maintained in these reserves is the key question.

Ex situ conservation status

Altogether, over 235 000 accessions are maintained in more than 200 *ex situ* collections.[34] Landraces, modern and obsolete improved cultivars are generally well conserved in wheat germplasm collections, while wild relatives of wheats are poorly represented.[35] Because of the specialized needs and conditions for developing and reliably maintaining genetic and cytogenetic stocks, these are not well represented in germplasm collections (probably in fewer than 90 collections) and are most likely to be found in research institutions. Regeneration progress is lacking in many country collections and is probably the single greatest threat to the safety of wheat accessions held in globally important genebanks. Lack of funding is the principle limitation.[36]

Genetic erosion and vulnerability

The instances of absence of genetic erosion or lack of vulnerability are rare. Chapter 1 highlights the increase in genetic diversity and allelic richness in varieties released from the CIMMYT spring bread wheat improvement program. Many CWR have a weedy habit and thrive in disturbed areas or areas of cultivation and thus are often widespread, but there is little known in general about the genetic diversity itself in these adventitious populations.

Regeneration progress is lacking in many country wheat genetic resources collections (about 10 percent of collection, globally) and it is probably the single greatest threat to the safety of wheat accessions held in globally important genebanks. Lack of funding is the principle limitation.[37]

Examples of concerns from country reports are: there is a gradual disappearance of landraces of wheat;[38] all primitive wheat cultivars are lost;[39] and old varieties of wheat are replaced by modern cultivars in main production areas.[40]

Gaps and priorities

As summarized in Chapter 3, according to the opinion of collection managers, the major gaps in collections relate to landraces and cultivars. Key users of wheat genetic resources, however, indicated the need for more mapping populations, mutants, genetic stocks and a wider range of wild relatives. This divergence of perceptions of the major function of collections between genebank managers and germplasm users complicates evaluation of the status of diversity.[41] CWR are relatively poorly represented in collections and more collecting is needed.[42, 43] The level of genetic diversity and breadth of provenance of wild related species maintained in existing collections is small.

One of the scenarios of climate change is increased regional temperatures. This could be beneficial for the wheat crop in some regions, but it could reduce productivity in regions where temperatures are optimal for wheat. New wheat cultivars will be needed to adapt the crop to changing environments and still meet the nutritional needs of people. Identification and deployment of heat-tolerant germplasm is a high priority.[44]

Safety duplication

Safety duplication is lacking for most country collections of wheat. Less than 10 percent of the globally important wheat collections have their entire collection duplicated elsewhere for safety, while a majority have only partial or no safety duplication in place.[45]

Utilization

There are large differences in productivity between countries, even when similar agronomic practices are applied. Thus, there is an opportunity to increase productivity in many countries and genetic resource collections will be important for this. Genetic and molecular stock collections are increasing in size and sophistication in concert with advances in biotechnological tools for genome analysis. These will increasingly be deployed (for example with MAS) to enable effective utilization of the genetic variation available in traditional germplasm collections.[46]

Role of crop in sustainable production systems

Wheat is produced for a wide range of end-users and it is a critical staple food for a large proportion of the world's poor farmers and consumers. It provides 16 percent of total dietary calories for humans in developing countries and is the single largest import food commodity into developing countries as well as a major component of food aid from developed countries. The lower food prices for wheat in developing countries, due to increased global production, has contributed to a reduction of the proportion of poor people in developing countries.[47]

A4.2.2 State of rice genetic resources

During the period 1996-2008, the yield of rice (*Oryza sativa*) increased by about 14 percent worlwide (Figure A4.1). In 2008, world rice production accounted for 685 million tonnes harvested from an area of 159 million hectares.[48] The highest producers of rice were China (28 percent of global production), India (22 percent), Indonesia (9 percent), Bangladesh (7 percent), and Viet Nam (6 percent).

The primary genepool has been a source of useful genes for breeding and research. It consists of the other domesticated species *O. glaberrima* and *O. rufipogan* and several other wild species, all with a common genome (A), that can hybridize naturally with *O. sativa*.[49] The secondary and tertiary genepools, *Oryza* species with genome constitutions other than A, have potential as gene sources, but introgression of genes into rice is proving difficult.[50] However anther culture and embryo rescue techniques can be used effectively to overcome hybrid sterility. At CIAT, advanced breeding lines from crosses between *O. sativa* and *O. latifolia* (CCDD genomes) have been generated and distributed to NARs in Latin America.[51]

In situ conservation status

Potential genetic reserve locations in Asia and the Pacific have been identified for *O. longiglumis*, *O. minuta*, *O. rhizomatis* and *O. schlechteri* which are high priority CWR for *in situ* conservation. Efforts for the conservation of landraces and CWR outside protected areas aimed to preserve globally significant agrobiodiversity of rice have been reported in Viet Nam.[52]

Ex situ conservation status

Overall, about 775 000 accessions are maintained in more than 175 *ex situ* collections; however, about 44 percent of these total holdings is conserved in five genebanks located in Asia.[53] Landraces, obsolete and modern improved cultivars, as well as genetic and cytogenetic stocks are generally well represented in rice germplasm collections. In general, CWR are poorly represented in the *ex situ* collections with the exception of those held at IRRI and at the National Institute of Agricultural Biotechnology in the Republic of Korea.

Genetic erosion and vulnerability

A sampling of the concerns raised by country reports include: the assessment that rice varieties have become more uniform and thus more genetically vulnerable,[54] the fact that specific rice varieties and landraces have disappeared,[55] and wild species in the primary genepool are becoming extinct.[56] Causes noted are increasingly unfavorable climate conditions, such as drought, replacement by introduced high-yielding, early-maturing varieties, and loss of habitat. In some countries, government policies do not facilitate germplasm collecting and therefore, the characterization and utilization of wild relatives of rice.

Gaps and priorities

Further collecting for better wild species representation in genebanks from all levels of genepools, as well as

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regeneration of existing wild accessions and networks for sharing conservation responsibility for wild species among the several genebanks and research centres that maintain them are needed.[57]

Safety duplication

Seed multiplication and safety duplication is inadequate in most rice collections.[58]

Utilization

Improved conservation protocols and facilities, as well as more systematic germplasm characterization would enhance utilization of accessions (e.g. glutinous rice accessions) that do not store well under the moisture and temperature regimes of conventional storage conditions.[59]

A4.2.3 State of maize genetic resources

During the period 1996-2008, the yield of maize (*Zea mays*) increased by 21 percent (Figure A4.1). In 2008, maize was grown in over 161 million hectares with a global production of 823 million tonnes, having overtaken rice and wheat in production since 1995.[60] The five highest producers of maize in 2008 were the United States of America (37 percent of global production), China (20 percent), Brazil (7 percent), Mexico (3 percent), and Argentina (3 percent).[61]

The primary genepool includes the maize species (*Zea mays*) and teosinte, with which maize hybridizes readily with production of fertile progeny. The secondary genepool includes *Tripsacum* species (~16 species), some of which are endangered. The variability among maize landraces (some 300 have been identified) exceeds that for any other crop.[62] Great variation exists for plant height, days to maturity, ears per plant, kernels per ear, yield per hectare and latitudinal and elevational ranges of cultivation.[63] Teosinte is represented by annual and perennial diploid species ($2n = 2x = 20$) and by a tetraploid species ($2n = 4x = 40$). They are found within the tropical and subtropical areas of Mexico, Guatemala, Honduras, and Nicaragua as isolated populations of variable population sizes, occupying from less than one hectare to several hundreds of square kilometres. The distribution of teosinte extends from the southern part of the cultural region known as Arid America, in the Western Sierra Madre of Chihuahua and the Guadiana Valley in Durango in Mexico, to the western part of Nicaragua, including practically the entire western part of Mesoamerica.[64]

In situ conservation status

It is extremely important to act now to complete ecogeographic sampling for New World maize, since economic and demographic changes are eroding the genetic diversity of maize in many areas that were once untouched by modern agricultural, horticultural, forestry, and industrial practices.[65]

Ex situ conservation status

While there are relatively few areas where no comprehensive collection has already been made, maize from portions of the Amazon basin and parts of Central America and waxy maize in Southeast Asia have never been adequately collected. Public or private tropical inbred lines are not well represented in collections, nor are important hybrids (or their bulk increases).[66] Wild *Zea* and *Tripsacum* species are potentially important sources of genetic variation for maize, but they are not well represented in collections and existing accessions are in small quantities. The Maize Genetic Cooperation Stock Center at the University of Illinois is the primary genebank holding maize mutants, genetic stocks, and chromosomal stocks.[67] Teosinte representation is uneven and incomplete in major genebanks.[68] The major teosinte collections are those of the INIFAP, the University of Guadelajara and CIMMYT in Mexico and in the USDA-ARS collections in the United States of America.[69]

Genetic erosion and vulnerability

As with wheat, a rare instance of improved genetic variability is the increase in genetic diversity and allelic richness in varieties released from CIMMYT's maize improvement program (Chapter 1). More typical is the report by individual countries of a loss of older varieties and landraces.[70] The predominant cause reported is replacement of traditional varieties by modern cultivars. All populations of teosinte are threatened.[71]

Gaps and priorities

National and international reserves need to be established to protect the remaining fragments of the Balsas, Guatemala, Huehuetenango, and Nicaraguan races of teosinte. CIMMYT's current *ex situ Tripsacum* garden at Tlaltizapan, Morelos, should continue to be maintained, with a duplicate garden established in Veracruz (or some equivalent lowland, tropical environment). Another *Tripsacum* garden could be established near IITA headquarters in Africa. *In situ* monitoring of *Tripsacum* populations should be conducted in Mexico and Guatemala, the center of diversity for the genus, and in other countries in Central and South America, where both widespread and endemic species are found. *Ex situ Tripsacum* gardens at CIMMYT and USDA in Florida should be enriched with the diversity found from the wild, and more collaboration should occur between these two unique sites.[72]

As summarized in Chapter 3, major gaps identified in existing *ex situ* maize collections include hybrids and tropical inbred lines, in addition to the gaps resulting from the loss of accessions from collections; for example, the entire collection of Dominica has been lost as has much of the material collected by IBPGR in the 1970s. The GCDT maize strategy emphasized specifically that hybrids and private inbred lines (not those now with plant variety protection [PVP] or with recently expired PVP) are missing from genebanks.[73]

There is a need to identify core subsets of the maize races, but it depends on expertise not only in statistical procedures, but more critically, in racial and accession classification and the availability of the type of data needed to develop reasonable classification decisions.[74]

While coverage of New World maize is good in genebanks,[75] about 10 percent of those New World holdings are in need of regeneration.[76] In some cases, recollection of adequate samples makes more sense than regeneration, particularly for high-elevation landraces growing in areas unaffected by improvement programs (much of Oaxaca and Chiapas in Mexico, many Central American highlands, much of Andean Argentina, Bolivia [Plurinational State of], Chile, Ecuador, Colombia, and Peru). Collection of indigenous knowledge must be a priority for all recollecting.[77]

Further collecting of wild species is needed, along with *in situ* conservation efforts. As with some landraces, recollecting of wild species is often more efficient than regeneration.[78]

Safety duplication

A network of safety duplicates for most accessions of major New World genebanks is in place. However, few of the accessions housed in the national collections of the Old World are backed up at the international centres; many are essentially unavailable to non-national (and sometimes even to national) users; and assurance of periodic regeneration is often uncertain.[79]

Safety backup for about 85 percent of the genetic stock collections is in place at the USDA NCGRCP, Ft. Collins, Colorado, the United States of America.[80]

Because the genetic diversity of teosinte and *Tripsacum* is relevant to maize research and breeding efforts for maize productivity, nutritional quality, bio-energy production, and other uses, *ex situ* backup of these materials is critical.[81]

Documentation, characterization and evaluation

Documentation of the materials held in national collections is inconsistent and sometimes poor, and is held in multiple databases that are not necessarily well maintained or easily accessible. Standardization across databases is lacking. The most pressing problem is to resolve the various acronyms and numbering systems used for the same accession. Only the US-GRIN system is internet accessible.[82] Implementation of a global information system for maize is anticipated and would serve especially to improve the regeneration progress. A separate database may be useful for teosinte.[83]

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An operational comprehensive maize metadatabase would make more efficient safety duplication for all accessions possible.[84]

Utilization

Distribution of germplasm accessions is an indirect measure of the use of genetic resources for crop improvement. The CIMMYT maize collection is one of the world's largest (second only to the Mexican national collection) and had its peak distribution year in 1989 followed by a net drop through 1995. However, there has been a net increase in distribution from 1996 through 2004 suggesting a renewed interest in germplasm utilization.[85] Increased use of germplasm may come about through improved technology for distribution of DNA itself.[86]

Constraints noted for greater utilization include ownership issues and inadequate personnel. Distribution of accessions is hampered by IPR concerns.[87] There is a serious need to train a new generation of maize germplasm specialists in conservation and use.[88]

Role of crop in sustainable production systems

Strategic evaluation of maize germplasm accessions combined with genetic enhancement will be important to achieve increased food security and reduced poverty and to protect the environment, particularly in Sub-Saharan Africa and in Indigenous areas of the Americas.[89]

A4.2.4 State of sorghum genetic resources

Over the period 1996-2008, the yield of sorghum (*Sorghum bicolor*) did not changed significantly (see Fig. A4.1). In 2008, sorghum was cultivated over a harvested area of 45 million hectares with a global production of 66 million tonnes.[90] Sorghum is mainly used for human consumption in Africa and India and for animal feed in China and the United States of America. The five highest producers of sorghum in 2007 were the United States of America (18 percent of global production), Nigeria (14 percent), India (12 percent), Mexico (10 percent), and the Sudan (6 percent).

The primary genepool consists of *S. bicolor* and its many races and several other species, the number of which depends on the taxonomic treatments.[91]

Ex situ conservation status

The major sorghum collections are at ICRISAT and at the USDA Plant Genetic Resources Conservation Unit, Southern Regional Plant Introduction Station, followed by those at the Institute of Crop Germplasm Resources (ICGR) in China and at the National Bureau of Plant Genetic Resources (NBPGR) in India. In addition, there are about 30 other institutions holding *ex situ* sorghum collections (primarily national collections). Altogether, over 235,000 accessions are maintained, of which 4,700 accessions are wild materials.[92] A high degree of duplication of accessions among collections is suspected, except for the Chinese collection which consists primarily of Chinese landraces.[93]

Genetic erosion and vulnerability

In Mali, 60 percent of local varieties of sorghum have disappeared in one region over the last 20 years due to the expansion of cotton production, introduction of maize cultivation, and the saturation of the available cropping area. In one village, diffusion of an improved variety displaced three local varieties of sorghum.[94] Several other African countries also indicated in their reports that improved varieties had displaced local varieties.[95] In Niger, however, no losses of varieties and landraces from farmers' fields had been detected in collecting missions.[96] In Japan, sorghum is no longer cultivated at all, but the farmers' varieties were collected for the national gene bank.[97]

Gaps and priorities

A massive number (28 000) of accessions urgently need regeneration, bottlenecks include quarantines and day length issues, labour costs and capacities.[98]

Ecosampling of the wild progenitors and landraces of *S. bicolor* in each of its primary, secondary, and tertiary centres of diversity is needed.[99] Further collection and conservation of wild close relatives is needed.[100] Gaps in geographic coverage were noted for West Africa, Central America, Central Asia and the Caucasus, and Sudan in Darfur and the south.[101]

Safety duplication

The status of safety duplication varies greatly from collection to collection. Only nine of the collections are stored under long-term storage conditions (or close to it) and only eight are backed up under secure conditions.[102] ICRISAT has proposed to duplicate its entire sorghum collection of about 38 000 accessions for deposit at the SGSV and so far has sent 13 000 accessions.[103]

Documentation, characterization and evaluation

While passport data are available for most accessions, the nomenclature used varies greatly among institutions making it difficult to target duplicates. Characterization data are documented electronically at a reasonable level, but evaluation data are lacking.[104] Most data are not accessible through the internet.[105]

Utilization

Germplasm exchange and thus utilization is limited. Additional constraints on utilization are lack of useful trait information about accessions, decline in breeding programs, insufficient seed availability, and poor communication between breeders and conservers.[106]

Core and mini-core collections based on sampling the available genetic diversity have been developed and used to identify trait-specific accessions resistant to biotic stresses.[107]

The two primary collections have distributed most. The main recipients from the USDA have been public sector breeders, while from ICRISAT, recipients have been in-house research scientists (focus on crop improvement).[108]

Role of crop in sustainable production systems

As demand increases for more reliable food and feed sources from environments challenged by water shortage and high temperatures, sorghum will play a more prominent role due to its wide adaptation and diverse uses.[109]

A4.2.5 State of cassava genetic resources

From 1996 to 2008, the yield of cassava showed a net increase of 2.7 tonnes/ha (Figure A4.2). In 2008, cassava (*Manihot esculenta*) was grown over a harvested area of 19 million hectares with a global production of 233 million tonnes.[110] Cassava is essential to food security in most regions of Africa. In 2008, almost 51 percent of global production was from Africa and the five highest producers of cassava were Nigeria (19 percent of global production), Thailand (12 percent), Brazil (11 percent), Indonesia (9 percent), and the Democratic Republic of Congo (6 percent).

