INTERNATIONAL CROP NETWORK SERIES 4

IBPGR

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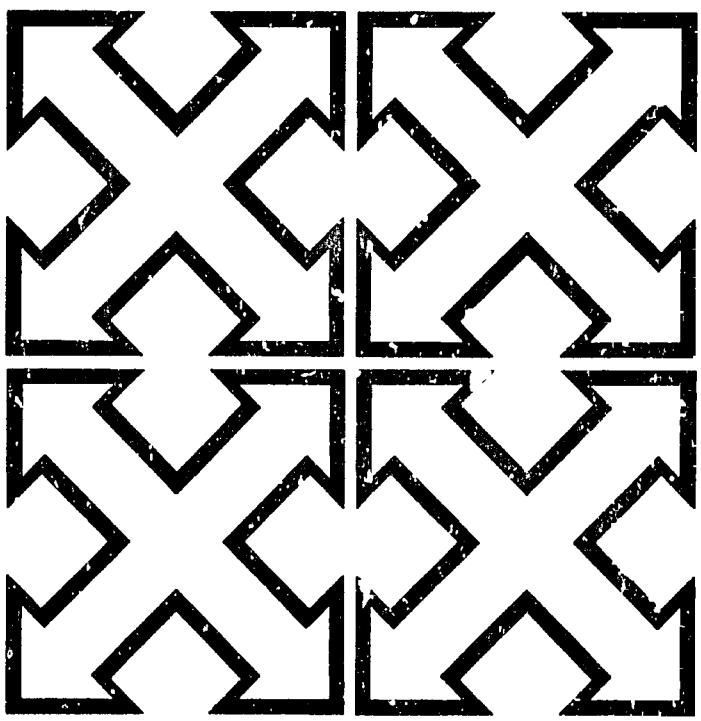
Searching for New Concepts for Collaborative Genetic Resources Management

edited by Th.J.L.van Hintum, L. Frese and P.M. Perret

Papers of the EUCARPIA/IBPGR symposium
held at Wageningen, The Netherlands
3-6 December 1990



INTERNATIONAL BOARD FOR PLANT GENETIC RESOURCES

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ROME 1991

The International Board for Plant Genetic Resources (IBPGR) is an autonomous international scientific organization under the aegis of the Consultative Group on International Agricultural Research (CGIAR). IBPGR was established by the CGIAR in 1974. The basic function of IBPGR is to promote and coordinate an international network of genetic resources centres to foster the collecting, conservation, documentation, evaluation and use of plant germplasm and thereby contribute to raising the standard of living and welfare of people throughout the world. Financial support for the core programme is provided by the Governments of Australia, Austria, Belgium, Canada, China, Denmark, France, Germany, India, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the UK and the USA, the United Nations Development Programme and the World Bank

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Foreword

The collecting, conservation, evaluation, documentation and utilization of plant genetic resources has long been recognized as the essential basic requirement for maintenance and continuous improvement of agricultural production. The preservation of biological diversity, and in particular the programmes for conservation of the crop genetic resources have received considerable public attention and are at present in public discussion more than ever before.

In the early years of genetic resources activities, faced with the problem of acute genetic erosion in many of the major food crops, much emphasis had to be given to safeguard endangered material. This and the still ongoing collecting activities have resulted in large germplasm collections which can hardly be maintained in an appropriate way Clearly, the adequate financial means required to preserve the total amount of collected germplasm (not to speak of evaluation and utilization) are not made available.

There is a general agreement that genetic resources programmes are not sufficiently funded. Genebanks should not cease to voice this fact in public discussions which at the end will hopefully result in appropriate support of institutions and programmes. However, there is general agreement that genebanks themselves can make more efficient use of the available funds by rationalization of the existing collections and collaboration in the field of collection and maintenance of the germplasm

The natural basis for task-sharing and mutual support is a specific crop. To establish a structural basis for collaboration, IBPGR has launched the concept of crop specific networks Such networks integrate the activities of experts involved in genetic resources conservation and utilization of a specific crop at a world, regional or national level. During the 'Crop Networks Symposium' various kinds of network structures were considered. It could be shown that crop networks can become a powerful instrument for rationalization of genetic resources programmes. In view of the potential benefit for plant breeding and agriculture, this concept should therefore receive the necessary support for further enhancement.

The organizing committee of the 'EUCARPIA/IBPGR Crop Networks Symposium' takes this opportunity to thank all participants for their vivid interest and valuable contributions. Special thanks are due to the EUCARPIA association for funding and several Dutch breeding companies and the Department of Agriculture, Nature Management and Fisheries, which provided financial means for the framework programme. The publication of the proceedings was financed by IBPGR and coordinated by Paul Stapleton of IBPGR.

The organizing committee

Organizational matters :

I.W. Boukema
Th Hazekamp
L.J.M. van Soest
H.M. Verkerke-Berentschot

Scientific matters :

L. Frese
Th.J.L. van Hintum
P.M. Perret

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Abstracts of the Posters

Genetic resources of vegetable crops in Poland

T. Kotliska
Research Institute of Vegetable Crops, ul. 22 Lipca 1/3, 96-100 Skierniewice, Poland

Conservation of germplasm of vegetable crops is a part of the National Plant Genetic Resources Conservation Programme coordinated by the Plant Breeding and Acclimatization Institute, in Radzików.

The Plant Genetic Resources Laboratory of the Research Institute of Vegetable Crops in Skierniewice carries responsibility for:

- Collection of old polish cultivated and obsolete cultivars, landraces, valuable breeding materials and wild species.
- Evaluation and documentation of genetic resources materials.
- Regeneration and multiplication as well as maintaining of a field genebank of vegetatively propagated species.
- Provision of seed materials to the central seed genebank at Radzików.

There are 1230 accessions of 40 species of vegetable crops of which 898 have been deposited in long-term storage and 583 are maintained vegetatively in the field.

Presently collections of genus *Lycopersicon* and genus *Allium* are being evaluated.

The *Lycopersicon* collection includes old cultivars (determinant and indeterminant types) and wild species.

The *Allium* collection consists of polish and russian old cultivars, and landraces of *Allium cepa* and *Allium sativum* (247 accessions) and wild species of *Allium* (323 accessions of 103 species, collected in Poland, Central Asia and Siberia).

All collected accessions are documented with regard to passport data and 40% of those accessions have been evaluated.

Main source of new materials are collecting missions in genetic diversity centers, which provided us rare, endemic species (f.e. *Allium pskemense, A. ceasium, A. longicuspis, A. altaicum, A. vavilovi*).

Special attention is paid to collecting ecotypes and landraces, which still exist in Poland in small, private farms. The specific structure of polish agriculture caused that genetic erosion in Poland has been progressing at slower rate than in other neighboring countries.

Collected germplasm is gaining appreciation by the breeders who more often search for new sources of plant resistance to pathogens, to stress, new sources of sterility, self-incompatibility etc.

ERGE : A microcomputer program for genetic resources of cereals database management

J. Guillon[1] and A. Le Blanc[2]
Institut National de la Recherche Agronomique (INRA),
[1] Station d'Amélioration des Plantes, BV 1540, F-21000 Dijon Cedex, France
[2] Station d'Amélioration des Plantes, Domaine de Crouelle, F-63039 Clermont Ferrand Cedex, France

The cereal collections are managed at two levels:
- A local level which concerns observations in one site (e.g. an INRA Station or private firm;
- A national level which gathers the observations made in each local level of the network.

The database, at the local level, is made of many tables which permit management of introduction of new materials, description of the genetic resources, preparation of the sowing plans and working on the information stocked in the database (sorting according to criteria).

Before being considered as genetic resources, the new materials are observed during one or two years and registered in a simplified database named TEST. After that, the operator is allowed to indicate his choice concerning each new material (the system permits

comparison of decisions of all the operators for each genotype observed in each site) and the data are transferred automatically, or not, into the genetic resources database named COLLECTION.

Some criteria related to seed stock management permits the operator the establishment of the annual sowing plans; some functions of the programme make the exploitation of these data easier: edition of lists of the lines sown, automatic loading of annual observations into the database, automatic transfer to the general database for genetic resources, with syntheses or not according to control material, of the annual observations.

The Centre for Genetic Resources, the Netherlands (CGN)

I.W. Boukema

Centre for Genetic Resources, the Netherlands (CGN), P.O.Box 224, 6700 AE Wageningen, the Netherlands

The Centre for Genetic Resources, the Netherlands (CGN) was established in 1985 by the Ministry of Agriculture and Fisheries of the Netherlands. It is now part of the Centre for Plant Breeding Research CPO, with an own budget and programme.

The objectives are :

- -To contribute to global activities in the conservation of genetic resources in cooperation with the International Board for Plant Genetic Resources (IBPGR).
- -Long term conservation of collections important to plant breeding in the Netherlands and elsewhere.
- -To improve accessibility and use of genetic variation.
- -To contribute to understanding of genetic variation and its conservation.

CGN holds base collections of *Allium, Brassica oleracea, Lactuca* and *Solanum*, besides working collections of wheat, maize, oats, barley, peas, fieldbean, spinach, various cruciferous crops and grasses. CGN is also responsible for the German-Dutch *Beta* collection.

Research is done in close cooperation with plant breeding institutes and the Agricultural University at Wageningen (evaluation, biosystematic studies, taxonomy of *Beta, Lolium* and *Solanum*, genetic analysis of primitive cultivars, etc.)

