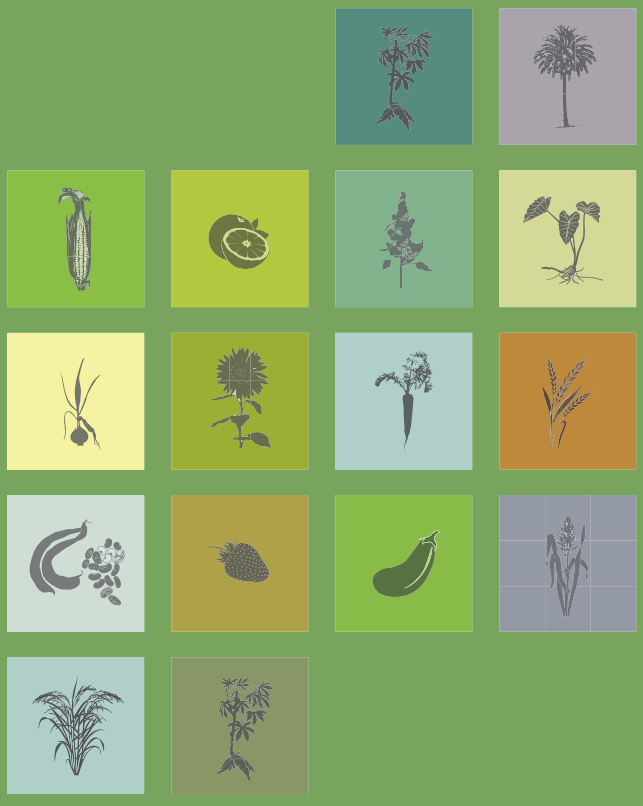
COUNTRY REPORT ON THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

ICELAND



STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE IN ICELAND

SECOND ICELANDIC REPORT ON CONSERVATION AND SUSTAINABLE UTILISATION OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Note by FAO

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BRIEF INTRODUCTION TO THE AGRICULTURAL SECTOR IN ICELAND

1. Natural conditions

Iceland is an island located in the North Atlantic Ocean between Greenland and Norway. The country borders the Arctic Circle and covers an area of 103 000 square kilometres. The coast is very indented, except for the south, with a total length of roughly 6 000 kilometres. The country is mountainous with only about fourth of the area below 200 metres. The climate is oceanic with relatively mild winters and wet and cool summers. The soils are characterized by their volcanic basaltic origin and mostly loessial and organic and fall into the category andosols.

Iceland was settled in the ninth and tenth century, mostly from the Scandinavian countries with some Celtic element, and the population is now around 310 000. Throughout the history of the country subsistence agriculture was the main industry, but during this century fishing has increased in importance and now forms the backbone of the economy beside tourism and metal smelters.

Iceland	Km^2
Total area	**103 000**
Vegetated, total	46 000
Wetlands	8 700
Grasslands	27 000
Cultivated land	1 300
Glaciers	11 000
Lakes	1 700
Natural woodlands	1 200

2. Agriculture in Iceland

Agriculture in Iceland is mostly based on livestock production with sheep and dairy industry dominating the production. Recently horse breeding has increased in importance. The farming is based primarily on grass cultivation and grazing on the open range which constitutes most of the country, except for lakes and glaciers. In recent years the cultivation of barley for feed has grown in importance. The grazing has had a profound effect upon appearance of the countryside and tolerance to environmental fluctuations. It is estimated that around one fourth of the country was covered with some form of forest or shrub vegetation at the time of settlement in the ninth century, but only 1.2 % of the country is covered with woodland today. Soil erosion and loss of vegetation is the single most serious environmental concern facing the farming community. However, reduction in sheep numbers over the last 25 years and more favourable climatic conditions have led to significant improvements in the rangeland vegetation.

Productivity in Icelandic agriculture increased considerably during the decades following the Second World War, resulting in overproduction of most commodities in the seventh decade and onwards. This development was made possible by the availability of commercial fertilizers and by bringing new land into cultivation. In most districts this was to a high degree based on drained boggy areas, and the drainage exceeded the needs for cultivation. The natural rangeland did not sustain the increased production following the easy procurement of winter fodder. Sustainable use of the natural rangelands and the introduction of quota system in both the dairy and sheep industry have been developed.

Simultaneously, a popular movement for land reclamation and afforestation has arisen. Research and plant breeding have been focused to a considerable degree towards this task supported by seed production. Large efforts have been put into the introduction and adaptation breeding of both ligneous and herbaceous species. Especially, the plant introduction work has been considerably successful, with many new species coming into cultivation. Recently, the value

of plant introduction has become increasingly debated on environmental and ethical grounds.

The state gives financial support to farmers, and other landowners, to plant woody species in their land. This can be trees for timber production, shelterbelts and recreation. These plantings are planned and regulated by governmental bodies, taking care of valuable habitats for plants or animals as well as cultural remnants.

