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15. Plant Genetic Resources Activities: International Perspective - R.K Arora, R.S. Paroda and J.M.M. Engels

Introduction

The field of plant genetic resources (PGR) has gained much momentum, particularly in the last two decades. It is well realised now that no single country or region can be self-sufficient in its needs on genetic diversity. It is estimated that average inter-dependence between all regions of the world is more than 50 percent - for some regions it may even be more than 90 percent (Wood, 1988). By and large, mankind depends on barely 25 crops for its major needs (Harlan, 1975). The monoculture practices, environmental degradation and urban development - all have contributed to loss of plant genetic diversity, so vital to man's food security (van Sloten, 1990 a, b). The need to protect and conserve these resources more systematically is getting recognised now more and more, and over 100 national programmes are presently operating (van Sloten, 1990 b). However, with the spread of awareness in plant genetic resources in **global** context, several issues have emerged and plant genetic resources have become the subject of political and economic controversy. Thus, **global** collaboration in PGR activities and their management is of vital importance (Esquinas-Alcazar, 1989; van Sloten, 1990 a, b).

The term 'Genetic Resources' started with the technical conference organised by the Food and Agriculture Organisation (FAO) in Rome in 1967, wherein scientific principles, methodologies and strategies of exploration, conservation, evaluation and documentation were elaborately discussed for the first time. A follow up of this resulted in a report on the survey of crop genetic resources (Frankel, 1970) and through subsequent conferences, in two more very timely publications (Frankel and Bennett, 1970; Frankel and Hawkes, 1975). Since then the activities have developed fast in national and international perspective. As for India, the national concern is well discussed in Chapter 14 of this book and, by and large, is also properly reflected in other topic-specific chapters. Here, it is intended to deal with the role of international organisations which have gone a long way in initiating, promoting and accelerating concern on plant genetic resources in all possible dimensions of PGR activities.

CGIAR

The Consultative Group on International Agricultural Research (CGIAR) was established in 1971. It is an association of countries, international and regional organisations and private foundations dedicated to supporting a system of agricultural research centres and programmes around the world (IBPGR, 1989 b). The research carried out is directed to improve the quantity and quality of food production in developing countries. The World Bank, FAO and UNDP are co-sponsors of this effort. The CGIAR is advised by a Technical Advisory Committee (TAC).

Currently, 13 International Agricultural Research Centres (IARCs) are working under the aegis of the CGIAR. Of these, nine are crop commodity institutes and are also involved in the conservation and utilisation of plant genetic resources (Hawkes, 1985; van Sloten, 1990 a, b). However, the main Centre for PGR activities under the CGIAR is the International Board for Plant Genetic Resources (IBPGR).

The purpose of the CGIAR support to plant genetic resources is to ensure that the diversity of germplasm is safely maintained and made freely available for use in research and crop improvement for long-term benefit of all people. The CGIAR seeks to achieve this goal both directly through the institutions it supports and indirectly through strengthening national capabilities. The PGR activities supported by the CGIAR are thus diverse and include exploration and collection, characterization, multiplication, evaluation, conservation, data management, information service and the supply of germplasm to plant breeders/research workers. Where appropriate, these activities are supported by research and training (IBPGR, 1989 b; van Sloten, 1989; 1990 a, b).

IARCs

Table 1 lists the 13 International Agricultural Research Centres (IARCs) of the CGIAR, the countries where these are situated and their mandate. Fig. 1 shows their geographical location. Of these, nine are crop commodity centres. With well defined goals, the efforts of these IARCs directed towards augmenting genetic diversity in their mandate crops have been appreciable (Hawkes, 1985). Table 2 lists the germplasm accessions assembled by these IARCs which represent a sizable part of the total world holdings for the respective crops. The world germplasm **collections** of food crops are listed in Table 3 based on recent analysis (Chang, 1987; Anderson *et al.,* 1988; van Sloten, 1990a). This also indicates the percentage of genetic material in terms of landraces and wild species, and the possible degree of threat posed to material still to be collected. The degree of comprehensiveness of germplasm **collections** among major food crops may thus be ranked in the order of cereals, common or Irish potato, grain legumes, sorghum and millets, cassava, soybean and peanuts, sweet potato and yam (Chang, 1987). It is also estimated that the duplication of accessions within a crop among the various genebanks may vary from 35 percent (in peanut) to 75 percent (in wheat). Details of lesser crops are given in papers published by Plucknett *et al.* (1983) and Lyman (1984). Most of the IARCs now have or are in a process of getting established long-term conservation facilities (van Sloten, 1990 a, b). These centres are also equally concerned with the development of overall data bases on world holdings of their mandate crops.

Fig. 1. The location of 13 International Agricultural Research Centres (IARCs) of the Consultative

Group on International Agricultural Research (CGIAR)

Table 1. International Agricultural Research Centres (IARCs) within the Consultative Group on International Agricultural Research, listed in order of year established

Acronym	Centre	Year Established	Research Programmes	Location
IRRI	International Rice Research Institute	1960	Rice	Philippines
CIMMYT	International Maize and Wheat Improvement Centre	1964	Maize, wheat, triticale, barley	Mexico
IITA	International Institute of Tropical Agriculture	1965	Maize, rice, cowpea, sweet potato, yams, cassava	Nigeria
CIAT	Centre Internacional de Agricultura Tropical	1968	Cassava, beans, rice, pastures	Colombia
WARDA	West Africa Rice Development Association	1971	Rice	Ivory Coast
CIP	International Potato Centre	1972	Potato	Peru
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics	1972	Chickpea, pigeonpea, pearl millet, sorghum, groundnut	India
ILRAD	International Laboratory for Research on Animal Diseases	1974	Trypanosimiasis, theileriosis	Kenya
IBPGR	International Board for Plant Genetic Resources	1974	Plant genetic resources	Italy
ILCA	International Livestock Centre for Africa	1974	Livestock production systems	Ethiopia
IFPRI	International Food Policy Research Institute	1975	Food policy	USA
ICARDA	International Centre for Agricultural Research in the Dry Areas	1976	Wheat, barley, triticale, faba bean, lentil, chickpea, forages	Syria
ISNAR	International Service for National Agricultural Research	1980	National agricultural research	Netherlands

Many of the centres also have economic or farming-systems research programmes. For locations of centres, see Fig. 1.

