GLOBAL STRATEGY FOR THE *EX SITU* CONSERVATION AND USE OF BARLEY GERMPLASM

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DISCLAIMER

This document, developed with the input of a large number of experts, aims to provide a framework for the efficient and effective *ex situ* conservation of globally important collections of barley.

The Global Crop Diversity Trust (the Trust) provided support for this initiative and considers this document to be an important framework for guiding the allocation of its resources. However the Trust does not take responsibility for the relevance, accuracy or completeness of the information in this document and does not commit to funding any of the priorities identified.

This strategy document (dated October 2008) is expected to continue to evolve and be updated as and when circumstances change or new information becomes available.

In case of specific questions and/or comments, please direct them to the strategy coordinator mentioned in the document.

EXECUTIVE SUMMARY

In the initial phase of development of the Global Strategy for the *Ex Situ* Conservation and Use of Barley Germplasm, the International Center for Agricultural Research in the Dry Areas (ICARDA) in Aleppo, Syria was commissioned by the Global Crop Diversity Trust, with major input from the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) Gatersleben, Germany, to coordinate the development of a global inventory of *ex situ* collections of barley genetic resources in order to asses their content and status. The barley strategy was planned with CGIAR and FAO assistance, and significant input was provided by a group of national and international barley experts and collection managers.

The inventory was primarily based on direct responses from institutional holders of major barley collections. Additional information was obtained from different national, regional, and international information sources, such as GIBGR (Global Inventory of Barley Genetic Resources hosted by ICARDA), EBDB (European Barley Database hosted by IPK), WIEWS (World Information and Early Warning System on Plant Genetic Resources for Food and Agriculture hosted by FAO), EURISCO hosted by Bioversity International, and the regional strategies commissioned by the Trust.

The inventory showed that the total of barley germplasm holdings at 47 major barley collections (those with more than 500 accessions) was 402,000 accessions. If 28 minor collections are included, then the global total would be 405,000 accessions. Of the total of 290,820 accessions where germplasm type is known, 15% are wild relatives, 44% are landraces, 17% are breeding materials, 9% are genetic stocks, and 15% are cultivars.

Information in a tabulated form is provided on collection holders, size and composition of the collections, storage facilities, regeneration needs, status of safety duplication and germplasm distribution.

Passport information is computerized in most collections; however, availability of characterization and evaluation data electronically is lower. Data on a number of collections may be accessed via the internet, but only some are searchable on-line. Global, regional and specialized systems have been developed to link different sources of locally-curated data. These include the CGIAR System-wide Information Network for Genetic Resources (SINGER), the Global Inventory of Barley Genetic Resources (GIBGR) and the International Barley Information System (IBIS); EURISCO and the European Barley Database (EBDB) developed by the European Cooperative Program on PGR (ECPGR) and the Database for Barley Genes and Barley Genetic Stocks maintained at NordGen.

To improve the accessibility of barley collections, the International Barley Core Collection (BCC) has been assembled by an international consortium since 1989. In 2007, the size of the BCC was about 1,500 accessions. Another important specialized collection is the Generation Challenge Programme (GCP) composite set of 3000 barley accessions developed by ICARDA, representing the range of diversity of the crop and its wild progenitor, *Hordeum vulgare* subsp. *spontaneum*.

Networks relevant to barley genetic resources conservation, evaluation, information and use operating at national, regional and international level were identified and their role in the global strategy for barley is discussed.

In the discussion on a strategic approach to conserving the barley genepool, the essential role of genetic diversity conserved within all unique accessions held *ex situ* in genebanks was recognized. These genetic materials are, in general, readily accessible for utilization in breeding and research. The other part of the crop genepool occurs under *in situ* condition or on-farm and remains to be collected.

Regarding the material that is already conserved within *ex situ* collections, there are some collections that represent a large part of genetic variation, that are well maintained and are readily available under the terms of the International Treaty. Such key collections may be a basis of a global network providing the genetic variation to the international community for crop improvement.

The first draft of the barley strategy was discussed in the Expert Consultation Meeting for Developing a Global Strategy for Ex Situ Conservation of Barley Genetic Resources held in Tunis, 4-6 September 2007, in which representatives of over 15 barley collections and other experts participated.

In the Tunis workshop, collections were classified into three groups: A) secured and well resourced; B) significant but may need capacity building; and C) more information is needed. The classification was based on the following compound criteria: i) structure – size, scope, uniqueness; ii) quality – documentation, facilities, resources; iii) access – accessibility and availability.

A rational approach to conserve the barley genepool would be for the international community to provide sustainable support to an integrated global network of the key collections to ensure that they meet and maintain international conservation standards and are able to distribute high quality seed in a timely manner to users worldwide. There may also be significant and large collections in categories B and C, holding unique, and in many cases local, genetic diversity of the barley genepool, that might be upgraded with targeted international support to meet the criteria of the key collections. Unique materials held in the smaller collections could thus be integrated into a key collection if funds were provided to cover the costs involved.

The Tunis meeting suggested steps in the implementation of the Global Strategy for Barley, such as circulating the final version of the document to the relevant journals, and using upcoming meetings and scientific events. The strategy was presented and discussed at the International Barley Genetics Symposium in April 2008, Alexandria, Egypt.

The Global Barley Conservation Strategy Advisory Group was constituted at the Tunis meeting to be responsible for reviewing periodically the strategy, assessing its implementation, identifying threatened collections and orphan collections (collections that seem to be being abandoned by research programs).

The sustainability of the Advisory Group was discussed. It is proposed that funding be sought to hold meetings and it was requested that the Trust assist in finding funding opportunities. It is important that the Advisory Group and the process be endorsed and recognized to give it legitimacy and the coordination should find an institutional home. It was proposed that ICARDA act as a clearing mechanism and the contact organization.

1. BACKGROUND

The growing human population which is expected to reach 9 billion by 2050 will require steady increases in agricultural production in increasingly unpredictable and changing climate. Conserving the rich diversity of crop varieties and related wild species is essential for providing farmers and plant breeders with raw materials for improving and adapting the crops to meet future challenges and produce sufficient food in the future.

The urgent need to conserve the endangered genetic resources was discussed in different international forums, as well as at national programs. It was also recognized that diverse germplasm is important for achieving continuous advance in crop improvement. In response to these challenges programs for genetic resources collection and conservation of landraces and crop wild relatives were promoted by the Food and Agriculture Organization of the United Nations (FAO), the International Board for Plant Genetic Resources (IBPGR) and its successor, the International Plant Genetic Resources Institute (IPGRI) – now Bioversity International, together with other International Agricultural Research Centers (IARCs) of the Consultative Group for the International Agricultural Research (CGIAR). A number of national agricultural research systems (NARS) were involved in these international activities and, in addition, some countries developed strong national plant genetic resources programs.

As a result, in the second half of the 20th century there was a significant increase in the number and size of plant genetic resources collection all over the world. Major cereal crop collections, including barley, had grown globally to more than 100,000 accessions. New long-term conservation facilities were built, in which thousands of small seed samples were preserved at relatively low costs.

In response to urgent needs, FAO, through its Commission on Plant Genetic Resources, and Bioversity International with other CGIAR Centers, worked to develop a more rational, efficient and effective system for the conservation and sustainable use of crop genetic resources. Their initiatives towards this end included:

1. Adoption of the International Undertaking on Plant Genetic Resources for Food and Agriculture at the FAO Conference in 1983. The undertaking, adhered to by over 100 countries, was the first comprehensive international agreement dealing with plant genetic resources and was an important milestone in ensuring equity of access to plant genetic resources for food and agriculture.
2. Development of agreed technical standards for the storage, regeneration, documentation and distribution of germplasm samples of crop species
3. Documentation of existing collections, their coverage and status and the publication of periodic reports and updates on the state of the world's plant genetic resources for food and agriculture.
4. Adoption of the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture by representatives of more than 150 countries at the Fourth International Technical Conference on Plant Genetic Resources in 1996.
5. The establishment and support for a range of regional and crop specific networks to facilitate a more rational and cooperative approach to the conservation, documentation and use of plant genetic resources. One of the more successful of these has been the

European Cooperative Programme for Crop Genetic Resources (ECPGR), which has developed European wide cooperative programs in a range of major and minor crops.

6. Successful entry into force of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) in June 2004 ratified by over 100 countries now. The Treaty which arose from, and replaced, the International Undertaking, provides a legally binding framework for access and benefit sharing in relation to plant genetic resources for a defined range of crops.
7. In 2004 the Global Crop Diversity Trust (the Trust), an endowment fund to support the conservation and availability of crop diversity over the long term, was established. The Trust is recognized as an essential element of the Funding Strategy of the International Treaty in relation to the *ex situ* conservation and availability of plant genetic resources for food and agriculture.

2. OBJECTIVE AND EXPECTED OUTPUTS OF THE BARLEY *EX SITU* CONSERVATION STRATEGY

In order to guide the allocation of funds to secure the conservation of the unique barley genetic resources, a strategy developed by the main stakeholders is essential.

2.1 Objective

To develop, in close consultation with relevant stakeholders, institutions, and networks, a strategy for the efficient and effective conservation of barley genetic resources globally that will promote the rationalization of conservation efforts at regional and global levels through encouraging partnerships and sharing facilities and tasks, and to identify the key global collections and priorities for urgent upgrading and capacity building needs.

2.2 Expected outputs

1. An evaluation and assessment, in consultation with a wide spectrum of stakeholders, of the barley collections of most importance regionally and globally based on agreed criteria of importance.
2. An assessment of the collections of the crops identified above that are “most important” in terms of size, extent of diversity, holdings of wild relatives and other standards of assessment, carried out in consultation with members of relevant regional networks.
3. A conservation strategy and recommendations for addressing priorities and promoting partnerships and sharing responsibilities, facilities and tasks.

2.3 Coordination and contribution

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Contributors to the strategy development process

- 25 barley collection curators completed the survey

- Representatives of over 15 barley collections and other experts (see participants in Appendix 4) participated in the Expert Consultation Meeting for Developing a Global Strategy for Ex Situ Conservation of Barley Genetic Resources, 4-6 September 2007. The results of this meeting are incorporated into this barley strategy.

3. MAJOR STEPS IN THE DEVELOPMENT OF THE STRATEGY

The following procedures were adopted in developing the Global *Ex Situ* Conservation Strategy for Barley:

1. The major germplasm collections of barley globally were identified from the Global Inventory of Barley Genetic Resources (GIBGR), other existing public databases including those held by FAO (WIEWS) and ECPGR (EURISCO, EBDB) and several on-line accessible national databases, such as GRIN-CA (Canada), SIBRARGEN (Brazil) and NIAS (Japan). Additional information was obtained from the Regional Conservation Strategies reports for West Asia and North Africa (WANA) and South, Southeast and East Asia (SSEEA) and from barley germplasm holder websites. Particular emphasis was given to identification of collections holding unique accessions of wild relatives, landraces and genetic stocks of barley.

2. A survey was designed and sent out to the curators of the 55 largest barley collections (holding more than 500 accessions) globally taken from the Global Inventory, FAO WIEWS, EURISCO, EBDB, SINGER (Appendix 2), to gather basic information on the numbers and types of accessions held, the conditions under which they were stored and their accessibility (see format in Appendix 1). A response to the survey was received from 28 genebanks (Appendix 3).

3. The major event in the development of the global strategy for barley was a workshop that took place in Tunis, Tunisia from 4-6 October 2007. The workshop, organized in collaboration with the Trust and ICARDA, involved barley collection curators, breeders and other experts who could advise on specific issues in terms of a comprehensive global strategy. The programme for the workshop is given in Appendix 4 and the list of participants in Appendix 5. A discussion paper with background information and data on barley collections was developed for the Tunis workshop. Participants discussed a wide range of issues, in particular those relating to increasing efficiency and effectiveness of *ex situ* conservation and strengthening links to germplasm users. The discussion in the plenary and/or working groups was structured in the following sections:

    1. Analysis of importance and uniqueness of collections
    2. Gaps in genetic diversity in *ex situ* collections
    3. Conservation status
    4. Regeneration status
    5. Distribution and links with users
    6. Key elements of an effective and efficient global barley conservation strategy
    7. Next steps

4. GLOBAL BARLEY *EX SITU* CONSERVATION STRATEGY

Barley is the fourth most important cereal crop in the world after wheat, maize, and rice with a global production of over 150 million tons produced from about 60 million ha. The area cultivated is now approximately the same as in 1960s, but the yield doubled from 1.3 t/ha to 2.6 t/ha. The major producers are listed in Table 1 below.

Table 1. Major barley producers (3-year averages, 2000-2002)

	Country	Area (ha x 1,000)	Yield (kg/ha)	Production (Mt x 1,000)
1	Russian Federation	8061	2134	17200
2	Germany	2052	5940	12192
3	Canada	4050	2609	10565
4	France	1627	6240	10154
5	Ukraine	3974	2253	8953
6	Spain	3138	2757	8652
7	Turkey	3606	2117	7633
8	United Kingdom	1159	5510	6388
9	Australia	3420	1719	5879
10	United States	1840	3136	5770
11	Denmark	774	5244	4061
	TOTAL	**33701**	**2891**	**97447**

Source: FAOSTAT - http://faostat.fao.org/

Barley is a tough cereal. It grows where other grains can't grow; it grows and thrives at arctic latitudes and alpine altitudes and can even be found in saline desert oases. It is a temperate crop, but is also grown in many tropical countries, typically by poor farmers in hostile, dry, cool environments. Barley is a globally important crop that is adapted to marginal and stress-affected environments and it is, therefore, of high importance to resource-poor farmers in many developing countries. The breeding strategy for barley crop improvement in the developing world is targeted to low-input stress-affected, mostly subsistence farming systems in highly diverse environments. This differs from that in developed countries where barley may be grown for different purposes using high-input technologies.

Barley was first domesticated in south-western Asia, in the area called the Fertile Crescent. The high importance of barley in the Mesopotamian city states and Egypt is evident in archaeological sites and artefacts from the period. Archaeologists think barley was more important than wheat in the early days of agriculture-based civilization. Now the main barley growing countries in the world are Russia, Canada and Germany. In Tibet, Nepal, Ethiopia, and the Andes, farmers cultivate barley on the mountain slopes at elevations higher than other cereals. In areas with little irrigation in the dry regions of North Africa, the Middle East, Afghanistan, Pakistan, Eritrea, and the Yemen, barley is often the only suitable cereal. Developing countries account for about 18 % of global production and 25 % of the harvested area of barley.

Due to the high proportion of meat in temperate zone diets, barley is nowadays more often used as fodder for livestock than human food. Barley's second most important use is in malting and brewing industry and the direct use of barley as human food ranks third. However, in some developing and transitional countries barley is still an important food grain.

The consumption per capita in 2001 was 42.1 kg in Morocco, 29.8 kg in Estonia, 21.0 kg in Moldova, 16.7 kg in Latvia, 13.5 kg in Lithuania and Azerbaijan, 12.8 kg in Ethiopia and Libya and 12.4 in Algeria[1] . It is also essential food in the highlands of Himalayas and Andes. The different uses have led to diversification and specialization of cultivars. Barley provides a good source of energy since carbohydrates constitute 80 percent of the barley kernel. Barley has been considered a high-energy food since the Roman times, when the gladiators were called "hordeari" (from Hordeum) because they were fed a barley diet before going to the Circus. Some Ethiopian landraces also have very high protein levels, with up to 18 % protein.

Barley straw is a valuable feed for small ruminants in the Central and West Asia and North Africa (CWANA) region, which, in dry years, may have a higher price than barley grain. Barley landraces from those countries have soft and highly palatable straw, but this trait is rare or lacking in the modern lodging-resistant varieties.

The work on barley by distinguished plant geneticist H.V. Harlan, in the 1930s, sounded the first alarm about the loss of crop diversity at the hands of modern agriculture.

4.1 The Barley Genepool

Genetic resources in barley can be divided into six major groups:

1. Modern cultivars in current use
2. Obsolete cultivars, often the elite cultivars of the past and often found in the pedigrees of modern cultivars
3. Landraces
4. Wild relatives in the genus Hordeum
5. Genetic and cytogenetic stocks
6. Breeding lines

This broad pool can also be subdivided into primary, secondary and tertiary gene pools[2,3]. The primary pool consists of the biological species, including cultivated, wild and weedy forms of the crop and gene transfer in this group is considered to be easy. In the secondary gene pool are the coenospecies from which gene transfer is possible but difficult, while the tertiary gene pool is composed of species from which gene transfer is possible only with great difficulty. The following description of the barley gene pool and the taxonomic concept of the genus Hordeum are based on von Bothmer, *et al.* 1995[2].

4.1.1 Primary genepool

This category of Germplasm is closely related to the crop species and there are no or very weak biological barriers for gene transfer. In barley, the primary genepool consists of landraces from various geographical regions, where they are still cultivated or have been used recently. However, landraces disappear rapidly and are no longer available from large regions, for example, northern and central Europe. They are still cultivated in Central and South-

[1] FAOSTAT (2004): http://faostat.fao.org/default.jsp?language=EN

[2] HARLAN J.R., DE WETT J.M.J. (1971): Towards a rational classification of cultivated plants. Taxon **20**: 509-517.

