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SURVEY OF EXISTING DATA ON *EX SITU* COLLECTIONS OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Table of Contents

	<i>Para.</i>
I Introduction	1-4
II Sources of Information and Nature of Collections Covered	5-7
III Results	
1. Size and location of collections	8
2. Type of germplasm present in collections	9-10
3. Characterization, evaluation and documentation	11
4. Conservation regimes	12-13
5. Origin of germplasm	14
6. Availability and exchange	15-16
7. Duplication of collections	17-18
8. Regeneration and genetic integrity	19-20
9. Financial status of collections	21-22
IV Conclusions	23

SURVEY OF EXISTING DATA ON *EX SITU* COLLECTIONS OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

I. INTRODUCTION

1. Following the discussions in the Ninth Session of the Working Group, FAO, in close cooperation with IPGRI, has prepared the present document, to facilitate countries' negotiations in relation to access to *ex situ* collections not addressed by the Convention on Biological Diversity (see document CPGR-Ex1/94/5), within the context of the revision of the International Undertaking on Plant Genetic Resources (Resolution 7/93 of the FAO Conference).

2. Under *ex situ* conditions, plants are usually conserved in controlled environments. *Ex situ* conservation is generally carried out by institutions maintaining plant collections, in the form of seed, pollen, tissue cultures, DNA or entire plants. These institutions include genebanks, and botanical gardens. Current *ex situ* collections of plant genetic resources for food and agriculture represent the most accessible and immediately useful source of genetic diversity to improve and enhance the stability of world food production. The overall security and maintenance of such collections is of prime importance to the international community. Their actual and potential value to all peoples, both today and in the future, is great, but difficult to quantify.

3. This data survey is restricted to *ex situ* collections of plant genetic resources for food and agriculture. The results of this study should be considered in the context of the overall conservation effort, *in situ* - particularly on-farm - as well as *ex situ*. The former is particularly relevant for crops of local importance. While traditional farming systems survive, local crops are often effectively maintained on-farm within them. However, as agriculture intensifies, it is likely that the genetic base of local crops of lesser economic value will be eroded, through replacement with other crops, without them ever reaching a level of economic importance that could lead to systematic conservation efforts.

4. It should be borne in mind that, when interpreting the figures in this survey, that they refer to accessions in *ex situ* storage. This paper, by its very nature, is not intended to estimate either how much genetic diversity is represented there, nor what proportion this is of the world's existing genetic diversity for food and agriculture.¹

II. SOURCES OF INFORMATION AND NATURE OF COLLECTIONS COVERED

5. There were two broad sources of basic information for this survey: FAO's World Information and Early Warning System for Plant Genetic Resources (WIEWS/PGR) database and the International Plant Genetic Resources Institute (IPGRI).² Various other less comprehensive sources of information were also

1 The most precise measure of genetic diversity is at the DNA-level. Differences may be detected in the DNA-sequence of nuclear or cytoplasmic DNA. Total diversity, investigated at this level, is essentially unknowable in extent. At the other extreme, genetic diversity can be detected in the expression of genes at the visually-detectable phenotype level. This has been the traditional tool used in estimating plant genetic diversity. It is relatively cheap, but is not particularly accurate. Genetic diversity can, of course, also be detected through estimating diversity in the intermediate products between the DNA-segments and the expression of morphological characteristics, that is, for instance, allozymes and other chemical products in the metabolic pathways leading to the expression of genes.

2 The WIEWS/PGR database builds on a database established by IBPGR. Databases from the CGIAR Centres, as well as a TAC Report for the recent Stripe Study of Genetic Resources in the CGIAR (December 1993 - March

consulted.

6. It should be borne in mind that none of these sources of information is comprehensive, and that the information they contain is not always compatible, and sometimes contradictory. The sources of their data, and the methods employed for data acquisition and processing are often different. Moreover, data are often difficult to compare, because they have been collected at different times, or for different periods. The data contained in the WIEWS/PGR, established following the guidance of the Commission - which was officially provided by governments - may be considered the most up-to-date. Nonetheless, at the time of the survey, only 85 governments had replied to the questionnaire sent to them in 1992 and 1993, and their replies were not always complete. About half of them have verified the data entered. The questionnaire itself will be improved in the light of experience with its use, and to seek data on matters that have acquired greater importance following the Convention on Biological Diversity, such as the countries of origin, and the type of material involved.