Table 2. Germplasm holdings of IARCs (van Sloten, 1990a)

IARC		Rounded number of accessions
CIAT	(Centro Internacional de Agricultura Tropical, Colombia)	66,000
CIMMYT	(International Maize and Wheat Improvement Centre, Mexico)	70,000
CIP	(International Potato Centre, Peru)	12,000
ICARDA	(International Centre for Agricultural Research in Dry Areas, Syria)	87,000
ICRISAT	(International Crops Research Institute for the Semi-Arid Tropics, India)	96,000

IITA	(International Institute of Tropical Agriculture, Nigeria)	36,000
ILCA	(International Livestock Centre for Africa, Ethiopia)	9,000
IRRI	(International Rice Research Institute, Philippines)	83,000
WARDA	(West Africa Rice Development Association, Cote d'Ivoire)	6,000
	Total	466,000
	Percentage of unduplicated world holdings*	35%

* Total worldwide holdings are estimated at 2,600,000 accessions, containing a considerable amount of duplication, possibly up to 60 percent (source: Holden, 1984). The number of unique samples in genebanks around the world is, therefore, estimated at 1,050,000. Allowing for an increase of unique material over the past six years, the current estimate of unique samples is 1,300,000.

Table 3. Collection of food crop germplasm (Anderson *et al.,* 1988)

Crop	Accessions in major gene banks (thousand)	Distinct accessions (thousand)	Percentage of genetic materials collected[a]		Threat to uncollected material
			Landraces	Wild species	
Wheat	400	125	95	60	Medium
Rice	200	70	70	10	Medium
Maize	70	60	90	n.e.*	n.a.
Barley	250	50	40	10	Medium
Sorghum	90	20	80	10	High
Phaseolus beans	65	33	50	10	Medium/low
Groundnut	33	10	70	50	Low
Sweet potatoes	8	3	60	1	High
Potatoes	42	30	95	n.e.	Low
Okra	3	2	80	3	Medium
Cowpeas	18	12	75	1	High

* n.a. Not enough information available., n.e. not estimated., a. The **base** for the percentage is a collection that is judged to be adequate; *Source*: IBPGR 1984.

The importance and relative advantage of the IARCs are:

1. The maintenance of **global collections** of the mandate crops, their thorough evaluation and active utilisation in the breeding programmes, are all integrated programmes in one and the same institute.

2. The existence of well managed cooperating networks with the national programmes mainly on crop improvement, but also more and more on PGR. This has facilitated the flow of germplasm and helped building-up capabilities/facilities in the participating countries.

The IBPGR has substantially assisted the IARCs to collect germplasm which is held in trust by the IARCs and in other PGR research activities. Since 1988, IBPGR and the concerned Genetic Resources Units of the IARCs meet regularly and discuss PGR issues of common interest in an Inter-Centre PGR Working Group.

IBPGR and its activities

The International Board for Plant Genetic Resources (IBPGR) was established in 1974 within the CGIAR system to promote and coordinate the collection, conservation, documentation, evaluation and use of germplasm. Since its inception, IBPGR has been instrumental in accelerating germplasm collecting activities based on crop as well as regional priorities according to the loss of genetic diversity through spread of modern cultivars/HYVs or other bio-ecological causes resulting in the depletion of genetic diversity.

In 1986, the CGIAR approved an extended mandate to enable IBPGR to catalyze whatever actions were needed to support and widen the already existing **global** genetic resources **network**. This mandate is to further the study, collection, preservation, documentation, evaluation and utilisation of the genetic diversity of useful plants for the benefit of people throughout the world. IBPGR shall act as a catalyst both within and outside the CGIAR system in stimulating the action needed to sustain a viable **network** of institutions for the conservation of genetic resources for these plants.

In order to meet the requirements as described in the mandate, IBPGR reconstructed its programme as follows (Engels, 1989; van Sloten, 1989, 1990 a, b):

Germplasm acquisition: monitoring degree of genetic erosion, collecting threatened germplasm, supplementing existing gaps in germ-plasm **collections** and facilitating germplasm flow on a **global** scale.

Germplasm characterization and evaluation: generating the badly needed data on the existing **collections** through standardization of procedures to process, store and distribute characterization and evaluation data. Data acquisition, data analysis, application and evaluation strategy are the programme elements.

Training: the development of conceptual, technical and managerial skills through support of manpower training. This involves postgraduate training, specialized short technical courses, individual training and intern fellowships.

In-vitro culture research: development of *in-vitro* techniques for the collection, conservation and exchange of genotypes for recalcitrant species including collecting and tissue culture technology, disease indexing and therapy, cryopreservation, genetic stability and a pilot study for *in-vitro* genebanks.

Genetic diversity research: to enhance our understanding on the origin, evolution and variation patterns of crop genepools. This includes species mapping, ecogeographic studies, development of biochemical methods of description and research on wild relatives in priority crop genepools.

Seed conservation research: to establish and implement standards for seed storage. This effort includes study of physiology of stored orthodox and recalcitrant seeds, their genetic stability, dormancy, regeneration and genetic integrity as well as non-destructive disease indexing.

***Global** genetic resources **network**:* developmental activities with the cooperating national programmes and IARCs including fostering **base** and active **collections** and data management and transfer. The important role of crop germplasm networks is more and more realised and used as an organisational instrument to bring all concerned workers together.

Technical services: provision of technical advice and information to all staff and scientific community, public affairs, publications and library.

The real strength of IBPGR in promoting PGR activities on **global** basis, particularly in the context of national programmes, has been its outreach programme (van Sloten, 1989; 1990 a, b). Eight regional offices have been established in different continents and spread in areas of developing countries, mainly those which hold rich genetic wealth, viz. in Mexico (based in CIMMYT, for Meso-America and the Caribbean); in Cali, Colombia (based in CIAT, for South America); in Rome (based at IBPGR Headquarters for Europe, North Africa and South-West Asia); in Niamey, Niger (based in the ICRISAT Sahelian Centre for West Africa); in Nairobi, Kenya (based in ILRAD for East and Southern Africa); in New Delhi, India (based in NBPGR, for South and South-East Asia - with a sub-office in Los Baños, the Philippines, based in IPB, for South-East Asia), and in Beijing, China (based in CAAS for East Asia). In addition, IBPGR's full time plant collectors are based in Cyprus and Zimbabwe. Distribution of germplasm collected as seed through the IBPGR supported missions is decentralized with Seed Handling Units in Kew, UK; Singapore; and Turrialba, Costa Rica (Fig. 2; van Sloten, 1989, 1990a).