CGN's own research programme aims at optimizing the utility of germplasm collections by increasing the accessibility and improving the composition of the collections.

Use is made of a newly developed Genetic Resources Information System (GENIS) for the documentation and administration of genetic resources.

Multivariate analysis of variation among hops (*Humulus lupulus* L.) accessions

D. Kralj[1], D. Vasilj[2], S. Kralj[3], J. Zupanec[1] and J. Psenicnik[4]

[1] Institute for Hop Research and Brewery, 63310 Zalec, Yugoslavia

[2] Faculty of Agriculture, Department of Genetics and Plant Breeding, 41000 Zagreb, Yugoslavia

[3] Institute Jozef Stefan, 61000 Ljubljana, Yugoslavia

[4] Agricultural Institute of Slovenia, 61000 Ljubljana, Yugoslavia

A sample of 95 accession from the World Hops Collection, maintained at the Institute for Hop Research and Brewery Zalec, Yugoslavia, was studied by multivariate analysis to explain the phenotypic relationships among the entries. These analyses patterns of essential oils suggest that diversity may have geographic patterning.

There are three groups of accessions: from Europe, from USA similar to that of Australia and the accessions from China and Japan which tend to have a common set of traits. Thirty components of essential oils in relative percentage and according to their interrelations are important parameters that discriminate *H. lupulus* accessions into 3 types of oil specific for geographic regions and 11 types of oil because of smaller variabilities in these regions and because of variabilities caused by crossings between regions.

Avena germplasm, its collection, use and distribution

J.M. Leggett
AFRC Institute of Grassland and Environmental Research, Welsh Plant Breeding Station, Aberystwyth, Dyfed SY23 3EB, United Kingdom

The cultivated oat *Avena sativa* L., is among the most important of our food crops, but comparatively little effort has been made to conserve the wild and weedy forms of oats, which, like the other major crop species are becoming increasingly important as sources of genetic variation.

The genus *Avena* L., (*Poaceae*) belongs to the tribe *Aveneae* and comprises a polyploid series with a basic chromosome number of x=7. Three ploidy levels are recognized, diploids (2n=2x=14) tetraploid (2n=4x=28) and hexaploids (2n=6x=42). All the representative species are annual inbreeders with the exception of *A. macrostachya* Bal. ex Cosson et Durieu, which is a perennial outbreeding autotetraploid.

Within this polyploid structure, some thirty taxonomic entities are generally recognized, which can be grouped into 14 'biological species' based primarily on the ability of the taxa within such a group to interbreed.

In recent years, IBPGR has sponsored collections of wild oat species that were poorly represented in world collections. These collections have added considerably to the available gene pool of the genus, and the information derives from species relationships of hybrids has helped to clarify the evolutionary sequences that gave rise to the cultivated oat crop. A number of these wild weedy species/ taxa have agronomically desirable characters which are being incorporated into the cultivated oat crop.

The germplasm held is available on request (as seed stocks permit), and laboratories worldwide have been supplied with seed for basic research, breeding programmes and to supplement their own collections. Collaboration already exists with a number of countries, and further collaboration to speed up the enhancement of *Avena* germplasm is planned.

Grain legume crops - present situation and possibilities of germplasm conservation in Yugoslavia

R. Henneberg, I. Kolak and J. Radosevi
Faculty of Agricultural Sciences, University of Zagreb, Simunska 25, 41000 Zagreb, Yugoslavia

Genetic erosion has been a threat to continue the improvement of new cultivars. Thus around the world and in Yugoslavia since 1989, collecting and conserving of local ecotypes and populations of various cultivated plant species has been done.

Yugoslavia belongs to the Mediterranean gene center and has rather specific orography due to many tectonic changes during and after formation of Dinarids. It is rich with unique areas and various endemic species.

According to the book *Flora* (Domac, 1950) - the tome *Fabaceae*, a new edition of *Analytic flora of Yugoslavia*, not released yet - on the territory of Yugoslavia there are seven genera of grain legume crops (*Cicer, Lens, Pisum, Vicia, Lathyrus, Lupinus, Phaseolus*) among which *Vicia* has 35 species, *Lathytus* 27, *Lens* three, *Pisum* three, *Phaseolus* two and *Lupinus* has four species.

Until now there have been collected and described at the Faculty of Agricultural Sciences, University of Zagreb, 27 accessions of *Cicer arietinum*, 70 of *Vicia faba*, 28 of *Vicia sativa*, 10 of *Lathyrus sativus*, 132 of *Phaseolus vulgaris*, 22 of *Pisum sativum*, 60 of *Glycine max*, 20 of *Lens esculenta* and 28 accessions of *Lupinus albus*.

Garden grain legume and soybean collections besides being collected at the University of Zagreb have been collected at University of Novi Sad and some other institutions in Yugoslavia.

Delaying collecting and saving the above germplasm on the territory of Yugoslavia might result in loosing very valuable genotypes.

International Wheat Database

M. Michalak, P. Kolasiski and W. Podyma
Plant Breeding and Acclimatization Institute, Radzików, 05-870 Bonie, Poland

The Working Group of Documentation of the Gene Bank Technical Advisory Committee for Eastern European Countries has initiated the international documentation of existing germplasm collections. International Databases have to facilitate exchange of material for breeding and research purpose by providing information on available germplasm. The meeting of the Group which was held at the Plant Breeding and Acclimatization Institute (PBAI), Radzików in 1989 recommended the establishment of an International Wheat Database. The PBAI was designated to combine the data, with support of specialists from all countries involved.

The IWDB contains computerized passport data of 56,712 accessions from 5 gene banks (see table).

The IWDB adopted scientific names of accessions according to the botanical classification currently used in the country, which holds the collection.

For 94 percent of the material species names have been identified. The high morphological variability is reflected by presence of 621 different botanical variety names for 71 percent of the deposited materials. The collections contain 18,179 accessions of collected materials (wild, landraces) and 17,708 breeding materials (cultivars, breeding lines). Based on differences in growth habit 26,351 winter, 24,464 spring and 1164 intermediate wheat accessions were identified.

Preliminary analysis of the names shows that 36 percent of the named materials are duplicates of other accessions.

The main service from the IWDB to breeders and scientists is to identify which gene bank has the required germplasm, and to provide related data. On the basis of the IWDB computerized Wheat Catalogue has been prepared, to provide users easy access to data.

Country	Institute	Number
USSR	N.I. Vavilov Institute of Plant Industry, Leningrad	17,464
Germany	Zentralinstut für Genetik und Kulturpflanzenforschung, Gatersleben	16,040
Poland	Plant Breeding and Acclimatization Institute, Radzików	8,872
Hungary	Research Centre for Agrobotany, Tapioszele	7,892
Czechoslovakia	Research Institute of Plant Production, Prague	6,744

The following descriptors have been included in the catalogue:
-genebank acronym,
-accession number in the national collection,
-scientific name,
-accession name,
-country of origin,
-donor name,
-accession number in donor collection,
-other accession name,
-status of sample,
-growth habit,
-pedigree,
-locality of collection site,
-availability,
-expedition name.

The long term objective of the International Wheat Database is to enable continuation of passport, characterization and evaluation data.

Studies on genetic shift in rye seeds after long term storage in seed bank

J. Puchalski, R. Kubiczak and M. Niedzielski

Botanical Garden of the Polish Academy of Sciences, 02-973 Warsaw, Poland

Long-term seed storage is used as a common method for the preservation of genetic diversity of plant germplasm. It was found however that during seed storage and regeneration the different genetic changes could occur. Due to selection caused by seed ageing and reduction of their viability the genetic shift is important role in decreasing genetic diversity.

The Botanical garden of the Polish Academy of Sciences in Warsaw possesses a rich collection of rye, wild and cultivated forms, exceeding 2000 accessions. Rye seeds dried to low moisture contents were stored in the seed bank for 5-13 years and some of them reduced their viability to different levels as low as to 5% germination. For these studies 9 rye cultivars were chosen represented by 36 seed samples showing the variable viabilities. All these samples were later regenerated under field conditions and used for the research. The aim of the research was the analysis of genetic shift effects by means of isozymes, seed storage proteins (secalins) and morphological traits.

Isozymes were analysed in the populations of rye accessions represented by the first generation of reproduced seed samples in comparison to control fully viable samples. Isozymes were separated by means of starch-gel electrophoresis technique and stained for 5 enzyme systems activities: esterase, aspartate aminotransferase, phosphoglucoisomerase, diaphorase and peroxidase. The changes were analyzed on the basis of the electrophoretic band frequencies. For genetic studies 4 enzyme loci were selected and allozyme and enzyme genotypes (zymotypes) were used for the comparison of rye accessions. The significant differences between original and reproduced samples were found for all enzyme systems and all enzyme loci. But it was difficult to detect the evident effect of genetic shift due to seed viability reduction. Similar results were obtained for the analysis of rye seed prolamins-secalins. Secalins were analyses by means of gel-slab electrophoresis technique in a vertical system. In two varieties of rye, Ceske Normalni and Dankowskie Zlote, 24 electrophoretic bands of secalins were detected. It was seen that secalin frequencies varied among rye accessions. The biggest differences were seen between seed populations of low and high viability. But these changes in secalin frequencies were eliminated in the next generations after reproduction.