Icelandic agriculture has relied heavily upon plant introductions for agricultural production as well as land reclamation and afforestation. The introductions have been most extensive for forest and amenity purposes. Many of the introduced plants have the potential to become or have already become permanent members of the Icelandic Flora. The great majority of introductions, however, have not become established. The introductions have mostly come through contacts with plant breeders and research institutes. Several expeditions have collected forest trees, amenity species and agricultural plants in areas at similar latitudes with comparable climate to that of Iceland.

3. Animal production

Production of milk and lamb meat is regulated by quotas. Number of farms with quota is 2 100, of which 64% depends mostly on lamb meat production, 29% on dairy production and 7% are mixed. Product quotas are based on the domestic market and import of quota-regulated products is negligible. The number of farms producing chicken/egg or pork is low and is almost entirely based on imported feeds. Most dairy and sheep farms keep horses, mostly for leisure, but also for selling life animals off the farm, and in recent years it is more and more common that farms, that neither produce milk or meat, keep horses. Most farms are owned by the farmer and run as a family enterprise.

The number of all types of farms has declined in recent years, but simultaneously the size has increased so total production has been fairly constant. Pig and poultry production is concentrated near urban areas, but dairy farms are more scattered, but most prominent though in 3-4 areas. Sheep production is strongest in the least populated regions, and is thus very important for regional development.

Dairy cows are kept indoors for 8-9 months and graze mostly on cultivated (i.e. fertilized) land during the summer months. Sheep do partly graze on cultivated land in spring and autumn, but during summer on common pastures, mainly in the highland. This is partly regulated, especially the onset of grazing in spring..

Horses graze mostly in the lowland from spring to autumn but also partly during the winter months. As number of horses in certain areas has grown considerably in recent years an indication of overgrazing is often seen in the lowlands As a result of reduced number of sheep, shortening of the grazing period as well as favourable growing conditions in recent years, vegetation in the highland areas is generally improving.

4. Horticulture

Vegetables are grown for domestic consumption on around 120 ha. With the exception of swedes (*Brassica napus* var. *naprobrassica*) all seed is imported and of foreign origin. Potato fields are approx. 750 ha covering around 60% of domestic use. Greenhouses, heated by geothermal energy, cover about 18 ha. About 25% is used for tomatoes, 20% for cucumber, 20% for sweet pepper and the rest for other edible products and ornamental plants.

CHAPTER 1

THE STATE OF DIVERSITY

The position of Iceland as an island in the North-Atlantic Ocean, rather far from any continent and other islands, has been a substantial hindrance for the natural colonization of many plant species after the last ice age and the number of species in the Flora is lower than would be expected on the grounds of the growing conditions alone. A number of species, perhaps up to half of the indigenous Flora of some 450 species, may have survived the last ice age *in situ*. Other species have immigrated naturally, and it is expected that around 130 have been brought by man, either intentionally or as weeds. The early introductions have included forages, medicinal plants, vegetables and spices. The introductions have been most prevalent during the first centuries of inhabitation and again in modern times. They have also included new forms of naturally introduced species. A number of the most recent successful introductions have not yet been included in the Flora as counted above.

Non vascular plants have been of considerable importance in the past and are of potential interest for the future. Of greatest importance is the lichen Iceland moss (*Cetraria islandica*) which has been used as food and for medicinal purposes, but several other lichens and sea weeds are also of interest.

Plant genetic resources in Iceland are on the whole not considered to be in much danger from genetic erosion or even extinction through activities of man, except species that have always been rare in the country. Preservation of land races and bred grass varieties is taken good care of within the work programme of the Nordic Gene Bank (NordGen). The numerous successful plant introductions of plant varieties and species indicate the need and value for Iceland of free and unhindered access to plant genetic resources in other regions. This applies both to new species of potential value as well as new genetic material of already acquired species for use in breeding programmes for increased adaptation as well as superior characteristics.

Special care has to be taken, though, in the introduction work to avoid species with undesirable characteristics. Also, there is the danger that vigorously competitive species may threaten habitats and plant associations that are considered to be of specific conservation value.

1.1 Cultivation and diversity of major agricultural crops

There is no central register on agriculture land, but it is assumed that hayfields (partially grazed) are 110 000-120 000 ha of which ca 25% have been reseeded in the last five years. It may be assumed, based on seed import, that yearly reseeding of hayfields is approx. 6 000 ha, annual fodder plants are grown on 7 700 ha and barley for grain on 5 000 ha.

1.2 State of diversity of forage crops

The plant composition of Icelandic hayfields was investigated 1990-1993. At that time about 50% of all hayfields were >20 years old and the mean cover was as follows:

Poa pratensis	28
Deschampsia caespitosa	15
Phleum pratense	13
Agrostis spp.	13
Festuca rubra	11
Poa annua	8
Alopecurus pratensis	4
Dicotyledons	5
Other species	3

Similar investigation has not been conducted since then. But one may assume that the situation has not changed on sheep farms, but the majority of dairy farms is now growing barley for grain and they regenerate their hayfields on a regular basis. The old hayfields may, however, be valuable as a gene pool.