The genepool consists of the cultivated *M. esculenta* and 70 to 100 wild *Manihot* species, depending on the taxonomic classification. Landraces, however, have been and will continue to be the primary sources of genes and gene combinations for new varieties. The wild species offer interesting traits (i.e. tolerance to post-harvest physiological deterioration, high protein content in the roots, resistance to pests and diseases), but are challenging to use and conserve.[111] The genus *Manihot* is native to the Americas, and most of the genetic diversification occurred there. Both Asia and Africa are important secondary centres of genetic diversity.[112]

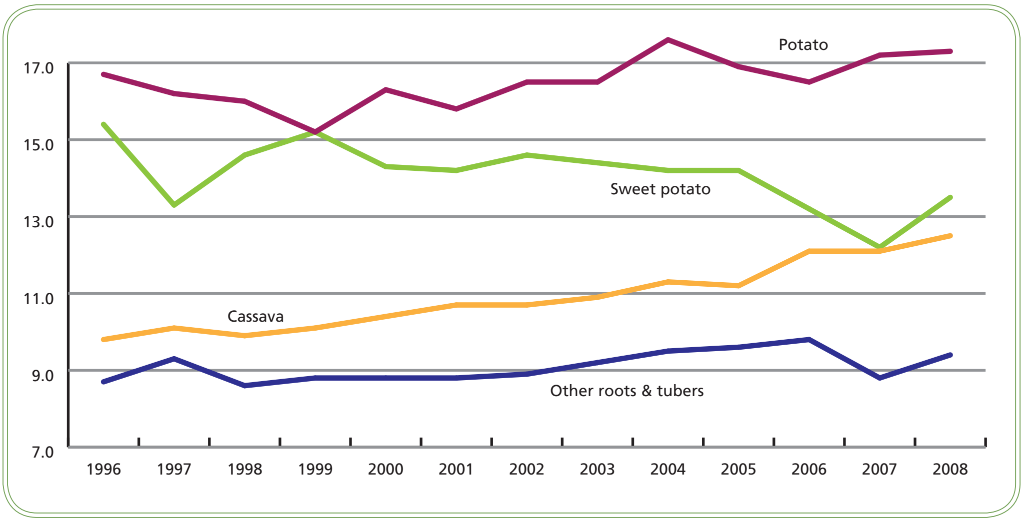
The primary genepool consists of the cultivars themselves and species known to cross readily with cassava and yield fertile offspring: *M. flabellifolia* and *M. peruviana*, native to South America.[113] Taxa crossing with difficulty with cassava but giving some positive results make up the secondary genepool, including *M. glaziovii*, *M. dichotoma*, *M. pringlei*, *M. aesculifolia* and *M. pilosa*.[114]

In situ conservation status

Despite long-standing proposals to create *in situ* reserves for wild *Manihot* species, this has not been realized.[115]

APPENDIX 4

FIGURE A4.2
Global yields of root and tuber crops (tonnes per hectare)



Source: FAOSTAT 1996/2008

Ex situ conservation status

The primary conservation strategy is field collections, *in vitro* collections are employed to a lesser extent, followed by cryopreservation.[116] Seed storage as a method for germplasm conservation has received limited attention, but shows promise as a means of preserving genes and especially for many wild species which are difficult to maintain by the alternative methods and are seed propagated in the wild. Cassava seeds are apparently orthodox in behavior and therefore can be stored under conventional conditions of low humidity and low temperatures.[117] CIAT has recently initiated a process to generate botanical seed through self-pollination of accessions in the cassava collection. The genotype of the accession is lost but its genes are preserved in the seeds produced.[118]

Most cassava-growing countries have established a genebank of local landraces. Nearly all rely primarily on field-grown plants, but may have part of their collection under *in vitro* propagation as well. Two international centres, CIAT and IITA, maintain regional collections for the Americas and Asia (CIAT) and for Africa (IITA). Overall, there are more than 32 000 accessions of cassava stored *ex situ*. Of these, 32 percent are estimated to be landraces.[119] According to a GCDT study, in order to represent the complete genetic diversity of the species, additional collecting should be carried out; priority countries for collecting the additional landraces are the Plurinational State of Bolivia, Brazil, Colombia, the Democratic Republic of the Congo, Haiti, Mozambique, Nicaragua, Peru, Uganda, the United Republic of Tanzania and the Bolivarian Republic of Venezuela.[120]

Gaps and priorities

Field collections are not in good shape and there are backlogs within *in vitro* collections due to funding shortages. High maintenance of conservation and relatively short regeneration intervals are key bottlenecks.[121]

Wild *Manihot* species are poorly represented in *ex situ* collections, both by species (only about one-third of the species in the genus) and by populations. Funding is a constraint. Further collecting is needed, some species are at risk from expanding agriculture and habitat loss.[122] Only EMBRAPA, Universidade de Brasilia (Nagib Nassar) and CIAT have a serious program for long-term conservation of wild *Manihot*.[123] The habitats of many populations are threatened by urbanization and expanding agriculture, especially in central Brazil. Effective collection and conservation are also compromised by the deficiencies in knowledge of taxonomy and phylogeny. Their *ex situ* conservation is difficult and needs intensive research to establish efficient and secure genebanks.[124]

Safety duplication

Safe duplication is not complete.[125]

Documentation, characterization and evaluation

Little documentation is available in national collections. A global database is an urgent priority.[126]

Utilization

Few countries engage in international exchange of cassava germplasm on a regular basis.[127] Major constraints to utilization is lack of accession information and difficulty of exchange.[128]

Efforts needed to enhance utilization include disease indexing of accessions, development of better protocols for seed and *in vitro* conservation and cryoconservation, viability testing for pollen conservation, and improved seed germination protocols.[129] CIAT, jointly with IITA, has initiated a process to generate partially inbred genetic stocks as a source of desirable traits for facilitated exchange of germplasm.[130]

Indexing methods for viruses that are exclusive to each continent are available and these need to be refined and made broadly available to genebank managers and quarantine agencies.[131]

Role of crop in sustainable production systems

Cassava is one of the most efficient crops in biomass production. In comparison with many other crops, it excels, under sub-optimal conditions, and can withstand drought conditions.

Most cassava production is still based on landrace varieties, although this is changing quickly, especially in the past decade, and in selected countries like Brazil, Colombia, Nigeria, Thailand and Vietnam. Landraces are still used extensively in breeding programs as parents in crossing nurseries.[132]

A4.2.6 State of potato genetic resources

Since 1995, the yield of potato has been erratic from year to year, though showing an overall slight increase (see Fig. A4.2). Potato was cultivated in 2008 over a harvested area of 18 million hectares with a global production of 314 million tonnes.[133] The five highest producers in 2008 were China (18 percent of the global production), India (11 percent), the Russian Federation (9 percent), Ukraine and the United States of America (6 percent).[134] Potato is important to food security and income generation in the developing world. In 2005, global potato production originating in developing countries surpassed production levels in the developed world.[135]

The genepool can be divided into four types of germplasm: [136]

1. modern cultivars (and old varieties) of the common potato (*Solanum tuberosum* subsp. *tuberosum*), the most cultivated potato subspecies in the world;
2. native cultivars, including local potato cultivars occurring in the center of diversity (seven to 12 species depending on taxonomic treatment);
3. wild relatives, consisting of wild tuber-bearing species and a few nontuber-producing species, occurring in the center of diversity (180 to 200 species depending on taxonomic treatment);
4. other germplasm or research material; all types of genetic stocks e.g., interspecific hybrids, breeding clones, genetically enhanced stocks, etc.

In situ conservation status

Farmers in the crop's centre of origin and diversity, particularly in the Plurinational State of Bolivia and Peru, still maintain hundreds of native cultivars and thereby actively contribute to the ongoing *in situ* conservation and evolution of the cultivated potato.[137, 138, 139] A better understanding of effective strategies to support these farmers is urgently needed. Little is known about the *in situ* conservation status of wild potato species and efforts towards the conservation of important habitats of endemic species are, as yet, non-existent.

Ex situ conservation status

Globally, about 98,000 accessions can be found *ex situ*, 80 percent of which are maintained in 30 key collections.[140] Accessions are conserved as botanical seeds or vegetatively as tubers and *in vitro* plantlets. Latin American collections contain many native cultivars and wild relatives and the collections in Europe and North America contain modern cultivars and breeding materials, as well as wild relatives.[141]

Genetic erosion and vulnerability

One example of erosion: before modernization of agriculture, peasant farmers on the Island of Chiloé cultivated 800 to 1,000 varieties of potato, now one finds only about 270 varieties.[142] The cultivated Andean diploid species *Solanum phureja* is also reported to be vulnerable.[143, 144] A recent study on the effect of climate change predicts that 7 to 13 out of 108 wild potato species studied may become extinct.[145]

Gaps and priorities

In Chapter 3, it was summarized that the most useful genetic material has already been collected and there are currently few significant gaps. However, several Latin American collections are threatened by lack of funding and, if any of those were lost, it would result in important gaps in the overall coverage of the genepool in collections.

The limited regeneration capacity is a constraint in all collections, especially for wild accessions and native cultivars. Genetic drift is becoming an issue in wild species collections where individual species are represented by too few accessions.[146]

Critical functions for optimal conservation such as regeneration, documentation, storage, health control, and safety duplication are not adequately performed in a number of genebanks. Several genebanks in Latin America and Russia do not have (access to) sufficient experience or facilities to keep the potato germplasm healthy.[147]

The extent of new collecting of wild material and monitoring of the conservation status of localized vulnerable populations in the centre of diversity has been very limited in the past 10 years. Approximately 30 wild species are not yet represented in collections and may still need to be collected. In addition, for another 25 wild species, fewer than three accessions are present in the collections. In the Andean context, because on-farm conserved potato cultivars are vital for regional food security, confronting climate change and long-term conservation, there is a need to strengthen understanding of the dynamic *in situ* and *ex situ* conservation systems that support farmers' livelihoods.[148]

Safety duplication

There is not in sufficient detail on how many accessions of potato are currently safety duplicated.[149]

Documentation, characterization and evaluation

National collection databases are incomplete and not accessible. Efforts to document and characterize *in situ* collections of wild and cultivated species and their inherent infraspecific diversity are needed as a baseline for future research on genetic erosion, species loss, genetic drift and integrity.[150]

Utilization

Breeders prefer to use well-adapted germplasm of *Solanum tuberosum* subsp. *tuberosum*, the most common potato, or research material with interesting properties.[151] Exotic germplasm has been used to great advantage, though relatively little has been used in comparison with the great breadth of materials available.

The substantial amount of potato germplasm distributed to users indicates that germplasm is extensively used. There are, however, large differences in distribution between genebanks, ranging from 23 to 7 630 accessions per year.[152] Unfortunately, recipients or users do not consistently return information from their evaluation of the requested germplasm to the providing genebank.[153] The most serious constraint to utilization of collections is lack of information about accessions, especially characterization and evaluation data.[154] Increased attention is needed to ensure the return and collation of such data for the benefit of the providing genebanks and ultimately for the benefit of all users.[155]

The domestic public sector makes use of germplasm most frequently, but some genebanks provide large numbers of accessions to the private sector (breeding companies). In South America and Canada, farmers and NGOs intensively use the germplasm of the national genebanks. However, some genebanks distribute a substantial number of accessions to users abroad. NGOs and farmers use native cultivars and old varieties, often for crop production on-farm, and contribute to *in situ* conservation (regeneration, evaluation, and storage) of germplasm with this activity.[156]

A technological tool to enhance germplasm utilization would be test kits for protection against viruses to be made widely available.[157]

A4.2.7 State of sweet potato genetic resources

Since 1996, the yield of sweet potato has been very erratic from year to year, with an overall decreasing trend (see Fig. A4.2). In 2008, sweet potato (*Ipomoea batatas*) was cultivated over a harvested area of 8 million hectares with a global production of 110 million tonnes.[158] The highest producers of sweet potato in 2007 were China (77 percent of global production), Nigeria (3 percent), Uganda (2 percent), Indonesia (2 percent), and Viet Nam (1 percent).

The genus includes 600 to 700 species of which sweet potato is the only one cultivated. More than 50 percent are in the Americas. Sweet potato and 13 wild *Ipomoea* species closely related to sweet potato belong to the section *Batatas*; all of these, except *I. littoralis* are endemic to the Americas.[159]

Ex situ conservation status

Globally, 35 500 accessions of sweet potato genetic resources are conserved, 80 percent of which are in less than 30 collections.[160] These accessions include landraces, improved material, and wild *Ipomoea* species. The global collection maintained in CIP, Peru, includes accessions from 57 countries, with Peru and other South American and Caribbean countries (primary centres of sweet potato diversity) as the most important contributors.[161] However, collection activities in the last 10 years produced only 1 041 accessions; most were improved material, followed by landraces.[162]

Some 162 CWR species are conserved in five collections, as seed. Thirteen of these species are especially closely related and are the focus of conservation efforts.[163]

Gaps and priorities

Chapter 3 notes that for sweet potato, the important geographic as well as trait gaps in collections have already been identified.

There are regeneration backlogs for most collections with 50 to 100 percent of accessions in some collections needing urgent regeneration. For collections holding wild accessions, 20 to 100 percent of the taxa need urgent seed regeneration. Many collections lack the capacity for *in vitro* regeneration or greenhouse conditions.[164] Most collections showed drawbacks and constraints in functions like plant health, documentation, regeneration, and safety duplication.[165]

Documentation, characterization and evaluation

Half of the collections have computerized databases and only a few are internet accessible. Standardization is needed.[166]

Utilization

Optimization of conservation protocols would enhance utilization.[167]

APPENDIX 4

Role of crop in sustainable production systems

Sweet potato is a tropical perennial, cultivated as an annual in temperate climates; grown in more than 100 countries.[168]

A4.2.8 State of common bean genetic resources

Since 1996, the yield of common bean (*Phaseolus vulgaris*) has been essentially flat (Figure A4.3). Dry beans were grown over a harvested area of 28 million hectares with a global production of 20 million tonnes in 2008 (excluding production from intercropped fields).[169] The six highest producers are India (19 percent of global production), Brazil (17 percent), Myanmar (12 percent), the United States of America and Mexico (6 percent), and China (5 percent).

The common bean primary genepool consists of the cultivars and wild forms of *P. vulgaris*. The primary genepool has two distinct geographic components: the Andean zone and the MesoAmerican zone with domestication presumed to have occurred independently in each zone. The secondary genepool consists of *P. costaricensis*, *P. coccineus*, and *P. polyanthus*, crosses of each with common bean result in hybrid progeny without any special rescue efforts, but the progeny can be partially sterile and difficult from which to retrieve stable common bean phenotypes. The tertiary genepool consists of *P. acutifolius* and *P. parvifolius*, crosses of either with common bean need embryo rescue to produce progeny.[170, 171]

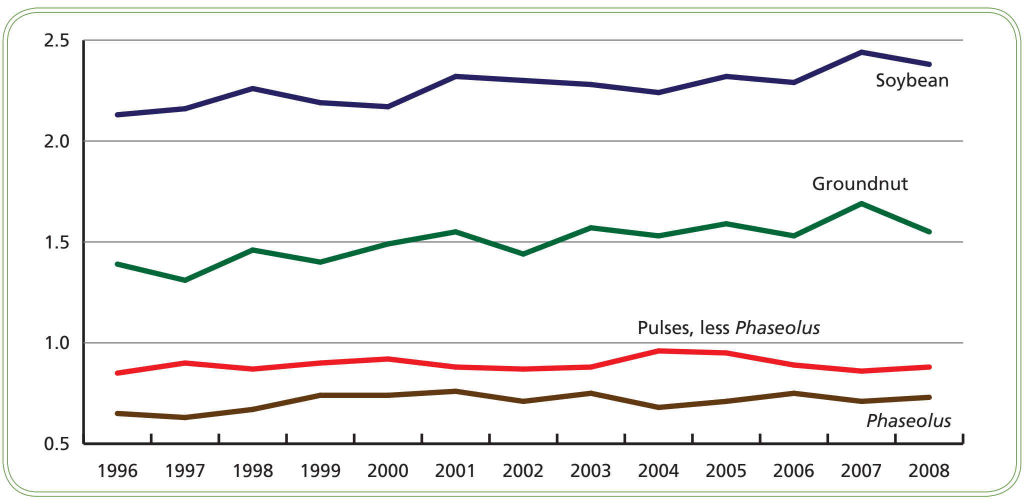
Ex situ conservation status

CIAT in Colombia is the primary global collection with some 14 percent of the world's approximately 262,000 genebank accessions of common bean.[172]

Genetic erosion and vulnerability

Genetic erosion is reported by several country reports for common bean and related taxa overall,[173] and, more specifically, cultivars have disappeared due to pathogen outbreaks,[174] eight years of recurring droughts,[175] and replacement by introduced varieties.[176]

FIGURE A4.3
Global yields of selected legume crops (tonnes per hectare)



Source: FAOSTAT 1996/2008

A4.2.9 State of soybean genetic resources

Since 1996, the yield of soybean (*Glycine max* (L.) Merrill) has varied up and down from year to year, but with an overall increase (Figure A4.3). Soybean was grown in 2008 over a harvested area of 97 million hectares with global production of 231 million tonnes.[177] The five largest producers of soybean in 2008 were the United States of America (35 percent of global production), Brazil (26 percent), Argentina (20 percent), China (7 percent), and India (4 percent).