The study on morphological traits in rye accessions were carried out on 9 cultivars. Among the 4 investigated characters: underflag leaf length, plant height, ear length and the weight of 1000 seed, the most significant differences were seen for plant height. In some varieties the plant height was reduced with the loss of seed viability. The differences between original and reproduced samples were observed for all 4 characters, however it was not possible to draw any conclusions about the genetic shift effects. It seems that regeneration eliminates putative effects caused by natural seed ageing.

The Czechoslovak programme on plant genetic resources of cultivated plants

L. Dotlacil

Research Institute for Plant Production (RIPP), Ruzyne 507,

16106 Prague 6, Czechoslovakia

The National Czechoslovak programme is coordinated by RIPP Prague, as advisory and coordinating body. The Czechoslovak Board on Genetic Resources of Cultivated Plants was established. Introduction of plant genetic resources (GR), information system of GR (EVIGEZ) and long term storage of seed-propagated crop collections are ensured by RIPP Prague as a service for GR community. Collections are studied at 29 cooperating crop institutes, stations and universities.

Annual introduction of GR amounts 3-5,000 samples (more than half by RIPP Prague), the export of GR is comparable. Distributed samples are after preliminary evaluation involved in collection, where base evaluation is performed (scale 1-9 according to the descriptor lists). More exact or special evaluation is done in selected materials with the aim to supply breeders with donors of important characters and provide information. More

than 43 thousands of accessions are held in Czechoslovak collections, most of them are cereals (23 thousands), vegetables (6,5 th.), legumes (5,6 th.) and fruit trees (2,8 th.). Resources of Czechoslovak origin constitute 7,2%.

Czechoslovak information system on GR consists of documentation of import/export, documentation of collections (passport data, evaluation data) and monitoring of gene bank. Nowadays passport data on 65% accessions and evaluation data on 65% of accessions are collected: to complete the passport database is the most urgent task for the near future.

Gene bank in RUPP Prague operates since 1989. It assures long term storage of seed samples for all cooperating collections. After purity, health and viability control the seeds are dried (4-9% moisture content) and packed in sealed glass jars (370cm^3, or 210cm^3). Active collection is stored at +2°C, base collection (materials of Czechoslovak origin) at -20°C. At present 4,600 samples are under storage.

The Netherlands, a leader in horticultural seeds

The Horticultural Seed Trade Association of the Netherlands (NTZ), P.O.Box 555, 2240 AM Wassenaar, The Netherlands

The Dutch horticultural seed sector has been a world leader for many years. In nearly every country Dutch vegetable and flower seeds are obtainable. Holland is second only to the USA in the production of horticultural seeds. Dutch seed firms have a total turnover of 670 million guilders. 80% of all the seed produced is exported, Western and Eastern Europe and the USA being the most important markets.

Early in the 19th century a few inventive Dutch market gardeners struck on the idea of trading vegetable seeds. Later on they also took up selection and breeding. By the end of the last century specialized firms has developed which were selling seeds to growers both at home and in various European countries. Soon the USA and other countries overseas were included in their export activities. By supplying a high grade quality product these Dutch firms achieved world-wide recognition in their field.

Through close contact with growers first-hand knowledge is gained of the seed characteristics they require. Improved varieties and methods for up-grading the quality of propagating material are the results. This makes considerable demands on the Dutch horticultural seed sector which invests an estimated 125 million guilders in research annually. Research activities include breeding, supported by biotechnological research, and quality control throughout the whole production process. Seed companies place great emphasis on seed technology as a means to improve the vitality, health and germination of the seed.

In Holland, 28 firms, ranging from one-man firms to companies with over 500 employees, are engaged in the breeding of vegetable and flower seeds. Altogether 2,400 people are employed, of whom 20% are university or advanced technical college graduates.

Most firms have the whole process, from breeding to sale, under their own management. Foreign markets are often served by affiliated companies operating in the countries concerned. Together they form the flourishing Dutch horticultural seed sector.

The Horticultural Seed Trade Association of the Netherlands (NTZ) is the national organization of companies active in the field of vegetable and flower seeds. Nationally and internationally the NTZ promotes the interests of the Dutch horticultural seed sector.

Forum discussion

6 December 1990, 10:45-12:15

The forum consisted of the following persons: J. Valkoun (chairman), J.J. Hardon, D.F.R. Bommer, P.M. Perret, P. Matthews and V.A. Dragavtsev. Points for discussion were prepared on the basis of issues identified by participants during the symposium.

European Community involvement in genetic resources management

The topic was introduced by Hardon who considered that, following the production of an inventory of the most important crops in Europe, institutes who would be prepared to take responsibility for the coordination of the network of one or more of these crops should be identified. The World Beta Network was cited as an example of the way in which such a network might operate. These networks would permit rationalization of genetic resources activities, might be initiated within the European Community, and later be extended to countries outside the EC. There was concern that 'rationalization' of genetic resources activities might lead to discontinuation of work objective to certain collections. However it was stressed that the objective should be to improve decision making in genebanks through coordination and thus develop a more rational policy towards collecting and maintenance, and a better accessibility of the material.

It was considered that any such initiative should be seen as an extension of the ECP/GR programme. Experience from ECP/GR activities showed that crop networks need inputs which allow basic activities like the appointment of crop coordinators and regular meetings of the participants working on the crops. Lack of funds was felt to be the major constraint of the ECP/GR programme. It was stressed that the programme envisaged should not duplicate ECP/GR activities but should permit it to be considerably enlarged to cover more crops and that European Community inputs should be sought for this.

The participants agreed that the ultimate aim in genetic resources conservation is a global network and the current political changes offer further opportunities to strengthen cooperation between West and East European countries

In situ conservation

Chauvet led the discussion and pointed out that wild relatives of crops constitute an untapped reservoir of genetic diversity for breeding needs of the future, and that this potential can be maintained through conservation of wild populations in their habitats (*in situ* conservation) in order to ensure that evolutionary processes continue. He considered that there was an urgent need for the international community to develop research programmes aimed at an improved understanding of the structure and evolution of genetic diversity in natural populations of wild relatives. *In situ* conservation of wild relatives should be specifically addressed in the regulations, and the monitoring and management policies, of governmental and international agencies concerned with nature protection.

It was noted that many small nature parks representing a variety of habitats might be needed to conserve the genetic variation of species and that this would be difficult to achieve and manage. One way of approaching this problem was through close cooperation between genebanks and those concerned with nature conservation. The need for a holistic approach to the conservation of the total genepool of a crop species and its wild relatives was stressed. *In situ* and the various *ex situ* conservation methods should be used jointly to develop an integrated conservation strategy for a genepool.

Evaluation activities

Jackson introduced this topic by suggesting that current evaluation strategies should be reexamined. It might be desirable for germplasm evaluation to be done selectively. A more precise understanding of genetic diversity might be more useful than large evaluation programmes which serve the needs of breeders. However it was noted that evaluation is a dynamic process which has to react to the plant breeders needs. It was considered that

meeting breeders needs (increasing accessibility through increased evaluation work) and an improved knowledge of genetic diversity were both important.

Biosystematics

Van der Maesen drew attention to the discrepancy between the need for taxonomic and biosystematic research and the decreasing number of taxonomists. More attention should be given to this urgent problem. It was noted that crop networks could be used to develop research in this area as illustrated by work stimulated by the *Avena* and *Beta* networks. The meeting agreed with the importance of this research and expressed its concern at the decline in the number of taxonomists.

Legal protection of landraces

Zeven suggested that landraces might be legally protected against loss caused by mismanagement just as historical monuments are in many countries, since they also form part of a nation's cultural heritage. It was noted that the FAO Undertaking on Plant Genetic Resources already contains a formal commitment of the signing countries to take this responsibility and that similar elements could be included in the UNEP convention on biological diversity.

Allium network

Perret proposed the establishment of an international *Allium* network extending the ECP/GR network. This was welcomed by the participants.

Resolution for the European Community

There was discussion of the draft of a Resolution on genetic resources to be forwarded to the European Community. The meeting decided that the agreed draft should be send to the president of EUCARPIA for submission to the Council of Ministers of the EC. It was proposed that the support of private industry be sought for the resolution and Veldhuyzen van Zanten agreed to take appropriate action to obtain the support of ASINSEL.

Resolution of the EUCARPIA/IBPGR 'Crop Networks' Symposium

The members of the EUCARPIA/IBPGR Symposium on Crop Networks representing private breeding companies, national and regional genetic resources programmes, and other agencies:

1 Note the needs of agricultural production to react to changing economic conditions in Europe, which necessitates efficiency in the continuity and development of European plant breeding programmes.

2 Take into account the European plant breeders and associated research disciplines dependence on the availability of a comprehensive range of genetic resources, predominantly originating from countries outside the community.

3 Note the need for international cooperation in crop germplasm conservation and strongly recommends involvement of the European Community.

4 Consider existing national and international collaborative structures, particularly the crop networks within the European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources (ECP/GR), the progressive integration and Western and Eastern European programmes in collaborative crop networks, coordinated by the International Board for Plant Genetic Resources (IBPGR).

5 Express concern about the lack of effective funding for such programmes which constitutes the major handicap in the efficient conservation and utilization of accessible and defined genetic resources.

6 Note the urgent need for further research, in amongst others modern biotechnology to develop methodology for evaluation and breeding, and to achieve efficient conservation and use of genetic resources.