Timothy (*Phleum pratense*) was introduced during the past century and is the most widely sown grass species for hayfield establishment. However, it often gives way in competition with other species, both sown cultivars and also naturally invading indigenous grass species. Hence, haymaking, especially on sheep farms, relies heavily on indigenous grasses.

Those old hayfields are also commonly used for grazing besides being cut for hay, in contrast to fields dominated by *Phleum pratense* which are mostly used for hay only.

This has prompted the interest for selection and breeding in these species. Earlier (up to ca. 1940-50), extensive natural meadows were also used for haymaking. Of particular importance were low lying seasonally inundated meadows with *Carex* species, especially *C. lyngbeyi* as the dominating vegetation. They are still of interest as reserves if the grass on cultivated fields fails e.g. due to winter damage.

1.3Cultivation and diversity of horticultural crops

With the exception of swedes (B*rassica. napus* var. *naprobrassica*) all seed of horticultural crops is imported and of foreign origin

1.4 Use of ornamental plants

Variety of ornamental species is considerable if all of those that have been planted in both official and especially private gardens are counted. Approximately 1 600 species and varieties of annuals, perennials, trees and shrubs are listed on commercial stock lists. Majority of perennials and trees and shrubs on the market have, until recently, been cultivated locally from species and varieties that have proved to thrive in Iceland. Due to concentration on the market and rapidly increasing import, old varieties and genotypes are being replaced by new varieties and new species that may not be as well suited to local climate as the older material. Similarly, the availability of species and varieties on the market seems also to be decreasing.

Systematic registration of old species, varieties and genotypes of ornamental plants has not been done.

A national program (Yndisgróður) in collaboration with plant nurseries and other stakeholders started in year 2007. This program mainly focuses on trees and shrubs.

Many species, seldom seen in cultivation in other countries, have been grown in Iceland, for example of genus *Lonicera*, *Salix* and *Sorbus*.

1.5 State of crop plants and relatives in the natural flora

The bulk of the naturally occurring species are of value indirectly through their contribution to the grazing value of the land. Very few wild species have been utilized directly by man and these do not seem to be in any imminent danger through genetic erosion.

Historically the following species were the most important pants for human consumption:

- *Angelica archangelica*
- *Rumex acetosa*
- *Cochlearia offcinalis*
- *Vaccinium uliginosum*
- *Vaccinum myrtillus*
- *Empetrum nigrum*
- *Cetraria islandica*
- *Rhodymenia palmata*

Vaccinium ssp as well as *Empetrum nigrum* are popular source of berries. *Archangelica archangelica* and *Cetraria islandica* are collected in nature and processed as natural medicine. *Rhodymenia palmate* is picked and sold for human consumption. *Cochlearia officinalis* was important as source of vitamin C but is not used now, nor is *Rumex acetosa*. Some other plants are utilized as natural medicine. There are no indications of non-sustainable use of these species.

The use of wild pants for dyeing was highly developed, making use both of vascular plants and lower plants such as lichens.

Leymus arenarius, a distant relative of wheat, used to be harvested for the grain and also root fibre. Possibly valuable traits like drought resistance and tillering capacity could be of value in relation to wheat breeding programmes. This species is very important in land reclamation as it controls sand dunes**.**

CHAPTER 2

THE STATE OF *IN SITU* AND ON-FARM CONSERVATION

2.1 On-farm conservation

The semi permanent nature of Icelandic hayfields implies that the natural genetic resources of forage plants, the currently most important culture plants, are not in risk of becoming extinct. There is a risk, however, that monocultures used for land reclamation purposes and forest plantations may eliminate rare species in certain areas.

2.2 In situ conservation

The law on natural conservation provides a legal basis to conserve wild plant resources. There are three national parks in the country. In addition, there is a long list of other areas and locations with varying degree of protection, some of which are protected for their vegetation. There are 31 species that are considered threatened to become extinct and are totally protected from any kind of destruction.

The neighbourhood of hot springs is a habitat with several rare species that is particularly vulnerable,to natural changes as well as human activities when harnessing this very valuable source of energy.

The botanical gardens in Akureyri in the north of the country and Reykjavík in the south acquire seeds from foreign expeditions that are made available through seed lists. The botanical gardens in Iceland likewise make seed lists themselves for distribution within the country and in their exchange with foreign botanical gardens. Included in this seed distribution are seed of foreign introduced plants as well as seeds of cultivated indigenous species and seeds collected in nature.

2.3 Priorities for *in situ* management of plant genetic resources

Many of the seed samples preserved in NordGen are collected in old hayfields. It is recommended in the National Programme for Genetic Resources in Agriculture that those hayfields should be mapped and maintained in collaboration with their owners.

CHAPTER 3

THE STATE OF *EX SITU* CONSERVATION

The responsibility for *ex situ* conservation of PGR germplasm from Iceland is shared between the Nordic Genetic Resource Centre (NordGen, the former Nordic Gene Bank) and the Council for Genetic Resources in Agriculture. This chapter with same wording can thus be found in reports from the other Nordic countries.