The genus *Glycine* includes about 20 annual and perennial species distributed primarily in Australia and Asia. The primary genepool consists of the cultivated forms of *G. max*, the annual wild soybean, *G. soja* (considered the immediate ancestor of the cultivated soybean), and a weedy species *G. gracilis*, with its diversification centre in China, Korea, Japan, and the Far East region of the Russian Federation. The secondary genepool consists of the other wild species of *Glycine*, and the tertiary genepool is considered to be species in the legume tribe *Phaseoleae*.[178]

Ex situ conservation status

The ICGR-CAAS maintains the primary global collection with some 14 percent of the world's approximately 230,000 genebank accessions of soybean.[179] Soybean is not one of the crops covered under the ITPGRFA.[180]

Genetic erosion and vulnerability

The genetic base of soybean production has been shown to be narrow for regions such as the southern United States of America[181] and Brazil.[182] In China, many traditionally grown local landraces can only be found in genebanks today.[183]

Utilization

In 2005, the need for information about the extent and distribution of diversity within the Chinese landraces was stressed in the context of an effort to estimate the genetic variation within and among four Chinese provinces for which accessions were available in the USNPGR. RAPD markers were used with ten landraces from each of the four geographically divergent provinces. It was suggested that these markers could be useful in generating a core collection, but the uneven representation of some provinces in the United States of America genebank would mean under-representation of some geographic areas in any core collection assembled in the United States of America.[184]

The distribution of landraces in China itself and the substantial representation of them in the Chinese genebank presented an opportunity for assessment of population genetic structure in the primary genepool of soybean. An analysis for genetic diversity and genetic differentiation was carried out based on 59 SSR loci with 1 863 of the Chinese landraces. The goal was to derive information useful for effective management of the material in the genebank and to facilitate effective utilization of the landraces for soybean improvement. The SSR loci generated 1 160 alleles and identified seven clusters among the landraces. This high level of genetic diversity suggests the landraces will be important sources for soybean cultivar improvement. The rare alleles found were at loci that had high polymorphism and have potential for use in categorization of germplasm collections and as unique markers. Rareness in alleles at multiple loci in landraces of a given cluster suggests isolation of those from other landraces and further suggests they may harbour rare alleles for functional traits as well.[185]

A core collection has been assembled in China and used as a foundation for marker-assisted soybean breeding.[186]

A4.2.10 State of groundnut genetic resources

Since 1996, the yield of groundnut (*Arachis hypogaea*) has varied up and down from year to year, but with an overall increase (Figure A4.3). Groundnut was grown in 2008 over a harvested area of 25 million hectares with global production of 38 million tonnes.[187] The five largest producers of groundnut in 2008 were China (38 percent of global production), India (19 percent), Nigeria (10 percent), the United States of America (6 percent),

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and Myanmar (3 percent). Groundnut (also known as peanut) provides high quality edible oil (36 to 54 percent) and easily digestible protein (12 to 36 percent). It is an important crop, cultivated either as a grain legume or an oilseed in 113 countries.[188] Groundnut is an allotetraploid species ($2n = 4x = 40$) thought to have originated in the region of South America encompassing the southern regions of the Plurinational State of Bolivia and northwestern Argentina.[189] The genus *Arachis* comprises 80 species placed in nine sections. The section *Arachis* contains cultivated groundnut. Wild diploid *Arachis* species in South America are promising pest and disease resistance gene sources for groundnut breeding programmes.[190, 191]

In situ conservation status

Regeneration of groundnut wild relatives is problematic. Ideally conservation strategies for *in situ* conservation should be developed for wild taxa of groundnut.[192]

Ex situ conservation status

The largest groundnut collection is that at ICRISAT consisting of 15 419 accessions (12 percent of the world's 128 461 accessions). Other organizations holding considerable numbers of accessions include the USDA-ARS in the United States of America, the NBPGR in India, INTA in Argentina and the ICGR-CAAS in China.[193]

Genetic erosion and vulnerability

With the introduction of improved varieties, urbanization and natural calamities, many landraces and wild species are being eroded in different countries.[194] More specifically, geographic- and habitat-focused collecting and conservation strategies are needed for the A and B-genome diploid wild *Arachis* species in South America, where many are at risk of extinction and are not well represented in existing collections.[195]

Safety duplication

ICRISAT has proposed to duplicate its groundnut collection for deposit at the SGSV and so far has sent 4 550 accessions.[196]

Documentation, characterization and evaluation

Passport, characterization, inventory and distribution databases are being maintained for the largest groundnut collection.[197] About 97 percent of the cultivated accessions have been characterized for 50 morpho-agronomic characteristics.[198]

Utilization

Both core (10 percent of the entire collection) and mini-core (10 percent of core collection, 1 percent of entire collection) collections have been established at ICRISAT. The mini-core, comprising 184 accessions, serves as a gateway to the utilization of groundnut genetic resources in crop improvement programmes. Using the mini-core collection, trait-specific germplasm for resistance to drought, salinity and low temperature and for agronomic and seed quality traits has been identified.[199]

Role of crop in sustainable production systems

Over two-thirds of groundnut global production occurs in seasonally rainfed regions. Groundnut is suitable for different cropping patterns. Strategic evaluation of groundnut germplasm accessions combined with genetic enhancement will be important to increase food security, reduce poverty and protect the environment.[200]

A4.2.11 State of major sugar crop genetic resources

Sugarcane (*Saccharum officinarum*) and sugarbeet (*Beta vulgaris*) are the two primary species used for sugar production. The global yield of sugarcane, accounting for about 70 percent of produced sugar, has varied greatly since 1996 with a period of low yields in 2000 through 2003, but ending with a net increase (Figure A4.4). Sugarcane was cultivated in 2008 over a harvested area of 24 million hectares with a total global production of 1 743 million tonnes.[201] The six largest producers of sugarcane in 2008 were Brazil (37 percent of global production), India (20 percent), China (7 percent), Thailand (4 percent), and Pakistan and Mexico (3 percent each).

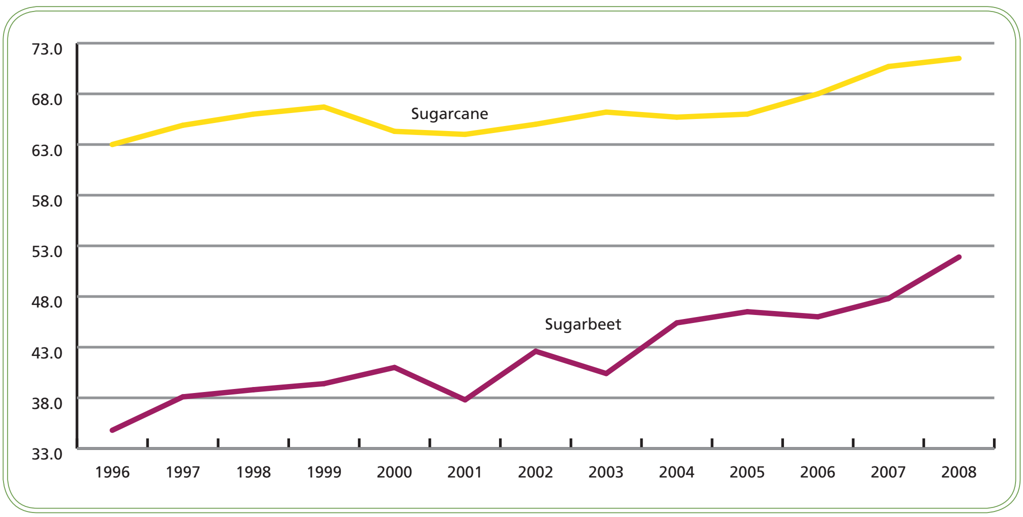
The cytotaxonomy and species relationships generating what today is the sugarcane crop plant are complex. The crop is of hybrid origin, the taxonomic status of the genus is not settled, and there may have been multiple domestication events.[202] Therefore the genepool definitions are also complicated. One presentation is that there are four species in genus *Saccharum*: *S. officinarum*, the 'type' cane of the genus, not known in the wild; *S. robustum*, the wild ancestor of *S. officinarum, S. spontaneum*, a more primitive wild ancestor than *S. robustum*; and *S. barberi*, with an unclear origin, one possibility is that it is of hybrid origin. Two separate origins for the domesticates are postulated: India and Papua New Guinea.[203] These four species would comprise the primary genepool of sugarcane and cultivars today are predominantly of hybrid origin from crosses between *S. officinarum* and one of the other species. In general, hybrid seedlings are more resistant to diseases and more adaptable to climate variables than is *S. officinarum*.[204]

A broader genepool is accessible, termed the *Saccharum* complex, and includes other genera now thought to be involved in the origin of sugarcane: *Erianthus*, *Ripidium*, *Sclerostachya*, *Narenga*, and possibly *Miscanthus*.[205] The wild species of *Saccharum* and the related genera *Erianthus* and *Miscanthus* have played important roles in the production of improved varieties of sugar cane. Their role in sugar-cane improvement will increase as breeders look into the production of high energy canes.

Sugarbeet production was not analyzed in the first SoW report, but the global yield of sugarbeet has also varied since 1995, with the perturbations coming in 2000 through 2003. There was a net increase in production by 2006 (Figure A4.4). Sugarbeet was cultivated in 2008 in a harvested area of 4.4 million hectares with a total global production of 227 million tonnes.[206] The five largest producers of sugarbeet in 2008 were France and the Russian Federation (each with 13 percent of global production), the United States of America (12 percent), Germany (10 percent), and Turkey (7 percent).

The genetic base of the sugarbeet crop (open pollinated) is considered narrow. The immediate

FIGURE A4.4
Global yields of sugar crops (tonnes per hectare)



Source: FAOSTAT 1996/2008

progenitor is the wild sea beet, a conspecific subspecies to the crop.[207] The primary genepool is the species in section *Beta* of genus *Beta*, in which the crop is also classified; two other of the four sections of the genus comprise the secondary genepool (*Corollinae* and *Nanae*), and the fourth section *Procumbentes* comprises the tertiary genepool.[208]

Ex situ conservation status

The Centro de Tecnologia Canavieira collection of sugarcane germplasm in Brazil is the largest global collection with 12 percent of the world's approximately 41 000 accessions; the Instituto Nacional de Investigación de la Caña de Azúcar in Cuba is second with 9 percent.[209]

The USDA collection of sugarbeet germplasm in the United States of America is the largest global collection with 11 percent of the world's approximately 22 500 accessions; the Genebank of the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany and Institute for Field and Vegetable Crops in Serbia are close seconds with 10 percent each.[210]

Genetic erosion and vulnerability

In Belgium there has been a reduction in sugarbeet varieties cultivated.[211]

A4.2.12 State of banana/plantain genetic resources

Since 1996, the yields of banana and plantain (species in genus *Musa*) have varied slightly, ending with net increases (Figure A4.5). Bananas and plantains were each grown in 2008 over harvested areas of 5 million hectares each, 10.2 million hectares in total, with a global production of 125 million tonnes (90 and 34 million tonnes, respectively).[212] The six largest producers of banana in 2008 were India (26 percent of global production), the Philippines (10 percent), China (9 percent), Brazil (8 percent), and Ecuador (7 percent). For plantain, the largest producers were Uganda (27 percent of global production), Colombia (10 percent), Ghana, Rwanda and Nigeria (8 percent each).

The genus *Musa* represents a group of approximately 25 forest-dwelling species, divided into four sections, distributed between India and the Pacific, as far north as Nepal and extending to the northern tip of Australia. The genus belongs to the family *Musaceae*, which also comprises some seven species of *Ensete* and possibly a third, monospecific, genus *Musella*, which is closely related to *Musa*. *Musa acuminata* subsp. *banksii* is believed to be the ancestral parent of the majority of edible banana cultivars, contributing what is called the 'A' genome while *Musa balbisiana* contributed the 'B' genome to several banana cultivar groups and all plantains. The largest portion of the genepool is in the form of 12 cultivar types or genome groups.[213]

A secondary region of diversity is in Africa where the crops were introduced some 3 000 years ago and radiated into more than 60 cooking types in the highlands of East Africa and 120 plantain types in West and Central Africa.[214] An additional group of edible bananas, known as Fe'I bananas, are confined to the Pacific. Their genetic origin is obscure, but taxonomic studies suggest ancestral links either with the wild species *Musa maclayi* or *M. lododensis*.[215]

Ex situ conservation status

About 13 000 accessions of *Musa* are reportedly conserved *ex situ*. Thirty-nine collections world-wide conserve more than 100 accessions each. Altogether they account for 77 percent of the total number of *Musa* accessions conserved *ex situ*.[216]

Wild species offer potential for genetic diversity for such traits as resistance to abiotic stresses and tolerance to cold, water logging, and drought.[217] CWR currently account for 7 percent of the global collection.[218]

The vast majority of the 60 or so *Musa*-dedicated national collections manage the majority of their accessions as full-sized plants in field collections. As part of a GCDT study, twenty-five field collections were surveyed and reported to hold slightly more than 6000 accessions in total. Of these institutions, 15 hosted *in vitro* collections containing slightly more than 2 000 accessions. In addition, the INIBAP Transit Center (ITC) holds an additional 1 176 accessions *in vitro*. The *in vitro* collections are used for safety duplication of the field collections and for rapid multiplication and dissemination of disease-free planting material. About 13 national collections also have international recognition and several contribute to the long-term conservation goals of the ITC global collection.[219]

Two cryopreservation protocols are available for a range of banana cultivar groups and the ITC is implementing a program for cryopreserving its entire collection as a more cost-effective alternative for backup.[220]

Genetic erosion and vulnerability

A large proportion of national collections of banana is deteriorating due to management limitations.[221] Hurricane impacts in Grenada have resulted in severe losses to banana production, which is one of the top three major traditional crops.

Gaps and priorities

It is reported in Chapter 3 that one of the best estimates of genepool coverage is available for banana and plantain. About 300 to 400 key cultivars are known to be missing from the ITC including 20 plantains from Africa, 50 *Callimusa* from Borneo, 20 to 30 *M. balbisiana* and 20 other types from India and China, 10 accessions from Myanmar, 40 wild types from Thailand and Indonesia, and up to 100 wild types from the Pacific.

Wild species account for about 7 percent of the collections and improved varieties amount to about 19 percent.[222] New wild species and varieties continue to be described and are inadequately represented in collections. Threats posed by habitat destruction and the replacement or loss of traditional cultivars intensify the urgency for collection and conservation efforts. There is a need for larger quantities of virus-indexed material within regions.[223]

Safety duplication

Field collections are safety duplicated with *in vitro* collections.[224]

Utilization

Better descriptor and characterization information is a priority to facilitate use of banana germplasm. In addition, development and implementation of cryopreservation of protocols for banana accessions would make them more available for use.[225] While diversity is demanded by researchers and growers, many national collections and large parts of major collections are underutilized. For example, 70 percent of the ITC collection have not been requested and remain unused. A partial reason is inadequate documentation of holdings.[226]

Most national collections regularly or occasionally exchange germplasm with the ITC and since its establishment the ITC has distributed more than 60 000 germplasm samples of 450 accessions to 88 countries. Accessions are supplied without fee, but a maximum of only five plants is made available per accession. Some national and regional collections also distribute to international users. Most national collections are directly associated with breeding initiatives and many provide material directly to farmers.[227]

A4.3 State of diversity of minor crops

A4.3.1 State of millet genetic resources

Since 1996, the yield of millets has increased only slightly (Figure A4.1). Millets were grown over a harvested area of 35 million hectares with a global production of 33 million tonnes (2008).[228] They are often dual-purpose crops (human consumption and animal feed) and are important staple foods in Africa and India. The highest producers in 2008 were India (32 percent of global production), Nigeria (25 percent), Niger (11 percent), China (5 percent), Burkina Faso (4 percent), and Mali (3 percent).[229] Millets include the major millet, pearl millet (*Pennisetum* spp.), and minor millets such as finger millet (*Eleusine coracana*), Japanese barnyard millet (*Echinochloa frumentacea*), common or proso millet (*Panicum miliaceum*), and foxtail millet (*Setaria italica*).

Ex situ conservation status

The primary global collection of pearl millet is at ICRISAT with 33 percent of the world's approximately 65 400 genebank accessions.[230] The ICGR-CAAS in China maintains 56 percent of the world's approximately 46 600 accessions of *Setaria*. The Indian National Bureau for Plant Genetic Resources maintains the largest *Eleusine* collection with 27 percent of the world's approximately 35,400 accessions. The National Institute of Agrobiological Sciences in Japan maintains the largest *Panicum* collection with 33 percent of the world's approximately 17 600 genebank accessions. ICRISAT conserves 10 193 accessions of the six small millet species.[231]

Genetic erosion and vulnerability

A number of studies and reports call attention to reduction in diversity of farmers' varieties and landraces in cultivation: traditional pearl millet varieties in Niger decreased as improved varieties were adopted by farmers;[232] absence of an early warning system threatens the diversity of indigenous cultivation of millets;[233] comparison of the number of landraces of finger millet found now in cultivation compared with that from 10 years ago showed serious genetic erosion had occurred;[234] there has been a gradual disappearance of landraces of native cultivated millets such as *Paspalum scrobiculatum*, *Setaria italica*, and *Panicum miliare*;[235] rice is replacing millet;[236] and high-yielding modern varieties of several millet species are replacing tradition varieties of those millets.[237]

Gaps and priorities

A total of 8 050 pearl millet accessions were conserved as a safety backup in the SGSV, Norway and the remaining accessions will be transferred in the near future. ICRISAT has proposed to deposit the entire collection of small millet to the SGSV and to date has sent 6 400 accessions.