7 Realize the far-reaching influence of genetic resources conservation in Community policies

8 Refer to the recommendations of the 1987 European Conference "Biological Diversity - A Challenge to Science, the Economy and Society" and also the resolution of the European Parliament on the genetic diversity of cultivated plants and trees and a related request from the EC Council of Ministries of Agriculture.

9 Ask the Commission of the European Communities to affirm and activate the following objectives:

-to provide sufficient/adequate funding for the support of European Crop germplasm institutions involved in European cooperative programmes of crop germplasm conservation;

-to give financial support to related research activities in order to rationalize conservation and achieve a more effective utilization of genetic resources;

-to consider within the framework of Community policies the prerequisites for effective germplasm conservation, accessibility and use;

-to establish an EC Committee on Crop Genetic Resources Conservation in order to assist the EC Commission in this respect and to strengthen joint action in stimulating activities in support of the goals of the ECP/GR

This resolution is based on the general concern that programmes on plant genetic resources conservation and utilization in EC member states are fragmented and do not reflect the importance of plant breeding and seed production of the various countries.

If, in the light of global concern about diminishing biodiversity, progress is to be achieved, the members of the Symposium ask the European Commission to take a leading role within a broad European framework to initiate and activate meaningful and effective cooperation in the areas of crop plant genetic resources conservation and utilization.

List of participants

Austria

R. Schachl, Federal Institute for Agro-Biology, P.O.Box 62, A-4025 Linz.

Belgium

K. Beese, Commission of the European Communities, Directorate-General for Science, Research and Development (XII), Directorate Biotechnology (F/2), 200, Rue de la Loi, B-1049 Brussels.
D. Cumming, Canadian Embassy, Brussels.

Czechoslovakia

L. Dotlacil, Research Institute for Plant Production (RIPP), Ruzyne 507, 16106 Prague 6.

France

M. Chauvet, Bureau des Ressources Génétiques, 57, rue Cuvier, F-75231 Paris Cedex 05.
J. Koenig, Institute National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes, Domaine de Crouelle, F-63037 Clermond-Ferrand Cedex.
E. Nguyen-Van, Bureau des Ressources Génétiques, 57, rue Cuvier, F-75231 Paris Cedex 05.
L. Olivier, Conservatoire Botanique Nationale de Porquerolles, Le Castel ste Claire, Rue ste Ciaire, F-83400 Hyeres.
A. Le Targa-Le Blanc, Institute National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes, Domaine de Crouelle, F-63039 Clermont-Ferrand.
M. Tronmetter, INRA-ERS Grenoble, INRA/IREP, B.P.47x, F-38040 Grenoble Cedex.

Germany

D.F.R. Bommer, Südring 1, D-3405 Rosdorf OT Obernjesa.
R. von Broock, KWS Kleinwanzlebener Saatzucht AG, Grimsehlstraße 31, D-3352 Einbeck.
P. Hanelt, Zentralinstitut für Genetik und Kulturpflanzenforschung (ZIGuK), Corrensstraße 3, D-O-4325 Gatersleben.
H. Knüpffer, Zentralinstitut für Genetik und Kulturpflanzenforschung (ZIGuK), Corrensstraße 3, D-O-4325 Gatersleben.
B. Kosak, Bundesministerium für Ernährung, Landwirtschaft und Forsten, Rochusstraße 1, 53 Bonn 1.
R. Melzer, Institut für Rübenforschung, Leninallee 3a, D-O-3105 Klein Wanzleben.

Italy

T. Hodgkin, International Board for Plant Genetic Resources (IBPGR), Via delle Sette Chiese 142, I-00145 Rome.
H. Ölez, Food and Agriculture Organization (FAO), Regional Office for Europe, via delle Terme di Caracalla, I-00100 Rome.
P.M. Perret, International Board for Plant Genetic Resources (IBPGR), Via delle Sette Chiese 142, I-00145 Rome.
P Perrino, Instituto del Germoplasma, via Amendola 165 A, I-70126 Bari.

Malaysia

N. Rajanaidu, Palm Oil Research Institute of Malaysia (PORIM), P.O.Box 10620, 50720 Kuala Lumpur.

The Netherlands

W. de Boef, CPO/CGN, P.O.Box 224, 6700 AE Wageningen.
I.W. Boukema, CPO/CGN, P.O.Box 224, 6700 AE Wageningen.
H. Dijkstra, CPO/CGN, P.O.Box 224, 6700 AE Wageningen.

L. Frese, CPO/CGN, P.O.Box 224, 6700 AE Wageningen.
J.J. Hardon, CPO/CGN, P.O.Box 224, 6700 AE Wageningen.
Th. Hazekamp, CPO/CGN, P.O.Box 224, 6700 AE Wageningen.
M. Heuver, Dienst Landbouwkundig Onderzoek (DLO), P.O.Box 59, 6700 AB Wageninger
Th.J.L. van Hintum, CPO/CGN, P.O.Box 224, 6700 AE Wageningen.
N.G. Hogenboom, CPO, P.O.Box 16, 6700 AA Wageningen.
L.J.G. van der Maesen, Wageningen Agricultural University, Department of Plant Tax onomy, P.O.Box 8010, 6700 ED Wageningen.
A.P.M. den Nijs, CPO, P.O.Box 16, 6700 AA Wageningen.
R.K. Raji Cebeco Zaden B.V., P.O.Box 139, 3200 AC Lelystad.
A. van der Reijden, Green Genetics, P.O.Box 2, 9679 ZG Scheemda.
L.J.M. van Soest CPO/CGN, P.O.Box 224, 6700 AE Wageningen.
J. Veldhuyzen, van Zanten Zaadunie BV, P.O.Box 26, 1600 AA Enkhuizen.
H. Verkerke-Berentschot, CGN/CPO, P.O.Box 224, 6700 AE Wageningen.
L. van Vloten-Doting, CPO, P.O Box 16, 6700 AA Wageningen.
P.A.Th.J. Werry, Dienst Landbouwkundig Onderzoek (DLO), P.O Box 59, 6700 Al Wageningen.
A.C. Zeven, Wageningen Agricultural University, Department of Plant Breeding, P.O.Bo 386, 6700 AJ Wageningen.

Poland

Z. Buliska-Radomska, Plant Breeding and Acclimatization Institute, Radzików, 05-87 Bonie.
T. Kotliska, Research Institute of Vegetable Crops, Plant Genetic Resources Lab., ul. 22 Lipca 1/3, 96-100 Skierniewice.
R. Kubiczek, Botanical Garden of the Polish Academy of Sciences, Prawdziwka 2, 02-97 Warsaw.
W. Podyma, Plantbreeding and Acclimatization Institute, Radzików, 05-870 Bonie.

Spain

R. Vellvé, GRAIN, Apartado 23398, 08080 Barcelona.

Sweden

M. Niklasson, The Nordic Genebank, P.O.Box 41, S-23053 Alnarp.

Syria

J. Valkoun, International Centre for Agricultural Research in the Dry Areas (ICARDA), P.O.Box 5466, Aleppo, Syria.

United Kingdom

M.J. Ambrose, John Innes Institute, Colney Lane, Norwich, Norfolk NR4 7UH.
M.H. Arnold, TAC, 'Hamlet', 4 Shelford Road, Wittlesford, Cambridge CB2 4PG
D. Astley, Institute of Horticultural Research (IHR), Genetic Resources Unit, Wellesbourne, Warwick CV35 9EF.
L. Currah, Institute of Horticultural Research (IHR), Natural Resources Institute, Wellesbourne, Warwick, CV35 9EF.
N. Green, Department of Agriculture and Fisheries for Scotland, Agricultural Scientific Services, East Craigs, Edinburgh EH12 8NJ.
M.T. Jackson, School of Biological Sciences, University of Birmingham, P.O.Box 363, Birmingham B15 2TT.
J.M. Leggett, AFRC Institute for Grassland and Environmental Research, Welsh Plant Breeding Station, Plas Gogerddan, Aberystwyth Dyfed SY23 3EB.
P. Matthews, John Innes Institute, Colney Lane, Norwich, Norfolk NR4 7UH.
B.F. Tyler, AFRC Institute of Grassland and Environmental Research, Welsh Plant Breeding Station, Plas Gogerddan, Aberystwyth Dyfed SY23 3EB.

USA

J. McFerson, USDA, ARS, Plant Genetic Resources Unit, Cornell University, New York State Agricultural Experiment Station, Geneva, 14456-0462 New York.

USSR

S.M. Alexanian, N.I. Vavilov All-Union Institute of Plant Industry (VIR), 42, Herzen Street, 190000 Leningrad.

V.A. Dragavtsev, N.I. Vavilov All-Union Institute of Plant Industry (VIR), 42, Herzen Street, 190000 Leningrad.

I.A. Shvytov, N.I. Vavilov All-Union Institute of Plant Industry (VIR), 42, Herzen Street, 190000 Leningrad.

