European Cooperative Programme for Crop Genetic Resources Networks
ECP/GR

Flax Genetic Resources in Europe

IPGRI

***Ad hoc* meeting, 7–8 December 2001, Prague, Czech Republic**

L. Maggioni, M. Pavelek, L.J.M. van Soest and E. Lipman, *compilers*

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The **International Plant Genetic Resources Institute (IPGRI)** is an autonomous international scientific organization, supported by the Consultative Group on International Agricultural Research (CGIAR). IPGRI's mandate is to advance the conservation and use of genetic diversity for the well-being of present and future generations. IPGRI has its headquarters in Maccarese, near Rome, Italy, with offices in more than 20 other countries worldwide. The Institute operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme and (3) the International Network for the Improvement of Banana and Plantain (INIBAP).

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In 2001 financial support for the Research Agenda of IPGRI was provided by the Governments of Albania, Armenia, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Republic of Korea, Lithuania, Luxembourg, Macedonia (F.Y.R.), Malta, the Netherlands, Norway, Peru, the Philippines, Poland, Portugal, Romania, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, Uganda, UK, USA and F.R. Yugoslavia (Serbia and Montenegro), and by the African Development Bank (AfDB), Asian Development Bank (ADB), Center for International Forestry Research (CIFOR), Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica (CATIE), Centro Internacional de Agricultura Tropical (CIAT), Centro Internacional de la Papa (CIP), Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), Common Fund for Commodities (CFC), European Commission, European Environmental Agency, European Union, Food and Agriculture Organization of the United Nations (FAO), German Foundation for International Development (DSE), Global Forum on Agricultural Research (GFAR), Instituto Colombiano para el Desarrollo de la Ciencia y la Tecnología (COLCIENCIAS), Inter-American Drug Abuse Control Commission (CICAD), International Center for Agricultural Research in the Dry Areas (ICARDA), International Center for Living Aquatic Resources Management (ICLARM), International Centre for Research in Agroforestry (ICRAF), International Crops Research Institute for the Semi-Arid (ICRISAT), International Development Research Centre (IDRC), International Food Policy Research Institute (IFPRI), International Foundation for Science (IFS), International Fund for Agricultural Development (IFAD), International Institute of Tropical Agriculture (IITA), International Livestock Research Institute (ILRI), International Rice Research Institute (IRRI), International Service for National Agricultural Research (ISNAR), International Water Management Institute (IWMI), Japan International Research Centre for Agricultural Science (JIRCAS), National Geographic Society, National Science Foundation (NSF), Programme on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (PGRA), Regional Fund for Agricultural Technology (FONTAGRO), Rockefeller Foundation, Taiwan Banana Research Institute (TBRI), Technical Centre for Agricultural and Rural Cooperation (CTA), Technova, United Nations Development Programme (UNDP), UNDP Global Environmental Facility (UNDP-GEF), United Nations Environment Programme (UNEP), UNEP Global Environmental Facility (UNEP-GEF), United States Department of Agriculture (USDA), United States Agency of International Development (USAID), Vlaamse Vereiniging voor Ontwikkelingssamenwerking en Technische Bijstand (VVOB), West Africa Rice Development Association (WARDA) and the World Bank.

The **European Cooperative Programme for Crop Genetic Resources Networks (ECP/GR)** is a collaborative programme involving most European countries aimed at facilitating the long-term conservation and increased utilization of plant genetic resources in Europe. The Programme, which is entirely financed by the member countries and is coordinated by IPGRI, is overseen by a Steering Committee composed of National Coordinators nominated by the participating countries and a number of relevant international bodies. The Programme operates through ten networks in which activities are carried out through a number of permanent working groups or through *ad hoc* actions. The ECP/GR networks deal with either groups of crops (cereals, forages, vegetables, grain legumes, fruit, minor crops, industrial crops and potatoes) or general themes related to plant genetic resources (documentation and information, *in situ* and on-farm conservation, inter-regional cooperation). Members of the working groups and other scientists from participating countries carry out an agreed workplan with their own resources as inputs in kind to the Programme.

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Introduction

Opening of the meeting

L. Dotlačil, Director of the Division of Genetics and Plant Breeding of the Research Institute for Crop Production, Prague-Ruzyne (RICP), opened the meeting, expressing his pleasure in hosting for the first time an ECP/GR *ad hoc* meeting on flax, and wishing the best success to the participants for their collaborative work.

M. Pavelek, chairman of the Working Group 1 of the FAO/ESCORENA Flax and other Bast Plants Network, and manager of the International Flax Database (IFDB), then welcomed all participants on behalf of AGRITEC Šumperk, the Czech organizing institute and host to the IFDB.

Background and history of the present meeting

The participants were told about the history and background of the present meeting. In 1999 L. van Soest contacted L. Maggioni about the possibility of establishing European cooperation in flax genetic resources. The major reasons for this request were that:

- The flax acreage in Europe has been decreasing during the last 10 years and may result in a loss of genetic resources of this crop in Europe. Action is required to avoid genetic erosion within collections.
- It is presently not known exactly which European countries maintain flax collections and how large these holdings are.
- A meeting of curators of the most important holdings is required in order to initiate European cooperation for the conservation of flax genetic resources.

In 1999, M. Pavelek submitted an EU project focused on flax genetic resources, including partners mainly from northwestern Europe. Since this project was not approved, the need for European cooperation remains. An opportunity to organize an *ad hoc* meeting was eventually found in the framework of during the ECP/GR Industrial Crops and Potato Network and this meeting was thus organized.

Selection of the Chairperson for the meeting

The group agreed that M. Pavelek chair the meeting on the first day and L. van Soest on the second day. The participants then briefly introduced themselves. The draft agenda was subsequently adopted with some modifications.

ECP/GR briefing and outcome of the mid-term Steering Committee meeting

L. Maggioni, ECP/GR coordinator, welcomed all the participants at the *ad hoc* meeting on flax genetic resources on behalf of IPGRI. He explained that this meeting had been organized following a suggestion of the Network Coordinating Group of the ECP/GR Industrial Crops and Potato Network, with the main objective of facilitating the development of the International Flax Database, as well as to exchange information about the status of flax genetic resources in Europe. He then said that representatives of the main European flax collections were invited to attend the meeting with the agreement of their respective country's plant genetic resources coordinator and he was pleased to see that nine European countries were represented. He said that he had received a message from France, with apologies for not being able to send a representative from INRA. However, a report on the status of flax genetic resources was received.

For the benefit of several participants attending an ECP/GR meeting for the first time, the coordinator briefly explained the history, objectives and mode of operation of ECP/GR and mentioned the Industrial Crops and Potato Network activities planned and carried out within Phase VI of ECP/GR (1999-2003). In particular, he summarized the relevant recommendations made by the Network Coordinating Group during its meeting in Bury St. Edmunds, United Kingdom, in September 1999. There it was considered important to intensify collaboration between ECP/GR and the ESCORENA networks on flax and fibre crops and on sunflower, to exchange publications, to involve the ESCORENA database managers in ECP/GR documentation activities and to jointly organize meetings and establish databases.

L. Maggioni also gave a brief account of the conclusions from the mid-term meeting of the ECP/GR Steering Committee, held in St. Petersburg, Russian Federation, 14-17 October 2001. Several policy issues were addressed; however no specific Material Transfer Agreement model was endorsed. It was preferred to wait for the adoption of the revised International Undertaking (IU), which was thought to be imminent.[1] A statement was made on the IU negotiations, recommending the extension of the list of crops to be included in a Multilateral System. Regarding the Industrial Crops and Potato Network, the Committee agreed that a meeting on flax genetic resources be held and endorsed the proposal that a modest sum of money be used to carry out flax germplasm characterization/evaluation. Finally, the Steering Committee recommended that sunflower experts be invited to the next Network Coordinating Group meeting to facilitate development of a sunflower database.

The Committee expressed support for the initiatives of the Working Groups to find mechanisms for sharing responsibilities and considered it very important that the issue of quality standards be addressed. The Committee was also pleased to see progress made for all of the ECP/GR objectives, but recommended increased attention to facilitate utilization of plant genetic resources (PGR) in Europe and to increase awareness on the importance of PGR conservation and use. In order to develop a strategy for the next phase (VII), two task forces composed of a few Steering Committee members were established to discuss 1) the repercussions on PGR of recent developments in science, technology and international policy; and 2) how genebanks should implement relevant international agreements and how this might affect the genebanks' operation.

In the following discussion, L. van Soest asked about the level of collaboration between IPGRI and FAO officers in Rome. L. Maggioni replied that IPGRI was in contact with the FAO Regional Office for Europe: however, his impression was that the ESCORENA networks activity and decision-making was mostly delegated to the various networks. He declared himself available to interact with appropriate FAO officers to discuss the opportunities for collaboration. M. Pavelek said that the ESCORENA networks are not particularly concerned with genetic resources and that collaboration with ECP/GR would therefore be very useful.

[1] On 3 November 2001, the renegotiation of the FAO International Undertaking came to an end. The revised text, adopted through a vote, is called "International Treaty on Plant Genetic Resources for Food and Agriculture". This new legally-binding international agreement will enter into force when ratified by at least 40 states.

Status of National Collections

Representatives from each country described the status of their national flax collections. *(Full reports are included in Part II)*

Bulgaria

D. Shamov presented the status of the flax genetic resources collection at the Institute of Plant Genetic Resources (IPGR), Sadovo, Bulgaria. The genebank of the Institute contains a total of 945 accessions, of which 516 are in long-term storage at -18°C, vacuum-packed in aluminium foil bags. Evaluation carried out on 450 accessions showed that 23% are linseed, 29% flax and 46% of intermediate type. The material is distributed as follows: landraces and old cultivars 58%, advanced cultivars 15% and breeder's lines 14%. Beside *L. usitatissimum*, there are 12 wild species in the collection: *L. altaicum, L. austriacum, L. bienne, L. flavum, L. grandiflorum, L. humile, L. perenne, L. punctatum, L. setaceum, L. strictum, L. trigynum* and *L. viscosum.*

A. Balabanova reported that the collection of the AgroBioInstitute (ABI), Kostinbrod, contains a total of 283 *Linum* accessions. Of these, 178 were received from IGR–Sadovo, 29 from other Bulgarian institutions, 71 from foreign institutions and 5 were bred at the institute. These accessions originate from Europe, Asia, Africa and America. Only 6.4% are of Bulgarian origin. Cultivars represent 54% of the collection, landraces and primitive cultivars 27.5%, breeding lines 15%, wild forms 1% and genetic stocks 2.5%.

According to plant type, fibre flax covers 31% of the collection, linseed 35%, intermediate type 32% and other types 2%.

A. Balabanova went on to explain that 259 accessions were described for 15 morphological traits, 5 biological and 4 yield characters, according to UPOV and to the IFDB descriptors and other descriptors for the species *L. usitatissimum* L.[2] Linseed and intermediate type accessions were also analyzed using biochemical methods for oil and protein content, Cd accumulation and fatty acid composition of oil according to ISO standards. Fibre quality evaluation of flax varieties was also made according to Bulgarian standards.

Discussion

M. Pavelek asked about the level of coordination of work on flax genetic resources in Bulgaria. A. Balabanova and D. Shamov explained that no full coordination exists at the moment, although there are plans to improve it in the near future.

Czech Republic

M. Pavelek explained that the Czech flax collection had been managed since the 1960s by AGRITEC Ltd., Šumperk. Work with flax genetic resources is financially supported by the Czech Ministry of Agriculture as part of the National Programme for Maintenance and Conservation of Crop Genetic Resources, which is coordinated and managed by the Research Institute of Crop Production in Prague–Ruzyne, where the central genebank is located. The national flax collection maintained at AGRITEC is one of the largest European collections, with 2011 accessions of flax, linseed, intermediate and wild types. Part of the collection is sown annually for regeneration and characterization and to prepare accessions for the central genebank in Prague for long-term storage. Flax accessions are kept here in glass jars at -5°C (active collection) and -15°C (base collection). Moisture content is reduced to 5% in both collections. Based on geographical representation, the main part of the collection is of European origin, followed by a number of accessions from Africa, the USA and Australia. The national documentation system EVIGEZ, developed at Prague-Ruzyne, is used for PGR documentation purposes in the whole country as well as in Slovakia. The Czech flax

[2] UPOV 1991, 1995; Pavelek 1994, 1995; Kutuzova *et al.* 1987 (references in Part II, p. 21).

collection is described according to the Descriptor list of *Linum usitatissimum*[3] by 22 passport descriptors and 55 special descriptors covering morphological traits, biological and yield characteristics.

France

A report was prepared before the meeting by G. Fouilloux, reporting that the French flax and linseed germplasm collection maintained by the INRA flax breeding laboratory contains about 1700 accessions including about 50 INRA-bred lines. G. Fouilloux (Versailles) and D. Dorvillez (Estrées-Mons) are in charge of the collection. The genetic resources were collected from 42 different countries, but mostly from USA (360 accessions), Argentina (327), former Soviet Union (192) and France (108). The collection is composed of 426 accessions of linseed, 273 of flax and 207 of intermediate *Linum*. Other genotypes seem to have no agricultural value but could be used as parents for breeding. Twenty per cent of the whole collection is sown every year. Characterization is thus completed and impurities or heterogeneous material are detected.

A catalogue of all accessions including their passport data is available on the Internet at <http://www.inra.fr/Internet/Produits/Lin/index.htm>. About 800 genotypes have been described almost completely for 17 qualitative and 14 quantitative traits.

Germany

K. Dehmer reported that a total of 2304 accessions of *Linum* genetic resources are maintained in the two German genebanks (621 accessions at the BAZ Gene Bank, Braunschweig, and 1683 at IPK Genebank, Gatersleben). Almost 95% of these accessions (2181) belong to *L. usitatissimum* as the only crop species of the genus. This species actually constitutes (with the exception of four yet undetermined accessions) the entire BAZ collection, while the IPK collection also contains 85 entries from at least 25 other species of the genus *Linum*.

With respect to the origin of the material, Russia and the former USSR (RUS/SUN) with 184 accessions, and Germany (GER, DDR and DEU) with 177 accessions are the major donor countries, followed by Italy (87 accessions), Hungary (75), France (72), Iran (67) and Portugal (58). In total, 67 countries are listed as donors (32 at BAZ, 67 at IPK). Regarding the continents, Europe with 1147 accessions is the origin of almost 50% of the entries, while Asia (179), America (154), Africa (82) and Australia (2) donated the other half, together with 745 accessions of unknown origin.

In the active collection of BAZ, modern varieties (72%) and breeding lines (21%) are predominant, only a few landraces (6%) being represented. In the IPK collection, modern varieties and breeding lines also form a major part (total 44%). It contains less than 1% of landraces and 5% of wild material, while the sample status of 50% of the accessions is unknown.

About equal numbers of linseed (37%) and fibre (45%) types are being maintained at Braunschweig, only 3% being classified as intermediate types. In Gatersleben, however, intermediate types predominate with 49%, followed by 27% fibre and 7% linseed types. The usage of 17% of the entries is unknown.

BAZ activities regarding characterization and evaluation focused on inflorescence, agronomic and seed traits. The evaluation table for the genus *Linum* includes 46 descriptors. One to several traits were described for 1100 BGRC accessions at least once. Some accessions were evaluated twice or more, making a total of 1702 data sets (tuples) documented in the database.

In the IPK Genebank, *Linum* accessions were also characterized for a majority of the IFDB descriptors, the respective data not yet being available in an electronic format.

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3 Pavelek 2002 (reference p. 28).

Hungary

A. Simon informed the group that the Institute for Agrobotany, where more than 56 000 accessions are available for use by Hungarian and foreign breeders and other users, is in charge of all the Hungarian national genebank activities. The National *Linum* Collection, which is over 45 years old, is part of the national collection and is composed of 409 accessions. The structure of the national *Linum* collection's database does not differ from that of the other crops in the Institute.

Ninety-four percent of the *Linum* collection belongs to the species *L. usitatissimum*. The analysis of *Linum usitatissimum* by subtaxa shows a wide range of variation.

The most important source of the national *Linum* collection is seed exchange with Hungarian and foreign institutes. Eighty percent of the collection derives from Hungary (40.3%), former Czechoslovakia (15.9%), Germany (13.2%), United Kingdom (3.2%), Romania (2.7%), France (2.4%) and Poland (2.2%). Seventy-one percent of the collection is composed of advanced cultivars. Characterization and evaluation have already been carried out on 307 accessions (i.e. 75% of the *Linum* collection).

Latvia

There was nobody from Latvia at the meeting. However the national PGR coordinator, I. Rashal, sent a short report on Latvian flax genetic resources after the meeting. This report is included in Part II.

Lithuania

The following report was received after the meeting from Alma Budvytyte. The collection from different countries of the world which is preserved at the Lithuanian Agricultural Institute and its branches and experimental stations includes 300 fibre flax samples, about 600 different mutant flax types, more than 160 oil flax accessions (intermediate—*Linum usitatissimum* L. var. *intermedia* and flax seed—*Linum usitatissimum* L. var. *intermedia*). During the period 1995-2000, research on genetic resources of industrial crops was carried out to examine the genetic diversity of the above-mentioned plant species and to determine valuable accessions according to their morphological characteristics and agronomic qualities. The whole flax collection was described according to accession resistance to lodging, disease resistance and many other characteristics. The contact person in Lithuania for flax genetic resources is Dr Kestutis Bacelis.[4]

The Netherlands

L. van Soest explained that the *Linum* collection was adopted by CGN in 1995, after a group of four private Dutch breeding companies encouraged the institute to take action for the proper conservation of this valuable collection. In 1996, an arrangement for cooperation in the field of maintenance and evaluation was established between the breeding companies and CGN. The collection includes 974 accessions and is divided into fibre flax, linseed, intermediate flax and wild species.

A minimal descriptor list was developed based on the descriptors for *Linum* of the International Flax Database (IFDB) of the FAO/ESCORENA Flax and other bast plants Network. The present CGN descriptor list includes 16 descriptors that can be divided into two groups:

- 10 mandatory descriptors: these traits should always be recorded during regeneration;
- 6 optional descriptors: these traits can be recorded if sufficient time is available or at the occurrence of diseases for which the character can be ideally scored in the field.

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[4] Contact details: Upytės Experimental Station, Lithuanian Institute of Agriculture, Upyte, 5335 Panevezio distr., Lithuania. Tel: (+370-54) 55423; E-mail: lzi.upyte@post.omnitel.net.

As part of a multidisciplinary fibre research programme, a core collection of fibre flax was developed. The core was generated over the period 1998-2001 and the development was conducted after different stages, resulting in the final core collection of 84 accessions.

Nordic countries

L. Maggioni informed the group that evaluation data on the fatty acid content of a *Linum* collection were available from the NGB Web site at <http://www.ngb.se/Databases/activities/pro_detail.php?379>.

Poland

I. Rutkowska-Krause explained that the Institute of Natural Fibres (INF) in Poznań conducts research work devoted to the preservation and sustainable exploration of flax and hemp genetic resources. Since 1982, the Institute has been responsible for organization of the genetic resources of the *Linum* genus. The flax collection of the INF Gene Bank comprises 864 accessions: 48 accessions of wild species, 29 landraces or primitive cultivars, 588 advanced cultivars, 102 breeder's lines and 97 accessions of unknown status. The INF collection also holds unique accessions of Polish origin. All genotypes present at the INF Gene Bank have been characterized for genetic and economic characters. The flax collection is also described in terms of resistance to diseases, especially the most serious one, i.e. fusarium wilt.

The INF Gene Bank has been equipped with modern cooling and freezing chambers to secure controlled storage conditions. The main aim of the INF Gene Bank is to help breeders in their work by increasing availability of genetic resources for breeding and research, and by screening the core collection for properties important for breeders.