[3] Bothmer, R. von, N. Jacobsen, C. Baden, R.B. Jørgensen, and I. Linde-Laursen. 1995. An Ecogeographical Study of the Genus *Hordeum*, 2nd ed. Systematic and Ecogeographic Studies on Crop Genepools No. 7. International Board of Plant Genetic Resources, Rome, Italy. 129 pp.

western Asia and parts of Northern Africa including Ethiopia. The progenitor of cultivated barley, i.e. *H. vulgare* subsp. *spontaneum* also belongs to the primary genepool. It was mostly used for transfer of disease-resistance genes into barley germplasm (Fischbeck *et al.* 1976, Moseman *et al.* 1983, Lehmann and Bothmer 1988). In recent years molecular marker studies identified in *H. vulgare* subsp. *spontaneum* a number of diverse genes of potential value for barley improvement. The barley wild progenitor has been extensively used in barley breeding for drought tolerance at the International Center for Agricultural Research in the Dry Areas (ICARDA). Lines derived from crosses with subsp. *spontaneum* are higher yielding and taller under drought stress than any materials based on cultivated barley germplasm and they retain spike extrusion even under severe drought conditions[4]

4.1.2 Secondary genepool

In barley, there is only a single representative of this category, the perennial, di- and tetraploid species, *H. bulbosum,* native to the Mediterranean region. It is the closest relative of cultivated barley, apart from subsp. *spontaneum,* and shares the **I** genome with *H. vulgare. H. bulbosum* has been widely used in barley and wheat breeding, because its chromosomes are normally eliminated in the young hybrid embryos during the first days of development, leaving one set of seven cultivated species chromosomes. The embryo develops into a haploid plant which can be chromosome-doubled through application of colchicine. It gives rise to a completely homozygous line of barley or wheat, which may be used directly in a breeding programme. Sometimes chromosome elimination does not take place, but the embryo develops into a true, stable hybrid (this is genotype/environment dependent). The chromosomal pairing during meiosis is often very high in the hybrids, but the fertility is extremely low[5]. Several characters in *H. bulbosum* are of interest for transfer into cultivated barley, e.g. resistance to diseases.

4.1.3 Tertiary genepool

All other *Hordeum* species belong to the tertiary gene pool of cultivated barley. Cultivated barley crosses with difficulty wit these species. Because of substantial genomic differences gene transfer has turned out to very difficult. Despite interesting genes e.g. for resistance, adaptation or qualitative traits the potential for barley improvement is therefore very limited, unless new techniques, such as somatic hybridization and gene transformation, are developed.

4.2 Taxonomic concept of the genus Hordeum

Hordeum L. belongs to the tribe *Triticeae* of the family *Poaceae (Gramineae).* The tribe includes a number of important cereal crops, such as wheat *(Triticum* spp.), rye *(Secale cereale),* barley *(Hordeum vulgare),* and the artificially synthesized triticale *(*x*Triticosecale).* In addition to these cereals many important forage grass species are referred to this tribe. Altogether the *Triticeae* comprises around 350 species.

[4] ICARDA Annual Report 1998**.** www.icarda.org/Publications/AnnualReport/98/AnPage29.HTML

[5] Bothmer, R. von, Flink, J., Jacobsen, N., Kotimäki, M. & Landström, T. 1983. Interspecific hybridization with cultivated barley *(Hordeum vulgare* L.). - Hereditas 99: 219-244.

Based on morphology, Bothmer and Jacobsen[6] recognized four sections: Sect. *Hordeum,* Sect. *Anisolepis,* Sect. *Stenostachys,* and Sect. *Critesion.*

1. Section Hordeum:
Hordeum vulgare L.
Hordeum bulbosum L.
Hordeum murinum L.

Key to the subspecies and some of the major varieties of H. vulgare[3].

1. Rachis brittle	2
2. Spike distichous	subsp. *spontaneum* (C. Koch.) Thell.
2. Spike hexastichous. subsp. *vulgare* convar. *vulgare* f. *agriocrithon* (Åberg) Bowd.	3
1. Rachis tough (subsp. *vulgare)*	
3. Spike tetra- or hexastichous, central spikelet sessile, fertile, the lateral ones also sessile and mostly fertile, with rather long awns (convar. *vulgare)*	4
4. Spike compact, hexastichous	5
5. Caryopses naked	var. *revelatum* Körn.
5. Caryopses not naked	var. *hexastichon* (L.) Aschers.
4. Spike lax, subhexa- to tetrastichous	6
6. Caryopses not naked	var. *vulgare*
6. Caryopses naked (var. coeleste L.)	7
7. Awns long	f. *coeleste*
7. Awns trifurcate	f. *trifurcatum* (Schlecht.) ined.
3. Spike distichous, central spikelet sessile, fertile, the lateral ones pedicellate, sterile or male fertile, with rather short awns (convar. *distichon* (L.) Alef.)	8
8. Lateral spikelets reduced to glume-like appendages	var. *deficiens* (Steud.) ined.
8. Lateral spikelets male or neuter, but developed	9
9. Spikes long, narrow, awns not divergent	10
10. Caryopses naked	var. *nudum* (L.) Alef.
10. Caryopses not naked	var. *distichon*
9. Spikes shortened, broad, awns divergent	var. *zeocrithon* (L.) Körn.

2. Section Anisolepis:
Hordeum pusillum Nuttall
Hordeum intercedens Nevski
Hordeum euclaston Steudel
Hordeum flexuosum Steudel
Hordeum muticum Presl

[6] Bothmer, R. von, & Jacobsen, N. 1985. Origin, taxonomy, and related species. - In: Rasmusson, D. (ed.), Barley. ASA Monograph No. 26: 19-56.

Hordeum chilense Roemer & Schultes
Hordeum cordobense Bothmer, Jacobsen & Nicora
Hordeum stenostachys Godron

3. Section Critesion:
Hordeum pubiflorum Hooker
Hordeum halophilum Grisebach
Hordeum comosum Presl
Hordeum jubatum L.
Hordeum arizonicum Covas
Hordeum procerum Nevski
Hordeum lechleri (Steudel) Schenck

4. Section Stenostachys:
Hordeum marinum Hudson
Hordeum secalinum Schreber
Hordeum capense Thunberg
Hordeum bogdanii Wilensky
Hordeum roshevitzii Bowden
Hordeum brevisubulatum (Trinius) Link
Hordeum brachyantherum Nevski
Hordeum depressum (Scribner & Smith) Rydberg
Hordeum guatemalense Bothmer, Jacobsen & Jørgensen
Hordeum erectifolium Bothmer, Jacobsen & Jørgensen
Hordeum tetraploidum Covas
Hordeum fuegianum Bothmer, Jacobsen & Jørgensen
Hordeum parodii Covas
Hordeum patagonicum (Haumann) Covas

Detailed description of the above species is given in von Bothmer et al. (1995).

5. OVERVIEW OF BARLEY COLLECTIONS

According to the FAO Report on the State of the World's Plant Genetic Resources[7] (FAO, 1996), genebank collections throughout the world comprise about 6.1 million accessions. The largest collection is of wheat, with barley occupying second place. The FAO estimated that about 485,000 barley accessions exist in *ex situ* germplasm collections such as genebanks, breeders' and research collections. Hintum and Menting[8,9] corrected this figure to ca. 373,000 and 371,000 accessions, respectively.

The survey of major barley genebank collections by Hintum and Menting[9] (2003) included also a complete set of passport data from the Canadian collection. The number of barley

[7] FAO, 1996. FAO State of the World's Plant Genetic Resources for Food and Agriculture. Rome.

[8] Hintum, Th.J.L. van and F. Menting. 2000. Barley genetic resources conservation - now and forever. Barley Genetics VIII(1)1:13-20.

[9] Hintum, Th.J.L. van and F. Menting. 2003. Diversity in *ex situ* genebank collections of barley. *In*: R. von Bothmer, Th. Van Hintum, H. Knüpffer and K. Sato (eds)\diversity in Barley (*Hordeum vulgare*), pp. 247-257. Elsevier Science B.V., Amsterdam, The Netherlands

accessions in genebanks worldwide is estimated to be 370,796. The number of accessions per species is as follows:

ca. 326,000	*H. vulgare* subsp. *vulgare*
ca. 37,000	*H. vulgare* subsp. *spontaneum*
1,370	*H. bulbosum*
6,307	wild *Hordeum* species of the tertiary genepool, totalling 31 species, including:
1,505	*H. murinum*
566	*H. marinum*
337	*H. jubatum*
335	*H. brevisubulatum*
323	*H. pubiflorum*
310	*H. chilense*
306	*H. brachyantherum*

In the process of developing this strategy data were assembled from diverse sources. Some of the main data assembled are presented in Tables 2-6.

5.1 An overview and analysis from the regional conservation strategies

Regional strategies for the long-term conservation and availability of plant genetic resources have been developed with support from the Global Crop Diversity Trust in most of the regions. The regional approach is complementary to the global crop conservation strategies that prioritize collections on a crop-by-crop basis.

Underscoring the crop's worldwide importance, barley was recognized as a priority crop in the majority of the regional strategies produced in cooperation with regional PGR networks (Table 2). The ranking was based on region-specific criteria.

Table 2. Prioritization of barley in regional conservation strategies

Region	Ranking of importance of barley in the region	Sub-region/country priority
Asia, Central & the Caucasus	1	
Asia, West & North Africa	4	North Africa 1, West Asia 2, Nile Valley and Red Sea 3, Arabian Peninsula 4
Asia, South, South East & East	7	India, Nepal, East Asia
Pacific	No	--
Africa, East	12	Ethiopia 1, Eritrea 1-2
Americas	Among 20 top priority crops	
Europe	High[10]	

Regions with primary and/or secondary centers of barley diversity are identified as playing especially important roles in regards to barley genetic resources:

(i) West Asia and North Africa (WANA)

[10] Working Group on Barley of the European Cooperative Program on Genetic Resources (ECP/GR) was established in 1983

(ii) Central Asia and the Caucasus (CAC)
(iii) Eastern Africa – Ethiopia and Eritrea
(iv) South America – Andean region

5.2 Size and composition of collections

Table 3 lists the major barley collections holding more than 500 accessions, including two minor collections in Estonia and Ecuador, which responded to the survey. Sources of information, as well as status of the ratification of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), are also presented. The total of 402,034 accessions does not include some 2500 additional accessions held at 26 minor collections in the world counted in the Global Inventory of Barley Genetic Resources (GBI). This total is 16% lower than the FAO's estimate[7] and 8% higher than more recently reported by Hintum and Menting[8,9]. In general, there is no major discrepancy between the genebank collection totals identified in this report and Hintum and Menting's data.

The largest collection of barley germplasm is held by Plant Gene Resources of Canada (PGRC). Its holdings represent 10% of the world total. This collection grew from 13,000 to 36,000 accessions in 1989 when the USDA collection was duplicated there. Consequently, there is a large overlap between PGRC and USDA collections. According Hintum and Menting[9], considerable duplications exist between the four globally largest collections, i.e. PGRC, USDA, EMBRAPA and ICARDA.

Table 3. Barley collections: information source, size and status of country ratification of the ITPGRFA

No.	Country	Institute[11] code	Genebank/Institute	Information source	Total no. of acces.	ITPGRFA ratification [12]
1.	Canada	CAN004	Plant Gene Resources of Canada, Saskatoon	Survey & GRIN-CA	39852	Yes
2.	USA	USA005	USDA-ARS National Small Grains Collection, Aberdeen, Idaho	Survey	29838	Signature
3.	Brazil	BRA003	Recursos Geneticos e Biotecnologia, Brasilia (EMBRAPA/ CENARGEN)	SIBRARGEN	29227	Yes
4.	GLOBAL	SYR002	ICARDA, Aleppo, Syria	Survey	26117	Yes
5.	United Kingdom	GBR011	John Innes Centre, Norwich	Survey	23603	Yes
6.	Germany	DEU146	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben	Survey	22106	Yes
7.	China	CHN001	Institute of Crop Germplasm Resources, CAAS, Beijing	Web	18818	No
8.	Korea, Rep.	KOR003	National Institute of	Survey	18764	No

[11] FAO Institute codes used in World Information and Early Warning System on Plant Genetic Resources (WIEWS) http://apps3.fao.org/wiews/wiews.jsp

[12] Ratification and other legal instruments of acceptance, approval or accession. Status reported on the web (http://www.fao.org/Legal/TREATIES/033s-e.htm) on 15 November 2007.

No.	Country	Institute[11] code	Genebank/Institute	Information source	Total no. of acces.	ITPGRFA ratification [12]
	of		Agricultural Biotechnology, Suwon			
9.	Russia	RUS001	N.I. Vavilov Institute of Plant Industry (VIR)	Survey	17850	No
10.	Ethiopia	ETH001	Institute of Biodiversity Conservation (IBC), Addis Ababa	Survey	15360	Yes
11.	Japan	JPN009	Research Institute for Bioresources, Okayama University	Survey	14106	No
12.	Sweden	SWE002	Nordic Gene Bank, Alnarp	Survey	13435	Yes
13.	Australia	AUS003	Australian Winter Cereals Collection, NSW Calala	Survey	12600	Yes
14.		MEX002	CIMMYT, El Batan, Mexico	Survey & SINGER	11202	Yes
15.	Japan	JPN009	National Institute of Agrobiological Science, Tsukuba	NIAS database	8806	No
16.	India	IND001	National Bureau of Plant Genetic Resources (NBPGR), New Delhi	GCDT SSEEA Regional Strategy document	8384	Yes
17.	Iran	IRN029	National Genebank of Iran, Genetic Resources Division, Karaj	GCDT WANA Regional Strategy document	7600	Yes
18.	Israel	ISR003	Institute for Cereal Crops Improvement, Tel Aviv University	Web & Report to ECP/PGR	6662	No
19.	Poland	POL003	Plant Breeding and Acclimatization Institute (IHAR), Radzików	Global Inventory of Barley GR (GBI)	5942	Yes
20.	France	FRA040	Station d'Amélioration des Plantes, INRA, Clermont-Ferrand	Survey	5517	Yes
21.	Mongolia		Research Institute of Agriculture and Plant Science, Darkhan	GCDT SSEEA Regional Strategy document	5255	No
22.	Korea, DPR		Pyongyang Crop Genetic Resources Institute, Pyongyang	GCDT SSEEA Regional Strategy document	4504	Yes
23.	Ukraine	UKR001	Institute of Plant Production "V.Y. Yurjev", Kharkiv	GBI & EURISCO	4394	No
24.	Bulgaria	BGR001	Institute for PGR "K. Malkov", Sadovo	Survey	4221	Yes
25.	Hungary	HUN003	Research Centre for Agrobotany (RCA), Tápiószele	Survey	4208	Yes
26.	Morocco	MAR003	Institut National de la Recherche Agronomique	Survey	3743	Yes

No.	Country	Institute[11] code	Genebank/Institute	Information source	Total no. of acces.	ITPGRFA ratification [12]
			(INRA, Morocco), Settat			
27.	Netherlands	NLD037	Centre for Genetic Resources, Wageningen	GBI & EURISCO	3507	Yes
28.	Israel	ISR004	Institute of Evolution, University of Haifa	Web & Report to ECP/PGR	3390	No
29.	Brazil	BRA015	Brazilian Agric. Research Company – Embrapa Wheat, Passo Fundo	Survey	3360	Yes
30.	Peru	PER002	Universidad Nacional Agraria, La Molina	Survey	2759	Yes
31.	Israel	ISR002	Israel Plant Gene Bank, ARO Volcani Center, Bet-Dagan	Survey	2720	No
32.	Czech Republic	CZE047	Agricultural Research Institute Kromeriz, Ltd.	Survey	2705	Yes
33.	Spain	ESP004	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Centro de Recursos Fitogenéticos, Alcalá de Henares	GBI	2421	Yes
34.	Italy	ITA004	Istituto del Germoplasma, CNR, Bari	GBI	2102	Yes
35.	Romania	ROM002	Research Institute for Cereals and Technical Plants (ICCPT), Fundulea	GBI	2096	Yes
36.	Slovakia	SVK001	SARC – Research Institute of Plant Production (RIPP), Piestany	Survey	2047	No
37.	Czech Republic	CZE122	Genebank Department, Crop Research Institute, Prague	Survey	1865	Yes
38.	Egypt	EGY008	Field Crops Institute, Agricultural Research Centre, Giza	GCDT WANA Regional Strategy document	1750	Yes
39.	Pakistan	PAK001	Plant Genetic Resources Institute, National Agricultural Research Centre, Islamabad	GCDT WANA Regional Strategy document	1274	Yes
40.	Italy	ITA024	C.R.A., Istituto Sperimentale par la Cerealicoltura, Fiorenzuola d'Arda	Survey	1240	Yes
41.	Syria	SYR055	Agricultural Research Center, Douma	GCDT WANA Regional Strategy document	1221	Yes
42.	Turkey	TUR001	Aegean Agriculture Research Institute, Izmir	Survey	1208	Yes

No.	Country	Institute[11] code	Genebank/Institute	Information source	Total no. of acces.	ITPGRFA ratification [12]
43.	Romania	ROM007	Suceava Genebank, Agricultural Research Station, Suceava	GBI	1199	Yes
44.	Switzerland	CHE001	Agroscope Changins-Wädenswil ACW, Nyon	Survey	795	Yes
45.	Lithuania	LTU001	Lithuanian Institute of Agriculture	GBI	760	Yes
46.	Austria	AUT001	Agrobiology Linz-Austrian Agency for Health and Food Safety/ Seed Collection,	GBI	747	Yes
47.	Latvia	LVA010	Latvian State Forestry Institute "Silava", Latvian Gene Bank, Salaspils	GBI	599	Yes
48.	Estonia	EST001	Jõgeva Plant Breeding Institute	Survey	116	Yes
49.	Ecuador	ECU023	Inst. Nacional de Investigaciones Agropecuarias	Survey	39	Yes
Total					**402034**	

Data on the composition of the collections in terms of number and percentages of accessions of wild relatives, landraces, breeding materials, genetic stocks and cultivars are shown in Table 4. Of the total of 290,820 accessions with germplasm type known, 15% are wild relatives, 44% belong to landraces, 17% include breeding materials, 9% are genetic stocks and cultivars represent the remaining 15%. Thus, larger proportion (59%) of global barley holdings includes germplasm that has evolved in long-term interaction with local environment and farmers' practices, while other three categories (41%) are products of modern plant breeding and research.