Fig. 2. The IBPGR network

The regional offices provide vital links within their area of operation between the IBPGR, national programmes and regional programmes in gearing PGR activities in the national plant genetic resources systems (van Sloten, 1990a). They also effectively maintain coordination and cooperation with the IARCs and other regional/international organisations within their jurisdiction. They organise periodic meetings of the national PGR coordinators of different countries within the region. Thus, these offices are playing greater coordinating role, advisory service and on-spot guidance to national programmes as per the needs of the latter. The professional staff at each office, Coordinator, Associate Coordinator or Assistant Coordinator, maintain effective dialogue and cooperation and are IBPGRs true life-lines in catalyzing and strengthening such activities.

Some of the major past achievements of the IBPGR are summarized below (Engels, 1989; van Sloten, 1990 a, b):

1. The development of a **global network** of genebanks to conserve germplasm. At present, the **network** comprises over 100 operating genebanks in developing and developed countries.

2. The stimulation of other institutions on national, regional and international levels to assume the responsibility to collect, characterize and store plant genetic resources. These genebanks now operate in over 100 countries and range from emergent national entities to highly sophisticated centres in the CGIAR and in some national programmes.

3. The establishment of priorities by species and regions for the collection of threatened germplasm. Over 400 collection missions worldwide were organised and/or supported.

4. The support to train over 1450 individuals in all aspects of genetic resources conservation and utilisation.

5. The standardisation of characterization and evaluation activities through the production of descriptor lists for all major crop species (over 60 crop descriptors have been prepared).

6. The publication and dissemination of scientific reports, directories and newsletters.

Between 1974 and 1989, 188,419 samples have been collected by the IBPGR or with IBPGR support (van Sloten, 1990 a, b). These are listed in Table 4. It should be mentioned here that IBPGR does not possess any germplasm itself, all the material collected with its support is maintained in one or more **global base collections** and with the respective national programmes.

Tables 4. Germplasm collections made with IBPGR support upto 1989 (van Sloten, 1990a)

Cereals	74,516
Forages	29,058
Food legumes	28,856
Root and tubers	19,140
Vegetables	17,012
Industrial	8,483
Fruits	7,237
Others	4,117
Total accessions collected	1,88,419

At present, some of the major issues in the PGR community and, therefore, of major concern to IBPGR are:

1. **Global network** of **base collections**.
2. Crop genetic resources networks.
3. Integrated conservation strategies.
4. Information management in databases.

Some other issues of concern to the IBPGR and relevant to the readers deal with biodiversity, biotechnology and the intellectual property rights.

Global network of base collections

Since 1976, the IBPGR has identified a number of **base** collection genebanks around the world to maintain **collections** of specific crops on a regional or **global** basis. These **base collections** cover mainly cereals (wheat, rice, maize, barley, sorghum and millets, oats and rye); food legumes (chickpea, faba bean, groundnut, lentil, lupin, *Phaseolus,* pigeonpea, soybean, mung bean, cowpea and winged bean); rootcrops (cassava, potato and sweet potato); vegetables (*Allium,* amaranth, *Capsicum,* cruciferous crops, cucurbits, okra, tomato and egg plant); industrial crops (cotton, sugarcane and tobacco); and forage legumes and grasses (16 genera). These genebanks hold the **collections** of specific crops under conditions which preserve their long-term viability. However, some of these **base collections** are held by centres with only medium-term storage conditions which are accordingly being encouraged to upgrade their facilities to attain the standards necessary for long-term seed storage.

So far, the IBPGR has an understanding with 39 genebanks for the long-term conservation of most of the major and a number of minor crops with orthodox seed (FAO, 1989b); of these, 31 are in the national institutes of the following countries: *Africa:* Ethiopia; Asia and the *Pacific:* Australia (2), Bangladesh, China P.R., India, Japan (3), the Philippines and Thailand (2); *Europe:* Belgium, Federal Republic of Germany (2), Greece, Hungary, Italy, the Netherlands, Poland, Portugal, Spain (2), Sweden, the UK (2), and the USSR; *Latin America* and the *Caribbean:* Argentina, Brazil and Costa Rica; *North America:* Canada and the USA; seven are located in the GGIAR centres (CIAT, CIP, ICARDA, ICRISAT, IITA, ILCA and IRRI); and one in the Asian Vegetable Research and Development Centre (AVRDC). Appendix I (a and b) gives the details on such genebanks (IBPGR, 1990), while the current status of institutes with long-term seed storage facilities, both in the developed and developing countries, is depicted in Fig. 3 (van Sloten, 1990 b).

Fig. 3. The number of institutes with long-term seed storage facilities (van Sloten, 1990b)

Crop genetic resources networks

The primary objective of a crop **network** is to improve and/or coordinate conservation and utilisation of the crop genepool starting with a dialogue between all concerned parties-germplasm collectors, curators, researchers, breeders and other users -following an integrated approach (IBPGR, 1989a; van Sloten, 1990 a, b). Through stimulating the developments of such networks, IBPGR is aiming at:

1. long-term secure storage in **base collections**;
2. ready provision of information through databases; and
3. ready availability of samples from active **collections** linked with **base collections** and improved use of crop genepool.

The IBPGR will act as a catalyst in bringing the specialists together who then develop plans for the **network**. The coordination of such networks can be with an international centre or a lead breeding institute. In order to gain experience and develop the concept, a task force was established and a pilot programme was launched to promote this concern on eight crops, viz. barley, maize, groundnut, sweet potato, medics, banana, okra and sugarbeet. Each **network** is being developed through meetings/workshops designed to bring together national and international bodies, **base** and active collection curators, researchers as well as the user community. Once these initially identified networks have been set up, IBPGR plans to devote more resources to creating others. Eventually, it is hoped that networks will be established for all major crops as well as for many of the minor species, and that these networks will become self-sustainable. The scheme of IBPGR's concept of networks is given in Fig.4 (van Sloten, 1989).

Fig. 4. Schematic plan of IBPGR's concept of crop networks (van Sloten, 1989)

Integrated conservation strategies

The starting point for devising a conservation strategy is the composition of the genepool. It will be more likely that a balanced application of technologies will be needed in both *in-situ* and *ex-situ* conservation. Within the latter category, a further balance needs to be made between seed, field genebank, *in-vitro,* pollen and, perhaps in the future, DNA and gene storage. Depending on the biological factors (Table 5), available (technical) infrastructure, amount of accessions at hand and some other factors, one will choose one or a combination of conservation methods for a given genepool. Examples of three selected crops are given in Fig. 5 demonstrating the differences between orthodox and recalcitrant seed crops between sexually and asexually propagated crops, between annual and perennial species, and the existence and/or distribution of the wild species in their natural habitat. In the latter case, the relevance by *in-situ* conservation is there, whereas a crop like coconut without related wild species does not require extensive *in-situ* conservation. The methods, listed in Table 6, are not all suitable for long-term conservation. The majority are only suitable for short or medium-term conservation, and some others such as cryopreservation and DNA or gene libraries need further research to be safely utilised for long-term conservation. At present, only seed storage and, although less used so far, pollen storage, are safe and suitable methods enabling long-term static conservation of genetic diversity. In the case of *in-situ* conservation, one allows the naturally occurring species to evolve in their ecosystem and, if proper monitoring is available, this will be an adequate form of dynamic conservation (Engels, 1990). A model developed by IBPGR depicting complementary conservation methods (van Sloten, 1990a), is elaborately dealt with in Chapter 11.

