GLOBAL STRATEGY FOR THE *EX SITU* CONSERVATION WITH ENHANCED ACCESS TO WHEAT, RYE AND TRITICALE GENETIC RESOURCES

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DISCLAIMER

This document has been developed by the crop experts. The objective of this document is to provide a framework for the efficient and effective *ex situ* conservation of the globally important collections of wheat, rye and triticale.

The Global Crop Diversity Trust (the Trust) provided support towards this initiative and considers this document as a critical framework for guiding the allocation of its resources. However the Trust does not take responsibilities 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 is expected to continue evolving and being updated as and when information becomes available. The Trust therefore acknowledges this version dated 20 September 2007.

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

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We applaud the Global Crop Diversity Trust for spearheading the development of this, and related, crop conservation strategy, and the interest and support given by the Grains Research and Development Corporation (GRDC) throughout this process.

Cover photo: Triticale spikes at anthesis (courtesy, Dr. Karim Ammar, CIMMYT)

EXECUTIVE SUMMARY

The Strategy Advisory Group was composed of a small group of experts with global experience in all aspects of the conservation and use of the genetic resources of wheat, rye and triticale. The major germplasm collections of wheat, rye and triticale globally were identified from existing public databases including those held by the Food and Agricultural Organisation of the United National (FAO), Bioversity International (former International Plant Genetic Resources Institute - IPGRI), and the European Cooperative Programme for Plant Genetic Resources (ECPGR). Particular emphasis was given to identification of collections holding unique accessions of wild relatives and genetic stocks of wheat. The wild relatives of wheat have proved to be highly useful sources of resistance to biotic and abiotic stresses in wheat breeding over the last two decades and this trend is expected to accelerate in the future. Similarly genetic stocks are finding increasing use as tools in the sophisticated application of modern biotechnologies in wheat improvement. Surveys were conducted of genebank managers and users (primarily wheat breeders). Catalogues of collections of precise genetic stocks and wild relatives of wheat were also compiled. Using information gleaned from the surveys and the Strategy Advisory Group, a list of key collections that should be targeted for inclusion in global networks of wheat, rye and triticale genetic resources was developed. Identification of gaps in the existing collections, establishment of priorities to fill those gaps and plans to meet the most urgent priorities is a high priority. Evaluation of options for the development of integrated information management systems for the global networks of collections of each of the crops and how these fitted with both current developments by strong existing networks as well as broad developments in the field of information technology was roundly endorsed.

1. BACKGROUND

This Global Strategy for the *ex situ* Conservation with Enhanced Access to Wheat, Rye and Triticale Genetic Resources is the result of consultations involving genetic resource specialists and crop researchers. We foresee this strategy to be a dynamic work in-progress, ever evolving as the client base of collections broaden and vary, as the collections themselves change, and as the world community becomes more aware of the incalculable value of crop genetic diversity. We strongly endorse the support of conservation networks, involving diverse stakeholders, oriented towards regional demands, and even involving crops beyond those discussed directly in this report. Bridging diverse cultures, philosophies, approaches to research, development and business, to achieve greater and more sustainable food and agricultural development in light of increased awareness of our changing climate are goals we can only fully achieve together.

1. Objectives and expected outputs of the global ex situ conservation strategy for wheat, rye and triticale genetic resources

1.1 Objective

To develop, in close consultation with relevant stakeholders, institutions, and networks, strategies for the efficient and effective conservation of wheat, rye and triticale genetic resources globally and to identify priority collections for support and their urgent upgrading and capacity building needs. The strategies will promote the rationalization of conservation efforts at regional and global levels, for example, through encouraging partnerships and sharing facilities and tasks, and will link with relevant regional conservation strategies.

1.2 Expected Outputs

1. Identification and assessment global, regional and national collections of wheat, rye and triticale genetic resources that are "most important" in terms of size, extent of diversity, holdings of cultigens and wild relatives and other standards of assessment as agreed by stakeholders.
2. Development of a global model for collaboration and sharing responsibilities for an effective and efficient management of key collections of genetic resources.
3. 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.
4. Identification of information technology needs for an integrated global network of genetic resource collections and steps required to meet these needs.
5. Identification of critical gaps in existing world collections of genetic resources and identification of strategies to fill these gaps
6. A conservation strategy and recommendations for funding priority collections, promoting partnerships and sharing responsibilities, facilities and tasks.

2. A MODEL GLOBAL GENETIC CONSERVATION SYSTEM

In developing a Strategy for the effective and efficient global conservation of wheat, rye and triticale genetic resources it is important to first establish the ultimate goal - what we are seeking to achieve. It is anticipated the ideal or model global conservation system for wheat, rye and triticale would consist of several elements:

a) A global network of wheat, rye and triticale collections that include all substantial national, regional and international collections and especially those that contain significant numbers of accessions not duplicated elsewhere. Particular emphasis would be given to national collections. However, large amounts of genetic resources are held outside of the national or institutional collections, and an important goal of the global network would be to locate those collections, assess their risk status, and if possible incorporate those into public collections.
b) Each institution in the network should have primary responsibility for the long-term conservation of the germplasm that is unique to their collection. The institution may choose to outsource some of the functions associated with the long–term conservation of their unique accessions (e.g., regeneration), but those decisions remain their own responsibility.
c) All unique accessions would be conserved and managed in accordance with agreed international scientific and technical standards.
d) All unique accessions would also be "black box" safety duplicated in at least one other gene bank to avoid loss due to mishap or catastrophe.
e) Complete passport and characterization data would be available for all accessions and accessible on-line.
f) The databases of all collections in the network would be linked through an integrated information sharing protocol that would allow public web access.
g) A global registry of conserved wheat, rye and triticale genetic resources will result from the network of linked databases. This would allow collection managers to suggest possibly unique accessions, estimate degrees of duplication and identify areas of gaps between collections and allow users to access material from the most appropriate or convenient collection.
h) The majority of accessions in the network would be accessible under the internationally agreed terms of access and benefit sharing provided for in the multilateral system as set out in the International Treaty on Plant Genetic Resources for Food and Agriculture. However, some collections or accessions will be governed by local regulations, or term-

limited material transfer agreements (MTA) or patents. Such collections or accessions should be included and the conditions for distribution, use, and benefit-sharing should be made available for review by potential users. Information systems that accurately and transparently track these intellectual property rights (IPR) restrictions will be of paramount importance.

3. MAJOR STEPS IN THE DEVELOPMENT OF THE STRATEGY

The following procedures were adopted in developing this Global Strategy for the *ex situ* Conservation with Enhanced Access to Wheat, Rye and Triticale Genetic Resources:

1. The major germplasm collections of wheat, rye and triticale globally were identified from existing public databases including those held by FAO, Bioversity International and ECPGR (Appendix IX). Particular emphasis was given to identification of collections holding unique accessions of wild relatives and genetic stocks of wheat. The wild relatives of wheat have proved to be highly useful sources of resistance to biotic and abiotic stresses in wheat breeding over the last two decades and this trend is expected to accelerate in the future. Similarly genetic stocks are finding increasing use as tools in the sophisticated application of modern biotechnologies in wheat improvement.
2. A survey was distributed to curators of more than 50 of the largest wheat collections to gather basic information on the numbers and types of accessions held, the conditions under which they were stored and their accessibility (Appendix II). Replies were received from 19 wheat collection curators.
3. A second survey was distributed globally to about 50 wheat researchers, mainly wheat breeders, to assess the importance and usefulness of collections and to understand, from their viewpoint, major shortcomings in the current collections (Appendix III). Replies were received from 33 clients of wheat collections.
4. Curators of special collections of wild relatives of wheat and defined genetic stocks were also surveyed to ascertain the size and status of their holdings and to better understand how they could be best included in a rationalised global system for the long term conservation of wheat genetic resources (the survey form for precise genetic stocks is given in Appendix IV and that for wild relatives was conducted by internet searches).
5. Organisation of a consultation meeting, in collaboration with The International Maize and Wheat Improvement Center (CIMMYT), involving a limited number of experts with global experience in all aspects of the conservation and use of the genetic resources of wheat, rye and triticale who could advise on specific issues in terms of a comprehensive global strategy (see Appendix I). This group was established as the Strategy Advisory Group. The workshop was held at CIMMYT Headquarters, El Batan, Mexico from June 20-22, 2006. The programme for the workshop is given in Appendix VIII.
6. Using information gleaned from the surveys and the Strategy Advisory Group, a list of key collections which should be targeted for inclusion in global networks of wheat, rye and triticale genetic resources was developed.
7. From this list of key collections, those that have relatively secure financial support, have good conservation standards, are accessible and available under internationally agreed terms of access and benefit sharing and where the holder may be willing to work in partnership to develop an efficient and effective global conservation system were identified as foundation or reference collections in an initial global wheat, rye and triticale conservation network.
8. A list of key collections that could be eligible for upgrading to meet the standards for a global conservation system was identified along with the priority areas for upgrading and capacity building.

9. Identification of gaps in the existing collections, establishment of priorities to fill those gaps and plans to meet the most urgent priorities.
10. Evaluation of options for the development of integrated information management systems for the global networks of collections of each of the crops and how these fit with both current developments by strong existing networks (e.g. the Consultative Group on International Agricultural Research (CGIAR) and the European Crop Plant Genetic Resources (ECPGR) Networks) as well as broad developments in the field of information technology.
11. Harmonization of the crop-specific strategies for wheat, rye and triticale and the regional strategies being developed in parallel, especially for the Central and West Asia, North Africa (CWANA), the Central Asia and Caucasus (CAC), the Americas, and South Asia regions.
12. Development of the first draft of the global wheat, rye and triticale strategies.
13. Distribution of the first draft to the Strategy Advisory Group and the curators of reference collections for comment.
14. Harmonization of the wheat, rye and triticale conservation strategy with other relevant, crop-specific strategies.
15. Establishment of a strategy implementation or coordination group for the Global Network of Wheat, Rye and Triticale collections.
16. Finalisation of the Global Conservation Strategy for Wheat, Rye and Triticale.

4. WHEAT *EX SITU* CONSERVATION STRATEGY

Wheat is the world's most widely grown crop with a global production of over 600 million tons produced from about 210 million hectares in many different countries in Europe, Asia, North Africa and the Americas. The area sown to wheat has doubled over the last 50 years and production per hectare has almost trebled. This increase in production is due in part to the efforts of national and regional breeding programmes, most in the public domain, in producing improved cultivars. Wheat is also the world's most widely traded food grain with about 105 million tons or about 18% of world production traded each year.

By the 1920s it was recognised that cultivated wheat species of the genus *Triticum* belonged to three ploidy groups with chromosome numbers of 2n = *2x* = 14 (*T. monococcum)*, 28 (*T. turgidum* and *T. timopheevii*), and 42 (*T. aestivum* and *T. zhukovskyi*) (Gill and Friebe, 2002). However, world wheat production is almost entirely based on only two species, *T. aestivum*, common or bread wheat which accounts for about 95% of world production and *T. turgidum* ssp. *durum*, macaroni or durum wheat, which accounts for the other 5% of production. The remaining cultivated species are largely historical relics.

Due to the strategic importance of wheat in food security and trade in many countries, and the critical importance of breeding in ensuring national industries remain competitive, over 80 autonomous germplasm collections holding in excess of an estimated 800,000 accessions have been established globally. These collections vary in size and coverage; the largest have over 100,000 accessions and the smallest a few hundred. They also vary greatly in coverage. Most collections evolved from breeders working collections and carry predominantly local or regional cultivars-advanced, obsolete or landrace-as well as introduced cultivars of interest to national or regional breeders. There is often substantial duplication within, and certainly between these sorts of collections. Virtually every wheat collection in the world would carry common popular cultivars such as Marquis and Bezostaya 1. However, there are also numerous small specialist collections of wild wheat relatives and genetic stocks.

An important issue in developing a global strategy for the conservation of wheat genetic resources is the diversity of accessions to be included in the strategy (see Merezhko, 1997). One extreme view would be to limit the network to the primary gene pool – the cultivated species and the closely related species with which they can be readily hybridised. The other extreme is that in the modern world of transgenics all biological species are potential genetic resources for wheat breeding and the concepts of primary, secondary and tertiary genepools are quaint and outmoded. It is suggested here following Merezhko (1997; 1999) we should restrict our focus to *Triticum* species and related genera of the Triticeae. This coverage aligns with the intention of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

4.1 The Wheat Gene Pool

Genetic resources in wheat can be categorized into 6 broad groups (after Frankel, 1977; FAO, 1983):

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 of crop species in the Triticeae tribe
5. Genetic and cytogenetic stocks
6. Breeding lines

These genetic resources represent the gene pool potentially available to breeders and other users of collections. This broad pool can be further subdivided into primary, secondary and tertiary gene pools (Harlan and de Wet, 1971). 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. Clearly the boundaries on these groups are fuzzy and also change with changes in technology. Consequently, several authors including Smartt (1980) and Konarev *et al.* (1986), have suggested the gene pools concept of Harlan and De Wet (1971) be modified to increase the number of gene pools from three to four to coincide with respectively, populations, species, genera and tribes (Merezhko, 1997). Unfortunately, even this simple concept is difficult to apply in wheat because of the lack of an accepted view on the classification of wheat species, the genus *Triticum*, and even the tribe Triticeae (von Bothmer *et al.*, 1992; Merezhko, 1997). The Wheat Genetics Resource Center at Kansas State University in the USA provides a comprehensive on-line source of information about wheat taxonomy, including a detailed comparison of the most often used classifications, as part of the *GrainTax* project (www.k-state.edu/wgrc/). Herein we will follow the most recent taxonomic treatment of *Triticum* and *Aegilops* of van Slageren (1994).

4.1.1 Triticum species

The cultivated species of *Triticum* and their genomic constitution are given in Table 1. It will be noted that there are two valid biological species at each ploidy level. The diploid *T. monococcum* has both cultivated and wild forms, while *T. urartu* only exists in the wild. Both tetraploid forms exist in both cultivation and the wild, while both hexaploid species only exist in cultivation. The distribution of these species is described by Gill and Friebe (2002).

TABLE 1. Species of genus *Triticum* and their genomic constitution

Species	**Genomic constitution**	
	Nuclear	**Organellar**
Triticum aestivum L.	ABD	B (rel. to S)*
Triticum aestivum subsp. *aestivum* (common or bread wheat) *Triticum aestivum* subsp. *compactum* (Host) Mackey (club wheat) *Triticum aestivum* subsp. *macha* (Dekapr. & A. M. Menabde) Mackey *Triticum aestivum* subsp. *spelta* (L.) Thell. (large spelt or dinkel wheat) *Triticum aestivum* subsp. *sphaerococcum* (Percival) Mackey (Indian dwarf wheat)		
Triticum turgidum L.	AB	B (rel. to S)
Triticum turgidum subsp. *carthlicum* (Nevski) A. Love & D. Love (Persian wheat) *Triticum turgidum* subsp. *dicoccoides* (Korn. ex Asch. & Graebn.) Thell. (wild emmer) *Triticum turgidum* subsp. *dicoccum* (Schrank ex Schubl.) Thell. (emmer wheat) *Triticum turgidum* subsp. *durum* (Desf.) Husn. (macaroni or durum wheat) *Triticum turgidum* subsp. *paleocolchicum* A. Love & D. Love *Triticum turgidum* subsp. *polonicum* (L.) Thell. (Polish wheat) *Triticum turgidum* subsp. *turanicum* (Jakubz.) A. Love & D. Love (Khorassan wheat) *Triticum turgidum* subsp. *turgidum* (pollard wheat)		
Triticum zhukovskyi Menabde & Ericz.	A^tA^mG	A (rel. to S)
Triticum timopheevii (Zhuk.) Zhuk.	A^tG	G (rel. to S)
Triticum timopheevii subsp. *armeniacum* (Jakubz.) Slageren (wild form) *Triticum timopheevii* subsp. *timopheevii* (cultivated form)		
Triticum monococcum L.	A^m	A^m
Triticum monococcum subsp. *aegilopoides* (Link) Thell. (wild form) *Triticum monococcum* subsp. *monococcum* (einkorn or small spelt wheat)		
Triticum urartu Tumanian ex Gandilyan (wild form)	A	A

* Related to S-genome species, cf. Table 2
Source: Gill and Friebe (2002)

4.1.2 Aegilops species

Aegilops is the most closely related genus to *Triticum* and has been widely used in wheat improvement. All *Aegilops* are annuals. The genus consists of 11 diploid species and 12 polyploid species, including tetraploids and hexaploids (Table 2). Their taxonomy and distribution is discussed by van Slageren (1994).

TABLE 2. Species of genus *Aegilops* and their genomic constitution

Species	**Genomic constitution**	
	Nuclear	**Organellar**
Aegilops bicornis (Forssk.) Jaub. & Spach	S^b	S^b
Aegilops biuncialis Vis.	$U\underline{M}\ (UM^o)$	U
Aegilops caudata L.	C	C
Aegilops columnaris Zhuk.	$U\underline{M}\ (UX^{co})$	U^2
Aegilops comosa Sm. in Sibth. & Sm. *var. heldreichii*	M	M
Aegilops crassa Boiss.	$\underline{D^{c1}M^c}(D^{c1}X^c)$	D^2
var. glumiaristata	$\underline{D^{c1}D^{c2}M^c}$ $(D^{c1}D^{c2}X^c)$	-
Aegilops cylindrica Host	D^cC^c	D
Aegilops geniculata Roth (syn. *Ae. ovata*)	$U\underline{M}\ (UM^o)$	M^o
Aegilops juvenalis (Thell.) Eig	$\underline{DMU}\ (D^cX^cU^j)$	D^2

Species	Genomic constitution	
	Nuclear	Organellar
Aegilops kotschyi Boiss.	$U\underline{S}$ (US^{l})	S^{v}
Aegilops longissima Schweinf. & Muschl.	S^{l}	S^{l2}
Aegilops mutica Boiss.	T	T,T^{2}
Aegilops neglecta Req. ex Bertol. (syn. *Ae. triaristata*)	$U\underline{M}$ (UX^{n})	U
var. recta (Zhuk.) Hammer	$\underline{UMN}$ $(UX^{t}N)$	U
Aegilops peregrina (Hack. in J. Fraser) Maire & Weiller (syn. *Ae. variabilis*)	$U\underline{S}$ (US^{l})	S^{v}
Aegilops searsii Feldman & Kislev ex Hammer	S^{s}	S^{v}
Aegilops sharonensis Eig	S^{sh}	S^{l}
Aegilops speltoides Tausch	S	S,G,G^{2}
Aegilops tauschii Coss. *var. tauschii, var. strangulata*	D	D
Aegilops triuncialis L.	$U\underline{C}^{t}$	U,C^{2}
Aegilops umbellulata Zhuk.	U	U
Aegilops uniaristata Vis.	N	N
Aegilops vavilovii (Zhuk.) Chennav.	$\underline{DMS}$ $(D^{c}X^{c}S^{v})$	D^{2}
Aegilops ventricosa Tausch	$D^{v}N^{v}$	D

Note: Underlined genomes are modified at the polyploid level; those in brackets were deduced from DNA analysis
Source: Gill and Friebe (2002) modified from Dvorak (1998) based on chromosome pairing and DNA analysis.