Safety duplication

A total of 8 050 pearl millet accessions were conserved as a safety backup in the SGSV, Norway and the remaining accessions will be transferred in the near future. ICRISAT has proposed to deposit the entire collection of small millet at the SGSV and to date has sent 6 400 accessions.[238]

Documentation, characterization and evaluation

Passport, characterization, inventory and distribution databases are being maintained for the pearl millet and small millets collections at ICRISAT.[239]

Utilization

In order to enhance the utilization of pearl millet germplasm, core[240] and mini-core collections have been developed. Due to the reduced size, the core and the mini-core sets have been evaluated and characterized precisely and useful trait-specific accessions have been identified for use in breeding programmes to develop cultivars with a broad genetic base. The core and mini-core collections of finger millet and foxtail millet[241] have been constituted at ICRISAT and trait-specific germplasm identified for early maturity, high yield, Fe (iron), Zn (zinc), Ca (calcium) and protein contents and for tolerance to drought and salinity.

A4.3.2 State of root and tuber crop genetic resources, other than cassava, potato and sweet potato

Since 1996, the yield of roots and tubers other than the aforementioned, treated separately, appeared to have increased through 2006; a drop in yield in 2007 was partially recovered the following year (Figure A4.2). Roots and tubers, other than cassava, potato, and sweet potato,[242] were grown in 2008 over a harvested area of 8 million hectares with global production of 72 million tonnes.[243] The seven largest producers in 2008 were Nigeria (with 56 percent of global production), Côte d'Ivoire (10 percent), Ghana and Ethiopia (each with 7 percent), and Benin, China and Cameroon (with 2 percent each).

Taro (*Colocasia esculenta*) and yam (species of *Dioscorea*) account for the bulk of this miscellany of roots and tubers. Others are ulluco (*Ullucus tuberosus*), yautia or new cocoyam (*Xanthosoma sagittifolium*), and giant swamp taro (*Cyrtosperma paeonifolius*) with regional importance in the Andes, West Africa, and Melanesia, respectively. Individually, these are all minor crops when considered on a global scale. Accordingly, research on diversity, basic biology, and species relationships has been minimal. Most is known for taro. There are two major genepools for taro: Southeast Asia and Southwest Pacific regions.[244]

Ex situ conservation status

Seed collections are not part of any aroid conservation strategies.[245] For **taro**, most collections are entirely field collections, with little use of *in vitro* conservation, and these suffer from losses, especially due to diseases. Many have been lost over the years. The primary risk is the high cost of maintenance and various biotic and abiotic stresses.[246]

Taro collections have been assembled in many countries in the Pacific and Southeast Asia as part of the TaroGen and Taro Network for Southeast Asia and Oceania (TANSAO) projects, respectively. From the 2 300 TANSAO accessions (complete with passport and characterization data), a core collection of 168 was selected based on morphological and DNA data as representative of the diversity found in the region.[247] TaroGen has done similar work in the Pacific and the regional core collection is conserved *in vitro* at the Centre for Pacific Crops and Trees at the Secretariat of the Pacific Community, Fiji.

There are also taro collections in China and India and they are characterized morphologically but no molecular information is available and no core collections from them have been established.[248]

Worldwide taro *ex situ* holdings reportedly account for a total of about 7 300 accessions.[249]

Genetic erosion and vulnerability

Both the number of farmers' varieties and wild species of taro have decreased globally in the last ten years and disease threats and replacement in production by sweet potato (in the Pacific) are among the causes in reduction in diversity of global taro cultivation.[250] Similarly at national levels, other reductions in diversity are reported: Wild yam species are considered likely to disappear soon.[251] Erosion of yam diversity is occurring both from traditional areas of cultivation and from the wild.[252] The indigenous diversity of cocoyam is under threat, in the absence of an early warning system to assess genetic erosion.[253] The market chain for some crops (e.g., species of *Colocasia* and *Xanthosoma*) is still poorly developed, and undervaluing of local crop varieties has partly contributed to the loss in diversity in such crops.[254] A study in several regions of Peru indicates that genetic erosion is ongoing in the crop species oca, ulluco, and mashua, as well as in some related wild species.[255] There is genetic erosion in yam species other than *Dioscorea alata* and cassava, attributed to acculturation, industrialization, and deforestation.[256] In its country report, Papua New Guinea claims that all root crops are threatened by replacement by rice cultivation and loss of traditional beliefs. Specifically, taro is threatened by the taro beetle, yam by labour shortages and replacement by introduced African yam, and taro kongkong by root rot disease.[257] Weather catastrophes can play a role in cultivar loss. Prior to Hurricane Ivan in 2004, the island of Grenada was self sufficient in root and tuber crop production, which has severely decreased since then.[258]

Gaps and priorities

Further collection of CWR is needed. There are gaps in collections for taro wild species representation, especially for wild taro and giant swamp taro.[259]

Many sources point out the need for funding and organization of networks for the many root and tuber crops to ensure cost effective and efficient study and conservation of these diverse taxa, especially as some (e.g. taro) are not covered by any CGIAR centre.

Safety duplication

There is a core collection of taro, that is well duplicated. The only collection of giant swamp taro is a field collection and needs duplication (preferably *in vitro*).[260]

Documentation, characterization and evaluation

Major international germplasm databases do not include edible aroids and where there is existing information it is often out of date.[261]

Utilization

The low use of taro and other aroid collections has led to vulnerability of those collections. Better coordination between improvement programmes and collections is needed. Cryopreservation protocols for taro would enhance germplasm availability.[262] The taro collections of most countries are not being used in improvement programs, adding to their vulnerability due to the high costs involved in their upkeep. Only in India, Papua New Guinea, and Vanuatu are taro collections part of crop improvement programmes.[263]

There is considerable research interest in CWR of several root and tuber crops due to their high allelic diversity. Markers to allow MAS are priorities.[264]

All the countries with major collections distribute taro germplasm within the country, albeit a modest amount, but none outside, except for Vanuatu and the Secretariat of the CePaCT in Fiji. Researchers, including breeders, are the most common recipients, rather than farmers and extension personnel. There is an indication from most countries that the amount of germplasm distributed is on the increase.[265] More attention to seed would facilitate use of collections, including directly by farmers.

Role of crop in sustainable production systems

In all countries where it is grown, **taro** plays an important role in food and nutritional security. It has a value for sustainable agriculture in midland and upland areas of the Philippines and Viet Nam. In addition to being an important food crop with high cultural value, taro is also a cash crop.[266]

Giant swamp taro plays an important role in food and nutritional security in Melanesia and the Federated States of Micronesia.[267]

For some crops (e.g., *Colocasia* spp. and *Xanthosoma* spp.) niche markets exist that can be strengthened, providing a source of income for vulnerable groups such as women.[268]

A4.3.3 State of pulse crop genetic resources, other than *Phaseolus*

Since 1996, the yield of pulses other than *Phaseolus* species was rather stable over the years (Figure A4.3). Pulses,[269] not counting *Phaseolus* species, were grown in 2008 over a harvested area of 46 million hectares with global production of 41 million tonnes.[270] The ten largest producers in 2008 were India (with 28 percent of global production), Canada (12 percent), Nigeria (7 percent), China (6 percent), the Russian Federation, Ethiopia and Australia (4 percent each), and, Niger, Turkey, and Myanmar (with 3 percent each).

Lentil (*Lens culinaris*), is one of the founding crops of agriculture, domesticated at about the same time as wheat and barley in the Fertile Crescent, from today's Jordan northward to Turkey and southeast to the Islamic Republic of Iran. A substantial portion of global lentil production is still concentrated in this area. However, the largest producers of lentils are India and Canada. The progenitor of lentil is identified as the wild subspecies *L. culinaris* subsp. *orientalis*, which looks like a miniature cultivated lentil and bears pods that burst open immediately after maturation. Selection by early farmers around 7000 BC led to the cultivated species with nondehiscent pods and nondormant seeds, more erect habit, and a considerable increase in seed size and variety in color. The crop has developed into a range of varieties adapted to diverse growing areas and cultural preferences, and containing unique nutritional compositions, colors, shapes, and tastes.[271]

Taxa contained within *L. culinaris* comprise the primary genepool for lentil. The three other species in the genus constitute the secondary-tertiary genepool. All four species are diploid (2n=14), annual, and self pollinating with a low outcrossing frequency.[272]

The genus *Cicer* comprises 42 wild species and one cultivated species, chickpea or garbanzo (*Cicer arietinum*). Chickpea is a crop of relatively minor importance on the world market, but is extremely important to local trade in numerous regions within the tropics and subtropics. Populations of what were botanically classified as a species distinct from *C. arietinum* were found by botanists in southeast Turkey and named *C. reticulatum*. However, they are cross fertile with and morphologically similar to domesticated chickpea and possibly represent wild forms of the crop species. This would suggest that chickpea was domesticated in present-day Turkey or in the northern parts of Iraq or the Syrian Arab Republic.[273]

The primary genepool for chickpea consists of varieties, landraces, *C. reticulatum*, and *C. chinospermum*. One of the species in the secondary genepool is *C. bijugum* and it is considered a priority for collection.[274]

Vicia is a large genus of 140 to 190 species, chiefly located in Europe, Asia, and North America, extending to temperate South America and tropical East Africa. Primary diversity for the genus is centered in the Near East and Middle East, with a large percentage of the species occurring in the Irano-Tauranian floristic region. Approximately 34 of the species have been utilized by humans. *V. faba* (faba bean) is cultivated primarily for its edible seeds, while a number of other species (*V. sativa*, *V. ervilia*, *V. articulata*, *V. narbonensis*, *V. villosa*, *V. benghalensis*, and *V. pannonica*.) are cultivated as a forage or grain legume for livestock, or for soil improvement.[275]

The wild progenitor and the exact origin of faba bean are unknown. In practice, a continuous variation in *V. faba* for most morphological and chemical traits has been observed, making discrete differentiation of varieties challenging.[276]

The grasspea genus *Lathyrus* comprises approximately 160 species, primarily native to temperate regions of the world, with approximately 52 species originating in Europe, 30 in North America, 78 in Asia, 24 in tropical East Africa, and 24 in temperate South America. Five *Lathyrus* species are grown as a pulse - i.e. that are harvested as a dry seed for human consumption: *L. sativus*, *L. cicera*, *L. ochrus* and, to a lesser extent, *L. clymenum*. Another species that is occasionally grown for human consumption, but for its edible tubers rather than its seed, is *L. tuberosus*, known as the tuberous pea or earthnut pea.[277]

Pigeonpea (*Cajanus cajan*), originated in India and is a major grain legume crop of the tropics and subtropics grown in about 87 countries lying between 30°N and 30°S latitudes accounting for 4.89 million harvested hectares in 2008.[278] It has wide adaptability to diverse climates and is mainly grown for its multiple uses. India is the largest producer (75 percent of total production in 2008).[279] Pigeonpea is the only cultivated species in the genus *Cajanus* and the other 31 species are wild. *Cajanus cajanifolius* is considered the progenitor of the cultivated pigeonpea species.

In situ conservation status

While perennial *Cicer* species should be collected before they are extirpated, their regeneration is problematic. Ideally conservation strategies for *in situ* conservation should be developed for these taxa.[280]

As reported in the GCDT's *Vicia faba* conservation strategy the creation of *in situ* conservation measures have been recommended for members of *Vicia* subgenus *Vicia* in the Eastern Mediterranean region, specifically, Lebanon, the Islamic Republic of Iran, Iraq, Israel, the Syrian Arab Republic, Turkey and the Caucasian Republics, with targeted sites encompassing the distinct ecogeographic preferences of individual taxa. The species within the subgenus most seriously threatened by extinction were shown to be restricted to Israel, Lebanon, the Syrian Arab Republic and Turkey; the highest concentration of potentially threatened taxa are located in the Syrian Arab Republic.[281]

Ex situ conservation status

The lentil collection at ICARDA is the single international collection and it is also the largest lentil germplasm collection holding 19 percent of the total world collections (58 405 accessions).[282] There are 43 other national collections conserving more than 100 accessions each.[283] The bulk of the accessions of most of these collections are landraces which were collected in more than 70 countries.[284]

Similarly, the faba bean collection at ICARDA is the single international collection and it is also the largest faba bean germplasm collection holding 21 percent of the total world collections (43 695 accessions).[285] There are 53 other national collections, each maintaining more than 100 accessions.[286] The bulk of the accessions of most of these collections are landraces originating from more than 80 countries.[287]

The two global chickpea collections (ICRISAT and ICARDA) hold about 33 percent of the total world collections (98 313 accessions). There are 48 other national collections with more than 100 accessions each. The bulk of the accessions of most of these collections are landraces from more than 75 countries.[288] Although the holdings of the wild species of *Cicer* are small compared to the cultivated species *C. arietinum*,[289] they are potentially very important for research and crop improvement

The grasspea collection at ICARDA is the single international collection and the second largest grasspea germplasm collection holding 12 percent of the total world collections (26 066 accessions) which are comprised of few large collections and several small but key collections, having a high proportion of indigenous accessions.[290] The collection maintained in France is the largest. There are about 62 other national collections whose number of accessions is greater than 50; landraces and wild materials comprise the bulk of the accessions which originate from about 90 countries.[291]

The majority of chickpea, grasspea, faba bean, and lentil collections reported that they have long-term storage conditions available, however, there is no guarantee that uniform criteria were used or understood to define 'long-term' by each reporting collection. Similarly the assessments of needs for regeneration are not necessarily reported by each collection using standard protocols and seed viability measures. It is probable that for many collections, long-term storage security, regeneration, and multiplication represent major constraints for security of accessions, especially for perennial, wild, and out-crossing accessions.[292, 293, 294, 295]

Genetic erosion and vulnerability

Country reports documented a wide variety of concerns and measures of loss or reduction in genotypes of many pulse crops:

- there is genetic erosion for *Hedysarum humile*, chickpea, pea, lupin, and lentil; for wild, endemic taxa attention is not paid to diverse biotypes;[296]
- the indigenous diversity of bambara groundnut is under threat in the absence of an early warning system to assess genetic erosion;[297]
- comprehensive studies on cowpea were conducted to quantify the level of genetic erosion. As judged by the number of landraces found in cultivation today compared with that found 10 years ago, serious genetic erosion has occurred; [298]
- food legumes are at risk because of drought, increased use of new commercial varieties, and some crop-specific pests and pathogens;[299]
- in Zimbabwe, recurrent droughts, most notably the 2002 cropping season, and flooding induced by cyclones have resulted in substantial loss of *in situ* plant diversity. Disaster recovery programmes led by the Government, have, in most cases, focused on providing chiefly hybrid seed of cowpea, beans, and groundnuts, and fertilizers. There are no records of attempts to restore the landraces and other plant genetic diversity of the affected areas, which suggests that lost material was not recovered;[300]
- In Nepal, there is gradual disappearance of landraces of cowpea and of native cultivated species such as *Vigna angularis* and *Lathyrus sativus*;[301]
- various local races/cultivars of chickpea, lentil, mung, and mash were observed to be lost in recent years from farmer's fields;[302]
- there is genetic erosion in mungbean, yardlong bean, and cowpea.[303]

Gaps and priorities

For **lentil**, landraces from Morocco and China and wild species, particularly from southwest Turkey, are not well represented in collections. There are gaps in **chickpea** collections from Central Asia and Ethiopia and there are relatively few accessions of wild relatives, particularly from the secondary genepool. For **faba bean** various geographic gaps have been identified including local varieties and landraces from North Africa, the Egyptian oases, South America and China. The small-seeded subspecies, *V. faba* subsp. *paucijuga*, is also under-represented in collections and there are trait gaps, especially for heat tolerance. Geographic gaps for **grasspea** include the Russian Black Sea coast and Volga-Kama region, the Kurdish area of Iraq, Northeast and Eastern India, high altitude areas of Ethiopia, Northeast and Central Afghanistan, and the Andalucia and Murcia regions of Spain. An important consideration for many legume collections is the need to collect and maintain samples of rhizobia. This is especially the case for wild legume species, but such rhizobia collections are rare (see also Chapter 3).[304, 305, 306, 307]

There are regeneration needs for chickpea, grasspea, lentil, and wild species of pigeonpea.[308]

Landraces of lentil in Morocco and in China are potentially undersampled and hence under-represented in germplasm collections.[309]

Landraces of chickpea from the Hindu-Khush Himalayan region, west and northern China, Ethiopia, Uzbekistan, Armenia, and Georgia are under-represented in collections. The world collection covers very little of the wild distribution for the *Cicer* genus, thus the accessions in *ex situ* collections represent only a fraction of the potential diversity available in wild populations.[310]

Species related to chickpea and lentil are greatly undersampled geographically in collections. Species related to grasspea are poorly known and both grasspea and pigeonpea CWR are not well collected.[311]

Research into regeneration and conservation protocols for wild chickpea and lentil species is a high priority.[312, 313]

Safety duplication

It is apparent that many important lentil, faba bean, chickpea, grasspea collections are inadequately duplicated and are thus at risk. Safety duplication requires a formal arrangement. The fact that an accession is present in another collection does not immediately signify that the accession is safety duplicated in long-term conservation conditions. At a minimum all unique materials should be duplicated for safety reasons, preferably in a second country. Depositions of safety backup samples with the SGSV is underway, especially by the global collections (e.g., those at ICARDA and ICRISAT).[314, 315, 316, 317] For example, ICRISAT has already deposited 5 000 of its 13 289 pigeonpea accessions with the SGSV.[318]

Documentation, characterization and evaluation

Some chickpea and lentil databases are not yet internet accessible, a global registry for each and documentation training are needed. Only a minority of grasspea databases are internet accessible, but there is a *Lathyrus* global information system managed by Bioversity and ICARDA which is available.[319]

Many chickpea and lentil accessions are not yet characterized or evaluated and little of the data that are available is electronically accessible.[320, 321]

Information currently held on *Vicia faba* accessions in collections is often fragmented and not easily accessible outside the institution. Genebank information systems generally need strengthening. Technical advice for information systems is needed.[322]

Utilization

Chickpea CWR have been sources of resistance used in breeding programs. Lentil CWR have been used in breeding programs to broaden the genetic base and provide genes for tolerance and resistance. Pigeonpea CWR are sources of resistance and protein.[323]

Lentil, faba bean, and chickpea genetic resources are underutilized due to deficiencies in accession level data; suboptimal availability and accessibility of that data; lack of pre-breeding, core-collection creation, and other 'value-adding' work in genebanks; and few collaborative relationships with user communities.[324, 325, 326] However, a core collection (10 percent of the entire ICRISAT collection) and a mini-core collection (10 percent of the core collection) for chickpea[327] and a core collection and a mini-core collection for pigeonpea[328] have been established.