Table 5. Biological factors determining conservation methods (Engels, 1990)

Biological factors	Preferred conservation methods	Remarks
1. Perennial species (especially tree species)	*In-situ/field* genebank *In-vitro*/seed and/or pollen storage	If tree species, be required for utilisation purpose
2. Annual species	Seed and/or pollen storage/ *in-vitro* field genebank	See also factors 3, 4, 6 and 7
3. Orthodox seeds	Seed storage	
4. Recalcitrant seeds	*In-vitro/in-situ/*field genebank/pollen	As under 1
5. Synthetic seeds	As orthodox seeds	Method under development
6. Vegetatively propagated species without viable seeds	Field genebank/*in-vitro*/pollen /cryopreservation	
7. Vegetatively propagated species with viable seeds	Field genebank/seed/pollen/ *in-vitro*/Cryopreservation	Field genebank or genotype needs to be conserved
8. Long living pollen	Pollen storage	
9. Tissue culturing feasibility	If low, look for alternative method	
10. Cryopreservation feasibility	If low, look for alternative method	
11. Genetic stability	If low for certain method, look for alternative method	

Fig. 5. The holistic conservation strategies-the approach is illustrated by examples of rice, sweet potato and coconut (Engels, unpublished)

Table 6. Most common methods used for germplasm conservation and the corresponding PGR categories (Engels, 1990)

Methods	Predominantly conserved PGR categories by corresponding method
Biosphere reserve	Ecosystem/biodiversity by and large
Nature reserve	Specific habitat/wild and/or weedy species genepool
Gene sanctuary	Ecosystem(specific)/ wild species genepool
On farm conservation (mass reservoirs, bulk hybrid populations)	Agro-ecosystem/landraces
Botanical garden/arboretum	Wild species, obsolete cultivars, tree crop germplasm
Field genebank	Wild species, vegetatively propagated crops, tree crop germplasm
Plant organ storage	Vegetatively propagated crops, mainly in the form of roots, tubers and bulbs
Seed storage	AH plant species which produce fertile and orthodox seeds
Pollen storage	In principle all species which produce long living pollen

In-vitro storage	Wild and cultivated species which produce recalcitrant or no seeds, vegetatively propagated crops, disease free germplasm as well as orthodox seeds
Cryopreservation	Germplasm mentioned above which permits cryopreservation
DNA and gene libraries	Special genetic stocks; in principle applicable for all germplasm

PGR data management

Central crop databases

The IBPGR coordinates and promotes a large **network** of crop genetic resources activities and has to collect, organise and provide information concerning different activities within the **network**. This category of information covers manpower, infrastructure and organisation of national programmes, active projects, scientific literature, training, germplasm collection with IBPGR support, etc. The IBPGR documentation programme is thus multidimensional and currently consists of the following major components:

1. Development and promotion of the use of standards for the documentation of genetic resources.

2. Support to national and international programmes to establish and/or strengthen systems for efficient handling of the data, and to acquire adequate data on accessions in **collections**.

3. Analysis and dissemination of genetic resources information on crops and other activities e.g. collecting, conservation, training, etc.

Central crop databases

Numerous advantages of integrating the data on germplasm held in different centres into one computer database were recognised by the IBPGR years ago. The technological advances in the field of data processing has made implementation of such databases technically feasible at a reasonable cost. Thus, in 1982, the IBPGR entered this new area of documentation of genetic resources, and the following policy was adopted with regard to establishment of centralised crop databases:

1. The data bases should be organised separately for each crop.

2. Crop databases should be located in an internationally recognised 'Centre of excellence' for the crops concerned.

3. Databases for mandate crops of the IARCs of the CGIAR should preferably be dealt by the IARCs concerned.

A central database should enable both managers of genebanks and agencies coordinating genetic resource activities to target collecting efforts; see whether accessions are safely deposited in **base collections** and available from active **collections**; plan collaborative trials aiming at characterization and/or evaluation of germplasm etc. Thus, a database is a service to breeders and other users.

FAO and plant genetic resources activities

FAO commission on plant genetic resources

International agreements/code of conduct

The initial role of the FAO, much earlier to the establishment of the IBPGR and the activities of the IARCs, has already been pointed out. Since 1983, FAO has developed a **global** system in plant genetic resources. This includes (Esquinas-Alcazar, 1989):

1. A flexible legal framework - the International Undertaking on Plant Genetic Resources;
2. An intergovernmental forum - the Commission on Plant Genetic Resources, and
3. The beginning of a financial mechanism - the International Fund for Plant Genetic Resources.

The *International Undertaking on Plant Genetic Resources* is a formal arrangement, the objective of which is to ensure that plant genetic resources, especially species of present or future economic and social importance, will be explored, collected, preserved, evaluated and made available without restriction for breeding and other scientific purposes. The *Commission on Plant Genetic Resources* is a unique intergovernmental **global** forum, where countries which are donors or users of germplasm as well as those which are sources of germplasm can discuss matters related to plant genetic resources on an equal footing, and monitor the implementation of the principles contained in the International Undertaking. The *International Fund For Plant Genetic Resources* is to help ensure the conservation and promote the use of plant genetic resources on a sustainable basis at world level. The Fund provides the mechanism for countries, intergovernmental and non-governmental organisations, and private industries and individuals to fulfil the common responsibility to maintain the world's plant genetic diversity (Esquinas-Alcazar, 1989). To date, 122 countries have either joined the Commission (102), have agreed to adhere to the International Undertaking (90) or taken both steps. In short, the above aspects safeguard the conservation and use of biological diversity, in plant genes, genotypes and genepools; at molecular, population, species and ecosystem level.