Dasypyrum [Haynaldia] villosum is among the Triticeae species as genetic resources for wheat breeding. It is an annual with V genome and is easily hybridized to *Triticum aestivum* or *T. turgidum.* Each of the chromosomes has been added to common wheat by E. Sears.

In addition to *Aegilops* a host of more distantly related annual and perennial members of related genera in the Triticeae have potential as a source of germplasm in wheat breeding including cultivated rye and barley and their near relatives as well as a host of perennial grasses.

4.1.3 Perennial Triticeae *species*

The bulk of the perennial Triticeae species have been difficult to exploit in wheat improvement primarily because their genomes are non-homologous to those of wheat, and genetic transfers cannot be made by homologous recombination. However gene transfer is possible via complex cytogenetic protocols. Over the last three decades hybridization per se has become less of a problem in inter-specific hybridization between *Triticum* species and more distantly related genera, although achieving timely practical outcomes using cytogenetic techniques is difficult in genera other than *Secale* and *Thinopyrum* (Mujeeb-Kazi and Rajaram, 2002). Nevertheless, variation for a number of economically important traits, including resistance to the cereal rust diseases, salt tolerance, and resistance to barley yellow dwarf virus have been transferred from perennial wild species into bread wheat. The disease resistance genes have been used in modern wheat cultivars. Mujeeb-Kazi and Hettel (1995) provide a comprehensive account of interspecific hybridization in the Triticeae. The perennial genera of the tribe Triticeae of interest in wheat improvement are given in Table 3 along with their genome designations and ploidy levels. All the genomes of the perennial Triticeae have been combined with the A, B, and D genomes of bread wheat (Mujeeb-Kazi, 1995).

TABLE 3. The nuclear genome of the perennial species of the tribe Triticeae (after Mujeeb-Kazi and Wang, 1995)

Species	Genome	Species	Genome
Agropyron cristatum	PP	*Leymus angustus*	NNNNNNXXXXXX
Agropyron cristatum	PPPPPP	*Leymus arenarius*	NNNNXXXX
Agropyron desertorum	PPPP	*Leymus chinensis*	NNXX
Agropyron fragile	PP	*Leymus cinereus*	NNXX
Agropyron michnoi	PPPP	*Leymus innovatus*	NNXX
Agropyron mongolicum	PP	*Leymus mollis*	NNXX
Australopyrum pectinatum	WW	*Leymus racemosus*	NNNNXXXX
Elymus abolinii	SSYY	*Leymus salinas*	NNXX
Elymus alvatavicus	SSYYPP	*Leymus tritcoides*	NNXX
Elymus arizonicus	SSHH	*Pascopyrum smithii*	SSHHNNXX
Elymus batalinii	SSYYPP	*Psathyrostachys alatavicus*	NN
Elymus canadensis	SSHH	*Psathyrostachys fragilis*	NN
Elymus caninus	SSHH	*Psathyrostachys huashanica*	NN
Elymus ciliaris	SSYY	*Psathyrostachys juncea*	NN
Elymus dahuricus	SSHHYY	*Psathyrostachys kronenburgii*	NN
Elymus drobovii	SSHHYY	*Pseudopyron deweyii*	SSPP
Elymus gmelinii	SSYY	*Pseudopyron tauri*	SSPP
Elymus grandiglumis	SSYYPP	*Pseudoroegneria libanotica*	SS, SSSS
Elymus kamoji	SSHHYY	*Pseudoroegneria spicata*	SS, SSSS
Elymus kengii	SSYYPP	*Pseudoroegneria stipifolia*	SS, SSSS
Elymus longearistatus	SSYY	*Pseudoroegneria strigosa*	SS, SSSS
Elymus panormitanus	SSYY	*Secale montanum*	RR
Elymus parviglume	SSYY	*Thinopyrum bessarabicum*	JJ
Elymus pendulinus	SSYY	*Thinopyrum caesitosum*	EESS
Elymus shandongensis	SSYY	*Thinopyrum curvifolium*	JJJJ
Elymus sibiricum	SSHH	*Thinopyrum distichum*	JJEE
Elymus strictus	SSYY	*Thinopyrum elongatum*	EE
Elymus tsukushiensis	SSHHYY	*Thinopyrum intermedium*	JJJJSS, JJEESS, EEEESS
Elymus ugamicus	SSYY	*Thinopyrum junceiforme*	JJEE
Elymus vaillantianus	SSHH	*Thinopyrum junceum*	JJJJEE
Elytrigia repens	SSSSHH	*Thinopyrum nodosum*	EESS
Hordeum bogdanii	HH to HHHHHH	*Thinopyrum ponticum*	JJJJEEEEEE
Hordeum brevisubulatum	HH to HHHHHH	*Thinopyrum sartorii*	JJEE
Hordeum iranicum	HH to HHHHHH	*Thinopyrum scirpeum*	EEEE
Hordeum jubatum	HH to HHHHHH	*Thinopyrum scythicum*	EESS
Hordeum violaceum	HH to HHHHHH	*Thinopyrum turcicum*	JJJJEEEE

4.1.4 Defined or Precise Genetic Stocks

Over the last 70 years, a wealth of defined or precise genetic stocks has been developed in bread and durum wheat. Genetic stocks collections are an important component of the total conserved genetic resources of wheat. They have played a crucial role in the rapid advances in wheat genetics over recent decades and their importance and use is likely to greatly increase as tools in the identification, location and isolation of specific genes and their manipulation and transfer into improved cultivars.

Most national and international genebanks have placed little emphasis on genetic stock collections for several reasons. First, they were seen principally as research and teaching tools that were marginal to the practical interests of varietal improvement programs, especially in developing countries. Second, they were seen as requiring specialised inputs and management strategies compared to those required by cultivar collections. Finally, the development of genetic stocks was seen as an expensive and time-consuming process that depended on strong interaction with sophisticated research programs and most genetic stock collections are in developed countries.

As a consequence, genetic stock collections have generally been regarded as the responsibility of the individuals or programs that initially developed and maintained them, even when they are clearly in the public domain, and they have usually been held in universities and government departments of agriculture. However, as such collections have grown in size and importance and their utility in modern crop improvement programs efforts have been recognised, efforts have been made to develop integrated national or international efforts to consolidate, document and conserve them. Such efforts have been done through national centres of excellence, for example Kansas State University (USA), Kyoto University (Japan) and the John Innes Centre (UK), or through scientific societies. The CGIAR Generation Challenge Programme (GCP) has recently embarked on an ambitious programme to collect, conserve and utilize existing genetic stocks involving alien gene transfers for enhancing drought tolerance in wheat.

The growing size and sophistication of genetic and molecular stock collections is testimony to their increasing contributions to enable the effective utilization of the variation conserved in "traditional" germplasm collections. The role of genetic stock collections in the global conservation effort of wheat germplasm should be re-evaluated and they should be afforded a higher priority in a rationalised system than they have been accorded in the past.

4.2 Conservation Priorities

This strategy focuses on the conservation and use of the full spectrum of the genetic resources of wheat with the exception of the perennial wild relatives.

Modern and obsolete improved cultivars are generally well conserved in global wheat germplasm collections. In light of intellectual property rights restrictions, the extent to which further collection of these types of germplasm will occur in national or global collections remains an open question. National and international collections must remain vigilant towards these genetic resources, as active breeding programs often view cultivar conservation temporally. The major focus of a global strategy for this category of genetic resource would be to reduce redundancy in the global set of collections to free up resources for other priorities.

Landrace varieties have received priority for collection, conservation and documentation in recent years supported by the efforts of FAO, the CGIAR and others because of the increasing threat to their continued existence by the spread of improved modern cultivars. Nevertheless, such cultivars are poorly represented in world collections compared to modern and obsolete cultivars and should remain a priority for the global strategy both to ensure the collection of material that still exists in the field but is not in collections and the long-term conservation of collected material in line with agreed international standards.

The wild relatives of wheat are also generally poorly represented in global wheat germplasm collections. There are several reasons for this. First, wild relatives are more difficult to use in conventional breeding programs than cultivars of the same species and usually require an extensive period of germplasm enhancement. They tended therefore to be collected and used by the small number of specialist institutes concerned with interspecific hybridization. Second, they are more difficult to seed increase and maintain because of their tendency to shatter their seed than crop cultivars. For this reason also the distribution and use of some wild species is limited because of their potential as weeds. Finally, wild species, because of their capacity to self-reproduce in nature, were seen as under less threat of extinction than the cultivated landraces.

Unfortunately many populations of the annual wild relatives of wheat, particularly those at the extremes of their distribution that are of special interest for breeding purposes, are under threat because of changing patterns of land use. At the same time, new technologies have made the use of the annual wild relatives as a germplasm source easier which has generated an interest and need for representative collections of annual wild relatives to be maintained in accessible collections. For these reasons the annual wild relatives should clearly be afforded a greater priority in the global wheat germplasm collections than they have had in the past. This is not to suggest that all or many collections need to move to collect or conserve the wild relatives of wheat, but rather, that those with the specialized knowledge and capacity to undertake the collection and conservation of this category of germplasm should be given priority support.

As noted above, it can also be argued that defined genetic stock collections should receive greater priority in a balanced global effort to conserve and make available for use the genetic resources of wheat. Again, because of the specialist needs to develop and reliably maintain genetic stocks as true-to-type accessions, it is expected that defined genetic stocks will be maintained by specialized institutes. The emphasis will be to support those institutes to develop a coordinated system that replaces the largely *ad hoc* system that has operated to date for the conservation of genetic stocks so that valuable material once developed and in the public domain is available on a continuing basis for all who need it.

The perennial wild relatives of wheat were not seen as a priority for conservation in the collective global wheat germplasm system. Again there are several reasons for this. The first, and perhaps most important, is that collections of many of these species are maintained in perennial grass collections for use in breeding programs as grazing species or for other uses. Second, despite the number of perennial wild relatives of wheat that exist, their extensive global spread, and the extensive research that has taken place, the number of examples of commercially successful gene transfer from perennial wild relatives to wheat remain modest. Third, the perennial wild relatives like their annual counterparts require specialized seed increase knowledge and facilities which is only likely to be available in specialized collections.

4.3 Global Wheat Germplasm Collections

Key global collections of wheat were identified from existing public databases including those held by FAO, Bioversity International, and ECPGR as well as the regional and crop specific surveys conducted as part of regional conservation strategies. The Wheat Strategy

Advisory Group recognizes nearly 40 collections (Table 4), consisting of more than 560,000 accessions, as major global wheat collections.

TABLE 4. Major Global Wheat Collections

Country	**Institute**	**No. of access-ions**	**IT-PGRFA ratified**
Global	CIMMYT, El Batan, Mexico	111,681	Yes
Global	ICARDA, Aleppo, Syria	37,830	Yes
Albania	Agricultural Research Institute, Lushjne	6,000	No
Albania	Albanian Genebank, National Seed and Seedling Institute, Tirane	2,015	No
Argentina	Banco Base Nacional de Germoplasma, Instituto de Recursos Biologicos, INTA	648	No
Australia	Australian Winter Cereals Collection, NSW Department of Primary Industries, Tamworth	23,917	Yes
Austria	Agrobiology Seed Collection, Linz	876	Yes
Bulgaria	Institute for Plant Genetic Resources "K. Malkov", Sadovo	9,747	Yes
Brazil	Recursos Geneticos e Biotecnologia, (EMBRAPA/ CENARGEN), Brasilia	5,169	Yes
Brazil	Centro Nacional de Pesquisa de Trigo (CNPT;EMBRAPA), Passo Fundo	13,594	Yes
Canada	Plant Gene Resources of Canada, Saskatoon	5,052	Yes
China	Institute of Crop Germplasm Resources (CAAS), Beijing	9,633	No
Cyprus	National Genebank (CYPARI), Agricultural Research Institute, Nicosia	7,696	Yes
Czech Republic	Genebank Department, Research Institute for Crop Production, Prague	11,018	Yes
Egypt	Field Crops Institute, Agricultural Research Centre, Giza	2,867	Yes
Ethiopia	Plant Genetic Resources Centre, Institute of Biodiversity Conservation and Research, Addis Ababa	10,745	Yes
France	Station d'Amelioration des Plantes, INRA, Clermont-Ferrand	14,200	Yes
Germany	Genebank, Institute for Plant Genetics and Crop Plant Research (IPK), Gatersleben	9,633	Yes
Hungary	Institute of Agrobotany, Tapioszele	7,531	Yes
India	National Bureau of Plant Genetic Resources (NBPGR), New Delhi	32,880	Yes
Iran	National Genebank of Iran, Genetic Resources Division, Karaj	12,169	Yes
Israel	Lieberman Germplasm Bank, Institute of Cereal Crop Development, Tel-Aviv	5,500	No
Israel	Institute of Evolution, Haifa University, Haifa	1,000	No
Italy	Instituto del Germoplama, Bari	32,751	Yes
Japan	Genebank, National Institute of Agrobiological Sciences, Tsukuba	7,148	No
Japan	Plant Germplasm Institute, Graduate School of Agriculture, Kyoto	4,378	No
Netherlands	Centre for Genetic Resources (CGN, CPRO-DLO), Wageningen	5,529	Yes

Country	Institute	No. of access-ions	IT-PGRFA ratified
Pakistan	Plant Genetic Resources Institute, National Agricultural Research Centre, Islamabad	2,572	Yes
Poland	Plant Breeding and Acclimatisation Institute (IHAR), Radzikow	12,974	Yes
Portugal	Banco de Germoplasma-Genetica, Estacao Agronomica Nacional, Oeiras	831	Yes
Portugal	Departmento de Genetica e Biotecnologia, Universidade Tras-os-Montes EAlto Douro,Vila Real	1,466	Yes
Romania	Suceava Genebank, Suceava	1,543	Yes
Russia	N.I. Vavilov Research Institute of Plant Industry (VIR), St. Petersburg	39,880	No
Serbia	Institute of Field and Vegetable Crops, Novi Sad	2,431	No
South Africa	Agricultural Research Council, Small Grains Institute, Bethlehem	2,527	No
Spain	Centro de Recursos Fitogeneticos, Madrid	3,183	Yes
Sweden	Nordic Gene Bank, Alnarp	1,843	Yes
Switzerland	Station Federale de Recherches en Production Vegetale de Changins, Nyon	6,996	Yes
Turkey	Plant Genetic Resources Department, Aegean Agricultural Research Institute, Izmir	6,381	Yes
Ukraine	Yurjev Institute of Plant Production, National Centre for Plant Genetic Resources of Ukraine, Kharkov	20,626	No
United Kingdom	Crop Genetics Department, John Innes Centre, Norwich	9,584	Yes
USA	Wheat Genetic Resource Centre, Kansas State University, Manhattan, Kansas	5,000	No
USA	USDA/ARS, Wheat Genetic Stocks Collection, University of Missouri, Columbia, Missouri	3,000	No
USA	USDA/ARS, National Small Grains Research Facility, Aberdeen, Idaho	56,218	No
Total	**44 institutes**	562,831	

Sources: Bioversity, 2006; FAO, 2007

4.4 Existing Networks Relevant to Wheat Genetic Resource Collections

Regional Plant Genetic Resource (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 fora that can be important in maintaining the continuity of the networks. Their main objective is to strengthen the national PGR programs of the member states and their NARS through information sharing, capacity building, and germplasm exchange and to enhance collaboration in the region on PGR issues especially in relation to important regional crops which may have received little attention globally.

Underscoring the crop’s worldwide importance, wheat was recognized as a priority crop in the majority of the regional strategies produced in cooperation with regional PGR networks (Table 5).

TABLE 5. Prioritization of *Triticum* et al. in Regional Crop Conservation Strategies

Region	*Triticum* et al. ranked amongst the top 20 important regional crop species	Rank of *Triticum* et al. amongst the top 20 regional priority crop species
Asia, Central & the Caucasus	Yes	1
Asia, West & North Africa	Yes	1*
Asia, South, South East & East	Yes	3
Pacific	No	--
Africa, East	Yes	4
Americas	Yes	16**
Europe	Yes	"High"
Africa, Southern	Yes	Country specific
Africa, West and Central	No	--

Source: GCDT, 2007

*Tied in first rank with "Forages".

**Based on a weighted scoring system to help identify the important crops in the broad geographical region of the Americas (Central, North and South America and the Caribbean).

Three regions are identified by this Strategy as playing especially important roles in regards to wheat genetic resources:

(i) West Asia and North Africa (WANA)
(ii) Central Asia and the Caucasus (CAC)
(iii) Europe

Four additional regional strategies considered wheat genetic resource conservation as a "top 20" priority (Table 5).

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, Turkmenistan, Tajikistan and Uzbekistan. In both cases, the priorities are improving communication and information systems for PGR.

In Europe, the European Cooperative Programme for PGR (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.

An ECPGR Working Group on Wheat was established in 1996. Wheat is one of Europe's most important crops and about 220,000 accessions, or about one-third of the global total, are held in some 65 collections in the member countries. The focus of the Wheat Working Group has been on enhancing cooperation and coordination amongst the European wheat collections. Recent priorities have included:

(i) the development of the European Wheat Database (EWDB), a coordinated central database covering all collections based on an agreed set of descriptors
(ii) identification of the unique accessions held by each collection
(iii) strengthening of quality standards for conservation
(iv) improving the level of safety duplication, and
(v) strengthening work on characterisation and documentation.

Given the success of ECPGR in general and the Working Group on Wheat in particular, despite the large number of countries and collections involved, it is felt that ECPGR provides a very useful model and source of experience for the Global Wheat Network. It is also clear, since Europe accounts for about one third of total global wheat accessions that the Global Program needs to be closely integrated with ECPGR.