Wild relatives

A major part of the wild relative collections is represented by the barley wild progenitor, *Hordeum vulgare* subsp. *spontaneum.* Its main collection holdings amount to 34,279 accessions (Table 5). The largest collection held at John Innes Centre, Norwich, UK is a working collection, not yet in public domain. Other main collections are maintained in Israel, Canada, USA, and Germany and at ICARDA. Number of original populations sampled (number of collection sites) and number of countries represented in a collection may be better indicator of diversity than collection size expressed in accession number. The spontaneum collection held at ICARDA is derived from 730 original populations that originate from 20 countries. Consequently, it may be considered as globally the most diverse source of ecological diversity.

Main collections of the wild barley species of the secondary and tertiary gene pool are held at PGRC and Nordic Genebank.

Landraces

Landraces represent the largest part of barley germplasm conserved in genebanks worldwide. Of the germplasm known type total, 128,870 accessions (44%) are landraces. Largest landrace collections are held in seven genebanks: ICARDA, CAAS China, IBC Ethiopia, PGRC Canada, USDA, IPK Germany and RIB Japan, each having more than 10,000

accessions. ICARDA with 15,496 landrace accessions leads the group. Barley collections maintained at CAAS China, IBC Ethiopia, VIR Russia, NIAB Korea, NGB Sweden, INRA Morocco, INRA France, Agroscope Switzerland and CRI Czech Republic posses a significant proportion of indigenous landraces materials.

Breeding material
Breeding materials are the second most frequent category of barley germplasm held in genebanks globally with 49,059 accessions. The largest collection is conserved at CIMMYT, followed by PGRC Canada, ICARDA, USDA, NIAR Japan and INRA France with more than 3,000 accessions.

Genetic stocks
The most extensive collection of genetic materials is held at Nordic Genebank in Alnarp, Sweden. It comprises about 10,000 accessions that resulted from a joint Scandinavian mutation research program and 685 translocation and 58 duplication lines. Large collections of genetic stocks are maintained at PGRC Canada, USDA and NIAR Japan.

Cultivars
This category includes finished products of plant breeding programs, both advanced and obsolete ones. There are many duplications of this type of barley germplasm between genebanks worldwide, as well as internal duplications within a genebank. The largest cultivar collections are possessed by VIR Russia, IPK Germany, PGRC Canada and USDA.

Table 4. Barley collections: content

Country	GB code	Genebank / institutes	Total no. of acces-sions	WR no.	Wild relatives %	LA no.	Land-races %	BM no.	Breeding material %	GS no.	Genetic stocks %	Cultivars no.	Cultivars %	Unknown status	Unknown status %
Canada	CAN004	PGRC	39852	5889	15	14074	35	4971	12	6011	15	5064	13	3843	10
United States	USA005	USDA	29838	1953	7	13106	44	3734	13	3203	11	4394	15	3448	12
Brazil	BRA003	Embrapa	29227		0		0		0		0		0	29227	100
GLOBAL	SYR002	ICARDA	26117	1863	7	15496	59	4330	17	551	2	2277	9	1600	6
United Kingdom	GBR011	IPSR	23603	13700	58	3722	16	2063	9	381	2	2739	12	998	4
Germany	DEU146	IPK	22106	1349	6	12482	56	2289	10	420	2	5172	23	394	2
China	CHN001	ICGR-CAAS	18818	2577	14	15472	82		0		0		0	769	4
Korea, Rep. of	KOR003	CES	18764	140	1	4487	24	1833	10		0		0	12304	66
Russia	RUS001	VIR	17850	250	1	5132	29	1760	10	579	3	9652	54	477	3
Ethiopia	ETH001	IBC	15360	57	0	15301	100		0		0		0	2	0
Japan	JPN009	HARA	14106	628	4	10588	75		0	2890	20		0	0	0
Sweden	SWE002	NGB	13435	686	5	2327	17	0	0	10024	75	372	3	26	0
Australia	AUS003	TAMAWC	12600	103	1	1270	10	134	1	11	0	129	1	10953	87
	MEX002	CIMMYT	11202		0		0	11067	99		0		0	135	1
Japan	JPN003	NIAR	8806	71	1	1374	16	3586	41		0		0	3775	43
India	IND001	IARI	8384		0		0		0		0		0	8384	100
Iran	IRN029	NPGBI	7600		0		0		0		0		0	7600	100
Israel	ISR003	TELAVUN	6662	6645	100	17	0		0		0		0	0	0
Poland	POL003	IHAR	5942	12	0	660	11	191	3	70	1	2404	40	2605	44
France	FRA040	INRA-CLERMON	5517	63	1	1493	27	3208	58	0	0	744	13	9	0
Mongolia		RIAPS	5255		0		0		0		0		0	5255	100
Korea, DPR			4504		0		0		0		0		0	4504	100
Ukraine	UKR001	IR	4394		0	486	11		0		0		0	3908	89
Bulgaria	BGR001	IPGR	4221	25	1	1384	33	263	6	99	2	1994	47	456	11
Hungary	HUN003	RCA	4208	6	0	56	1	1562	37	0	0	271	6	2313	55
Morocco	MAR003	INRA	3743	10	0	3522	94	5	0		0	150	4	56	1
Netherlands	NLD037	CGN	3507	105	3	1832	52	605	17	7	0	792	23	166	5
Israel	ISR004	HAIFA	3390	3390	100		0		0		0		0	0	0

Table 4 - continued

Country	GB code	Genebank / institutes	Total no. of acces-sions	WR no.	Wild relatives %	LA no.	Land-races %	BM no.	Breeding material %	GS no.	Genetic stocks %	Cultivars no.	Cultivars %	Unknown status no.	Unknown status %
Brazil	BRA015	CNPT	3360	1300	39	20	1	350	10	860	26	150	4	680	20
Peru	PER002	La Molina	2759		0	100	4	2000	72	100	4	59	2	500	18
Israel	ISR002	IGB	2720	2240	82	125	5	285	10	9	0	56	2	5	0
Czech Republic	CZE047	KROME	2705	20	1	111	4	61	2	0	0	2161	80	352	13
Spain	ESP004	INIACRF	2421	138	6	158	7	1788	74		0	323	13	14	1
Italy	ITA004	IDG	2102	77	4	1339	64		0		0	43	2	643	31
Romania	ROM002	ICCPT	2096		0	9	0	331	16		0	1588	76	168	8
Slovakia	SVK001	SVKPIEST	2047	4	0	52	3	632	31	1	0	1316	64	42	2
Czech Republic	CZE122	RICP	1865	74	4	44	2	827	44	0	0	918	49	2	0
Egypt	EGY008	EGB	1750	0	0		0		0		0		0	1750	100
Pakistan	PAK001	NARC	1274		0		0		0		0		0	1274	100
Italy	ITA024	FIORENZ	1240	40	3	50	4		0		0		0	1150	93
Syria	SYR055	GCSAR	1221		0		0		0		0		0	1221	100
Turkey	TUR001	NGB-AARI	1208	122	10	1015	84		0		0	31	3	40	3
Romania	ROM007	BRGV Suceava	1199		0	459	38	548	46		0	177	15	15	1
Switzerland	CHE001	RAC	795		0	786	99		0		0		0	9	1
Lithuania	LTU001	LIA	760		0	1	0	172	23	84	11	503	66	0	0
Austria	AUT001	BVAL	747	51	7	290	39	2	0		0	399	53	5	1
Latvia	LVA010	PGL-IB	599		0	1	0	440	73	0	0	21	4	137	23
Estonia	EST001	JPBI	116		0		0	22	19		0	94	81	0	0
Ecuador			39		0	29	74		0		0	10	26	0	0
Total			**402034**	**43588**	**11**	**128870**	**32**	**49059**	**12**	**25300**	**6**	**44003**	**11**	**111214**	**28**
% of known type total					**15**		**44**		**17**		**9**		**15**		

Table 5. Barley collections: wild barley major collections

No.	Country	Genebank/Institute	Wild rela-tives	*H. vulgare* subsp. *spontaneum*- No. of acces.	Spontaenum - origin		Spontaneum - % of the wild species total
					No. of countries	No. of col. sites	
1.	United Kingdom	John Innes Centre, Norwich	13700[13]	13700	1	213	100
2.	Israel	Institute for Cereal Crops Improvement, Tel Aviv University	6645	6500	2	304	98
3.	Canada	Plant Gene Resources of Canada, Saskatoon	5889	3783	16		64
4.	Israel	Institute of Evolution, University of Haifa	3390	3390	3	80	100
5.	Israel	Israel Plant Gene Bank, ARO Volcani Center, Bet-Dagan	2240	2210	1	6	99
6.	GLOBAL	ICARDA, Aleppo, Syria	1863	1738	20	730	95
7.	USA	USDA-ARS National Small Grains Collection, Aberdeen, Idaho	1953	1479	14	224	76
8.	Germany	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben	1349	925	15	118	69
9.	China	Institute of Crop Germplasm Resources, CAAS, Beijing	2577	475			19
10.	Japan	Research Institute for Bioresources, Okayama University	628	179			29
Total			**40206**	**34379**			**81%**

Holdings of germplasm of indigenous germplasm are of particular importance. Table 6 indicates that many collections comprise a significant part of their holdings collected in country. For example, almost all germplasm held at IBC Ethiopia is of indigenous origin.

5.3 Storage facilities

Table 6 documents that nearly all barley collections listed are maintained in long-term facilities under long-term storage conditions, i.e. in cold storage at or below -18^{o}C.

[13] working collection, not in public domain

Table 6. Barley collections: origin and storage facilities

No.	Country	Genebank/Institute	Total no. of acces.	Collected in the country % (national origin)	Facilities – long-term
1.	Canada	Plant Gene Resources of Canada, Saskatoon	39852		Yes
2.	USA	USDA-ARS National Small Grains Collection, Aberdeen, Idaho	29838	18	Yes
3.	Brazil	Recursos Geneticos e Biotecnologia, Brasilia (EMBRAPA/ CENARGEN)	29227		Yes
4.	GLOBAL	ICARDA, Aleppo, Syria	26117	n.a.	Yes
5.	United Kingdom	John Innes Centre, Norwich	23603	16	
6.	Germany	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben	22106	7	Yes
7.	China	Institute of Crop Germplasm Resources, CAAS, Beijing	18818	67	Yes
8.	Korea, Rep. of	National Institute of Agricultural Biotechnology, Suwon	18764	39	Yes
9.	Russia	N.I. Vavilov Institute of Plant Industry (VIR)	17850	20	Yes
10.	Ethiopia	Institute of Biodiversity Conservation (IBC), Addis Ababa	15360	95	Yes
11.	Japan	Research Institute for Bioresources, Okayama University	14106	16	Yes
12.	Sweden	Nordic Gene Bank, Alnarp	13435	83[14]	Yes
13.	Australia	Australian Winter Cereals Collection, NSW Calala	12600	0	Yes
14.		CIMMYT, El Batan, Mexico	11202		Yes
15.	Japan	National Institute of Agrobiological Science, Tsukuba	8806		Yes
16.	India	National Bureau of Plant Genetic Resources (NBPGR), New Delhi	8384		Yes
17.	Iran	National Genebank of Iran, Genetic Resources Division, Karaj	7600		Yes
18.	Israel	Institute for Cereal Crops Improvement, Tel Aviv University	6662	99	No
19.	Poland	Plant Breeding and Acclimatization Institute	5942	2	Yes

[14] Nordic countries origin: Sweden, Denmark, Norway, Finland and Iceland

No.	Country	Genebank/Institute	Total no. of acces.	Collected in the country % (national origin)	Facilities – long-term
		(IHAR), Radzików			
20.	France	Station d'Amélioration des Plantes, INRA, Clermont-Ferrand	5517	22	Yes
21.	Mongolia	Research Institute of Agriculture and Plant Science, Darkhan	5255		
22.	Korea, DPR	Pyongyang Crop Genetic Resources Institute, Pyongyang	4504		
23.	Ukraine	Institute of Plant Production "V.Y. Yurjev", Kharkiv	4394	6	
24.	Bulgaria	Institute for PGR "K. Malkov", Sadovo	4221	4	Yes
25.	Hungary	Research Centre for Agrobotany (RCA), Tápiószele	4208	1	Yes
26.	Morocco	Institut National de la Recherche Agronomique (INRA, Morocco), Settat	3743	67	Yes
27.	Netherlands	Centre for Genetic Resources, Wageningen	3507	<1	Yes
28.	Israel	Institute of Evolution, University of Haifa	3390	72	No
29.	Brazil	Brazilian Agric. Research Company – Embrapa Wheat, Passo Fundo	3360	25	No
30.	Peru	Universidad Nacional Agraria, La Molina	2759	20	No
31.	Israel	Israel Plant Gene Bank, ARO Volcani Center, Bet-Dagan	2720	87	Yes
32.	Czech Republic	Agricultural Research Institute Kromeriz, Ltd.	2705	7	Yes
33.	Spain	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Centro de Recursos Fitogenéticos, Alcalá de Henares	2421	7	Yes
34.	Italy	Istituto del Germoplasma, CNR, Bari	2102	7	Yes
35.	Romania	Research Institute for Cereals and Technical Plants (ICCPT), Fundulea	2096	<1	
36.	Slovakia	SARC – Research Institute of Plant Production (RIPP), Piestany	2047	20	Yes
37.	Czech Republic	Genebank Department, Crop Research Institute, Prague	1865	33	Yes
38.	Egypt	Field Crops Institute, Agricultural Research Centre, Giza	1750		Yes
39.	Pakistan	Plant Genetic Resources Institute, National Agricultural	1274		Yes

No.	Country	Genebank/Institute	Total no. of acces.	Collected in the country % (national origin)	Facilities – long-term
		Research Centre, Islamabad			
40.	Italy	C.R.A., Istituto Sperimentale par la Cerealicoltura, Fiorenzuola d'Arda	1240	10	No
41.	Syria	Agricultural Research Center, Douma	1221		Yes
42.	Turkey	Aegean Agriculture Research Institute, Izmir	1208	100	Yes
43.	Romania	Suceava Genebank, Agricultural Research Station, Suceava	1199	15	Yes
44.	Switzerland	Agroscope Changins-Wädenswil ACW, Nyon	795	92	Yes
45.	Lithuania	Lithuanian Institute of Agriculture	760	5	
46.	Austria	Agrobiology Linz-Austrian Agency for Health and Food Safety/ Seed Collection,	747	18	Yes
47.	Latvia	Latvian State Forestry Institute "Silava", Latvian Gene Bank, Salaspils	599		Yes
48.	Estonia	Jõgeva Plant Breeding Institute	116	20	Yes
49.	Ecuador	Inst. Nacional de Investigaciones Agropecuarias	39	60	

5.4 Regeneration needs

Table 7 indicates regeneration needs, in many cases urgent, for different categories of barley germplasm. While many collections have urgent regeneration needs, the largest collections, such as PGRC Canada, USDA, ICARDA and IPK Germany are in good shape and germplasm availability is high for all the categories.

Table 7. Feedback on regeneration needs received through the survey May 2007

Country	Name of Institute	Total no of acc.	WR[15] %	LR %	CV %	BM %	GS %	UNK %
Canada	PGRC	39738	3	11	3	3	3	
USA	USDA-ARS	29838	25				10	
Brazil	Embrapa	29227						
Global	ICARDA	26117	5	3	3	3	3	3
Germany	IPK	22106	5	5	5	5	5	5
Korea, Rep. of		18764	43	37	11	23		32
Russia	VIR	17850	13	71	50	90	94	

[15] WR – wild relatives; LR – landraces; CV – cultivars, advanced and obsolete; BM – breeding materials; GS – genetic stocks; UNK - unknown

Country	Name of Institute	Total no of acc.	WR[15] %	LR %	CV %	BM %	GS %	UNK %
Ethiopia	IBC	15360		38				
Japan	Okayama University	14106	25					
Sweden	NGB	13435	40	5	5	10		
Australia	AWCC	12600	0	0	0	0	0	
	CIMMYT	11202	25	25	25	25		
United Kingdom	John Innes Centre	9903	0	0	0	0	0	
Iran	National Genebank	7600	70	40				
France	INRA	5517	0	0	0	0	0	
Bulgaria	IPGR "K. Malkov"	4221		30	20			
Hungary	RCA	4208	0	0	0	0	0	
Morocco	INRA	3743	90	18	8			70
Brazil	CNPT	3360	100	100	15	10	15	100
Peru	Universidad La Molina	2759	0	80	50	0	0	
Czech Republic	ARI Kromeriz	2705	25	25	20	25		
Italy	CRA-ISC	2102	8	5	5	5	5	
Slovakia	SARC - RIPP	2047			10	10		
Czech Republic	RICP	1865	34	14	11	14		
Turkey	AARI	1208	50	10				20
Switzerland	Agroscope Changins	795	0	0	0	0	0	
Latvia	Latvian Gene Bank	599		100	22	15		
Estonia	Jõgeva PBI	116			5			

In the Tunis meeting it was proposed that first priority be given to wild species and genetic stocks. Wild relatives should be differentiated between secondary and tertiary genepool.

The following collections were indicated as having urgent regeneration needs:
- Eritrea
- Ethiopia
- Mongolia
- Iran
- Peru (for long-term storage)

A proposed approach could be to undertake regeneration through the network for the difficult species.

5.5 Safety duplication

The workshop in Tunis agreed that all unique accessions should be safety duplicated. The following points were suggested:

- A proposed definition of safety duplication was a formal agreement in long-term storage in distant location not necessarily as black box.
- First priority should be given to most valuable unique diversity of wild relatives, landraces and genetic stocks, second priority to cultivars and a third priority to breeding material.
- It was proposed by the group to look into including the information on safety-duplication in the global barley registry.
- ICARDA facilities could be used for hosting safety-duplicates.
- In addition to safety duplication under long-term storage conditions in a genebank, a second level of safety duplication is highly desirable. The Svalbard Global Seed Vault Svalbard facilities would be most appropriate location for the second level safety net.

Table 8 gives information on the current status of safety duplication in genebanks that responded in the survey. Even if the information is incomplete, it is obvious that the current status of safety duplication is inadequate.