Romania

V. Ilea explained that the breeding and seed production of fibre flax started relatively late in Romania (1973). In the following years, after long-term experiments carried out between 1973 and 2000, 420 foreign cultivars representing different ecological regions of flax cultivation from 22 countries were tested under intensive cropping.

Since 1980, the most important Romanian fibre flax breeding programme has been undertaken at the Agricultural Research Station Livada. This programme has produced new fibre flax varieties which replaced the foreign varieties 'L 1120', 'Prima', 'Milenium', 'Lintex' and 'Hera'.

A study of the collection over 12 years (1976-1987) had the objective of identifying the best varieties for northwestern Romania and of using these in a breeding programme to improve quality. Improved material obtained at the Agricultural Research Station-Livada over the period 1980-2000 achieved genetic progress for stem yield and fibre content, compared with the foreign control varieties 'L 1120', 'Primo', 'Regina' and 'Lintex'.

A report received from Silvia Strajeru, director of the genebank of Suceava, said that the *Linum* genus is represented in the national flax collection by 3845 accessions, mainly of *L. usitatissimum* (98%), with 20 other species. Only 220 accessions are thought to be duplicates. 2161 accessions are oil varieties, 1068 are fibre type, 71 are intermediate, and 545 are of unknown use. The institutions holding flax collections in Romania are the Research Institute for Cereals and Industrial Crops at Fundulea (2880 accessions), the Suceava genebank (520), the Livada Agricultural Research Station (420) and the Simnic Agricultural Research Station (25). The National Genebank of Suceava is responsible for preserving *ex situ* Romanian agrobiodiversity. The genebank stores both active (+4°C) and base (-20°C) collections while the other institutions do not have controlled conditions to maintain their breeding material. About one-third of the collection is of Romanian origin, of which a few are old cultivars.

Russian Federation

N. Brutch told the group that the VIR collection of flax genetic resources consists of 5521 accessions. It covers a wide range of diversity and includes all three flax types: fibre, oil (usually called linseed), and intermediate types which can be used for both purposes. Some wild species are also included in the collection. The collection covers the whole area where flax is grown. More than half the collection is represented by local folk-bred varieties. Also several commercial varieties, lines and other breeding material are stored. Most of the collection is composed of accessions originating from the former Soviet Union Republics. The main donors of genetic material are Russia, Uzbekistan, Ukraine and Tajikistan. The majority of these accessions are landraces, which can now be found only in this collection. Practically all the commercial flax varieties ever bred in the USSR are maintained. Breeding lines and donors of different agronomic characters are also widely represented.

Apart from the former Soviet Union, flax genetic material from 58 foreign countries is included in the collection. Some countries such as India and Ethiopia are represented mostly by local accessions. For other countries, e.g. Germany and USA, the collection is represented mainly by commercial varieties and breeding material.

A genetic collection consisting of about 250 inbred lines and lines of lower generations is conserved at VIR. These lines carry different morphological and agronomic characters. This collection includes different phenotypes with traits such as specific colours and shapes of flowers and seeds, resistance to rust, duration of vegetative growth, plant height, etc. For many of them, genetic control of the character has been identified.

N. Brutch showed a series of slides with different flower genotypes showing the wide range of variation present in *L. usitatissimum* in the VIR collection. She showed that the variation in flower colour exceeds the present range of states included in the IFDB descriptor list for characterization data.

Discussion

The group discussed the need to make changes related to flower colour in the present IFDB descriptor list but came to the conclusion that it was not necessary.

M. Pavelek asked about the amount of duplication in the Torzhok collection. N. Brutch replied that 90% is derived from the VIR collection.

Ukraine

V. Virovets stated that the current collection of flax in Ukraine contains 1042 samples. The collection was only established after 1992, since all the material necessary for carrying out scientific research and breeding work was previously obtained from the N.I. Vavilov Research Institute of Plant Industry (VIR). The collection, based in Glukhiv, is currently composed of samples from 45 countries, mostly from Russia (256); 117 are from Sweden, 54 from the Netherlands, 75 from the Czech Republic and Slovakia, 52 from Ukraine, 52 from USA, 34 from Argentina, 30 from France, 23 from Poland, 23 from Hungary and 61 from Germany. So far, 870 accessions have been characterized and a number of samples have been singled out for their useful properties (132 as fast-ripening, 154 for seed yield, 81 for straw yield, 76 for straw fibre content, 42 for plant height, 114 for good spinning capacity of fibre, 41 for resistance to lodging). All the material has also been evaluated for its resistance to disease and five carriers of resistance to fusarium wilt have been identified. Characterization of the collection is carried out and includes information about country of origin, originating institute, authors, botanical species, infraspecific taxon, life cycle, type of development, ploidy, value of the sample, availability, etc. Unfortunately this work is still far from complete.

A national seed storehouse for long–term storage was created at the Centre of Genetic Resources, where 218 samples have been deposited so far. All the available information is regularly forwarded to the Centre of Genetic Resources of Ukraine for inclusion in the computerized information system. Two catalogues with the characteristics of 282 accessions have been issued. Samples of flax seed are sent to *bona fide* users, such as scientific/research institutions of higher education, colleges, technical colleges and schools. In 2001, more than 150 samples were distributed to different users.

The International Flax Database (IFDB)

M. Pavelek gave general information about the International Flax Database (IFDB), that has been managed and coordinated by the AGRITEC company since 1994 and includes data for 1416 accessions, stored in 13 contributing genebanks in 11 countries. These are described by 22 passport and 25 specific characterization and evaluation descriptors. He indicated that the contents of the database are estimated to be 5% of the total number of accessions (possibly around 25 000) in storage in Europe. He said that passport data are included in the database for 82% of the accessions, while only 16% are described by characterization descriptors. In order to evaluate flax genetic resources properly, a set of standard varieties including both fibre and linseed varieties was defined and their relevance to the respective trait's expression was published (see list p. 26).

Use of FAO/IPGRI Multicrop Passport Descriptors

M. Pavelek showed the group the list of passport descriptors originally agreed for the IFDB in 1994 and asked whether these should be maintained or modified.

L. Maggioni reminded the group that a list of FAO/IPGRI *Multicrop passport descriptors* (MCPDs) was agreed for data exchange by the European database managers in 1996[5], and has since been adopted by most of the central crop databases in Europe. He also explained that the revision of the MCPDs was almost complete and that the new version would be used as a basis for the upcoming European Internet Search Catalogue (EURISCO).[6]

After discussing internationally standardized multicrop passport descriptors, the group agreed on the following:

Recommendations

- *To use for the IFDB the EURISCO passport data based on the new version of the FAO/IPGRI MCPDs and expected to be finalized and distributed by IPGRI at the beginning of 2002.*[7]
- *To add the following passport descriptors:*

Year of release [YYYY]
Year of release of the cultivar, or year of registration
Type of use
1. Flax
2. Linseed
3. Combined/Intermediate
Pedigree
Parentage or nomenclature, and designations assigned to breeder's material.

Discussion on further development of the database

The group agreed that the compilation of passport data for all the accessions held in European genebanks would be the first priority for the development of the IFDB and that the addition of characterization/evaluation data would also be recommended in a subsequent

[5] See Lipman, E., M.W.M. Jongen, Th.J.L. van Hintum, T. Gass and L. Maggioni, compilers. 1997. Central crop databases: Tools for plant genetic resources management. International Plant Genetic Resources Institute, Rome, Italy/CGN, Wageningen, The Netherlands.

[6] See also <http://www.ecpgr.cgiar.org/epgris/index.htm>.

[7] The new list is now available at <http://www.ipgri.cgiar.org/system/page.asp?frame=catalogue/select.asp>.

phase. The following was agreed:

Workplan

- *All participants will make sure that the passport data of their national collections (cultivated and wild species) are sent to the IFDB database manager within one year from receipt of the finalized agreed format, to be distributed by M. Pavelek to all participants.*
- *M. Pavelek will also contact other holders of flax genetic resources, with a request to forward their passport data to the IFDB. In particular, a request will be sent to the UK, the Nordic Gene Bank and the Baltic States, as well as, in a second stage, to Canada and the United States.*

Considering the importance of Belarus for flax breeding and the likely existence of breeding stations holding valuable local material, V. Virovets stressed the importance of including the related passport data in the IFDB. N. Brutch agreed to send further information to the ECP/GR coordinator and the IFDB database manager in order to establish a fruitful contact with Belarus for flax genetic resources.

Inclusion of characterization/evaluation data

The participants considered that they could realistically aim at including in the common database only a small number of agreed characterization data.

Considering that the cost of planting the seeds of the collections and all the standard varieties would not be sustainable for most genebanks, it was agreed that the group would initially aim at including in the IFDB only an initial set of a few characters. A set of characters useful for breeders and less dependent on environmental factors, for which most genebanks have already collected data, was chosen.

Workplan

*Participants will make sure that characterization data for their national collections are sent to the IFDB **by the end of 2003**, for the following characters:*

- **Petal colour: colour of corolla (when fully developed)**
  1 White
  2 Light blue
  3 Blue
  4 Pink
  5 Red violet
  6 Violet
- **Seed colour**
  1 Yellow
  3 Light brown
  5 Brown
  7 Dark brown
  9 Green
- **Anther colour**
  1 Yellowish
  2 Bluish
  3 Greyish
  4 Orange
- **Flower – size of corolla**
  3 Small
  5 Medium
  7 Large
- **Flower shape**
  1 Regular
  2 Star
  3 Semi-star
- **1000-seed weight [g]**
  (In grams, to two decimal places)

The complete IFDB characterization and evaluation descriptors for *L. usitatissimum,* approved by the FAO/ESCORENA Working Group on Breeding and Genetic Resources in 1998 and revised according to IPGRI standards was made available, after the meeting, from the entry page of the IFDB at http://www.ecpgr.cgiar.org/databases/Crops/flax.htm. It was suggested that participants use this list as far as possible for characterization purposes, but the use of standard varieties needs to be further discussed. Indeed, the group expressed the opinion that the list proposed within the ESCORENA WG is too long for practical implementation in the field trials.

Cooperation with the FAO/ESCORENA Flax and other Bast Plants Network

M. Pavelek summarized the activities of Working Group 1 that started its activity in 1989 and was created as an individual group for breeding and genetic resources during the workshop in Bonn in 1993. The first meeting of the group was held in Poznań, Poland in 1993; the IFDB was then established and its management assigned to AGRITEC Sumperk (Czech Republic). The first structure of the passport descriptor list was also developed during this meeting. During the following four meetings, the IFDB was further developed and it now includes 1416 accessions of 13 collection holders. During the fifth meeting in St. Petersburg, Russian Federation, the standard varieties to be used for characterization and evaluation activities were discussed at length and resulted in a list of 17 flax and 24 linseed varieties.

M. Pavelek agreed to keep the ESCORENA network informed about the ongoing activity on flax within ECP/GR.

EU proposal "EuroBioFlax" (EBF)

M. Pavelek said that an international project called "Utilization of European flax germplasm biodiversity for improving and increasing sustainable flax production in Europe" (EuroBioFlax, EBF) had been submitted for funding on 18 October 2001 to the European Commission within the 5th Framework Programme.[8] The project has the following objectives:

- to combine and complete knowledge of European flax germplasm collections and to provide the users with the data;
- to standardize the methods of evaluation, description and characterization in the International Flax Database;
- to identify probable duplicate accessions maintained under synonymous names;
- to use molecular methods to identify duplicated (redundant) flax germplasm in the International Flax Database and to work towards the development of a European flax "core" collection.

[8] In January 2002, M. Pavelek informed the project partners that the evaluation panel of the European Commission acknowledged the importance and European significance of the proposed research. However, the project did not reach an overall evaluation threshold sufficient to consider the project for funding.

Use of available funds for flax genetic resources actions

L. van Soest said that the Steering Committee of ECP/GR approved some funding for PGR activities for flax collection holders. The funding made available was US$ 19 000 and could be used for the establishment of the database and for characterization work. A proposal for the distribution of the funds based on the size of the different collections and the need for data documentation and characterization was discussed. It was proposed to split the funds into an advance payment in 2002 and a final payment in 2003. The final payment would only be made to countries after they submitted substantial sets of passport data to the IFDB and an agreed set of characterization data. The group accepted the proposal and it was outlined that ECP/GR would make contracts with the countries concerned. The ECP/GR coordinator will enter in contact, after consultation with the country coordinators, with the appropriate national institutions (Bulgaria, Czech Republic, Hungary, Poland, Romania, Russia and Ukraine) who would then sign letters of agreement with IPGRI. In case the Eurobioflax project is approved, the group agreed that the partners of the EU project would not receive ECP/GR funds.

Application to the ECP/GR Steering Committee to become an official Working Group

The group thought that it would be useful to submit a request to the Steering Committee of ECP/GR to formalize the establishment of a Working Group on Flax, in order to guarantee that it would meet again in the future.

It was also suggested that in the Flax Working Group, hemp and other fibres could be included. However, it was felt that in many countries it would be difficult to identify experts working on flax, hemp and other fibre crops at the same time.

It was agreed that a submission would be made to apply for the establishment of a Working Group on Flax. L. van Soest and M. Pavelek will prepare a letter describing the progress made by the *ad hoc* group and the reasons for setting up this Working Group. The letter will be sent no later than February 2003 to the ECP/GR coordinator who would include it among the background documents in preparation for the Steering Committee meeting to be held in October 2003.

The group agreed on the need to hold a meeting in 2004. The representatives of Bulgaria and Poland offered to organize this meeting and the group thankfully agreed to take these offers into consideration in due time.

Conclusion

The section *Discussion and Recommendations* of the report was presented to the participants and was approved with minor modifications.

It was agreed that M. Pavelek would act as Chairman of the a*d hoc* group, with the help of L. van Soest, until its next meeting.

M. Pavelek thanked all the participants who had handed in diskettes with their collection’s current passport data (Bulgaria, Netherlands, Poland, Russia–only Russian accessions). This was considered a great step ahead towards the development of the IFDB. He also thanked all the participants for their active contribution and hoped for a continued and fruitful collaboration.

Part II. Presented Papers

Status of the Bulgarian national flax collection

Docho Shamov
Institute for Plant Genetic Resources (IPGR), Sadovo, Bulgaria

The Institute for Plant Genetic Resources in Sadovo is responsible for the collecting, conservation, documentation and evaluation of the flax germplasm in Bulgaria.[9] The Institute is located in the Thracian plain in central southern Bulgaria, 20 km from Plovdiv, at an elevation of 141 m asl and latitude 42º07'N/24º56'E. The mean annual temperature is 12.4ºC and annual precipitation 410 l/m² (Velev 1990).

Composition of the national collection

The IPGR genebank holds 945 *Linum* accessions, 516 of which are kept in long-term storage at -18°C, vacuum-packed in aluminium foil bags (Fig. 1). The majority of the accessions (156) were stored in 1994. About 15% of them are duplicated at the Institute in Sadovo and 30% are in the active collection of the experimental station for potatoes and flax in Samokov.

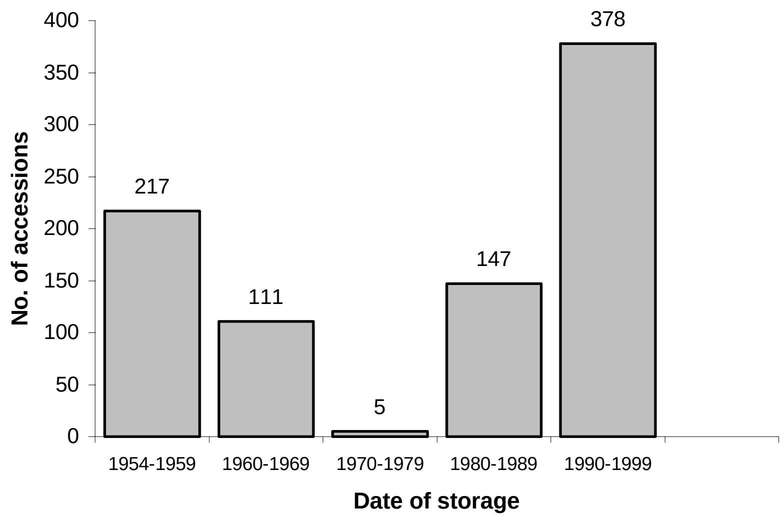

Fig.1. Accessions stored at the IPGR genebank (1954-1998).

Taxonomic composition

Beside *Linum usitatissimum,* which constitutes the majority of the collection (928 accessions) the IPGR genebank holds 12 other *Linum* species, represented by 17 accessions (Table 1).

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9 The AgroBioInstitute in Kostinbrod also holds a flax collection (see paper by A. Balabanova and A. Atanassov, pp. 19-21).

Table 1. *Linum* species stored at the IPGR genebank

Species	No. of accessions
L. usitatissimum	928
L. altaicum	1
L. austriacum	1
L. bienne	4
L. flavum	1
L. grandiflorum	1
L. humile	1
L. perenne	1
L. punctatum	1
L. setaceum	1
L. strictum	2
L. trigynum	2
L. viscosum	1
Total	**945**

Origin of the accessions

The great majority of accessions (97%) are of foreign origin and only 3% are local. The countries most represented are Russia, with 192 accessions, Germany (187) and Hungary (130) (Table 2).

Table 2. Distribution of flax accessions by country of origin

Country of origin	No. of accessions
Russia	192
Germany	187
Hungary	130
USA	68
France	46
Poland	45
Canada	32
Holland	32
Portugal	30
Bulgaria	27
Czech Republic	27
Romania	27
Other	50

Status of sample

Accessions are divided between landraces and primitive cultivars (58%), advanced cultivars (15%), breeder's lines 14%), wild forms (2%) and unknown (11%) (Fig. 2).

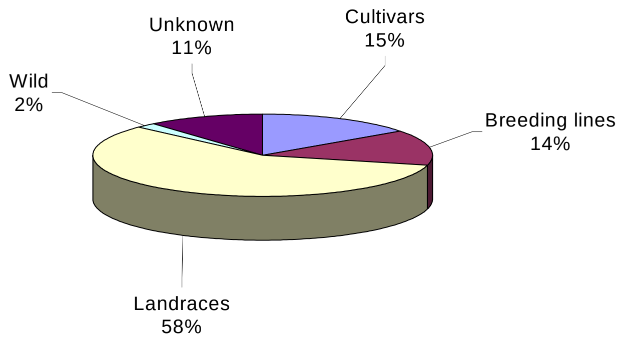

Fig. 2. Distribution of flax accessions according to status of sample.

Type of use

Flax accessions belong to the three main groups: linseed 23%, fibre flax 29% and intermediate type 46% (Fig. 3).

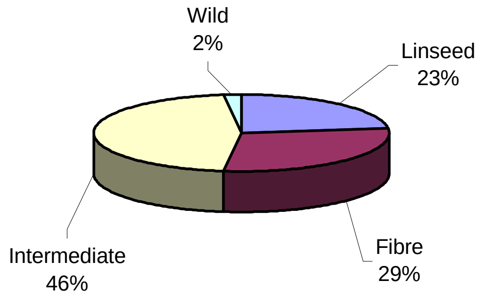

Fig. 3. Distribution of flax accessions by type of use.

Evaluation

The material is evaluated for morphological, biological and some agronomic characters according to the IFDB descriptor list (Pavelek 1995). Average values displayed by the accessions according to their origin (Table 3) show that the fibre flax cultivars from Poland and the Netherlands, with 56.30 cm and 54.20 cm respectively, have the highest technical stem length. Samples from Romania are typical linseed types with the following values: boll number per plant 18.2; 1000-seed weight 6.0 g; crude oil content 37.18%. Accessions from Germany and most of those from Bulgaria belong to the intermediate type. Characteristics of Bulgarian accessions are listed in Table 4.