The features of ECPGR and the Working Group on Wheat that have contributed to its success include:
(i) Long term support of the program by the participating governments and institutions
(ii) The establishment of a representative Steering Committee involving all the partners
(iii) The establishment of a dedicated Secretariat which can implement the decisions of the Steering Committee
(iv) In the case of wheat, the establishment of a decentralised European collection, whereby every country takes responsibility for the long- term maintenance of a subset of the collection with priority given to its own unique accessions
(v) The rational and coordinated assessment of duplicate samples

Clearly, while the Global Wheat Network would need to maintain a working relationship with all Regional PGR networks where wheat was among the crops covered, developing a strong working relationship with WANA, Europe and CAC will be crucial because of the importance of the crop in these regions, the high levels of unique indigenous held in collections in these regions but that are often maintained in less than optimal storage conditions, and because of the continued existence of uncollected landraces and wild relatives in the field. It is also suggested that the features of ECPGR be replicated in the Global Network of Wheat Genetic Resource Collections.

4.5 Surveys of Collections and their Clients

The managers and users of four main types of collections were surveyed to enable them to assist in the development of this strategy document:

1. Curators of major national and international wheat germplasm collections
2. Clients of wheat germplasm collections including breeders, molecular geneticists and wheat researchers
3. Collections of wheat wild relatives
4. Curators of specialist genetic stock collections

The responses to each of the surveys are considered below.

4.5.1 Curators of major national and international wheat germplasm collections

This survey was sent to curators or genebank managers of 47 of the largest wheat genetic resource collections in the world. A summary of the responses of the curator and manager survey is given in Appendix V.

Storage facilities

It is clear from the genebank managers' responses that, with a few significant exceptions, genebanks generally have adequate storage facilities for medium and long-term storage.

Problems in meeting international standards arise because of lack of sufficient and consistent operating budgets to meet the costs of routine operations such as regeneration, evaluation and documentation, especially in developing countries. Another major deficiency identified in this survey was the lack of full "black box" safety duplication of many important collections.

Database systems

Most genebanks, in both developed and developing countries have computerised data management systems and many have, or will achieve in the near future, web-based access to their information systems. However, there is a great diversity of software systems, differing in sophistication and options, used in different genebanks. The development of an integrated web-based system that allows the searching of the databases of all cooperating genebanks is clearly one of the major challenges facing the development of an integrated global conservation system for wheat genetic resources.

Gaps in collections

In response to a question on gaps in existing collections collection managers felt that there was inadequate conservation of landraces, primary wild relatives and cultivars (in descending order of importance). This contrasts sharply with the responses from collection users whose perception of the deficiencies in the current conservation of wheat genetic resources were lack of mapping populations, mutant and genetic stocks mutants, and the wider range in wild relatives (see Table 6; and section 4.5.2), while users discounted the importance of the expanded conservation of landraces. Users of contemporary collections appear to view them more as sources of research tools (i.e., characterized genetic variability, or sources of variability and information) than for direct application in applied breeding programs. This survey result suggests that for many genebanks there remains a gap between the perception of genebank managers and users in the major function of collections.

TABLE 6. Collection managers' and collection users' perceptions of inadequately conserved genetic variability in existing wheat collections (responses normalized to a standard sample size)

Genetic Resource	Bread Wheat		Durum Wheat	
	Collection Managers	Collection Users	Collection Managers	Collection Users
Modern cultivars	**		**	**
Obsolete cultivars		*		*
Landraces	****	**	****	*
Primary genepool species	***	*	**	*
Secondary genepool species	**	***	*	***
Genetic stocks	*	**	*	***
Mutants		****		***
Mapping populations	*	*****	*	****

4.5.2 Clients of wheat germplasm collections including breeders, molecular geneticists and wheat researchers

The client survey was distributed to 46 wheat breeders and wheat scientists from a total of 33 countries and international institutes. The response was good, with 31 breeders and scientists from 26 countries responding. A summary of the results is given in Appendix V.

The survey indicated that most users satisfied their germplasm needs primarily from their national or regional genebanks and the international centres (CIMMYT and ICARDA). Some of the larger national collections, such as the USDA-ARS National Small Grains Research Facility, were also commonly used because of the ready access to information via the internet.

Clients indicated that the major impediments to the greater use of gene-banks were:

(i) a lack of ready access to information

(ii) a lack of reliable evaluation data on accessions

(iii) a lack of known genetic variability for applied germplasm enhancement for a range of important traits including drought and heat tolerance, *Fusarium* head blight, crown rot, and *Septoria* blotch and other unspecified diseases

(iv) intellectual property rights issues, or more often the uncertainty surrounding these.

(v) the clients' perception of inadequately conserved germplasm was strongly biased towards mapping populations, mutants, genetic stocks and wild species or derivatives of them. As noted above, this contrasts sharply with the views of the genebank curators who took the more traditional view that their focus should be on landraces and the near relatives of wheat. This suggests that genebank clients are expecting collections to increase the range of materials they hold and distribute, in line with advances in the science of genetics and breeding, while curators maintain a more traditional view of the role of genebanks.

Many genebank curators and managers would no doubt argue that they receive limited support which is barely adequate to cover the stocks they already carry and is certainly not adequate to move into the collection and conservation of new classes of materials such as mapping and mutant populations. However, many genebanks unnecessarily conserve the same material, and a great advantage of a more rational conservation system is that it would allow genebanks to reduce the numbers of cultivars they carry in favour of materials such as mapping and mutant populations which are in greater demand by genebank clients.

4.5.3 Survey of Specialised Collections of Wild Relatives

Of the approximately 325 perennial and annual grasses within the Triticeae tribe, relatively few have been hybridized with wheat (Mujeeb-Kazi, 1995). *Triticum* (Appendix VIIa) and *Aegilops*, *Amblyopyrum* species and *Secale cereale* (Appendix VIIb) appear to be well conserved. Collections of *Dasypyrum [Haynaldia] villosum* are maintained by the Wheat Genetics Resource Center at Kansas State University, University of Tuscia, Italy and the University of California at Davis.

Estimation of the degree of duplication between collections, initially using basic geographic information systems (GIS) comparison tied with molecular diversity analysis, is an urgent priority as many accessions maybe the result of inter-collection exchanges. As *in situ* populations of these species become vulnerable approaching extinction, the identification of gaps within the global *ex situ* collection is essential to conserve these threatened sources of wheat-related genetic variability.

4.5.4 Survey of Specialised Genetic Stock Collections

Clients of wheat germplasm collections cited the conservation of wheat genetic stocks as a high priority. The polyploid nature of *T. aestivum, T. turgidum* and other *Triticum* species permits genomic manipulation through intervarietal and interspecific translocations, chromosome and chromosome arm additions and deletions, chromosome and alien substitution addition lines, mono- and polysomic series, point and other mutations, and synthetics, involving species within and beyond the Triticeae. The resulting genetic stocks are often the products of painstaking years of cytogenetic investigation and observation. Significant impacts on wheat science and applied breeding have been the outcome of these germplasm, as they have provided vehicles to bridge interspecific cross incompatibility, thereby increasing dramatically the availability of useful genetic diversity to wheat researchers and breeders.

These valuable wheat genetic stocks are often conserved under less than optimal conditions, often to-this-day in the laboratories, or the successor laboratories, of the original developer cytogeneticists. Proper recording of the genetic descriptions and characterizations of these stocks can be problematic. Chromosomal instability can require special conditions for the proper regeneration of genetically sound germplasm, including cytogenetic observation on individual regenerated plants. Many stocks may remain in private collections, their existence hidden, and their value to science and breeding obscured. Finally, due to the intimate relationship between the scientist and the wheat genetic stock germplasm they develop, full and proper recognition of intellectual oversight and ownership of this germplasm is particularly critical.

From an informal survey, distributed to recognized collections of wheat genetic stocks, responses were limited to 18 collections (Appendix VI). Significant repositories in Japan, Russia, the USA (3), and the United Kingdom did not respond, nor did several key laboratories elsewhere. Nevertheless, fora such as the International Wheat Genetics Symposium reveal important stocks and collections. Expert oversight of the conservation of these stocks is critical.

The surveys did not address the conservation of transgenic wheat germplasm, but this is an area that may become increasingly important, both as repositories for research materials and potentially new sources of genetic variability.

4.6 Major Wheat Collections of a Global Network of Genetic Resources

In order for an efficient and effective global system for the conservation of wheat genetic resource, it is proposed that the participating collections fulfil the following key criteria:

(i) globally or regionally important
(ii) accessible under the internationally agreed terms of access and benefit sharing provided for in the multilateral system as set out in the ITPGRFA
(iii) committed to the long-term conservation of the unique resources it holds
(iv) well-managed and in conformity with agreed scientific and technical standards of management
(v) maintaining effective links to users of plant genetic resources
(vi) indicated willingness to act in partnership with others to achieve a rational system for conserving wheat genetic resources.

From the list of over 40 major wheat collections listed in Table 4, the Strategy Advisory Group proposed a subset of at least 23 collections that seem to fulfil these criteria and to be approached to formally initiate a wheat global network (Table 7).

Despite the bias towards developed countries particularly in the American continent and Europe, the potential foundation set of collections provides a strong base on which to build an inclusive integrated global network of wheat collections.

TABLE 7. Collections of a Global Network of Wheat Genetic Resources

Country	Institute	No. of access-ions
Australia	Australian Winter Cereals Collection, Tamworth	23,917
Bulgaria	Institute for Plant Genetic Resources "K. Malkov", Sadovo	9,747
Canada	Plant Gene Resources of Canada, Saskatoon	5,052
Cyprus	National Genebank (CYPARI), Agricultural Research Institute, Nicosia	7,696
Czech Republic	Research Institute of Crop Production, Prague	11,018
Ethiopia	Plant Genetic Resources Centre, Institute of Biodiversity Conservation and Research, Addis Ababa	10,745
France	INRA Station d'Amelioration des Plantes, Clermont-Ferrand	15,850
Germany	Genebank, Institute for Plant Genetics and Crop Plant Research (IPK), Gatersleben	9,633
Global	CIMMYT, El Batan, Mexico	111,681
Global	ICARDA, Aleppo, Syria	37,830
India	National Bureau of Plant Genetic Resources (NBPGR), New Delhi	32,880
Iran	National Genebank of Iran, Genetic Resources Division, Karaj	12,169
Japan	Genetic Resources Management Section, NIAR (MAFF), Tsukuba	7,148
Japan	Plant Germplasm Institute, Graduate School of Agriculture, Kyoto University	4,378
Netherlands	Centre for Genetic Resources, Wageningen	5,529
Russia	N.I. Vavilov Research Institute of Plant Industry (VIR), St. Petersburg	39,880
Spain	Centro de Recursos Fitogeneticos, INIA, Madrid	3,183
Sweden	Nordic Gene Bank, Alnarp	1,843
Switzerland	Station Federale de Recherches en Production Vegetale de Changins, Nyon	6,996
Turkey	Plant Genetic Resources Department, Aegean Agricultural Research Institute, Izmir	6,381
United Kingdom	Crop Genetics Department, John Innes Centre, Norwich	9,584
USA	USDA-ARS, National Small Grains Facility, Aberdeen, Idaho	56,218
USA	Wheat Genetics Resource Center, Kansas State University, Manhattan	5,000
Total	**23 institutes**	**434,358**

Source: Bioversity, 2006

4.7 Implementing the Global Network of Wheat Genetic Resource Collections

The development of the Global Network of Wheat Genetic Resources and rationalisation of collections will be a major long-term undertaking, given the number and diversity of the countries and collections involved. It will be important at the outset to ensure that the mechanisms and management systems are in place to ensure the task can be systematically carried through to completion. To do so, it will require three crucial steps:

1. The development of formal agreements between the national governments, institutes holding potential reference collections and a coordination institution. Such agreements are vital to secure a long-term commitment to the development and ongoing management of the global network from potential participants in the network. It would be possible to

develop a global network based on informal agreements. However, such agreements are often highly dependent on individuals, and are therefore prone to instability if those individuals change jobs or retire.
2. The establishment of an appropriate steering or management committee for the network. This needs to be agreed by potential members of the Global network. One model would be to have a representative from each of the collections in the network on the steering committee. Another approach could involve representatives from the regional genetic resource networks where wheat is a priority crop, representatives of specialised genetic stock and wild relative collections, and representatives of CIMMYT and ICARDA.
3. The establishment of a dedicated Secretariat to implement the decisions of the steering committee and facilitate the smooth functioning of the global network. The Strategic Advisory Group recommended and endorsed that CIMMYT lead this effort in close association with ICARDA and other Global Network partners.

Separate steering committees and secretariats for each cereal crop would be expensive and overly redundant. Alternately, oversight committees (e.g., based on general autogamous, allogamous, vegetative crop reproductive systems) could be established to recommend and monitor standard operating procedures across crop collections. Experiences gained from the AEGIS (***A European Genebank Integrated System*** for plant genetic resources for food and agriculture) project should be monitored for applicability to global conservation networks. Crop specialty steering committees, such as the Strategic Advisory Group for Global Wheat, Rye and Triticale Conservation, could convene periodically (e.g., in conjunction with the quinquennial international wheat symposia) to monitor crop specific issues such as gaps in collections, vulnerability in current ex situ, laboratory or breeding collections due to retirement or institutional priority changes, changing client germplasm needs, networking opportunities, implementation of the global conservation strategies, etc. It is essential that:
(i) the steering committee has strong linkages with the collections and represent their views
(ii) the steering committee has strong expertise and knowledge of the crops it is dealing with, and
(iii) the secretariat is sufficiently well-resourced to ensure the network develops effectively.

4.8 Capacity building to expand the Global Network

Once a Global Network of Wheat Genetic Resources Collections and its administrative infrastructure have been established, the steering committee should consider priority actions to expand the network to other collections indicated in Table 4 considering the following areas for capacity building.

4.8.1 Policy and legal issues

One reason why some collections were not included in the initial set of collections was the fact that the host country had not ratified the ITPGRFA. However, a number of countries are planning to ratify the treaty over the next few years. An interim measure could be for the legal owner of the collection to ensure that the specified material is accessible and available under the terms compatible with the ITPGRFA. In this way it should be possible to formally include these countries as partners in the Global Network relatively quickly.

Realistically, however, some collections or accessions, however, may continue to be governed by local regulations, or term-limited material transfer agreements (MTA) or patents, and not by the ITPGRFA. Such collections or accessions should be included and the conditions for distribution, use, and benefit-sharing should be made available for review by potential users.

Information systems that accurately and transparently track these intellectual property rights (IPR) restrictions will be of paramount importance.

4.8.2 Conservation standards

A second major reason why collections could not be included in the initial set of collections was their failure to meet internationally agreed standards in genebank management for long-term conservation. For the most part, these deficiencies arise from lack of adequate resources for critical genebank management functions rather than a lack of physical facilities. The great majority of collections have at least medium term storage facilities, and with the ready availability and low-cost of stand alone freezer units, providing long-term storage facilities, collections do not require high capital expenditure and should not be a significant issue for moving forward.

The lack of funding is a far more serious and intractable problem and has lead to a number of outstanding issues including:

a) Untimely regeneration which is threatening the viability and safety of a significant number of genebank accessions
b) Failure to arrange safety duplication of accessions which is also contributing to the threat to the safety of unique accessions
c) Inability to provide seed and information on request
d) Lack of characterisation and documentation of collections including the establishment of information systems

Nevertheless, these issues will need to be addressed as a matter of priority if a comprehensive and truly representative global network of wheat collections that can safely conserve the great bulk of unique wheat accessions held in genebanks is to be established.

4.8.3 Regeneration of Accessions

The long-term conservation of wheat accessions requires that seed are periodically screened for viability, and when viability falls below an internationally accepted level (<80 %), the accession is regenerated and fresh seed is placed in the genebank. Regeneration is a relatively expensive procedure and is often one of the first activities postponed when funds supporting gene-bank activities remain static in the face of rising costs or are reduced.

It is clear that regeneration of accessions is probably the single greatest threat to the safety of wheat accessions held in globally important genebanks. Table 8 indicate as far as possible regeneration priorities for wheat. It is clear that regeneration needs are generally greater in developing countries nevertheless, even in some major developed countries, regeneration is an urgent issue. Collections were assigned either a priority 1 or 2 on the basis of the perceived urgency, the proportion of unique accessions estimated to require regeneration.

TABLE 8. Regeneration Priorities for Wheat Collections

Country	Institution	Priority	Proportion of collection %	No. of accessions for regener-ation*	Est. Cost (USD)**
Armenia	PGR Unit, Yerevan	1	75%	2,250	$7,200
Azerbaijan	National PGR Bank	1	100%	1,163	$3,722
Bulgaria	IPGR, Sadovo	1	25%	2,437	$7,789
Ethiopia	IBC Addis Ababa	1	25%	2,686	$8,596
Hungary	Ag. Res. Inst, Martonvasar	1	25%	583	$1,865
India	NBPGR, New Delhi	1	10%	3,288	$10,552
Israel	Inst. of Cereal Crop Devt., Tel-Aviv	1	25%	1,375	$4,400
Poland	IHAR, Radizkow	1	25%	3,239	$10,363
Russia	VIR, St. Petersburg	1	25%	9,465	$30,288
Tajikistan	National PGR Bank	1	100%	1,115	$3,568
Turkey	PGRC, Aegean Agric. Res. Inst., Izmir	1	25%	1,595	$5,105
Turkmenistan	National PGR Bank	1	100%	1,233	$3,946
	Sub-total	**12**		**30,429**	**$97,394**
Global	CIMMYT	2	5%	3,178	$10,169
Global	ICARDA	2	10%	3,157	$10,102
Hungary	Inst. Agrobot., Tapiozele	2	25%	1,883	$6,025
Israel	VIAR, Bet-Dagan	2	25%	1,097	$3,510
Kazakhstan	National PGR Bank	2	10%	2,347	$7,511
Romania	Suceava Genebank	2	25%	385	$1,233
Ukraine	Yurjev Inst. of Plant Prod., Kharkov	2	25%	2,399	$7,678
Uzbekistan	National PGR Bank	2	25%	2,336	$7,474
	Sub-total	**8**		**16,782**	**$53,702**
	Grand Total			**47,211**	**$151,096**

* Estimated figures by an expert consultation, August 2006.
** Based on an estimated cost of US $3.20/accession

It is estimated that about 10% of the total global wheat accessions are in urgent need of regeneration and the likely cost to do this exceeds US$150,000.