NordGen consists of divisions for the three sectors; Plants, Forestry and Farm animals. This merger of three sectors into a joint NordGen is a regional and political initiative carried out in the Nordic countries through the Nordic Council of Ministers. Joining Nordic forces of genetic resources improves the quality of work and outcome and also rationalises the administrative work.

NordGen is a collaborative institution representing the Nordic Countries. As such NordGen applies a regional and cooperative approach throughout its work. In the plant sector NordGen takes care of the germplasm of the seed-propagated agricultural and horticultural crops for all the Nordic countries. NordGen's external PGR network consists of 4 crop specific working groups in which also the respective national programmes are represented.

Responsibility for conservation and maintenance of vegetatively propagated crops lies within the national programme. However, there is collaboration between NordGen and the national programme regarding documentation, databases and creating a Nordic system for joint security of accessions of clone varieties.

3.1 Conservation of seed propagated crops and potatoes

NordGen is responsible for the conservation of genetic diversity in seed propagated agricultural and horticultural crops and for the potato variety collection for the five Nordic countries. Details on conserved germplasm can be found on the NordGen website and the online database SESTO (www.nordgen.org/SESTO).

The active NordGen seed collection is situated in Alnarp, Sweden and a duplicate of the active collection (called the base-collection) is stored in Årslev, Denmark. Both collections apply a number of household freezers (-18°C) in accordance to the techniques developed through the Nordic Model for storage of seed samples. Cryopreservation is being investigated as a new method for conservation of germplasm in a limited number of species. NordGen has also a safety-collection on Svalbard in the Svalbard Global Seed Vault.

The main tasks over the past 10 years have been running regeneration activities and documentation of the material. To prevent genetic erosion in the collections during regeneration, a sufficient number of plants of each accession is ensured and regeneration procedures are followed to prevent unwanted pollination. Time and space isolation is practiced for wind pollinated crops, and cages are used for insect pollinated crops.

NordGen has an implemented routine for initiating regeneration activities when the seed germination falls below 60%. Thereby seed viability is maintained with a relatively high frequency of regeneration.

Inventory activities within the active, base and safety-collections have been carried out and the *ex situ* information system SESTO has continuously been upgraded.

Additional collecting missions and enlargements of the collections have also been carried out. During the last 10 years NordGen has carried out collecting missions to the Nordic countries and the autonomous regions of Scandinavia (The Faeroe Islands, Greenland and the Åland Islands). Data and material from these collecting missions have been stored in SESTO.

The documentation system SESTO includes a GIS mapping tool, where it is possible to identify on a map where collection expeditions have been carried out. NordGen registers seed collections also by use of GPS coordinates. Increased focus will be given on documentation of relevant evaluation data, genetic data and data on cultural history.

3.2 Germplasm conserved at NordGen

At the end of 2007 a total of 27 747 seed accessions are conserved at NordGen, either on long term or short term conditions. All the material is, according to decisions in the Nordic Council of Ministers, plant genetic resources jointly owned by the five Nordic countries (Kalmar Declaration). The storage conditions for long term and medium term conservation are identical, but the medium term material is not monitored for viability and not regenerated.

Available documentation about the material is recorded in SESTO. This includes also the country of origin of the germplasm. An overview of the number of accessions in different collection categories is shown in Table 1.

TABLE 1

Accessions conserved at NordGen on 31.12.2007 categorised by country of origin, collection category and whether the material is conserved for long or medium term

	DNK	FIN	ISL	NOR	SWE	Other*	Total
Long Term							
Ordinary Seed Collection	1 520	1 152	300	1 512	2 465	447	7 396
Special Barley Collections	24			1684	7	43	2 451
Collection of Wild *Triticeae*	5	14	8	6	12	1 174	219
Pisum Genetic Stock	25	45			831	748	1 649
Other Special Collections	5				390	425	820
Total number of accessions	**1 579**	**1 211**	**308**	**1 518**	**5 382**	**3 537**	**13 535**
Medium Term							
Ordinary Seed Collection	1 740	354	22	93	1 062	1 782	5 053
Special Barley Collections	370				7 880		8 250
Collection of Wild *Triticeae*						1	1
Pisum Genetic Stock					84	820	904
Other Special Collections	4	4					
Total number of accessions	**2 110**	**354**	**22**	**93**	**9 026**	**2 607**	**14 212**

*The Other column contains accessions from non-Nordic countries or material of unknown origin.

At present (October 2008) 383 accessions of seed propagated material of Icelandic origin are stored at NordGen. This includes varieties, landraces, breeding lines and germplasm collected from wild or semi-natural habitats. Approximately 75 % of the accessions are forage species and a major part is collected from agricultural or semi-natural habitats. Table 2 shows the distribution of these 383 accessions in crop species.