Yugoslavia

R. Henneberg, University of Zagreb, Faculty of Agricultural Sciences, Simunska 25, 41000 Zagreb.

J. Kralj, Institute for Hop Research and Brewery, 63310 Zalec 38.

Presented papers

The historical development of international collaboration in plant genetic resources

D.F.R. Bommer
Südring 1, D-3405 Rosdorf OT, Obernjesa, Germany

Summary
The concern about genetic resources for plant breeding dates back at least one hundred years. The discovery of genetic diversity of crop plants and their wild relatives in the so called 'geographic centres of origin' of cultivated plants by N.I. Vavilov in the twenties of the century stimulated exploration of this diversity for plant breeding and for research on the evolution of cultivated plants. Contacts from scientist to scientist and free exchange of material between them characterized the collaboration during this early period. Discovery, exploration and scientific advancement determined the interests. Concern about possible losses, already voiced in the case of landraces a hundred years ago, became an internationally recognized subject only 30 years ago. The developments of international collaboration are reviewed beginning with the interests emerging during the late fifties and early sixties in FAO and EUCARPIA and leading through various initiatives primarily by FAO and CGIAR to the establishment of the IBPGR in 1974. The strategies for collaboration fostered by CGIAR, IBPGR and FAO have evolved through various stages over the last 15 years. The 'International Undertaking on Plant Genetic Resources' of FAO and the establishment of the FAO Commission has given an increased political recognition to the collaboration in plant genetic resources. New avenues of collaboration are under discussion in Europe as well as at global level.

The early period

This year 1990 there were many remarkable events. One small, yet remarkable in the field of plant genetic resources was the first joint symposium ever held between the two genetic resources centres in Germany, Gatersleben and Braunschweig. It commemorated 100 years of the collection and utilization of landraces and the 20th anniversary of the establishment of the genebank at Braunschweig-Völkenrode. Both are flashlights on the development of collaboration in plant genetic resources and a good start to talk about its history.

Christian Lehmann reminded us in the symposium on the International Agricultural and Forestry Congress held in 1890 in Vienna where Emanuel Ritter von Proskowetz and Franz Schindler reported on the value of landraces of agricultural crops in relation to bred varieties. Von Proskowetz systematic collection of barley landraces in Moravia gave not only birth to the once famous Hanna-barleys but also to the evaluation and exchange of these resources with breeders of other countries. Moreover, he outlined already 100 years ago the major tasks genetic resources centres should perform: Collection, characterization, evaluation and documentation (Lehmann 1990; Schachl 1985).

The events 100 years ago may be called the early beginning of work and collaboration in plant genetic resources. It is worth noting that the appeal of von Proskowetz to collect landraces was already guided not only by the value for breeding but also by the concern about their possible losses.

Also, yet in another way, the establishment of the Plant Introduction Office in 1989 and the introduction of permanent inventory records for introduced germplasm in the USA (White 1985) can be mentioned as an important early recognition of exchange and collaboration in plant genetic resources.

The contact from scientist to scientist and from institute to institute very much determined international collaboration from this early period onwards to the midst of this century. The important stimulus the work of Nikolai Ivanovich Vavilov gave in the twenties to research on the evolution of cultivated plants and to plant breeding and his postulation

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of centres of genetic diversity attracted many scientists of other countries to visit with him and his colleagues in the Soviet Union in order to learn from their worldwide experience in the genetic diversity of wild and primitive forms of crop plants. The unexpected wealth of this diversity discovered by Vavilov and its potential reservoir for plant breeding prompted many collections and exploration activities by scientists from other countries. (i.e. Bommer & Beese 1987; Bennet *et al.* 1974; Frankel 1985; Hyland 1975; Scheibe 1987).

The exchange of material and of scientific information dominated international collaboration during this early period. The main interest concentrated on the search for new genetic variability useful in plant breeding and on scientific developments in genetics and plant evolution. Thus the need for international collaboration was very well recognized. Yet, concerns about possible losses and about the need to maintain genetic diversity of existing resources, may be with the exception of landraces, was only in a few cases expressed (Harlan & Martini 1936).

Growing awareness

We can speak of a period of growing awareness of the importance of plant genetic resources for plant breeding, of the danger of losses in existing variability and of the need to collaborate beyond national boundaries in order to safeguard the resources starting in the forties, and increasing in the fifties and sixties.

The events leading in various steps and through numerous problems to the collaboration in plant genetic resources of today are documented in more detail by Hawkes (1986) for EUCARPIA, by Frankel (1985), Kuckuck (1988) and others (FAO 1985a; CGIAR/TAC 1980) for the International Biological Programme (IBP) and the Food and Agriculture Organization of the United Nations (FAO) and by Baum (1986) for the Consultative Group on International Agricultural Research (CGIAR) and the International Board for Plant Genetic Resources (IBPGR).

FAO started in 1950 to publish lists of genetic stocks of various crops existing in the world and developed a number of other activities related to plant exploration and introduction (Kuckuck 1988). The 10th FAO Conference in 1959 passed a resolution on the importance of and danger to genetic resources. A Technical Meeting on Plant Exploration and Introduction 1961 in Rome already proposed a first international action plan including the establishment of international exploration centres to facilitate the access to new genetic material and its introduction into other areas of adaptation and use. One of these centres became established on the invitation of Turkey in 1964 with the support of FAO and UNDP. However it never assumed the role originally proposed (Kuckuck 1988).

At the same time EUCARPIA became involved in plant introduction and also in genetic resources conservation, Rudorf introduced the subject to the EUCARPIA Conference in 1960. A proposal was developed by him, Dorst, Hawkes and Ross for a cooperative potato genebank for Europe which after six years was reactivated by Akerberg and others and submitted to OECD (Organization for European Economic Cooperation) for support and implementation. The Third EUCARPIA Congress in 1962 had already passed a resolution on the danger of genetic erosion in wild species and primitive forms.

It was also in the early sixties that the so-called 'Green Revolution' began. The spread of high-yielding varieties, first of spring wheats in Mexico, Pakistan and India and since 1966 of irrigated rice in Asian countries aggravated the speed of replacement of traditional varieties in an increasing number of developing countries seriously affecting also those areas considered to be the centres of genetic diversity of cultivated plants. Alarming news came from various scientists, prominently from Kuckuck which he brought back from missions in the Near East and Ethiopia.

Formulating action

Efforts grew in the mid sixties to formulate and implement actions of international cooperation in plant genetic resources in order to counteract the danger of losses, to conserve inherited genetic diversity and to improve their utilization by plant breeding. IBP, FAO and EUCARPIA were the main organizations involved.

IBP, established under the auspices of the International Council of Scientific Unions (ICSU) adopted as one of the principal themes, the maintenance of 'genepools' of wild species and primitive forms of cultivated plants following a proposal of Stebbins. The chairman of the Working Group of the IBP, Sir Otto Frankel, developed contacts to FAO in 1965 which led in 1967 to the organization of a joint FAO/IBP Technical Conference on the Exploration, Utilization and Conservation of Plant Genetic Resources. This conference is considered as a landmark for the so-called 'Genetic Resources Movement' (Frankel 1985). Sir Otto Frankel and Erma Bennett were in charge of the very thorough preparation of this conference. Their publication of the proceedings under the IBP is considered the first comprehensive book on plant genetic resources (Frankel & Bennet 1970).

The conference moved the emphasis towards a comprehensive system of genetic resources including exploration, evaluation, documentation, utilization and conservation. The need for long-term preservation was recognized and the method of *ex situ* long-term seed storage adopted as its most important method. A 'generalist' strategy of collection and conservation was supported as more appropriate than a mission oriented approach.

An action programme was proposed by the conference giving highest priority to primitive cultivars and endangered wild species of economic importance. FAO was urged to assume international coordination and guidance and to seek the resources for the implementation of the programme. The direct follow-up to this proposal was somewhat disappointing. Yet, FAO established a Crop Ecology and Genetic Resources Unit in 1968. The FAO Panel of Experts on Plant Exploration and Introduction which was set up already in 1965 pursued a number of issues addressed in the conference. It actually laid the groundwork to many activities of later years (Frankel 1985). FAO also established in 1986 a Panel of Experts on Forest Genetic Resources taking stock of forest genetic resources and proposing priorities for action.

A programme based on the proposal of the conference of 1967 developed in FAO failed to receive financial support in 1971 by UNDP (United Nations Development Programme). Yet, in the United Nations Conference for the Human Environment in 1972 in Stockholm, FAO with the help of Sir Otto Frankel gave the issue of plant genetic resources world recognition. The Conference requested FAO to take responsibility in assisting the establishment of an international resources programme, UNEP to take partial responsibility for plant resources, and called on all countries to participate (CGIAR/TAC 1980).

Parallel and in close contact with the developments in FAO, EUCARPIA pursued proposals for collaboration in plant genetic resources in Europe. A Genebank Committee (EGBC) was formed in 1968 with Ellerstrom, Lamberts and Lein as first members. They proposed a regional network for Europe with four sub-regional genebanks recognizing main agroclimatic zones in the continent. Kuckuck (1988) and Scheibe (1987) proposed in the same year a genebank to be set up in the F.R. Germany. Only two years later the author was fortunate to establish this genebank with the support of German plant breeders and the government in the Institute of Crop Science and Seed Research (now Plant Breeding) of the Federal Agricultural Research Centre (FAL) at Braunschweig-Völkenrode (Bommer 1972). The genebank was intended to also serve as sub-regional centre for North-Western Europe as proposed by EUCARPIA. I remember the degree of satisfaction I shared with Scarascia-Mugnozza, who somewhat earlier had established the genebank for Southern Europe at Bari, Italy, that we had put into action what others had discussed for years.