Table 8. Barley collections: safety duplication

No.	Country	Genebank/Institute	Total No. of acces.	Safety duplication
1.	Canada	Plant Gene Resources of Canada, Saskatoon	39852	Yes, mostly at USDA
2.	USA	USDA-ARS National Small Grains Collection, Aberdeen, Idaho	29838	100%, NCGRP Ft. Collins, USA
3.	Brazil	Recursos Geneticos e Biotecnologia, Brasilia (EMBRAPA/ CENARGEN)	29227	Mostly integrated in USDA collection
4.	GLOBAL	ICARDA, Aleppo, Syria	26117	33%, CIMMYT – black box; 65% integrated in other collections
5.	United Kingdom	John Innes Centre, Norwich	23603	No safety duplication
6.	Germany	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben	22106	15% IPK branch in Malchow, Germany
7.	Korea, Rep. of	National Institute of Agricultural Biotechnology, Suwon	18764	40% Natl. Yeongnam Agricultural Institute – black box
8.	Russia	N.I. Vavilov Institute of Plant Industry (VIR)	17850	Partly integrated in IPK, NGB and ICARDA collections
9.	Ethiopia	Institute of Biodiversity Conservation (IBC), Addis Ababa	15360	No safety duplication
10.	Japan	Research Institute for Bioresources, Okayama University	14106	38% NIAS genebank, Tsukuba, Japan

No.	Country	Genebank/Institute	Total No. of acces.	Safety duplication
11.	Sweden	Nordic Gene Bank, Alnarp	13435	NGB Svalbard
12.	Australia	Australian Winter Cereals Collection, NSW Calala	12600	100% CSIRO Plant Industry
13.		CIMMYT, El Batan, Mexico	11202	ICARDA and USDA, black box
14.	France	Station d'Amélioration des Plantes, INRA, Clermont-Ferrand	5517	No safety duplication
15.	Bulgaria	Institute for PGR "K. Malkov", Sadovo	4221	No safety duplication
16.	Hungary	Research Centre for Agrobotany (RCA), Tápiószele	4208	No safety dupplication
17.	Morocco	Institut National de la Recherche Agronomique (INRA, Morocco), Settat	3743	No safety duplication; partly integrated in ICARDA, USDA, CIMMYT and CGN collections
18.	Brazil	Brazilian Agric. Research Company – Embrapa Wheat, Passo Fundo	3360	EMBRAPA Brasilia
19.	Peru	Universidad Nacional Agraria, La Molina	2759	USDA
20.	Israel	Israel Plant Gene Bank, ARO Volcani Center, Bet-Dagan	2720	Haifa University & Tel-Aviv University
21.	Czech Republic	Agricultural Research Institute Kromeriz, Ltd.	2705	8%, RIPP Piestany, Slovakia
22.	Slovakia	SARC – Research Institute of Plant Production (RIPP), Piestany	2047	6% CRI Prague, Czech Republic
23.	Czech Republic	Genebank Department, Crop Research Institute, Prague	1865	1%, RIPP Piestany, Slovakia
24.	Italy	C.R.A., Istituto Sperimentale par la Cerealicoltura, Fiorenzuola d'Arda	1240	No safety duplication
25.	Turkey	Aegean Agriculture Research Institute, Izmir	1208	4%, CRIFC Ankara, Turkey
26.	Switzerland	Agroscope Changins-Wädenswil ACW, Nyon	795	100%, IPK Gatersleben – black box, USDA – fully integrated
27.	Latvia	Latvian State Forestry Institute "Silava", Latvian Gene Bank, Salaspils	599	3% Nordic Genebank, Alnarp, Sweden
28.	Estonia	Jõgeva Plant Breeding Institute	116	17% Nordic Genebank, Alnarp, Sweden
29.	Ecuador	Inst. Nacional de Investigaciones Agropecuarias	39	No safety duplication

5.6 Barley collections: distribution

Table 9 presents a list of barley collections most active in germplasm distribution. Three collections, USDA, ICARDA and IPK, are major providers of germplasm internationally with more than 2000 accessions/year. In general, responses to the survey show that most barley collections are greatly underutilized. Strengthening links to the users and increasing their effectiveness is, therefore, a priority in the global strategy for barley.

Table 9. Feedback on barley accession distribution received through the survey (May 2007) – collections with more than 500 accessions distributed/year

Institute code	Institute	No. of samples distributed annually		
		Nationally	Internationally	Total
USA005	USDA NSGC	5000	3000	8000
SYR002	ICARDA	2800 (ICARDA)	2600	5400
DEU146	IPK, Gatersleben	1731	2326	4057
AUS003	AWCC	3256	164	3420
RUS001	VIR	2958	350	3308
JPN009	RIB	1252	387	1639
CZE047	ARI Kroměříž	1210	256	1466
SWE002	NGB	250 (Nordic countries)	500	750

6. INFORMATION AND DATA MANAGEMENT SYSTEMS

6.1 Documentation status of barley collections

Table 10 summarizes information on the status of collections regarding passport and characterization/evaluation data, indicating whether the data are held electronically and if they can be accessed via the internet. Passport information is computerized in most of the collections; availability of characterization/evaluation data electronically is lower. A number of collections may be accessed via the internet, but only some are on-line searchable.

Table 10. Barley collections: documentation held electronically and internet access

No.	Country	Genebank/Institute	Passport data	Charact./ evaluation data)	Web acces
1.	Canada	Plant Gene Resources of Canada, Saskatoon	Yes (100%)	Yes (100%)	http://pgrc3.agr.ca/search_grinca-recherche_rirgc_e.html
2.	USA	USDA-ARS National Small Grains Collection, Aberdeen, Idaho	Yes (100%)	Yes (100%)	http://www.ars-grin.gov/npgs
3.	Brazil	Recursos Geneticos e Biotecnologia, Brasilia (EMBRAPA/ CENARGEN)	Yes (100%)		http://www.cenargen.embrapa.br/recgen/sibrargen/bases.html
4.	GLOBAL	ICARDA, Aleppo, Syria	Yes (100%)	Yes (100%)	http://singer.grinfo.net
5.	United Kingdom	John Innes Centre, Norwich	Yes (100%)	Yes (100%)	http://www.jic.ac.uk/GERMPLAS/bbsrc_ce/index.htm

No.	Country	Genebank/Institute	Passport data	Charact./ evaluation data)	Web acces
6.	Germany	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben	Yes (100%)	Yes (100%)	http://gbis.ipk-gatersleben.de
7.	China	Institute of Crop Germplasm Resources, CAAS, Beijing	Yes	Yes	http://icgr.caas.net.cn/cgris_english.html (in Chinese)
8.	Korea, Rep. of	National Institute of Agricultural Biotechnology, Suwon	Yes (100%)	Yes (80%)	http://genebank.rda.go.kr/english/
9.	Russia	N.I. Vavilov Institute of Plant Industry (VIR)	Yes (100%)	Yes (10%)	http://www.vir.nw.ru/data/dbf.htm
10.	Ethiopia	Institute of Biodiversity Conservation (IBC), Addis Ababa	Yes (100%)	Yes (50%)	http://ibc-et.org/ibc/dbase/
11.	Japan	Research Institute for Bioresources, Okayama University	Yes (60%)	Yes (50%)	www.shigen.nig.ac.jp/barley/
12.	Sweden	Nordic Gene Bank, Alnarp	Yes (100%)	Yes (20%)	www.nordgen.org/ngb/
13.	Australia	Australian Winter Cereals Collection, NSW Calala	Yes (100%)	Yes (80%)	http://www2.dpi.qld.gov.au/extra/asp/auspgris/
14.		CIMMYT, El Batan, Mexico	Yes (90%)	Yes (90%)	http://singer.grinfo.net
15.	Japan	National Institute of Agrobiological Science, Tsukuba	Yes (100%)	Yes (100%)	http://www.gene.affrc.go.jp/plant/
16.	India	National Bureau of Plant Genetic Resources (NBPGR), New Delhi	Yes		
17.	Iran	National Genebank of Iran, Genetic Resources Division, Karaj	Yes	Partly	
18.	Israel	Institute for Cereal Crops Improvement, Tel Aviv University	Yes (100%)	Yes	http://www2.tau.ac.il/ICCI/default.asp
19.	Poland	Plant Breeding and Acclimatization Institute (IHAR), Radzików	Yes	Yes	No
20.	France	Station d'Amélioration des Plantes, INRA, Clermont-Ferrand	Yes (100%)	No	No
21.	Mongolia	Research Institute of Agriculture and Plant Science, Darkhan			
22.	Korea, DPR	Pyongyang Crop Genetic Resources Institute, Pyongyang			
23.	Ukraine	Institute of Plant Production "V.Y. Yurjev", Kharkiv	Yes		No
24.	Bulgaria	Institute for PGR "K. Malkov", Sadovo	Yes (100%)	Yes (100%)	http://eurisco.ecpgr.org
25.	Hungary	Research Centre for Agrobotany (RCA),	Yes (100%)	Yes (80%)	No

No.	Country	Genebank/Institute	Passport data	Charact./ evaluation data)	Web acces
		Tápiószele			
26.	Morocco	Institut National de la Recherche Agronomique (INRA, Morocco), Settat	Yes (100%)	No	No
27.	Netherlands	Centre for Genetic Resources, Wageningen	Yes (100%)	Yes (100%)	http://www.cgn.wur.nl/UK/
28.	Israel	Institute of Evolution, University of Haifa	Yes	Yes	Yes
29.	Brazil	Brazilian Agric. Research Company – Embrapa Wheat, Passo Fundo	Partly	Partly	No
30.	Peru	Universidad Nacional Agraria, La Molina	Yes (90%)	Yes (90%)	No
31.	Israel	Israel Plant Gene Bank, ARO Volcani Center, Bet-Dagan	Yes	Yes	http://igb.agri.gov.il/
32.	Czech Republic	Agricultural Research Institute Kromeriz, Ltd.	Yes (100%)	Yes (82%)	http://genbank.vurv.cz/genetic/resources/
33.	Spain	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Centro de Recursos Fitogenéticos, Alcalá de Henares	Yes		
34.	Italy	Istituto del Germoplasma, CNR, Bari	Yes		No
35.	Romania	Research Institute for Cereals and Technical Plants (ICCPT), Fundulea	Yes		
36.	Slovakia	SARC – Research Institute of Plant Production (RIPP), Piestany	Yes (70%)	Yes (70%)	http://eurisco.ecpgr.org
37.	Czech Republic	Genebank Department, Crop Research Institute, Prague	Yes (100%)	Partly	http://genbank.vurv.cz/genetic/resources/
38.	Egypt	Field Crops Institute, Agricultural Research Centre, Giza	Yes		
39.	Pakistan	Plant Genetic Resources Institute, National Agricultural Research Centre, Islamabad	Yes		No
40.	Italy	C.R.A., Istituto Sperimentale par la Cerealicoltura, Fiorenzuola d'Arda	Partly		No
41.	Syria	Agricultural Research Center, Douma	Yes	Yes	No
42.	Turkey	Aegean Agriculture Research Institute, Izmir	Yes (100%)		No
43.	Romania	Suceava Genebank, Agricultural Research	Yes (100%)		http://www.svgenebank.ro/index.htm

No.	Country	Genebank/Institute	Passport data	Charact./ evaluation data)	Web acces
		Station, Suceava			
44.	Switzerland	Agroscope Changins-Wädenswil ACW, Nyon	Yes (100%)		www.bdn.ch
45.	Lithuania	Lithuanian Institute of Agriculture	Yes		
46.	Austria	Agrobiology Linz-Austrian Agency for Health and Food Safety/ Seed Collection,	Yes		No
47.	Latvia	Latvian State Forestry Institute "Silava", Latvian Gene Bank, Salaspils	Yes (85%)	Yes (5%)	www.nordgen.org/sesto
48.	Estonia	Jõgeva Plant Breeding Institute	Yes (90%)	Yes (80%)	www.nordgen.org/sesto
49.	Ecuador	Inst. Nacional de Investigaciones Agropecuarias	No	No	

In addition to individual genebank data management systems, global, regional and specialized systems have been developed to link different sources of locally curated data, such as CGIAR System-wide Information Network for Genetic Resources (SINGER), Global Inventory of Barley Genetic Resources (GIBGR) and International Barley Information System (IBIS); EURISCO (European PGR catalogue) and the European Barley Database (EBDB) developed by ECPGR at IPK; and Database for Barley Genes and Barley Genetic Stocks developed by ECPGR at NGB. Some of them are presented below in more detail.

6.2 Global Inventory of Barley Genetic Resources (GIBGR)

Genetic Resources Unit (GRU) of ICARDA in collaboration with European Barley Data Base and major barley collections has compiled a Global Inventory of Barley Genetic Resources. The project was supported by SGRP published on CD and soon to be published on the Internet. The Inventory lists more than 190,000 accessions from 61 institutes/genebanks. Approximately 40% of a 'global collection' refers to landraces, collected in the field, or selections from landraces. The inventory identified over 300 collection missions to 57 countries during the period 1921-2001. Whenever the collection site data were sufficiently detailed, the collection sites were geo-referenced to facilitate production of distribution maps and links with GIS. As expected, a significant part of conserved material is the result of breeding efforts and we attempted to cross-reference accessions using standardized names. For large part of breeding material the system also records pedigree, developer and date of release.

The assembled data was standardized in conformity with the Multi-Crop Passport Descriptors (MCPD) proposed by IPGRI/FAO. In particular, priority was given to standardization of names and/or numbers identifying accessions and to geo-referencing collection sites.

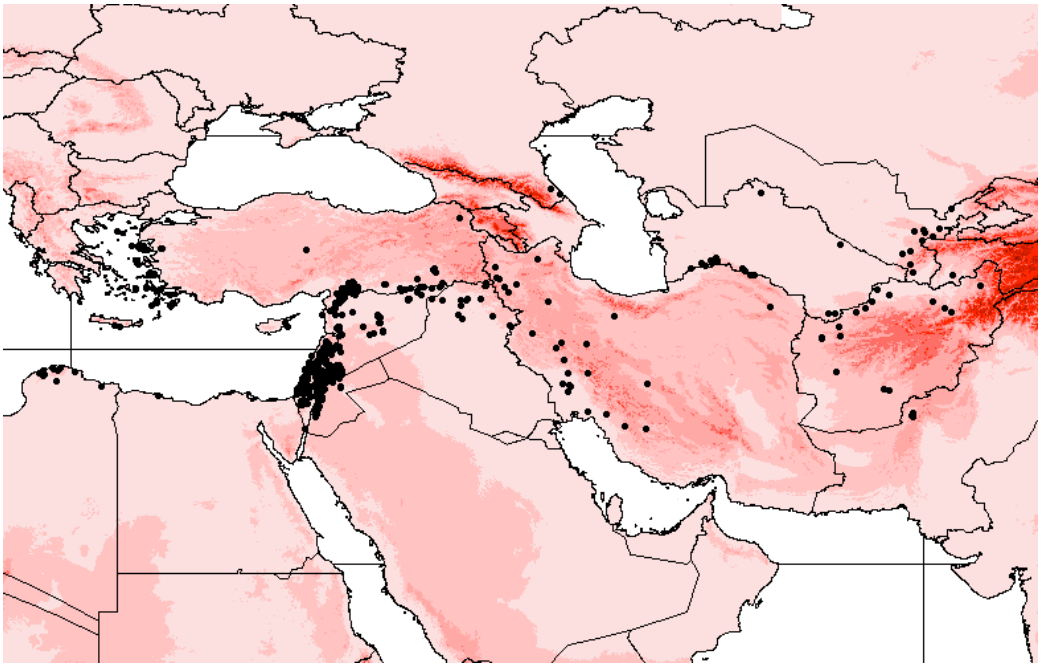
There is significant overlap between the collections due to independent acquisition of material from the original collectors and breeders and exchange of accessions between collections. It is imperative for the global inventory to detect such overlap and to indicate to the users in which

collections the same or similar material is available. Accessions were cross-referenced using two inter-related approaches:

1. For material originally collected in the field, the collection sites were assigned unique site codes and accessions were linked to the normalized collection site records. Currently the inventory registers 302 collection missions, which yielded 29,255 accessions from 14,200 sites. An additional 50,000 accessions have collection site data (over 7,800 different sites) but the mission could not be identified due to lack of data (collection date and/or collectors). Whenever sufficient information was available, the collection sites were geo-referenced and thus can be linked to Geographic Information Systems (GIS) for further processing.
2. For accessions that originated from crop improvement programs, the combined data on accession names, type of material, breeding organization and pedigree were used to identify identical or closely related accessions. It should be noted that the term "accession name" is frequently ambiguous and therefore the project attempted to clarify the meaning of "names" in addition to applying several rules to standardize the names (like use consistent transliteration to Latin, convert to upper case, etc.).

A register of cultivars, landraces and breeding lines was created and currently contains 43,770 entries linked to over 92,000 accessions. The register lists 8,850 cultivars linked to nearly 40,000 accessions. Breeding lines are less frequently replicated in collections as 23,700 accessions refer to 17,000 research and breeding lines.

Figure 1. Geographical distribution of *H. vulgare* subsp. *spontaneum* collection sites



The wild progenitor

The Global Inventory includes nearly 12,500 accessions of *H. vulgare* subsp. *spontaneum* originating from 25 countries. Its geographical distribution is concentrated in the western part of the Fertile Crescent (Figure 1). Some 11,000 accessions were collected from more than 1,300 sites, of which 789 are geo-referenced.