FAO commission on plant genetic resources

The role of the International Commission on Plant Genetic Resources is to serve as a unique intergovernmental body that monitors the implementation of the Undertaking, and ensures the comprehensiveness and efficiency of the **global** system in full coordination with other national, regional and international organisations involved. Since the establishment of the Commission in November 1983, and during the debates in its first two meetings (March 1985 and March 1987), which were attended both by member and non-member countries of the Commission (the latter as observers), the major reservations raised by some countries to the FAO Undertaking and Commission have been in regard to: (i) the compatibility of the Undertaking with existing national laws related to Plant Breeders' Rights for many developed countries and to restriction of exchange of certain species in some developing countries; (ii) the possible overlap between the Commission and other organisations dealing with plant genetic resources. Apart from Plant Breeders' rights, Farmers' rights have also been recognised. The International Undertaking recognises the rights of both plant breeders and farmers to benefit from their contributions to the improvement of agriculture. The adoption of Plant Breeders' rights has encouraged the development, marketing and widespread use of improved crop varieties but it has been partly responsible for reduction in the pool of crop germplasm conserved by growers. The effects of the adoption of Farmers' rights are not yet evident but should result in improved funding for and appreciation of plant genetic resources. The International Commission on PGR will have the responsibility to provide a continuing scientific and technical contribution to the discussions and debates on these topics and ensure that information of the highest standard is readily available as a basis for the formulation of national and international policies on germplasm availability and exchange (FAO, 1989b).

International agreements/code of conduct

The Commission considered the development of international agreements for the conservation and use of plant genetic resources.

In this context, it recommended that the Secretariat, in cooperation with the Working Group, should draft a code of conduct for international collectors of germplasm as also cover the conservation and use of PGR; and develop a code of conduct for biotechnology as it affects conservation and use of plant genetic resources.

FAO/IBPGR/IARCs collaboration

The IARCs and IBPGR recognise the importance of collaboration and consultation with FAO on all aspects of plant genetic resources activities. It is further recognised that FAO and the FAO Commission are probably in a better position than IBPGR and IARCs to address a number of issues of a political nature, many of which require governmental legislation. Some specific areas for collaboration are (van Sloten 1989; 1990 a, b; and the recently signed Memorandum of Understanding between the IBPGR and the FAO):

1. The Commission is to continue to follow-up on the free availability of germplasm and the support of all IARCs to the joint FAO/ IBPGR effort on the development of guidelines for the safe transfer of germplasm of specific crops.

2. The establishment of an organisational framework for plant genetic resources work at the national and, if required, at the regional level. The IBPGR and IARCs have for some time recognised the need for national committees, programmes and coordinators, through which and with whom they can work. It is believed that it should be the responsibility of the Commission to encourage the countries to establish this structure.

3. It is recognised that in a number of countries the development of national programmes requires technical assistance for institution building. The IBPGR and the IARCs can provide the scientific inputs in joining FAO and the Commission in mobilizing these funds.

4. In the setting-up of crop networks, the Commission should be involved in obtaining the agreements for the designations of Centres to hold **base collections**. The technical aspects of coordinating the networks and filling the gaps in collecting and characterization can be undertaken by IBPGR/IARCs and the collaborating institutes.

5. Safety duplication of **base collections** in permafrost could be another area for collaboration between the Commission, the IARCs and IBPGR.

6. The designation of *in-situ* reserves is a national responsibility; the Commission should follow this up with the Governments concerned. IBPGR and IARCs can advise on the technical aspects of the identification and management of these areas.

7. National capability in germplasm evaluation and plant breeding in developing countries requires strengthening and this is seen as a major task of the Commission and the FAO.

Other international/regional organisations

Besides the CGIAR **network** and the FAO, there are several other centres involved in PGR activities. The Asian Vegetable Research and Development Centre (AVRDC, Taiwan) has performed parallel activities as those of the IARCs. The International Development Research Centre (IDRC) is also actively engaged in PGR utilisation and conservation - bamboos and rattans, banana, oilseeds, smaller millets; the International **Jute** Organisation (IJO) in promoting collection, utilisation and conservation of **jute** and kenaf genetic resources; the Japanese International Cooperation Agency (JICA); the German Agency for Technical Cooperation (GTZ); USAID and other assistance agencies in creating conservation facilities. There is an International **Network** for the Improvement of Banana and Plantain (INIBAP, France), the Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia); well established country centres, such as the National Plant Germplasm System, USDA (USA), and the N.I. Vavilov All-Union Scientific Research Institute of Plant Industry/VIR (USSR); in Africa, the Plant Genetic Resources Centre/Ethiopia (PGRC/E); in Latin America, CENARGEN, Embrapa (Brazil); in East Asia, the Institute of Crop Germplasm Resources under the Chinese Academy of Agricultural Sciences (CAAS), Beijing; in South-East Asia, the National Plant Genetic Resources Laboratory, University of the Philippines at Los Baños, Philippines; and in South Asia, the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India. Lately, the Commonwealth Science Council (CSC), UK, has also exhibited much concern and interest in this discipline, confined to lesser known plants/traditional useful plants-plants of ethnobotanical interest (Paroda *et al.,* 1988; Harris and Kapoor, 1990). The objectives of these centres/organisations may vary broadly depending on national/regional/international mandate but, by and large, the PGR activities carried out by them are complementary, with emphasis on conservation and utilisation of plant genetic wealth. More recently, much concern on these activities has been highlighted, both globally and nationally, by several NGOs (Non-Governmental Organisations)/voluntary organisations such as RAFI, KENGRA, GRAIN, and in India, the Chipko movement.

Biodiversity

Biological diversity is basic to both ecological and food security. Sustainable advances in biological productivity will not be possible without access to biological diversity (Swaminathan, 1989). Thus, safeguarding this endowment of nature is of paramount importance to human welfare. Its conservation is now receiving more and more attention. Several United Nations agencies have become involved in this field including the FAO, United Nations Environment Programme (UNEP), and the United Nations Educational, Scientific and Cultural Organisation (UNESCO). Many non-governmental organisations are involved in the discussions on the conservation of biodiversity as well, both at the **global** and the national level. At the **global** level, this includes organisations, such as the World Wide Fund for Nature (WWF), the International Union for Conservation of Nature and Natural Resources (IUCN), the World Resources Institute (WRI), and many others (van Sloten, 1990a; IBPGR, 1990b).

Most of the organisations mentioned here are concerned about species loss rather than the loss of diversity within species. Nevertheless, there is a movement by these organisations to look below the species level as well, as shown in the 'Botanic Gardens Strategy' discussed below. A **global** UN Conference on the Environment and Development will be held in Brazil in June 1992, and biodiversity will play a central role in the debates.

Botanic gardens and plant genetic resources conservation

In a recent document prepared by the WWF and IUCN-BGCS (1989), it has been pointed out that as many as 60,000 plant species may be in danger of extinction or serious genetic erosion during the next 30 to 40 years. Thus, multi-pronged efforts are required to halt such species extinction and promote their conservation, study and utilisation. The botanical gardens have to play a pivotal role in this context with the triple purpose of conservation, propagation and public awareness. Their role in the last few centuries as centres of plant collection, introduction and distribution of material as well as seats of active research in systematic and economic botany has been well realised all over the world.