The sub-regional function of both Bari and Braunschweig never really materialized. Only the Nordic Genebank established in 1979 at Lund, Sweden became a true collaborative sub-regional institution of the five Scandinavian Nations. The other earlier attempt of EUCARPIA to establish an European Potato Genebank with the help of OECD also failed to receive sufficient support by European governments. After five years of unsuccessful discussion in Paris, Lamberts and my-self got support within the German-Dutch Agreement on Cooperation in Agricultural Research to set up a Dutch-German Potato Genebank linked to the genebank at Braunschweig which became operational in 1974. This arrangement expanded in 1984 also to other crops handled in the form of a division of labour between the institutes in the Netherlands and in Germany. Its example may serve further developments in collaboration in Europe (Bommer & Beese 1987).

Simultaneously with the developments described for FAO and EUCARPIA the CGIAR and its system of International Agricultural Research Centres (IARCs) emerged (Baum 1986). As the success of the 'Green Revolution' on which the development of the CGIAR was based was primarily effected by plant breeding, the interest of the IARCs in genetic resources developed early. The International Rice Research Institute, established in 1960 in the Philippines made extensive use of earlier germplasm collections, became the leader of a comprehensive cooperative programme for rice germplasm in 1971 and was soon considered a leading genetic resources centre assisting other countries to set up their national programmes and facilities (Chang 1975). The International Maize and Wheat Improvement Centre (CIMMYT) established 1963 in Mexico never did assume such a leading role in genetic resources conservation. Yet, many of the other IARCs established in subsequent years became also prominent as genetic resources centres for their mandate crops. The admission in 1972 of the International Potato Centre (CIP) in Peru into the CGIAR was even particularly supported by the idea to explore and safeguard the genetic diversity of potato species in the Andes. Thus, the majority of the IARC's became not only important users but also strong actors for the preservation of genetic resources of major food and forage crops of and for developing countries and for the world as a whole.

Implementation

Encouraged by the new developments of the CGIAR in which FAO acted as cosponsor together with UNDP and the World Bank, FAO submitted in 1972 its proposal to establish a network of genetic resources centres to the second meeting of the Technical Advisory Committee (TAC) of the CGIAR. TAC asked an *ad hoc* Working Group under the chairmanship of Sir Otto Frankel to prepare an action programme for the collection, evaluation and conservation of plant genetic resources. The so-called 'Beltsville Report' (CGIAR/TAC 1972) prepared by the Working Group was very much based on the FAO proposal. It recommended a global network involving equally developing and developed countries. Its main focus should be on nine genetic resources centres located strategically in the main regions of genetic diversity as established by Vavilov plus a smaller number of crop specific centres including primarily the IARC's of the CGIAR! The coordination should be located in FAO with close collaboration to respect to FAO activities and for the administrative and logistic services of the network. A trust fund in FAO should support the various activities of the network.

The Beltsville proposal, considered too ambitious, was revised by TAC and the CGIAR in priorities, in timing and in the respective roles of FAO and the IARC's. Finally a sub-committee of the CGIAR worked out the details and recommended the establishment of the International Board for Plant Genetic Resources (IBPGR). The Board was perceived as an independent entity reporting to the CGIAR, placed in FAO which would provide the secretariat by its Crop Ecology and Genetic Resources Unit. The Board met for the first time in June 1974 in Rome (IBPGR 1974).

Having been member of all the bodies involved, the Beltsville group, TAC, and the sub-committees of TAC and the CGIAR, I remember the challenges involved, the various interests and pressures before the IBPGR came into being. There was a strong move to ensure self-governance and independence from FAO including the FAO Panel. Establishing IBPGR, however, as a coordinating and catalyzing body closely cooperating with and being located in FAO was purposely considered to be different from an IARC as a new challenge for the CGIAR. These challenges and the problems involved with this arrangement I experienced for the next 12 years joining FAO immediately afterwards becoming responsible i.a. for the overall supervision of the FAO/IBPGR relationship.

Seeking its own way of operating and its own approach it took for IBPGR some time before a clear policy and programme emerged. It finally came back to the principle elements established by the FAO Panel of Experts and the Beltsville Group. Nevertheless within a few years IBPGR could reach a high reputation and demonstrate remarkable achievements. One of the reasons was the broad range of collaboration with scientists all over the world the IBPGR had to establish because of its size and structure. Furthermore the integration with

FAO considerably facilitated the access to all countries particularly in the developing world.

The basic functions of the IBPGR were defined as promoting an international network of genetic resources activities to further the collection, conservation, documentation, evaluation and use of plant germplasm and thereby contributing to raising the standard of living and welfare of the people throughout the world. Now after 16 years of existence the IBPGR has an impressive record of achievements and impact (Fischbeck 1986; IBPGR 1990; Williams 1984, 1985). Through its activities the awareness of the problems of genetic erosion and of the importance of genetic resources has vastly increased. A worldwide active collaboration has developed and is further strengthening.

Over the years the strategy and the programme of the IBPGR evolved as documented in its Annual Reports (IBPGR 1976-1990), in its strategy documents (IBPGR 1981, 1984, 1988) and in the periodic external reviews of its activities (CGIAR/TAC 1980, 1986; Hawkes 1985). Only a few broad lines of these developments can be indicated here.

Regional versus national approach

The IBPGR tried first to follow the approach of regional strategically located centres each coordinating a network of national institutes. These centres would lead in the exploration and documentation of germplasm in its region and would serve as depository under long-term storage conditions. In revising the Beltsville report TAC proposed to concentrate in a first period on three regional centers, for SW-Asia, for Ethiopia and for Meso-America. The centre at Izmir, Turkey, considered as regional centre for SW-Asia existed since 1964. The proposals for two other centres in Ethiopia and in Costa Rica were picked up by the German bilateral aid. They became established in 1976 and have developed to active partners in international collaboration in spite of their regional function could not be implemented.

Already after a few years the IBPGR learned that it was not feasible to implement the regional concept as proposed at Beltsville. National interests and political difficulties were among the most prominent problems experienced. Therefore the emphasis changed to national institutes and to various forms of their regional collaboration. Such cooperation was pursued in SW-Asia, in the Mediterranean and in SE-Asia, where an IBPGR Regional Committee has been very active for some time. The European Cooperative Programme for Conservation and Exchange of Crop Genetic Resources (ECP/GR) is probably one of the most successful regional programmes. Based on the wealth of existing collections in Europe, on the interest in plant breeding and on the advice by EUCARPIA a collaborative spirit has developed which underlines the desire for continuation. The fact that the programme is entirely funded by the participating countries since four years now is a kind of guarantee for its continuation also in the nineties. Important in its structure has been the active link between Eastern and Western Europe to which also the Scientific-Technical Council for Plant Genetic Resources within the COMECON contributed. These links so essential for the development of the programme during the 10 years of its existence will become a new and even more important quality after the recent political changes in Europe. The time may have come now to consider not only the development of crop networks within ECP/GR but also to move into a new collaborative structure which will allow for a division of labor and for increased efficiency.

National institutions and programmes very soon became the main targets and components, beside the IARC's, in the global network the IBPGR pursued. Direct and indirect assistance to help national programmes to develop or even to become established has been and still is a highly valued part of IBPGR's programme. Training is the most important component of such assistance beside advice and sometimes also the provision of equipment for drying and storage or computer technology. Support to collection activities with national institutes and contracting research for various aspects of plant genetic resources increased in importance in the collaboration as fostered by the IBPGR.

The direct contact to national programmes and the support and development of regional collaboration has recently become the main task of the IBPGR Regional Coordinators stationed in seven regions of the world.

Relation with other IARC's

The IARC's which were only emerging at the time of the Beltsville meeting, were already then considered as an important component of a global genetic resources network. Nine of the other centres supported by the CGIAR (CIAT, CIMMYT, CIP, ICARDA, ICRISAT, IITA, ILCA, IRRI and WARDA) perform a range of genetic resources activities related to the crops of their specific mandate. The relationship between them and the IBPGR has evolved over various stages. Some were from the beginning leading forces in genetic resources activities whereas others were hesitant to use their core funds for collections or for the improvement of their conservation facilities (Hawkes 1985). Over the years, however, a real complementary relationship has developed. Most of the IARC's have assumed responsibility as basic and active collections of their mandate crops. In 1988 when the CGIAR adopted a Policy on Plant Genetic Resources (CGIAR 1989) for the whole of the system, the IARC's and IBPGR formed an Inter-Centre Working Group on Plant Genetic Resources. It pursues collaboration in various areas such as collecting, wild species, training, strategic research and networking.

Crop priorities and the acquisition of germplasm

The economic importance of crops, the danger of erosion in areas of important genetic diversity and the material already available in collections guided the priorities developed by the IBPGR for the crops to be considered under its activities. Whereas the major food crops dominated during the initial years the range of crops expanded from cereals, roots and tubers, food legumes, fruits and vegetables towards forages, industrial crops, and now may be even forest trees. However, questions are raised if the priorities sufficiently reflect regional concerns and those related to the diminishing diversity of crop species including losses experienced of potentially useful plants of the wild flora.

IBPGR has recently reviewed its past activities of germplasm acquisition. Collecting has been a major task in the early years when massive genetic erosion occurred. Meanwhile the collection period for some major crops reaches completion. Shifts in emphasis of crops and towards more targeted collections including wild relatives determine now the acquisition programme. Ecogeographic surveys and increased research into aspects of genetic diversity determine future orientation and direction.

Important is that the collection of germplasm is considered the primary task of scientists of the country concerned to whom IBPGR renders assistance as may be required and that only duplicates of the collected material may leave the country to be distributed through designated seed distribution centres and safeguarded in respective base or active collections.