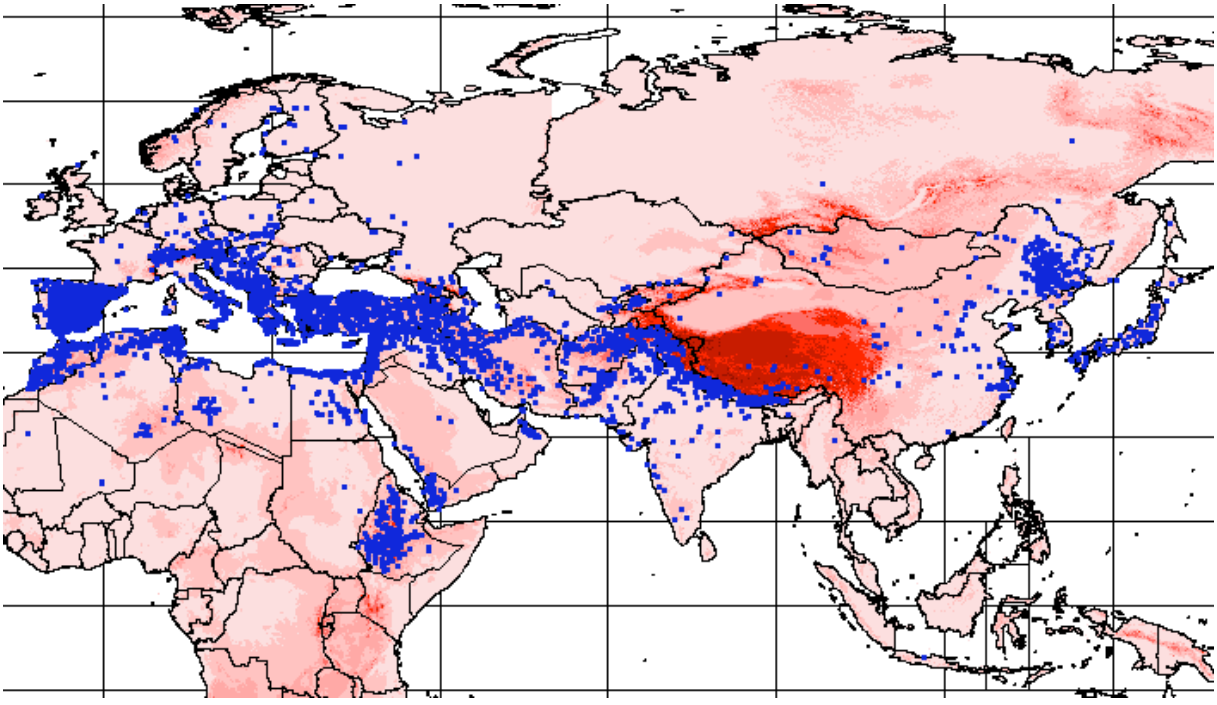
Landraces

Of the total of 129,000 accessions with Germplasm type information, 66,000 accessions (51%) are landraces and mostly originate from a developing part of the world (Table 11 and Figure 2).

Table 11. Global barley landrace holdings by country of origin

Origin	No. accessions
Ethiopia	15353
China	5966
Turkey	5884
Nepal	3162
Switzerland	2964
India	2629
Pakistan	2575
Russia	2387
Afghanistan	1582
Iran	1509
Ukraine	1275
Morocco	1263
Total	**46549**

Figure 2. Geographical distribution of cultivated barley (mostly landraces) collection sites



For more than 50,000 accessions site information is available and some 30,000 geo-referenced accessions were sampled from nearly 16,000 sites. A total of 13,500 accessions have more than 5,000 names. This could indicate that only 38% are unique, but many of the names just relate to geographical origin and germplasm type. Collection number data show that a high proportion (61%) of landrace accessions may be unique. The numbers given in

Table 11 are global landrace holdings by country of origin, which include different proportion of duplications or multiplications.

Cultivars
In total, 36,173 accessions are classified as cultivars of which 25,291 have pedigree information. Since only 3,774 different pedigrees were identified in the Global Inventory, the percentage of unique accessions for the cultivar category is only 15%, indicating a high redundancy in the genebanks.

Table 12. Most frequent cultivar accessions origin

Country	Country code	No. acces.
Germany	DEU	6494
United States	USA	3644
Great Britain	GBR	2919
France	FRA	2598
Japan	JPN	1909
Sweden	SWE	1802
Netherlands	NLD	1286
Czechoslovakia[1]	CSK	1260
Denmark	DNK	1238
Russia	RUS	1137
Austria	AUT	1113
	Total	**25400**

[1] Includes former Czechoslovakia, Czech Republic and Slovakia

If only accession names are considered, then more than 91 % of 36,173 cultivar accessions are duplications or replications. Contrary to landraces, improved cultivars have their origin in developed countries (Table 12) with a long history of barley breeding (cf. Fischbeck, 2003)[16]. The twelve countries listed in the Table 3 developed more than 70% of cultivar accessions held in genebanks worldwide. As expected, many cultivar accessions have moved from one genebank to another and, as a result, there are many multiple copies held in genebank collections (Table 13).

Table 13. The top cultivar replications

Name	Pedigree	Country code	No. acces.
Isaria	Danubia/Bavaria	DEU	48
Kenia	Binder/Gull	DNK	46
Binder	Selection from Hanna	DNK	44
Tschermaks	(Kirsches Winter/Kirsches 2-Row)/(4-Row Winter/Heines Giant Winter)	AUT	41
Wisa	(Weihenst.MR I/Breun IN 2511)/Isaria	DEU	39
Trumpf (Triumph)	Diamant/Hadm. 14029/64/6 ((Alsa/S3170/Abyss)/11719/59)/Union	DEU	38
Union	(Weihenst.MR II/Donaria)/Firlb. 621	DEU	38

[16] Fischbeck, G., 2003. Diversification through breeding. In: R. von Bothmer, Th. van Hintum, H. Knüpffer and K. Sato (eds), Diversity in Barley (*Hordeum vulgare*), pp. 29-52. Elsevier Science B.V., Amsterdam, The Netherlands.

Breeding material
19,000 accessions, which represent a significant part of the barley global holdings, are breeding materials or "material under development". According to their pedigrees, the level of replication is much lower than in cultivars, since 66 % of accessions of this category are unique.

Other wild barley species
1,351 accessions of wild barley species of the secondary and tertiary gene pool are represented in the Global Inventory. Among them, *Hordeum bulbosum* L., *Hordeum murinum* L. and *Hordeum marinum* Huds. were the most frequent with 328, 223 and 137 accessions, respectively. Since the important Canadian wild barley collection is not included in the Global Inventory, these figures are much lower compared to the global study by Hintum and Menting (2003) (cf. sect. 4.3.2).

6.3 The European Barley Database (EBDB)

The European Barley Database (EBDB) is central to the activity of the ECPGR Barley Working Group. It forms the major contribution to the Global Barley Inventory (cf. sect. 4.5.1).

The first version of the EBDB was developed between 1984 and 1987. It contained passport data of 55,000 barley accessions from ca. 35 genebanks in Europe. A second version was built in 1997, including 90,000 accessions. Within the framework of the EU project on Barley Genetic Resources (1999-2002), the database was developed into a Barley Information System. The EBDB currently includes ca. 155,000 accessions from 23 European countries and from three non-European genebanks (the Australian Winter Cereals Collection (AWCC), Tamworth, Australia; ICARDA, Syria; and the Barley Germplasm Centre, Kurashiki, Japan), which led to the inclusion of ca. 38,000 additional accessions. Moreover, 1293 accessions from the International Barley Core Collection (BCC) are documented. The data of most contributing genebanks have not been updated in the last 10 years, due to personal capacity.

Besides passport data, the EBDB includes also evaluation results from the GENRES project on Barley Genetic Resources, available since August 2003. The database utilizes the "Dynamic Data Analyser" (DDA) developed by M. Huldén and D.T.F. Endresen (Nordic Gene Bank) for visualizing evaluation data. The DDA was adapted to the GENRES evaluation data.

The EBDB was transferred to a new database platform, Oracle, in recent years. It is now also searchable via http://pgrc-35.ipk-gatersleben.de/ebdb/ (passport data only). For evaluation data searching, the "old" portal has to be used.

6.4 Database on Barley Genes and Genetic Stocks (BGS)

During the Cereals Network meeting[17] (Armenia, 2003) the information about the Database on Barley Genes and Genetic Stocks (BGS) was presented. The database was developed using AceDB, the database software used also for GrainGenes.

[17] Report of a Cereals Network. First meeting, 3-5 July 2003, Yerevan, Armenia. http://www.ecpgr.cgiar.org/Networks/Cereals/CGR_EUR.pdf

BGS will be included in GrainGenes and provides the possibility of including more data on genetic stocks collections. At IPK, Germany, there is a collection of mutants and other genetic stocks, which is not documented electronically yet. It was therefore recommended that links be established between the Web sites of the AceDB Barley Genetic Stocks Database and the EBDB.

6.5 Information management -Tunis meeting recommendations

At the Tunis meeting several points were raised and recommendation made on global management of information and databases that would facilitate the access to the information and promote the utilization of collections: The main points were summarized in the plenary session:

- Main clients of Barley Information System(s) will be scientists and breeders. They demand, first of all, evaluation data
- There is still great need to strengthen capacity of National Programs in data curation (in documentation in general)
- Development of crop portal is suggested.
- Evaluate GBIF approach (to establish standardized web services for data providers) for accessing data in collections. (probably better approach is to recommend the use of the best technological options available at a time - JK) (I do not know a better available technology at the moment. HK)
- International standards for data exchange should be applied for all crops. The notion to consider revision of multi-crop passport descriptors (MCPD) was put forward within the GPG2 project of the System-wide Program of the CGIAR on crop register. In particular, handling of identifying names and numbers could be improved. However, coordination of the MCPD revision process needs to improve, and a much more transparent process needs to be initiated by Bioversity International.
- Evaluation data were discussed. No clear conclusion but the idea of "champions" was put forward (needs further elaboration)
- Geo-referencing was encouraged, recognizing that this is important mainly for wild material and landraces. Accuracy of geo-referencing needs to be recorded and then taken into account for analysis
- There may be set-specific variables/descriptors in addition to common ones, e.g. genetic stocks will require specific descriptors
- GPG2 project on Crop Registers has started. All collections identified during the workshop should become data providers for Barley Register (use of web-services is preferred if feasible, otherwise other available technologies of data provision should be used). The Register will also include information from the Global Inventory of Barley Genetic Resources (GIBGR).

Step 1 – ICARDA will develop the first version (all collections should be data providers)

Step 2 – Advisory Group should guide the development of system, particularly with regard to inclusion of data other than passport. Composition of the group:

- Mike Ambrose
- Roland von Bothmer
- Stefania Grando

- Bryan Harvey
- Helmut Knüpffer
- Jan Konopka
- Hassan Ouabou
- Thomas Payne

6.6 Gaps in the coverage of global genetic diversity in existing collections

Natural populations of barley wild progenitor, *Hordeum vulgare* subsp. *spontaneum* and other wild relatives are endangered, because of habitat lost by overgrazing, changes in land use and other negative human-induced activities. Landraces are gradually replaced with improved germplasm, but they are still grown in low-input farming systems, particularly in marginal and stress-affected areas. To assess accurately the gaps in the *ex situ* collections globally, it is first necessary to complete geo-referencing of existing collections as much as possible and map the collection sites on the distribution area of natural populations of wild relatives and landrace-growing regions.

7. NETWORKS RELEVANT TO BARLEY GENETIC RESOURCES COLLECTIONS

7.1 Regional Networks

Regional PGR networks have been established for all geographical subregions in the world, often with the support of FAO and the CGIAR. The regional PGR networks often function under the umbrella of regional agricultural organizations that can be important in maintaining the continuity of the networks. The main objective of most of these networks is to strengthen the national PGR programs of the member states and their NARS through information sharing, capacity building, and germplasm exchange. It will enhance collaboration in the region on PGR issues especially in relation to important regional crops which may have received little attention globally.

In the WANA region, the Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA) is currently establishing a PGR regional network in collaboration with Bioversity International, and the International Center for Agricultural Research in Dry Areas (ICARDA).

In the CAC region, the Central Asia and Trans-Caucasus Network on PGR (CATCN-PGR) was established in 1996. Member countries include Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Turkmenistan, Tajikistan and Uzbekistan. In both cases, the priorities are improving communication and information systems for PGR.

In Europe, the European Cooperative Programme for Plant Genetic Resources (ECPGR) was founded in 1980 on the basis of recommendations of UNDP, FAO and EUCARPIA. It is a collaborative program now involving 38 European countries, as well as a number of associated countries, aimed at ensuring the long-term conservation and increased use of plant genetic resources in Europe. The programme is entirely financed by participating countries and is governed by a steering committee of national coordinators with the secretariat hosted at Bioversity International. It operates through crop-specific working groups in which country representatives nominated by their respective country coordinator work together to establish needs and set priorities for each crop.

The ECPGR Working Group on Barley was convened for the first time in 1983, as one of the original six Working Groups developed during the first Phase of ECPGR. The Group developed and updated workplans at successive meetings. The last meeting (Seventh meeting) as held in Yerevan, Armenia, in July 2003, in conjunction with a full meeting of the ECPGR Cereals Network.

7.2 The Barley Core Collection

As mentioned in section 5.3, it is estimated that there are more than 400,000 accessions of barley around the world. To improve the accessibility of such large collections and to rationalize evaluation of plant genetic resources, the concept of core collections was developed[18].

The International Barley Core Collection (BCC) has been developed since 1989 by an international consortium as a voluntary activity of the participating institutions[19]. It attempts to create a common set of barley genotypes for use mainly in research, allowing the compilation of a large set of data on the genetic diversity in barley.

In 1989 the ECPGR Barley Working Group recommended that an *ad hoc* working group should develop the concepts for setting up a European Barley Core Collection – BCC. In 1991, after three meetings and discussions with about 100 barley experts worldwide, the BCC task force presented this concept at the Sixth International Barley Genetics Symposium in Helsingborg, Sweden. The Symposium recommended the involvement of non-European specialists and germplasm collections, in order to develop a truly International Barley Core Collection. An international BCC working group met in ICARDA, Syria, in 1992, and an international symposium on Core Collections was held in Brazil in the same year, where the BCC was presented, discussed and developed further[18]. Since then, the International BCC Committee has organized business meetings and open workshops to monitor progress and coordinate activities, in connection with the International Barley Genetics Symposia in Saskatoon, Canada (1996), Adelaide, Australia (2000), and Brno, Czech Republic (2004).

The BCC is a selected and limited set of accessions. It optimally represents the genetic diversity of cultivated barley and the wild species of *Hordeum*, covering the three genepools (cf. section 4.1 above), and includes well-known genetic standards. This differs from the original definition given by Frankel and Brown[17]: "A core collection consists of a limited set of accessions derived from an existing germplasm collection, chosen to represent the genetic spectrum in the whole collection. The core should include as much as possible of its genetic diversity. The remaining accessions in the collection are called the reserve collection". The BCC is a "synthetic core collection"[20] (Brown, 1995), and it differs from the original definition in the following respects:

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[18] Frankel, O. H., and A. H. D. Brown. 1984. Plant genetic resources today: A critical appraisal. Pp. 249–257 in Crop Genetic Resources: Conservation and Evaluation, J.H. W. Holden and J. T. Williams, eds. London: Allen and Unwin.

[19] Knüpffer, H. and Th.J.L. van Hintum. 1995. The barley core collection: an international effort. Pp. 171-178 *in* Core Collections of Plant Genetic Resources (T. Hodgkin, A.H.D. Brown, T.J.L. van Hintum and E.A.V. Morales, eds.). John Wiley and Sons, Chichester, UK.

[20] Brown, A.H.D. 1995. The core collection at the crossroads. Pp. 3-19 *in* Core Collections of Plant Genetic Resources (T. Hodgkin, A.H.D. Brown, T.J.L. van Hintum and E.A.V. Morales, eds.). John Wiley and Sons, Chichester, UK.

- BCC accessions are selected from all internationally available accessions, rather than from a single genebank collection.
- The BCC is a separate collection, rather than part of an existing genebank collection divided into a core and a "reserve collection".

The BCC is being developed in order to:
1. increase the knowledge about the barley genepool;
2. increase the efficiency of evaluation and thus of utilization of existing collections;
3. provide a manageable and representative, highly diverse selection of the available barley germplasm for use in research and plant breeding;
4. provide adequate standards, e.g., for studies of genetic diversity in barley.

The BCC does not replace existing collections and does not make them superfluous. It is a key for better utilization of the existing collections. For example, data on distribution of CWANA wild and cultivated barley core collections from ICARDA in 2000-2006 show that core collection accessions were distributed from its genebank 11 times more often than the other ones.

The BCC accessions are, as far as possible and when appropriate, homozygous and homogeneous lines derived from genebank accessions by techniques such as single seed descent or doubled haploids. The homogeneity issue has been one of the most controversial issues within the BCC concept. The decisive advantages of homogeneity are the possibility of identical reproduction at different locations over a long period of time (stability of accessions), and the availability of identical material for various investigations (standards). A great disadvantage of homogeneity is, however, that a variable landrace is represented by only one of its lines although reference to the original landrace in the genebank collection is maintained.

The BCC is developed in an international network, which consists of a coordinating committee and subset coordinators, responsible for the selection of BCC subsets, creation of BCC accessions via single seed descent, initial multiplication of BCC accessions and distribution to the 'active BCC centers'. These 'active BCC centers', major research institutions, are responsible for the distribution of BCC samples to *bona fide* users in their respective regions:
- the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) in Gatersleben, Germany, for Europe,
- the International Centre for Agricultural Research in the Dry Areas (ICARDA) in Aleppo, Syria, for the WANA region,
- the Research Institute for Bioresources (RIB), Barley Germplasm Centre in Kurashiki, Japan, for South and East Asia,
- the USDA Small Grain Cereals Collection in Aberdeen, Idaho, U.S., for the Americas,
- the Australian Winter Cereals Collection (AWCC) in Tamworth, Australia, for Australia.

The size of the BCC does not exceed 1,500 accessions at present. Given the maximum size of 2,000 accessions, this leaves room for future additions.