There are about 1500 botanic gardens and arboreta in the world, and these are playing their role in achieving conservation of plant life - wild species, cultivated types and as seeds in genebanks. The three main objectives of the living resources conservation are to:

(a) maintain essential ecological processes and life support systems,

(b) preserve genetic diversity, and (c) ensure that the utilisation of species and ecosystem is sustainable (WWF-IUCN-BGCS, 1989). Currently, the IUCN Botanic Gardens Conservation Secretariat (BGCS) is operating from Kew Garden, Richmond, UK.

The Botanic Gardens Conservation Strategy provides a rationale for the involvement of botanic gardens in conservation, and gives policy guidance on how this can be achieved and the urgency of this task. It recommends that:

1. Each individual garden clarifies its commitment to conservation in a Mission Statement and adopts more professional standards of management to achieve its Mission on conservation, documentation and exchange of information on plant species held.

2. Provides the basis for a more coherent Accessions Policy that takes account of conservation needs and what plants are held in other botanic gardens.

3. For *in-situ* conservation, it outlines the role of the garden in habitat evaluation, rare species monitoring, 'habitat gardening' and managing protected areas.

4. For managed *ex-situ* conservation, proposes strict rules and procedures for the establishment of seed banks, field genebanks and other germplasm **collections**, and outlines methods of sampling populations to maintain adequate genetic variation.

It proposes that maximum emphasis be put on collaboration between gardens at a national level or, where appropriate, regional level. It recommends collaboration at international level through the IUCN Botanic Gardens Conservation Secretariat.

Developments in biotechnology

The impact of biotechnology affects the accessibility of germplasm. There has been an active interest in the use of biotechnology for germplasm work for several years. *In-vitro* collecting of germplasm and its conservation under slow growth conditions are proving to be useful additional technologies for genetic resources work. Cryopreservation techniques are also under active investigation. Analyses of species relationships in genepools using molecular genetic techniques have provided useful results to guide collecting and utilisation programmes. The development of reliable and sensitive disease indexing procedures using antibody techniques is helping the safe transfer of germplasm throughout the world. Thus, it is necessary to ensure that new techniques are adapted for wider application in plant genetic resources work. A pragmatic approach is required alongside more conventional technologies.

General considerations

The international perspective on PGR activities, as these are taking shape today, is highlighted above. The linkages and mandates of different organisations have been reflected. It is quite evident that the problems relating to management, use and conservation of plant genetic resources are of diverse nature - scientific, technical, legal and political.

Safeguarding of crop germplasm assumes high priority. Much **collections** have been made and stored in genebanks. But inside agricultural experimental stations and genebanks genetic erosion continues at an alarming rate (Chang, 1987). This is particularly so in tropical countries where high temperature and humidity shorten the period during which seeds remain viable and where a considerable number of accessions can only be maintained in rather unsafe field genebanks at a high cost. Preservation is often handicapped by lack of adequate cold storage facilities, meagre support for genebank operations, shortage of trained people or discontinuity of their service and poor financial or other incentives (Chang, 1987). These situations, which hamper genetic conservation, need to be improved.

There are, in IBPGR's **network**, around 140 **base collections** of crops and 50 centres/genebanks. This **network** now has spread to China, and links have been developed with the USSR. However, much needs to be done by major genebanks in comparing holdings, culling redundancy and filling in gaps. The goal should be to promote judicious exchange and consolidation among **collections** so that duplicate storage can be provided for every valid accession.

The quality of seeds entering storage, the efficacy of storage facilities, the extent of scientific activities, the level of management, and the security of conserved stocks of seeds vary considerably from one genebank to another. It is not surprising, therefore, that genetic erosion occurs in every genebank to some extent. A collection may suffer great losses, if it is improperly monitored for viability or if rejuvenation to produce fresh seeds is delayed.

The number of genebanks has steadily increased. The distribution of genebanks in developed and developing countries is shown in Fig. 3 (van Sloten, 1990b).

Though, during the last two decades, the IARCs and the IBPGR have facilitated international exchange of germplasm, the scenario has changed with private seed firms/multinationals coming into picture and, in some cases, monopolising specific germplasm resources to their advantage. This has led to some apprehensions that breeding of elite cultivars might fall largely into a private sector which also produce agricultural chemicals. Further, widespread government regulations related to the Plant Breeders' Rights could restrict the farmers from use of patented seeds and plants. This has been the subject of debate for quite sometime and recently, the Seed Association of India had organised an international symposium. The IBPGR concern was highlighted (IBPGR, 1983; Seed Association of India, 1990; Engels and Arora, 1990). The FAO Commission is also much involved as indicated above in these issues related to Plant Breeders' Rights and Farmers' Rights. To mitigate the apprehensions of the developing countries, some of the activists/NGOs (Mooney, 1979; Kloppenburg, 1989; Fowler and Mooney, 1990) have widely publicised these issues which are still being debated. Possibly, steps such as the implementation of International Undertaking on Plant Genetic Resources will provide a bridge to ensure free access to crop germplasm on a **global** basis. Thus, much public awareness has been generated. The society is well aware now about the importance of germplasm and its use. Practical management and policy measures need to be worked out. Some of the controversial issues are also being discussed in an independent forum facilitated by the Keystone Centre. The outcome of the second meeting in the Dialogue Series on PGR, held in Madras in 1990, has been published in a comprehensive report (Keystone, 1990).