Information

Access to genetic resources and their use in any breeding or research programme depends on the description and information about them. This simple truth is one of the well recognized bottlenecks for the genetic resources movement and collaboration from the beginning. The attempts to assemble and distribute such information actually initiated FAO's involvement in 1950. IBPGR was somewhat mislead in its first five years to put priority to the development of computer software for genetic resources information. Yet subsequently the Board quickly learned that internationally standardized descriptors for the identification characterization and evaluation of crop germplasm were the most important missing instruments. Over 60 such descriptor lists have meanwhile been published, some of them even several times revised and all developed in close cooperation with the scientists and breeders most familiar with the respective crop. The most arduous task, however, is the actual use of these descriptors in completely identifying and characterizing the large numbers of germplasm already conserved in existing collections. It has to be done by all participating worldwide in the collaboration. Considerable progress has been made, but more needs to be done. IBPGR can ensure description only for material newly collected under its support.

The progress made in the whole field of genetic resources information including also directories of existing collections, inventories, catalogues and various databases is impressive.

The establishment of international crop databases is a logical consequence of the efforts so far to facilitate the search and surveys on a crop by crop basis.

The lack of evaluation of germplasm collections is often assumed as a main reason for the under-utilization by breeders of plant genetic resources existing even in well managed genetic resources centres (Brown *et al.* 1989). The support to systematic evaluation, often recommended to IBPGR, was always beyond its means and its capacity. It is also recognized as of doubtful value (Marshal 1989). Targeted, selective evaluation of germplasm for new genetic traits with subsequent pre-breeding to make these traits more easily available is considered to be the more productive and feasible way.

The global network

More than 100 institutions, national institutes, genetic resources centres, universities and international research centres participate in one way or the other in the international network promoted by IBPGR. Base collections for long-term seed storage form the core of the network. IBPGR has been active over the years to make arrangements with existing genebanks to agree on holding base collections of particular crops or groups of crops ensuring conservation under international standards developed by IBPGR and its research collaboration and with the condition of unrestricted exchange. The exchange is through active collections which are also responsible for rejuvenation, characterization and possibly evaluation as well as for medium-term conservation. IBPGR's support to active collections is more recent.

The maintenance of genetic resources of vegetatively propagated crops also receives considerable emphasis in the network. IBPGR has made agreements with over 20 institutes to take responsibility for field genebanks of such crops. Intensified research into *in vitro* conservation methods and in cryopreservation of plant tissue intends to further improve the conservation of vegetatively propagated germplasm.

The early development of the global network very much depended on the few institutions having long-term storage facilities. They were located in industrialized countries or in IARC's and therefore much of the material collected was deposited with them. In addition these institutions commanded already over large collections. After 16 years of operation of IBPGR and much efforts to establish and support national genetic resources programmes and long-term storage facilities in developing countries a considerable shift has occurred. Today 106 institutions in the world have long-term seed storage facilities compared to eight 16 years ago. Nevertheless, the negative image prevails that the majority of plant genetic resources is held in base collections located in industrialized countries.

The location of *ex situ* genetic resources base collections and their ownership were raised as critics against the IBPGR and the CGIAR. Legally the ownership is with those holding the collection. The CGIAR therefore points out in its policy of 1989 that 'collections assembled as a result of international collaboration should not become the property of any single nation, but should be held in trust for the use of present and future generations of research workers in all countries throughout the world'. This is an important aspect for the long-term future when IARCs may have their major function as custodian of global collections of plant genetic resources.

Also the fact that the IBPGR is not an inter-governmental organization has raised questions about the legal character of agreements made with institutions in relation to internationally collected material. The aspect of ownership becomes aggravated in considering intellectual property rights in particular related to methods of genetic engineering and to the possibility of patenting genes or genetically engineered plants. Fears exist that the unrestricted exchange of germplasm may become severely hampered and the power and influence of those holding such patents on genetic resources considerably increased.

The International Undertaking on Plant Genetic Resources and the FAO Commission

Against this background the issue of plant genetic resources, their unrestricted availability and their conservation as common heritage of mankind became the subject of intensive debates in 1983 in FAO (Mooney 1983). In consequence the FAO Conference adopted in the same year an International Undertaking on Plant Genetic Resources. The

Undertaking provides a broad umbrella for national and international actions and collaboration. Its objectives aim at ensuring that plant genetic resources of economic and/ or social interest, particular for agriculture, will be explored, preserved, evaluated and made available for plant breeding and scientific purposes. Its main feature is to establish strong commitments, primarily by governments (Bommer 1984).

A FAO Commission on Plant Genetic Resources was established to monitor the international arrangements proposed in the Undertaking, to recommend measures to ensure the comprehensiveness of the global system on plant genetic resources and to review relevant policies, programmes and activities of FAO. The Commission met for the first time in 1985 and had its third meeting in 1989 (Bommer 1985; FAO 1985b, 1989). After a number of controversies in the text of the Undertaking have been removed the Commission is becoming an important political instrument to foster and monitor international collaboration in plant genetic resources. The USA originally strongly opposed has recently become a member of the Commission and is expected also to accept the Undertaking.

The first one of the international arrangements which are at the core of the Undertaking relates to the development of a network of national, regional and international centres with the responsibility to hold, for the benefit of the international community, base collections or active collections of plant genetic resources under the auspices of the FAO. This arrangement is intended not only to complement the network developing with the support of the IBPGR but also to provide for these collections an international framework. The network under the auspices of FAO has started to develop and in a recent agreement between FAO and IBPGR of 21 september 1990 both parties agree to work towards merging both networks of base collections, IBPGR providing the scientific, technical leadership and FAO the legal and political framework. This agreement between both organizations also brings to an end the debates and sometimes struggle in their relationship. Over the years IBPGR had grown out of its integration in FAO and expanded towards a real autonomous IARC. Space and time do not allow a more extended treatment of this relationship. However, the new arrangement of 1990 promises to be an enlarged and very constructive basis for international collaboration in plant genetic resources.

The International Undertaking also puts considerable emphasis on the development of *in situ* conservation, which is considered to be preferable to any *ex situ* measures. A network of *in situ* conservation areas covering both plant and animal genetic resources is requested from FAO to be studied. It should complement the network of *ex situ* conservation base collections. Of particular interest are areas for *in situ* conservation of wild relatives of annual crops. For the conservation and enhancement of local landraces of crops participatory schemes of farmers receive particular interest (FAO 1989). *In situ* conservation is closely related to ecosystem conservation. Therefore, the Ecosystem Conservation Group (ECG) in which FAO, Unesco (United Nations Educational, Scientific and Cultural Organization), UNEP and IUCN (International Union for Conservation of Nature and Natural Resources) collaborate established the *ad hoc* Working Group on *in situ* Conservation of Plant Genetic Resources in which also IBPGR participates. The Working Group has developed a programme to meet the recommendations made by the FAO Commission (FAO *et al.* 1989).

In situ conservation was so far excluded from the CGIAR policy on plant genetic resources. However, IBPGR in preparing its new strategy plan for the nineties intends to become also involved. It sees in particular a radical new approach in the integration of both *ex situ* and *in situ* conservation.

Other aspects of the work of the FAO Commission such as a global information system can not be considered here. Yet, the establishment of a Fund for Plant Genetic Resources to support relevant activities in developing countries must be at least mentioned. Likewise important is a resolution on 'Farmer's rights' prepared by the Commission and adopted by the 1989 FAO Conference (FAO 1989). 'Farmer's rights' recognizes the past, present and future contributions of farmers, particularly in the centres of origin respective genetic diversity of cultivated plants in conserving and improving plant genetic resources.

Towards a Convention on Biological Diversity

The concern about plant genetic resources is part of a growing concern about the threats to the biological diversity of the earth. It seems therefore important to at least briefly refer to other initiatives addressing these broader issues. A convention on Biological Diversity is for some years now under considerations in IUCN. Its main emphasis is on ecosystem conservation as an essential means to conserve biological diversity including all groups of organisms. Moreover the UNEP explores the desirability and form of an umbrella convention for the conservation of biological diversity. Also this convention covers plant genetic resources and aspects of biotechnology. Its development seems to meet considerable interest by governments.

The numerous organizations involved with various aspects of the conservation of biological diversity call for some coordination of efforts. The UNEP Convention is one approach to it. Another one is the proposal by the so-called Madras Dialogue Group supported by the Keystone Centre to set up within the United Nations a Commission on Biological Diversity. The Commission should be supported by a Global Independent Advisory Committee and a Technical Committee and should have a fund at its disposal (Keystone Centre 1990).

Looking to these various developments and being at the same time concerned about the urgency of action the multiplicity of bodies, structures and proposals are somewhat confusing. However the worldwide interest and the collaboration which were mobilized not the least by the movement on plant genetic resources and its achievements, justifies the strong belief, that the further degradation in biological diversity can be arrested or even reversed.

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Actual and future concepts for collaboration in crop genetic resources

P.M. Perret
International Board for Plant Genetic Resources, Via delle Sette Chiese 142, 00145, Rome, Italy

Summary
IBPGR is proposing the implementation of genetic resources networks based on the concept of crop genepools. The network would be based on information exchange, joint planning, data- and responsibility sharing. The activities of crop networks are discussed, an integrated conservation approach proposed, and methodologies of establishing networks suggested.