Subsets of the BCC

Landraces and cultivars from Central and West Asia and North Africa (CWANA)
The selection of 285 accessions of the CWANA subset was initiated by ICARDA in 1993/1994. The accessions went through a cycle of single seed descent, after which they were multiplied. The material became available in 1996.

Landraces and cultivars from South and East Asia
The Barley Germplasm Centre of the Okayama University in Kurashiki is responsible for selecting and managing East Asian accessions from Japan, Korea, China, Nepal, Bhutan and India.

Landraces and cultivars from Europe
An initial set of 320 European barley landraces and cultivars was selected by using the European Barley Database, and requested from various European genebanks.

Landraces and cultivars from the Americas
A first selection of American landraces and cultivars was made in consultation with breeders and researchers from the U.S., Canada, Mexico and several South American countries. The current set includes 155 accessions.

Cultivars from Oceania and other parts of the world
A selection of ten Australian and one New Zealand cultivars has been made. This subset includes material grown in southern Africa as, so far, predominantly Australian varieties.

Hordeum vulgare subsp. spontaneum
Originally 152 entries of *H. vulgare* subsp. s*pontaneum* selected from 16 locations in the early 1990s. Since the accessions were already single lines, single seed descent was not considered necessary. This original subsp. *spontaneum* subset was handed over to R. von Bothmer (Sweden) for continued maintenance, and multiplied. A set selected by ICARDA complements the existing set. At present, 150 accessions from 17 countries are available from this subset.

Other wild Hordeum *species*
In the subset representing the wild species, excluding *H. vulgare* subsp. *spontaneum*, two entries were selected from each species (when available). These samples were multiplied after a cycle of single seed descent. Due to problems in the multiplication of the cross-pollinating species *H. bulbosum* and *H. brevisubulatum*, material of these species is not yet available but the other 45 entries of 22 species are.

Genetic stocks
The selection and preparation of the subset with genetic stock was completed recently. U. Lundqvist and J. Franckowiak selected a basic list of candidate accessions, and arrangements for checking and regeneration have been made. In general, only material which is not too difficult to regenerate by genebank staff will be included in the BCC. Most of the material is available from USDA.

7.3 Generation Challenge Program (GCP) composite collection of barley

Within the Generation Challenge Programme (GCP) Subprogram 1 – Genetic Diversity of Global Genetic Resources, ICARDA was assigned the responsibility for developing the

composite set of 3000 barley accessions, representing the range of diversity of the crop and its wild progenitor, *Hordeum vulgare* subsp. s*pontaneum.*

Landrace and wild barley selection was based on agroclimatological data of collection sites, since site coordinates are available for 72% landrace and 52% spontaneum accessions. Using detailed agroclimatological information (67 variables) generated by GIS, accessions were clustered by two-step cluster analysis into 260 clusters, accessions of different geographical origin were selected from each cluster. Improved germplasm selection was based on passport information, including pedigrees, to ensure that most frequent parental varieties/lines are represented in the composite set. In addition, a set of drought-tolerant germplasm was chosen by ICARDA barley breeders and added to the improved germplasm selection. The GCP set includes 150 and 59 accessions of the CWANA wild and cultivated barley core collections, respectively.

The Generation Challenge Program barley composite set consists of the following germplasm (Figure 3):

***H. vulgare* subsp. *spontaneum* (15%)**
The barley wild progenitor is represented by 445 accessions, 65 % of this total are original accessions from ICARDA Genetic Resources Unit (GRU) collection missions. Hyper-arid, arid and semi-arid collection sites represent 1%, 20% and 63% of the total, respectively. The set originates from 20 countries and collection sites belong to 58 ecological clusters.

Landraces (65%)
Landraces are a major part of the set with 1935 accessions. A significant part (20 %) is original material collected by ICARDA. Hyper-arid, arid and semi-arid collection sites are present with 3%, 33% and 43%, respectively. The landrace set originates from 85 countries and 78% is of CWANA origin (Figure 3). Collection sites belong to 255 ecological clusters.

Improved germplasm (20%)
This category includes cultivars, unfinished breeders' materials and genetic stocks, which represent 13%, 6% and 1% of the GCP barley set, respectively.

Figure 3. GCP barley set by type

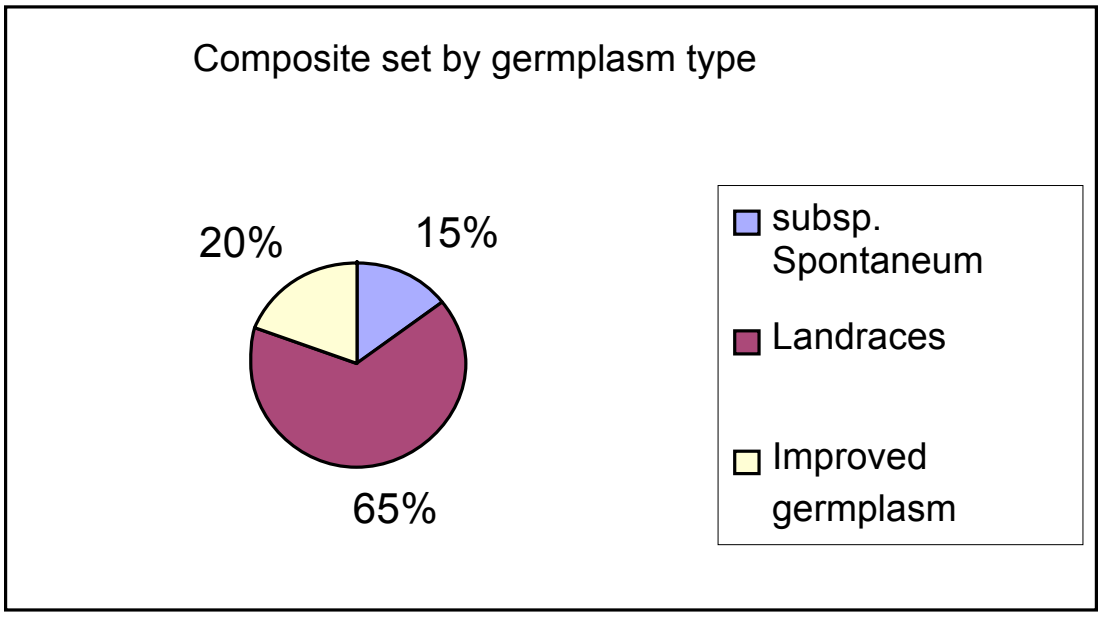
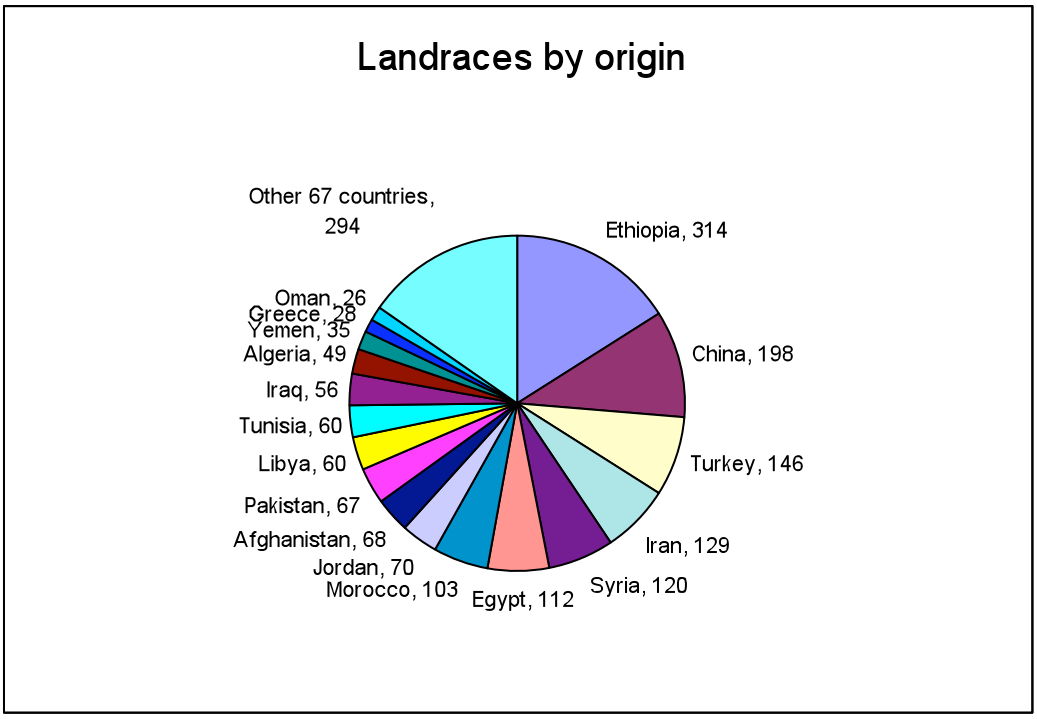


Figure 4. GCP barley set by origin



7.4 Networking and collaboration – Tunis meeting recommendations

Global Barley Strategy areas for collaboration to be strengthened:

- evaluation networks (common set of germplasm, e.g. drawn from the international barley core collection. It is planned to compile a review paper on the utilisation of the BCC for research and evaluation, including a compilation of major research results. This may help identify gaps of future genotype/phenotype work across contrasting environments that might be of interest for cross-regional collaboration.)
- molecular characterization / genomics
- diversity analysis / mapping
- climate modeling
- specialist networks, e.g. genetic stocks network

Networks work on different levels:
- national
- regional
- international

Suggestion / recommendation 1: The Global Crop Diversity Trust could play a valuable role at the institutional level or at ministerial level, to help with recognition of individuals' participation in meetings and expert panels. In a way, to put a "Trust mark" on the individuals and networks.

Suggestion / recommendation 2: That the Barley Genetic Resources Committee of the International Barley Genetic Symposium be re-established.

In order to facilitate regular meetings and to maintain momentum in completing the overview of global resources, coordination is crucial, preferably not in the form of an institute taking the lead. Is this possibly a task of the Global Crop Diversity Trust? Further suggested this might be taken up to the Governing body of the ITPGRFA (see article 16). This could also constitute a mechanism to promote the work of the Treaty in the US, indicating that institutions can get something back from cooperating.

8. POLICY ISSUES

Barley is included within the multilateral system for access and benefit-sharing under the Treaty on PGRFA, listed in the Annex 1 of the Treaty. Consequently, countries that are parties to the Treaty have an obligation to help facilitate their collections of barley genetic resources available under the terms specified in the Treaty. The current status of countries hosting collections relating to the Treaty is given in Table 2. Most countries represented in the Table 2 are parties to the Treaty and 9 countries of the total of 39 have yet to ratify.

9. CAPACITY BUILDING

Training needs were discussed at the Tunis meeting and the following priority activities were proposed:

- Training of staff in general PGR conservation
- Regional workshop for database managers
- Regional Training courses in data providing ("How to become a GBIF Data Provider" tailored for Genebanks)
- Genebanks' visits and on site training for database managers and other areas of PGR conservation
- On-site assistance to database managers to become GBIF data providers (including assistance in installation and configuration of data provider software and mapping of the local database to ABCD)
- Training of trainers in documentation
- Training modules on how to access information and materials from collections
- Training materials for university courses
- Strategies for conservation of wild material and genetic stocks
- Networking to assist with conservation
- Ensuring that new taxonomists are trained to replace "soon to retire" taxonomists
- Human resources in molecular genetics and taxonomy
- Sequence between activities and timing issues
- Networks could review priorities as activities and training is implemented

Most of the proposed training and capacity building activities are non-crop-specific and probably also useful for other crop and regional strategies.

10. A STRATEGIC APPROACH TO CONSERVING THE BARLEY GENEPOOL

The crop genepool includes genetic diversity conserved within all unique accessions held *ex situ* in genebanks. These genetic materials are, in general, readily accessible for utilization in

breeding and research. The other part of the crop genepool occurs under *in situ* condition or on-farm and remains to be collected.

Regarding the material that is already conserved within *ex situ* collections, there are some collections that represent a large part of genetic variation, they are well maintained and are readily available under the terms of the International Treaty. Such key collections may be a basis of a global network providing the genetic variation to international community for crop improvement.

In the Tunis workshop the collections were classified into three groups (Table 14): A – secured and well resourced; B – significant but may need capacity building; C – more information is needed. The classification was based on the following compound criteria: i) structure – size, scope, uniqueness; ii) quality – documentation, facilities, resources; iii) access – accessibility and availability.

A rational approach to conserve the barley genepool would be to provide a sustainable support of the international community to integrated global network of the key collections to ensure that they meet and maintain international conservation standards and are able to distribute high quality seed in a timely manner to users worldwide. There may also be significant and large collections in the category B and C, holding unique, and in many cases local genetic diversity of the barley genepool that might be upgraded with targeted international support to meet the criteria of the key collections. Unique materials held at the smaller collections could thus be integrated into a key collection if funds were provided to cover the costs involved.

Table 14. List of barley main collections

Country	Genebank / institutes	Institute code	Category A/B/C	Notes on categories	Total no. of accessions
Canada	PGRC	CAN004	A		39852
United States	USDA	USA005	A		29838
GLOBAL	ICARDA	SYR002	A		26117
United Kingdom	IPSR	GBR011	A		23603
Germany	IPK	DEU146	A		22106
Korea, Rep. of	CES	KOR003	A	Unique material also from Mongolia, Central Asia	18764
Japan	RIB	JPN009	A		14106
Sweden	NGB	SWE002	A		13435
Australia	TAMAWC	AUS003	A		12600
	CIMMYT	MEX002	A	scope restricted	11202
Japan	NIAR	JPN003	A		8806
Poland	IHAR	POL003	A		5942
France	INRA-CLERMONT	FRA040	A		5517
Hungary	RCA	HUN003	A		4208
Netherlands	CGN	NLD037	A		3507
Czech Republic	KROME	CZE047	A		2705
Spain	INIACRF	ESP004	A		2421
Slovakia	SVKPIEST	SVK001	A		2047
Czech Republic	RICP	CZE122	A		1865
Switzerland	RAC	CHE001	A		795

Country	Genebank / institutes	Institute code	Category A/B/C	Notes on categories	Total no. of accessions
Austria	BVAL	AUT001	A		747
Sub-total cat. A	**21 genebanks**				**250183**
Brazil	Embrapa	BRA003	B	documentation	29227
Russia	VIR	RUS001	B	storage; documentation	17850
Ethiopia	IBC	ETH001	B	accessibility, storage, safety duplication, documentation	15360
Iran	NPGBI	IRN029	B	documentation and safety duplication	7600
Morocco	INRA	MAR003	B	Accessibility	3743
Brazil	CNPT	BRA015	B	Documentation	3360
Peru	La Molina	PER002	B	Storage, documentation, duplication	2759
Turkey	NGB-AARI	TUR001	B	Possibly documentation	1208
Sub-total cat. B	**8 genebanks**				**81107**
China	ICGR-CAAS	CHN001	C	Accessibility, more info on content	18818
India	IARI	IND001	C		8384
Israel	TELAVUN	ISR003	C	Need more information	6662
Mongolia	RIAPS		C		5255
Korea, DPR			C		4504
Ukraine	IR	UKR001	C	Possibly in VIR	4394
Bulgaria	IPGR	BGR001	C		4221
Israel	HAIFA	ISR004	C	Limited scope	3390
Israel	IGB	ISR002	C		2720
Italy	IDG	ITA001	C	Viability of material, duplication?	2102
Romania	ICCPT	ROM002	C		2096
Egypt	EGB	EGY008	C		1750
Pakistan	NARC	PAK001	C		1274
Italy	FIORENZ	ITA024	C	Working collection, genetic stocks and should be incorporated into another long-term collection	1240
Syria	GCSAR	SYR055	C	Largely duplicated	1221
Romania	BRGV Suceava	ROM007	C		1199
Lithuania	LIA	LTU001	C		760
Latvia	PGL-IB	LVA010	C		599
Estonia	JPBI	EST001	C		116
Ecuador		ECU023	C		39
Sub-total cat. C	**20 genebanks**				**70744**
Total	**49 genebanks**				**402034**
Additional collections					
Nepal			C		
Argentina			C		
Uruguay			C		
Chile			C		
Bolivia			C		
Colombia			C		

Country	Genebank / institutes	Institute code	Category A/B/C	Notes on categories	Total no. of accessions
China provincial/territorial genebanks			C		
Eritrea			C	May need urgent regeneration and safety duplication	

11. NEXT STEPS

The Tunis meeting suggested the following steps in the implementation of the Global Strategy for Barley:

Final version of the Strategy document to be circulated to the:

- Barley Newsletter
- Barley Genetics Newsletter
- Grain Genes

Upcoming meetings and opportunities to present the global barley strategy:

- ECPGR Cereals Network meeting, Izmir, Turkey, spring 2008
- International Barley Genetics Symposium (next meeting 5-10 April 2008, in Alexandria, Egypt)
- Barley genetics meeting (regional and national)

<u>Advisory Group and implementation of the Strategy</u>

- The Global Barley Conservation Strategy - Advisory Group is constituted of the participants of the Tunis meeting.
- The Advisory Group would be responsible for reviewing periodically the strategy, assessing its implementation, identifying threatened collections and orphan collections (collections to be abandoned by research programmes)
- The Advisory Group could report to the International Barley Genetics Symposium.
- Jan Valkoun was proposed to represent the Advisory Group at the next IBGS meeting and present the global barley strategy
- A letter should be send to IBGS International Committee from the Trust (Cary Fowler) requesting to:
  - Re-establish the barley germplasm committee
  - Consider questions raised in the strategy
  - Play a facilitating role
- It was proposed that the Trust endorses this group to facilitated institutional commitment in its participation.
- The sustainability of the Advisory Group was discussed and is of concern. It is proposed that funding be sought to hold meetings (the next one at the IBGS) and it was requested that the Trust assist in finding funding opportunities.
- It is important that the Advisory Group and the process be endorsed and recognized to give it legitimacy and the coordination should find an institutional home. It was proposed that ICARDA act as a clearing mechanism and the contact organization. It was therefore proposed that the Trust (Cary Fowler) sends a letter to ICARDA's DG.