7. Three types of collections were distinguished: national, regional and international. Data on national collections in 131 countries, which are under the jurisdiction of individual governments, are included in the analysis. They are usually housed in national genebanks, research agencies or universities, under a wide range of legal personalities. The regional collections represented in the data are those in the Tropical Agriculture Research and Training Centre (CATIE) in Central America, and the Nordic Genebank (NGB) in Scandinavia. The International collections represented were established under the aegis of the Consultative Group on International Agricultural Research (CGIAR). Currently, ten International Agricultural Research Centres (IARCs) maintain such collections within the CGIAR system. A few private collections, inventoried by national programmes for FAO, contain a further 62,000 accessions and are included here, in the national category.

III. RESULTS

III.1 Size and location of collections

8. According to the data analyzed, there are 4.41 million accessions currently in *ex situ* storage. Table 1 shows that 50.4% of accessions are held in developed countries, and 38% in developing countries; the CGIAR Centres hold the remaining 11.6%. Table 2 breaks the data down by region: Europe holds 30.4% of accessions, Asia 22%, North America 17%, Latin America 10%, Africa 6%, and Oceania 3%; the balance is the 11.6% held by the CGIAR Centres. Table 3 presents the data by groups of crops, and shows that most *ex situ* holdings are of cereals (46.8%) and food legumes (16.2%). Numerous crops that are important at the national and local level are not well represented.³ This concentration of effort on major crops is partly due to the fact that the CGIAR Centres have specific mandates for these crops.

III.2 Type of germplasm present in collections

9. It is important to ascertain the type of sample maintained *ex situ*, and, in particular, whether wild species, farmers' varieties, breeders' varieties, or other breeders' materials. Although such data are maintained in both the FAO and IPGRI databases, it is based on replies to questionnaires and other forms of

1994) were the source of the data about the CGIAR collections.

3 In certain regions, efforts have recently been made on local crops, such as, for instance, Andean roots and tubers, local leafy vegetables, and indigenous fruits and forages, which are the subject of increased collecting and conservation efforts.

enquiry, and the precise situation at the genebank level may not always be well known to the respondent. This should be borne in mind in interpreting Table 4, which summarizes the information available on the type of samples held in the collections covered.

10. Overall, the type of sample is known for over 30% of the world's holdings. In the case of the CGIAR Centres, it is identified for about 58% of the holdings, and, in the case of national holdings, for about 24%. Of world holdings for which the type of sample is recorded, 43% are varieties developed by farmers and 41% are varieties and other materials of formal breeders. The use-value of these different types of germplasm will not be the same, but will depend on who uses it. The remaining 16% is of wild samples.

III.3 Characterization, evaluation and documentation

11. The use of germplasm is facilitated when samples have been adequately characterized, evaluated and documented. Passport data have been recorded and are available for just over one-half of the world's holdings (55%), including the CGIAR-maintained germplasm. For the remaining 45%, passport data is only partial (30%), or not available at all (3%), or there is no information on these matters (12%). Of the material held in collections of the 52 countries that responded to the relevant questions in the FAO questionnaire, 55% have not been characterized for basic morphological traits. In the case of 21 of these countries, over two-thirds of their holdings have not been characterized at all. However, if duplication in the world holdings is taken into account (which may be substantial for major crops), it is possible that a particular holding has been characterized, at least in one of the duplicates: this would mean that a far greater proportion of material in *ex situ* storage has, in fact, been characterized than the figures given above suggest.

III.4 Conservation regimes

12. The data-sets provide a breakdown of holdings by maintenance type: long-term storage (0° to -18°C), medium-term storage (0° to 10°C), short-term storage (>10°C), *in vitro* storage, and storage in field collection. Over 1,200 institutions have some sort of *ex situ* collection. Of these, 308 institutes have the capacity for medium-term storage, and 175 have the capacity for long-term storage; of the latter, 119 have the capacity for storage at temperatures as low as -18°C⁴. There are no data on which to determine which institutes that have the capacity to store germplasm also have adequate storage rooms, seed testing and related facilities, or a freezer only.

13. The number of accessions maintained under each of these regimes is given in Table 5. Both *in vitro* and field collections could be categorized as either short-term or medium-term storage. However, it was not possible to make this differentiation in the analysis. There is no information on the number of accessions being cryopreserved or held in DNA libraries.