In practice, development of improved cultivars and their distribution will remain in the hands of governmental institutions in developing countries and of the IARCs, though private sector enterprise, particularly in USA, has begun to contribute funds to germplasm conservation programmes. The CGIAR has placed equally great emphasis on these issues related to exploitation of plant germplasm and ensuring their security (Jain, 1988). There is increasing need in educating administrators, politicians, donors, journalists, social activists/NGOs, students and teachers, and the general public in this context. An expanded dialogue with many sectors of society is essential for public support. An overall PGR concern is well expressed in some of the recent thought provoking articles (Frankel, 1985, 1986 a and b, 1987, 1989; Esquinas-Alcazar, 1989; van Sloten, 1990 a, b), and books brought out on this subject (Frankel and Bennett, 1970; Frankel and Hawkes, 1975; Harlan, 1975; Frankel and Soulé, 1981; Hawkes *et al,* 1983; Holden and Williams, 1984; Plucknett *et al.,* 1987, Brown *et al.,* 1989). The growing interest and concern is also well evident from the informative international journals such as 'Diversity' from the USA, and 'Geneflow' from Rome, published by the IBPGR. Special publications such as 'Botanical Gardens Conservation Strategy' (WWF-IUCN-BGCS, 1989) and 'Plant Genetic Resources and their Conservation *in-situ* for Human Use' (FAO, 1989a) are some of the more recent additions. The national and regional programmes have also effectively contributed in this direction by organising symposia, etc. (Hutchinson, 1974; Ramanujam and Ayer, 1974; Singh and Chomchalow, 1982; Mehra and Sastrapradja, 1985; Paroda, Arora and Chandel, 1988; Suzuki, 1988; Engels *et al.,* 1991), and in bringing out relevant publications, such as training manuals (Mehra *et al.,* 1981), wild relatives of crop plants in India (Arora and Nayar, 1984) and less known edible food plants (Arora, 1985). The PGR community presently thus is much richer in its knowledge on plant genetic resources.

The above issues apart, with all our achievements on this front, there is still *a* need to augment genetic diversity from protected and natural habitats, such as unimproved germplasm grown in traditional farmlands, orchards and forestlands. The national programmes are playing a more concerted role in this direction than ever before though these are frequently handicapped by funding aspects. These gene-rich countries would need an international umbrella to support their activities. The IBPGR has been providing the required impetus in this direction through training programmes (Stalker and Chapman, 1989), distribution of information, guideline manuals, free advisory service and need-based support since its inception in collecting, conservation and documentation activities; though lately, it has taken up more of a catalyzing and advisory role. Certainly, national programmes, which are the backbone to the future build up and survival of this networking and coordination, must be strengthened further.

Summary

Concern on plant genetic resources has attained **global**, regional and national importance, particularly in the last two decades. The International Agricultural Research Centres (IARCs) are playing great role in the improvement and utilisation of their mandate crops, and in the collection and conservation of the concerned crop genetic diversity. However, the overall key role in promoting concern on plant genetic resources activities in a **global** context and in coordinating these activities is being performed by the International Board for Plant Genetic Resources (IBPGR) in close interaction with the FAO and IARCs, and the national programmes. The FAO Commission on Plant Genetic Resources, as an inter-governmental body, is concerned with several policy issues to ensure the efficiency of operating a **global** system in full coordination with national, regional and international organisations. A broad perspective highlighting these activities in international context has been discussed. The role of other international organisations, such as the International Union for Conservation of Nature and Natural Resources (IUCN), the World Wide Fund for Nature (WWF) and several others has also been stressed.

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Appendix I (a). Base collections of seed crops, which accepted responsibility for long-term conservation (IBPGR Annual Report, 1989)

Crop	Species covered		Scope of collection		Institute
			Global	Regional	
Cereals	Barley		·	*European African*	PGR, Ottawa, Canada NGB, Lund, Sweden PGRC/E, Addis Ababa, Ethiopia
			·	*Asian*	NIAR, Tsukuba, Japan ICARDA, Syria
	Maize			*New World* *Asian* *Asian* *European* *Mediterranean*	NPGS, USA NIAR, Tsukuba, Japan TISTR, Bangkok, Thailand VIR, Leningrad, USSR Portuguese Genebank, Braga, Portugal
	Millets	*Pennisetum*	·		NPGS, USA
			·		PGR, Ottawa, Canada
			·		ICRISAT, India
		Eleusine	·		PGRC/E, Addis Ababa, Ethiopia
			·		ICRISAT, India
		Minor Indian millets		*Indian*	NBPGR, New Delhi, India

		Eragrostis	·		PGRC/E, Addis Ababa, Ethiopia
		Panicum miliaceum	·		ICRISAT, India
		Setaria italica	·		ICRISAT, India
	Oats	*Avena*	·		PGR, Ottawa, Canada
			·		NGB, Lund, Sweden
			·		FAL, Braunschweig, FRG
	Rice	*Oryza sativa-indica*	·		IRRI, Philippines
		javanica	·		IRRI, Philippines
		japonica	·	*African*	NIAR, Tsukuba, Japan IITA, Ibadan, Nigeria NPGS, USA
		Wild species	·		IRRI, Philippines
	Rye		·		Polish Genebank, Radzikow
			·		NGB, Lund, Sweden
	Sorghum		·		NPGS, USA
			·		ICRISAT, India
	Wheat	Cultivated species	·		VIR, Leningrad, USSR
			·		CNR, Bari, Italy
			·		NPGS, USA
				Asian	CAAS, Beijing
			·		ICARDA, Syria
	Wild species (*Triticum* and *Aegilops*)		·		Plant Germplasm Institute, University of Kyoto, Japan
			·		ICARDA, Syria
Food	Chickpea		·		ICRISAT, India
Legumes			·		ICARDA, Syria
	Cicer spp.		·		ICARDA, Syria
	Faba bean		·		CNR, Bari, Italy
			·		ICARDA, Syria
	Groundnut		·		ICRISAT, India
				South American	INTA, Pergamino, Argentina
	Lentil		·		ICARDA, Syria
	Lens spp.		·		ICARDA, Syria
	Lupin		·		ZIGuK, Gatersleben, GDR
				European	INIA, Madrid, Spain

	Pea		·	*Mediterranean* *Central and East European*	NGB, Lund, Sweden CNR, Bari, Italy Polish Genebank, Radzikow, Poland
	Phaseolus	Wild species	·		JBNB, Bruxelles, Belgium
		Cultivated species	·		CIAT, Colombia
			·		NPGS, USA
				European	FAL, Braunschweig, FRG
	Pigeonpea		·		ICRISAT, India
			·		NBPGR, New Delhi, India
	Soybean		·		NIAR, Tsukuba, Japan
			·		NPGS, USA
		Wild perennial	·		CSIRO, Canberra, Australia
	Vigna	Wild species	·		JBNB, Bruxelles, Belgium
	V. mungo		·		NBPGR, New Delhi, India
	V. radiata		·		IPB, Los Baños, Philippines
			·		AVRDC, Taiwan, China
	V. umbellata		·		NBPGR, New Delhi, India
	V. unguiculata		·		IITA, Nigeria
			·		NPGS, USA
	Winged bean		·		IPB, Los Baños, Philippines
			·		TISTR, Bangkok, Thailand
Root	Carrot		·		IHR, Wellesbourne, UK
crops	Cassava (seed)		·		CIAT, Colombia
	Solanum spp.		·		CIP, Peru
	Sweet potato (seed)		·		NPGS, USA
				Asian	AVRDC, Taiwan, China
			·		NIAR, Tsukuba, Japan
Vegetables	*Allium*		·		CGN, Wageningen, Netherlands
			·		IHR, Wellesbourne, UK
			·		NPGS, USA