4.8.4 Safety Duplication

Safety duplication refers to the need for duplicate samples of accessions in a collection to be maintained in more than one genebank as a form of insurance against disastrous loss (for example, due to fire, earthquake or war). "Black box" duplication, whereby the genebank of origin is responsible for the quality of the stored samples and their regeneration, and the recipient genebank merely holds the samples in long-term storage, is considered the most convenient and cost-effective method of safety duplication.

Duplication of accessions for safety is a requirement of agreed international standards for genebank management. Yet, less than 10% of the globally important wheat collections have their entire collection duplicated elsewhere for safety, while a majority have partial or no safety duplication in place. Clearly, this is a major area for concern and full safety duplication, of at least unique accessions, must be the goal of an efficient rationalised global network of collections.

The lack of safety duplication is linked, in part, to the need for urgent regeneration of samples in many collections. Curators sensibly see no point in sending seed of accessions that may require regeneration due to low viability to duplicate black box storage. Consequently, these two safety issues, regeneration of accessions and safety duplication need to be considered simultaneously with samples of newly regenerated seed also used for safety duplication.

4.9 Information Management in the Global Network

Accessible information is the key to the development of an efficient Global Network of Wheat Genetic Resource Collections. It is clear from the surveys of collections that there is great variation in the systems used to record, store and distribute information. It is also clear that there are significant deficiencies in the documentation of collections, with some accessions lacking basic passport data on a significant proportion of their holdings. As a first step in developing an integrated information system for the Global Network of Wheat Genetic Resource Collections, it will be necessary to ensure all members of the network have adequate information storage and retrieval infrastructure and to rectify the deficiencies in the documentation of collections. This will involve, at a minimum:

- Computerisation of data on the collections.
- Agreed protocols for data ontology and quality.
- Transfer of all key passport, characterization, evaluation and other relevant data in collections to electronic databases.
- Improve the documentation of collections, particularly passport data, critical to improve accessibility and as a tool to assist in the management and rationalisation of collections.
- Establishment of web access for all collections' databases.
- Link individual databases into an integrated global system that can be accessed all collections, and the collections' user clientele.

Many genebanks have data management systems, with varying levels of data quality control and innovation support. The issue will be to link the information resources of each genebank into an integrated web-based network. Fortunately in recent years considerable progress has been made in developing "middleware" solutions to such problems. We envision a "Googlized" system that links disparate sources of locally curated data. In the case of genetic resources several such systems have been developed (e.g., the System-wide Information Network for Genetic Resources (SINGER); Bundesinformationssystem Genetische Ressourcen (BIG) developed by four agencies in Germany; EURISCO developed by ECPGR; the Focused Identification of Germplasm Strategy (FIGS) sampling methodologies developed by the N.I. Vavilov Research Institute of Plant Industry (VIR), the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Australian Winter Cereals Collection (AWCC - hosted by the New South Wales Department of Primary Industries); and, the International Crop Information Systems (ICIS) through collaborative efforts of the International Rice Research Institute (IRRI), CIMMYT and ICARDA and public sector partners). It is anticipated that the development of an integrated global information network based on existing and improved individual genebank databases is feasible and achievable in the short to medium term.

4.10 Rationalising Existing Collections

It is acknowledged that the task of rationalising collections and identifying duplicates will be difficult and time consuming. This is due, in part, to the fact that a variety of names and numbering systems are used for the same accessions, or because landraces which have been collected from several geographical distinct sites and represent genetically different samples, may have the same name. It is also due in part to the fact that accessions have limited passport data available which makes determination of their origin and uniqueness difficult. Nevertheless, the experience in ECPGR suggests that this step is crucial to the development of a more effective, rational and cooperative system and in the long term, is worth the considerable time and effort, involved.

Once a full listing or registry of accessions held in collections is available, it should be possible to initiate the rationalisation of collections. It is anticipated that:

- This will empower curators to identify unique and duplicated accessions held in each collection in the network, and from this, assign each different accession in the overall system to a pair of genebanks which would be responsible for its long term conservation. Each collection would be assigned responsibility for the unique accessions it holds of national collections, cultivars released or collected in that country for the conservation, regeneration, characterisation, documentation, distribution and safety duplication of that accession on behalf of the Global Network.. Assignment of other accessions to particular collections will be by negotiation.
- Collections would be free to maintain duplicates of accessions for which other genebanks had been assigned primary responsibility if they wished because of quarantine requirements or for the convenience of their clients. However, it would be expected that a collection would give first priority to the effective management, particularly regeneration, characterisation and documentation, of the accessions for which it held primary responsibility and could maintain duplicates in an active collection or negotiate with other genebanks for limited samples of material to distribute to local users.
- Over time, as confidence in the effectiveness of the Global Network grows and users accept that they can request and receive samples from any collection in the network in a timely manner, curators will be able to shift resources from maintaining duplicates to the better maintenance of the accessions for which they have primary responsibility and the acquisition of new higher priority unique accessions. In this way, the Global Network should enhance both the security of existing collections and free up resources that can be used to build up accessions of high interest to breeders such as genetic stocks or mapping populations.

It must be noted, however, that the identification of genetic duplicates within and between collections is not a trivial exercise. Genetic drift within accessions due to out crossing, founder affect restricted sampling, genotype by environment interactions, unrecognized selection pressures and mechanical mixtures have been observed. Improved molecular genetic techniques, with greater genomic saturation and precision and with reduced per sample costs, will aid in the characterization of unique and cosmopolitan genetic diversity.

4.11 Identifying and Rectifying Gaps in Existing Collections

An important consideration for the steering committee of the Global Network of Wheat Collections will be establishing priorities for identifying and rectifying gaps in existing collections. These priorities need to be established for three classes of materials:

1. Landrace or traditional varieties: these have been replaced by higher yielding improved cultivars. However, in parts of Eastern Europe, WANA, the Arabian Peninsula and the Andean Highlands, materials likely still exists in the field that are poorly represented in genebanks and these have been identified as priority areas for the further collection. Collecting priorities should be decided in conjunction with regional programs which have expert knowledge of the material.
2. Wild relatives: the survey of wild wheat relatives held in genebanks suggests that the level of genetic diversity and breadth of provenance of these species captured in existing

collections is small. Collection of wild species has been given less emphasis than the collection of land races in the past, as they were considered to be under less threat given their unaided survival and reproduction. However, more and more wild species are coming under threat due to changing patterns of land use and this, as well as the need to have samples of wild species on hand for research projects, has increased the need to substantially increase the genetic diversity of the wild relatives of wheat held in collections.

3. Genetic and mutant stocks and mapping populations: The conservation of germplasm developed with a high degree of intellectual and scientific investment was recognized as a high priority. Significant impacts on wheat science and applied breeding have been the outcome of these germplasm. This historic legacy should not be squandered.
4. Cultivars: As with highly developed research germplasm, germplasm that is more intensively characterized and evaluated was prioritized for conservation. In the foreseeable future, information systems will exist that pull together numeric and text molecular and evaluation data, literature and knowledge. Cultivars are often more rigorously characterized and broadly evaluated due to release practices and regulations, resulting in a higher short-term "value" for immediate, direct use in wheat breeding programs.

5. RYE *EX SITU* CONSERVATION STRATEGY

Rye (*Secale cereale* L.) is the world's eighth largest cereal crop with a global production of approximately 18.4 million tons which accounts for about 1.5% of total global cereal production. In recent years, rye production has decreased in importance relative to the major cereal crops wheat, rice and maize. It is principally grown in Europe, particularly Germany, Poland, Russia and Lithuania, several northern European and Central Asian republics and China. Europe and the republics of the former Soviet Union account for about 90% of total global production, with much of the rest occurring in countries such as USA, Canada, and Argentina which have significant immigrant populations from Europe. Much of the global rye production goes into traditional European rye breads with the remainder going into animal feed and alcohol production.

Rye is extremely winter hardy and can grow in difficult soils (poor sandy soils and soils deficient in some micronutrients) and is often cultivated in areas that are not suitable for the production of wheat and barley. The number of different cultivars of rye grown globally is relatively small especially compared to wheat and considerably less effort has been expended in the improvement of rye. However, F_1 hybrid rye cultivars have been available in Europe for about twenty years and have dominated sales in the last decade. The use of hybrids has led to substantial increases in average yields. Open pollinated cultivars are still available in marginal areas.

5.1 Rye Evolution and Taxonomy

The taxonomy of the genus *Secale* is still uncertain despite decades of scientific research. Rye's primary centre of origin appears to be south-western Asia, essentially the same area of origin as bread wheat, barley and oats. It moved from its centre of origin into northern Europe either via Russia or Turkey or both in the first millennium BC. From there it spread throughout Europe and subsequently around the globe in all major cereal producing countries.

The genus includes cultivated rye and between 2 to 11 wild species depending on the criteria used for species definition. However, modern studies have tended to recognise only three or four taxonomic groups. The four species are the two annual autogamous species *Secale sylvestre* Host and *S. vavilovii* Grossh, the annual outbreeder *S. cereale* L. and the perennial *S.*

strictum Persl. (syn. *S. montanum*). Those that recognise only three species include *S. vavilovii* forms in *S. cereale*. Both *S. strictum* and *S. cereale* are complex species containing geographically distinct subspecies. *S. strictum* is generally regarded as the ancestor of cultivated rye.

All rye species, including the cultigen, contain seven pairs of somatic chromosomes, although artificially produced tetraploid rye has been grown on a limited scale in Europe. All species of *Secale* can be hybridised and are partially fertile. Both the annual and perennial wild forms are therefore potentially valuable genetic resources for the crop and have been used as sources of genes for disease resistance and cytoplasmic male sterility and fertility restoration.

5.2 Major Rye Collections

Global rye collections contain more than 20,000 accessions of which about 10,000 accessions are held in Europe. Table 9 lists the major rye collections, which could potentially form the basis of an integrated Global Network similar to that proposed for wheat.

These data illustrate that five countries (Russia, Germany, Poland, USA and Canada) hold relatively large collections of rye germplasm and that they account for nearly 70% of the global accessions. The remainder are held in relatively small collections in many different countries, and often different institutes in the same country. A survey of European collections in 1996 suggested that there were high levels of duplication of accessions in some of the larger European collections, while some of the smaller collections, which had focused strongly on conserving indigenous materials contained high levels of unique materials.

TABLE 9. Major Global Rye Collections

Country	**Institution**	**No of access-ions**
Bulgaria	Institute for Plant Genetic Resources,	400
Canada	Plant Gene Resources of Canada, Saskatoon	1,440
Czech Republic	Cereal Research and Breeding Institute, Kromeriz	663
Germany	Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben	2,154
Global	CIMMYT, El Batan, Mexico	747
Hungary	Institute for Agrobotany, Tapioszele	361
Poland	Botanical Garden of the Polish Academy of Sciences, Warsaw	1,630
Poland	Plant Breeding and Acclimatization Institute (IHAR), Radzikow	1,354
Portugal	Banco de Germoplasma-Genetica, Oeiras	580
Russia	N.I. Vavilov Institute of Plant Industry, St Petersburg	2,685
Spain	Centro de Recursos Fitogeneticos, INIA, Alcala	412
Sweden	Nordic Gene Bank, Alnarp	365
Turkey	Aegean Agricultural Research Institute, Izmir	585
USA	National Small Grains Collection, Aberdeen, ID	1,897
Total	**14 institutes**	**15,273**

Source: Bioversity, 2006

It is worth noting that none of the CGIAR centres have significant collections of rye despite their interests in interspecific crosses in wheat and the use of rye germplasm in triticale and wheat breeding.

5.3 Existing Networks of Rye Collections

ECPGR, because of the importance of rye as a traditional crop in many European countries, held the first *Secale* Working Group meeting in 1982 soon after its establishment. The working group designated the Polish Genebank as the crop germplasm centre for the European *Secale* Database and recommended collation of passport data from other European rye collections. While some early work was done it was not until additional funding became available in 1994 that the Centre for Plant Genetic Resources in Poland was able to update and expand the European *Secale* database. The database now contains passport data on 9,901 accessions maintained in 21 European institutions.

In 1996 ECPGR held an international conference involving both European and USA scientists entitled "Challenges in rye germplasm conservation". The conference recognised that a complete verified listing of all accessions in cooperating collections was important to allow rationalisation of collections and the development of an efficient integrated network. The available data in the European *Secale* database suggests:

- Overall there were at least 30% duplicates in the European collections. However, when other important global collections are taken into account this figure is likely to be much higher as the USA, Russia and Canada obtained much of the material they hold from Europe.
- The levels of duplication of accessions tend to be higher in the larger European collections. Some of the smaller collections, which have focused strongly on conserving indigenous materials, contained high levels of unique accessions.
- Passport data in many collections was incomplete and this made identification of duplicates difficult. For example only 70% of accessions had a species identifier.
- Accessions of wild relatives of cultivated cereal rye are poorly represented in collections, varying from 0-6% of accessions.
- Regeneration is more difficult in rye, because of it is a cross-pollinated species, compared to the other small grained cereals and requires special isolation procedures. Regeneration of genebank samples is therefore a significant problem for rye collections. Nevertheless, because of the cross-pollinated nature of this species, accession duplication may be less than the passport information suggests.
- The levels of safety duplication for rye collections in Europe are very poor.

5.4 Establishing a Global Network of Rye Collections

The programme of activities conducted under the auspices of the ECPGR Cereals Network provides a strong base for the development of a Global Network of Rye Collections. ECPGR already includes the majority of European countries. Indeed the only major collections not included in ECPGR are those in the USA and Canada. Consequently it is suggested that ECPGR assume responsibility for the establishment and oversight of the Global Network of Rye collections. This could be achieved by inviting representatives from the USA and Canada to attend ECPGR ad hoc rye meetings and including a segment on the Global network in the meetings. ECPGR is developing a coordinated European database for rye. The USA and Canada use a common integrated genetic resources information system (GRIN). Consequently, the development of a global information system for rye should be easier in rye than many other crops.

Priorities for the Global Network of Rye collections will be:

- Development of an integrated and accessible database of accessions held in the global network. This is a critical first step in rationalising collections by identifying duplications and preventing new unnecessary duplication, in identifying gaps in existing collections, and in setting priorities for regeneration and safety duplication.

- Ensuring the safety of accessions currently held in collections by identifying those that need urgent regeneration and putting a program in place to ensure all unique accessions are safety duplicated.
- With regional networks, develop a programme of targeted collection aimed at filling the gaps in existing collections. Obvious targets are cultivated rye in Eastern Europe and the wild relatives of rye, which are very poorly represented in all collections, throughout their respective distributions.
- Improving the quality of characterization and evaluation data to facilitate usage.

6. TRITICALE CONSERVATION STRATEGY

Triticale (X *Triticosecale* Wittmack) was bred by producing fertile stabilised hybrids between wheat (usually *T. turgidum* and *T. aestivum*) and cereal rye (*Secale cereale*). Hexaploid triticale (durum wheat x rye; $2n = 6x = 42$) is a more successful crop plant than either octoploid (bread wheat x rye; $2n = 8x = 56$) or tetraploid triticale (wheat x tetraploid rye; $2n = 4x = 28$), and is the basis of most of global triticale production. The first wheat-rye cross was reported by A.S. Wilson in Scotland in 1875 and the first partially fertile cross by W. Rimpau in Germany in 1888. However, it was not until the 1960s that triticale cultivars suitable for commercial production were bred. Since that time, triticale production has expanded continuously and the crop is now grown on over 3 million hectares worldwide producing about 13 million tons annually. Production is concentrated in Europe, particularly Poland, Germany, France, and Belgium, as well as the Russia Federation, Belarus and China, with limited production in many other countries.

Triticale is mainly used in stock feed and fodder with a limited amount milled for human food. The major advantage of triticale is that it combines, in part, the higher yield potential of wheat with the resistance to harsh climates and poor soils of rye.

6.1 Triticale Genetic Resources

Most triticale germplasm has been bred since the 1960s and consists of breeding lines developed to enhance and broaden the germplasm base for triticale improvement, superseded cultivars and current cultivars. The primary genetic resources for triticale are those of the parental species wheat and rye. Only a very small sample of the enormous genetic diversity in wheat and rye has been used in triticale improvement. As a result, the genetic base in triticale is much smaller than in either of the parental crops.

Four types of triticale lines are recognised:

1. Primary triticale: The result of hybridising wheat and rye and doubling the chromosome number of the hybrid plant.
2. Secondary triticale: Produced by crossing different cultivars of triticale (e.g. primary x primary, primary x secondary, secondary x bread wheat).
3. Complete triticale: Carry all 7 rye chromosomes unchanged.
4. Substituted triticale: Have one or more rye chromosomes replaced by wheat chromosomes.

By intercrossing triticale with bread wheat and backcrossing the progeny to bread wheat it is possible to generate a range of lines ranging from wheat like plants that carry only a small amount of rye chromatin to complete triticales with all seven rye chromosomes. This raises the question of defining, in light of the wide spectrum of types that can be generated by hybridising wheat and rye, what is wheat (albeit carrying alien chromatin) and what is triticale? While the decision is necessarily an arbitrary one, it is usually assumed that classified as triticale a plant must carry four or more rye chromosomes.

6.2 Major Triticale Collections

The available information from FAO, Bioversity International and our own survey suggests that about 35,000 accessions are held in genebanks globally, listed in Table 10.

The major collections are in North America (CIMMYT and the USDA) and Europe (Russia, Poland, and Ukraine). Apart from these major collections, many countries have small collections of a few hundred accessions, often housed in university research (breeding and cytogenetic) laboratories. The North American Triticale Generic Resources Collection is a noteworthy resource (Furman *et al.*, 1997), curated within the USDA-ARS collections at Aberdeen, Idaho. Most of the larger collections, except those in Russia and the Ukraine, are believed to conform to the recommended international standards for long-term conservation. A major deficiency of triticale collections, as with wheat and rye, is safety duplication. While the USDA collection is fully duplicated for safety, and the CIMMYT collection is partially duplicated, the level of safety duplication in the other collections is poor.

TABLE 10. Major Global Triticale Collections

Country	**Institution**	**No. of Access-ions**
France	Plant Breeding and Genetics Department, INRA, Clermont-Ferrand	800
Germany	Institute for Plant Genetics and Crop Plant Research (IPK), Gatersleben	1,576
Global	CIMMYT, El Batan, Mexico	17,871
Poland	Institute of Plant Breeding, University of Agriculture, Lublin	1,748
Poland	Plant Breeding and Acclimatization Institute (IHAR), Radzikow	2,032
Russia	N.I. Vavilov Research Institute of Plant Industry, St Petersburg	3,744
Switzerland	Agroscope Changins-Wädenswil ACW	750
Ukraine	Yurjev Institute of Plant Breeding, Kharkov	1,778
USA	National Small Grains Germplasm Research Facility, Aberdeen, Idaho	2,007
USA	Department of Agronomy, University of Missouri, Columbia	1,400
Total	**9 Institutions**	**31,958**

Source: Bioversity, 2006; Gert Kleijer, pers. comm.