Appendix 1. Barley Conservation Strategy Survey - April 2007

1. Background

The Global Crop Diversity Trust is undertaking a series of studies to support the development of international collaborative conservation strategies for different crops. As such strategies evolve, they will provide a basis for the allocation of resources from the Trust to the most important and needy collections. This questionnaire has been developed in order to seek the advice and input of representatives of the world's major barley collections in the development of the barley conservation strategy. In particular the questionnaire aims to assess the status of barley conservation throughout the world. As the strategy document is intended to be made available publicly, results of the survey could be included and therefore published. As curator of a key barley collection, we kindly request you to complete the sections 1-17 of the questionnaire. We estimate that his procedure may take approximately 1 hour of your time. We appreciate your patience. **Please return the questionnaire no later than Friday 15 May 2007 to:** Dr Jan Valkoun, Email: j.valkoun@iol.cz

2. Information about your organization

2.1 Name and address of your organization holding/maintaining the barley collection
2.2 Curator in charge of the barley collection
2.3 Contact details of respondent to this questionnaire

2.4 Date of response of this questionnaire: _____

3. Additional key contacts for the barley germplasm collection

4. Description of your organization

4.1 Please describe your organization

- ☐ Governmental organization
- ☐ University
- ☐ Private organization
- ☐ Other (please specify): _____

4.2 Is the institution in charge of the barley collection the legal owner of the collection?

☐ YES ☐ NO

4.2.1 If NO, who is the owner (including no owner identified)?

4.3 Is the barley collection subject to the terms and conditions of the International Treaty on Plant genetic Resources for Food and Agriculture? ☐ YES ☐ NO

4.3.1 If NO, is expected to become under the International Treaty in the near future?

☐ YES ☐ NO 4.3.1.1 If YES, indicate expected date:

5. Overview of your barley collection

5.1 Please describe the main objectives of the barley collection (long-term conservation, working collection, breeding collection etc**.):**

5.2 Indicate the species and the respective number of accessions from the barley germplasm types that are included in your collection (Please write the number of accessions in brackets after each species name.

Type of barley germplasm	Species name (number of accessions per species in brackets)
Wild related species of barley	
Landraces	
Obsolete improved varieties	
Advanced improved varieties	
Breeding/research materials	
Inter-specific derivatives	
Unknown	
Other	

5.3 Please indicate the share (in %) from each specific type of germplasm that is AVAILABLE for distribution:

Type of barley germplasm (where known**)**	**% available for distribution**
Wild related species of barley	
Landraces	
Obsolete improved varieties	
Advanced improved varieties	
Breeding/research materials	
Inter-specific derivatives	
Unknown	
Other	

5.4 Origin of the barley collection: please indicate the proportion (%) of accessions on the total amount that were... *(Note: the sum should be 100 %!)*

Origin	**Proportion %**
...collected originally in your own country (national origin)	
...collected originally in your own region (regional origin)	
...introduced from a collection abroad	
...from other origin (please define the origin):	

5.5 Are there major gaps in your barley collection? Please indicate major gaps concerning your barley collection:

Species coverage of the crop: ☐ YES ☐ NO
Population (sample) representation per species: ☐ YES ☐ NO
Ecological representation of the species: ☐ YES ☐ NO
Other, please specify the gap concerning your barley collection:
5.5.1 If there are major gaps, please provide details on the plans to fill these gaps:

6. Aspects on the potential of the barley collection

6.1 What would you consider to be the most interesting aspects of your barley collection, making it unique?

6.2 Please describe the main potential/importance of your barley collection for use and breeding:

7. Conservation status (germplasm management)

7.1 Please indicate the proportion (in %) of the barley accessions maintained under different facilities: *(Note: if the same accessions are maintained under more than one storage condition the sum may exceed 100%)*	**Percentage %**
Short-term storage conditions	
Medium-term storage conditions	
Long-term storage conditions	
Other, please specify:	

7.2 Please indicate the proportion (in %) of the barley accessions conserved as: *(Note: if the same accessions are stored as different types of germplasm the sum may exceed 100%)*	**Percentage %**
Seeds	
Field accessions	
In vitro	
Cryopreservation	
Pollen	
DNA	
Other, please specify:	

7.3 Please describe the MAIN storage facility available for your barley collection:
*(If you have **more than one** facility, please use the fields for 'additional facilities' too)*

	Main Facility 1	Additional facility 1	Additional facility 2
Type of facility			
Temperature			
Relative Humidity (%)			
Packing material			
Other, please specify:			

7.4 Please mark for which activity you have established a genebank management system and/or have written procedures and protocols:

- ☐ Acquisition (*including collecting, introduction and exchange*)
- ☐ Regeneration
- ☐ Characterization
- ☐ Storage and maintenance
- ☐ Documentation
- ☐ Health of germplasm
- ☐ Distribution
- ☐ Safety-duplication
- ☐ Other please specify: _____

7.5 In case you have procedures and protocols, are you able to provide the Global Crop Diversity Trust with this information (i.e. provide a copy)? ☐ YES ☐ NO

7.6 Please describe your quality control activities, in terms of frequency, protocols/methods and actions upon results:

Activities	Description of quality control
Germination tests:	
Viability testing:	
Health testing:	
Other, please specify:	

7.7 Is the barley collection affected by diseases that can restrict the distribution of the germplasm?

☐ YES ☐ slightly, only few accessions ☐ NO

7.7.1 If you indicated YES or slightly above, are knowledge and facilities available at your institution for eradication of these diseases? ☐ YES ☐ limited ☐ NO

7.8 What is the normal regeneration interval to maintain the viability of the barley collection?

7.9 Indicate the proportion (%) of each germplasm type that requires urgent regeneration

Type of barley germplasm	% of barley accessions with urgent regeneration need
Wild related species	
Landraces	
Obsolete improved varieties	
Advanced improved varieties	
Breeding/research materials	
Inter-specific derivatives	
Unknown	
Other, please specify:	

7.10 Please indicate the current situation of the barley collection with respect to the following conditions:
(*where: 1 = high/good, 2 = adequate/moderate, 3 = not sufficient/bad, NA = not applicable*)

Condition	**Current situation**	**Expected situation in 2010**
Funding for routine operations and maintenance		
Retention of trained staff		
Interest for plant genetic resource conservation by donors		
Genetic variability in the collection as needed by users/breeders		
Access to germplasm information (passport, charact., evaluation)		
Active support/feedback by users		
Level of use by breeders		
Other factors (please specify):		

8. Safety duplications in other institutions

(Safety duplication: defined as the storage of a duplicate/copy of an accession in another location for safety back-up in case of loss of the original accession.)

8.1 Are barley accessions safety-duplicated in another genebank? ☐ YES ☐ NO

8.1.1 If YES, please specify in the table (and add lines as necessary):

Name of institute maintaining your safety duplicates:	**Number of accessions**	**Storage conditions (short, medium, long term)**	**Nature of the storage (e.g. black box, fully integrated in host collection, etc.)**
1.			
2.			
3.			
4.			
5.			
Etc.			

9. Institutions storing safety duplicates of barley in your genebank

9.1 Is there any barley germplasm of other collections safety-duplicated at your facilities?

☐ YES ☐ NO

9.1.1 If YES, please specify in the table (and add lines as necessary):

Name of holder of the original collection:	**Number of accessions**	**Storage conditions (short, medium, long term)**	**Nature of the storage (e.g. black box, fully integrated in host collection, etc.)**
1.			
2.			
3.			
4.			
5.			
Etc.			

10. Further issues on duplication of barley collection

10.1 To what extent do you consider the barley accessions in your collection to be unique and not duplicated extensively elsewhere (i.e. EXCLUDING safety-duplication)?

☐ Fully unique
☐ Mostly unique
☐ Partially unique
☐ Fully duplicated elsewhere

10.2 Are there any constraints to duplicating the barley collection elsewhere outside your country?

☐ YES ☐ NO 10.2.1 If YES, please specify:

11. Information management

11.1 Do you use an electronic information system for managing the barley collection (data related to storage, germination, distribution, etc.)? ☐ YES ☐ partly ☐ NO

11.1.1 If YES, what software is used? _____

11.2 Please indicate the proportion (%) of the following types of data is: (1) documented and (2) the proportion that is available electronically:

Type of barley germplasm	Passport data		Characterization data		Evaluation data	
	Doc.	Electr.	Doc.	Electr.	Doc.	Electr.
Wild related species	%	%	%	%	%	%
Landraces	%	%	%	%	%	%
Obsolete improved varieties	%	%	%	%	%	%
Advanced improved varieties	%	%	%	%	%	%
Breeding/research materials	%	%	%	%	%	%
Inter-specific derivatives	%	%	%	%	%	%
Unknown	%	%	%	%	%	%

11.3 In case the information on the barley collection is not computerized, are there plans to do so in the future?

☐ No plans
☐ Computerization planned within 3 years
☐ Other

11.4 Is information of the barley collection accessible through the Internet?

☐ YES ☐ Partly ☐ NO
If YES, please indicate the address of the website: http://_____

11.4.1 If there is NO data available in the internet, is an electronic catalogue distributed on CD or by Email?
☐ YES ☐ NO
11.4.1.1 If YES, would you be able to provide the Trust with a copy? ☐ YES ☐ NO
11.4.2 If there is NO data available electronically do you produce a printed catalogue?
☐ YES ☐ NO
If YES, please include a copy to Dr Jan Valkoun (j.valkoun@iol.cz) when returning the completed questionnaire.

11.5 Are data of the barley collection included in other databases?

National	☐ YES	☐ partly	☐ NO
Regional	☐ YES	☐ partly	☐ NO
International	☐ YES	☐ partly	☐ NO

11.5.1 If YES or partly, indicate the database (e.g. GRIN, SINGER, EURISCO etc.):
11.5.2 Would you consider an international crop specific catalogue for barley genetic resources (International Barley Database) to be useful? ☐ YES ☐ partly ☐ NO
11.5.3 Would you like to contribute data to an international Barley Database?

Passport data	☐ YES	☐ partly	☐ NO
Pedigree data	☐ YES	☐ partly	☐ NO
Characterization and evaluation data	☐ YES	☐ partly	☐ NO
Molecular data (Marker, Genome, Proteome)	☐ YES	☐ partly	☐ NO
Pictures	☐ YES	☐ partly	☐ NO

Other data (please indicate): _____

12. Distribution and use of material

12.1 What proportion (%) of the total barley collection is AVAILABLE for the following distributions?
Nationally: _____% Regionally: _____% Internationally: _____%

12.2 Please fill in the number of barley accessions DISTRIBUTED annually, and indicate the expected change over the next 3-5 years, where: + = increasing, 0 = no change, - = decrease

	Number of accessions distributed annually (average of last 3 years)	**Expected change for the next 3-5 years**
Nationally		
Regionally		
Internationally		

12.3 Do you put specific conditions or requirements for distribution of barley accessions?

☐ YES ☐ NO

12.3.1 If YES, please specify: _____

12.4 What is the proportion of barley germplasm sufficiently available in terms of QUANTITY for distribution? _____% of accessions is sufficiently available

12.5 Is the distribution of barley germplasm limited because of its HEALTH status?

☐ YES ☐ partly ☐ NO

12.6 Do you have adequate procedures in place for...

…Phytosanitary certification? ☐ YES ☐ NO

…Packaging? ☐ YES ☐ NO

…Shipping? ☐ YES ☐ NO

…Other, please specify: (_____) ☐ YES ☐ NO

12.7 Do you keep records of the barley accession distribution? ☐ YES ☐ NO

(e.g. who received it, quantity, date of shipment, nature of distributed material etc.)

12.8 Please indicate the proportion (in %) of users who received barley germplasm from you in the past 3 years:

12.8.1 Provenance of users:	**Proportion of total distribution %**
Domestic users	
Foreign users	
12.8.2 Type of users:	**Proportion of total distribution %**
Farmers and Farmers' organizations	
Other genebank curators	
Academic Researchers and Students	
Plant breeders - public sector	
Plant breeders - private sector	
NGOs	
Others, please specify:	

12.9 Describe briefly how you inform potential users about the availability of barley accessions and their respective data in your collection?

12.10 Describe briefly what are the most important factors limiting the use of the barley material maintained in your collection?

12.11 Indicate if users have to pay money or not when they request material from you:

for accessions: ☐ free ☐ cost (in US$/accession): _____

for the shipment: ☐ free ☐ cost (in US$/accession): _____

12.12 Do you use a Material Transfer Agreement when distributing material? ☐ YES ☐ NO

12.13 Do you have any restrictions on who can receive barley materials? ☐ YES ☐ NO

12.13.1 If YES, please specify: _____

13. Networks of barley genetic resources

13.1 Do you collaborate in (a) network(s) as a barley collection holder? ☐ YES ☐ NO

13.2 If you collaborate in (a) network(s) please provide the following information of them:

*(**A**) name, (**B**) type (national, regional or worldwide), (**C**) main objectives, and (**D**) a brief description of the main reasons to participate in the network.*

A **Name of network**	**B** **Type of network** National/Regional/Worldwide	**C** **Main objectives of the network**	**D** **Brief description of the main reasons to participate in the network**

14. Major constraints: Please list the 5 major limitations you are facing in the management of the barley collection:

Appendix 2. Institutions with barley collections invited to respond to the survey

No.	Country	Institute	Email address
1.	Argentina	Banco Base Nacional de Germoplasma	znoga@cirn.inta.gov.ar
2.	Australia	Australian Winter Cereals Collection	michael.mackay@dpi.nsw.gov.au
3.	Austria	AGES - Austrian Agency for Health and Food Safety, Linz	wolfgang.kainz@ages.at
4.	Brazil	Centro Nacional de Pesquisa de Trigo (CNPT), EMBRAPA, Paso Fundo	iorcz@cnpt.embrapa.br
5.	Brazil	EMBRAPA Brasilia	cgoedert@emprapa.br
6.	Bulgaria	Institute of Plant Genetic Resources "K. Malkov"	s_stoyanova@gbg.bg
7.	Canada	PGRC	diederichsena@agr.gc.ca
8.	Chile	INIA	iseguel@inia.cl
9.	China	Institute of Crop Germplasm Resources (CAAS)	zhangjing@caas.net.cn
10.	Cyprus	ARI	Athena.della@arinet.ari.gov.cy
11.	Czech Republic	Agricultural Research Institute Kromeriz, Co. Ltd.	spunar@vukrom.cz
12.	Czech Republic	Research Institute of Crop Production (RICP)	stehno@vurv.cz
13.	Ecuador	INIAP	iniap@iniap-ecuador.gov.ec
14.	Egypt	National Gene Bank, Cairo	info@ngb.gov.eg
15.	Estonia	Jogeva Plant Breeding Institute	kylli.annamaa@jpbi.ee
16.	Ethiopia	Institute of Biodiversity Conservation	dg-ibc@ethionet.et
17.	France	Genetic Resources Center, UMR 1095 Amélioration et Santé des Plantes	adiddier@clermont.inra.fr
18.	Germany	Institute of Plant Genetics and Crop Plant Research	knupffer@ipk-gatersleben.de
19.	Global	CIMMYT, El Batan, Mexico	t.payne@cgiar.org
20.	Global	ICARDA, Aleppo, Syria	j.konopka@cgiar.org
21.	Greece	NAGREF	kbladen@otenet.gr
22.	Hungary	Research Centre for Agrobotany	lholly@agrobot.rca.hu
23.	India	NBPGR	aksingh@nbpgr.ernet.in

No.	Country	Institute	Email address
24.	Iran	Seed and Plant Improvement Institute, Karaj	jmozafari@yahoo.com
25.	Israel	Israeli Gene Bank for Agricultural Crops (IGB)	rihadas@volcani.agri.gov.il
26.	Israel	Institute for Ceral Crops Improvement, Tel Aviv University	ceral@post.tau.ac.il
27.	Israel	Institute of Evolution, University of Haifa	nevo@research.haifa.ac.il
28.	Italy	Ist. Sperim. per la Cerealicoltura, Sezione di Fiorenzuola d'Arda	michele@stanca.it
29.	Japan	Barley Germplasm Center, Research Institute for Bioresources, Okayama University	kazsato@rib.okayama-u.ac.jp
30.	Japan	NIAS Tsukuba	genebank@nias.affrc.go.jp
31.	Korea	NIAB, Genetic Resources Division	yipark@rda.go.kr
32.	Latvia	Latvian Gene Bank of Cultivated Plants, LSIF Silava	agnese@silava.lv
33.	Lithuania	Lithuanian Institute of Agriculture	alge@lzi.lt
34.	Mexico	Universidad Agronoma de Chapingo	cuevasax@taurusl.chapingo.mx
35.	Mexico	INIFAP	espinosal@inifap2.inifap.conacot.mx
36.	Mongolia	Mongolian State University of Agriculture	infotech@magicnet.mg
37.	Morocco	INRA, Morocco	ouabbou@yahoo.com
38.	Netherlands	Centre for Genetic Resources, the Netherlands (CGN)	nbrtje@wur.nl
39.	Pakistan	NARC, Plant Genetic Resources Program	zahmad51@hotmail.com
40.	Peru	Universidad Nacional Agraria, La Molina	pcereal@lamolina.edu.pe
41.	Poland	Plant Breeding Smolice	zdbakow@kki.pl
42.	Poland	IHAR	z.bulinska@ihar.edu.pl
43.	Romania	Banca de Resurse Genetice Vegetale Suceava	genebank@suceava.astral.ro
44.	Romania	NARDI Fundulea	office@incda-fundulea.ro
45.	Russia	N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry	o.kovaleva@vir.nw.ru
46.	Slovakia	Research Institute of Plant Production (RIPP)	benkova@vurv.sk
47.	Spain	IRTA, Area de Cultivos Extensivos	joseluis.molina@irta.es