Almost all national collections of faba beans appear to be distributing almost entirely to domestic users.[329]

Higher and more stable yields are key breeding objectives for chickpea. Some of the wild relatives have been utilized in breeding programs and resistance to abiotic and biotic stresses have been incorporated into the crop from *Cicer reticulatum* and *C. echinospermum*, chickpea's closest relatives.[330]

Constraints in chickpea and lentil germplasm utilization are deficient data (and data access) about accessions, lack of pre-breeding, and collaborative relationships. Similarly, lack of accession information is a constraint for grasspea germplasm. For pigeonpea germplasm, constraints include inadequate accession data, difficulty in use of CWR, genetic contamination in collections, absence of pest and disease resistance traits, and poor interaction between breeders and collections' curators.[331]

There are relatively few efforts throughout the world to genetically improve grasspea. There are some important programs that aim to improve its yield, resistance to biotic and abiotic stresses and, most importantly, to reduce the percentage, or ideally eliminate, the neurotoxin from the seed. However, local landraces and cultivars are being lost as farmers switch to alternative crops, potentially limiting the progress that can be made through genetic enhancement.[332]

Role of crop in sustainable and organic production systems

Chickpea is grown and consumed in large quantities from South East Asia across the Indian sub-continent, and throughout the Middle East and Mediterranean countries, playing an important cultural as well as nutritional role. Over 95 percent of production and consumption of chickpea takes place in developing countries. The crop meets up to 80 percent of its nitrogen requirement from symbiotic nitrogen fixation and can fix up to 140 kg nitrogen per hectare per season from the air.[333]

Lentil plants provide a number of functions aside from being sources of human food. Lentil straw is an important fodder for small ruminants in the Middle East and North Africa, and through nitrogen sequestration, the plant improves soil fertility and therefore increases sustainability of agricultural production systems.[334]

Pigeonpea has wide adaptability to diverse climates and soils. About 92 percent of pigeonpea cultivation is in developing countries. Due to its multiple uses as food, fodder, fuelwood, hedges, windbreaks, soil binder and soil enricher. It is also used as green manure and for roof thatching and rearing lac insects in Malawi, the United Republic of Tanzania and Zambia in Africa. As it is also used in many cropping systems, it therefore plays an important role in sustainable production systems.[335]

Because of the extreme tolerance of grasspea to difficult environmental conditions, including both drought and water-logging, it often survives when other crops are decimated. However, in years when conditions are particularly harsh, human consumption of this survival food may increase, due to the lack of any suitable alternative, especially among the poorest rural people, to a level at which there is a severe risk of the consumer succumbing to a neurological disorder, lathyrism, caused by the presence of a neurotoxin in the seed. The toxicity results in irreversible paralysis, characterized by lack of strength in, or inability to move the lower limbs. It is particularly prevalent in some areas of Bangladesh, Ethiopia, India, and Nepal, and affects more men than women.[336]

Grasspea is important locally for the poorest of the poor in many of the harshest agro-environments, especially in South Asia and Ethiopia.[337]

A4.3.4 State of grape genetic resources

During 1996-2004 the yield of grapes (*Vitis*) increased, since then it has remained constant (Figure A4.5). Grapes were grown in 2008 over a harvested area of 7 million hectares with global production of 68 million tonnes.[338] The five largest producers of grapes in 2008 were Italy (12 percent of global production), China (11 percent), the United States of America and Spain (9 percent each) and France (8 percent).

In situ conservation status

Little information was available from the country reports on actual numbers of traditional varieties maintained in farmers' fields. Some 525 indigenous grape varieties are still being grown in the mountainous countryside and isolated villages in Georgia,[339] while in the Western Carpathians of Romania, more than 200 local landraces of crops have been identified.[340]

Ex situ conservation status

Approximately 59 600 accessions of *Vitis* are held in the world's genebanks. The six largest hold between nine and four percent of the total accessions each.[341] The project "Management and Conservation of Grapevine Genetic Resources", funded under the European Union Council Regulation (EC) No 870/2004", lasting four years (2007-2010), has the goal of promoting an optimized scheme for the safe conservation of *Vitis* germplasm, including *V. sylvestris* presently threatened with local extinction and involving several conservation means (*ex situ* collections, cryopreservation, on-farm conservation) so that the resources are conserved, made accessible and field-tested in a pertinent agricultural context.[342]

Field collections have been established for the 70 most important autochthonous grapevine cultivars in Portugal.[343] Field collections of local cultivars can also be found in Albania, Armenia, Azerbaijan, Bulgaria, Croatia, France, Georgia, Germany, Italy, Montenegro, Republic of Moldova, the Russian Federation, Serbia, The former Yugoslav Republic of Macedonia and Ukraine.[344] Conservation of grapevine genetic resources in the Caucasus and North Black Sea area has been promoted since 2003 under the coordination of IPGRI (now Bioversity International). New collections of local varieties have been established in Armenia, Azerbaijan, Georgia and the Russian Federation.[345]

Genetic erosion and vulnerability

Traditional grapevine varieties are still used. However the number of varieties used at a large scale has been substantially reduced.[346] The traditional grapevine crop is threatened by genetic erosion in Portugal.[347] The ECPGR Working Group on Vitis expressed serious concern for genetic erosion of the grapevine variability and clonal diversity. The causes of this erosion were listed as follows:[348]

- increased international trade;
- predominance of a small number of varieties in several countries;
- predominance of a few clones of each single variety;
- a decrease in the area of land devoted to viticulture, especially in those sites particularly rich in biodiversity;
- restrictive laws not allowing the use of traditional varieties for planting and marketing.

Recommendations were also expressed that each country should maintain its own traditional varieties in national or regional ampelographic collections and should also protect *V. sylvestris in situ*, as well as strive to preserve clonal variability as far as possible.

Documentation, characterization and evaluation

The European Vitis Database has been maintained since 2007 by the JKI and the Institute for Grapevine Breeding Geilweilerhof, Siebeldingen, Germany. The aim of the database is to enhance the utilization of relevant and highly valuable germplasm in breeding. The database contains passport data of more than 31 000 accessions representing 31 *Vitis* collections from 21 European countries. Characterization and evaluation data on phenology, yield, quality and biotic stresses are also available for about 1 500 accessions.[349]

Utilization

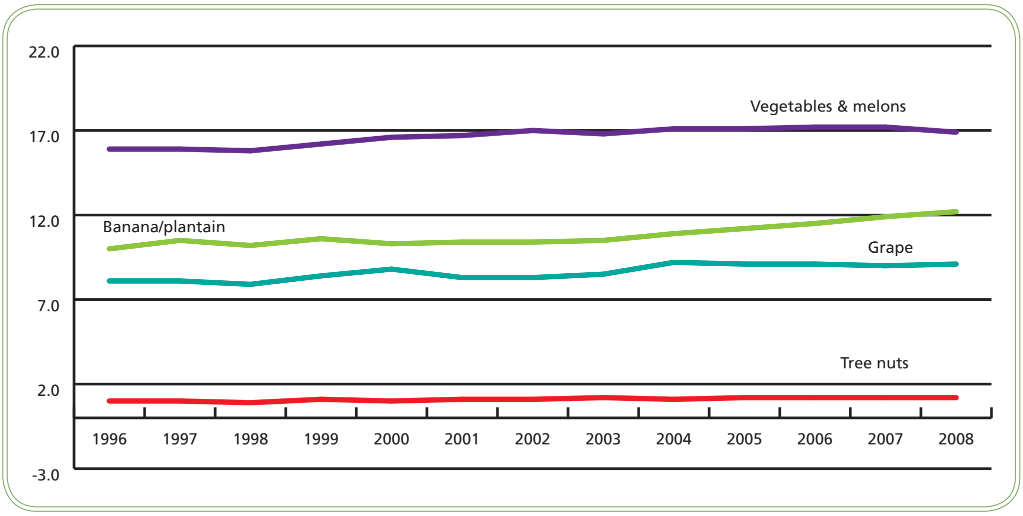
Efforts to enhance access to diversified grape genetic resources and to promote the improvement of varieties, tastes, products and brands also by limiting the impact of grape cultivation on the environment through a reduced use of pesticides, are being supported by the European Union-funded project GrapeGen06 (2007-2010). The project is being accomplished in collaboration with wine growers and professional organizations. It also supports characterization of grape genetic resources, some of which are today either forgotten, endangered or underexploited.[350]

A4.3.5 State of tree nut genetic resources

Since 1996, the yield of tree nuts has moderately grown (Figure A4.5).[351] Tree nuts were grown in 2008 over a harvested area of nine million hectares with global production of eleven million tonnes.[352] The six largest producers in 2008 were the United States of America (with 15 percent of global production), China (14 percent), Turkey and Viet Nam (11 percent), and India and Nigeria (6 percent each). China produced the most diverse assemblage of this large group of tree nuts with 6 out of 8 of them, the United States of America, Italy, and Turkey each produced 5, and the Islamic Republic of Iran and Pakistan each produced 4.

APPENDIX 4

FIGURE A4.5
Global yields of miscellaneous crops (tonnes per hectare)



Source: FAOSTAT 1996/2007

Ex situ conservation status

- Cashew nut (*Anacardium occidentale*): about 9 800 accessions are conserved in world genebanks, with 35 percent of the accessions maintained in Ghana, 9 percent in India, 8 percent in Thailand and about 6 percent in both Brazil and Nigeria;[353]
- Almond (under synonyms *Prunus amygdalus*, *P. dulcis* and *Amygdalus communis*): about 3 000 accessions are conserved in the world with the main collections in Italy, the Islamic Republic of Iran and Turkey;[354]
- Hazelnut (species of *Corylus*): about 3 000 accessions are conserved worldwide, 28 percent of which are held in the United States of America and 14 percent in Turkey;[355]
- Pistachio (*Pistacia vera*): about 1 200 accessions are in world collections, with 29 percent in the Islamic Republic of Iran and 26 percent in the United States of America;[356]
- Chestnut (*Castanea sativa*): about 1 600 accessions are conserved worldwide, 75 percent of which are in France, Japan, Italy and Spain;[357]
- Brazil nut (*Bertholletia excelsa*): only about 50 accessions are held in world genebanks, mostly in Brazil.[358]

Documentation, characterization and evaluation

The European Union-funded project GEN RES 68 for the Safeguard of hazelnut and almond genetic resources (SAFENUT) (2007–2010) ensures data acquisition of the genetic diversity present in the European Mediterranean Basin, *ex situ* and *in situ* collections of *Corylus avellana* and *Prunus dulci*, as well as characterization of interesting genotypes, with particular attention to the nutritional and nutriceutical aspects of nuts.[359] Documentation of European almond accessions was part of the European Union-funded project GEN RES 61 on *Prunus* (International Network on *Prunus* genetic resources [1996–1999]). A European *Prunus* Database (EPDB) was prepared including passport, characterization and evaluation data.[360]

Genetic erosion and vulnerability

Wild almond trees in Georgia are under threat due to the replacement by new varieties.[361]

In the Beka'a Valley in Lebanon, all commercial almond orchards consist of one or two early-blooming varieties, thus susceptible to spring frost, explaining the observed decrease in national almond production in certain years.[362]

A4.3.6 State of vegetable and melon genetic resources

The yield of vegetables and melons increased slightly during 1996-2002, since then it has remained relatively constant (Figure A4.5).[363] Vegetables and melons were grown in 2008 over a harvested area of 54 million hectares with a global production of 916 million tonnes.[364] The six largest producers in 2008 were China (50 percent of global production), India (9 percent), the United States of America (4 percent), Turkey (3 percent), and the Russian Federation and the Islamic Republic of Iran (2 percent each). China produced the most diverse assemblage of this large group of vegetables and melons with 24 out of 25 of them, the United States of America produced 23, Turkey, Spain, and Mexico produced 20 each, Japan produced 19, and Italy produced 18. The eight most produced vegetables in 2008 were tomatoes (under synonyms *Lycopersicon esculentum*, *Solanum lycopersicum*, etc.) accounting for 14 percent of total production within the vegetables and melons group, followed by watermelons (*Citrullus lanatus*) with 11 percent, cabbages and other brassicas (*Brassica* spp.) 8 percent, dry onions (*Allium* cepa) 7 percent, cucumbers and gherkins (*Cucumis sativus*) 5 percent, eggplants (*Solanum melongena*) 4 percent, and other melons including cantaloupes (*Cucumis* spp.) and peppers (*Capsicum* spp.) 3 percent each.

Ex situ conservation status

Approximately half a million accessions of vegetable crops are conserved *ex situ* worldwide.[365] Landraces and traditional and advanced cultivars represent about 36 percent of these total holdings, wild materials about 5 percent and genetic stocks 8 percent. AVRDC holds about 57 000 accessions of vegetable germplasm including some of the largest world vegetable collections. About 35 percent of total vegetable accessions are conserved in the national genebanks of nine countries.[366]

- Tomato: almost 84 000 accessions are conserved in genebanks worldwide, 19 percent of these are advanced cultivars, 17 percent old cultivars and landraces, 18 percent genetic stocks and research materials, and 4 percent CWR. The two largest tomato collections are at AVRDC (about 9 percent of the total world collections) and USDA Northeast Regional Plant Introduction Station (8 percent);[367]
- Pepper (*Capsicum* spp.): the global holdings of peppers account for about 73 500 accessions from more than 30 *Capsicum* species. The six largest *Capsicum* collections are at AVRDC (about 11 percent of the total world collections), the USDA Southern Regional Plant Introduction Station and INIFAP in Mexico (6 percent each), NBPGR in India (5 percent), the Instituto Agronómico de Campinas in Brazil and the National Institute of Agrobiological Sciences (NIAS) in Japan (3 percent each);[368]
- Cantaloupe (*Cucumis* spp.): about 44 300 accessions are conserved worldwide, 3 percent of these are wild relatives. *C. melo* is represented by 52 percent of the total accessions and *C. sativum* by 38 percent. The six largest collections are held in the United States of America, Japan, the Russian Federation, China, Brazil and Kazakhstan;[369]
- *Cucurbita* spp.: total accessions for this genus amount to 39 583, of these 9 867 accessions are *C. moschata*, 8 153 accessions are *C. pepo* and 5 761 accessions are *C. maxima*. The largest collections of this genus are found at VIR in the Russian Federation (15 percent of the total world collection), CATIE (7 percent) and CENARGEN in Brazil (5 percent). CWR are relatively poorly represented accounting for only 2 percent of the total *ex situ* germplasm of *Cucurbita*;[370]
- *Allium* spp.: about 30 000 accessions are conserved *ex situ*. Onions (*A. cepa*) are represented by 15 326 accessions and garlic (*A. sativum*) by 5 043 accessions. More than 200 additional *Allium* species

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are also conserved. CWR are well represented in the collections of the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany and of the Millennium Seed Bank Project, Royal Botanic Gardens in the United Kingdom;[371]

- Eggplant (*Solanum melongena*): total world collections amount to about 21 000 accessions. The three largest collections with more than 1 000 accessions each, are at NBPGR in India, AVRDC and NIAS in Japan; altogether they account for 35 percent of the total *ex situ* holdings. CWR represent 11 percent of the total accessions;[372]
- Watermelon (*Citrullus lanatus*): more than 15 000 accessions constitute the world collection, 42 percent of which is conserved in the Russian Federation, China, Israel and the United States of America;[373]
- Carrot (*Daucus carota*): about 8 300 accessions from 19 *Daucus* species are conserved worldwide. The three largest collections with more than 1 000 accessions each, are at the USDA North Central Regional Plant Introduction Station in the United States of America (14 percent of the total accessions), the Horticultural Research International, University of Warwick in the United Kingdom (13 percent), and at VIR in the Russian Federation (12 percent). CWR represent 14 percent of the total accessions.[374]

Genetic erosion and vulnerability

A diversity of countries reported instances of concern for diversity of several different vegetables:

- in Madagascar several vegetable crops (carrot, turnip, eggplant, onion, and cauliflower) are at risk from new commercial varieties (Madagascar Country Report);[375]
- in Trinidad and Tobago there is loss of diversity in vegetables crops;[376]
- in Nepal there is gradual disappearance of cabbage and cauliflower landraces;[377]
- in Pakistan, due to market demand and unavailability of local seeds, the rate of genetic erosion has been very high in major vegetables like tomatoes, onions, peas, okra, brinjal (eggplant), cauliflower, carrots, radish, and turnips. Indigenous diversity is still found in cucurbits, bitter gourd, spinach, luffa, and species of *Brassica*. The genetic resources of indigenous underutilized minor-crop species face rapid destruction owing to the erosion of traditional farming culture, change of traditional food habits, and the introduction of high yielding crops;[378]
- in the Philippines, there is genetic erosion in eggplant, bitter gourd, sponge gourd, bottle gourd, and tomato;[379]
- in Tajikistan, due to importing new varieties and hybrids and lack of seeds of local varieties, the rate of genetic erosion has been very high in major vegetables like cucumbers, tomatoes, onions, cabbage, carrots, radish, black radish, turnips, etc.;[380]
- in Greece genetic erosion in vegetable crops, due to the replacement of local germplasm by modern varieties, has been 15 to 20 years behind the rate in cereals, however, in recent years, local landraces are being rapidly displaced even from backyard gardens;[381]
- in Ireland, commercial horticultural production is dominated by imported modern high-yielding varieties, few or no landraces or farmers' varieties are grown. In contrast, great diversity in horticulture crops is found in the various private gardens around the nation in the form of home-saved seed.[382]

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231 **Rai, K.N.** Principal Scientist (Millet Breeding) and Director, HarvestPlus-India Biofortification, ICRISAT; personal communication 2009.