III.5 Origin of germplasm

14. The origin of a germplasm sample (that is, where the germplasm sample was originally collected or bred) is part of the basic passport data, of value for access to, and the use of, the material. Data available with IBPGR in 1987/88 on material in the world's *ex situ* collections record the country of origin of accessions in about 27% of cases. In response to questionnaires, information on origin is often not provided. There also seem to be misunderstandings as to what was meant by sample origin (particularly about the difference between the country where the material was originally developed or collected, and the country from which the gene-bank received it), which has led to inaccuracies in the data. From data available on national holdings, in

4 This is the FAO/IPGRI recommendation for long-term storage (Genebank Standards, FAO/IPGRI, 1994.)

particular, it may not be possible to draw accurate conclusions.

III.6 Availability and exchange

15. Data available with IBPGR in 1987/88 indicate that under 60% of the germplasm in *ex situ* storage is designated as "freely available". About 7% is designated as "restricted", and less than 1% (some 30,000 accessions) as "not available". There is no information on the remaining 32%.⁵

16. There is no general data-set that describes how much germplasm is exchanged and used, at a world level. According to the CGIAR Centres, they distributed over 745,000 samples between 1987 and 1991. The recipients were recorded for 80% of this material, but not always clearly. Nearly half (46%) of this exchange took place within the CGIAR system, 32% was distributed, by individual Centres, to their host country national programme, 20% to other countries, and 2% to the private sector.

III.7 Duplication of collections

17. The duplication of genetic material is an important aspect of *ex situ* germplasm management, but there is currently no global data-set containing information on duplication that can be consistently interpreted. The information available suggests that, for collections representing about 6% of total accessions, the accessions have been totally duplicated. In the case of collections representing a further 36% of total accessions, an unspecified proportion of holdings has been duplicated. The degree of safety duplication varies greatly by crop. For example, the wild wheat database indicates that, for wild *Triticum* or *Aegilops* (about 25 000 accessions at a world level), there is a very low level of duplication: slightly more than three-quarters of accessions are unique, and less than 10% of accessions occur in three or more genebanks.

18. The CGIAR Centres have duplicated for safety about 35% of their holdings in 78 backing-up genebanks. Twenty of these are located in twelve developing countries; thirty-five are located in eight developed countries; and twenty-three are located in eleven other International Centres. In total, about 9% of the IARC's accessions are backed up on the basis of a formal written agreement with the recipient institute.

III.8 Regeneration and genetic integrity

19. The FAO questionnaire asked for estimates of the number of seed accessions that were in need of regeneration within national collections. Forty-five countries replied, and gave answers that ranged from "0" to "100%". In these countries, about 46% of accessions held in national collections were estimated to be in need of regeneration.

20. Technical standards for the maintenance of the genetic integrity of *ex situ* germplasm have been defined at the international, and sometimes at the national level, for most of the activities involved in the *ex situ* maintenance of plant genetic resources. However, *ex situ* practices in common use do not ensure genetic integrity. For example, samples are often regenerated under agroecological conditions that greatly differ from those where they originated, a practice which is likely to cause genetic erosion within that sample.

III.9 Financial status of collections

21. Because of the varied nature of responses to the FAO questionnaire, it was not possible to compare

5 The reasons for non-availability are not always clear: they include that the material is in need of regeneration or multiplication, and that it is simply not available from that country.

data and reach any clear conclusions on the financial status of collections. Nonetheless, it was possible to draw a number of conclusions. Most governments indicated a stable funding situation (which should not be interpreted as a satisfactory situation), or an expected rise in funding: this results from the construction of new facilities in some developing countries, and stronger commitments to national programmes in developed countries. External funding comes essentially from the CGIAR Centres, especially from IPGRI, a few developed country governments, and a relatively few nongovernmental organizations. Private sector funding for developing countries is mainly for germplasm collecting.

22. The CGIAR Centres spend approximately \$US 16 million per year of their core funding on plant genetic resources conservation. This figure includes IPGRI's entire annual budget of about \$US 10 million.

IV. CONCLUSIONS

23. Overall, the data-sets available at the international level on *ex situ* collections of PGRFA at national, regional and international level are in need of improvement. Aside from the technical and financial security of current collections, a number of major issues seem to merit particular attention for more detailed investigation. More precise data is needed on the countries of origin of accessions and on the type of material, maintained in *ex situ* collections. The data should differentiate between the country that provided the accessions to the collections, and the country of origin of the germplasm. Work towards assembling these data should begin at the national level. There is also a need for additional studies on the exchange and use of germplasm from *ex situ* collections.