Table 3. Characteristics of flax accessions according to country of origin

Country of origin	Technical length (cm)	Boll number/ plant	Seed yield/plant (mg)	Straw yield/plant (mg)	1000-seed weight (g)	Crude oil content (%)
Russia	51.30	12.7	445	795	4.3	33.18
Germany	47.90	16.9 a	689	1079	5.6 a	35.16
Hungary	42.20	15.0	603	983	5.9 b	34.08
USA	45.30	15.3	588	944	5.3	34.56
France	53.80 a	15.3	767 b	1251 c	4.8	34.01
Poland	56.30 b	14.4	585	1045	4.5	33.90
The Netherlands	54.20 a	11.4	438	882	4.3	35.08
Czech Republic	53.20 a	16.0	697	1115 a	5.3	32.30
Romania	43.80	18.2 c	707 a	1057	6.0 b	37.18 c
Bulgaria	47.70	15.9	678	984	5.1	34.28
Mean value	**49.57**	**15.1**	**620**	**1013**	**5.1**	**34.37**

a: P=5%
b: P=1%
c: P=0.1%

Table 4. Characteristics of the Bulgarian accessions

No.	Accession	Technical length (cm)	Boll number/plant	Seed yield/plant (mg)	Straw yield/plant (mg)	1000-seed weight (g)	Crude oil content (%)
1	95BM6*	55	16	600	1000	5.0	35.60
2	95502014	45	20	700	1000	5.0	36.07
3	95502015	53	23	800	1400	5.5	33.40
4	95502016	46	11	550	650	4.5	34.72
5	95502019	53	18	750	1200	4.5	32.54
6	95502020	45	18	750	1100	6.0	37.40
7	95502021	50	16	750	1100	6.5	35.92
8	95502022	49	14	750	1050	4.0	31.49
9	95502024	46	12	553	730	6.0	32.08
10	95502025	46	13	550	720	6.0	33.30
11	95502038	47	18	950	1400	4.5	35.62
12	95502039	44	17	800	900	4.5	31.87
13	95502066	48	15	600	1020	4.5	-
14	95502067	50	16	650	950	5.0	34.88
15	90502045	38	12	420	540	5.5	35.01

* 95BM6 is the Bulgarian fibre flax standard = cultivar 'Kaliakra' with a technical stem length of 55 cm.

Collecting activities

During the past years the activity of IPGR-Sadovo was largely directed towards enrichment of the collection with germplasm of local origin (old varieties and populations, wild species). Evidence gathered by Stoyanov and Kitanov (1967) and Yordanov (1963, 1976) shows that 19 species of flax including 9 subspecies and 10 varieties are represented in the Bulgarian flora. During systematic expeditions in major floristic regions of the country the following *Linum* species were collected: *L. austriacum* L., *L. bienne* Mill., *L. catharticum* L., *L. flavum* L., *L. hirsutum* L., *L. nervosum* Waldst. et Kit., *L. tauricum* Willd., *L. tenuifolium* L. and *L. thracicum* (Griseb.) Deg. (Table 5). The perennial species *L. tauricum, L. austriacum* and *L. tenuifolium* are very common along the Black Sea coast. Valuable data on habitats, regions of distribution and population dynamics have been collected for these species.

Table 5. *Linum* species collected in Bulgaria

Species of the Bulgarian flora	Collected
L. alpinum Jacq.	
L. austriacum L.	+
L. bienne Mill.	+
L. capitatum Kit. ex S.	
L. catharticum L.	+
L. corymbulosum Reichenb.	
L. elegans Sprun. ex Boiss.	
L. extraaxillare Kit.	
L. flavum L.	+
L. hirsutum L.	+
L. hologynum Reichenb.	
L. nervosum Waldst. et Kit.	+
L. nodiflorum L.	
L. pallasianum Schult.	
L. tauricum Willd.	+
L. tenuifolium L.	+
L. thracicum (Griseb.) Deg.	+
L. trigynum L.	
L. uninerve (Roch.) Borb.	

Documentation

All accessions are documented for passport data using dBase III+ software and evaluation data are currently being entered in the database.

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Preservation, evaluation and utilization of *Linum* L. germplasm in the AgroBioInstitute, Kostinbrod, Bulgaria – Current status and strategy

Alexandra Balabanova and Atanas Atanassov
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Introduction

Situated in the southeastern part of the Balkan Peninsula, the territory of Bulgaria is characterized by extremely diverse relief, soil and climatic conditions, which have resulted in a great diversity of wild species and landraces and allow the cultivation of many crops (Atanassov 2001).

The Bulgarian flora includes 19 species of the genus *Linum* L. Some species, e.g. *L. elegans* Sprun. ex Bois and *L. thracicum* (Griseb.) Deg. are endemic to the Balkans (Yordanov and Kuzmanov 1979). *Linum usitatissimum* L. is represented by populations located mainly in mountainous regions, river valleys and the Black Sea coast.

The Bulgarian *Linum* collections held by the Institute for Plant Genetic Resources (IPGR), Sadovo[10] and the AgroBioInstitute (ABI), Kostinbrod, include old cultivars, landraces, advanced cultivars, populations and wild species. The material is conserved both *in situ* and *ex situ*. The collections contain fibre flax, linseed, intermediate and other types of *L. usitatissimum* L. Long–term (IPGR-Sadovo) and short–term (IPGR-Sadovo and ABI-Kostinbrod) conservation are carried out according to the standard requirements (Balabanova and Lozanov 1998; Balabanova 2000; Koeva *et al.* 2001).

Composition of the ABI flax collection

The ABI *Linum* L. collection includes a total of 283 accessions, of which 178 were received from IPGR-Sadovo, 29 from other Bulgarian institutions and 71 from foreign institutions. Five are the breeding materials of ABI.

Status of sample

The collection includes accessions of the following types: cultivars (55.1%), landraces and primitive cultivars (28.6%), breeding lines (15.2%), wild species (1.1%) and genetic stocks (2.5%).

Type of use

The material is distributed as follows: fibre flax (31.0%), linseed (34.8%), intermediate (31.9%) and other types (2.3%).

Origin of the accessions

Accessions originate from Europe, Asia, Africa and America. Bulgarian accessions represent only 6.4% of the collection.

[10] For details on IPGR collection see previous paper by D. Shamov, pp. 14-18.

Description and evaluation

Passport descriptors

Passport data of the collection are recorded according to the International Flax Database (IFDB) descriptors (Rosenberg 1993).

Characterization descriptors

The majority of the accessions (259) are described for 15 morphological, 5 biological and 4 agronomic characters according to UPOV descriptors (UPOV 1991, 1995), IFDB descriptors (Pavelek 1994, 1995) and specific descriptors for *L. usitatissimum* L. (Kutuzova *et al.* 1987). The different types of accessions and their quality were evaluated on the basis of their anatomical structure. Linseed and intermediate type accessions were analyzed by biochemical methods for their oil and protein content, Cd accumulation and fatty acid composition of oil according to ISO standards. Fibre quality evaluation of flax varieties was carried out according to Bulgarian standards.

Achievements

1. Creation of a working collection including fibre flax, linseed and intermediate types; this collection will be the basis for the development of a selection programme for *Linum usitatissimum* L.
2. Tests carried out to evaluate the degree of distinctness, uniformity, stability and agronomic and processing characters of flax and linseed.
3. Development of a scale for Bulgarian standard types.
4. Identification of selection targets for flax and linseed under Bulgarian conditions.
5. Identification of 11 advanced foreign varieties of flax and linseed to be recommended for official testing.

Strategy

1. Further development of the ABI collection and of up-to-date methods for the preservation of important *Linum* accessions for specific breeding objectives.
2. Evaluation of the material for biotic and abiotic stress tolerance.
3. Molecular, cytogenetic and biochemical evaluation and identification of existing and new accessions.
4. Development of a comprehensive information system for flax genetic resources and establishment of links with the international flax genetic resources networks.

Needs and areas of cooperation

1. Adoption and development of advanced methods for flax genetic resources evaluation and identification.
2. Establishment of a comprehensive flax genetic resource database.
3. Development of international links and intensification of collaboration with other institutes working with flax.
4. Integration and active participation in international flax genetic resources networks.

Conclusion

It is planned to further develop research and breeding work on flax and linseed in the context of a modern programme for flax genetic resources evaluation, identification and preservation.

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Status of the Czech national flax collection and management of the International Flax Data Base within the framework of the FAO/ESCORENA Flax and other Bast Plants Network

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This report presents the status of the Czech flax collection, the evaluation, description, maintenance and utilization of flax genetic resources, and the management of the International Flax Data Base (IFDB) within the framework of the FAO/ESCORENA Flax and other Bast Plants Network. Opportunities for closer cooperation with ECP/GR networks are also discussed.

The Czech national flax collection

The Czech national flax collection (*Linum usitatissimum* L.) has been managed by AGRITEC Ltd. in Šumperk since the 1960s. Work on flax genetic resources is financially supported by the Czech Ministry of Agriculture as part of the National Programme of maintenance and conservation of crop genetic resources, coordinated and managed by the Research Institute of Crop Production in Prague-Ruzyne (RICP). RICP also hosts the central genebank where genetic resources of all crops, including flax, are maintained.

Part of the flax collection is sown annually in order to regenerate the accessions, to record passport and other descriptive data and to entrust the multiplied accessions to the central genebank in Prague for long-term storage. The genebank in RICP is run by the Division of Genetics and Plant Breeding. The National Programme for plant genetic resources conservation and utilization coordinated by this institute covers all essential activities on plant genetic resources (PGR) in the Czech Republic. Within this programme the genebank deals with the gathering of plant genetic resources and their exchange with similar institutions abroad. The national documentation system EVIGEZ developed at RICP (Faberová 1998) is used for PGR documentation purposes in the whole country as well as in Slovakia. The genebank ensures maintenance of all seed-propagated collections in the country. Seed samples accompanied by relevant information are distributed to users free of charge. The genebank is equipped with all necessary equipment for drying, control and long-term storage of accessions. Flax accessions are kept in glass jars at -5°C (active collection) and -15°C (base collection). Moisture content of the seed is reduced to 5% in both collections.

Composition of the collection

The national flax collection maintained by AGRITEC is one of the largest European collections. It holds 2011 accessions of flax, linseed, combined/intermediate types and other types.

Geographic origin of the accessions

The main part of collection is made up of European accessions, followed by accessions from America, Asia, Africa, USA and Australia (Table 1).

Status of sample and type of use of the material

The composition of the Czech flax collection according to the status of sample and type of use of the material is given in Table 2.

Table 1. Geographic origin of the accessions in the Czech national flax collection

Origin	No. of accessions
Northern Europe	122
Central Europe	680
Southern Europe	37
Western Europe	285
Eastern Europe	440
Total Europe	1564
North America	142
South America	139
Total America	281
Asia	88
Africa	73
Australia	5
Grand total	**2011**

Table 2. Distribution of accessions in the Czech flax collection according to status of sample and type of use

	No. of accessions (%)
Type of sample	
Landraces and primitive forms	26
Breeding material	24
Varieties	50
Type of use	
Flax	53
Linseed	39
Both types	8

Documentation

The flax national collection is described according to the *Linum* Descriptor list (Pavelek 2002) for 22 passport descriptors (data available for 1885 accessions, i.e. 93.73% of total) and 55 other descriptors covering morphological and biological traits and yield characteristics (data available for approximately one-third of the accessions).

Passport data

A national accession number (ECN) is assigned to each accession. This number, consisting of the code of the holding institution, crop code and serial number of the accession within the collection, is a unique identifier. Passport data provide information on taxonomy, cultivar name, country of origin, status of sample, year of inclusion in the collection, breeder, institution, etc. Many passport data are encoded and all necessary coding tables are incorporated in the passport data section. This section is well designed in terms of data input, options and variable outputs. Flax genetic resources are described in agreement with the national documentation system EVIGEZ, using the passport descriptors listed below.

Passport descriptors used for the Czech flax collection

National accession number
Country of collection holder
Botanical characteristic
Variety, GR name
Country of origin
Donor country
Identification number of donor country
Origin
Breeding method
Year of inclusion in the collection
Type of vegetation
Life cycle (annual, biennial, perennial)
Introduction number
Year of breeding process termination
Year of registration in country of origin
Year of restriction in country of origin
Breeding company
Pedigree

Additional information related to passport data

Number of trials
Last year of evaluation
Region code
ECN of the check cultivar

Characterization and evaluation data

This section contains the results of detailed evaluation of all other characteristics. These data are crop-specific. All characterization and evaluation data are recorded on a 1-9 scale, using the descriptor list for the respective genus according to rules for scoring the manifestation of each trait. These descriptor lists are developed in collaboration with collection curators on the basis of international IBPGR/IPGRI and COMECON descriptor lists, with additional region-specific characters (Faberová 1998). As already mentioned the descriptor list for *Linum usitatissimum* L. (Pavelek 2001) includes 55 characterization and evaluation descriptors describing morphological and biological traits and yield-related data, recorded according to the above-mentioned evaluation scale. They are listed below.

Characterization and evaluation descriptors used for the Czech flax collection

Morphological characters

Stem – plant natural height
Stem – technical length
Stem – branching
Stem – number of branches
Stem – branching base
Stem – position of top
Stem – thickness
Cotyledon – shape
Cotyledon – size
Leaf – size
Leaf – shape
Leaf – colour
Leaf – anthocyanin colouring
Flower – diameter of corolla
Flower – corolla shape in horizontal section
Flower – corolla shape in vertical section
Flower – petal colour
Flower – petal length
Flower – petal shape
Flower – petal tips
Flower – petals vein colouring
Sepal – length
Sepal – tips
Sepal – shape
Sepal – colour
Sepal – dotting
Sexual organs – position
Sexual organs – stigma colour
Sexual organs – anther colour
Capsule – shape
Capsule – shape at base
Capsule – size
Capsule – dehiscence
Capsule – anthocyanin colouring
Capsule – septa hairiness
Capsule – number per plant
Seed – colour
Seed – shape
Seed – 1000-seed weight (TSW)

Biological characters

Days to flowering: sowing – beginning of flowering
Days to maturity: sowing – maturity
Speed of rapid growth
Lodging resistance
Emergence influenced by pathogen complex
Resistance to pathogen complex
Resistance to wilt (*Fusarium oxysporum* f.sp.*lini*)

Agronomic characters

Stem yield (% of standard variety)
Seed yield (% of standard variety)
Oil content in dry seed matter (% of standard variety)
Oil yield (% of standard variety)
Fibre yield (% of standard variety)
Linolenic acid content in dry matter (in absolute value)

The International Flax Data Base (IFDB)

The International Flax Data Base (IFDB) has been managed and coordinated by the AGRITEC company since 1994 according to the rules published for the IFDB management (Pavelek 1995, 1997, 1998).

Composition of the IFDB

Origin of the accessions in the IFDB according to contributing country

The IFDB contains a total of 1416 accessions. Contributing countries and their respective number of accessions are listed in Table 3.

Table 3. Composition of the IFDB according to contributing country

	Accessions included	
Contributing country	**Number**	**%**
Bulgaria	10	1
Czech Republic	100	7
France	62	4
Germany	178	13
Ireland	14	1
The Netherlands	56	4
Poland	59	4
Romania	48	3
Russia	482	34
Ukraine	38	3
USA	369	26
Total	**1416**	**100**

Status of sample and type of use of the material

The composition of IFDB according to status of sample and type of use is given in Table 4.

Table 4. Current composition of the IFDB according to status of sample and type of use

	No. of accessions in the IFDB (%)
Status of sample	
Advanced cultivars	38.5
Genetic stocks	27.0
Breeding material	20.3
Landraces, primitive and wild forms	14.2
Type of use	
Fibre	50.2
Linseed	33.7
Intermediate types	10.6
Other types	5.5

Documentation

The majority of accessions (82%) are currently described for 22 passport descriptors, while 16% are described only by 25 other characterization and evaluation descriptors covering morphological traits (14), biological traits (5) and yield characters (6) (Pavelek 1995, 1997). The revised version of the IFDB descriptor list is given as Appendix I to this report, pp. 72-73.

Coverage of European collections in the IFDB

Only a very small part (approximately 5%) of the European flax genetic resources are included to the International Flax Data Base. The total European genepool is estimated at approximately 25 000 accessions. It is expected that a new, updated version of the IFDB will include data for over 12 000 accessions maintained in European genebanks.

Standard varieties for evaluation

In order to evaluate flax genetic resources and varieties, a set of standard varieties including both fibre and linseed varieties was submitted and their relevance to the respective trait's expression published (Pavelek 1998). These standard varieties are listed below.

- **Fibre flax**

Viking	Tomskij 16	Novotorzhski
Ariane	Texa	Svetoch
Opaline	Jitka	Slavnyj 82
Regina	Laura	Orshanskii 2
Reina	Belinka	Torzhokskii
Natasja	Merkur	I-7
Zareckij krja•	Nike	K-6

- **Linseed**

Liflora	Deep Pink	Olin
Amazon	Geria	Sandra
Mikael	Iris	SZ 30
Antares	Azur	Ica 32
Hella	Gentiana	Flanders
Kreola	Slavnyi 82	ED-40
Blue Chip	BR 1	
Ocean	Midin	

EuroBioFlax

In order to increase the usefulness of IFDB for end-users and the effectiveness of work on flax genetic resources, an international project called "Utilization of European flax germplasm biodiversity for improving and increasing sustainable flax production in Europe" (EuroBioFlax, EBF) has been submitted to the 5th EU Programme with the following goals:

Major aim

The major aim of the project will be to contribute to better organization and utilization of European flax genetic resources in breeding programmes regarding the following aspects:
- to standardize the methods of evaluation, description and characterization in the framework of the IFDB;
- to combine and complete knowledge about European flax germplasm collections and to provide breeders with the respective data;
- to identify accessions maintained under synonymous names;
- to avoid duplicated (redundant) flax germplasm in the framework of IFDB on the basis of molecular methods;
- to characterize flax genetic resources in different climatic conditions with regard to disease resistance as well as fibre content, yield and quality, seed yield, oil content and quality;
- to screen for useful traits to be included in new flax varieties in order to satisfy market demands.

Specific objectives

The specific objectives of this project, aimed at improving the whole process of work on flax genetic resources in Europe, will be carried out as follows:

1. **Update and generate a new version of the IFDB including current and newly obtained passport and characterization data in order to make flax PGR more readily accessible to potential users such as researchers and plant breeders.**
   The system of flax germplasm evaluation, description and characterization is not uniform, either in Europe or in the USA and Canada, and differs according to breeders' requests in each country. In order to exploit the richness of flax genetic diversity, a good system of evaluation, description and characterization is necessary. This system should be standardized, at least in European countries. The International Flax Data Base established within the framework of the FAO/ESCORENA Flax and other Bast Plants Network can be considered as a preliminary step to solve this problem. However, the IFDB lacks data about several European collections and the further development and subsequent accessibility of the IFDB will be an important task of this project. The accessions recorded in the database will be described, characterized and evaluated according to the IFDB descriptor list and the data will be loaded onto the Internet in order to become available to a large number of users. The IFDB will be the basis for the development of a core collection (IFDB-CC) of approximately 250 accessions.
2. **Rationalize individual European flax collections, utilizing image analysis of agromorphological traits and molecular methods for tracing and eliminating redundant accessions; thus, only unique germplasm would be maintained in Europe and recorded in the IFDB.**
   On the basis of data analysis of accessions recorded in the IFDB, identification methods will be applied in order to reduce the number of records that can be considered as identical. Different identification methods will be used to fulfil this objective, including computer–assisted image analysis of seed morphology or surface micromorphology using a scanning microscope. Digital photography will be used to document cultivar and genotype differences in the anatomy and morphology of shoot parts. In addition, a set of characteristic DNA markers for flax genomic sequences will provide the basis for: i) future automated discrimination and identification of flax and linseed cultivars or genotypes used in breeding and improvement processes; ii) future automated testing of cultivar purity in commercial lots; iii) identification of cultivars and duplicated flax germplasm in national databases and the IFDB; and iv) image documentation within national and international flax descriptors.
3. **Screen all material of an initial prototype collection (IFDB-PC) containing 400 accessions to identify a final core collection (IFDB-CC) of 250 accessions with useful agronomic properties, including disease resistance and fibre quality; this screening will also be carried out by molecular means, and will lead to a core collection including as much genetic diversity as is available in European flax germplasm.**
   Initial data obtained as a result of characterization and evaluation by individual partners will be analyzed and the accessions will be divided into groups according to their abilities and characteristics, covering the widest genetic variability. This will be the basis for the establishment of the IFDB prototype (IFDB-PC). Furthermore within IFDB it is planned to establish an IFDB prototype collection of about 400 accessions chosen on the basis of individual collections, in particular with respect to disease resistance (*Fusarium oxysporum* f.sp. *lini, Rhizoctonia solani, Oidium lini*) and agronomic traits. The creation of the IFDB core collection (IFDB-CC) at the end of the IFDB project will gather the diversity of flax accessions maintained in European genebanks and contribute to the screening of material required for breeding programmes.