6.3 Existing Networks of Triticale Collections

The ECPGR, through its Cereals Network, established the European Triticale Database (ETDB), in 1996 at Agroscope Changins-Wädenswil ACW in Nyon, Switzerland. Data are being collected from 22 institutes in 18 countries that conserve a total of 11,708 accessions. As with wheat and rye, the development of a comprehensive central database of the passport and characterisation data of all accessions conserved in Europe is seen as a critical first step in rationalising collections by allowing the identification of duplicates accessions in different genebanks in the European network.

Triticale has received less attention in other networks that have focused on the major crops. Nevertheless, in the NORGEN network, USA and Canada, again as they have with wheat and rye, have agreed to share a common database system (the GRIN system) that should allow them to more easily identify duplicates in their collections.

6.4 Establishing a Global Network of Triticale Collections

The establishment of a Global Network of Collections maybe easier for triticale than wheat or rye for the following reasons:

- Fewer players are involved, and most of the important collections already meet the basic criteria for ensuring long-term conservation and availability. Furthermore, the triticale community is often intensely passionate about the potential of the crop.
- Only limited unique material is held in smaller collections because triticale, unlike wheat and rye, has not had a long period of development or evolution. The one exception to this is primary triticale germplasm. Primary triticales have often been developed in University or NARS research programmes to meet specific local needs, and the primary triticale lines developed, in contrast to the best of the secondary triticale derivatives, have not necessarily found their way into the major collections. This is a deficiency that requires rectification.
- Computerised databases with passport and characterisation data are available for the European collections (ETDB), the major collections in North America (GRIN) and the CGIAR (SINGER and ICIS). It should therefore be feasible to develop a global database of collections with a minimum of effort compared to many other crops.

Since all centres with major triticale collections also have major wheat collections, it is suggested that the wheat and triticale global networks should share a common secretariat or management committee. Among the priority tasks for the steering committee would be:

- Development of an integrated global database of conserved triticale germplasm
- Identification of important germplasm, particularly primary triticale lines, not currently conserved in the proposed Global Network of Triticale Collections, with the development of a program to ensure the long term conservation of this germplasm.
- Remedial programmes to bring all the collections in the proposed global network up to agreed international standards for long term conservation and management.
- Development of a comprehensive programme of safety duplication of all unique samples in the proposed global network.

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APPENDIX I: Advisory Group, Global Wheat, Rye and Triticale Conservation Strategy
Established at the consultation meeting in June 2006

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11.	Nordic Genebank (NGB)	**Dr. Bent Skovmand†** Director, The Nordic Genebank (NGB), P.O. Box 41 SE230 53 Alnarp, , SWEDEN, Tel: +46.40.536644/40 Web: http://www.ngb.se/
12.	Global Crop Diversity Trust	**Brigitte Laliberté**, Scientist Global Crop Diversity Trust Via dei Tre Denari 472/a, 00057, Maccarese, Rome, ITALY Tel:+39-06-611-8272, Fax:+39-06-619-79661 Email: brigitte.laliberte@croptrust.org, Web: www.croptrust.org

APPENDIX II: The questionnaire used to survey the curators/managers of major global collections of wheat, rye and Triticale

The Global Crop Diversity Trust is supporting efforts to develop strategies for the more efficient and effective conservation of crop diversity. The Trust has commissioned Dr. Don Marshall, Plant Breeding Solutions, Australia, to coordinate the development of a wheat and related species conservation strategy. This questionnaire has been developed in order to seek the advice and input of representatives of the world's major wheat and related species collections in the development of the conservation strategy. In particular, this questionnaire seeks to assess the conservation status of wheat, Triticale, rye and their related species throughout the world. We are keen to have your active participation in the development of this global conservation strategy for wheat, Triticale, rye and related species and will be pleased to keep your informed on its progress and consult you during the development until completion. As a key curator of a wheat, Triticale, rye and their related species collection, we kindly request that you complete this questionnaire.

1. Organisation information:

Name and address of organisation holding/maintaining the wheat, Triticale, rye and related species collection
Curator in charge of the wheat, Triticale, rye and related species collection:
Name of respondent to this questionnaire if different then above

1.2 Additional key contact persons for the above germplasm collections:

1.3 Please describe your organisation:

__ National Governmental organisation
__ University
__ International Public organization
__ Non-governmental organization
__ Private organisation
__ Other: please describe:

1.4 Is your institution the legal owner of the collection?

_ yes __ no __ don't know 1.4.1 If no, who is the owner?

1.5 Is the collection subject to the terms and conditions of the International Treaty on Plant Genetic Resources for Food and Agriculture? __ yes _ no __ don't know

1.5.1 If no, is it expected to become under the International Treaty in the near future? __ yes, indicate expected date: __ no

2. Overview of your wheat, Triticale, rye and related species collection:

2.1 Main objective of your collection is:

_ long-term conservation
working collection
_ breeding collection
__ other (please specify)

2.2 Current number of accessions in your collection (provide detail numbers of accessions, if available, or overall totals):

	Common Wheat	Durum Wheat	Triticale	Rye	TOTAL
Modern Cultivars					
Obsolete Cultivars					
Landraces			na		
Species, Closely Related			na		
Species, Secondary Genepool			na		
Genetic stocks					
Mutant stocks					
Mapping populations and parents					
Other					
TOTAL					

2.3 Mark (x) where there are major gaps in your wheat, Triticale, rye and related species collection, as related to your clients' needs.

	Common Wheat	Durum Wheat	Triticale	Rye
Modern Cultivars				
Obsolete Cultivars				
Landraces			na	
Species, Closely Related			na	
Species, Secondary Genepool			na	
Genetic stocks				

Mutant stocks				
Mapping populations and parents				
Other				

2.3.1 If major gaps are indicated, what plans, if any, are you contemplating to fill such gaps?

2.4 Origin of the collection: please indicate the proportion (%) of accessions on the total amount that were:

	Percentage %
- 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):	

2.5 What would you consider to be the most interesting aspects of your collection, making it unique?
2.6 Please describe the main potential/importance of your collection for use and breeding:
2.7 Please list and rank, in your opinion, the most important wheat, Triticale, rye and related species collections in the world:

3. Conservation status (germplasm management):
3.1. Conservation facilities:

Please indicate the proportion of the accessions maintained under: (Note: if accessions are maintained under more than one storage condition the total percentage may exceed 100%)	**Percentage %**
Short-term storage conditions	
Medium-term storage conditions	
Long-term storage conditions	
Other, please specify:	

3.2 Storage form:

Please indicate the proportion of the accessions stored as:	**Percentage %**
Seeds	
Field accessions	
DNA	
Other, please specify	

3.3 Please describe your storage facilities:

	Short-term	**Medium-term**	**Long-term**
Type of facilities:			
Temperature:			
Relative Humidity (%):			
Packing material:			
Other, please specify:			

3.4 Mark (x) if you have procedures and protocols for:

_ Germplasm Acquisition (*including collecting, introduction and exchange*)
_ Regeneration
_ Characterisation
_ Storage and maintenance
_ Documentation
_ Phytosanitary Certification
_ Packaging and Shipping
__MTA tracking
__Safety-duplication

3.4.1 In case you have procedures and protocols, are you able to provide the Global Crop Diversity Trust with this information in written format? __ yes _ no

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

Germination tests	
Viability testing	
Phytosanitary testing	
True-to-type	
Other, please specify:	

3.6 Is the collection affected by diseases that may restrict the distribution of the germplasm?

__ yes __ slightly, only few accessions _ no

3.6.1 If yes or slightly, are procedures and facilities available at your institution for the monitoring and eradication of these diseases? __ yes __ limited __ no

3.7 Is the collection affected by GMO transgene presence that may restrict the distribution of the germplasm?

__ yes __ slightly, only few accessions _ no

3.7.1 If yes or slightly, are procedures and facilities available at your institution for the testing and monitoring of GMO presence? __ yes __ limited __ no

3.8 Please indicate the proportion (%) of the collection that requires urgent regeneration (apart from the normal routine regeneration):

	Common Wheat	Durum Wheat	Triticale	Rye
Modern Cultivars				
Obsolete Cultivars				
Landraces			na	
Species, Closely Related			na	
Species, Secondary Genepool			na	
Genetic stocks				
Mutant stocks				
Mapping populations and parents				
Other				
TOTAL				

3.9 Please indicate the current and expected situations of the collection with respect to the following factors, where: 1 = high/good, 2 = adequate/moderate, 3 = not sufficient/bad, NA = not applicable:

Factors	**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, characterisation, evaluation)		
Active support/feedback by users		
Level of use by breeders		
Other factors (please specify):		

4. 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**):**

4.1 Are accessions from your collection safety-duplicated in another genebank?
__ yes, fully _ yes, partially __ no 4.1.1 If yes, please specify:

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.)
Add lines as necessary			

4.2 Is there any wheat, Triticale, rye or related species germplasm of other institutes' collections safety-duplicated at your facilities? __ yes _ no 4.2.1 If yes, please specify:

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.)
Add lines as necessary			

4.3 To what extent do you consider the wheat, Triticale, rye and related species germplasm 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

4.4 To what extent do you consider the data associated and available with the wheat, Triticale, rye and related species accessions in your collection, to be unique and not duplicated extensively elsewhere?

__ Fully unique
__ Mostly unique
__ Partially unique
__ Fully duplicated elsewhere

4.5 Are there any constraints to duplicating (backing up) your collection elsewhere, outside your country?

__ yes __ no 4.4.1 If yes, please specify.

5. Information management:

5.1 Do you use an electronic data system for managing:

the collection inventory	__ yes	__ no
passport data	__ yes	__ no
pedigree maintenance	__ yes	__ no
characterization and evaluation phenotypic data	__ yes	__ no
molecular characterization data	__ yes	__ no

5.1.1 If yes to any of the above, please specify which software is used:

5.2 In case the collection is not computerised, are there plans to do so in the future?

_ No plans
__ Computerisation planned within 3 years
__ Computerisation planned within 6 years

5.3 Does your Germplasm Bank have an Internet webpage? __ yes __ no

5.3.1 If yes, please provide the Internet address:

5.4 Are information and data of your wheat and related species collection accessible through the Internet? __ yes __ no

5.4.1 If yes, please provide the Internet address:

5.5 Are data of the collection included in other databases?

- National __ yes __ partly __ no
- Regional __ yes __ partly __ no
- International __ yes __ partly __ no

5.5.1 If yes or partly, specify the databases:

6. Distribution and use of material:

6.1 What proportion (%) of the total collection is AVAILABLE for the following distributions?

Nationally: __________% Regionally: ___________% Internationally: __________%

6.1.1 Please fill in the number of accessions DISTRIBUTED annually

	Number of accessions distributed annually (average of last 3 years)
Within your Institution	
Nationally	
Internationally	

6.2 Do you set specific restrictive conditions for distribution of germplasm? Please specify:

6.6 Do you keep records of the distribution? __ yes __ No

6.7 Which of the following received germplasm from you in the past 3 years?

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

6.8 How do you inform potential users about the availability of accessions and their respective data in your collection?

6.8 How do potential users most often contact you to request germplasm?

6.9 What limitations do you consider to be most important regarding the enhanced utilization of the genetic resources from public gene banks?
(1 = Very Important, 2 = Some what Important, 3 = Not Important, na = not applicable)

	Current	2010
Access to data		
Accession molecular characterization		
Accession morphological characterization		
Accession performance evaluation		
Collation of data from various sources		
Inadequate levels genetic diversity		
Intellectual property issues		
Tools to better select representative or criteria-defined sets of germplasm		
Other (specify):		

6.10 Please mark (x) your policy regarding accessibility and distribution of wheat and related species germplasm:

Cost of accessions: _ free __ cost: ____________
Cost of shipment: __ free _ cost: ____________
Use of Material Transfer Agreement: __ yes _ no
6.10.1 Do you have any restrictions on who can receive materials? __ yes __ no If yes, please specify:

7. Networks of wheat and related species genetic resources:

7.1 Do you collaborate in (a) network(s) as a wheat and related species collection holder?

__ yes _ no

7.1.1 If, yes please provide the following information for each of the networks related to wheat and related species to which you participate:

A- Name of network	B - National/ Regional/ Worldwide	C – Name of Network Coordinator	D – Network Coordinator Email Contact Address

8. Major constraints:

Please list the 5 major limitations you are facing in the management of your collection:

9. Please add any further comments you may have regarding strategies for the conservation of wheat, Triticale, rye and their related species:

APPENDIX III: Questionnaire used to survey users of global wheat, rye and Triticale collections

The Global Crop Diversity Trust is developing a series of regional and crop specific genetic resource conservation strategies. The strategies are to identify global germplasm collections containing the widest and most important diversity of a given crop, and to identify areas where further investments maybe needed, including infra-structure, human resource capacity, enhanced collecting and characterization, and improved access to data. This survey assesses the importance and adequacy of wheat, triticale, rye and related species collections or gene banks in your country or region, and how they impact your active research or breeding program.[*]

Name and address of the respondent to this questionnaire

1. Prioritize the importance of the following crops in your research/breeding program.
(1 = Very important, 2 = Moderately important, 3 = Minor importance, 4 = Not important)

	Spring Habit	Winter Habit
Bread Wheat		
Durum Wheat		
Triticale		
Rye		

2. List (most important first) the public wheat, triticale, rye and related species gene banks from which you have requested and received germplasm within the past five years.

3. List (most important first) the public wheat, triticale, rye and related species gene banks, collections or programs from which you have obtained germplasm-related data within the past five years.

4. What limitations have you experienced that hinder greater use of wheat, triticale, rye and related species genetic resources held in public gene banks?

5. What limitations do you consider to be most important regarding the enhanced utilization of the genetic resources from public gene banks?
(1 = Very Important, 2 = Some what Important, 3 = Not Important, na = not applicable)

	Current	2010
Access to data		
Accession molecular characterization		
Accession morphological characterization		
Accession performance evaluation		
Collation of data from various sources		
Inadequate levels genetic diversity		
Intellectual property issues		
Tools to better select representative or criteria-defined sets of germplasm		
Other (specify):		

6. List (most important first) the five most important public wheat, triticale, rye and related species gene banks, nationally, regionally and internationally.

7. For the public collections with which you have regular interaction or knowledge, what is your perception of the adequacy of the levels of genetic variability conserved in the wheat, triticale, rye and related species gene banks.
(1 = Fully Adequate, 2 = Moderately Adequate, 3 = Inadequate, na = Not Important)

	Bread Wheat	Durum Wheat	Triticale	Rye
Modern Cultivars				
Obsolete Cultivars				
Landraces				
Species, Closely Related				
Species, Secondary Genepool				

[*] Please provide responses to questions in the provided text boxes, and ignore document formatting, and page breaking that may result there from.

Genetic stocks				
Mutant stocks				
Mapping populations and parents				
Other				

8. Please list the germplasm collection missions (e.g., countries), or targeted accession acquitions (e.g., types of germplasm or species needed) needed to strengthen your research/breeding during the next ten years.

9. For which traits is there currently limited genetic variability for future germplasm enhancement, and what traits are most import for your research/breeding objectives? Mark (x), as appropriate.

Trait or common name of disease	Limited Genetic Variability	Importance to Your Program
Aluminium tolerance /Acid soils		
Aphids (not specified)		
BYDV		
Diseases (not specified)		
Drought Tolerance		
Dwarf Bunt		
Earliness		
Eyespot		
Fusarium Head Blight		
Fusarium Root/Crown Rot		
Grain Yield		
Heat tolerance		
Height and Lodging resistance		
Hessian fly		
Insect resistance (not specified)		
Karnal bunt		
Kernel weight		
Leaf Rust		
Lodging		
Powdery Mildew		
Quality		
Russian Wheat Aphid		
Salt tolerance		
Septoria spp.		
Sprouting Tolerance		
Stem rust		
Suni Bug		
Take-all		
Virus diseases (not specified)		
Water logging tolerance		
Wheat midge		
Winter Hardiness		
WSMV		
Yellow Rust		
Other (specify)		
Other (specify)		
Other (specify)		

10. Project the importance of agronomic traits, diseases and quality characteristics in wheat breeding programs in 10 years. (1 = High Priority, 2 = Medium Priority, 3 = Low Priority, 4 = Not Important)

	Priority
Acid soils / Aluminium tolerance	
Disease resistance	
Drought tolerance	
Earliness	
Frost tolerance	
Grain Colour	
Heat tolerance	
Insect resistance	
Kernel weight	
Micro-nutrients	
Milling/baking requirements	
Nematode resistance	
Nitrogen efficiency	
P-efficiency	
Plant height	
Protein content	
Salt tolerance	
Stability across environments	
Test weight	
Winter hardiness	
Yield increase	
Yield stability	
Other (specify)	
Other (specify)	

11. Rate the importance of the following gene sources for resistance to disease, tolerance to abiotic stresses, and contribution to yield potential for your research/breeding program.
(1 = Most Important, 2 = Moderately Important, 3 Least Important, 4 = Not Important)

	Disease Resistances	Abiotic Stresses	Yield Potential
Advanced lines, From other programs			
Advanced lines, From own Program			
Germplasm, From International or Regional Nurseries			
Germplasm, From public collections			
Landrace varieties			
Modern cultivars			
Synthetic or Translocation Introgression Stocks			

12. Other comments related to the development of a global wheat, triticale, rye and related species conservation strategy.