TABLE 1

***EX SITU* COLLECTIONS: BY DEVELOPMENT STATUS OF COUNTRIES
WHERE COLLECTIONS ARE HELD, AND BY THE CGIAR**

Economic Group or CGIAR	Number of Accessions	Percent of Total
Developed	2,227,200	50.4%
Developing	1,678,000	38.0%
CGIAR	510,500	11.6%
TOTAL	4,415,700	100%

TABLE 2

***EX SITU* COLLECTIONS: BY REGION, AND BY THE CGIAR**

Region or CGIAR	Number of Accessions	Percent of Total
Africa ¹	265,000	6.0%
Asia ¹	971,500	22.0%
Europe ¹	1,344,000	30.4%
Latin America	441,500	10.0%
North America	750,700	17.0%
Oceania	132,500	3.0%
Subtotal (Country and Regional) ²	3,905,200	88.4%
International (CGIAR) ³	510,500	11.6%
TOTAL	4,415,700	100%
<p>¹ This includes, for their respective regions, the collections at CATIE and NGB, since they are controlled by, or service, the governments of the region.</p> <p>² From the WIEWS/PGR data-base, May 1994.</p> <p>³ From the Stripe Study of Genetic Resources in the CGIAR.</p>		

TABLE 3

EX SITU COLLECTIONS: BY GROUPS OF CROPS¹

Crop	National Collections	CGIAR Centres	Total	% of Total ²
Cereals	1,750,200	317,200	2,067,400	46.82
Food legumes	600,200	118,150	718,350	16.27
Forages	374,450	50,900	425,350	9.63
Vegetables	336,600	--	336,600	7.62
Fruit	174,400	--	174,400	3.95
Roots and tubers	157,400	22,450	179,850	4.07
Oil crops	89,750	--	89,750	2.03
Fibre crops	70,300	--	70,300	1.59
Beverages	42,900	--	42,900	0.97
Rubber	30,500	--	30,500	0.69
Miscellaneous	17,350	--	17,350	0.39
Sugarcane	16,700	--	16,700	0.38
Narcotics and drugs	14,650	--	14,650	0.33
Condiments,spices, flavourings,herbs	10,050	--	10,050	0.23
Shelter crops	9,600	--	9,600	0.22
Chocolate crops	8,750	--	8,750	0.20
Ornamentals	4,550	--	4,550	0.10
Medicinal plants	2,950	--	2,950	0.07
Dyes	1,023	--	1,023	0.02
Perfume crops	550	--	550	0.01
Building materials	400	--	400	0.01
Weeds	17	--	17	0.00
Timber crops	10	--	10	0.00
Unknown	191,900	--	191,900	4.34
Banana		1,500 ³	1,500	0.03
Multipurpose trees		300 ³	300	0.01
TOTAL	3,905,200	510,500	4,415,700	100.0
<p>¹ According to the species groupings in WIEWS/PGR; data as in May 1994.</p> <p>² Figures do not add up to 100 due to rounding.</p> <p>³ The CGIAR Centres class bananas and multipurpose trees as separate categories. In the case of national collections, they are subsumed into other categories and not reported separately.</p>				

TABLE 4

***EX SITU* COLLECTIONS: BY TYPE OF MATERIAL¹**

Sample Type	National Collections	CGIAR Centres	Total	% of Total
Wild species	177,600	36,100	213,700	16%
Farmers' varieties ²	373,800	205,400	579,200	43%
Breeders' varieties ³	243,200	4,000	247,200	19%
Other breeders' materials ⁴	233,400	54,300	287,700	22%
TOTAL	1,028,000	299,800	1,327,800	100%
¹ Where information on the type of material is available, that is, for about one-third of the germplasm in <i>ex situ</i> collections. ² Landraces and old cultivars. ³ Advanced cultivars or commercial varieties. ⁴ Essentially "unfinished" varieties and breeding lines, genetic stocks, mutants and introgressed forms.				

TABLE 5

EX SITU COLLECTIONS: BY MAINTENANCE REGIME¹

Maintenance Regime	Number of Accessions ²
Short-term storage	628,500
Medium-term storage	2,333,100
Long-term storage	2,045,200
<i>In vitro</i> storage	37,600
Field collections	302,300

¹ From WIEWS/PGR: includes information on the CGIAR system that needs updating.
² These numbers should not be summed: the data were interpreted on the assumption that, when a mixture of categories was given, the crop is stored in *all* the indicated manners, and this may have inflated some figures. To derive percentages would be misleading.