4. **Start (pre-) breeding programmes focused on properties required for new markets with selected genetic resources from the core collection, including sources of disease resistance and (fibre) quality parameters.**
   In order to fulfil new market demands, flax genetic resources as well as varieties with requested traits will be chosen and included into the breeding programmes. For this purpose it is necessary to have a good knowledge of the agronomic potential of each accession, such as resistance to *Fusarium oxysporum* f.sp. *lini*, fibre content and yield, seed yield, oil content and fatty acid composition. Molecular markers can be helpful for the evaluation. However, the methods of evaluation will be simplified and applied by individual partners according to their specialization and breeding aims.

Conclusions

- In 2001, the Czech national flax collection contained 2011 accessions. It is still being developed in order to cover the widest possible genetic diversity of *Linum usitatissimum* L.
- The International Flax Data Base currently covers a very small proportion of European flax germplasm and it should be further developed. In order to reach this goal, all members of the ESCORENA Working Group 1 (Genetic and Breeding Resources) are asked to provide IFDB with further passport and characterization data of new accessions.
- The international project EuroBioFlax (EBF) "Utilization of European flax germplasm biodiversity for improving and increasing sustainable flax production in Europe" has been submitted to the 5th EU Programme with the aim of increasing the effectiveness and usefulness of work on European flax genetic resources.[11]

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[11] Update provided January 2002: the evaluation panel of the European Commission acknowledged the importance and European significance of the proposed research. However, the project did not reach an overall evaluation threshold sufficient to consider the project for funding.

The French flax and linseed germplasm collections—status 2001

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The INRA collection

The French flax and linseed germplasm collection maintained by the INRA flax breeding laboratory contains about 1700 accessions, including about 50 INRA-bred lines. Guy Fouilloux (INRA-Versailles) and Daniel Dorvillez (INRA-Estrées-Mons) are in charge of the collection.

Origin of the accessions

The genetic resources were collected from 42 different countries but originate mainly from USA (360 accessions), Argentina (327), former Soviet Union (192) and France (108) (Table 1).

Table 1. Origin of *Linum* accessions in the French INRA collection

Country	No. of accessions	Code	Country	No. of accessions	Code
United States	360	USA	Australia	15	AUS
Argentina	327	ARG	Romania	12	ROM
Former Soviet Union	192	SUN	Former Czechoslovakia	12	CSK
France	108	FRA	Brazil	10	BRA
The Netherlands	73	NLD	Egypt	8	EGY
Canada	50	CAN	Turkey	7	TUR
Germany	43	GER	Denmark	6	DEN
Uruguay	39	URU	Chile	5	CHI
Hungary	35	HUN	Paraguay	5	PAR
Finland	35	FIN	Former Yugoslavia	4	YUG
Belgium	34	BEL	Italy	3	ITA
China	30	CHN	Venezuela	3	VEN
Ireland	28	IRL	Japan	3	JPN
India	25	IND	Peru	2	PER
Poland	25	POL	Kenya	2	KEN
Afghanistan	21	AFG	Iran	2	IRN
Bulgaria	19	BUL	Tunisia	2	TUN
Morocco	17	MAR	Greece	2	GRC
Portugal	17	PRT	Austria	1	AUT
United Kingdom	16	GBR	Cyprus	1	CYP
Ethiopia	15	ETH	New Zealand	1	NZL
			Unknown	81	NOC
Total number of accessions = 1696					

Type of use

The material is distributed as follows: 426 linseed, 273 flax and 207 intermediate *Linum* accessions. The other genotypes seem to have no agricultural value but they could be used as parents.

Management of the collection

This *Linum* collection is maintained according to the conservative breeding method (three lines per accession) and about one-fifth of the accessions are sown each year. Descriptions are thus completed and impurities or heterogeneous materials detected.

Documentation

The list of accessions and their passport data are available on the Internet at the following address: <http://www.inra.fr/Internet/Produits/Lin/index.htm>.

About 800 genotypes are almost fully described for 17 qualitative traits and 14 quantitative traits. The list of fields corresponding to these descriptors is given below.

Descriptor fields

Passport data
Name
Suffix
Origin
Breeder
Short name
Year of introduction

Seed traits
1000-seed weight
Seed colour
Beak shape

Flower characteristics
Sepal dotting
Petal colour
Striation
Petal shape
Petal size
Flower opening
Anther filament colour
Filament winding
Anther colour
Pollen colour
Style colour
Stigma colour

Boll traits
Ciliation
Size
Pigmentation

Plant height
At 20-days
At flowering
At maturity

Earliness
First flower
50% flowering
Maturity

Disease resistance or tolerance
Fusarium oxysporum
Oidium lini
(*Septoria, Polyspora*, burning)

Agricultural qualities
Lodging tolerance
Cold and winter tolerance
Miscellaneous characteristics

Technological qualities
Fibre content
Oil content

The genetic variation among the accessions is very wide. Examples are given in Table 2.

Table 2. Examples of genetic variation in the INRA *Linum* collection

Trait	Range
1000-seed weight	3.25 g - 12.75 g
Height at maturity	0.30 m - 1.25 m
Oil content	25% - 46%
Fibre content	13% - 45%

Descriptive data for the collection are held in a computerized database (Paradox 1.0). A descriptive card in French or English can be produced for each accession (Fig. 1).

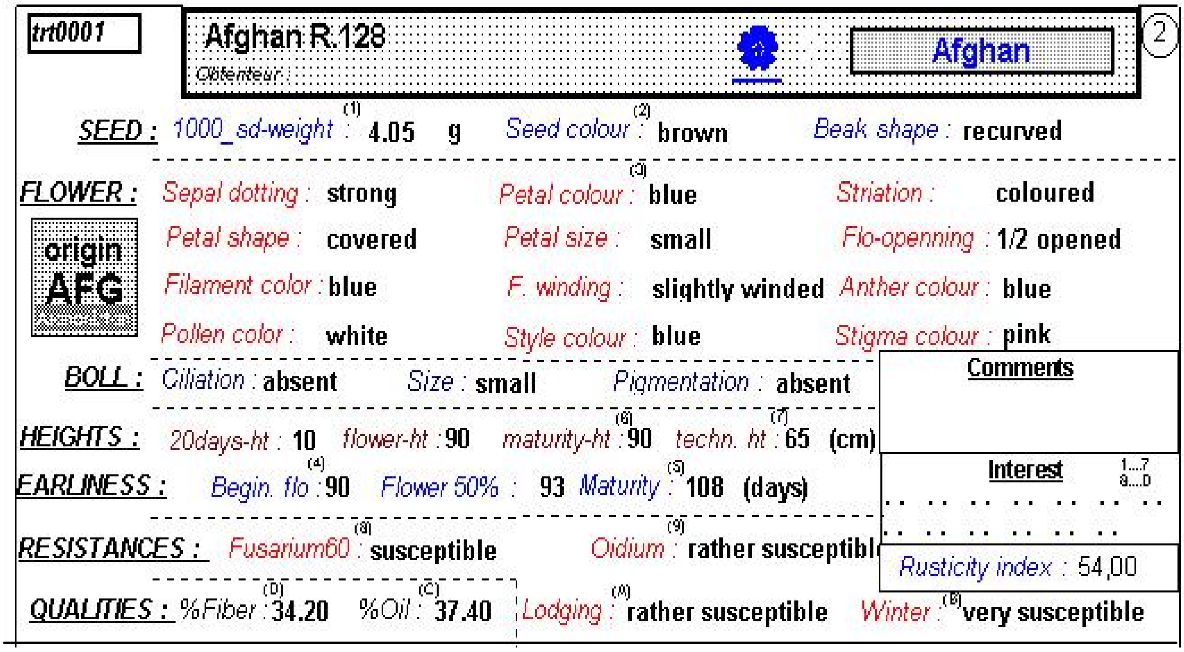

Fig. 1. Example of a descriptive card for a *Linum* accession in the INRA collections.

The GEVES collection

Another *Linum* collection is maintained at GEVES-La Minière (collection not available to the public). It contains European cultivars registered on the official European catalogue and old cultivars deleted from the catalogue.

Status report on the *Linum* collections in German genebanks

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The German Linum *collections*

The two German genebanks maintain a total of 2304 accessions of *Linum* genetic resources: the BAZ genebank in Braunschweig holds 621 accessions, and the IPK genebank in Gatersleben 1683 accessions.

Taxonomic composition

Almost 95% of these accessions (2181) belong to *L. usitatissimum*, the only crop species of the genus. This species actually constitutes—with the exception of four yet undetermined accessions—the entire BAZ collection, whereas the IPK collection also contains 85 accessions of at least 25 other species of the genus *Linum* (Table 1).

Table 1. Number of *Linum* accessions in German genebanks tabulated by species

Linum species	No. of accessions		
	BAZ	**IPK**	**Total**
L. alpinum Jacq.	-	1	1
L. altaicum Ledeb.	-	3	3
L. austriacum L.	-	16	16
L. campanulatum L.	-	1	1
L. capitatum Kit. ex Schultes	-	2	2
L. decumbens Desf.	-	2	2
L. elegans Sprun. ex Boiss.	-	1	1
L. flavum L.	-	9	9
L. grandiflorum Desf.	-	9	9
L. hirsutum L.	-	2	2
L. komarovii Juss.	-	1	1
L. leonii F. W. Schultz	-	1	1
L. lewisii Pursh	-	2	2
L. marginale A. Cunn. ex Planch.	-	2	2
L. mesostylum Juz.	-	2	2
L. narbonense L.	-	2	2
L. nodiflorum L.	-	2	2
L. pallescens Bunge	-	2	2
L. perenne L.	-	10	10
L. stelleroides Planch.	-	1	1
L. suffruticosum L.	-	1	1
L. tauricum Willd.	-	3	3
L. tenuifolium L.	-	6	6
L. thracicum Degen	-	2	2
L. trigynum L.	-	1	1
L. usitatissimum L.	617	1564	2181
Linum sp.	4	34	38
Total	**621**	**1683**	**2304**

Geographic origin

With respect to the origin of the material, Russia and the former USSR (RUS/SUN) with 184 accessions, and Germany (GER, DDR and DEU) with 177 accessions are the major donor countries, followed by Italy (87 accessions), Hungary (75), France (72), Iran (67) and Portugal (58). In total, 67 countries are listed as donors (BAZ 32, IPK 67) (Table 2). Regarding continents, Europe is the origin of almost 50% of the entries (1147 accessions), while Asia (179), America (154), Africa (82) and Australia (2) provided another 20%; 745 accessions are of unknown origin (Fig. 1).

Table 2. Number of *Linum* accessions in German genebanks tabulated by country of origin

		No. of accessions					No. of accessions		
Country	**Code**	**Total**	**BAZ**	**IPK**	**Country**	**Code**	**Total**	**BAZ**	**IPK**
Afghanistan	AFG	14	-	14	Italy	ITA	87	2	85
Argentina	ARG	52	24	28	Japan	JPN	13	1	12
Australia	AUS	6	-	6	Kazakhstan	KAZ	1	-	1
Austria	AUT	6	1	5	Kirghizstan	KGZ	1	-	1
Belgium	BEL	13	4	9	Libya	LBY	5	-	5
Bulgaria	BGR	52	1	51	Lithuania	LTU	3	-	3
Belarus	BLR	3	-	3	Latvia	LVA	14	-	14
Brazil	BRA	5	1	4	Morocco	MAR	19	5	14
Canada	CAN	25	12	13	Netherlands	NLD	42	31	11
Switzerland	CHE	3	-	3	Norway	NOR	1	-	1
Chile	CHL	4	-	4	Nepal	NPL	1	-	1
China	CHN	17	2	15	New Zealand	NZL	2	1	1
Columbia	COL	3	1	2	Pakistan	PAK	1	-	1
Canary Islands	CRY	1	-	1	Poland	POL	38	16	22
CSFR	CSK	30	13	17	Korean DPR	PRK	5	-	5
Cyprus	CYP	5	-	5	Portugal	PRT	58	1	57
DDR	DDR	6	4	2	Romania	ROM	34	4	30
Germany	DEU	144	71	73	Russia	RUS	5	-	5
Germany (before 1945)	GER	27	-	27	El Salvador	SLV	1	-	1
Denmark	DNK	29	26	3	USSR	SUN	179	88	91
Algeria	DZA	1	-	1	Slovakia	SVK	7	-	7
Egypt	EGY	10	3	7	Slovenia	SVN	1	-	1
Eritrea	ERI	2	-	2	Sweden	SWE	26	21	5
Spain	ESP	29	-	29	Tunisia	TUN	1	-	1
Estonia	EST	7	-	7	Turkey	TUR	46	2	44
Ethiopia	ETH	42	-	42	Taiwan	TWN	1	-	1
Finland	FIN	14	1	13	Ukraine	UKR	3	-	3
France	FRA	72	13	59	Uruguay	URY	21	4	17
UK	GBR	18	13	5	USA	USA	36	18	18
Georgia	GEO	7	-	7	Uzbekistan	UZB	7	-	7
Greece	GRC	20	-	20	Yugoslavia	YUG	8	-	8
Guatemala	GTM	1	-	1					
Croatia	HRV	1	-	1	Balkans*	BAL*	14	-	14
Hungary	HUN	75	25	50	Africa*	AF*	1	-	1
India	IND	21	2	19	America*	AM*	1	-	1
Ireland	IRL	13	7	6	Asia*	AS*	25	-	25
Iran	IRN	67	-	67					
Iraq	IRQ	1	-	1	Unknown		745	203	542
Israel	ISR	5	-	5					

Total number of accessions = 2304
(BAZ = 621 / IPK = 1683)

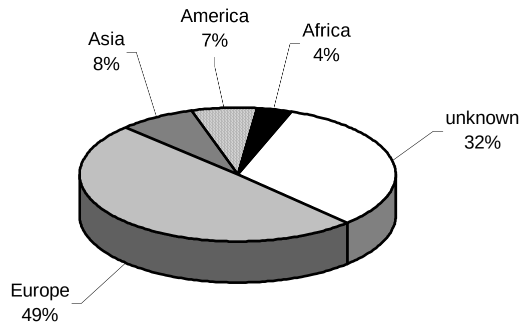

Fig. 1. Geographic origin of *Linum* germplasm in German genebanks (total: 2304 accessions).

Status of sample and type of use

Status of sample

In the active collection of the BAZ, modern varieties (72%) and breeding lines (21%) are predominant, whereas only a few landraces (6%) are represented. Modern varieties and breeding lines also form the majority of the IPK collection (total 44%; differentiation is not easy). Less than 1% landraces and 5% wild material are represented. The sample status of 50% of the accessions is unknown (Table 3).

Type of use

About equal numbers of oil (37%) and fibre (45%) types are maintained at Braunschweig; only 3% are classified as intermediate types. In Gatersleben, however, according to the classifications of Kulpa and Danert (1962), intermediate types predominate with 49%, followed by 27% fibre and 7% oil types. The usage of 17% of the accessions is not known (Table 3).

Table 3. Sample status and type of use of *Linum* germplasm in German genebanks

	No. of accessions		
	BAZ	**IPK**	**Total**
Sample status			
Advanced cultivar	449	742	1321
Breeder's line	130		
Landrace	37	13	50
Weedy	1	0	1
Wild	0	85	85
Unknown	4	843	847
Type of use			
Fibre	282	448*	730
Oil	229	118**	347
Intermediate	16	831***	847
Unknown	94	286	380

* convar. *elongatum* Vav. et Ell.

** convar. *mediterraneum* (Vav. ex Ell.) Kulpa et Danert

*** convar. *usitatissimum*, according to Kulpa and Danert 1962

Characterization and evaluation

BAZ concentrates its characterization and evaluation activities on the inflorescence and on agronomic and seed traits. The evaluation table for the genus *Linum* includes 46 descriptors. These descriptors, not listed here, are mostly identical to the International Flax Data Base (IFDB) descriptors. One or more traits were described for 1100 BGRC accessions at least once. Some accessions were evaluated twice or more, making a total of 1702 data sets (tuples) documented in the database (see Table 4 for amount of data for IFDB descriptors). In the IPK Genebank, the *Linum* accessions were also characterized for most of the IFDB descriptors. These data have not yet been computerized, so only the availability of the data is listed in Table 4.

Table 4. Availability of data with respect to IFDB descriptors (*in italics: additional trait recorded in German genebanks*)

	Genebank	
Descriptor	**BAZ***	**IPK****
Morphological traits		
Plant natural height	1691	+
Growth height homogeneity	*95*	-
Early growth development	*1016*	-
Stem length	222	+
Flower - size of corolla	-	+
Sepal dotting	-	-
Petal colour	1343	+
Petal longitudinal folding	-	-
Petal length/width coefficient	-	+
Anther colour	234	-
Stamen filament colour at top	232	-
Style colour (at base)	233	-
Boll type	-	(+)
Boll size	-	-
Boll - ciliation of septa	-	-
1000-seed weight	192	+
Seed colour	1077	+
Biological traits		
Resistance to lodging (lodging tendency at flowering/before harvest)	1 457/128/131	-
Fusarium resistance	-	(-)
Rust resistance	-	(-)
Days to maturity	22	+
Time of beginning of flowering	453	+
Flowering date end	*475*	+
Crop uniformity before harvest	*438*	-
Maturity period	*133*	+
Ripening uniformity	*363*	-
Agronomic traits		
Seed yield *(seeds/fruit; fruits/plant)*	173/173	-
Straw fibre content	-	-
Fibre yield	-	-
Dry matter yield	*506*	-
Dry matter content	*192*	-
Oil content	974	-
Oil yield	192	-
Linolenic acid content	13	-
Oleic acid content	*13*	-
Palmitic acid content	*13*	-
Stearic acid content	*13*	-
Eicosenic acid content	*13*	-

* data points per trait
** (+) = data available; (-) = not available

BAZ Gene Bank

For almost 26 years the Federal Agricultural Research Centre (FAL) managed a collection of plant genetic resources which became part of the Federal Centre for Breeding Research on Cultivated Plants (BAZ) in July 1996. Since then the collection of plant genetic resources located at Braunschweig has been called the "BAZ Gene Bank".

Surplus food production was considered a significant economic problem of agriculture in the 1980s. The former Ministry of Food, Agriculture and Forestry (BML) (now Ministry for Consumer Protection, Food and Agriculture, BMVEL) therefore promoted research on the production potential of non-food crops with the aim of relieving agricultural markets and increasing crop diversity in agricultural production systems (Anonymous 1990). Amongst many different neglected crops the former Institute of Crop Science and Plant Breeding of the FAL investigated breeding and crop production aspects of *Linum usitatissimum* L. This is a typical example of a research project promoted by the Ministry to gain the scientific knowledge required for political decision-making.