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235 Country report: Nepal.

236 Country report: Sri Lanka.

237 Country report: Yemen.

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242 Taro, yam, yautia, and roots and tubers not counted elsewhere.

243 Op cit. Endnote 28.

244 **GCDT.** 2007. Edible aroid conservation strategies [Draft]. Global Crop Diversity Trust. Rome, Italy.

245 Ibid.

246 Op cit. Endnote 23.

247 Op cit. Endnote 244.

248 Op cit. Endnote 244.

249 Op cit. Endnote 34.

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251 Country report: Madagascar.

[252] Country report: Kenya.

[253] Country report: Ghana.

[254] Country report: Uganda.

[255] Country report: Peru.

[256] Country report : Philippines.

[257] Country report: Papua New Guinea.

[258] Country report: Grenada.

[259] Op cit. Endnote 23.

[260] Op cit. Endnote 244.

[261] Op cit. Endnote 244.

[262] Op cit. Endnote 23.

[263] Op cit. Endnote 244.

[264] Op cit. Endnote 23.

[265] Op cit. Endnote 244.

[266] Op cit. Endnote 244.

[267] Op cit. Endnote 244.

[268] Country report: Uganda.

[269] Bambara bean, broad or horse bean, chickpea, cowpea, lentil, lupin, pea (dry), pigeonpea, vetch and other pulses not counted elsewhere.

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[271] **GCDT.** 2008. Global strategy for the *ex situ* conservation of lentil (*Lens* Miller). Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/web/LensStrategy_FINAL_3Dec08.pdf

[272] Op cit. Endnote 251.

[273] **GCDT.** 2008. Global strategy for the *ex situ* conservation of chickpea (*Cicer* L.). Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/web/CicerStrategy_FINAL_2Dec08.pdf

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[275] **GCDT.** 2009. Global strategy for the *ex situ* conservation of faba bean (*Vicia faba* L.). Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/web/Faba_Strategy_FINAL_21April09.pdf

[276] Ibid.

[277] **GCDT.** 2007. Strategy for the *ex situ* conservation of *Lathyrus* (grass pea), with special reference to *Lathyrus sativus, L. cicera, L. ochrus.* Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/web/Lathyrus-Strategy-FINAL-31Oct07.pdf

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[279] Op cit. Endnote 34.

[280] Op cit. Endnote 275.

[281] Op cit. Endnote 275.

[282] Op cit. Endnote 34.

[283] Op cit. Endnote 34.

[284] Op cit. Endnote 34.

[285] Op cit. Endnote 34.

[286] Op cit. Endnote 34.

[287] Op cit. Endnote 34.

[288] Op cit. Endnote 34.

[289] Op cit. Endnote 34.

[290] Op cit. Endnote 34.

APPENDIX 4

291 Op cit. Endnote 34.

292 Op cit. Endnote 271.

293 Op cit. Endnote 273.

294 Op cit. Endnote 275.

295 Op cit. Endnote 277.

296 Country report: Algeria.

297 Country report: Ghana.

298 Country report: Malawi.

299 Country report: Morocco.

300 Country report: Zimbabwe.

301 Country report: Nepal.

302 Country report: Pakisan.

303 Country report: Philippines.

304 Op cit. Endnote 271.

305 Op cit. Endnote 273.

306 Op cit. Endnote 275.

307 Op cit. Endnote 277.

308 Op cit. Endnote 23.

309 Op cit. Endnote 271.

310 Op cit. Endnote 273.

311 Op cit. Endnote 23.

312 Op cit. Endnote 273.

313 Op cit. Endnote 271.

314 Op cit. Endnote 271.

315 Op cit. Endnote 273.

316 Op cit. Endnote 275.

317 Op cit. Endnote 277.

318 Op cit. Endnote 196.

319 Op cit. Endnote 23.

320 Op cit. Endnote 273.

321 Op cit. Endnote 271.

322 Op cit. Endnote 275.

323 Op cit. Endnote 23.

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329 Op cit. Endnote 275.

330 Op cit. Endnote 273.

331 Op cit. Endnote 23.

332 Op cit. Endnote 277.

333 Op cit. Endnote 273.

334 Op cit. Endnote 271.

335 Op cit. Endnote 196.

336 Op cit. Endnote 277.

3372 Op cit. Endnote 277.

338 Op cit. Endnote 28.

339 Country report: Georgia.

340 Country report: Romania.

341 Op cit. Endnote 34.

342 **GrapeGen06**; http://www1.montpellier.inra.fr/grapegen06/accueil.php

343 Country report: Portugal.

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345 **Maghradze, D., Failla, O., Turok, J., Amanov, M., Avidzba, A., Chkhartishvili, N., Costantini, L., Cornea, V., Hausman, J-F., Gasparian, S., Gogishvili, K., Gorislavets, S., Maul, E., Melyan, G., Pollulyakh, A., Risovanava, V., Savin, G., Scienza, A., Smurigin, A., Troshin, L., Tsertsvadze, N. & Volynkin, V.** 2006. Conservation and sustainable use of grapevine genetic resources in the Caucasus and Northern Black Sea region. Poster presented at the Ninth International Conference on Grape Genetics and Breeding, Udine, Italy, 2-6 July 2006. http://www.vitis.ru/pdf/magh2.pdf

346 Country report: Greece.

347 Country report: Portugal.

348 Op cit. Endnote 344.

349 The European *Vitis* Database, http://www.eu-vitis.de/index.php

350 Ibid. **GrapeGen06**.

351 Almond, Brazil nut, cashew, chestnut, hazelnut, pistachio, walnut, and nuts not elsewhere counted.

352 Op cit. Endnote 28.

353 Op cit. Endnote 34.

354 World Information and Early Warning System on PGRFA (WIEWS), http://apps3.fao.org/wiews/wiews.jsp?i_l=EN

355 Op cit. Endnote 34.

356 Op cit. Endnote 34.

357 Op cit. Endnote 354.

358 Op cit. Endnote 354.

359 SAFENUT, http://safenut.casaccia.enea.it/

360 Genetic Resources in Agriculture: A Summary of the Projects Co-Financed Under Council Regulation (EC) No 1467/94, Community Programme 1994-99, http://ec.europa.eu/agriculture/publi/genres/prog94_99_en.pdf

361 Country report: Georgia.

362 Country report: Lebanon.

363 Artichokes, asparagus, beans (green), cabbages, carrots and turnips, cauliflower and broccolis, chillies and peppers (green), cucumbers and gherkins, eggplants, garlic, leguminous vegetables not counted elsewhere, lettuce and chicory, maize (green), mushrooms, okra, onions (green), onions (dry), cantaloupes and other melons, peas (green), pumpkins and squash, spinach, beans (string), tomatoes, fresh vegetables not counted elsewhere and watermelons.

364 Op cit Endnote 28.

APPENDIX 4

366 Ibid. Endnote 354.

366 Brazil, China, France, Germany, India, Japan, the Philippines, the Russian Federation and the United States of America.

367 Op cit. Endnote 34.

368 Op cit. Endnote 34.

369 Op cit. Endnote 34.

370 Op cit. Endnote 34.

371 Op cit. Endnote 34.

372 Op cit. Endnote 34.

373 Op cit. Endnote 34.

374 Op cit. Endnote 34.

375 Country report: Madagascar.

376 Country report: Trinidad and Tobago.

377 Country report: Nepal.

378 Country report: Pakistan.

379 Country report: Philippines

380 Country report: Tajikistan.

381 Country report: Greece

382 Country report: Ireland

Abbreviations and acronyms

AARI	Aegean Agricultural Research Institute of Turkey
AARINENA	Association of Agricultural Research Institutions in the Near East and North Africa
ABI	Institute for Agrobotany (Hungary)
ABS	Access and benefit-sharing
Acc.	Accessions
ACCI	African Centre for Crop Improvement
ACIAR	Australian Centre for International Agricultural Research
ACSAD	Arab Centre for the Study of Arid Zones and Dry Lands
AD-KU	Department of Agronomy, Faculty of Agriculture, University of Kasetsart (Thailand)
ADMARC	Agricultural Development and Marketing Corporation
AEGIS	A European Genebank Integrated System
AFLP	Amplified Fragment-Length Polymorphism
AGRESEARCH	Margot Forde Forage Germplasm Centre, Agriculture Research Institute Ltd (New Zealand)
AICRP-Soybean	All India Coordinated Research Project on Soybean (India)
AMFO	G.I.E. Amelioration Fourragère (France)
AMGRC	Australian Medicago Genetic Resource Centre, South Australian Research and Development Institute
ANGOC	Asian NGO Coalition for Agrarian Reform and Rural Development
AOAD	Arab Organization for Agricultural Development
APAARI	Asia-Pacific Association of Agricultural Research Institutions
ARC (LBY001)	Agricultural Research Centre (Libyan Arab Jamahiriya)
ARC (SDN001)	Plant Breeding Section, Agricultural Research Corporation (Sudan)
AREO	Agricultural Research and Education Organization, Iran (Islamic Republic of)
ARI (CYP004)	National (CYPARI) Genebank, Agricultural Research Institute, Ministry of Agriculture, Natural Resources and Environment (Cyprus)
ARI (ALB002)	Agricultural Research Institute (Albania)
ARIPO	African Regional Industrial Property Organization
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASEAN	Association of Southeast Asian Nations
ASN	Africa Seed Network
ASPNET	Asia-Pacific Network
ATCFC	Australian Tropical Crops & Forages Genetic Resources Centre
ATFCC	Australian Temperate Field Crops Collection
AusPGRIS	Australian Plant Genetic Resource Information Service
AVRDC	Asian Vegetable Research and Development Centre
AWCC	Australian Winter Cereals Collection
AYR-DPI	Mango Collection, Ayr, Department of Primary Industries (Australia)

BAAFS	Beijing Academy of Agriculture and Forestry Sciences (China)
BAL	Banco Activo de Germoplasma de Papa, Forrajeras y Girasol Silvestre (Argentina)
BAP	Banco Activo de Germoplasma de Pergamino (Argentina)
BAPNET	Banana Asia Pacific Network
BARI	Plant Genetic Resources Centre (Bangladesh)
BARNESA	Banana Research Network for Eastern and Southern Africa
BAZ	Federal Centre of Breeding Research on Cultivated Plants (Braunschweig, Germany)
BB	Banana Board (Jamaica)
BBC-INTA	Banco Base de Germoplasma, Instituto de Recursos Biológicos, Instituto Nacional de Tecnología Agropecuaria (Argentina)
BCA	Bunda College of Agriculture (Malawi)
BCCCA	Biscuit, Cake, Chocolate and Confectionery Association
BECA	Biosciences Eastern and Central Africa
BGCI	Botanic Garden Conservation International
BGRI	Borlaug Global Rust Initiative
BGUPV	Generalidad Valenciana, Universidad Politécnica de Valencia. Escuela Técnica Superior de Ingenieros Agrónomos, Banco de Germoplasma (Spain)
BG-VU	Botanical Garden, Vilnius University (Lithuania)
BINA	Bangladesh Institute of Nuclear Agriculture
BJRI	Bangladesh Jute Research Institute
BNGGA-PROINPA	Fundación para la Promoción e Investigación de Productos Andinos, Regional Altiplano (Bolivia, Plurinational State of)
BNGTRA-PROINPA	Banco Nacional de Germoplasma de Tubérculos y Raíces Andinas, Fundación para la Promoción e Investigación de Productos Andinos (Bolivia, Plurinational State of)
BPGV-DRAEDM	Portuguese Bank of Plant Germplasm
BRDO	Biotechnology Research and Development Office (Thailand)
BRGV Suceava	Suceava Genebank (Romania)
BRRI	Bangladesh Rice Research Institute
BSRI	Bangladesh Sugarcane Research Institute
BTRI	Bangladesh Tea Research Institute
BVRC	Beijing Vegetable Research Centre (China)
BYDG	Botanical Garden of Plant Breeding and Acclimatization Institute (Poland)
CAAS	Chinese Academy of Agricultural Sciences
CABMV	Cowpea Aphid-Borne Mosaic Virus
CACAARI	Central Asia and the Caucasus Association of Agricultural Research Institutions
CacaoNet	Global Cacao Genetic Resources Network
CACN-PGR	Central Asian and Caucasian Network on Plant Genetic Resources
CAPGERNET	Caribbean Plant Genetic Resources Network
CARBAP	Centre Africain de Recherches sur Bananiers et Plantains

CARDI	Caribbean Agricultural Research and Development Institute
CAS-IP	Central Advisory Service on Intellectual Property
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza
CBD	Convention on Biological Diversity
CBDC	Community Biodiversity Development Conservation
CBG	Central Botanical Garden (Azerbaijan)
CBICAU	Crop Breeding Institute (Zimbabwe)
CBNA	Conservatoire Botanique National Alpin de Gap-Charance (France)
CC	Cartón de Colombia S.A.
CCSM-IASP	Centro de Citricultura «Sylvio Moreira», Instituto Agronomico de São Paulo (Brazil)
CCRI	Central Cotton Research Institute, Multan (Pakistan)
CEARD	Centre of Excellence for Agrobiodiversity Resources and Development of China
CENARGEN	Embrapa Recursos Genéticos e Biotecnologia (Brazil)
CENICAFE	Centro Nacional de Investigaciones de Café "Pedro Uribe Mejia", Federación Nacional de Cafeteros de Colombia
CePaCT	Centre for Pacific Crops and Trees
CEPEC	Centro de Pesquisa do Cacao (Brazil)
CERI	Cereal Institute, National Agricultural Research Foundation (Greece)
CGIAR	Consultative Group on International Agricultural Research
CGN	Centre for Genetic Resources
CGRFA	Commission on Genetic Resources for Food and Agriculture
CIAT	Centro Internacional de Agricultura Tropical
CICR	Central Institute for Cotton Research (India)
CIFACOR	Junta de Andalucía, Instituto Andaluz de Investigación Agroalimentaria y Pesquera, Centro de Investigación y Formación Agroalimentaria Córdoba (Spain)
CIFAP-CAL	Centro de Investigaciones Forestales y Agropecuarias, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (Mexico)
CIFP	Centro de Investigaciones Fitoecogenéticas de Pairumani (Bolivia, Plurinational State of)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CIP	Centro Internacional de la Papa
Cirad	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (France)
CIS	Commonwealth of Independent States
CISH	Central Institute for Subtropical Horticulture (India)
CITH	Central Institute of Temperate Horticulture (India)
CLAN	Cereal and Legume Asia Network
Clayuca	Consorcio Latinoamericano y del Caribe de Apoyo a la Investigación y al Desarrollo de la Yuca

CN	Centre Néerlandais (Côte d'Ivoire)
CNPA	Embrapa Algodão (Brazil)
CNPAF	Embrapa Arroz e Feijão (Brazil)
CNPAT	Embrapa Agroindústria Tropical (Brazil)
CNPF	Embrapa Florestas (Brazil)
CNPGC	Embrapa Gado de Corte (Brazil)
CNPH	Embrapa Hortaliças (Brazil)
CNPMF	Embrapa Mandioca e Fruticultura Tropical (Brazil)
CNPMS	Embrapa Milho e Sorgo (Brazil)
CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnológico
CNPSO	Embrapa Soja (Brazil)
CNPT	Embrapa Trigo (Brazil)
CNPUV	Embrapa Uva e Vinho (Brazil)
CNRRI	China National Rice Research Institute
COILLTE	Coillte Teoranta, The Irish Forestry Board (Ireland)
CONSEFORH	Proyecto de Conservación y Silvicultura de Especies Forestales de Honduras
COP	Conference of the Parties to the Convention on Biological Diversity
COPAL	Cocoa Producers Alliance
COR	National Clonal Germplasm Repository, United States Department of Agriculture, Agricultural Research Services
CORBANA	Corporación Bananera Nacional S.A. (Costa Rica)
CORPOICA	Centro de Investigación La Selva, Corporación Colombiana de Investigación Agropecuaria (Colombia)
CORRA	Council for Partnerships on Rice Research in Asia
COT	Crop Germplasm Research Unit, United States Department of Agriculture, Agricultural Research Services
CPAA	Embrapa Amazônia Ocidental (Brazil)
CPACT/Embrapa	Embrapa Clima Temperado (Brazil)
CPATSA	Embrapa Semi-Árido (Brazil)
CPBBD	Central Plant Breeding and Biotechnology Division, Nepal Agricultural Research Council
CPRI	Central Potato Research Institute (India)
CPU	Central Processing Unit
CRA-CAT	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Unità di Ricerca per le Colture alternative al Tabacco (Italy)
CRA-FLC	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Centro di Ricerca per le Produzioni Foraggere e Lattiero-Casearie (Italy)
CRA-FRF	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Unitá di Ricerca per la Frutticoltura (Italy)
CRA-FRU	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Centro di Ricerca per la Frutticoltura (Italy)