		·	*South and East European*	RCA, Tapioszele, Hungary
			Asian	NIAR, Tsukuba, Japan
Amaranthus		·		NPGS, USA
			Asian	NBPGR, New Delhi, India
Capsicum		·		CATIE, Turrialba, Costa Rica
		·		AVRDC, Taiwan, China
			Asian	NBPGR, New Delhi, India
Cruciferae	*Brassica carinata*	·		FAL, Braunschweig, FRG
		·		PGRC/E, Addis Ababa, Ethiopia
	B. oleracea	·		CAAS, Beijing, China
		·		IHR, Wellesbourne, UK
		·		CGN, Wageningen, Netherlands
	Raphanus	·		CAAS, Beijing, China
		·		IHR, Wellesbourne, UK
			Asian	NBPGR, New Delhi, India
	Wild species	·		Universidad Politécnica Madrid, Spain
		·		Tohoku University, Sendai, Japan
Oilseeds and green manures	B. *campestris*	·		PGR, Ottawa, Canada
	B. juncea		*Asian*	NBPGR, New Delhi, India
	B. napus, Sinapis alba	·		FAL, Braunschweig, FRG
Vegetables and Fodders				
	B. campestris, B. juncea, B. napus	·		IHR, Wellesbourne, UK
	B. napus	·		FAL, Braunschweig, FRG
All Cruciferae crops			*East Asian*	NIAR, Tsukuba, Japan
Lactuca spp.		·		IHR, Wellesbourne, UK

			·		CGN, Wageningen, Netherlands
	Okra		·		NPGS, USA
			·		NBPGR, New Delhi, India
	Safflower		·		NBPGR, New Delhi, India
	Tomato		·		CATIE, Turrialba, Costa Rica
			·		ZIGuK, Gatersleben, GDR
			·		NPGS, USA
				Asian	EPB, Los Baños, Philippines
	South-East Asian vegetables			*Southeast Asian*	IPB, Los Baños, Philippines
	Cucurbitaceae				
		Benincasa, Luffa, Momordica, Trichosanthes	·		IPB, Los Baños, Philippines
		Cucumis, Citrullus, Cucurbita	·		NPGS, USA
		Citrullus, Cucurbita	·		VIR, Leningrad, USSR
		Cucumis, Citrullus	·		INIA, Madrid, Spain
	Eggplant		·		CGN, Wageningen, Netherlands
			·		NPGS, USA
			·		NBPGR, New Delhi, India
Industrial crops	Beet		·		FAL, Braunschweig, FRG
			·		NGB, Lund, Sweden
				Mediterranean	Greek Gene bank, Thessaloniki
	Cotton			*Mediterranean*	Green Gene Bank, Thessaloniki
	Sugarcane (seed)		·		NAIR, Tsukuba, Japan
			·		NPGS, USA
			·	*Mediterranean*	Green Gene Bank, Thessaloniki
	Jute and Kenaf		·		BJRI, Dhaka, Bangladesh
Forages	Legumes	*Centrosema*	·		CIAT, Colombia
			·		CENARGEN, Brazil

			·		CSIRO, Brisbane, Australia
		Desmodium	·		CIAT, Colombia
			·		CSIRO, Brisbane, Australia
		Desmanthus	·		CSIRO, Brisbane, Australia
		Stylosanthes	·		CIAT, Colombia
			·		CSIRO, Brisbane, Australia
		Leucaena	·		NPGS, USA
		Lotononis	·		ILCA, Ethiopia
			·		Seed bank, RBG, Kew, UK
		Macroptilium	·		CENARGEN, Brazil
			·		CSIRO, Brisbane, Australia
		Neonotonia	·	*African*	ILCA, Ethiopia
			·		Seed Bank, RBG, Kew, UK
		Zornia	·		NPGS, USA
			·		CIAT, Colombia
		Trifolium	·	*African*	ILCA, Ethiopia
			·		Seed Bank, RBG, Kew, UK
	Grasses	*Cynodon*	·		NPGS, USA
		Cenchrus	·		Seed Bank, RBG, Kew, UK
			·		ILCA, Ethiopia
			·		CSIRO, Brisbane, Australia
		Digitaria	·		ILCA, Ethiopia
			·		CSIRO, Brisbane, Australia
			·		Seed bank, RBG, Kew, UK
		Pennisetum	·		NPGS, USA
		Paspalum	·		NPGS, USA
		Urochloa	·		CSIRO, Brisbane, Australia
Others	Tree species (*Fuel and environmental stabilization in arid areas*)		·		Seed Bank, RBG, Kew, UK
	Sesame		·		KARI, Nairobi, Kenya
			·		RDA, Rep. Korea

	Sunflower	·	*European, Mediterranean*	Research Institute of Plant Production, Czechoslovakia

Appendix I (b). Field genebanks (active collections for vegetative material) which have accepted responsibility for conservation (IBPGR Annual Report, 1989)

Crop	Species covered	Scope of collection Global	Regional	Institute
Roots and Tubers	Cassava	·		CIAT, Colombia
			Central American	INIA, Mexico
			African	IITA, Nigeria
	Sweet potato		*Asian and Pacific*	AVRDC, Taiwan, China
		·		IITA, Nigeria
Fruits	Banana	·		Banana Board, Jamaica
			Southeast Asian	PCARRD, Philippines
			African	DGRST, Cameroon
	Citrus		*East Asian*	Fruit Tree Research Station, Tsukuba, Japan
			Mediterranean	INIA, Valencia, Spain
			Mediterranean and African	IRFA, Corsica, France
			North American	USDA, USA
			Latin American	CENARGEN, Brazil
			South Asian	IIHR, India*
	Subfamily Aurantiodes	·		University of Malaya, Kuala Lumpur, Malaysia
Industrial crops	Cocoa/Cacao	·		University of the West Indies, Trinidad and Tobago
				CATIE, Costa Rica
	Sugarcane	·		Sugarcane Breeding Institute, Coimbatore, India
		·		USDA, Florida USA
Perennial species	*Allium*	·	*Short day* species	Hebrew University of Jerusalem, Israel*
		·	*Long-day* species	Research Institute for Vegetable Growing and Breeding, Olomouc, Czechoslovakia
	Arachis (wild)		*Latin American*	CENARGEN, Brazil
	Glycine (wild)	·		CSIRO, Australia

* Under discussion or awaiting formal agreement.

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