One task of the former FAL genebank was to acquire germplasm for research projects. The dynamism of these activities is illustrated in Fig. 2 (grey bars). Germplasm ordered in 1979 and 1980 was first multiplied and then evaluated in 1982 (Seehuber and Dambroth 1983). Additional material arrived in 1984 and was integrated into the existing collection. In 1991, lines resulting from the breeding programme were added to the collection to safeguard the breeding progress achieved so far. Between 1979 and 2000 the genebank accepted or actively acquired 1183 *Linum* accessions including 481 accessions from the IPK collection. The germplasm was donated by 35 institutions from 17 countries.

After BAZ accepted responsibility for the former FAL holding, management concepts aiming at the rationalization of the collection were developed. Table 5 refers to this genebank management concept outlined by Bücken and Frese (2000) and further developed by Germeier *et al.* (accepted). The table describes the current status of the material stored at Braunschweig. The *Linum* holding is divided into four categories. Two recently received accessions need to be increased and/or tested for germination. If the technical management standards are fulfilled, accessions belonging to the category NEW can be added to the germplasm holding either as a primary genetic resource (PGR) or reference sample (REF). Germplasm received from the IPK Genebank was identified thanks to the IPK accession numbers recorded in the BAZ Gene Bank information system. For the time being this material is classified as safety-duplicate samples (SDS) and kept in the base collection (BAS). During the past 22 years 35 accessions were discarded or lost (EXE). Four accessions require taxonomic classification (TOC/TAX). The active collection (ACO) today includes 621 accessions of which four are unavailable due to the small number of viable seeds. Access to 508 accessions is restricted (RES) because flags NEW, TOC, EXE or BAS have been set in the information system.

Table 5. Accession categories in the BAZ Gene Bank

CATEGORY[1]	ACCSTATUS[2]	ACTIVITY[3]	EXE_REASON[4]	No. of accessions
NEW	RES	ACO		2
PGR	PUB	ACO		9
PGR	PUB	TOC	TAX	3
REF	PUB	ACO		612
REF	PUB	TOC	TAX	1
REF	RES	EXE	DUP	17
REF	RES	EXE	UNB	8
SDS	RES	BAS	DUP	481

[1] Category: NEW = new sample, regeneration and/or germination test is required; PGR = primary genetic resource; REF = reference sample; SDS = duplicate samples

[2] Accession status: RES = restricted; PUB = public, available for exchange

[3] Activity: ACO = active collection; TOC = temporary out of collection; EXE = accessions discarded or lost; BAS = base sample

[4] Reason for TOC, EXE and BAS: TAX = require taxonomic classification; UNB = not known; DUP = duplicate

IPK Genebank

The development of the Gatersleben *Linum* collection is illustrated by the number of newly accepted accessions or their first field multiplication (Fig. 2). The first accessions stem from the early years of the Gatersleben collection (1935 ff.), while major increases took place in 1954 (64 accessions), 1955 (88), 2000 (64) and especially in 1963 (767), when a large amount of material from the Institute of Plant Breeding at Halle/Hohenthurm was accepted (712 accessions); in the other years, the germplasm increases could not be attributed to single donors (data not shown).

One of the main aims of germplasm-related research at the IPK is the quality control of the stored accessions by means of germination tests. In this respect, *Linum usitatissimum* seems to be a very easily storable species under IPK conditions: newly multiplied/harvested seeds generally show very high germination rates (a prerequisite for their transfer to the cold store; data not shown here); after different periods of storage at –15°C ranging from less than 2 to more than 15 years, almost every accession checked displayed germination rates above 70% (Fig. 3). With wild species, however, lower rates are sometimes observed.

Another aim at IPK for the coming years, not merely for the genus *Linum,* is to increase on-line availability of characterization and evaluation data, together with molecular and opticometric documentation data. The amount of information offered on each accession will thus be increased, hopefully leading to higher utilization rates of the germplasm. Most of these changes will be made during or after the merging of the two German genebank collections.

Outlook to the future: merging of the BAZ and IPK genebanks

With respect to the future of the German plant germplasm collections, it has been decided by the Ministry of Consumer Protection, Food and Agriculture (BMVEL) and the Ministry of Education and Research (BMBF) to merge the whole BAZ holding and database with those of IPK during the next three years. This process will include a review of all the BAZ collection, including *Linum.* The BAZ *Linum* collection was mainly acquired from institutions in Canada, the Czech Republic, Denmark or the Netherlands. It is suggested to check whether BAZ Gene Bank accessions still exist in partner genebanks in these four countries and the other 13 countries from which accessions were received. A decision on the primary maintenance responsibility can then be taken jointly with the aim of rationalizing germplasm management in Europe. After the review, decisions regarding safety-duplicate samples—which are in fact common duplicates (van Hintum and Knüpffer 1995)—will also need to be made. The agreements reached during the decision-making process can be documented in information systems as suggested by Germeier *et al.* (accepted).

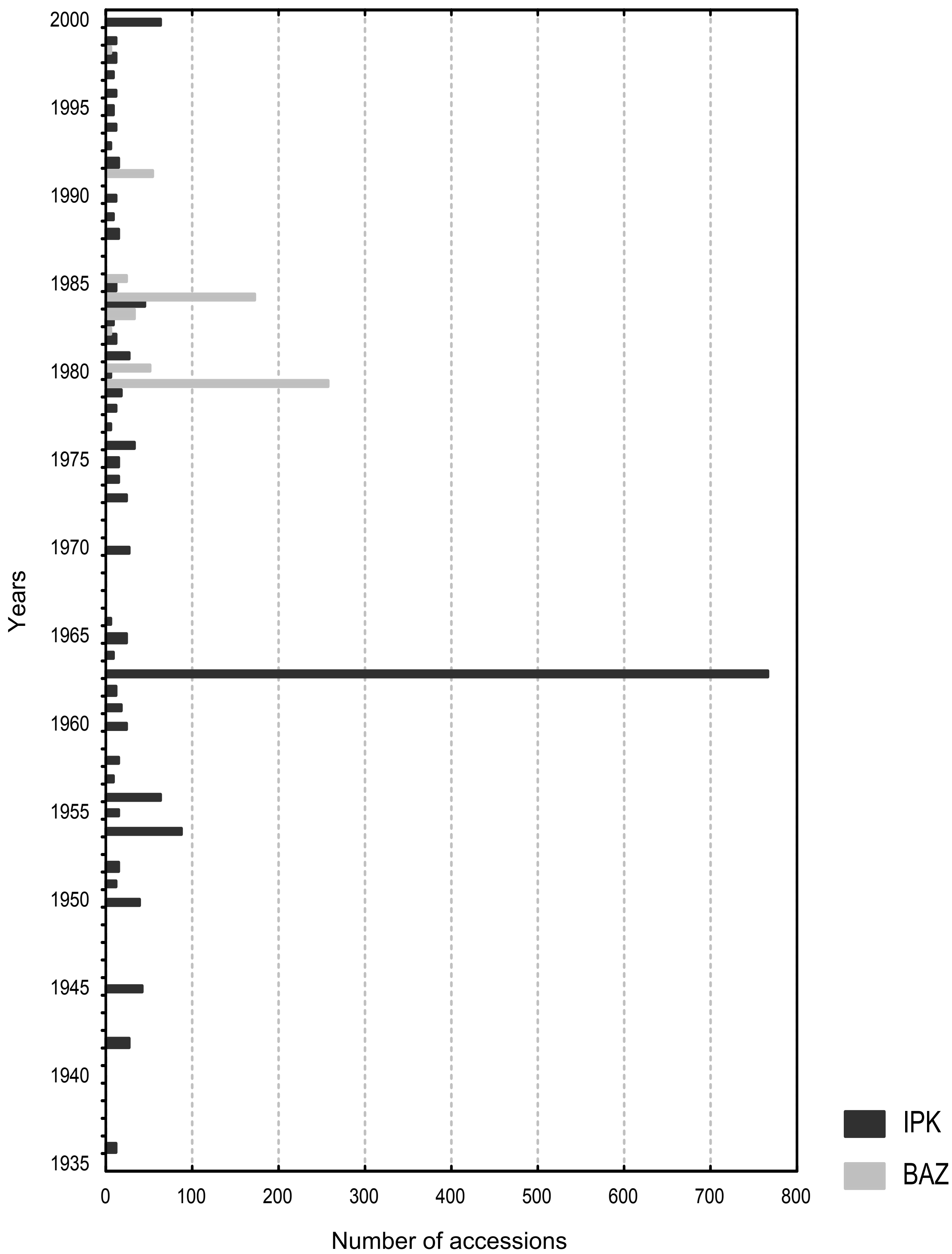

Fig. 2. Number of *Linum* accessions accepted (BAZ) or accepted/undergoing first multiplication (IPK) in German genebanks per year.

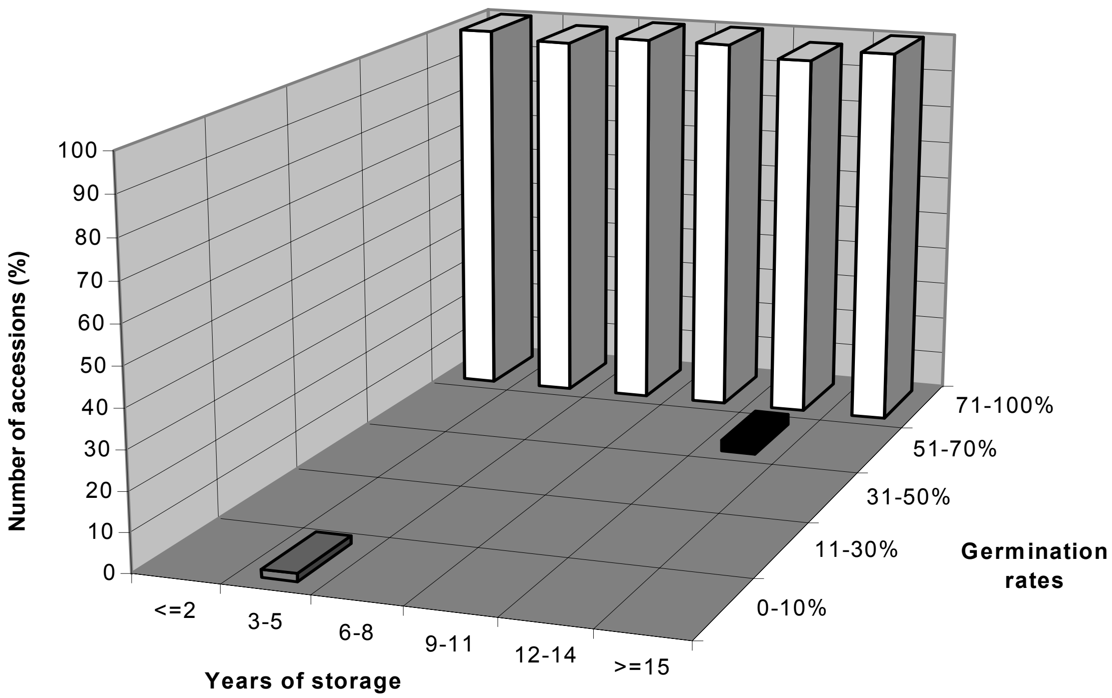

Fig. 3. Germination rates of *Linum usitatissimum* L. accessions after different periods of storage (-15°C) in the IPK Genebank.

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Status of the Hungarian national *Linum* collection

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Introduction

The Institute for Agrobotany (ABI) is responsible for the coordination of genebank activities at the national level and for the development of genetic resource collections of field and vegetable crops. Its various collections, including that of *Linum*, contain more than 56 000 accessions available to Hungarian and foreign breeders and other users.

Status and taxonomic composition of the Linum *collection*

The *Linum* collection of the Institute for Agrobotany contains 409 accessions, of which 94% belong to the species *L. usitatissimum* (Table 1). Wild relatives are represented by only 26 accessions. The accessions of *Linum usitatissimum* belong to a wide variety of subtaxa (Table 2).

Table 1. Taxonomic composition of the Hungarian *Linum* collection

Species	No. of accessions
altaicum Ledeb.	1
austriacum L.	9
bienne Miller	2
flavum L.	6
grandiflorum Desf.	2
perenne L.	5
punctatum C. Presl	1
usitatissimum L.	383
Total	**409**

Table 2. Infraspecific classification of the *Linum usitatissimum* collection

Subtaxon	No. of accessions
(not specified)	273
convar. *crepitans* (Boenningh.) Kulpa et Danert var. *crepitans* Boenningh.	1
convar. *elongatum* Vav. et Ell.	1
convar. *elongatum* Vav. et Ell. var. *elatum-multicaule* Schur	35
convar. *elongatum* Vav. et Ell. var. *elongatum-multicaule* Schur	2
convar. *elongatum* Vav. et Ell. var. *regale* Scheidw.	15
convar. *mediterraneum* (Vav. ex Ell.) Kulpa et Danert var. *macrocarpum* Alef.	10
convar. *mediterraneum* (Vav. ex Ell.) Kulpa et Danert var. *mediterraneum*	1
convar. *mediterraneum* (Vav. ex Ell.) Kulpa var. *macrocarpum* Alef.	1
convar. *mediterraneum* var. *mediterraneum*	1
convar. *usitatissimum*	1
var. *albidum* How. et Rahm.	1
var. *album* How. et Rahm.	2
convar. *usitatissimum* var. *caesium* How. et Rahm.	22
convar. *usitatissimum* var. *indicum* How. et Rahm.	1
convar. *usitatissimum* var. *luteum* How. et Rahm.	1
convar. *usitatissimum* var. *usitatissimum*	13
var. *oleiferum*	1
var. *fibriferum*	1
Total	**383**

Development of the Linum *collection*

The creation of the national *Linum* collection dates back to the foundation of the Institute for Agrobotany. The oldest *Linum* accession maintained in the Institute was obtained in 1954 (Fig. 1).

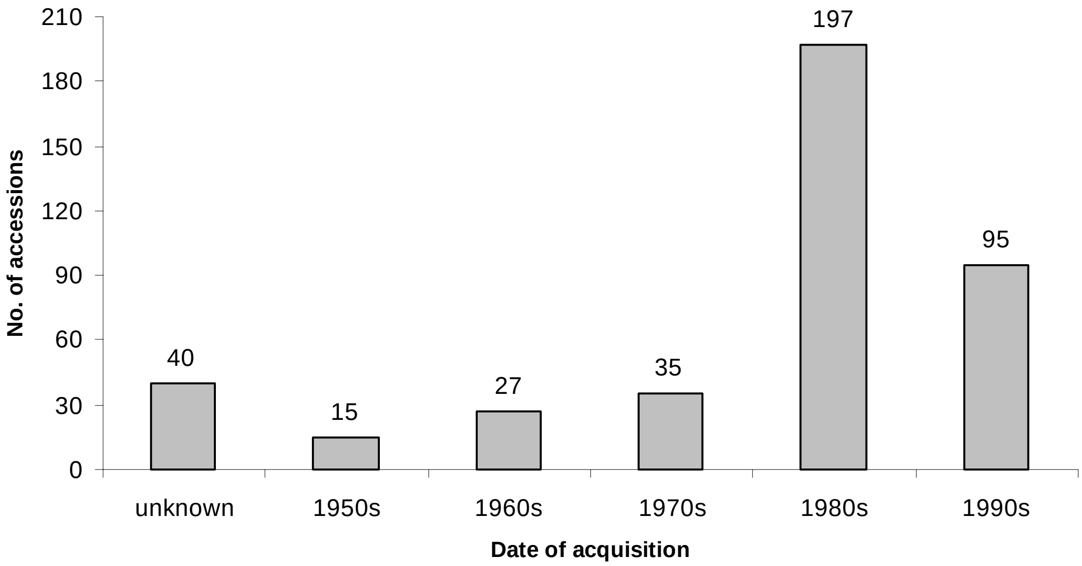

Fig. 1. Distribution of the *Linum* collection according to year of acquisition.

Origin of the accessions

The main source of the national *Linum* collection is seed exchange with Hungarian and foreign institutes (Table 3). Most of the accessions (40.3%) were received from Hungarian institutes, but a considerable number of accessions were obtained from former Czechoslovakia (14.7%) and Germany (13.2%). Other important contributors were the United Kingdom (3.2%), Romania (2.7%), France (2.4%) and Poland (2.2%).

Table 3. Composition of the *Linum* collection by donor country

Country code (ISO)	No. of accessions	% of collection	Country code (ISO)	No. of accessions	% of collection
HUN	165	40.3	BGR	4	1.0
CSK	60	14.7	NLD	4	1.0
DEU	29	7.1	JPN	3	0.7
DDR	25	6.1	MAR	3	0.7
GBR	13	3.2	CAN	2	0.5
ROM	11	2.7	IND	2	0.5
FRA	10	2.4	AUS	1	0.2
POL	9	2.2	AUT	1	0.2
SUN	6	1.5	DNK	1	0.2
BEL	5	1.2	NOR	1	0.2
CHE	5	1.2	RUS	1	0.2
CZE	5	1.2	Unknown	38	9.3
ITA	5	1.2			
Total number of accessions = 409					

Documentation

The database structure is based on international genebank standards and follows FAO/IPGRI recommendations. The data are recorded in dBase, and some of their specific features are essential for effective daily database management. Passport data and genebank management data are not separated and are recorded in the same way for all crops.

The database of the national *Linum* collection was converted to the multicrop structure for comparison (Table 4). There is only one difference between our structure and the recommended multicrop database structure. It concerns the field INSTCODE. Although our code is similar to this, we do use not the FAO institute numbers or acronyms, but our own codes, developed earlier.

Table 4. Field completeness of the ABI *Linum* database for the multicrop passport descriptors

Field name	Type	Width	Completeness (%)
ACCENUMB	Character	10	100
GENUS	Character	6	100
SPECIES	Character	18	100
SUBTAXA	Character	113	27
ACCNAME	Character	37	75
ORIGCTY	Character	3	20
COLLSITE	Character	9	1
LATITUDE	Character	5	1
LONGITUDE	Character	6	1
ELEVATION	Character	4	0
ACQDATE	Character	4	90
SAMPSTAT	Character	1	71
COLLSRC	Character	1	0
DONORCODE	Character	6	91
DONORNUMB	Character	9	0
OTHERNUMB	Character	6	100
STORTYPE	Character	3	100
AVAILABLE	Character	1	100

Status of sample

The SAMPSTAT (status of sample) field shows that 71% of the *Linum* collection is made up of advanced cultivars (Table 5). Only 2 accessions are traditional cultivars/landraces. This explains why the fields describing the collecting site, its latitude, longitude, elevation and collecting source are blank. Unfortunately 117 accessions are coded with a "0" value, which means that the sample status is still unknown.

Table 5. Composition of the *Linum* collection by SAMPSTAT (status of sample)

Status of sample	No. of accessions	%
Unknown	117	28.6
Traditional cultivar/landrace	2	0.49
Advanced cultivar	290	70.90
Total	**409**	**100.00**

Storage

All accessions of the *Linum* collection are maintained under medium-term storage at 0ºC. The base collection chambers (-20ºC) contain 75 accessions.

Characterization and evaluation

The characterization and evaluation of *Linum* genetic resources are carried out according to the internationally accepted descriptor list, but some technical characters are not evaluated at our institute. So far 307 accessions (i.e. 75.1% of the *Linum* collection) have been characterized and evaluated for these descriptors.