TABLE 2

Accessions of forage plants, cereals, vegetables and other seed propagated plant species of Icelandic origin conserved at NordGen*

Scientific name	Crop	No. Acc.
Forage plants		
Agrosis capillaris	Common Bent	108
Agrostis stolonifera	Creeping Bent	2
Deschampsia caespitosa	Tuftet hairgrass	17
Festuca rubra	Red Fescue	96
Phalaris arundinacea	Reed canary-grass	1
Phleum pratense ssp. *pratense*	Timothy	2
Poa pratensis	Meadowgrass	105
Cereals		
Hordeum vulgare ssp *vulgare*	Barley	6

Scientific name	Crop	No. Acc.
Vegetables		
Brassica napus var. *napobrassica*	Swede	13
Allium oleraceum		1
Others		
Leymus arenarius	Lyme grass	22
Phleum alpinum	Alpine cat´s-tail	1
Elymus alaskanus	Alaskan wheatgrass	3
Elymus caninus	Bearded Couch-grass	5

*Numbers from SESTO in October 2008

In addition to this, 20 populations of Ph. pratense and some populations of *Lupinus nookatensis* were collected in 2008.

NordGen is also responsible for conservation of the Nordic collections of potato varieties, landraces and breeding lines. This collection contains 64 accessions, of which 7 are considered to be of Icelandic origin.

3.3 Priorities for NordGen *ex situ* conservation and management

The NordGen priorities for the upcoming years are to sustain existing collections and secure continuous funding of the activities, such as:

1. Implementation of sustainable acquisition systems,
2. Training and educating staff,
3. Updating and applying sufficient equipment,
4. Improving and updating documentation,
5. Continuing collecting missions,
6. Emphasising the utilisation and information sharing and finally,
7. Increasing public knowledge and access.

A strategy plan for NordGen's next four years is currently under development and will be presented in the autumn of 2008. Increased focus on utilisation and information will be indicated. However, since NordGen is a Nordic knowledge centre alongside being a gene bank, future emphasis will also comprise improvements of the activities for education, research and public communication.

Other priorities are rescuing endangered special / research collections, collecting missions on wild species and repatriation of Nordic germplasm from gene bank collections abroad.

NordGen wishes to carry out research focusing on the material in the gene bank both within documentation, utilisation and information, in order to display and demonstrate the value of the conservation of biodiversity. To accomplish this task NordGen needs to collaborate with skilled researchers and expertise in the field of PGR.

Maintaining sufficient funding in order to continue to run the gene bank in a constructive and professional way is a challenge, also for NordGen. Securing funding from all Nordic governments and the Nordic Council of Ministers is important. Additional funding options can be external fundraising through collaborations, networking and research projects.

Efforts to maintain public support in the Nordic countries and in funding bodies for The Nordic model of gene banking is emphasised. This model has been considered to be the best and most cost-efficient way of doing gene banking for the Nordic countries, and it has also been implemented in other parts of the world.

Among optional internal reforms which can save costs, enhance quality and extend the activities are measures for sharing the burdens of the costs of conservation and development of low cost technologies. NordGen is also committed to participate actively in the European initiative on AEGIS (A European Gene Bank Integrated System), which is a strategic direction towards a more rationalised gene bank system at the European level.

Other strategic directions for NordGen are projects relevant to climate change and environmental impact.

3.4 Conservation of vegetatively propagated vegetables

Rhubarb (*Rheum undulatum)* is the only vegetatively propagated vegetable in Iceland. A collection of 7 Icelandic genotypes from old private gardens and two foreign cultivars are maintained in the Botanical Garden in Reykjavík.

3.5 Conservation of berries

There is no commercial production of berries in Iceland but *Rubus* species are popular in private gardens. A collection of these, and other species, are preserved by private gardener with support and under supervision of the Council of Genetic Resources in Agriculture. Some of these species have very limited practical interest, but number of accessions is as follows:

Ribes rubrum	9
Ribes nigrum	17
Ribes uva-crispar	5
Lonifera carules var. *edulis*	9
(collection from Siberia)	11
Rubus idaeus	13
Malus domestica	5
Prunus avium	8
Prunus domestica	5
Fragaria ssp.	25

3.6 Conservation of medicinal and aromatic plants

NordGen collected during an expedition in autumn 2008 samples from wild populations of *A. archangelica* spp *archangelica, Carum carvi, Thymus praecox* ssp. *arcticus, Achillea millefolium, Rhodiola rosea, Valeriana officinalis and Allium oleraceum and few other species.*

3.7 Conservation of ornamental plants

The botanical gardens in Reykjavík and Akureyri keep collections of number of species and varieties of foreign origin and are constantly trying new material in collaboration with other botanical gardens. The Agricultural University of Iceland has also planted an archive of ornamental scrubs for conservation and educational purpose.

3.8 Documentation and information

Documentation and information about accessions held at NordGen are stored and displayed through their data base system SESTO (http://www.nordgen.org/sesto/index.php?scp=ngb&thm=sesto).

This is also the case for accessions of vegetatively propagated crops such as vegetables and fruits, which have been collected and registered in cooperation between NordGen and the national PGR programme. Collection, characterisation and evaluation of these crops have been coordinated through the Nordic gene bank working groups and generated data have accordingly been filed in NGB / NordGen. Data about vegetable crops have been compiled and displayed, while the fruit database is under development.