APPENDIX IV: Questionnaire used to survey collections of precise genetic stocks

Dear Colleague, On behalf of the Wheat Steering Committee of the Global Crop Conservation Trust (http://www.croptrust.org/main) we are carrying out a survey to ascertain the extent and whereabouts of precise genetic stocks of hexaploid, tetraploid, and diploid wheat which can be preserved and curated as a public resource for use by future generations of wheat researchers and breeders. The aim of the survey is to provide a public inventory of what is available and from whom it can be obtained. The types of precise genetic stocks that we are seeking information on are the following:

Conventional
Mapping populations (DH, RIL)
Isogenic lines for key genes (*Rht, Ppd, Vrn* etc)
Mutant populations (TILLING populations)
Mutant isogenics

Aneuploid derived
Deletion lines
Monosomics
Ditelocentrics
Double-diteolocentrics
Isochromosomes
Trisomics
Tetrasomics
Nulli-tetrasomics
Single chromosome substitution lines
Recombinant substitution lines
Intra-varietal translocation lines (5B/7B etc)

Alien material
Synthetics
Hybrids
Amphiploids
Alien additions
Alien substitutions
Alien translocations
Alloplasmic lines

If you are developing or curating any of these stocks and would like to see them preserved as a public resource then we would be grateful if you could fill in the attached questionnaire and email it to us, and we would be happy to answer any questions about the survey.

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APPENDIX V: Summary of responses to genebank curators/managers and clients/users surveys

Bank Managers survey distribution sent and response received (number per country)

Country	Managers Sent	Managers Received	Country	Managers Sent	Managers Received
Armenia	1	1	Israel	1	1
Australia	1	1	Italy	1	
Belgium	1		Japan	2	
Brazil	1	1	Korea	1	
Bulgaria	1	1	FYR Macedonia	1	1
Canada	1	1	Netherlands	1	1
China	1	1	Norway	1	
CIMMYT	1	1	Pakistan	1	
Croatia	1		Poland	1	
Cyprus	1		Portugal	1	
Czech Republic	1	1	Romania	1	1
Estonia	1		Russia	1	
Ethiopia	1	1	Serbia	1	1
Finland	1		Slovakia	1	
France	2		South Africa	1	
Georgia	1		Spain	1	1
Germany	2	1	Sweden	1	1
Hungary	1		Switzerland	1	1
ICARDA	1		Turkey	1	
India	1		UK	1	
Iran	1		Ukraine	1	
Ireland	1		USA	2	2

Clients survey distribution sent and response received (number per country) and client's crop specialization

Country	Clients Sent	Clients Received	Clients Crop	Country	Clients Sent	Clients Received	Clients Crop
Argentina	1	1	BW, S	Kazakhstan	1	2	BW/DW, S
Armenia	1	1	BW, W	Kyrgyzstan	1	1	BW, W
Australia	2	2	BW, S	Poland	1		
Austria	1			Portugal	1		
Azerbaijan	1	1	BW/DW, W	Romania	1	1	BW, W
Brazil	1	1	BW, S	Russia	2	2	BW/DW, S
Bulgaria	1	1	W	South Africa	1	1	BW, S
Canada	1	1	BW, S	Spain	1	1	DW, S/W
Chile	1			Switzerland	1	1	BW, S
China	3	3	BW, S/W	Tajikistan	1	1	BW, S/W
CIMMYT	3	3	BW/DW/Tcl, S	Turkey	1		
France	2			UK	1	1	BW, W
Georgia	1	1	BW, W	Ukraine	1		
Germany	1	1	BW/Rye, S/W	Uruguay	1		
ICARDA	3			USA	4	4	BW, W
India	1	1	BW/DW, S	Zimbabwe	1		
Iran	2	2	BW/DW, S				

Clients = Wheat Breeders, Molecular Geneticists, Wheat Pathologists, Wheat Researchers
Primary crop interest (BW=Bread Wheat; DW=Durum Wheat; Tcl=Triticale; Rye; W=Winter

Wheat bank data

Questions:

1. Jurisdiction of the collection?
2. Legal guardian of the collection?
3. Subject to ITPGRFA? If "no", then by which year (projected).
4. Type of collection (B=Base; A=Active; W=Breeding)?
5. Facilities, short term (%)?
6. Facilities, medium term (%)?
7. Facilities, long term (%)?
8. Total wheat, rye and triticale (and related species) accessions?

	Sent	Received	1, Jurisd.	2, Guardian	3, ITPGRFA	4, Type	5, Short	6, Medium	7, Long	8, Total
Armenia	x	x	University	Yes	No	A,W	100			2643
Australia	x	x	State	Don't know	Don't know	B,A			100	35592
Brazil	x	x	National	Yes	Yes	B,A,W		100		
Bulgaria	x	x	National	Yes	Yes	B,A		52	68	13765
Canada	x	x	National	Yes	Yes	B	30		70	15428
China	x	x	National	Yes	No, 2009	B,A,W	36	64		37134
CIMMYT	x	x	Global	In-trust	Yes	B,A,W		100	100	147895
Ethiopia	x	x	National	Yes	Yes	A			100	12471
Macedonia	x	x	National	Don't know	No, 2008	B,A,W	32	38		
Netherlands	x	x	National	No claim	Yes	B		100	100	5551
Romania	x	x	National	Yes	Yes	B,A		98	62	1535
Serbia	x	x	National	Yes	No, 2007	A,W	15			3920
Spain	x	x	National	Yes	Yes	B,A		100	66	4135
Switzerland	x	x	National	Yes	Yes	B		100	100	8221
USA	x	x	National	Yes	Yes	A		100		57089

Questions:

9. National origin (%)?
10. External origin (%)?
11. Unknown origin (%)?
12. Procedures and protocols available?
13. Safety duplication, elsewhere?
14. Safety duplication, constraints?
15. Electronic data software used?
16. Webpage for collection?
17. Form accession requests are most received?
18. Cost of supplying accessions?
19. Cost of shipping accessions?
20. MTA used?
21. Restrictions on availability?

	9, National	10, External	11, Unknown	12, P&P	13, Dupl.	14, Constr.	15, Softw.	16, Web	17, Requ.	18, Acc.	19, Ship	20, MTA	21, Restr.
Armenia	80	18	2		Partial	No	Access	No	Visits	Free	Charged	Yes	No
Australia		25	75	Yes	Yes	Yes	Access	Yes	Email	Free	Free	Yes	No
Brazil		90	10	Yes	Partial	Yes	Dbase	No		Free	Charged	Yes	
Bulgaria	20	40	40	No	No	Yes	Access	Yes	Email	Charged	Charged	No	No
Canada	50	50		Yes	Partial	No	Oracle	Yes	Email	Free	Free	No	
China	65	35		No	Partial	Yes	FoxPro	Yes		Free	Charged	No	
CIMMYT	50	40	10	Yes	Partial	No	ICIS	No	Email	Free	Review	Yes	No
Ethiopia	96	4		Yes	No	Yes	Access	No		Free			Yes
Macedonia	61	39			No	No	Excel	No		Free	Charged	Yes	No
Netherlands	3	84	13	Yes	Yes	No	Oracle	Yes	Web	Free	Free	Yes	Yes
Romania	43	30	36	Yes	No		FoxPro	Yes	Email	Free	Free	Yes	No
Serbia	19	81		Yes	No	No	Word 6	No	Email	Free	Free	Yes	Yes
Spain	51		48	Yes	Partial	No	Access	Yes	Email	Free	Free	Yes	No
Switzerland	65	35			Partial	No	SQL	Yes	Email	Free	Free	No	No
USA	12	88		No	Yes	No	GRIN	Yes	GRIN	Free	Free	No	Some

Clients' (+) perceptions of inadequately conserved genetic variability

	BW	DW	Tcl	Rye
Cultivars		++	++	+
Obsolete Cultivars	+	+	+	
Landraces	++	+	+	
Primary genepool species	+	+	+	+
Secondary genepool species	+++	+++	+	+
Genetic stocks	++	+++	+++	+
Mutants	++++	+++	++	+
Mapping Populations	+++++	++++	+++	+

Clients' (+) and Bank Managers' (!) perceptions of inadequately conserved genetic variability, data normalized to sample size.

	BW	DW	Tcl	Rye
Cultivars	!!	++ !!	++ !!	+ !!!
Obsolete Cultivars	+	+	+	
Landraces	++ !!!!	+ !!!!	+	!!!
Primary genepool species	+ !!!	+ !!	+	+ !!
Secondary genepool species	+++ !!	+++ !	+ !	+
Genetic stocks	++ !	+++ !	+++ !	+ !
Mutants	++++	+++	++	+
Mapping Populations	+++++ !	++++ !	+++	+

Managers' and clients' perceived "significant collections"

- *T. aestivum*: All
- *T. durum*: All
- Triticale: CIMMYT, VIR
- Rye: Bulgaria, Canada, Spain, USDA
- "Species": Armenia, Agroscope, AWCC, CIMMYT, ICARDA, USDA
- Genetic Stocks: AWCC, Bulgaria, CAAS, Canada, KSU, GCP

Clients' perceptions (no. of "hits") of traits for which there is currently limited genetic variability for further germplasm enhancement (n=34).

Aluminum tolerance /Acid soils	8
Aphids (not specified)	16
Barley yellow dwarf virus (BYDV)	15
Diseases (not specified)	20
Drought tolerance	26
Dwarf bunt	2
Earliness	13
Eyespot	10
Fusarium head blight	23
Fusarium root/crown rot	17
Grain yield	18
Heat tolerance	26
Height and lodging resistance	11
Hessian fly	7
Insect resistance (not specified)	13
Karnal bunt	9
Kernel weight	10
Leaf rust	14
Lodging	14
Powdery mildew	17
Quality	19
Russian wheat aphid	8
Salt tolerance	14
Septoria spp.	20

Sprouting tolerance	19
Stem rust	15
Suni bug	10
Take-all	13
Virus diseases (not specified)	9
Water logging tolerance	9
Wheat midge	3
Winter hardiness	11
Wheat streak mosaic virus (WSMV)	3
Yellow rust	15
Nematode resistance	2
Micronutrient deficiencies	2
Macronutrient efficiencies	2

Clients' perceptions of collection "missions" required to fill perceived gaps in current wheat collections:

- Former Soviet Union (4 responses), Canada (3), Western Europe (3), Turkey (3), Australia (2), China (2), Iran (2), Iraq (2), Mexico (2), North Africa (2), USA (2), Central Asia & Caucasus (1), Eastern Europe (1), Southern Cone South America (1)
- Drought affected (3), Industrial quality enhanced (3), Fringe stress environments, at species boundaries (2), Heat affected (2), *Triticum tauschii* (2), Disease affected (1), Yield potential (1)
- Land mine affected areas (1), Frontier areas between countries in the Middle East (1)

Average distribution (%) of wheat germplasm to various research/development communities:

Public Plant Breeders	59
Private Plant Breeders	2
Univ. & Students	25
Farmers	2
NGOs	5
Other Banks	6

Clients' perceptions of areas that hindered their access to wheat collections, ranked.

1. Access to Information (Internet) or Inadequate data search tools (17 responses)
2. Germplasm in un-adapted backgrounds, Modern cultivars not available, or Lack of useful characterization (7)
3. IP Restrictions (real or uncertain), Complicated Exchange Procedures, Financial Limitations (6)
4. No hindrance (3)

Clients' perceptions of areas of importance to enhance use of wheat genetic resources.

	Very Important	Somewhat Important	Not Important
Access to data (general)	++++++		
Access to molecular data	++	++	+
Access to morphological data	+++	+++	
Access to performance data	++++	++	
Linking of various data bases	+++	+	+
Inadequate genetic diversity conserved	++	++	++
Intellectual property rights restrictions	+++	++	+
Better core-subset selection tools	+++	++	

Bank managers' perceptions regarding current constraints to optimal bank management.

	Good	Moderate	Bad
Access to data	***	*	*
Sufficient genetic diversity	**	**	*
Adequate user support	*	**	**
Collections used by breeders	*	**	*
Retention of Good Staff	**	*	**
Retention of Donor Interest		**	**
Adequate funding	**		***

Client's active receipt of germplasm from wheat collections:

- CIMMYT (25 responses), USDA/NSGC (11), ICARDA (9), AWCC (5), JIC (4)
- Agroscope (1), Bulgaria (1), Canada (1), CAAS (1), CENARGEN (1), Czech Rep. (1), India (1), INIA/Spain (1), INRA/France (1), IPK Gatersleben (3), Iran SPII (1), Kagamwa (1), Kazakhstan (1), KSU/WGRC (2), Univ. Sydney (1), Wageningen (1), VIR (2)

Client's active receipt of data from wheat collections:

- CIMMYT (23 responses), ICARDA (8), USDA/NSGC (7)
- Agroscope (1), AWCC (1), CAAS (1), JIC (3), Canada/PGRC (1), GrainGenes (1), GRDC (1), India (1), INIA/Spain (1), INRA/France (1), IPK Gatersleben (2), Iran (1), IWWIP (5), KSU/WGRC (2), OSU (1), TAMU (1)

Clients and Bank Managers perceptions of significant wheat collections:

- CIMMYT, ICARDA, USDA/NSGC, VIR
- Agroscope, AWCC, Canada/PGRC, CAAS, EMBRAPA, Ethiopia, France/INRA, Hungary, India, IPK, Iran, Israel, Japan/Kihara, JIC, NGB, Romania, Siberian, Spain/CRF, Turkey, Ukraine/Kharkov, KSU/WGRC, Univ. California, Univ. Missouri, Wageningen
- European Networked Collections

APPENDIX VI: Survey results of wheat genetic stocks collections

	AUS, AWCC	AUS, Morris	BGR, Ganeva	BGR, Landjeva	CHE, Agroscope	CZE, Faberova	DEU, Borner	DEU, IPK	HUN, anyagok	HUN, Marta	HUN, MV
Conventional Material											
Mapping populations, doubled haploid			276		384						
Mapping populations, recombinant inbred lines			50		243						
Isogenic Lines (Rht, Ppd, Vrn, differentials, etc.)	69	yes	4								
Mutant populations (TILLING)		yes									
Mutant isogenic lines					1						
Aneuploids											2
Addition	6										
Deletion lines	8								18		
Monosomics	6				1				21		33
Ditelocentrics/Double-ditelocentrics									46		
Nulli-tetrasomiics	73										
Trisomics/Tetrasomics	5										
Single chromosome substitutions	125			26			2 sets	40			
Recombinant substitutions							29 sets	29			28
Intra-varietal translocation lines			5								
Translocation stocks	4		30								
Other aneuploids							84				
Alien material											
Synthetic hexaploids (CIMMYT)	604										
Synthetic amphiploids	14		1							3	
Hybrids	8		40							1	
Alien additions			3	3						41	2
Alien substitutions			1	1						1	
Alien translocations										5	
Alloplasmic lines						279					
Other germplasm (please specify)											
Durum											
Triticale											
Rye											
Wild species											
"Genetic stocks"	1383				limited				3		
Disease differentials	322										

APPENDIX VI: Survey results of wheat genetic stocks collections, continued.

	ITA, Milano	KAZ, Bogdanova	NDL, Wagen-ingen	RUS, Merezko	RUS, Novosibirsk Koval	USA, UC-Riverside	USA, NDSU	USA WGGRC
Conventional Material								
Mapping populations, doubled haploid							3	2
Mapping populations, recombinant inbred lines							2	5
Mutant populations (TILLING)								
Mutant isogenic lines							23	
Aneuploids						885		
Addition								
Deletion lines								397
Monosomics								421
Ditelocentrics/Double-ditelocentrics								44
Nulli-tetrasomiics								329
Trisomics/Tetrasomics								42
Single chromosome substitutions						78	53	23
Recombinant substitutions						4557	1688	207
Intra-varietal translocation lines								
Translocation stocks								
Isogenic Lines (Rht, Ppd, Vrn, differentials, etc.)				21				
Other aneuploids						129	35	
Alien material								
Synthetic hexaploids (CIMMYT)								258
Synthetic amphiploids			22			30	45	107
Alien additions								370
Alien substitutions								231
Alien translocations						128		163
Alloplasmic lines								8
Durum						118		
Triticale						662		
Rye						64		
Wild species						134		
"Genetic stocks"		200			96			
Disease differentials								
Triticum aestivum	4000							
Triticum spp.	1985							
Durum wheat 1AS.1AL-1DL translocation lines carrying *Glu-D1d*							4	
Hexaploid triticale D-genome disomic substitution lines.							10	
Hexaploid triticale carrying Glu-B3 from Edmore and Kharkof-5 and Glu-D1d from Len.							6	
Multiploid Mutant							1	
Male sterile mutants in hexaploid wheat							5	
Blue Aleurone Langdon							1	
Monogenic lines for stem rust resistance in hexaploid and tetraploid wheat							97	
Mutants of an inhibitor of stem rust resistance.							15	
Rusty Durum							1	

APPENDIX VIIa: Internet and local surveys of selected wheat collections containing wild *Triticum* accessions

Species*	ICARDA	CIMMYT	USDA GRIN	WG-GRC	JPN KOMUGI	ECPGR WHEAT	DEU IPK	GBR JIC	TOTAL **	WWW CATALOG ***
Triticum abyssinicum					171	797			968	
Triticum aestivum subsp. compactum		27	80	4	91	1,212		17	1,414	
Triticum aestivum subsp. macha		1	32	2	72	183	38	7	290	
Triticum aestivum subsp. spelta		209	1,296	3	227	3,742	231	37	5,477	
Triticum aestivum subsp. sphaerococcum		32	32	1	54	301	81	12	420	
Triticum ispahanicum			7		4	30	9	2	41	
Triticum monococcum	450	102	235	44	78	1,893	198	71	2,802	
Triticum monococcum subsp. aegilopoides		477	993	548	256	1,500		105	3,774	1,660
Triticum sp.					262	123		3	385	
Triticum timonovum						57			57	
Triticum timopheevii	93	2	7		22		17	4	124	
Triticum timopheevii subsp. armeniacum		7	267	303	388	156		2	1,121	657
Triticum timopheevii subsp. timopheevii		10	42	9		196			257	
Triticum turgidum subsp. carthlicum		93	97	101	25	311	86	8	627	
Triticum turgidum subsp. dicoccoides		854	917	394	102	1,243	141	40	3,510	1,907
Triticum turgidum subsp. dicoccon		1,416	620	53	159	1,773	572	45	4,021	
Triticum turgidum subsp. paleocolchicum			4	2	11			2	17	
Triticum turgidum subsp. polonicum		52	81	11	25	316	102	2	485	
Triticum turgidum subsp. turanicum		2	110	8		83	39	1	203	
Triticum turgidum subsp. Turgidum			458	23		1,172		68	1,653	
Triticum urartu	558	213	210	188	18	258	58	48	1,445	537
Triticum vavilovii	3	1	3		15	46	14	1	68	
Triticum zhukovskyi	3		7	1	3	30	6	1	44	
TOTAL	**1,107**	**3,498**	**5,498**	**1,695**	**1,983**	**15,422**	**1,592**	**476**	**29,203**	**4,761**

* Based on the taxonomic nomenclature reported by the respective databases.
** Total of ICARDA, CIMMYT, USDA/GRIN, WGGRC, KOMUGI, and ECPGR Wheat collections.
*** Konopka & Valkoun, 2005.