Latvian flax genetic resources

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Before the Second World War, flax production was very important in the Latvian economy. Latvia was one of the first flax exporters in the world. Flax breeding started in Latvia in 1923. At least 6 varieties were bred in Latvia, based on selection from the best local landraces. After the Second World War, flax growing was not recognized as important for Latvia and the areas under flax were gradually reduced. Varieties of foreign origin (mainly from Russia) were used for commercial flax growing. No flax variety was bred in Latvia after the Second World War. Flax breeding stopped in 1970.

In 1992 however, breeding and plant genetic resources activity started again. Fifteen accessions of Latvian origin were repatriated from the N.I. Vavilov Research Institute of Plant Industry (VIR, St. Petersburg, Russian Federation) and from the Genebank of the Institute of Plant Genetics and Crop Plant Research (IPK, Gatersleben, Germany). These accessions, which include 3 varieties and 12 landraces, are kept in long-term storage in the Latvian Gene Bank of Cultivated Plants, created in 1997 (Table 1).

Table 1. Flax accessions of Latvian origin preserved in the Latvian Gene Bank of Cultivated Plants

Accession	Donor	Status
Osupes 30	VIR	Variety
Osupes 31	VIR	Variety
Priekulu 665	VIR	Variety
Blue di Riga	IPK	Landrace
Riga Freis	IPK	Landrace
Riga Originario	IPK	Landrace
Riga Vilmorin	IPK	Landrace
Rigar B	IPK	Landrace
Rigaer 27/12	IPK	Landrace
Rigaer 6/5	IPK	Landrace
Rigaer (LIN 748/82)	IPK	Landrace
Rigaer (LIN 780/81)	IPK	Landrace
Vietejais 1	VIR	Landrace
Vietejais 3	VIR	Landrace
Vietejais 6	VIR	Landrace

Accessions of Latvian origin are used in the flax breeding programme currently run by the Centre of Agricultural Science of the Latgale Region. A working collection of foreign varieties and breeder's lines is also propagated and evaluated. The collection includes 189 accessions of fibre flax and 72 accessions of linseed. At the moment, breeding is carried out essentially for the textile industry.

Current status of the CGN *Linum* collection

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Introduction

The *Linum* collection was established long before the Second World War by the Department of Plant Breeding (IVP) of the Agricultural University of Wageningen. Later it became a working collection of the former Foundation for Plant Breeding (SVP) at Wageningen and was used in flax breeding research programmes from 1948 until 1990. The *Linum* germplasm was used mainly to provide resistance to flax scorch (*Pythium megalacanthum),* fusarium wilt (*Fusarium oxysporum* f.sp. *lini)* and rust *(Melampsora lini).* Material from the collection was also used for the improvement of fibre content.

The collection was adopted by CGN in 1995 following encouragement by a group of four private Dutch breeding companies which wanted to see this valuable collection properly maintained and stored under optimal conditions. In 1996 cooperation began between the breeding companies and CGN.

Composition of the collection

Type of material

The collection includes 974 accessions and is divided in material of fibre flax, linseed, intermediate flax and wild species (Table 1). The collection consists predominantly of cultivated material of the species *Linum usitatissimum* and includes landraces, cultivars and research material (Table 1).

There are several old landraces in the collection, e.g. 'Fries landras' (NLD, 1816), 'Crete' (TUR, 1914), 'Bombay' (IND, 1917) and 'Soddo' (ETH, 1914). The date of origin of several other landraces is not known. Furthermore, several cultivars developed early last century, often from old landraces, are included in the collection, e.g. 'Blenda' (NLD, 1926), 'Frontier' (USA, 1898), 'Pioneer' (GBR, 1921) and 'Ottawa White Flower' (CAN, 1913). Many accessions described as research material are found in the collection. The information on this material is limited: the origin as well as the properties for which the material (particularly research lines) was selected are often not known. All the research material was developed more than 20 years ago.

The collection also includes 15 accessions of 7 different wild species: *L. bienne, L. marginale, L. austriacum* subsp. *euxinum, L. perenne* subsp. *anglicum, L. grandiflorum, L. decumbens* and *L. monriseo* (this species is probably a type of linseed).

Table 1. Population types included in the CGN *Linum* collection

Population type	Fibre flax	Linseed	Intermediate flax	Other	Total
Landraces	27	17			44
Cultivars	165	117	6		288
Research lines	230	240			470
Unknown	80	76	1		157
Wild				15	15
Total	**502**	**450**	**7**	**15**	**974**

Origin of the accessions

Much of the collection is of European origin but accessions from the USA, Canada, Australia, Turkey, Japan and several North African countries are also included in the collection.

Table 2. Origin of *Linum usitatissimum* accessions in the CGN collection

		No. of accessions			
Origin	**No. of countries**	**Fibre flax**	**Linseed**	**Intermediate flax**	**Total**
Benelux	2	55	4	1	60
UK/Ireland	2	35		2	37
Central Europe	5	41	15		56
Eastern Europe	4	43	16	1	60
Nordic countries	6	28	6		34
Mediterranean countries	5	11	9		20
Total Europe	24	213	50	4	267
North America	2	89	48	3	140
South America	5	19	76		95
Total Americas	7	108	124	3	235
Asia	7	29	46		75
North Africa	4	8	26		34
Unknown		144	204		348
Grand total	**42**	**502**	**450**	**7**	**959**

Documentation

Passport data

Lately CGN has put a lot of emphasis on the documentation of passport data of the *Linum* collection. Although much time has been spent, it was not possible to document the complete collection and several data are missing, including information on the country of origin, year of development, ancestry of several cultivars, etc.

A list of 22 passport descriptors for *Linum* was developed for the International Flax Data Base (IFDB) of the FAO/ESCORENA Flax and other Bast Plants Network (Rosenberg 1993; Pavelek 1994). The database management system GENIS (Genetic Resources Information System of CGN) (van Hintum 1989) includes multicrop passport descriptors for all crops maintained by CGN. The passport table in GENIS provides fields for 23 descriptors (van Hintum and Hazekamp 1992). Most of these descriptors are also listed in the proposed list of IFDB. There are however some differences in the descriptor states of some passport descriptors of both lists.

The available passport data have been included in GENIS. Data of the CGN *Linum* collection can be found on CGN's Web site: <http://www.plant.wageningen-ur.nl/cgn/>.

Presently passport information of nearly 900 accessions in the collection can be obtained on the Internet. Since early 2001 passport data can be searched on-line and characterization and evaluation data can be downloaded from the Internet.

Characterization and evaluation data: development of a minimal descriptor list

In order to conduct the characterization and evaluation of the collection a minimal descriptor list was developed (van Soest 1996). The descriptors for *Linum* are based on the descriptor list of the IFDB (Rosenberg 1993; Pavelek 1994, 1995). The original IFDB descriptor list comprising 14 morphological and 10 important agromorphological and evaluation characters was sent to all private flax breeders, who were requested to prioritize these descriptors using a 1-3 scale (1 = high priority, 3 = low priority). A similar procedure was followed for the development of a descriptor list for wheat in connection with a regeneration programme of this crop in the Netherlands (Loosdrecht *et al.* 1988). As a result of the questionnaire 16 descriptors were included on the list and after a final discussion with flax breeders the list was divided into the following two groups:

- 10 mandatory descriptors: these traits should be always recorded during the regeneration;
- 6 optional descriptors: these traits can be recorded when sufficient time is available or in the case of diseases for which the character is ideally scored in the field. Some of these descriptors (quality properties) cannot be screened during the maintenance of the material since special analyses are required (e.g. fibre and oil content).

Details of the procedure of the development of the *Linum* descriptor list are reported by van Soest and Bas (1998).

A set of 8 standard varieties has been selected for the description of the agromorphological characters included in the minimal descriptor list. The standard varieties used are 'Amazone', 'Ariane', 'Hermes', 'Laura', 'Liflora', 'Mikael', 'Opaline' and 'Regina'.

Regeneration and characterization/evaluation

The last regeneration of the *Linum* collection was conducted by the former Foundation for Plant Breeding (SVP) in 1981. The collection was stored in paper bags under medium-term storage conditions (+4°C and 30% relative humidity). Material from the collection was used in breeding research until 1990. Although the viability of the seeds in the collection was still reasonable, seed of many accessions became scarce. In 1995 CGN decided to adopt the collection and in 1996 an agreement was made between CGN and four Dutch private flax breeding companies whereby the breeders agreed to rejuvenate, characterize and partly evaluate the *Linum* collection. Annually, each company receives 50 accessions which are multiplied, characterized and evaluated for some properties following a jointly developed descriptor list (van Soest 1996). This cooperative programme was terminated at the end of 2001: practically all accessions have been rejuvenated. After a viability test the last group of accessions will be stored in the genebank.

Storage

Presently nearly 900 *Linum* accessions are stored in the genebank. Storage is conducted under optimal conditions after drying to a seed moisture content of approximately 5% (van Hintum and van Soest 1997). The seeds are packed in laminated aluminium foil bags and stored at -20°C (long-term storage) and +4°C (medium-term storage).

Utilization

Since 1998 seed samples of 118 accessions and stems of 126 accessions have been distributed to users. Users are supplied with 300 seeds when they request cultivated material, but for wild species, smaller amounts are supplied. Additional passport information of the material is sent with the samples. However, since the inclusion of passport and evaluation data on the Web site of CGN, users have been able to obtain the data from this source themselves. They have to sign the Material Transfer Agreement (MTA) of CGN before they can obtain material. More information on the MTA can be found on the Web site of CGN.

Development of a core collection for fibre flax types

As part of a multidisciplinary fibre research programme, a core collection of fibre flax was created between 1998 and 2001. This took place in four stages:

- **Initial core:** selection of material from the 506 accessions of the CGN *Linum* collection, which is predominantly of the fibre flax type. Selection was based only on passport descriptors such as origin, age of the accession, population type and ancestor. From the unknown origin group, only accessions with a variety name were selected and research material with codes or acronyms were excluded.

- **Improved core I:** the initial core was further reduced on the basis of a comparison of available characterization data of accessions from the same origin group (or country). These data were obtained from previous field observations in the Netherlands.
- **Improved core II:** the Improved core I (164 accessions) was grown as one replication on sandy soil at Wageningen and described for 10 descriptors and tested for fibre content in the autumn of the same year using the "green decorticating method".
- On the basis of agromorphological data, especially fibre content, data of the 164 accessions were reduced by a further 50 (Table 3). In this process important passport information such as origin, population type and ancestor was always considered.
- **Final core:** a similar procedure to that described under the Improved core II was followed to leave the final core. The 114 accessions of the Improved core II were grown again in the Wageningen fields and described and evaluated for fibre content. On the basis of this information the number was reduced by a further 30, leaving 84 in the final core (Table 3).

Table 3. Development of a core collection for fibre flax types

Group	No. of countries	Accessions in CGN collection	Initial core	Improved core I	Improved core II	Final core
Benelux	2	48	21	17	10	7
UK/Ireland	2	37	16	14	10	7
Central Europe	5	39	19	15	10	7
Mediterranean countries	5	10	6	6	5	4
Nordic countries	6	28	13	11	9	7
Eastern Europe	4	45	17	18	12	9
North America	2	91	37	27	19	14
South America	3	20	10	8	7	5
Asia/Australia	7	29	17	16	10	8
North Africa	4	8	6	7	5	4
Unknown		145	21	14	8	6
Standards		6	6	11	9	6
Total	**42**	**506**	**189**	**164**	**114**	**84**
% of CGN collection		**100**	**37**	**32**	**22**	**17**

The final 84 accessions were sown at two locations in 2001, one on a sandy soil at Wageningen and the other on an alluvial soil near the river Rhine near Wageningen. Data from these trials need further processing: fibre content will be measured in late 2001.

Prospects for the future

In 2002 the entire *Linum* collection will be regenerated and stored under optimal conditions. The developed "core" collection of *Linum* will be used in future research projects. Passport data and, in a later stage, characterization data of the CGN collection will be included in the International Flax Data Base.

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The flax and hemp collection of the Institute of Natural Fibres, Poland

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Introduction

The Institute of Natural Fibres (INF) is one of the many institutions involved in the national programme for plant genetic resources conservation which conforms to the Convention on Biological Diversity (CBD) signed by 165 countries, including Poland, in 1992.

Early work on plant genetic resources collection and conservation in Poland was conducted at the State Science Institute of Rural Farming in Pulawy in the 1920s. Since 1979 the collection and protection of genetic resources of all crops has been coordinated by the Department of National Genetic Resources of the Plant Breeding and Acclimatization Institute in Radzików.

The INF collection is part of the Polish Gene Bank and included in the central database. It is supervised and partially financed by the Polish Ministry of Agriculture. Since 1982 INF is responsible for the management of *Linum* genetic resources. In 2001 a research programme aimed at collecting, identifying and conserving genetic resources of *Linum* species was started at the institute. Since 1998 the programme also includes *Cannabis* species. This programme, entitled "Collection and evaluation of flax and hemp cultivars and ecotypes for the Plant Breeding and Acclimatization Institute" is part of the national research project on "Collection and maintenance of plant genetic resources for the needs of breeding and science".

Composition of the INF collection

Status of sample

The flax collection of the INF Gene Bank currently comprises 864 accessions, made up of 588 advanced cultivars, 102 breeder's lines, 48 wild species, 29 landraces or primitive cultivars and 97 accessions of unknown status (Fig. 1).

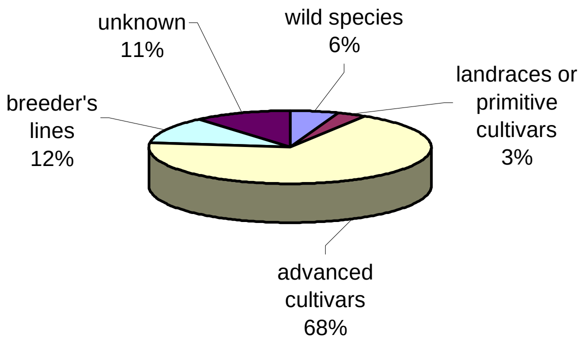

Fig. 1. Structure of the INF flax collection according to status of sample.

Type of use

The collection consists of over 300 fibre flax accessions, 200 linseed, 31 intermediate types and over 200 accessions of other and unknown types (excluding wild and primitive forms) (Fig. 2).

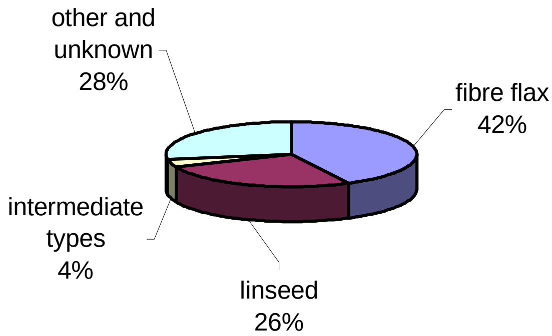

Fig. 2. Structure of the INF flax collection according to use of the material.

Origin of the accessions

The INF collection contains 75 unique Polish accessions (Table 1). These include advanced cultivars bred by Polish breeders (type 3 = 24 accessions = 32%), landraces or primitive cultivars (type 2 = 18 accessions = 24%) and breeder's lines (type 4 = 33 accessions = 44%).

Development of the collection

The number of accessions in the collection increases every year. New acquisitions are made mainly on an exchange basis with other genebanks and through purchase and direct contact with breeders who have created new cultivars. Domestic and foreign breeders use these resources. Cooperation with other collections and breeding companies used to be very active, but recently breeders seem to be unwilling to give access to their resources and even their new cultivars, except on a commercial basis.

The INF collection is divided into 19 multiplication groups. Every year one group is multiplied in the field at the experimental station. This procedure keeps the whole collection alive.

The accessions chosen for the multiplication are seeds of the oldest group and seeds of recently included cultivars. New cultivars for which a 3-year evaluation cycle is to be completed in the current year are included in the current multiplication group and are described according to the required agricultural, morphological and biological characters.

After the completion of harvesting and laboratory testing, 50 g seed samples are delivered to the National Gene Bank in Radzików. Simultaneously, 5 g seed samples are prepared for INF's own genebank—the so-called "reserve"—for long-term storage at -20°C. The remaining seeds are stored at –2°C-0°C.

Table 1. Accessions of Polish origin held in the INF flax collection

Catalogue no.	Accession name	Type*	Status of accession**
37	Fortuna	F	3
52	Izolda	F	3
54	K-378	O	4
55	K-401	F	4
56	K-471	O	4
60	Kotowiecki	O	3
65	LCSD 200	O	3
95	R 2/1	F	4
144	Golecinski	F	3
154	Kujawa 1-362	F	3
155	K-291	F	4
156	J.J	F	4
157	Lazur	F	3
166	Pulawski 2-13	F	4
167	Pulawski 2-43	F	4
168	Pulawski Odporny	F	4
169	Pulawski Oliwkowy		4
185	Swadzimski	F	3
194	Zwisly	F	3
195	Alba	F	3
204	Ariadna	F	3
213	Bryta=PET-79	F	3
277	Nike=PEK 382	F	3
288	PEK-382	F	3
289	PET-179	F	4
332	Waza	F	3
359	K 507	F	4
369	Pulawski rózowy	F	4
370	Pulawski 2-I-II	F	4
374	RI - 15	F	4
375	RI - 16	F	4
380	Svapo	F	3
392	LCSD 210	F	3
393	Len IHAR E 0934	F	4
394	Lipinska I	F	2
395	Lipinska II	F	2
396	Lipinska III	F	2
397	Lipinska IV	F	2
398	LipinskaV	F	2
399	Lipinska VI	F	2
400	Lipinska VII	F	2
401	Lipinska IX	F	2
402	Lipinska X	F	2
403	Lipinska XII	F	2
404	Lipinska XIII	F	2
405	Lipinska XIV	F	2
406	Lipinska XV	F	2
407	Lipinska XVI	F	2
408	Lipinska XVII	F	2
409	Lipinska XVIII	F	2
410	Lipinska XIX	F	2
411	Lipinska XX	F	2
414	Milenium	F	3
415	PET 23	F	4
419	1778/1783		4
571	D-81-01	O	4
572	LST - 3LC 134	O	4
573	CVT - LC - 36	O	4
574	LG - 01 - 89	O	4
575	CVT-Id-I	O	4
576	LS - 153	O	4
577	LG - 01 - 1,8	O	4
578	LS - 100	O	4
579	LG - 01 - 96	O	4
580	LG - 0,1 - 1,1	O	4
598	84 / 315 / 6	F	4
599	Jenny	O	4
612	Wiko	F	3
645	Opal	O	3
646	Szafir	O	3
804	Artemida	F	3
805	Modran	F	3
806	Selena	F	3
813	SIK 600 (line 848)	F	4
814	SIK 701 (Ród 843)	F	4

* F = fibre flax; O = linseed

** 1 = wild form (not represented in Polish accessions); 2 = landrace or primitive cultivar; 3 = advanced cultivar; 4 = breeders' line; 5 = mutation (not represented in Polish accessions)

Evaluation of agricultural, morphological and biological characters

Accessions have been described in detail since 1982. All genotypes present in the INF genebank have been characterized for genetic and economic characters. New accessions are sown at the INF experimental station for the 3 following years and evaluated for the agricultural, morphological and biological characters listed below.