These are the most important food crops of which varieties and old cultivars from the Nordic countries can be requested for plant breeding or for other scientific investigation. These data have been further distributed to international databases, such as EURISCO and the ECPGR Central Crop Databases.

Equivalent information about other field collections has so far not been gathered, compiled and displayed. A final decision on whether to develop a common Nordic solution together with NordGen or national solutions has not been taken.

3.9 Priorities for national *ex situ* conservation in field gene banks

Collections of *Agrostis capillaris*, *Deschampsia caespitosa*, *Festuca rubra* and *Poa pratensis* in NordGen are assumed to cover the actual genetic diversity in old hayfields. The National Programme for Genetic Resources in Agriculture emphasises the need for further collection of *Alopecurus pratensis*, *Phleum pratense*, *Ttrifolium repens* and *Ttrifolium pratense*

CHAPTER 4

THE STATE OF USE

Icelandic agriculture has relied heavily upon plant introductions for agricultural production as well as land reclamation purposes. The introductions have been most extensive for forestry and amenity use. Many of the introduced plants have the potential to become or have already become permanent members of the Icelandic Flora. The great majority of introductions however, has not become established in the wild. The introductions have mostly come through contacts with plant breeders and research institutes. Several expeditions have collected forest trees, amenity species and agricultural plants in areas at similar latitudes with comparable climate to that of Iceland.

Icelandic agriculture is mostly based on ruminants which are fed indoors for 5-8 months. Species used for hay production are therefore the most important resource for Icelandic agriculture. Barley production has increased steadily over the last 20 years, and on-farm grown barley is now an important feedstuff on majority of dairy farms and to lesser extent on sheep farms. Development of new varieties, adapted to Icelandic soils and climate has played a major role in this development.

Varieties of forage crops sown to establish hayfields were originally of foreign origin only, although naturally invading grasses in reality constitute more than a half of the sward. Grass seed for amenity purposes is all imported, although some varieties may be partly of Icelandic origin. In the latter half of this century selections from collections of genotypes within the country have produced new varieties. In some cases as for timothy, the phenotypes derive from earlier plantings and are better adapted than the original seed. For some species the seed has to be grown abroad, and for others the use of domestic varieties has been hampered by difficulties in seed production.

Land reclamation is now to a high degree based on domestic production of seed, although about a half of the grass seed sown is still imported. Most of the seed is used together with moderate fertilizer doses, in a program based on cooperation with farmers and landowners. The Soil Conservation Service carries out planning work and provides seed and fertilizer while the farmers are responsible for field work and management. Continuously new species and varieties are being tested for this purpose. Some of the imported seed, such as *Lolium* spp., with quick establishment and early growth is used to provide temporary cover until more hardy vegetation becomes established.

4.1 Plant breeding in Iceland

There have been considerable efforts put into the development of barley varieties adapted to local conditions in Iceland over the last 15 years. This has resulted in a number of breeding lines that have been extensively tested throughout the country. Two registered cultivars are already on the market but are only registered in Iceland.

Disease resistance of barley is of growing concern and there is currently a project being carried out to characterize the fungal diseases that affect barley cultivation in Iceland with the aim of improving the resistance of the breeding material.

The *Phleum pratense* cultivar SNORRI, has been available on the market since spring 2008. It is an outcome of a joint Nordic breeding project for the northern areas called Nordgrass.

Local varieties of *Alecopecuris. pratensis*, *Poa. pratensis* and *Festuca rubra*, based on collections from old hayfields in Iceland and Greenland, are currently in the process of multiplication. Selections have also been made in *Deschampsia caespitosa* and *D. beringensis* for use in land reclamation.

Crosses have been made between *Trifolium repens* of southerly and northerly origin and the progeny tested under field conditions in Korpa, Iceland and Løken, Norway. The most promising material was selected and is being multiplied in Norway.

A number of research projects have been carried out on *Trifolium repens* in the last few years to support breeding efforts, including studies of morphological variation of locally adapted material, both in the greenhouse and in the field and physiological responses, with emphasis on unsaturated fatty acids and carbohydrates status in autumn and winter.

The Icelandic Research Council supports research on the genetic diversity of contrasting populations of *Trifolium. repens* and *Trifolium. pratense* cultivars that have been grown in a common experiment at selected sites across Europe

under the auspices of COST 852. Genetic diversity in bred cultivars of white clover of contrasting climatic origin compared with that in semi natural and natural populations from extreme environments adapted to local conditions in Iceland is of special importance.

Breeding programmes for land reclamation have included to species from Alaska, *Deschampsia beringensis* and *Lupinus nootkatensis.* The seed production of *Leymus. arenarius* is from natural populations only. Breeding research which also includes foreign populations of *Leymus mollis* is in progress.

4.2 Diversity in the seed and transplant sector

Seed of long lived perennial grass species for the hayfields, annual species for green fodder production and barley for grain dominate the trade. Three to four commercial companies handle most of the volume. Plant breeding is carried out by the Agricultural University of Iceland, a governmental institution. Timothy (*Phleum. pratense*) and a few other species are used for the permanent hayfields, and the bulk of this seed is produced abroad, and so is all the seed of annual species. Bred Icelandic varieties are also grown for seed abroad.