Sources:
ICARDA: Konopka & Valkoun, 2005
CIMMYT: IWIS3, local database.
USDA GRIN: http://www.ars-grin.gov/npgs/acc/acc_queries.html
WGGRC: Jon Raupp, pers. comm.
JPN KOMUGI: http://www.shigen.nig.ac.jp/wheat/komugi/top/top.jsp
ECPGR WHEAT: http://www.ecpgr.cgiar.org/databases/crops/wheat.htm
DEU IPK: http://www.ipk-gatersleben.de/en/
GBR JIC: http://www.jic.bbsrc.ac.uk/corporate/Home/index.htm

Appendix VIIb: Internet and local surveys of selected wheat collections containing *Aegilops*, *Amblyopyrum* and rye accessions.

Species*	ICARDA	CIMMYT	USDA GRIN	WG-GRC	JPN KOMUGI	ECPGR WHEAT	DEU IPK	GBR JIC	TOTAL **	WWW CATALOG ***
Aegilops aucheri					121				121	
Aegilops beldreichi		1							1	
Aegilops bicornis	19	9	2	12	15	29		5	86	48
Aegilops biuncialis	379	85	246	37	514	561	3	4	1,822	1,296
Aegilops columnaris	121	8	26	12	53	80		2	300	214
Aegilops comosa	45	31	30	20	80	113	16	8	319	74
Aegilops comosa var. subventricosa		41	43	8					92	
Aegilops crassa	113	2	19	26	54	93	45	15	307	306
Aegilops cylindrica	473	56	151	43	188	1,137	98	10	2,048	1,293
Aegilops geniculata	411		183	142		438	216		1,174	693
Aegilops juvenalis	20	3	7	9	21	23	12	1	83	52
Aegilops kotschyi	66	3	18	19	89	59	10		254	206
Aegilops lorentii							98		0	
Aegilops longissima	25	7	46	9	7	69	40	16	163	86
Aegilops markgrafii		3	75	17	287	218	111	5	600	466
Aegilops neglecta	140	21	202	67	655	645	74	14	1,730	1,348
Aegilops peregrina	224		75	29	147	33	22	11	508	174
Aegilops peregrina var. peregrina		4	1	6				9	11	137
Aegilops searsii	56		58	21	13	25	21	5	173	71
Aegilops sharonensis	2	2	90	7	6	114	16	10	221	18
Aegilops speltoides	213	93	132	104	126	237	83	44	905	339
Aegilops speltoides var. ligustica		3	23	11					37	223
Aegilops speltoides var. speltoides				59					59	160
Aegilops spp.	45	32	2				170		79	
Aegilops tauschii	449	155	168	555		982	181	55	2,309	1,312
Aegilops triuncialis	778	229	514	186	869	1,691	272	70	4,267	3,100
Aegilops umbellulata	76	43	84	46	208	75	30	44	532	374
Aegilops uniaristata	6	2	7	21	15	19	5	2	70	30
Aegilops vavilovii	104			8		77			189	187
Aegilops ventricosa	46	4	10	16	9	107	49	4	192	149
Amblyopyrum muticum var. muticum	24	2	9	19	58		8	14	112	100
Secale cereale		236	1,775		76		1,832		2,087	
TOTAL	**3,835**	**1,075**	**3,996**	**1,509**	**3,611**	**6,825**	**3,412**	**348**	**20,851**	**12,456**

* Based on the taxonomic nomenclature reported by the respective databases.
** Total of ICARDA, CIMMYT, USDA/GRIN, WGGRC, KOMUGI, and ECPGR Wheat collections.
*** Konopka & Valkoun, 2005.

Sources:
ICARDA: Konopka & Valkoun, 2005
CIMMYT: IWIS3, local database.
USDA GRIN: http://www.ars-grin.gov/npgs/acc/acc_queries.html
WGGRC: Jon Raupp, pers. comm.
JPN KOMUGI: http://www.shigen.nig.ac.jp/wheat/komugi/top/top.jsp
ECPGR WHEAT: http://www.ecpgr.cgiar.org/databases/crops/wheat.htm
DEU IPK: http://www.ipk-gatersleben.de/en/
GBR JIC: http://www.jic.bbsrc.ac.uk/corporate/Home/index.htm

APPENDIX VIII: Global Conservation Strategy Workshop June 2006 - Programme

Global Conservation Strategy for Wheat, Rye and Triticale
Strategy Advisory Group Workshop, CIMMYT HQ, El Batan, Mexico, 20-22 June, 2006

Objective: To establish the key elements of a global strategy for the efficient and effective conservation of wheat, rye and triticale genetic resources.

Outcomes:
1. Identification, and assessment of key global, regional and national collections of wheat, rye and Triticale genetic resources against agreed international scientific and technical standards for conservation and management,
2. Identification of critical gaps in existing collections and identification of strategies to fill these gaps
3. Model for collaboration and sharing of responsibilities for the effective and efficient management of key collections and associated conservation services
4. Identification of information technology needs of an integrated global network of genetic resource collections of wheat, rye and Triticale and the steps required to meet these needs
5. Identification of urgent support for upgrading to international standards or capacity building and the nature of that support or upgrading to key existing collections

Time	Topic	Chair
	DAY1: Tuesday June 20, 2006	
9:00-10:30	**Opening Session** o Welcome and opening of the workshop (*Don Marshall*) – *10 minutes* o Brief introduction of the participants (*All*) – *5 minutes* o Approval of the Draft Program and logistics information (*All*) – *5 minutes* o Global Genetic Resource Conservation (*Masa Iwanaga, CIMMYT DG*) – *10 minutes* o International Treaty for Plant Genetic Resources for Food and Agriculture, 1st Governing Body Meeting (*Rodomiro Ortiz*) o Introduction of the Global Crop Diversity Trust and conservation strategies (*Brigitte Laliberté) – 30 minutes* o Discussion – *30 minutes*	Don Marshall
10:30-11:00	***Coffee Break***	
11:00-12:30	**Developing a Global Conservation Strategy for Wheat** o The key elements of a global conservation strategy for wheat (*Don Marshall*) – *30 minutes* o Summary of information from the regional conservation strategies *(Brigitte Laliberté) – 15 minutes* o Discussion - *45 minutes*	Don Marshall
12:30-14:00	***Lunch***	
14:00-15:30	**Developing a Global Conservation Strategy for Wheat, Rye and Triticale** o Results of genebank users survey (*Tom Payne*) – *15 minutes* o Results of collections status survey (*Tom Payne*) – *15 minutes* o Discussion on the outcomes of the surveys – *30 minutes* o Defining the foundation or reference collections of an integrated global wheat conservation network (*Don Marshall*) – *30 minutes*	Jan Valkoun
15:30-16:00	***Coffee Break***	
16:00-17:30	**Linking the collections in the global network-potential models** o The AEGIS project in Europe (*Geert Kleijer*) – *15 minutes* o The Japanese Komugi network (*Takashi Endo*) – *15 minutes* o VIR Wheat Collection (*Anatoly Merezhko*) – *15 minutes* o CAAS Wheat Collection (*Jia Jizeng*) – *15 minutes* o Discussion – *30 minutes*	Iva Faberova
18:45	Departure from CIMMYT	
19:00-21:00	Dinner at home of Dr Masa Iwanaga, CIMMYT DG	

DAY2: Wednesday June 21, 2006		
8:30-9:30	**Expanding the network of collections** o Identifying the partners in the conservation services (characterization/evaluation, regeneration/multiplication, documentation, distribution) (*Don Marshall*) – *20 minutes* o Identification of key collections not in the foundation or reference set of collections (*Don Marshall*) – *20 minutes* o Discussion – *20 minutes*	John Snape / Jia Jizeng
9:30-10:30	**Specialist Collections** o Wheat wild relatives and landraces (*Jan Valkoun*) – *20 minutes* o Genetic Stock Collections (*Bikram Gill*) – *20 minutes* o Discussion – *20 minutes*	John Snape / Jia Jizeng
10:30-11:00	***Coffee Break***	
11:00–12:30	**Gaps in existing collections** o Landraces (Discussion leader *Jan Valkoun*) – *15 minutes* o Wild relatives (Discussion leader *Bikram Gill*) – *15 minutes* o Genetic stocks (Discussion leader *John Snape*) – *15 minutes* o Other genetic resources (Discussion leader *Tom Payne) – 15 minutes* o Discussion- *30 minutes*	Bent Skovmand
12:30-14:00	***Lunch***	
14:00-15:30	**Gaps in existing collections – *continued*** o Steps needed to upgrade other key collections for inclusion in the global network (*All*) – *45 minutes* Collaboration towards a global rational system for wheat conservation o Constraints and opportunities for collaboration o Policy and legal aspects o Presentation on Global Public Good's project of the CGIAR o Discussion	Don Marshall
15:30-16:00	***Coffee Break***	
16:00-17:00	**Developing Strategies for Triticale and Rye** o Update on ECPGR Rye activities *(Geert Kleijer) - 20 minutes* o Issues in developing a global strategy for the conservation of Triticale genetic resources - *20 minutes* o Discussion - *20 minutes*	Anatoly Merezhko
17:00-17:30	**Svalbard Safety Vault Initiative** (*Bent Skovmand*) – *30 minutes*	
DAY 3: Thursday June 22, 2006		
8:30-10:30	**Developing Integrated Information Systems** o Existing International Databases (*Graham McLaren*) – *20 minutes* o The European experience-approaches and problems (*Iva Faberova*) – *20 minutes* o Discussion– *20 minutes* o The way forward (*All*) – *60 minutes*	Geert Kleijer
10:30- 11:00	***Coffee Break***	
11:00-12:30	**Identification of Priority Areas for Support from the Trust** o Landrace and variety collections (Discussion leader *Jan Valkoun*) o Wild relatives – *ex situ* (Discussion leader *Bikram Gill)* o Genetic Stocks (Discussion leader *John Snape)*	Takashi Endo
12:30-14:00	***Lunch***	
14:00- 15:30	**Managing the Global Wheat Network into the Future** o The need for an ongoing working group (*Don Marshall*) o Composition, responsibilities and mode of operation of working group	Don Marshall
15:30-16:00	***Coffee Break***	
16:00-17:30	**Concluding Session** o Conclusions from the meeting (*Don Marshall*) o The next steps (*All*) o Closing the Meeting *(Brigitte Laliberté*)	Don Marshall

APPENDIX IX: Global collections of wheat, rye and Triticale and related species germplasm

The collections are ranked into three groups in terms of importance for inclusion into integrated global network of collections. The three groups are: (i) Important collections whose inclusion in the network is essential to ensure full coverage of genetic diversity available in these crops (Group A) (ii) Significant collections whose inclusion in the network would be desirable (Group B) and (iii) Other collections, often smaller working collections (Group C).

Group A: Important collections of wheat, rye, triticale and related species, world wide, whose inclusion in a comprehensive global network is essential

Country	INSTCODE	Name of institute	Email	Triticum Acc.	ITPGRFA
Argentina	ARG0017	Banco Base Nacional de Germoplasma, Instituto de Recursos Biológicos, INTA, Castelar	nhompanera@cirn.inta.gov.ar	648	
Australia	AUS0003	Australian Winter Cereals Collection, Agricultural Research Centre, Tamworth	Michael.Mackay@dpi.nsw.gov.au	23917	Yes
Austria	AUT0001	Agrobiology Linz - Austrian Agency for Health and Foodsafety / Seed Collection, Linz	kainz@lwlnz.ages.at	876	Yes
Brazil	BRA0003	Recursos Geneticos e Biotecnologia (EMBRAPA/CENARGEN), Brasilia	cgoedert@cenargen.embrapa.br	5619	Yes
Brazil	BRA0015	Centro Nacional de Pesquisa de Trigo (CNPT), EMBRAPA, Passo Fundo	alfredo@cnpt.embrapa.br	13594	Yes
Bulgaria	BGR0001	Institute for Plant Genetic Resources "K.Malkov", Sadovo	s_stoyanova@gbg.bg	9747	Yes
Canada	CAN	Plant Gene Resources of Canada, Saskatoon	richardsk@agr.gc.ca	5052	Yes
China	CHN0001	Institute of Crop Germplasm Resources (CAAS), Beijing	hongjie@caas.net.cn	36797	
Czech Republic	CZE0122	Genebank Dept, Div. of Genet. & Plant Breeding, Res. Inst. of crop Production, Ruzyne	faberova@vurv.cz	11018	Yes
Egypt	EGY0002	Field Crops Institute Agricultural Research Centre (ARC), Giza	info@ngb.gov.eg	2867	Yes
Ethiopia	ETH0001	Biodiversity Conservation and Research Institute, Addis Ababa	biod-et@telecom.net.et	10745	Yes
France	FRA0010	Station d'Amelioration des Plantes INRA, Clermont-Ferrand	annick.leblanc@geves.fr	3531	Yes
France	FRA0040	INRA Station d'amelioration des Plantes	annick.leblanc@geves.fr	10765	Yes
Georgia	GEOi004	Scientific Research Institute of Farming, Tblisi	tamrikoj@yahoo.com	138	
Germany	DEU0146	Genebank, Inst. for Plant Genetics and Crop Plant Research (IPK), Gatersleben	boerner@ipk-gatersleben.de	9633	Yes
Hungary	HUN0003	Institute for Agrobotany	lhorvath@agrobot.rcat.hu	7531	Yes
India	IND0001	National Bureau of Plant Genetic Resources (NBPGR), New Delhi	directornbpgr@yahoo.co.in	32880	Yes
Iran	IRN	Seed and Plant Improvement Institute, Karaj	spii.int@abdnet.com		Yes
Israel	ISR0004	Institute of Evolution Haifa University, Haifa	nevo@research.haifa.ac.il	1000	
Japan	JPN0001	Plant Germplasm Institute, Graduate School of Agriculture, Kyoto University	kawatai@mbox.kudpc.kyoto-u.ac.jp	4378	
Japan	JPN0003	Genetic Resources Management Section, NIAR (MAFF), Tsukuba	okusan@affrc.go.jp	7179	

Country	INSTCODE	Name of institute	Email	Triticum Acc.	ITPGRFA
Mexico	MEX0002	Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT), Texcoco	t.payne@cgiar.org	73559	
Netherlands	NLD0037	Centre for Genetic Resources (CGN), Wageningen	noortje.bas@wur.nl	5529	Yes
Pakistan	PAK0002	Institute of Agricultural Biotechnology and Genetic Resources, Islamabad	ghafoor59pk@yahoo.com	1962	Yes
Poland	POL0003	Plant Breeding and Acclimatization Institute (IHAR)	z.bulinska@ihar.edu.pl	12974	Yes
Portugal	PRT0005	Banco de Germoplasma- Genetica, Estacao Agronomica Nacional	bmacas@oninet.pt	831	Yes
Portugal	PRT0105	Dept. de Genetica e Biotecnologia Univ. Tras-os-Montes e Alto Douro	hgp@utad.pt	1466	Yes
Romania	ROM0007	Suceava Genebank, Suceava	genebank@suceava.astral.ro	1543	Yes
Russia	RUS0001	N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St. Petersburg	a.mitrofanova@vir.nw.ru	39880	
Serbia	YUG0002	Institute Of Field and Vegetable Crops, Novi Sad	dencic@ifvcns.ns.ac.yu	2431	
South Africa	ZAF0049	Small Grain Institute, Bethlehem	LeRouxC@arc.agric.za	2527	
Spain	ESP0004	Centro de Recursos Fitogeneticos, INIA, Madrid	cuadra@inia.es	3183	Yes
Sweden	SWE0001	Dept. of Plant Breeding Research, Swedish Univ. of Agricultural Sciences	Urban.Emanuelsson@cbm.slu.se	350	Yes
Sweden	SWE0002	Nordic Gene Bank, Alnarp	http://www.ngb.se	1843	Yes
Switzerland	CHE0001	Station Federale de Recherches en Production Vegetale de Changins, Nyon	geert.kleijer@rac.admin.ch	6996	Yes
Syria	SYR0002	Int. Centre for Agricultural Research in Dry Areas (ICARDA), Aleppo	a.amri@cgiar.org	31572	Yes
Turkey	TUR0001	Plant Genetic Resources Dept. Aegean Agricultural Research Inst., Izmir	aari@egenet.com.tr	6381	Yes
Ukraine	UKR0169	Institute of Plant Production n.a. V.J. Yurjev of UAAS	ncpgru@kharkov.ukrtel.net	9597	
United Kingdom	GBR0011	John Innes Centre, Crop Genetics Dept., Norwich	mike.ambrose@bbsrc.ac.uk	9584	Yes
USA	USA	Wheat Genetic Resources Center, Kansas State University, Manhattan	bsg@ksu.edu		
USA	USA	USDA-ARS, University of Missouri, Columbia	gustafsonp@missouri.edu		
USA	USA0029	USDA-ARS, National Small Grains Germplasm Research Facility, Aberdeen, ID	hbockelman@ars-grin.gov	56218	
USA	USA0109	Department of Botany and Plant Sciences, Univ. of California, Riverside	adam.lukaszewski@ucr.edu	2787	

Sources: Bioversity, 2006; FAO, 2007

Group B: Significant collections of wheat, rye, triticale and related species, world wide, whose inclusion in a comprehensive global network would be desirable