Descriptors used at INF

Passport data (recorded for each accession)

Catalogue number
Genotype name
Country of origin
Type of use

Status of the accession

1. wild form
2. landrace or primitive cultivar
3. advanced cultivar
4. breeder's line
5. mutation

Agricultural characters (for fibre flax)

Total yield
Straw yield
Seed yield
Straw fibre content (%)
Fibre yield

Physiological characters

Length of the growing season
Beginning and length of the flowering period
Resistance to lodging
Resistance to diseases

Morphological characters

Total and technical length of straw
Stalk diameter
Panicle length
Type of panicle
Number of branches
Angle of leaf inclination:
  acute, right, pendent (flagging)
Flower colour
1. light blue
2. blue
3. dark blue
4. violet-blue
5. pink
6. white

Colour and presence of sepal dotting
1. green
2. with anthocyan
3. white-dotted

Presence of petal veins
1. visible over the whole length
2. visible over half the length
3. visible over 1/3 of the length
4. visible over 2/3 of the length

Colour of petal veins
1. transparent
2. pink
3. violet
4. blue

Edge of corolla
1. smooth, plain
2. crumpled

Shape of capsules
1. round
2. oval
3. conical
4. round-oval

1000-seed weight
Seed colour
1. brown
2. yellow
3. green

Flower shape
1. bell-shaped
2. curled
3. round
4. stellar

Pistil colour
- a. style
  1. white
  2. yellow
  3. light blue
  4. dark blue
  5. violet
- b. stigma
  1. white
  2. pink
  3. purple
  4. violet
  5. light blue
  6. dark blue

Stamen colour
- a. anther
  1. dark blue
  2. light blue
  3. orange
  4. yellow
- b. filament
  1. dark blue
  2. light blue
  3. violet
  4. white
  5. dotted

Biochemical properties
The fibre content is measured in de-seeded stalks, using a chemical method. INF is equipped with a modern laboratory for fibre quality testing. For some linseed cultivars the oil content and fatty acid composition are measured by HPLC chromatography. This is done rather irregularly, depending on available funds. However it is planned to test all linseed cultivars.

Disease resistance

The flax collection is also tested for resistance to diseases, especially the most dangerous—fusarium wilt. Cultivars are tested in the field in conditions of natural infestation. Resistance to fusarium wilt is then evaluated in a deliberately infected greenhouse. Before starting the experiment, the soil is inoculated with a mixture of *Fusarium* species: *F. oxysporum* f. *lini, F. avenaceum, F. culmorum, F. gibbosum, F. sambucinum* and *F. poae* (Andruszewska and Byczyńska 1995). Infected plants are counted three times: (i) after germination; (ii) when seedlings are 10-12 cm high; and (iii) during flowering. The health of plants in the experimental field is rated on a scale of 1-9 (Heimann 1983) given below:

9 = all plants on the plot are healthy
8 = presence of single infected plants
7 = up to 8% of infected plants, spread regularly
6 = small concentrations of fusarium wilt appear, covering up to 15% of the plot
5 = concentrations of fusarium wilt cover up to 25% of the plot area
4 = concentrations of fusarium wilt cover up to 35% of the plot area
3 = concentrations of fusarium wilt cover up to 50% of the plot area
2 = concentrations of fusarium wilt cover more than 50% of the plot area
1 = plot totally or almost totally destroyed

Up to now 501 flax and linseed accessions have been tested. On the basis of 3-year testing, they have been divided into five resistance groups (Table 2). The standard cultivars, which are very resistant to this disease, are 'Nike' (PL) and 'Natasja' (NL).

Table 2. Classification of 501 flax accessions according to their resistance to fusarium wilt

Resistance group	No. of accessions
Very resistant	97
Resistant	66
Medium resistant	152
Medium susceptible	100
Very susceptible	86

Such a detailed description of genebank accessions is very time-consuming. In recent years we have experienced problems owing to shortage of technicians. We strongly believe that the success of the EuroBioFlax project submitted to the EU 5th Framework Programme would help solve our problems with the management of the flax collection.

Equipment

Great efforts have been made at INF to equip the genebank with modern cooling and freezing chambers to secure controlled seed storage conditions. A big chamber at -2°C is prepared for the storage of the flax and hemp base collection, and a smaller one at -20°C is used for long-term storage of the "reserve".

A "breeder-friendly genebank"

The main goal of fibre flax breeding is to obtain early-maturing, high-yielding cultivars with good quality fibre and good resistance to lodging and diseases. With traditional breeding methods, 14 to 16 years are required to obtain a new cultivar (Kowalińska 1994).

INF has seven experimental stations located in different climatic zones in Poland and experiencing different ecological conditions. Breeding work and comparison trials are carried out at these stations.

The INF genebank aims at helping breeders in their work by:

- improving the protection and preservation of flax and hemp genetic resources,
- increasing the availability of genetic resources to breeders and researchers,
- screening the core collection for properties that are important for breeders, and
- developing the core collection based on the total genepool and organizing it so as to cover the maximum diversity with a minimal number of accessions.

The Polish fibre flax cultivars included in the list of currently registered cultivars in Poland and bred in INF's experimental stations—'Alba', 'Artemida', 'Modran', 'Nike', 'Selena' and 'Wiko'—were created from INF genebank material. All cultivars bred at INF since its foundation and which are not included in the registration list anymore are also carefully preserved in our collection. There are 14 of these old cultivars: 'LCSD 200', 'LCSD 210', 'Zwisly', 'Golęciński', 'Swadzimski', 'Kotowiecki', 'Waza', 'Milenium', 'Fortuna', 'Minerwa', 'Ariadna', 'Izolda', 'Bryta' and 'Swapo'.

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The Romanian flax collection

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The area of flax grown in Romania was large before 1990 (over 50 000 hectares), but it then gradually decreased and by 2001 was reduced to only 672 ha. This dramatic reduction resulted in a considerable increase of artificial fibre imports. However the national flax collection has been well maintained and has not declined.

Composition of the flax collection

Taxonomic composition

The Romanian *Linum* collection covers 21 species, represented altogether by 3845 accessions, of which 220 are duplicates (Table 1). *Linum usitatissimum* is the most important species with 3776 accessions, and the most used in breeding programmes.

Table 1. Distribution of the Romanian *Linum* collection by species

Species	No. of accessions
L. usitatissimum	3776
L. perenne	13
L. pallescens	2
L. nervosum	2
L. mediterraneum	1
L. marginale	1
L. narbonense	1
L. humile	7
L. hispanicum	1
L. hirsutum	1
L. grandiflorum	3
L. gallicum	1
L. decumbens	1
L. corymbeiferum	3
L. austriacum	10
L. angustifolium	16
L. altaicum	1
L. africanum	2
L. tenue	1
L. sulcatum	1
L. strictum	1
Total	**3845**

Status of sample

The distribution of *L. usitatissimum* samples is as follows: advanced cultivars 1944 accessions, breeder's lines 1610, landraces 213, weedy 3 and wild 6 (Fig. 1). The status of Romanian accessions is shown in Fig. 2 (advanced cultivars 56, breeder's lines 942 and landraces 82).

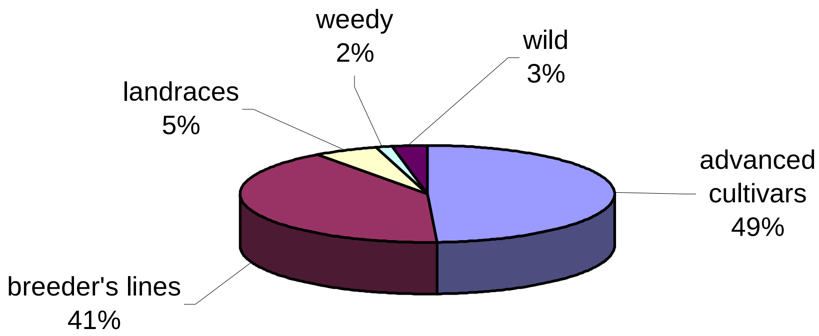

Fig. 1. Distribution of flax accessions according to status of sample.

Type of use

The collection contains 2161 accessions belonging to the linseed type, 1068 to fibre flax, and 71 to intermediate type; the status of 545 accessions is unknown.

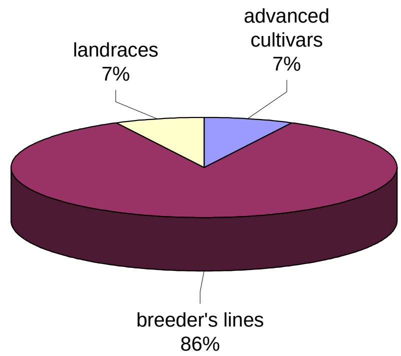

Fig. 2. Distribution of Romanian accessions in the flax collection according to status of sample.

Origin of the accessions

Table 2 shows the distribution of accessions by country of origin. About one-third of the collection (1080 accessions) is of Romanian origin.

Table 2. Distribution of the flax accessions by country of origin

Country of origin	No. of accessions	Country of origin	No. of accessions
Afghanistan	7	Ireland	18
Argentina	188	Iran	8
Armenia	1	Italy	18
Australia	22	Japan	36
Belgium	34	Kazakhstan	1
Bulgaria	17	Kenya	3
Belarus	8	Korea	2
Brazil	22	Lithuania	5
Canada	56	Morocco	28
China	33	Malta	1
Czechoslovakia	76	Nigeria	2
Cyprus	2	The Netherlands	105
Czech Republic	41	New Zealand	3
Germany	305	Poland	166
Denmark	9	Portugal	16
Algeria	1	Romania	1080
Egypt	21	Russian Federation	403
Spain	1	USSR	137
Estonia	6	Sweden	25
Ethiopia	3	Tajikistan	1
Finland	6	Turkmenistan	1
France	75	Tunisia	1
United Kingdom	34	Turkey	12
Greece	11	Ukraine	7
Georgia	2	Uruguay	3
Guatemala	1	USA	225
Hungary	157	Yugoslavia	3
India	241	South Africa	2
		Unknown	153
Total = 3845			

Collection holders

Four stakeholders are involved in the conservation of flax genetic resources, including breeders who use this germplasm in their crop improvement programmes and the National Genebank of Suceava, responsible for the *ex situ* preservation of Romanian agrobiodiversity (Table 3). The Suceava Genebank stores both active (+4°C), and base (-20°C) collections. The other institutions do not have controlled conditions for the maintenance of breeding material.

Table 3. Institutions holding flax collections in Romania

Institution name	No. of accessions
Research Institute for Cereals and Industrial Crops of Fundulea	2880
Suceava Genebank	520
Agricultural Research Station of Livada[12]	420
Agricultural Research Station of Simnic	25

[12] See also paper by V. Ilea on breeding activities at Livada (following pages).

Progress in fibre flax breeding at the Agricultural Research Station Livada, Romania

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Fibre flax breeding and seed production started relatively recently in Romania (1973). During the following years, 420 foreign cultivars from all typical ecological regions found in the majority of flax-growing regions in 22 countries from Europe, South and North America, Asia and the Middle East have been tested under intensive cropping in long-term experiments (from 1973 to present).

The goal of this long-term study of the collection is to identify the best varieties for northwestern Romania and use them in the breeding programme. The characters studied are quality, total and technical lengths, fibre content, resistance to rainfall and to *Fusarium* sp.

Since 1980 the most important fibre flax breeding programme in Romania has been carried out at the Agricultural Research Station Livada (ARS Livada).

This paper presents the results for stem yield and fibre content of the improved material created at ARS Livada over the period 1980-2000, in experiments conducted on genetic resources of this institute's collection compared with control varieties.

Materials and methods

The experiments were carried out every year on a slightly acidic brown luvic soil (pH 5.6, with mobile phosphorus 60 ppm and potassium 300 ppm). The material was sown every year between 10th and 20th April. The size of experimental plots was 3 m^2 with three replicates, providing a yield of 2800 grains/m^2. Throughout the years the following characters were evaluated: stem and seed production, coefficient of variation of total and technical length, stem fibre content using 1.8% NaOH.

Experimental data were subjected to analysis of variance and regression analysis (Finlay and Wilkinson 1963; Ceapoiu 1968; Snedecor 1968).

Resistance to rainfall was recorded on the first and seventh days after the first rain according to the FAO scale 1-9.

Resistance to *Fusarium* sp. was evaluated in the field by the infection rate of flax cultivated in monoculture since 1985; infected stems were incorporated into the soil at ploughing in autumn to facilitate natural infection. The scale proposed by Kommedahl *et al.* (1970) was used to evaluate the resistance level. All observations of the resistance reported in this study were made at full maturity.

Results and discussion

Success in fibre flax improvement is conditioned by the pursuit of clear objectives: yield capacity, resistance to lodging and wilt (*Fusarium* sp.) associated with a high fibre content.

The identification of the most valuable sources in the germplasm for resistance to unfavourable weather conditions, together with earliness, yield capacity and high fibre content, was an important step in fibre flax varietal breeding.

Duration of growing period

The growth period of the genotypes studied ranged from 84 to 102 days (average value for the control variety in the collection: 90 days).

All varieties tested at our station take a long time from flowering to yellow maturity.

Out of 419 cultivars, 36 present a notable precocity and 9 a pronounced lateness at flowering, while at yellow maturity 25 are precocious and 32 late.

Resistance to lodging

Resistance to lodging is a major component of high stem quality. The evaluation of lodging was done on the first and seventh days after the first rainfall using the FAO scale 1-9. According to the final score recorded at yellow maturity, 72 cultivars present very good resistance, 66 are resistant, 166 moderately resistant and 115 moderately susceptible or very susceptible (Table 1).

Table 1. Flax genetic resources classified according to resistance to lodging

Resistance group	Score on FAO scale	Cultivars		Cultivars with total length >80 cm
		No.	%	
Very resistant	1	72	17.2	K1051, Primorski, Saravia 4700, Pobediteli, Nataja, Superior, Noblesse. Silva, Ariane, Fany, Codruta, Ioana, Rares, Cosmin, etc.
Resistant	2	66	15.8	Olina, Falkentrop, Olivario, Caspica, Verum, Concurent, Zichenauer 92, Eva, Holandia, etc.
Moderately resistant	3-4	166	39.6	Na-98, Horal orig 443, Zichenauer 93, Na 96, Hera, Bertelin, Mures, Rolin, Lintex, Mira, Eva, K6, L1120, etc.
Moderately susceptible	5-6	93	22.2	Primo, Fibra, Belan, Crista, Regina, Milenium, Thallasa, Smolenski
Susceptible	7-8	22	5.2	Vpered, Pskovski 359, Izolda, Linda, Reina, Nynke, Viera, Fortuna

Resistance to wilt (*Fusarium* sp.)

Fibre wilt caused by *Fusarium* sp. is the most damaging and dangerous disease of this crop, especially in countries where flax is grown for oil (linseed). The best 30 genotypes in the collection were selected and tested in the nursery for evaluation of their agronomic value and resistance to wilt. Among these genotypes 10 were resistant, 3 moderately resistant and 17 moderately susceptible, susceptible and very susceptible using the scale proposed by Kommedahl *et al.* (1970) (Table 2). All observations of the resistance were made at full maturity.

Table 2. Results of tests in wilt nursery (scale of Kommedahl *et al.* 1970)

Resistance group	Cultivars
Resistant (0-19%)	Codruta, Laura, Natasja, SV 65080, Ariane, Fany, G184, Waza, Iordan, Elena
Moderately resistant (20-39%)	Belan, Primo, T10
Moderately susceptible (40-59%)	Eva, Nynke, Mures, Madaras
Susceptible (60-79%)	Hera, Marina, Thallasa, Rolin, Belinka, Bertelin, Minerva
Very susceptible (80-99%)	Lazurnii, Regina, Mira, Pet-79, Opaline, Lintex

Yield

Experimental data obtained over the period 1983-2000 in the comparative trials with the line considered as the most productive in ARS Livada revealed a wide range of variation in yield capacity among new varieties.

The indicator used to evaluate genetic improvement was the amplitude of stem yield variation (y max - y min) from year to year, which depends on the weather and the behaviour of the genotypes.

Other indicators used include:

- minimum crop yield (y min) compared to average yield (y) which, if large, indicates that the cultivar is not very tolerant of weather variation;
- the ratio (maximum yield/minimum yield), which indicates that cultivars with a value greater than 2 are suitable for intensive cultivation;
- coefficient of variation and regression according to which the cultivars can be classified in stability classes (medium, high and low).

Conclusion

The results of this study lead to the conclusion that the available genetic material contains a sufficient genetic variability, depending on the country of origin, the ecological zone and the plant type, either for fibre or for oil. This study allowed identifying useful germplasm for the improvement of fibre content, resistance to lodging and wilt. Among the more than 400 cultivars under study, types were identified with a maturation period ranging from 84 to 102 days from spring to maturity. Very good resistance to lodging was detected in 72 varieties reaching a height of over 80 cm. The most representative varieties were tested in the field for their reaction to various diseases and 10 varieties showed a good resistance to wilt. This study allowed selecting the most promising varieties of the collection to be used as parents in top cross, diallel cross, single cross and other breeding schemes. As a result, the following cultivars were obtained and registered: 'Codruta' in 1995; 'Ioana' in 1997; 'Carolina', 'Elena' and 'Monica' in 1998; 'Alin', 'Cosmin', 'Iordan' and 'Rares' in 1999; 'Bazil', 'Louis', 'Martin' and 'Sabena' in 2000; and 'Elisa' and 'Radu' in 2001.

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The flax genetic resources collection held at the Vavilov Institute, Russian Federation

Nina B. Brutch

N.I. Vavilov Research Institute of Plant Industry (VIR), St. Petersburg, Russian Federation

The VIR flax collection, founded in 1922 by N.I. Vavilov, is the oldest and one of the largest flax genetic resource collections in the world. During almost 80 years it was enriched by numerous collecting missions. Many commercial varieties, lines and breeding material were received from other genebanks, breeders and scientists from all over the world. The collection currently contains 5521 accessions. However a look at the VIR collection catalogue shows that the last accession registered holds the number 8237: this discrepancy is due to losses during the Second World War. The institute's collections remained in blockaded Leningrad. Many scientists died of starvation, but no seeds were eaten. It was impossible to maintain the collection, the fields of the institute being situated on occupied territory. There was no heating in the buildings and more then 2500 flax accessions lost their germinating ability because of bad storage conditions. But almost 3000 accessions collected before the war survived. They represent more then half of the present flax collection, and its most valuable part.

Composition of the flax collection

Type of use

The collection covers a wide range of diversity. It includes all three flax types (Table1). The fibre type has a long stem with a small inflorescence on top, while the oil type, usually called linseed, has many short stems with big branched inflorescences. There are also many representatives of the intermediate type, which can be used for both purposes. This type includes several so-called "winter" accessions. Flax does not have real winter genotypes, because it does not need freezing to start flowering. Both "spring" and "winter" types can be successfully grown when sown in spring and autumn in appropriate conditions (Sisov 1955; Brutch *et al.* 2001b). The collection also contains some wild species.

Table 1. Distribution of flax accessions in the VIR collection according to type of use

Flax type	No. of accessions	%
Fibre	2033	37
Intermediate	1867	34
Oil	1568	28
Wild	53	1
Total	**5521**	**100**

Geographic origin

Flax is a widely spread species and can be grown in different climatic conditions, including mountainous regions, on all continents except the Antarctic. The collection covers the whole range of flax geographical distribution (Table 2).

Table 2. Distribution of accessions in the VIR collection according to geographic origin

Continent	No. of accessions	%
Europe	3429	62
Asia	1239	22
America	534	10
Australia	62	1
Africa	217	4
Unknown	40	1
Total	**5521**	**100**

Status of sample

Different kinds of genetic resources are included in the collection (Table 3).

More then half of the collection is represented by local folk-bred varieties. Most of these accessions were collected before the Second World War. Others were received from genebanks and botanical gardens from different countries.

The collection also includes many commercial varieties received from breeders and other genebanks. Transfers between genebanks are a common procedure, but they sometimes give rise to problems of variety identification. If they are received from a third country, it is not always possible to determine their real origin.

Lines and other breeding material also form an important part of the collection. They were obtained from breeders and foreign genebanks. The distribution of different kinds of accessions from different countries is not equal.