There is a need for hardy grass species for the land reclamation work being carried out under very harsh conditions. For this purpose both indigenous and introduced species are being used. Some of these species and varieties are not commercially available. Seed production has, therefore, been established in the country for these species.

In recent years the emphasis in plant breeding and seed production has shifted more towards leguminous and other nitrogen fixing species. Most of these have been introduced but the use of indigenous species is also being developed.

Seed production and import in 2008 is listed in Table 3 together with category of use.

TABLE 3
Seed import, seed production and seed use in 2008

Species	Kg	Origin	Use
Perennial grasses			
Phleum pratensis	85 900	Imported	Hayfields
Poa pratense	4 000	Imported	Amenity
Poa pratense	37 600	Imported	Hayfields
Festuca. rubra	7 600	Icelandic	Land reclamation
Festuca . rubra	5 900	Imported	Amenity
Festuca rubra	28 300	Imported	Land reclamation
Lolium. perenne	7 100	Imported	Hayfields
Lolium perenne	3 000	Imported	Amenity
Leymus arenarius	11 200	Icelandic	Land reclamation
Deschampsia beringensis	9 300	Icelandic	Land reclamation
Mic. *mixtures*	47 400	Imported	Hayfields
Festuca. ovina	1 900	Imported	Amenity
Mic. *mixtures*	12 000	Imported	Amenity
Annual fodder crops			
Lolium multiflorum var westerwoldicum	64 900	Imported	Green fodder
Lolium multiflorum var italicum	76 000	Imported	Green fodder
Brassica . napus var. *annua*	700	Imported	Green fodder
Brassica napus va. biennis	31 800	Imported	Green fodder
Brassica oleracea var. *acephala*	500	Imported	Green fodder
Brassica campestris	20	Imported	Green fodder
Avena sativa	72 500	Imported	Green fodder
Grain crops			
Hordeum vulgare var. *vulgare*	971 900	Imported	Grain
Avena. sativa	25 000	Imported	Grain

Species	Kg	Origin	Use
Legumes			
Trifolium repens	500	Imported	Hayfields
Trifolium. pratense	1 100	Imported	Hayfields
Lupinus nookatensis	850	Icelandic	Land reclamation

4.3 Use of PGR in small scale and non-commercial production

Private gardening is common in Iceland, mostly for ornamental plants but also vegetables and root crops. Botanical gardens, The Horticultural Society of Iceland and some private clubs are active in distribution of PGR to the common user.

CHAPTER 5

THE STATE OF THE NATIONAL PGR PROGRAMME, TRAINING AND LEGISLATION

Plant genetic resources in Iceland are on the whole not considered to be in much danger from genetic erosion or even extinction, except species that have always been rare in the country. Preservation of land races and bred grass varieties is taken good care of within the work programme of NordGen. The number of species in the country is unexpectedly small, due to the isolation of the country after the ice age. Numerous successful plant introductions of plant varieties and species indicate the need and value for Iceland of free unhindered access to plant genetic resources in other regions. This applies both to new species of potential value as well as new genetic material of already acquired species for use in breeding programmes for increased adaptation as well as superior characteristics.

Special care has to be taken though in the introduction work to avoid species with undesirable characteristics. Also consideration is given to the fact that vigorously competitive species may threaten habitats and plant associations that are considered to be of specific conservation value.

5.1 Achievements in the Icelandic Plant Genetic Resource Programme

5.1.1 The National PGR programme

The national programme is integrated into the strategy and work programme of the regional Nordic institute NordGen. The Icelandic Council of Genetic Resources in Agriculture links to Nordgen and is the formal national forum for discussions and planning in this field.

5.1.2 Partners in the national PGR programme

Research on plant genetic resources including plant breeding is primarily carried out at the Agricultural University of Iceland. The Icelandic Institute of Natural History is responsible for the monitoring of the natural Flora and issues a list of species and habitats that are considered threatened.

The Council of Genetic Resources in Agriculture is a forum for discussion on genetic sources in agriculture. Members of the Council are appointed by Agricultural University of Iceland, The Icelandic Institute of Natural History, The Institute of Freshwater Fisheries, The Iceland Forest Service, The Agricultural Society of Iceland and Ministry of Fisheries and Agriculture. The Council works under the auspices of the Ministry for Fisheries and Agriculture

5.2 Education and training

At the University of Iceland and the Agricultural University of Iceland education leading to B.Sc. and M.Sc. in biology is offered including courses in genetics and ecology, but no specific courses in plant breeding or genetic resources are offered. Presently master programmes in cooperation with the research institutes in applied biology open the possibilities for training in this field. Education and training in the field of plant genetics and breeding is almost exclusively sought at universities in other countries. There is a very close cooperation between the five Nordic countries in graduate training in the field of plant genetics and breeding and the staff of the NordGen has been involved in the joint Nordic courses arranged in the programme. These Ph.D. courses have therefore become important venue information in the work programme of NordGen.