Country	INSTCODE	Name of institute	Triticum Acc.	ITPGRFA
Albania	ALB0001	Plant Breeding/Seed Production Section, Dep. of Agronomy, Agricultural Univ.	2015	
Albania	ALB0002	Agriculture Research Institute	8000	
Argentina	ARG0003	Estacion Experimental Agropecuaria Marcos Juarez – INTA	1289	
Argentina	ARG0014	Estacion Experimental Agropecuaria Bordenave, INTA	974	
Armenia	ARM	Armenian Academy of Agricultural Sciences	3000	Yes
Azerbaijan	AZE	Azerbaijan Academy of Agricultural Sciences	1163	
Belarus	BLR	Belarus Academy of Agricultural Sciences		
Canada	CAN0015	Cereal Research Centre, Agriculture and Agri-Food Canada	5052	Yes
Canada	CAN0045	Soil and Crops Research and Development Centre, Agriculture and Agri-Food Canada	3700	Yes
Chile	CHL0002	Instituto de Investigaciones Agropecuarias,C.R.I. La Platina	8000	
Chile	CHL0004	Inst de Inv. Agropecuarias, Centro Regional de Investigación Carillanca	5285	
Chile	CHL0008	Centro Regional de Investigación Quilamapu, INIA	9333	
Colombia	COL0017	Corporacion Colombiana de Investigacion Agropecuaria (CORPOICA)	800	
Cyprus	CYP0004	National (CYPARI) Genebank, Agricultural Research Institute,	7696	Yes
France	FRA0051	Collection Nationale Céréales à Paille, Unite experimentale du Magneraud GEVES	1986	Yes
Germany	DEU0227	Rye & Triticale Collection, Inst. Plant Gen. & Crop Plant Res. (IPK)	1269	Yes
Greece	GRC0001	Cereal Institute, National Agricultural Research Foundation	1917	Yes
Greece	GRC0005	Greek Genebank, Agric. Res. Center of Makedonia and Thraki, NAGREF	309	Yes
Hungary	HUN0020	Martonvasar Institute Hungarian Academy of Sciences	2337	Yes
India	IND0202	Department of Genetics Punjab Agricultural University	2578	Yes
Israel	ISR0002	Agricultural Research Organisation, The Volcani center	4327	
Israel	ISR0003	Lieberman Germplasm Bank, Inst. Cereal Crop Dev., Tel-Aviv Univ.	5500	
Israel	ISR0005	Dept. of Plant Sciences, The Weizmann Institute of Science	600	
Italy	ITA	Istituto Sperimentale Cerealicoltura, Lodigiano		Yes
Italy	ITA0004	CNR - Istituto di Genetica Vegetale	32751	Yes
Kazakhstan	KAZ	Kazakhstan Academy of Agricultural Sciences	23472	
Kyrgyzstan	KGZ	Kyrgyzstan Academy of Agricultural Sciences	60	
Latvia	LVA0018	Latvian Agriculture Academy	60	Yes
Morocco	MAR	Moroccan Ministry of Agriculture		Yes
New Zealand	NZL0027	New Zealand Institute for Crop and Food Research Ltd.	2000	
Poland	POL0001	Botanical Garden of the Polish Academy of Sciences	1509	Yes
South Korea	KOR0003	National Institute of Crop Science		
Tajikistan	TJK	Tajikistan Academy of Agricultural Sciences	1115	
Turkmenistan	TKM	Turkmenistan Academy of Agricultural Sciences	1233	
Uruguay	URY0003	Estacion Experimental Alberto Boerger, La Estanzuela, Banco Base de INIA	1168	Yes
USA	USAi105	Wheat Genetic Stock Collection, USDA-ARS National Small Grains Research Facility	334	
Uzbekistan	UZB	Uzbekistan Academy of Agricultural Sciences	9342	

Sources: Bioversity, 2006; FAO, 2007

Group C: Other collections of wheat, rye, triticale and related species, world wide

Country	INSTCODE	Name of institute	Triticum Acc.	ITPGRFA
Afghanistan	AFG0001	Plant Genetic Resources Unit Crop Improvement Div., Min. of Agric.	1726	Yes
Algeria	DZA0003	Institut Technique des Grandes Cultures (ITGC)		Yes
Argentina	ARG0037	Estacion Experimental Agropecuaria Santa Cruz, INTA	3	
Australia	AUS0201	Australian Medicago Genetic Resources Centre, SARDI	15	Yes
Austria	AUT0002	Kaerntner Saatbaugenossenschaft/Carinthian Agricultural Company	322	Yes
Austria	AUT0005	Genebank Tyrol / Tyrolean Government	222	Yes
Austria	AUT0006	Forschungsintegration, Bundesamt & Forschungszentrum fuer Land	618	Yes
Austria	AUT0034	Austrian Agency of Health and Foodsafety / Lwvie - Institute of Agroecology	805	Yes
Bangladesh	BGD0009	Genetic Resources Centre Bangladesh Agric. Research Inst.	135	Yes
Belgium	BEL0001	Centre de Recherche Agronomique de l'Etat, Station d'Amélioration des Plantes	828	
Belgium	BEL0012	Center for Applied Biology	981	
Belgium	BEL0030	N.V. Clovis Matton Plant Breeding Station		
Belgium	BEL0097	Conservatoire Botanique de Ressources Genetiques de Wallonie	15	
Bhutan	BTN0025	Centre for Agricultural Research and Development		Yes
Bolivia	BOL0003	Centro de Investigaciones Fitoecogenéticas de Pairumani	112	
Bolivia	BOL0004	Centro de Investigaciones en Forrajes	15	
Brazil	BRA0006	Instituto Agronômico de Campinas (I.A.C.)	2800	Yes
Canada	CAN0005	Universite Laval	1500	Yes
Canada	CAN0011	Charlottetown Research Station Agriculture Canada	925	Yes
Canada	CAN0014	Swift Current Research Station Agriculture Canada, Swift Current Research Station		Yes
Canada	CAN0041	Lethbridge Research Centre Agriculture Canada,	1900	Yes
Canada	CAN0122	Seeds of Diversity Canada	4	Yes
Chile	CHL0003	Facultad de Ciencias Agrarias, Universidad Austral de Chile	9	
Chile	CHL0028	Instituto de Inv. Agropec. Centro Reg. Inv. Intihuasi Banco Base	25	
China	CHN0094	Institute of Crop Research, Sichuan Academy of Agricultural Sciences	2635	
Colombia	COL0002	Instituto Colombiano Agropecuario - ICA	150	
Colombia	COL0003	Centro Internacional de Agricultura Tropical (CIAT)	1	
Colombia	COL0019	CORPOICA, C.I. Obonuco, Regional 5	700	
Colombia	COL0029	CORPOICA, C.I. La Selva	536	
Costa Rica	CRI0007	Escuela de Ciencias Agrarias, Universidad Nacional	1	Yes
Cuba	CUB0005	Instituto Nacional de Ciencias Agricolas (INCA)	52	Yes
Czech Republic	CZE0047	Agricultural Research Institute Kromeriz, Co. Ltd.	679	Yes
Denmark	DNK0002	Institute of Botany, Royal Veterinary & Agric. University	500	Yes
Ecuador	ECU0001	Estacion Experimental Santa Catalina, DENAREF, INIAP	144	Yes
Estonia	EST0001	Jõgeva Plant Breeding Institute	249	Yes
Ethiopia	ETH0013	International Livestock Research Institute (ILRI)	462	Yes
Finland	FIN0020	Boreal Plant Breeding Institute	512	Yes
France	FRA0036	ORSEM S.A.	1500	Yes
France	FRA0041	Stat. de Genetique et Amelioration des Plantes, INRA C.R. Montpellier	2000	Yes
France	FRA0043	Station de Génétique et d'Amélioration des Plantes, INRA	1300	Yes
France	FRA0050	Groupement Agricole Essonnois	258	Yes
France	FRA0065	Station de Génétique/Amélioration des Plantes, INRA	2500	Yes
France	FRA0081	SCA Adrien Momont et fils, S.A.		Yes
France	FRA0094	Station de Génétique Végétale, INRA	650	Yes
France	FRA0242	Reseau Cereales a paille	1967	Yes
Georgia	GEOi003	Protection Society of Agrobiodiversity, DIKA	151	
Germany	DEU0004	State Plant Breeding Institute, University of Hohenheim	910	Yes
Germany	DEU0013	Institute of Plant Breeding, University of Hohenheim	300	Yes
Germany	DEU0063	Max-Planck-Institut für Züchtungsforschung	1330	Yes
Germany	DEU0085	Institute for Resistance Genetics der BAZ	1061	Yes

Country	INSTCODE	Name of institute	Triticum Acc.	ITPGRFA
Germany	DEU0089	Saatzuchtwirtschaft Walter Engelen		Yes
Germany	DEU0168	Institute for Epidemiology of the BAZ		Yes
Germany	DEU0189	Saatzucht Steinach GmbH Station Bornhof		Yes
Germany	DEU0380	Dept. of Taxonomy, Inst. for Plant Genetic & Crop Plant Research		Yes
Germany	DEU0442	Institute for Breeding of Crop Plants of the BAZ		Yes
Guatamala	GTM0001	Instituto de Ciencia y Technología Agrícola (ICTA)	15	Yes
Honduras	HND0907	Estación Experimental Santa Catarina, DICTA	5	Yes
Hungary	HUN0013	Univ. of Agricultural Sciences Department of Crop Production	1000	Yes
Hungary	HUN0016	Fleischmann Rudolph Agricultural Research Inst, Uni. of Agricultural Sciences	4	Yes
Hungary	HUN0017	Faculty of Agricultural Sciences Pannon University of Agriculture	25	Yes
Hungary	HUN0018	Research Centre of Debrecen Agricultural University	10	Yes
Hungary	HUN0019	Cereal Research Institute	500	Yes
Hungary	HUN0052	Department of Agronomy, Pannon University of Agriculture	1	Yes
India	IND	ICRISAT		Yes
India	IND0069	All Indian Coordinated Wheat Programme, IARI	17000	Yes
Iraq	IRQ0001	Plant Genet. Resources Unit,, State Board of Seeds Testing	310	
Ireland	IRL0009	Department of Plant Science, National University of Ireland	20	Yes
Ireland	IRL0011	Faculty of Agriculture University College	50	Yes
Italy	ITA0015	Istituto di Miglioramento Genetico Vegetale, Universita' di Perugia	7	Yes
Italy	ITA0021	Institute of Agronomy and Field Crops	30	Yes
Italy	ITA0034	Inst. of Plant Breeding and Agric. Research Nazareno Strampelli	623	Yes
Italy	ITA0042	Istituto de Agronomia, Facolta di Scienze Agrarie, Univ. di Pisa	45	Yes
Italy	ITA0044	CR Casaccia INN-Bioag-Prove	1100	Yes
Kenya	KEN0015	National Genebank of Kenya, Crop Plant Genetic Resources Centre, KARI	266	Yes
Latvia	LVA0006	Priekuli State Plant Breeding Station	85	Yes
Latvia	LVA0019	Stende State Plant Breeding Station	620	Yes
Libya	LBY0001	Agricultural Research Centre (ARC)	1850	Yes
Lithuania	LTU0001	Lithuanian Institute of Agriculture	42	Yes
Madagascar	MDG0002	Department de Recherches Agronom. de la Republique Malgache	450	Yes
Mexico	MEX0006	Banco Nacional de Germoplasma Veget, Dep. de Fitotecnia, Univ. Aut. de Chapingo	34	
Mexico	MEX0008	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP)	134	
Mexico	MEX0022	Programa de Recursos Genéticos, Centro de Invest. Forestales y Agropecuarias	134	
Morocco	MAR0016	Centre de Production des Semences Pastorals	1	Yes
Nepal	NPL0055	Central Plant Breeding and Biotec. Nepal Agricultural Research Council	381	
Netherlands	NLD0011	Zelder B.V.	25	Yes
Netherlands	NLD0027	Plant Breeding Station Cebeco-Zaden B.V.	1002	Yes
New Zealand	NZL0004	Crop Research Division, Canterbury Agric. and Science Centre, DSIR		
Nigeria	NGA0010	National Centre for Genetic Resources and Biotechnology, FMST	886	
Norway	NOR0010	Vaagones Agricultural Research Station	2	Yes
Norway	NOR0038	Safety Base Collection of NGB	1280	Yes
Paraguay	PRY0008	Centro Regional de Investigacion Agricola (CRIA)	206	Yes
Peru	PER0002	Universidad Nacional Agraria La Molina	7000	Yes
Peru	PER0014	Estación Experimental Illpa-Puno, INIEA	680	Yes
Peru	PER0041	Estacion Experimental Canaan-Ayacucho, INIEA	44	Yes
Peru	PER0070	Facultad de Agronomia, Universidad Nacional del Centro del Perú	93	Yes
Poland	POL0024	Plant Breeding Station Mikulice	12	Yes
Poland	POL0025	Institute of Genetics and Plant Breeding, University of Agriculture	3406	Yes
Poland	POL0032	Dept. of Plant Genetics, Breeding and Biotechnology, Warsaw Agric. Univ.		Yes

Country	INSTCODE	Name of institute	Triticum Acc.	ITPGRFA
Portugal	PRT0001	Banco Português de Germoplasma Vegetal (BPGV)	845	Yes
Portugal	PRT0072	Direccao Regional de Agricultura de Tras-os-Montes	8	Yes
Portugal	PRT0076	Departamento de Cereais Est. Nacional Melhoramento Plantas	1300	Yes
Portugal	PRTi006	Banco de germoplasma, Universidade da Madeira	176	Yes
Romania	ROM0001	University of Agricultural Sciences Cluj	825	Yes
Romania	ROM0002	Research Institute for Cereals and Technical Plants Fundulea	726	Yes
Romania	ROM0008	Agricultural Research Station Simnic-Dolj	488	Yes
Romania	ROM0012	Institutul National de Informare si Documentare	315	Yes
Romania	ROMi009	University of Agricultural Sciences and Veterinary Medicine Timisoara	41	Yes
Romania	ROMi011	Agricultural Research Station Podu Iloaiei-Iasi	243	Yes
Romania	ROMi012	Agricultural Research Station Suceava	786	Yes
Romania	ROMi014	Agricultural Research Station Turda-Cluj	684	Yes
Rwanda	RWA0002	Institut des Sciences Agronomiques du Rwanda (ISAR)	100	
Serbia	YUG0001	Maize Research Institute Zemun Polje	536	
Slovakia	SVK0001	Research Institute of Plant Production Piestany	3638	
Slovakia	SVK0035	Botanical Garden of the University of Agriculture in Nitra	34	
South Africa	ZAF0001	Division of Plant and Seed Control, Department of Agriculture Technical Service	846	
South Africa	ZAF0058	Grassland Research Centre, Department of Agricultural Development	1	
Spain	ESP0007	Estacion Experimental Aula Dei CSIC	160	Yes
Spain	ESP0013	Centro UdL, Institut de Recerca i Tecnologia Agroalimentaries (IRTA)	1971	Yes
Spain	ESP0028	Compania Espanola de Cultivos Oleaginosos, S.A. (CECOSA)	352	Yes
Spain	ESP0032	Principado de Asturias. Servicio Reg. de Investig. y Desarrollo Agroalimentario	31	Yes
Sweden	SWE0015	Department of Plant Breeding Research, Uppsala Genetic Center	400	Yes
Switzerland	CHE0002	Swiss Federal Research Station for Agronomy (FAP)		Yes
Switzerland	CHE0091	Pro Specie Rara	26	Yes
Switzerland	CHE0097	Schweizer Bergheimat	122	Yes
Switzerland	CHE0100	Safeguard for Agricultural Varieties in Europe	16	Yes
Syria	SYR0003	General Commission for Scientific Agricultural Research	1516	Yes
Tunisia	TUN0003	Laboratoire de Genetique et Amelioration des Plants (INAT)	149	Yes
Uganda	UGA0010	Buginyanya Agricultural Research Institute	419	Yes
Ukraine	UKR0003	Mironovskyi Institute for Wheat Breeding and Seed Production	2285	
Ukraine	UKR0008	Ustimovskaya Experimental Station for Plant Cultivation	3221	
Ukraine	UKR0043	Institute of Plant Physiology and Genetics		
Ukraine	UKR0044	Institute of Agroecology and Biotechnology	20000	
Ukraine	UKR0170	Plant Breeding and Genetics Inst.	9620	
Ukraine	UKR0172	Inst. for Irrigated Agriculture	227	
United Kingdom	GBR0004	Seed Bank, Seed Conservation Sect. Royal Botanic Gardens, Kew	4	Yes
United Kingdom	GBR0015	Scottish Agricultural Science Agency, Cereal Cultivar Ref.Coll.	840	Yes
United Kingdom	GBR0016	Welsh Plant Breeding Station, Institute of Grassland and Environmental Research	14	Yes
United Kingdom	GBR0040	National Institute of Agricultural Botany	250	Yes
United Kingdom	GBR0052	Zeneca Seeds UK Limited Plant Breeding and Research Centre		Yes
USA	USA	University of California Davis		
USA	USA0005	National Seed Storage Laboratory USDA, ARS	838	
USA	USA0022	Western Regional Plant Introduction Station, USDA-ARS, Washington State Univ.	9	
Vietnam	VNM0002	National Genebank Vietnam Agricul. Sciences Inst.	456	
Vietnam	VNM0024	Centre for Introduced Crops Viet-Nam Inst. Agric. Sci. & Tech.	400	
Yemen	YEM0016	El-Kod Agricultural Research Centre, Dr. Res. & Extension	10	Yes
Zambia	ZMB0001	Mount Makulu Agric. Research Station	12	Yes

Sources: Bioversity, 2006; FAO, 2007

Appendix X: Acronyms and Abbreviations

BIG	Bundesinformationssystem Genetische Ressourcen, developed by four agencies in Germany
Bioversity	Bioversity International – previously the International Plant Genetic Resources Institute
CATCN-PGR	Central Asia and Trans-Caucasus Plant Genetic Resources Network
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Centre
CWANA	Central and West Asia and North Africa
EA-PGR	East Asia Plant Genetic Resources Network
ECPGR	European Cooperative Programme for Plant Genetic Resources
ETDB	European Triticale Database of ECPGR
EUCARPIA	European Association for Plant Breeding Research
EURISCO	European Internet Search Catalogue for Plant Genetic Resources
EWDB	European Wheat Database of ECPGR
FAO	Food and Agriculture Organization of the United Nations
GCP	Generation Challenge Programme of the CGIAR
GRIN	Genetic resources Information network of the National Genetic Resources Program, USA
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIS	International Crop Information System
IPGRI	International Plant Genetic Resources Institute, now Bioversity International
ITPGRFA	International Treaty for Plant Genetic Resources for Food and Agriculture
NARS	National Agricultural Research System
NORGEN	North America Plant Genetic Resources Network Plant Genetic Resources
PGRFA	Plant Genetic Resources for Food and Agriculture
PROCISUR	Programa Cooperativo para el Desarrollo Tecnológico Agropecuario del Cono Sur
SANPGR	South Asian Network on Plant Genetic Resources
SINGER	CGIAR System-wide Information Network for Genetic Resources
SMTA	Standard Material Transfer Agreement
TRUST	Global Crop Diversity Trust
UNDP	United Nations Development Programme
USDA-ARS	United Stated Department of Agriculture – Agricultural Research Service
WANANET	West Asia and North Africa PGR Network