Table 3. Distribution of accessions in the VIR collection according to sample type

Sample type	No. of accessions	%
Local	3095	57
Variety	1127	20
Breeding material	1001	18
Wild	53	1
Line	245	4
Total	**5521**	**100**

Donor countries

Most of the collection is made up of accessions originating from the former Soviet Union Republics (Table 4), primarily Russia, followed by Uzbekistan, Ukraine and Tajikistan. The majority of these accessions are local folk-bred varieties, which can now be found only in our collection (Table 5). We also maintain practically all flax commercial varieties ever bred in USSR. Breeding lines and donors of different agronomic characters are also widely represented.

Table 4. Main countries represented in VIR flax collection

Country	No. of accessions
Former USSR (including Russia)	2974
Russia	1520
Argentina	202
Czech Republic	201
India	166
USA	154
Germany	143
Turkey	143
Ethiopia	134
The Netherlands	133
Canada	120

Table 5. Flax genetic resources from Russia included in the VIR collection

Sample status	No. of accessions	%
Local	920	61
Variety	263	17
Breeding material	139	9
Wild	6	0
Line	192	13
Total	**1520**	**100**

Considering the former Soviet Union as one country, flax genetic material from 58 foreign countries is included in the collection. Most of these accessions were obtained from Argentina, the Czech Republic, India, USA, Germany, Turkey, Ethiopia, the Netherlands and Canada. Some countries, e.g. India and Ethiopia, are represented mainly by local accessions (Table 6). The preservation of local accessions from different countries is very important for the world community. At the end of the 20th century, local varieties were intensively replaced by commercial varieties and it is now difficult to find this kind of genetic material. Several countries started working with plant genetic resources when part of the original folk-bred material was already lost following the introduction of commercial varieties. Sometimes the collected accessions were lost because of wars and political changes. In such cases we help these countries to recreate their collections. For example all living accessions from Ethiopia and Portugal preserved in our institute have been repatriated to their original countries (Brutch *et al.* 2001b).

Table 6. Flax genetic resources from Ethiopia included in the VIR collection

Sample status	No. of accessions	%
Local	128	96
Variety	2	1
Breeding material	4	3
Total	**134**	**100**

For other countries, e.g. Germany (Table 7) and USA (Table 8), the collection is represented mainly by commercial varieties and breeding material. The conservation of old commercial varieties and breeding material is a very important part of genebank work. Breeders usually do not conserve their material for long if they change the direction of their work. But after a few years, they may need their own old varieties again to include them in breeding programmes. It is very important to preserve lines and varieties carrying identified genes for genetic studies in order to be able to compare them later on with new similar genes or to create genetic maps.

Table 7. Flax genetic resources from Germany included in the VIR collection

Sample status	No. of accessions	%
Local	18	13
Variety	94	66
Breeding material	24	16
Wild	7	5
Total	**143**	**100**

Table 8. Flax genetic resources from the USA included in the VIR collection

Sample status	No. of accessions	%
Local	5	3
Variety	77	50
Breeding material	72	47
Total	**154**	**100**

Evaluation

Since 1922, flax accessions have been evaluated at several sites under different climatic conditions. Morphological traits such as colour and shape of flowers and seeds are recorded. Agronomic characters recorded include resistance to rust and other diseases, duration of growth period, plant height, yield of seed and straw, resistance to lodging, fibre and oil contents and quality, boll dehiscence, etc. Evaluation results are regularly published in the "catalogues of VIR world collection" (Anonymous 1968, 1975, 1984, 1991, 1994, 2000). Multilateral accession evaluation showed that sources can be found for the majority of breeding characters and revealed a wide intraspecific diversity (Brutch *et al.* 2001a).

The genetic collection was established in the 1970s on the basis of the evaluation of the collection. It now consists of about 250 inbred lines and lines of lower generations. These lines possess different morphological and agronomic characters. This collection includes contrasting phenotypes of traits such as colour and shape of flowers and seeds, resistance to rust, duration of growing period, plant height, etc. The genetic control of many of these traits has been identified (Kutuzova and Brutch 1992; Kutuzova 1994; Brutch *et al.* 1998, 2001a; Brutch 1999; Brutch and Porohovinova 1999).

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The Ukrainian fibre flax collection and related breeding activities

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Ukraine is traditionally a flax-growing country. There was a time when fibre flax occupied as much as 240 000 ha and Ukraine was first in the world for flax fibre production. Unfortunately, from 1992 onwards the area under flax and flax manufacture declined. By 2000 the area sown had decreased 8-fold. However in recent years the situation has stabilized and the area under flax has increased to over 26 000 ha.

The Ukrainian fibre flax collection

Composition of the collection

The Ukrainian fibre flax collection currently contains 1042 samples. It did not exist before 1992. At the time of the former Soviet Union there was no need for a separate collection, since all the material needed for scientific research and practical breeding was received from the common Soviet genebank—the genebank of the N.I. Vavilov Research Institute of Plant Industry (VIR, St. Petersburg), the richest in the world—according to an agreement on scientific and technical cooperation. Many flax samples from the VIR collection were studied at our institute, and these samples formed the basis of the Ukrainian national flax collection.

Research and methodical guidance on the creation, study and conservation of the fibre flax collection is currently being carried out by the National Centre of Ukraine (NCGRU) at the Yuriev Institute of Plant Breeding (named after V.G. Yuriev of the Ukrainian Academy of Agrarian Sciences) in Kharkov.

Status of samples

The distribution of accessions according to status of sample is given in Table 1.

Table 1. Flax and hemp collection held at the genebank of the Institute of Bast Crops (status 2001)

	No. of accessions		
Status of sample	***Linum usitatissimum***	***Cannabis sativa***	**Total**
Ukrainian breeding varieties	35	52	87
Foreign varieties	521	31	552
Local varieties and forms	151	62	213
Breeding lines	15	2	17
Synthetic populations	9	3	12
Hybrids	0	26	26
Wild	1	10	11
Status undetermined	310	209	519
Total number of samples	**1042**	**395**	**1437**

Origin of the accessions

The Ukrainian flax collection contains accessions from 45 countries. The largest contribution comes from Russia (256 samples), followed by Sweden (117), the Netherlands (54), the Czech Republic and Slovakia (75), Ukraine (52), USA (52), Argentina (34), France (30), Poland (23), Hungary (23) and Germany (61).

Evaluation
Since the very beginning of its establishment the collection has been carefully studied. At present 870 accessions have been investigated and classified according to their useful characters: 132 as fast-ripening, 154 for seed yield, 81 for straw yield, 76 for stalk fibre content, 42 for plant height, 114 for good fibre spinning capacity, and 41 as resistant to lodging; the remaining 230 accessions have no useful traits. All the material is also evaluated for disease resistance. Five donors of resistance to fusarium wilt have been identified.

Storage
Studies related to the organization of the long–term storage of the collection samples are also being carried out. A national seed storehouse was created in the centre of genetic resources. At present 218 samples have been handed in for long-term storage. All the available information is regularly transmitted to the centre of genetic resources of Ukraine for inclusion in a computerized database.

Use of the collection
A very important issue for the improvement of information services to collection users is the publication of catalogues. Two catalogues providing the characteristics of 282 variety samples have been issued. Flax seed samples are sent to scientific/research/higher education institutions, colleges, technical colleges and schools upon request. During 2001 more than 150 sample packages have been sent to various recipients.

Flax breeding activities
One of the current problems in flax growing is fibre quality. A detailed study of the world collection for this trait is necessary in order to identify valuable initial breeding material. This depends greatly on the methods used for fibre quality evaluation in small tests. The methods developed for this purpose by several researchers proved to be time–consuming, ineffective and were not widely used in practical breeding work (Shukshin 1950; Ordina 1960; Tumalewicz and Pyszinska 1967; Tikhvinskii and Dudina 1976; Afonin *et al.* 1982). Research in this direction is now being carried out at the Institute of Bast Crops. A method for the estimation of fibre spinning capacity in individual elite plants according to their physical and mechanical properties has been developed. It is proposed to evaluate fibre quality by an index defined as the "yarn relative breaking load " (RBL). An empirical formula with flexibility and durability indices corrected to fibre mass was developed, since, without it, fibre quality was over-estimated for thin light weight stalks.

Data on fibre mass, flexibility and breaking load are entered into a special computer program which calculates the RBL index. The method was tested on varieties known for their high spinning capacity ('Orshansky 2', '806/03 and '1288 /12') or low spinning capacity ('Gera', 'Verhnevolzhsky' and 'Yakub') (Table 2).

Table 2. Results of thrice-repeated positive (+) or negative (-) selection on the yarn relative breaking load index (RBL) of individual fibre flax plants

Varieties	Average yarn relative breaking load (cN/tex)*					
	1993		1995		difference	
	+	-	+	-	+	-
High fibre quality varieties	12.30	12.39	12.82	11.14	0.52	-1.25
Low fibre quality varieties	11.57	11.48	12.08	10.94	0.51	-0.54

***** cN/tex = tenacity (centinewtons per tex)
+ = selection on RBL increase; - = selection on RBL decrease

The results in Table 2 show that for positive selection (+) in varieties with high fibre quality the cN/tex value increased by 0.52 whereas for negative selection (-) it decreased by 1.25. In varieties with low fibre quality the difference in the results of positive and negative selection proved to be somewhat smaller.

Investigations showed that selection on RBL increase carried out on these varieties had a positive influence on physical and mechanical fibre properties (Table 3).

Table 3. Influence of RBL selection on the physical and mechanical fibre qualities of fibre flax, 1997

Fibre properties	Average for varieties with high fibre quality	Average for varieties with low fibre quality
Without selection		
Fibre flexibility (mm)	45.8 ± 1.60	38.7 ± 1.69
Firmness (kgf)	14.2 ± 0.53	16.5 ± 0.58
Thinness (mm/mg)	118 ± 2.89	116 ± 1.95
Durability of yarn (km)	11.05 ± 0.31	10.80 ± 0.29
Selection repeated 4 times		
Fibre flexibility (mm)	47.8 ± 1.61	42.5 ± 1.76
Firmness (kgf)	16.6 ± 0.26	19.1 ± 0.78
Thinness (mm/mg)	153 ± 1.93	148 ± 2.74
Durability of yarn (km)	12.20 ± 0.40	12.09 ± 0.34

The results show that repeated selection notably improved all physical and mechanical fibre properties. In varieties with high fibre quality, flexibility increased from 45.8 to 47.8 mm (i.e. by 4.4%), firmness from 14.2 to 16.6 kgf (16.9%) and thinness from 118 to 153 mm/mg (29.6%). This was reflected in fibre durability, which increased from 11.05 to 12.20 km (10.4%). In varieties with low fibre quality, the physical and mechanical properties indices were worse than those of the varieties with high spinning capacity; however selection resulted in an increase in flexibility of 9.8%, firmness 15.7%, thinness 27.5% and yarn durability 11.9%.

The method thus developed for the evaluation of fibre quality in individual elite plants using the yarn RBL index provides an objective assessment of spinning capacity. It is therefore used in fibre flax breeding and for the estimation of fibre quality of the collection samples during the first stages of selection.

Selection work aims at creating highly productive varieties with improved fibre quality and resistance to lodging and diseases. New initial material was received in the period 1996–2000 and over 30 varieties of local and foreign origin have been used in diallel, saturated and other crossings.

The certification of varieties, which includes information about the country of origin, donor institute, breeders, botanical species, infraspecific taxon, life cycle, type of development, ploidy, value of the sample, availability and other characters, is an essential part of the work with the collection. Unfortunately this work is still far from completion.

Proposed future activities

- To submit annually to the Centre updated information about the best flax samples.
- To simplify the procedure for mutual exchange of seeds of valuable varieties.

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Appendices

Appendix I. International Flax Data Base (IFDB) descriptors

Passport descriptors

The database is using the 28 FAO/IPGRI Multi-crop passport descriptors (see http://www.ipgri.cgiar.org/publications/pubfile.asp?ID_PUB=124).

Additionally, the following passport descriptors are used:

A. Year of release [YYYY]
Year of release of the cultivar, or year of registration

B. Type of use
1 Flax
2 Linseed
3 Combined/Intermediate

C. Pedigree
Parentage or nomenclature, and designations assigned to breeder's material

D. Year of input into IFDB [YYYY]
Year on which the accession data were first entered into the IFDB

E. Date of updating [YYYYMMDD]
Date on which the accession data were updated in the IFDB

Characterization and evaluation descriptors (28)

Morphological characters (17)

1. Plant growth habit
1 Prostrate
2 Spreading
3 Semi-erect
4 Erect

2. Plant life cycle
1 Annual
2 Biennial
3 Perennial

3. Plant natural height
1 Very short
3 Short
5 Medium
7 Tall
9 Very tall

4. Stem length
1 Very short
3 Short
5 Medium
7 Long
9 Very long

5. Flower: size of corolla
3 Small
5 Medium
7 Large

6. Flower: shape
1 Regular
2 Star
3 Semi-star

7. Sepal dotting
1 Absent or very weak
3 Weak
5 Medium
7 Strong
9 Very strong

8. Petal colour: colour of corolla (when fully developed)
1 White
2 Light blue
3 Blue
4 Pink
5 Red violet
6 Violet

9. Petal: longitudinal folding
0 Absent
1 Present

10. Anther colour
1 Yellowish
2 Bluish
3 Greyish
4 Orange

11. Stamen: filament colour at top
1 White
2 Blue
3 Violet

12. Style colour at base
1 White
2 Yellow
3 Blue

13. Boll type
1 Dehiscent, fully opened
3 Dehiscent, half-opened
5 Semi-dehiscent
7 Weakly dehiscent
9 Undehiscent

14. Boll size
3 Small
5 Medium
7 Large

15. Boll: ciliation of septa
0 Absent
1 Present

16. 1000-seed weight [g]
(In grams, to two decimal places)

17. Seed colour
1 Yellow
3 Light brown
5 Brown
7 Dark brown
9 Green

Biological characters (4)

18. Resistance to lodging
1 Very low
3 Low
5 Medium
7 High
9 Very high

19. Fusarium susceptibility
1 Very low
3 Low
5 Medium
7 High
9 Very high

20. Vegetation period (to maturity)
1 Very early
3 Early
5 Medium early
7 Medium late
9 Late

21. Time of beginning of flowering
9 Very early
7 Early
5 Medium early
3 Medium late
1 Late

Agronomic characters (6)

22. Fibre content in straw
9 Very high
7 High
5 Medium
3 Low
1 Very low

23. Fibre yield
9 Very high
7 High
5 Medium
3 Low
1 Very low

24. Seed yield
9 Very high
7 High
5 Medium
3 Low
1 Very low

25. Oil content
9 Very high
7 High
5 Medium
3 Low
1 Very low

26. Oil yield
9 Very high
7 High
5 Medium
3 Low
1 Very low

27. Linolenic acid content
9 Very high
7 High
5 Medium
3 Low
1 Very low

Cytological character (1)

28. Ploidy level
(2x, 3x, 4x, etc.)

Appendix II. Abbreviations and acronyms

ABI	AgroBioInstitute, Kostinbrod, Bulgaria
ABI	Institute for Agrobotany, Tápiószele, Hungary
BAZ	Bundesanstalt für Züchtungsforschung an Kulturpflanzen (Federal Centre for Breeding Research on Cultivated Plants), Braunschweig, Germany
BGRC	Braunschweig Genetic Resources Collection, Germany
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (Federal Ministry for Economical Cooperation and Development), Germany
CBD	Convention on Biological Diversity
CGN	Centre for Genetic Resources, Wageningen, The Netherlands
COMECON	Council for Mutual Economic Assistance
EBF	EuroBioFlax project
ECP/GR	European Cooperative Programme for Crop Genetic Resources Networks
EPGRIS	European Plant Genetic Resources Information Infrastructure
ESCORENA	European Cooperative Research Network on Flax and other Bast Plants (FAO)
EU	European Union
EURISCO	European Internet Search Catalogue (EPGRIS project)
FAL	Federal Agricultural Research Centre, Germany
FAO	Food and Agriculture Organization of the United Nations, Rome, Italy
IFDB	International Flax Database
INF	Institute of Natural Fibres, Poznań, Poland
INRA	Institut national de la recherche agronomique (National Agronomic Research Institute), France
IPGR	Institute of Plant Genetic Resources, Sadovo, Bulgaria
IPK	Institut für Pflanzengenetik und Kulturpflanzenforschung (Institute for Genetics and Plant Breeding), Germany
IU	International Undertaking
MCPDs	Multicrop passport descriptors (FAO/IPGRI)
NGB	Nordic Gene Bank, Alnarp, Sweden
PGR	Plant genetic resources
RICP	Research Institute of Crop Production, Prague, Czech Republic
UPOV	Union internationale pour la protection des obtentions végétales (International Union for the Protection of New Varieties of Plants), Geneva, Switzerland
VIR	N.I. Vavilov Research Institute of Plant Industry, St. Petersburg, Russian Federation

Appendix III. Agenda

ECP/GR* Ad hoc *meeting on Flax genetic resources
RICP Prague-Ruzyne, Czech Republic, 7-8 December 2001

Thursday 6 December
Arrival of participants in Prague

Friday 7 December
8.30 Departure from the hotel

09.00 - 10.00 Introduction
- Opening of the meeting, welcome (*M. Pavelek)*
- Background and history of the present meeting (*L. van Soest*)
- Selection of the Chair for the meeting
- Brief self-introduction of the participants

09.30 – 10.00 ECP/GR briefing
- General briefing on ECP/GR (*L. Maggioni*)
- Outcome of ECP/GR Steering Committee meeting in October 2001 and consequences for Flax genetic resources (*L. Maggioni*)

10.00 – 10.30 Coffee break

10.30 – 12.30 National collections status report
Representatives are requested to present shortly (5-7 minutes) the status of their national flax collection. Full papers will be included in the final report of the meeting.

- Bulgaria (*D. Shamov and A. Balabanova*)
- Czech Republic (*M. Pavelek*)
- France (*G. Fouilloux*)
- Germany (*K. Dehmer*)
- Hungary (*A. Simon*)
- The Netherlands (*L. van Soest*)
- Poland (*I. Rutkowska*)
- Romania (*V. Ilea*)
- Russian Federation (*N. Brutch*)
- Ukraine (*V. Virovets*)

12.30 – 14.00 Lunch

14.00 - 15.30 General discussions *(M. Pavelek)*
- Current situation
- Use of FAO/IPGRI Multi-crop Passport Descriptors
- Discussion on further development
- Inclusion of characterization/evaluation data, possible selection of minimal set of descriptors

15.30 – 16.00 Coffee break

16.00 – 17.30 Plan to implement the European/International Flax Database

- How to forward data to the database
- First priority on passport data
- Second priority on minimum set of descriptors of characterization/evaluation data
- Inclusion of data of other flax collections within Europe and in a later stage outside Europe

17.30 – 18.00 End of the first day, return to the hotel

18.00 – 23.00 Social dinner at the hotel

Saturday 8 December

8.00 Departure from the hotel

8.30 – 9.30 Finalizing discussions on the European/International Flax Database

- Time schedule for delivery of the passport data by the participants

9.30 – 10.00 *Ad hoc* actions

- Cooperation with FAO/ESCORENA Flax and other Bast Plants Network (*M. Pavelek and A. Balabanova*)
- Use of available funds for Flax genetic resources actions (*L. Maggioni*)
- EU proposal "EuroBioFlax" (EBF) (*M. Pavelek*)

10.00 – 10.30 Coffee break

10.30 – 12.30 Any other business

- Application to the ECP/GR Steering Committee to become an official Working Group on Flax
- Proposal for next meeting

12.30 – 14.00 Lunch

14.00 – 18.00 Drafting of the report

18.00 – 19.00 Approval of workplan and recommendations

19.00 – 19.15 Closing remarks

19.30 Departure from the institute

Sunday 9 December

Departures

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