CRAGXPP	Département de Lutte Biologique et Ressources Phytogénétiques, Centre de Recherches Agronomiques de Gembloux, Ministere des Classes Moyennes et de l'Agriculture (Belgium)
CRA-OLI	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Centro di Ricerca per l'Olivicoltura e l'Industria Olearia (Italy)
CRA-VIT	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Centro di Ricerca per la Viticoltura (Italy)
CRC	Central Romana Corporation (Dominican Republic)
CRI	Citrus Research Institute, Chinese Academy of Agricultural Sciences
CRIA	Central Research Institute for Agriculture (Indonesia)
CRIG	Cocoa Research Institute of Ghana
CRIN	Cocoa Research Institute of Niger
CRU	Cocoa Research Unit, University of the West Indies (Trinidad and Tobago)
CSFRI	Citrus and Subtropical Fruit Research Institute (South Africa)
CSIRO	Commonwealth Scientific & Industrial Research Organization, Division of Horticultural Research
CTA	Technical Centre for Agricultural and Rural Cooperation
CTC	Centro de Tecnologia Canavieira (Brazil)
CTRI	Central Tobacco Research Institute (India)
CWR	Crop wild relatives
DANAC	Fundación para la Investigación Agrícola DANAC (Venezuela, Bolivarian Republic of)
DAR	Department of Agricultural Research, Ministry of Agriculture (Botswana)
DAV	National Germplasm Repository, United States Department of Agriculture, Agricultural Research Services, University of California
DB NRRC	Dale Bumpers National Rice Research Centre, United States Department of Agriculture, Agricultural Research Services
DCRS	Dodo Creek Research Station, Ministry of Home Affairs and Natural Development (Solomon Islands)
DENAREF	Departamento Nacional de Recursos Fitogenéticos y Biotecnología (Ecuador)
DFS	Artemivs'k Experimental Station (Ukraine)
DGCB-UM	Department of Genetics and Cellular Biology, University Malaya (Malaysia)
DLP Laloki	Dry-lowlands Research Programme, Laloki (NARI) (Papua New Guinea)
DNA	Deoxyribonucleic acid
DOA	Department of Agriculture, Papua New Guinea University of Technology
DOR	Directorate of Oilseeds Research (India)

DTRUFC	División of Tropical Research, United Fruit Company (Honduras)
EA-PGR	Regional Network for Conservation and Use of Plant Genetic Resources in East Asia
EAPGREN	East African Plant Genetic Resources Network
EAPZ	Escuela Agrícola Panamericana El Zamorano (Honduras)
EARTH	Escuela de Agricultura de la Region Tropical Humeda (Costa Rica)
ECICC	Estación Central de Investigaciones de Café y Cacao (Cuba)
ECOWAS	Economic Community of West African States
ECPGR	European Cooperative Programme for Genetic Resources
EEA INTA Anguil	Estación Experimental Agropecuaria "Ing. Agr. Guillermos Covas" (Argentina)
EEA INTA Bordenave	Estación Experimental Agropecuaria Bordenave (Argentina)
EEA INTA Cerro Azul	Estación Experimental Agropecuaria Cerro Azul (Argentina)
EENP	Estación Experimental Napo-Payamino (Ecuador)
EETP	Estación Experimental Pichilingue (Ecuador)
EFOPP	Enterprise for Extension and Research in Fruit Growing and Ornamentals (Hungary)
Embrapa	Empresa Brasileira de Pesquisa Agropecuaria
ENSCONET	European Native Seed Conservation Network
ePIC	Electronic Plant Information Centre (United Kingdom)
ESA	Environmentally Sensitive Areas
ESCORENA	European System of Cooperative Research Networks on Agriculture
ETC Group	Action Group on Erosion, Technology and Concentration
EUFORGEN	European Forest Genetic Resources Network
EURISCO	European Internet Search Catalogue
EWS R&D	East West Seed Research and Development Division (Bangladesh)
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistical Database
FARA	Forum for Agricultural Research in Africa
FAST	Faculté des Sciences et Techniques (Benin)
FCRI	Food Crops Research Institute (Viet Nam)
FCRI-DA	Field Crops Research Institute – Department of Agriculture (Thailand)
FF.CC.AA.	Facultad de Ciencias Agrarias (Peru)
FHIA	Fundación Hondureña de Investigación Agrícola
FIGS	Focused Identification of Germplasm Strategy
FONTAGRO	Fondo Regional de Tecnología Agropecuaria
FORAGRO	Foro de las Américas para la Investigación y Desarrollo Tecnológico Agropecuario
FPC	Firestone Plantations Company (Liberia)
FRIM	Forest Research Institute of Malaysia

FRUCTUS	Association Suisse pour la Sauvegarde du Patrimoine Fruitier (Switzerland)
GBREMR	East Malling Research (United Kingdom)
GBWS	Germplasm Bank of Wild Species (China)
GCDT	Global Crop Diversity Trust
GCP	Generation Challenge Programme
GEF	Global Environment Facility
GEN	Plant Genetic Resources Unit, Cornell University, New York State Agricultural Experiment Station, United States Department of Agriculture, Agricultural Research Services
GEVES	Unité Expérimentale de Sophia-Antipolis, Groupe d'Étude et de Sophia-Antiopolis contrôle des Variétés et des Semences (France)
GFAR	Global Forum on Agricultural Research
GIPB	Global Partnership Initiative for Plant Breeding Capacity Building
GIS	Geographic Information System
GM	Genetically modified
GMO	Genetically modified organisms
GMZ	Gene Management Zones
GPA	Global Plan of Action for the Conservation and Utilization of Plant Genetic Resources for Food and Agriculture
GPRI	Genetic Resources Policy Initiative of Biodiversity International
GPS	Global Positioning Systems
GRENEWECA	Genetic Resources Network for West and Central Africa
GRI	Genetic Resources Institute (Azerbaijan)
GRIN	Germplasm Resources Information Network
GSC	Guyana Sugar Corporation, Breeding and Selection Department
GSLY	C.M. Rick Tomato Genetics Resource Centre (United States)
GSPC	Global Strategy for Plant Conservation
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (Germany)
HBROD	Potato Research Institute Havlickuv Brod Ltd. (Czech Republic)
HIV/AIDS	Human immunodeficiency virus/ Acquired Immune Deficiency Syndrome
HOLOVOU	Research and Breeding Institute of Pomology, Holovousy Ltd. (Czech Republic)
HRC, MARDI	Horticulture Research Centre, Malaysian Agricultural Research and Development Institute
HRI-DA/THA	Horticultural Research Institute, Department of Agriculture (Thailand)

HRIGRU	Horticultural Research International, University of Warwick, Genetic Resources Unit (United Kingdom)
HSCRI	Horticulture and Subtropical Crops Research Institute (Azerbaijan)
IAC	Instituto Agronómico de Campinas (Brazil)
IAO	Istituto Agronomico per l'Oltremare (Italy)
IAPAR	Instituto Agronomico do Paraná (Brazil)
IARC	International Agricultural Research Centre
IARI	Indian Agricultural Research Institute
IBC	Institute of Biodiversity Conservation (Ethiopia)
IBERS-GRU	Institute of Biological, Environmental & Rural Sciences, Genetic Resources Unit, Aberystwyth University (United Kingdom)
IBN-DLO	Institute for Forestry and Nature Research (Netherlands)
IBONE	Instituto de Botánica del Nordeste, Universidad Nacional de Nordeste, Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina)
IBOT	Jardim Botânico de São Paulo (Brazil)
IBPGR	International Board for Plant Genetic Resources
ICA/REGION 1	Corporación Colombiana de Investigación Agropecuaria Tibaitata (Colombia)
ICA/REGION 5	Centro de Investigación El Mira, Instituto Colombiano Agropecuario El Mira (Colombia)
ICA/REGION 5	Centro de Investigaciones de Palmira, Instituto Colombiano Agropecuario Palmira (Colombia)
ICABIOGRAD	Indonesian Centre for Agricultural Biotechnology and Genetic Resources Research and Development
ICAR	Indian Council of Agricultural Research
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICBA	International Centre for Biosaline Agriculture
ICCI-TELAVUN	Lieberman Germplasm Bank, Institute for Cereal Crops Improvement, Tel-Aviv University (Israel)
ICCO	International Cocoa Organization
ICCPT Fundul	Research Institute for Cereals and Technical Plants Fundulea (Romania)
ICG	Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore
ICGN	International Coffee Genome Network
ICGR-CAAS	Institute of Crop Germplasm Resources, Chinese Academy of Agricultural Sciences
ICGT	International Cocoa Genebank (Trinidad and Tobago)
ICPP Pitesti	Fruit Growing Research Institute Maracineni-Arges (Romania)
ICRAF	International Centre for Research in Agroforestry (now the World Agroforestry Centre)

ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICRR	Indonesian Centre for Rice Research
ICVV Valea C	Wine Growing Research Institute Valea Calugareasca-Prahova (Romania)
IDB	Inter-American Development Bank
IDEFOR	Institut pour le Développement des Forêts (Côte d'Ivoire)
IDEFOR-DCC	Département du Café et du Cacao, Institut pour le Développement des Forêts (Côte d'Ivoire)
IDEFOR-DPL	Département des Plantes à Latex, Institut pour le Développement des Forêts (Côte d'Ivoire)
IDESSA	Institut des Savanes (Côte d'Ivoire)
IDI	International Dambala (Winged Bean) Institute (Sri Lanka)
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IFAP	International Federation of Agricultural Producers
IFS	International Foundation for Science
IFVCNS	Institute for Field and Vegetable Crops (Serbia)
IGB	Israel Gene Bank for Agricultural Crops, Agricultural Research Organization, Volcani Centre
IGC	The WIPO Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore
IGFRI	Indian Grassland and Fodder Research Institute
IGV	Istituto di Genetica Vegetale, Consiglio Nazionale delle Richerche (Italy)
IHAR	Plant Breeding and Acclimatization Institute (Poland)
IICA	Instituto Interamericano de Cooperación para la Agricultura
IIT	Instituto de Investigaciones del Tabaco (Cuba)
IITA	International Institute of Tropical Agriculture
ILETRI	Indonesian Legume and Tuber Crops Research Institute
ILK	Institute of Bast Crops (Ukraine)
ILRI	International Livestock Research Institute
IMIACM	Comunidad de Madrid, Dirección General de Agricultura y Desarrollo Rural, Instituto Madrileño de Investigación Agraria y Alimentaria (Spain)
INBAR	International Network for Bamboo and Rattan
INCANA	Inter-regional Network on Cotton in Asia and North Africa
INCORD	Cotton Institute for Research and Development (Viet Nam)
INERA	Institut National pour l'Etude et la Recherche Agronomique (Congo)
INGENIC	International Group for the Genetic Improvement of Cocoa
INGER	International Network for the Genetic Evaluation of Rice
INIA-CENIAP	Centro Nacional de Investigaciones Agropecuarias, Instituto Nacional de Investigaciones Agrícolas, Venezuela (Bolivarian Republic of)

INIA CARI	Centro Regional de Investigación, Instituto Nacional de Investigaciones Agrícolas, Carillanca (Chile)
INIA INTIH	Banco Base, Instituto de Investigaciones Agropecuarias, Intihuasi (Chile)
INIA QUIL	Centro Regional de Investigación, Instituto de Investigaciones Agropecuarias, Quilamapu (Chile)
INIACRF	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria,Centro de Recursos Fitogenéticos (Spain)
INIA-EEA.ILL	Estación Experimental Agraria, Illpa (Peru)
INIA-EEA.POV	Estación Experimental Agraria, El Porvenir (Peru)
INIAFOR	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Centro de Investigaciones Forestales (Spain)
INIA-Iguala	Estación de Iguala, Instituto Nacional de Investigaciones Agrícolas (Mexico)
INIAP	Instituto Nacional de Tecnología Agropecuaria (Ecuador)
INIBAP	International Network for the Improvement of Banana and Plantain
INICA	Instituto Nacional de Investigación de la Caña de Azúcar (Cuba)
INIFAP	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (Mexico)
INRA	Institut national de la recherche agronomique (France)
INRA/CRRAS	Institut national de la recherche agronomique/Centre Régional de la Recherche Agronomique de Settat (Morocco)
INRA/ENSA-M	Institut national de la recherche agronomique/Station de Recherches Viticoles (France)
INRA-ANGERS	Institut national de la recherche agronomique/Station d'Amélioration des Espèces Fruitières et Ornementales, (France)
INRA BORDEAUX (FRA057)	Unité de Recherches sur Espèces Fruitières et Vigne (France)
INRA BORDEAUX (FRA219)	Institut national de la recherche agronomique/Recherches Forestières (France)
INRA-CLERMONT	Institut national de la recherche agronomique/Station d'Amélioration des Plantes (France)
INRA-DIJON	Institut national de la recherche agronomique/Station de Génétique et d'Amélioration des Plantes (France)
INRA-MONTPELLIER	Institut national de la recherche agronomique/Genetics and Plant Breeding Station (France)
INRA-POITOU	Institut national de la recherche agronomique/Station d'Amélioration des Plantes Fourragères (France)
INRA-RENNES (FRA010)	Institut national de la recherche agronomique/Station d'Amélioration des Plantes (France)
INRA-RENNES (FRA179)	Institut national de la recherche agronomique/Station d'Amélioration Pomme de Terre et Plantes à Bulbes (France)
INRA-UGAFL	Institut national de la recherche agronomique/Unité de Génétique et Amélioration des Fruits et Légumes (France)

INRENARE	Instituto Nacional de Recursos Naturales Renovables (Panama)
IOB	Institute of Vegetable and Melon Growing (Ukraine)
IOPRI	Indonesian Palm Oil Research Institute
IP	Intellectual property
IPB-UPLB	Institute of Plant Breeding, College of Agriculture, University of the Philippines, Los Baños College (Philippines)
IPCC	Intergovernmental Panel on Climate Change
IPEN	International Plant Exchange Network
IPGR	Institute for Plant Genetic Resources «K.Malkov» (Bulgaria)
IPGRI	International Plant Genetic Resources Institute
IPK (DEU271)	External Branch North of the Department Genebank, Leibniz Institute of Plant Genetics and Crop Plant Research, Oil Plants and Fodder Crops in Malchow (Germany)
IPK (DEU159)	External Branch North of the Department Genebank, Leibniz Institute of Plant Genetics and Crop Plant Research, Potato Collection in Gross-Luesewitz (Germany)
IPK (DEU146)	Genebank, Leibniz Institute of Plant Genetics and Crop Plant Research (Germany)
IPPC	International Plant Protection Convention
IPR	Intellectual property rights
IPRBON	Institute for Potato Research, Bonin, Poland
IPSR	Department of Applied Genetics, John Innes Centre, Norwich Research Park (United Kingdom)
IR	Institute of Plant Production n.a. V.Y. Yurjev of UAAS (Ukraine)
IRCC/Cirad	Institut de Recherches du Café et du Cacao et autres Plantes Stimulantes/Centre de Coopération Internationale en Recherche Agronomique pour le Développement (Côte d'Ivoire)
IRCT/Cirad	Département des Cultures Annuelles/Centre de Coopération Internationale en Recherche Agronomique pour le Développement (France)
IRRI	International Rice Research Institute
IRTAMB	Generalitat de Catalunya, Institut de Recerca i Tecnologia Agroalimentàries, Centre Mas Bové (Spain)
ISAR	Institut des Sciences Agronomiques du Rwanda
ISF	International Seed Federation
ISFP	Initiative on Soaring Food Prices
ISRA-URCI	Institut Sénégalais de Recherche Agricole-Unité de recherche commune en culture *in vitro*
IT	Information technology
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
ITRA	Institut Togolais de Recherche Agronomique
IUCN	International Union for Conservation of Nature

IVM	Institute of Grape and Wine «Maharach» (Ukraine)
JARC	Jimma Agricultural Research Centre (Ethiopia)
JICA	Japan International Cooperation Agency
JIRCAS	Japan International Research Centre for Agricultural Sciences
JKI	Julius Kühn Institute, Federal Research Centre for Cultivated Plants (Germany)
JKI (DEU098)	Julius Kühn Institute, Federal Research Centre for Cultivated Plants - Institute for Grapevine Breeding Geilweilerhof (Germany)
JKI (DEU451)	Julius Kühn Institute, Federal Research Centre for Cultivated Plants - Institute of Horticultural Crops and Fruit Breeding (Germany)
KARI	Kenya Agricultural Research Institute
KARI-NGBK	National Genebank of Kenya, Crop Plant Genetic Resources Centre, Muguga (Kenya)
KEFRI	Kenya Forest Research Institute
KLOST	Federal College and Research Institute for Viticulture and Fruit Growing (Austria)
KPS	Crimean Pomological Station (Ukraine)
KROME	Agricultural Research Institute Kromeriz, Ltd. (Czech Republic)
KST	Crimean Tobacco Experimental Station (Ukraine)
LACNET	Latin America and Caribbean Network
LAREC	Lam Dong Agricultural Research and Experiment Centre (Viet Nam)
LBN	National Biological Institute (Indonesia)
LD	Linkage Disequilibrium
LEM/IBEAS	IBEAS, Laboratoire d'Ecologie Moléculaire, Université de Pau (France)
LFS	L'viv Experimental Station of Horticulture (Ukraine)
LIA	Lithuanian Institute of Agriculture
LI-BIRD	Local Initiatives for Biodiversity, Research and Development (Nepal NGO)
Linseed	All India Coordinated Research Project on Linseed, CSA University of Agriculture & Technology, Kanpur, Uttar Pradesh (India)
LPGPB	Laboratory of Plants Gene Pool and Breeding (Armenia)
LRS	Lethbridge Research Station, Agriculture (Canada)
LUBLIN	Institute of Genetics and Plant Breeding, University of Agriculture (Poland)
MARDI	Malaysian Agricultural Research and Development Institute
MARS	Makoka Agricultural Research Station (Malawi)
MAS	Marker Assisted Selection
MDG	Millennium Development Goal
MEA	Millennium Ecosystem Assessment