No.	Country	Institute	Email address
48.	Spain	Centro de Recursos Geneticos, INIA	ayerbe@inia.es
49.	Sweden	Nordic Gene Bank	louise@nordgen.org
50.	Switzerland	Station de Recherche, Nyon	geert.kleijer@acw.admin.ch
51.	Syria	GCSAR	majdjamal@scs-net.org
52.	Turkey	Aegean Agricultural Research Institute (AARI)	pgr@aari.gov.tr
53.	Ukraine	National Center of Plant Genetic Resources	npcgru@kharkov.ukrtel.net
54.	United Kingdom	John Innes Centre, Dept. of Applied Genetics - Norwich Res. Park	mike.ambrose@bbsrc.ac.uk
55.	USA	USDA, National Small Grains Collection	nsgchb@ars-grin.gov

Appendix 3. List of replies to the survey

No.	Country	Name of Institute	Name
1.	Australia	Australian Winter Cereals Collection, NSW Department of Primary Industries	Michael Mackay michael.mackay@dpi.nsw.gov.au
2.	Brazil	Brazilian Agricultural Research Company - Embrapa Wheat	Edson Jair Iorczeski iorcz@cnpt.embrapa.br
3.	Bulgaria	Institute of Plant Genetic Resources "K. Malkov"	Siyka Stoyanova s_stoyanova@gbg.bg
4.	Canada	Plant Gene Resources of Canada	Ken Richards richardsk@agr.gc.ca
5.	Czech Republic	Crop Research Institute	Zdenek Stehno stehno@vurv.cz
6.	Czech Republic	Agricultural Research Institute Kromeriz, Ltd.	Jarmila Milotová milotova@vukrom.cz
7.	Ecuador	Instituto Nacional de Investigaciones Agropecuarias, INIAP	Miguel Rivadeneira cereales@puntonet.ec(respondent)
8.	Estonia	Jõgeva Plant Breeding Institute	Külli Annamaa kylli.annamaa@jpbi.ee
9.	Ethiopia	Institute of Biodiversity Conservation	Adugna Abdi Wodesamayat adugnaa@yahoo.com
10.	France	INRA (Institut Nacional de la Recherche Agronomique)	Audrey Didier adiddier@clermont.inra.frJean Koenig
11.	Germany	LeibnitzLeibniz Institute of Plant Genetics and Crop Plant Research	Andreas Börner, Helmut Knüpffer knupffer@ipk-gatersleben.de
12.	GLOBAL	International Center for Agricultural Research inn in the Dry Areas (ICARDA), Syria	Jan Konopka j.konopka@cgiar.org
13.	GLOBAL	Centro International de Mejoramiento del Maiz y Trigo (CIMMYT), Mexico	Thomas S. Payne t.payne@cgiar.org
14.	Hungary	Central Agricultural Office, Directorate of Plant Production and Horticulture, Research Centre for Agrobotany (RCA)	Lajos Horváth Laszlo Holly lholly@agrobot.rcat.hu
15.	Israel	Agricultural Research Organization Volcani Center	Rivka Hadas rihadas@volcani.agri.gov.il
16.	Italy	C.R.A., Istituto Sperimentale per Cerealicoltura	A. Michele Stanca michele@stanca.it
17.	Japan	Research Institute for Bioresources, Okayama University	Kazuhiro Sato kazsato@rib.okayama-u.ac.jp
18.	Korea, Rep. of	National Institute of Biotechnology, Suwon	Yong-Jin Par yipark@rda.go.kr
19.	Latvia	Latvian State Forestry Research Institute "Silava", Latvian Gene Bank	Agnese Galite agnese@silava.lv
20.	Morocco	Institut Nacional National de la Recherche Agronomique, INRA	Hassan Ouabbou ouabbou@yahoo.com
21.	Peru	Universidad Nacional Agraria, La Molina	Luz Gomez-Pando luzgomez@lamolina.edu.pe
22.	Russia	N.I. Vavilov Institute of Plant Industry	Olga N. Kovaleva

No.	Country	Name of Institute	Name
			o.kovaleva@vir.rw.ru
23.	Slovakia	SARC - Research Institute of Plant Production (RIPP)	Michaela Benková benkova@vurv.sk
24.	Sweden	Nordic Gene Bank	Morten Rasmussen morten.rasmussen@nordgen.org
25.	Switzerland	Agroscope Changins-WädenswillWaedenswil ACW	Geert Kleijer geert.kleijer@acw.admin.ch
26.	Turkey	Aegean Agricultural Research Institute	Ayfer Tan pgr@aari.gov.tr
27.	United Kingdom	John Innes Centre	Mike Ambrose mike.ambrose@bbsrc.ac.uk
28.	USA	USDA-ARS National Small Grains Collection	Harold E. Bockelman hbockelman@ars-grin.gov

Appendix 4. Programme of the Expert Consultation meeting, Tunis, Tunisia, 4-6 September 2007

Objective:
To consult representatives of relevant barley collections and other experts on key elements of a global strategy for the efficient and effective ex situ conservation of genetic resources of barley

Expected outcomes:
1. Development of a Strategy for the Global Conservation of Barley Genetic Resources.
2. Identification and assessment of global, regional and national collections of barley genetic resources meeting the international standards for conservation and playing a key role in a global conservation system.
3. Development of a global model for collaboration and sharing responsibilities for an effective and efficient management of key collections of barley genetic resources.
4. Identification of major needs and opportunities for upgrading key collections and building the capacity of managers to maintain and distribute them efficiently and effectively over long term.
5. Identification of information technology needs for an integrated global network of genetic resource collections of barley and steps required to meet these needs.
6. Identification of critical gaps in existing world collections of barley genetic resources and identification of strategies to fill these gaps by comparing International/ National databases.

DAY 1	**Tuesday, 4th September 2007**
0830-0900	**Registration (**near the Meeting Venue**)**
0900-1015	**Opening Session -** Chair: Dr Mohammed El Mourid ▪ Welcome address from Prof. Abdelaziz Mougou, President IRESA, Tunisia ▪ Welcome by ICARDA - Dr Mohammed El Mourid (North Africa Regional Coordinator) ▪ Welcome by Global Crop Diversity Trust - Brigitte Laliberté ▪ Introduction of participants ▪ Discussion and approval of agenda ▪ Logistic arrangements (ICARDA NA Regional Office) ▪ Introduction to the Global Crop Diversity Trust and Conservation Strategies - B. Laliberté (30 minutes)
1015-1040	***Group photograph and coffee break***
1040-1230	**Developing a Global Conservation Strategy for Barley –** Chair: Dr Adugna Abdi Woldesemayat ▪ International Treaty on PGRFA - Bryan Harvey (30 minutes including discussion) ▪ Barley Conservation Strategy (process, results so far, and gaps) – J. Valkoun (facilitator) (30 minutes) ▪ Discussion (20 minutes) ▪ European Cooperative Programme for Plant Genetic Resources (ECPGR), Barley Working Group –H. Knüpffer (15 minutes)
1230-1330	***Lunch Break***

1300-1530 **Linking the collections into a global network - potential models -** Chair: S. Grando

- Special collections:
  - Barley Wild Relatives Collections – R. von Bothmer (15 minutes)
  - The International Barley Core Collection – H. Knüpffer (15 minutes)
  - Genetic Stocks Collections – H. Bockelman (15 minutes)
  - Generation Challenge Program (Barley sets) – ICARDA (15 minutes)
  - CIMMYT collection – T. Payne (15 minutes)

Discussion (30 minutes)

1530-1600 ***Coffee Break***

1600-1800 **Promoting the use of barley collections -** Chair: J. Špunar

- Information Systems for Barley Genetic Resources –J. Konopka (20 minutes)
- Creating PGR Information Networks Using GBIF technology - H. Knüpffer (15 minutes)
- Focused Identification of Germplasm Strategy – M. Mackay (20 minutes)
- Farmers' participation in barley diversity conservation and breeding – S. Grando, ICARDA (20 minutes)
- Discussion and recommendations for the global barley strategy (40 minutes)

1930 **Reception Dinner**

DAY 2 **Wednesday, 5th September 2007**

0830 - 0900 **Discussion on the presentations of the session on Promoting the use of barley collections**

0900-1030 **PLENARY - Information/data on status of collections** - Chair: B. Laliberté

- Presentation of the data gathered from different sources and the survey and review the information on barley collections – J. Valkoun
- Propose the major key collections and agree on factors of importance such as size of the collection, origins (e.g. number of accessions originating nationally), nature (e.g. the relative proportions of local landraces, wild relatives, advances lines etc.), etc.
- Identify other significant collections and sets of accessions within collections, and consider their possible roles within, and contributions to a more rational global conservation system.
- Identify major gaps in the genetic diversity coverage of existing collections
- Identify additional information required in order to fully address the above issues

1030-1100 ***Coffee/tea break***

1100-1230 **WORKING GROUP SESSION 1 – barley information networking**

Parallel sessions

- Assess the current status of information systems
- Indicate how to move forward with a global barley information system to facilitate access for use of the germplasm
- Recommendations and priorities for the barley strategy

1230-1330 ***Lunch break***

1330-1430 **REPORTS on INFORMATION SYSTEMS**: Chair: Dr. J. Mozafari

Reports of the 2 working groups, discussion of issues and recommendations for a global barley strategy

1430-1530 **WORKING GROUP 2 - Links with users**

- Assess the effectiveness of current links to users (especially professional plant breeders, researchers and farmers)
- Identify ways in which greater use of the conserved germplasm can be promoted
- How feedback from users can be obtained and included in information systems.

WORKING GROUP 3 - Networking and collaboration

- Identify the main areas of collaboration for the global barley strategy
- Assess the effectiveness of existing international cooperation, coordination and technical support mechanisms: networks, international programs etc.
- How can collaboration be strengthened / improved?
- Identify partners able to provide specific conservation and other services (e.g. genetic stocks collections, wild species of secondary and tertiary genepool etc…)
- Other ideas on networking and collaboration

1530-1600	***Coffee break***
1600-1730	**Report from WG 2: links with users** - Chair: Roland von Bothmer ▪ Discussion of issues and recommendations for a global barley strategy **Report from WG3: networking and collaboration -** ▪ Discussion of issues and recommendations for a global barley strategy
DAY 3	**Thursday, 6 September**
0830-1030	**Summary outcomes of DAY discussions -** Chair: H. Bockelman ▪ Key collections for the global barley strategy ▪ Information systems / networks ▪ Links with users ▪ Collaboration
1030-1100	***Coffee/tea break***
1100-1230	**Additional topics** - Chair: Michael Mackay ▪ Identify the urgent regeneration needs ▪ Safety-duplication: to what extent are collections already duplicated for safety reasons? What should be the strategy for such duplication – including duplication in the International Arctic Seed Vault? ▪ Identify major upgrading and capacity-building needs
123-1330	***Lunch***
1330-1500	**Conclusions of the meeting and the next steps** - Chair: Brian Harvey a) Next steps with the strategy document b) Next steps with implementation of strategy and activities Closure (ICARDA and Trust representatives)

Appendix 5. List of Participants

Expert Consultation Meeting for Developing a Strategy for the Global Conservation of Barley Genetic Resources, 4-6 September 2007, Tunis, Tunisia

	Country	Name	Institution	Address
1.	Australia	**Michael Mackay**	Australian Winter Cereals Collection, NSW Dept. Primary Industries	4 Marsden Park Rd. Calala NSW 2340 Australia Tel: +61 2 67631500 Mob: +61 4 04562800 Fax: + 61 2 67 631154 Email: Michael.mackay@dpi.nsw.gov.au
2.	Brazil	**Edson Jair Iorczeski**	Embrapa – Brazilian Corporation for Agricultural Research	Tel: +55 54 33165800 Fax: +55 54 33165801 Email: iorcz@cnpt.embrapa.br
3.	Canada	**Bryan Harvey**	Plant Sciences Dept University of Saskatchewan	51 Campus drive Saskatoon sk. 57N5A8, Canada Tel: 1 306 966 5795 Email: Bryan.harvey@usask.ca
4.	Czech Republic	**Jaroslav Spunar**	Agricultural Research Institute, Kromeriz, Ltd.	Havlickova 2787/121, 767 01 Kromeriz Czech Republic Tel: +420 573317193 Mob: 728462857 Fax: +420 573339725 Email: spunar@vukrom.cz
5.	Ethiopia	**Adugna Abdi Woldesemayat**	Institute of Biodiversity Conservation	P.O. Box IS838 Addis Ababa, Ethiopia Tel: + 251 11 6512029 Mob: + 251 911076995 Fax: + 251116613722 Email: adugnaa@yahoo.com
6.	Germany	**Helmut Knüpffer**	Leibniz institute of Plant Genetics and Crop Plant Research (IPK)	Corrensstr. 3, D - 06466 Gatersleben, Germany Tel: +49394825283 Fax: +49394825155 Email: knupffer@ipk-gatersleben.de
7.	Iran	**Javad Mozafari**	National Plant Gene-Bank, Seed &Plant Improvement Institute	Mahdast Road, Karaj, Iran Tel: +982612701260 Mob: +989123763457 Fax: +98 2612716793 Email: jmozafar@yahoo.com
8.	Japan	**Kazuhiro Sato**	Research Institute for Bioresources Okayama Univ.	2 – 201, Chu-o, Kurashiki 710-0046. Japan Tel: +81864341244 Fax: +81864341249 Email: kazsato@rib.okayama-u.ac.jp
9.	Morocco	**Hassan Ouabbou**	INRA- Morocco	CRRA Settat B.P. 589, Settat 29000 Tel: 023729300/07 Mob: 061475211 Fax: 023720927 Email: ouabbou@yahoo.com

	Country	Name	Institution	Address
10.	Peru	**Luz Gómez Pando**	Universidad Nacional Agraria La Molina, Programa de Cereales Universidad	Av. La Molina S/N La Molina-Lima, Peru Tel: 00 511 3495799 Fax: 00 511 3495800 Email: luzgomez@lamolina.edu.pe pcereal@lamolina.edu.pe
11.	Russia	**Olga Kovaleva**	VIR, Dept. of Oat, Rye, Barley	Bolshaya Morskaya st. 44 s. St. Petersburg, Russia Tel: + 7 812 5719388 Mob: + 7 921 304 3411 Email: o.kovaleva@vir.rw.ru
12.	Sweden	**Roland von Bothmer**	LTJ Faculty Swedish Univ. Agric Sciences	P.O. Box 52 SE 23053 ALNARP Sweden Tel: +4640415001 Mob: +46706764418 Fax: + 4640415010 Email: roland.von.bothmer@ltj.slu.se
13.	Tunisia	**Abdelhakim Issaoui**	Ministère de l'Environnement et eu developpement durable	Avenue de la Terre 2080 Ariana Tunisia Tel: 216 70 728 694 Mob: 216 98 905 322 Email: hakissaoui@yahoo.fr Pgh.pca@minent.gov.tn
14.	Tunisia	**Mouldi Elfelah**	INRAT _ IRESA	Rue Hédi Karray, 2049 Ariana _ Tunisia Tel: + 216 71 231509 Mob: + 216 98526679 + 216 24526679 Fax: +216 71231509 Email: elfalah.mouldi@iresa.argrinet.tn
15.	United Kingdom	**Michael J. Ambrose**	John Innes Centre	John Innes Centre, Norwich Research Park, Colney, Norwich, NR4 7UH, UK Tel : +44 0 1603 450630 Fax: +44 0 1603 450045 Email: mike.ambrose@bbsrc.ac.uk
16.	USA	**Harold Bockelman**	USDA	1691 S. 2700 W. Aberdeen, ID 83210 Tel: 112 208 397 4162 Fax: 112 208 397 4165 Email: hbockelman@ars-grin.gov
17.		**Jan Valkoun**	Scientific Consultant	Dienzenhoferovy sady 6/1117 150 00 Praha 5 Czech Republic Tel: + 420 257 316878 Mob: +420 608 450681 Email: j.valkoun@iol.cz
18.		**Jan Konopka**	ICARDA	ICARDA P.O. Box 5466. Aleppo, Syria Tel: 963 21 2213433 Mob: 5210540 Fax: 963 21 2213490, 5744622 Email: j.konopka@cgiar.org
19.		**Stefania Grando**	ICARDA	ICARDA P.O. Box 5466. Aleppo, Syria Tel: 963 21 2213433 Mob: 963-966- 415681 Fax: 963 21 2213490, 5744622 Email: s.grando@cgiar.org

	Country	Name	Institution	Address
20.		**Mohammed El Mourid**	ICARDA	ICARDA - Tunis n° 1 rue des Oliviers - El Menzah V - 2037 Tunis - Tunisia Post Office Box: 435 El Menzah 1- 1004 Tunis - Tunisia Tel: ++ 216 71 752 134/099 Mob: ++ 216 71 753 170 Email: melmourid@yahoo.fr – secretariat@icarda.org.tn
21.		**Thomas S. Payne**	CIMMYT	Apdo. Postal 6-641 06600 Mexico, D.F. Mexico Tel: + 52 55 5804 2004 Fax: + 52 55 5804 7558 Email: t.payne@cgiar.org
22.		**Brigitte Laliberté**	Global Crop Diversity Trust	c/o Bioversity International Via dei Denari, 472/a 00057 Maccarese, Rome, Italy Tel: 39 06 6118272 Fax: 39 06 61979661 Email: b.laliberte@cgiar.org
23.		**Britta Skagerfält**	Global Crop Diversity Trust	c/o FAO Viale delle Terme di Caracalla 00153 Rome, Italy Tel: + 39 0657056284 Mob:+ 393475712730 Fax: +39 0657055609 Email:britta.skagerfalt@croptrust.org

	Unable to attend:	
1.	**Vince Logan**	GRDC, Australia
2.	**Richard St-Pierre**	PGRC Canada
3.	**Zhang Jing**	CAAS, China
4.	**Victor Shevtsov**	Krasnodar University, Russia
5.	**George Ayad**	Director, CWANA regional office of Bioversity International, Aleppo, Syria