Icelandic students have also studied plant genetics in other European countries and in the United States.

5.3 National legislation

The activities of the Council of Genetic Resources in Agriculture are based on the Agriculture Act 70/1998 and Directive 151/2005.

5.4 Public awareness

The public awareness of the values related to plant genetic resources has increased significantly during the last decade.

CHAPTER 6

THE STATE OF REGIONAL AND INTERNATIONAL COLLABORATION

Iceland has ratified the convention on Biological Diversity, and the Country Action Plan has recently been completed. Iceland has also been an active member of the ECP/GR.

Also in cooperation with other Nordic countries the Icelandic Development Agency ICEIDA has participated in the development of a regional Gene Bank of the SADC countries in southern Africa where NordGen has acted as a management consultant of the project.

6.1 Nordic cooperation

NordGen (formerly the Nordic Gene Bank) was established in 1979. For the last 30 years, it has served as a common regional gene bank for important species in agriculture and horticulture in the Nordic countries. The policy has been to conserve crop genetic diversity from the five Nordic countries and today very few accessions in the seed collections have their origin in other countries.

The Nordic cooperation on genetic resources is organised under the Nordic Council of Ministers. From the 1st of January 2008 the Council's work on genetic resources within plants, animals and forest trees was unified in the Nordic Genetic Resource Centre (NordGen), with the aim to strengthen and coordinate efforts and activities in genetic resources in all sectors.

During the first 10 years, collection of old crop varieties was carried out nationally by breeders, researchers etc. and the seed samples were deployed in the common gene bank. National members of six crop oriented working groups of the gene bank were in charge of the conservation of national plant genetic resources, and these individuals also served as a national advisory committee in PGR matters to the Ministry of Agriculture.

Through this Nordic cooperation coordinated by the Nordic Gene Bank/NordGen, varieties of vegetatively propagated crops as fruits and some vegetables from the five countries have also been collected. These accessions were successively conserved in national field gene banks and they are still conserved nationally. However, documentation and database work has been carried out and coordinated on a Nordic basis.

The Nordic Gene Bank/NordGen has over the years conducted projects regarding characterisation, evaluation and the use of the conserved genetic material, including cooperation with national breeding companies. The SESTO database has been developed and this now holds available data of all gene bank material.

In 2003 the Nordic Council of Ministers adopted declarations and recommendations stating that the collections held or administered by the Nordic Gene Bank (now by NordGen), are to be regarded as a common Nordic resource, under common Nordic management. The material is freely accessible and relevant material is included under the Multilateral System of the International Treaty on Plant Genetic Resources on Food and Agriculture. The security collections held by NordGen for other gene banks are of course excluded.

The Nordic Gene Bank/NordGen has also coordinated Nordic participation in European and international networks and projects.

NordGen is still the main body for conservation of Icelandic PGR of seed propagated crops and potatoes in addition to documentation systems covering all agricultural and horticultural crops, including material maintained in national field gene banks. There is close collaboration and coordination between NordGen and The Council of Genetic Resources in Agriculture.

6.2 International programmes and agreements

Iceland has ratified the convention on Biological Diversity, and currently work is under way on the Country Action Plan. Iceland has also ratified the International Treaty on Plant Genetic Resources (ITPGRFA) and International Convention for the Protection of New Varieties of Plants (UOPV).

Iceland has participated in the ECP/GR. from its initiation and coordinates its activity with the other Nordic countries through Nordgen.

Also in cooperation with other Nordic countries the Icelandic Development Agency ICEIDA participated in the development of a regional Gene Bank of the SADC countries in southern Africa where NordGen acts as a management consultant of the project. Similarly NordGen acts as a vehicle for cooperation with the Baltic countries which aim at developing a joint regional genebank.

CHAPTER 7

ACCESS TO PLANT GENETIC RESOURCES, SHARING OF BENEFITS AND FARMERS' RIGHTS

7.1 Access to plant genetic resources for food and agriculture

In 2003 the Nordic Council of Ministers adopted the Kalmar declaration stating that the collections held or administered by the Nordic Gene Bank (now by NordGen), are to be regarded as a common Nordic resource, under common Nordic management. The material is freely accessible and relevant material is included under the Multilateral System of the International Treaty on Plant Genetic Resources on Food and Agriculture. The security collections held by NordGen for other gene banks are of course exempted.

7.2 Sharing of benefits arising from the use of plant genetic resources

Development of new forage cultivars have been based on collection from old hayfields, partly in collaboration with other Nordic countries, leading to the benefit of farmers through better adapted and higher yielding varieties. Development of new barley cultivars, adapted to Icelandic soil and climate has been a major breakthrough for barley growers.

7.3 Farmers' Rights

Iceland is a member of the UPOV Convention.

CHAPTER 8

CONTRIBUTION TO FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

Icelandic authorities believe that preserving genetic diversity, and access to it is of outmost importance for food security and sustainable development on local as well as global level. This is the reason for the commitment and contributions to plant genetic resource activities, both national and international.