MHRP	Main Highlands Research Programme, Aiyura (Papua New Guinea)
MIA	Subtropical Horticultural Research Unit, National Germplasm Repository- Miami, United States Department of Agriculture
MLS	Multilateral System
MPOB	Malaysia Palm Oil Board
MRB	Malaysian Rubber Board
MRIZP	Maize Research Institute «Zemun Polje» (Serbia)
MRS	Msekera Research Station (Zambia)
MSBP	Millennium Seed Bank Project
MUSACO	Réseau Musa pour l'Afrique Centrale et Occidentale
MUSALAC	Plantain and Banana Research and Development Network for Latin America and the Caribbean
NA	U.S. National Arboretum, United States Department of Agriculture, Agricultural Research Services, Woody Landscape Plant Germplasm Repository
NABNET	North Africa Biosciences Network
NAEP	National Agri-Environment Programme (Hungary)
NAKB	Inspection Service for Floriculture and Arboriculture (Netherlands)
NARC (LAO010)	Napok Agricultural Research Centre (Lao People's Democratic Republic)
NARC (NPL026)	Nepal Agricultural Research Council
NARS	National Agricultural Research System
NBPGR (IND001)	National Bureau of Plant Genetic Resources (India)
NBPGR (IND064)	Regional Station Jodhpur, National Bureau of Plant Genetic Resources (India)
NBPGR (IND024)	Regional Station Thrissur, National Bureau of Plant Genetic Resources (India)
NC7	North Central Regional Plant Introduction Station, United States Department of Agriculture, Agricultural Research Services
NCGRCD	National Clonal Germplasm Repository for Citrus & Dates, United States Department of Agriculture, Agricultural Research Services
NCGRP	National Centre for Genetic Resources Preservation (United States)
NE9	Northeast Regional Plant Introduction Station, Plant Genetic Resources Unit, United States Department of Agriculture, Agricultural Research Services, New York State Agricultural Experiment Station, Cornell University
NEPAD	The New Partnership for Africa's Development
NFC	National Fruit Collections, University of Reading (United Kingdom)
NGO	Non-governmental organization
NIAS	National Institute of Agrobiological Sciences (Japan)

NISM	National Information Sharing Mechanism on GPA implementation.
NMK	National Museums of Kenya
NordGen	Nordic Genetic Resources Centre
NORGEN	Plant Genetic Resources Network for North America
NPGRC	National Plant Genetic Resources Centre (United Republic of Tanzania)
NPGS	National Plant Germplasm System
NR6	Potato Germplasm Introduction Station, United States Department of Agriculture, Agricultural Research Services
NRCB	National Research Centre for Banana (India)
NRCOG	National Research Centre for Onion and Garlic (India)
NRCRI	National Root Crops Research Institute (Nigeria)
NSGC	National Small Grains Germplasm Research Facility, United States Department of Agriculture, Agricultural Research Services
NUC	Njala University College (Sierra Leone)
OAPI	African Intellectual Property Organization
OAU	Organization of African Unity
OECD	Organisation for Economic Co-operation and Development
OPRI	Oil Palm Research Institute (Ghana)
ORSTOM-MONTPELLIER	Laboratoire des Ressources Génétiques et Amélioration des Plantes Tropicales, ORSTOM (France)
OSS Roggwil	Verein Obstsortensammlung Roggwil (Switzerland)
PABRA	Pan-African Bean Research Alliance
PAN	Botanical Garden of the Polish Academy of Sciences (Poland)
PAPGREN	Pacific Agricultural Plant Genetic Resources Network
PBBC	Plant Breeding and Related Biotechnology Capacity assessment
PBR	Plant breeders' rights
PCA-ZRC	Philippine Coconut Authority-Zamboanga Research Centre
PCR	Polymerase Chain Reaction
PDO	Protected Designation of Origin
PERUG	Dipartimento di Biologia Applicata, Universitá degli Studi, Perugia (Italy)
PES	Payment for environmental services
PG	Pomological Garden (Kazakhstan)
PGR	Plant genetic resources
PGRC (CAN004)	Plant Gene Resources of Canada, Saskatoon Research Centre, Agriculture and Agri-Food Canada
PGRC	Plant Genetic Resources Centre (Sri Lanka)
PGRFA	Plant genetic resources for food and agriculture
PGRI	Plant Genetic Resources Institute (Pakistan)
PGR-IZs	Plant Genetic Resources Important Zones
PGRRI	Plant Genetic Resources Research Institute (Ghana)
PHES	Plew Horticultural Experimental Station (Thailand)

PhilRice	Philippine Rice Research Institute
PNP-INIFAP	Programa Nacional de la Papa, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (Mexico)
PotatoGene	Potato Gene Engineering Network
PPB	Paticipatory plant breeding
PRC	Plant Resources Centre (Viet Nam)
PRGA	Participatory Research and Gender Analysis
PROCIANDINO	Programa Cooperativo de Innovación Tecnológica Agropecuaria para la Región Andina
PROCICARIBE	Programa para la Cooperación de Institutos de Ciencia Agrícola y Tecnología en el Caribe
PROCINORTE	Programa cooperativo en investigación y tecnología para la Región Norte
PROCISUR	Programa Cooperativo para el Desarrollo Tecnológico Agropecuario del Cono Sur
PROCITROPICOS	Programa Cooperativo de Investigación y Transferencia de Tecnología para los Trópicos Suramericanos
PRUHON	Research Institute of Landscaping and Ornamental Gardening (Czech Republic)
PSR	Pro Specie Rara (Switzerland)
PU	Peradeniya University (Sri Lanka)
PULT	Department of Special Crops (Tobacco), Institute Soil Science and Plant Cultivation (Poland)
PVP	Plant variety protection
QDPI	Queensland Department of Primary Industries, Maroochy Research Station (Australia)
QPM	Quality protein maize
QTL	Quantitative trait locus
RAC (CHE019)	Domaine de Caudoz - Viticulture RAC Changins (Switzerland)
RAC (CHE001)	Station Fédérale de Recherches en Production Végétale de Changins (Switzerland)
RAPD	Random Amplification of Polymorphic DNA
RBG	Millennium Seed Bank Project, Seed Conservation Department, Royal Botanic Gardens, Kew, Wakehurst Place (United Kingdom)
RCA	Institute for Agrobotany (Hungary)
RDAGB-GRD	Genetic Resources Division, National Institute of Agricultural Biotechnology, Rural Development Administration (Republic of Korea)
RECSEA-PGR	Regional Cooperation in South East Asia for Plant Genetic Resources
REDARFIT	Andean Network on Plant Genetic Resources
REDBIO	Red de cooperación técnica en biotecnología vegetal
RedSICTA	The Agricultural Innovation Network Project
REGENSUR	Plant Genetic Resources Network for the Southern Cone

REHOVOT	Department of Field and Vegetable Crops, Hebrew University of Jerusalem (Israel)
REMERFI	Mesoamerican Network on Plant Genetic Resources
RFLP	Restriction fragment length polymorphisms
RGC	Regional Germplasm Centre (Secretariat of the Pacific Community)
RIA	Research Institute of Agriculture (Kazakhstan)
RICP (CZE061)	Genebank Department, Vegetable Section Olomuc, Research Institute of Crop Production (Czech Republic)
RICP (CZE122)	Genebank Department, Division of Genetics and Plant Breeding, Research Institute of Crop Production (Czech Republic)
RICP	Research Institute of Crop Production (Czech Republic)
RIGA	FAO Rural Income Generation Project
RIPV	Research Institute of Potato and Vegetables (Kazakhstan)
RNA	Ribonucleic acid
RNG	School of Plant Science, University of Reading (United Kingdom)
ROCARIZ	West and Central Africa Rice Research and Development Network
ROPTA	Plant Breeding Station Ropta (Netherlands)
RPPO	Regional Plant Protection Organization
RRI	Rubber Research Institute (Viet Nam)
RRII	Rubber Research Institute of India
RRS-AD	Banana National Programme (Uganda)
RSPAS	Research School of Pacific and Asian Studies (Australia)
S9	Plant Genetic Resources Conservation Unit, Southern Regional Plant Introduction Station, University of Georgia, United States Department of Agriculture, Agricultural Research Services
SAARI	Serere Agriculture and Animal Production Research Institute (Uganda)
SADC	Southern African Development Community
SADC-FANR	Southern African Development Community, Food, Agriculture and Natural Resources Directorate
SADC-PGRN	Southern African Development Community, Plant Genetic Resources Network
SamAI	Samarkand Agricultural Institute named F. Khodjaev (Uzbekistan)
SANBio	South African Network for Biosciences
SANPGR	South Asia Network on Plant Genetic Resources
SARD	Sustainable Agriculture and Rural Development
SAREC	Swedish Agency for Research Cooperation
SASA	Science and Advice for Scottish Agriculture, Scottish Government (United Kingdom)
SAVE Foundation	Safeguard for Agricultural Varieties in Europe (Foundation)

SCAPP	Scientific Centre of Agriculture and Plant Protection (Armenia)
SCRDC	Soil and Crops Research and Development Centre, Agriculture and Agri-Food Canada
SCRI	Scottish Crop Research Institute (United Kingdom)
SDC	Swiss Agency for Development and Cooperation
SDIS	Southern African Development Community Documentation and Information System
SEABGRC	South East Asian Banana Germplasm Resources Centre, Davao Experimental Station, Bureau of Plant Industry (Philippines)
SeedNet	South East European Development Network on Plant Genetic Resources
SFL	Holt Agricultural Research Station (Norway)
SGRP	System-wide Genetic Resources Programme
SGSV	Svalbard Global Seed Vault
SHRWIAT	Plant Breeding Station (Poland)
SIAEX	Junta de Extremadura. Servicio de Investigación y Desarrollo Tecnológico, Finca la Orden (Spain)
SIBRAGEN	Sistema brasileiro de informação de recursos genéticos
SICTA	Sistema de Integracion Centroamericana de Tecnologia Agricola
SINAC	National System of Conservation Areas (Costa Rica)
SINGER	System-wide Information Network for Genetic Resources
SKF	Research Institute of Pomology and Floriculture (Poland)
SKUAST	Sher-E-Kashmir University of Agricultural Sciences and Technology of Kashmir (India)
SKV	Plant Genetic Resources Laboratory, Research Institute of Vegetable Crops (Poland)
SMTA	Standard Material Transfer Agreement
SOUTA	School of Biological Sciences, University of Southampton (United Kingdom)
SoW	State of the World
SOY	Soybean Germplasm Collection, United States Department of Agriculture, Agricultural Research Services
SPB-UWA	School of Plant Biology, Faculty of Natural and Agricultural Sciences, University of Western Australia
SPC	Secretariat of the Pacific Community
SPCGF	Scientific Production Centre of Grain Farming "A. I. Baraev" (Kazakhstan)
SPGRC	Southern African Development Community Plant Genetic Resources Centre
SPS	Sanitary and Phytosanitary Measures Agreement
SR, MARDI	Strategic Resource Research Centre MARDI (Malaysia)
SRA-LGAREC	La Granja Agricultural Research and Extension Centre (Philippines)

SRI	Sugar Crop Research Institute, Mardan (Pakistan)
SSC-IUCN	Species Survival Commission, International Union for Conservation of Nature
SSEEA	South, South East and East Asia
SSJC	Soutnern Seed Joint-Stock Company (Viet Nam)
SUMPERK	AGRITEC, Research, Breeding and Services Ltd. (Czech Republic)
SVKBRAT	Research Institute for Viticulture and Enology (Slovakia)
SVKLOMNICA	Potato Research and Breeding Institute (Slovakia)
SVKPIEST	Research Institute of Plant Production Piestany (Slovakia)
TAMAWC	Australian Winter Cereals Collection, Agricultural Research Centre
TANSAO	Taro Network for Southeast Asia and Oceania
TARI	Taiwan Agricultural Research Institute
TaroGen	Taro Genetic Resources Network
TOB	Oxford Tobacco Research Station, Crops Science Department, North Carolina State University
TRI	Tea Research Institute (Sri Lanka)
TRIPS	Trade-Related Aspects of Intellectual Property Rights
TROPIC	Institute of Tropical and Subtropical Agriculture, Czech University of Agriculture
TROPIGEN	Amazonian Network for Plant Genetic Resources
TSS-PDAF	Taiwan Seed Service, Provincial Department of Agriculture and Forestry
TWAS	Third World Academy of Science
U.NACIONAL	Facultad de Agronomía, Universidad Nacional de Colombia
UAC	Université d'Abomey Calavi (Benin)
UACH	Banco Nacional de Germoplasma Vegetal, Departamento de Fitotecnia, Universidad Autónoma de Chapingo (Mexico)
UBA-FA	Facultad de Agronomía, Universidad de Buenos Aires (Argentina)
UC-ICN	Instituto de Ciencias Naturales (Ecuador)
UCR-BIO	Banco de Germoplasma de Pejibaye UCR-MAG, Escuela de Biología, Escuela de Zootecnia, Universidad de Costa Rica
UDAC	Unidade de Direcção Agraria de Cajú (Mozambique)
UDS	Ustymivka Experimental Station of Plant Production (Ukraine)
UH	University of Hawaii at Manoa (United States of America)
UHFI-DFD	Department of Floriculture and Dendrology, University of Horticulture and Food Industry (Hungary)
UHFI-RIVE	Institute for Viticulture and Enology, University of Horticulture and Food Industry (Hungary)
UM	Universiti Malaya (Malaya University, Malaysia)
UN	United Nations
UNALM	Universidad Nacional Agraria La Molina (Peru)

UNCED	United Nations Conference on Environment and Development
UNCI	Université Nationale de Côte d'Ivoire
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNMIHT	Horticulture Department, Michigan State University (United States)
UNSAAC	Universidad Nacional San Antonio Abad del Cusco, Centro K'Ayra (Peru)
UNSAAC/CICA	Universidad Nacional San Antonio Abad del Cusco
UPASI-TRI	United Planters' Association of South India-Tea Research Institute (India)
UPLB	University of the Philippines, Los Baños
UPM	University Putra, Malaysia
UPOU	University of Philippines Open University
UPOV	International Union for the Protection of New Varieties of Plants
URG	Unité des Ressources Génétiques (Mali)
USDA	United States Department of Agriculture
USDA-ARS	United States Department of Agriculture-Agricultural Research Service
USP	University of South Pacific
UzRICBSP	Uzbek Research Institute of Cotton Breeding and Seed Production
UzRIHVWM	Uzbek Research Institute of Horticulture, Vine Growing and Wine Making named R.R. Shreder
UzRIPI	Uzbek Research Institute of Plant Industry
VEGTBUD	Station of Budapest, Vegetable Crops Research Institute (Hungary)
VINATRI	Tea Research Institute of Viet Nam
VIR	N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry (Russian Federation)
W6	Western Regional Plant Introduction Station, United States Department of Agriculture, Agricultural Research Services, Washington State University
WABNET	West Africa Biosciences Network
WACCI	West African Centre for Crop Improvement
WADA (AUS137)	Australian Trifolium Genetic Resource Centre, Western Australian Department of Agriculture
WADA (AUS002)	Western Australian Department of Agriculture (Australia)
WANA	West Asia and North Africa
WANANET	West Asia and North Africa Genetic Resources Network
WARDA	West African Rice Development Association
WASNET	West Africa Seed Network
WCF	World Cocoa Foundation

WCMC	World Conservation Monitoring Centre
WDPA	World Database on Protected Areas
WICSBS	West Indies Central Sugarcane Breeding Station
WIEWS	World Information and Early Warning System on PGRFA
WIPO	World Intellectual Property Organization
WLMP	Sir Alkan Tololo Research Centre, Bubia (Papua New Guinea)
WRS	Cereal Research Centre, Agriculture and Agri-Food Canada
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization

Plant genetic resources provide a basis for food security, livelihood support and economic development as a major component of biodiversity. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture demonstrates the central role plant genetic diversity continues to play in shaping agriculture growth in the face of climate change and other environmental challenges. It is based on information gathered from Country Reports, regional syntheses, thematic studies and scientific literature, documenting the major achievements made in this sector during the past decade and identifying the critical gaps and needs that should urgently be addressed.

The Report provides the decision-makers with a technical basis for updating the *Global Plan of Action on Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture.* It also aims to attract the attention of the global community to set priorities for the effective management of plant genetic resources for the future.

ISBN 978-92-5-106534-1

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I1500E/1/4.10/3000