Introduction
Activities for the collection and conservation of crop genetic resources have been undertaken at least since the beginning of this century (Vilmorin, Vavilov, etc.), but those have notably increased towards the end of the sixties, a fortuitous chronological repair because of the invasion of southern corn leaf blight in US maize fields. In these times, the severe yield losses of corn, due to the predominance of the T cytoplasm susceptible to a new race of Helminthosporium maydis, raised awareness on dangers of genetic uniformity in modern cultivars; simultaneously, the "green revolution" was accelerating the genetic erosion of landraces and primitive cultivars.

This lead to systematic collecting activities and to the creation of numerous genebanks/collections with the purpose of conserving the disappearing germplasm and to make it available to users, so that there is actually around 3.3 million samples kept by more than 600 collections/institutions across 109 countries.

However, there are many question marks on the nature, availability and viability of many of those samples. Indeed, the lack of information at the accession level for many of them impede to draw any conclusions on their intrinsic value. It is furthermore very difficult to make proper estimates of the total amount of redundancy between collections and, in addition, many of those samples may have dead seeds or the holders may lack the funds to regenerate them before the total loss of their viability.

One of the main challenges, which is nowadays occurring, is also to acquire a more comprehensive understanding of genetic diversity structures within crop genepools. This will allow a meaningful collecting of the remaining material before its possible disappearance, the application of adequate regeneration methods and above all, the promotion of the collected material to the users.

Crop genetic resources networks
As a tool for improving the global status of crop genetic resources, IBPGR is proposing the implementation of genetic resources networks based on the concept of the crop genepool.

The network is conceived as a partnership in learning and problem solving. Its activities are not only based on exchange of information on methodologies and results and on the scientific consultation in planning, but it also includes the sharing of material and data and defined commitments for all partners of the network and also the acceptance of special duties/responsibilities by the partners which are in the best position to provide services bringing benefits to all participants of the network.

The crop and its genepool is the building block which allows to bring together specialists from different fields and agreeing on a collaborative action plan; the conservation of genetic diversity only becomes meaningful when applied to the crop genepool concept.

The experience acquired through the European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources has greatly helped IBPGR to lay the bases of its crop networks programme. European Governments requested IBPGR in 1982 to assume the

overall coordination of Phase II of the ECP/GR which, in its Phase I, was an FAO/UNDP project. It is now in its Phase IV (1990-1992) under a new title (European Cooperative Programme for Crop Genetic Resources Networks). Working Groups for Allium, Prunus, barley, grass and forage legumes, sunflower and Avena are operational, whereas Brassica, Vitis and Pisum Working Groups should be created within the next two years [1].

The IBPGR's crop networks programme was approved by its Programme Committee in 1988 and to date, three networks are in operation: *Beta* under the coordination of the Centre for Genetic Resources the Netherlands (CGN) (which was originally an ECP/GR Working Group), Musa under the coordination of the International Network for the Improvement of Banana and Plantain (INIBAP), and rice under the coordination of the International Rice Research Institute (IRRI). Activities tending to the creation of networks of medics, barley, maize, groundnut, okra and sweet potato are underway. In addition, the establishment of networks for cassava and coconut is also planned.

The next section enumerates activities for which crop networks/Working Groups have an undeniable advantage compared to single national programmes/programmes from an international Institute.

Activities and objectives of crop networks

Documentation

i) Inventory of all existing accessions

The inventory of *ex situ* accessions of a crop widespread in the diverse collections of a region/the world is an essential exercise for the implementation of a crop genetic resources network. This inventory will provide real accessibility to the germplasm by all participants, and, in addition, it is a prerequisite for the proper planning of all activities which will be described further. At the early stage of the ECP/GR, those inventories were consisting of a minimum set of passport descriptors per accession, e.g. 9 for the ECP/GR Forages Working Group [2]; however it was soon realized that additional passport data were absolutely necessary for the coordination of activities such as collecting missions so that the number of passport descriptors required by each Working Group increased progressively.

The production of comprehensive inventories requires an institute to compile the data and to standardize them when necessary. The growth of the ECP/GR Working Groups' activities, and especially the extension of the concept of a limited inventory into the registration of all available passport data, has revealed the key role that the Institutes which originally produced a "one-off" inventory, as in the publication of a catalogue, have had to assume as regional or international databases. Those have to continuously complete and update the data, and on the other side, they have to assume additional responsibilities which are emerging with the expansion of their databases, for example, the analysis of the content of the database files with proposals for further activities.

ii) The use of a common Descriptor List

The exchange of data is specified in a magnetic (computer readable) form. Sending of manual files or listings of data to an international database is acceptable only in very specific circumstances. In the early stage of the ECP/GR the exchange of computerized data arose numerous incompatibilities creating many bottlenecks. Even when the same software was used, documentation officers were sometimes unable to utilize the magnetic media or understand the format under which the data were written. Data files transfer centres (institutes transforming data from one medium to another or from one type of software to another) were created and a standardized format for recording genetic resources data in view of the exchange was adopted [3].

Nowadays the constraints caused by incompatibilities have been largely overcome, due to the increasing availability of hardware and software in genebanks, to the software industries' standardization, and to the experience acquired by the persons responsible of collections in exchanging data.

Data maintained in an international database must be interpretable in the correct way, thus a clear definition of the descriptor must accompany all data, descriptor states must be defined without ambiguity and the conditions of recording (e.g. phenological stage of the plant, number of plants observed, etc.) must also be explained. However data for the same character originating from different sources become internationally relevant when they can be directly compared, i.e. maintained in the same computer file for further analyses so that the same descriptors and descriptor states should be used everywhere to observe genetic resources in the field.

The IBPGR descriptor lists have been published, and often widely used, long before the implementation of the ECP/GR Crop Working Groups or crop networks. Nevertheless, the experience has shown that the establishment of crop networks, and of their linked international/regional databases, promotes the use of common descriptors. Furthermore, the increased practice of exchanging and comparing data has led to the improvement and sharpening of the descriptor definitions and descriptor states, which ultimately helps to provide insight into the biological significance of the characters for which data exist. Thus crop networks stimulate the publication and use of comprehensive international descriptor lists which provide specialists wishing to record many biological characters with an international standardized set of descriptors, in which they may select the most appropriate ones for their own purposes.

iii) Widening the scope of the international databases

The increased coordination of activities within a crop network and the consequent sharing of results requires that more than passport data be collated in a central database. In accordance with IBPGR nomenclature these are: a) management (which may include some passport descriptors but are more effective in the daily management of the germplasm), b) characterization and preliminary evaluation, and c) evaluation data.

a) Management data It would appear, at a first glance, that this type of data is of concern only to each genebank separately (e g. location of the accession within the cold store). However the full sharing of some management descriptors, e.g. "germination percentage", "seed's stock" may become absolutely essential, once participants of a crop network have fully accepted that their own crop collections are an integral part of the crop world collection (refer to rationalization of collections).

b) Characterization and preliminary evaluation data These descriptors characterize traits that have high heritability and are stable in different environments, usually botanical characters, or those which are generally considered by the largest community of users as essential in helping to characterize and possibly differentiate accessions.

Many criticisms have been expressed over the usefulness of characterization descriptors recommended by IBPGR but morphological descriptors as well as genomic or molecular markers are required to adequately classify the accessions. In this context only crop networks can develop a widely agreeable standardized taxonomic nomenclature with its relevant taxonomic key which will be applied for classification of all accessions. The description of genetic resources held in collections is not only of primary interest to breeders, but also to many other biological researchers and characterization data, which provide a better understanding of genetic diversity, have a major importance.

The choice of preliminary evaluation descriptors, i.e descriptors which are thought to be essential by a large community of curators and users, must be the result of a continuous interaction between specialists both at the national and international levels. These data, together with some characterization data, should receive priority for registration into an international data base. The agreement on a minimum set of characterization and evaluation descriptors within a crop network renders their observation by national programmes compulsory or, at least, a very high priority.

The selected descriptors will never fully satisfy all participants as it will only be a compromise in which the costs and time involved in observing those characters have to be taken into consideration. Those data, when compiled into international databases and thereafter analyzed and compared with the results of further collaborative research, will provide a better under-

standing of the variation in each crop genepool. Subsequently a more representative set of minimum descriptors can be selected for each crop.

c) Evaluation data The usefulness of diverse evaluation data into an international crop database is yet questionable. Two types of arguments are prevailing: the first one is based on biological considerations, mainly on the genotype x environment interaction (see further development under evaluation section), whereas the second type of arguments deals mainly with the reluctance of national breeding programmes to share data which could be exploited through the use of relevant material without any return to them (refer a basic principle).

Further than to offer better access on information and material, evaluation data accumulated in an international database could be used to help in the development of special projects for breeding in developing countries. For example, a search for suitable parents which combine spot blotch resistance with photoperiod insensitivity that can improve barley in subtropical environments could be undertaken when the international barley documentation system will be established [4].

iv) Further circulation of information

The vocation of national genebanks is to provide the most comprehensive information on their own germplasm but also to make available all information which may be relevant for the conservation and utilization of the crop genetic resources (refer to integrated conservation approach). Crop networks have a primary role firstly by making internationally available dispersed information in a central place, and secondly by adopting dynamic collaborative approaches. Four examples are cited below.

a) Computerized bibliography of crop genetic resources publications This exercise has been undertaken within the ECP/GR *Allium* and sunflower Working Groups through nationals sending reference (and a photocopy, when it is an article) of all relevant publications dealing with genetic resources of the crop [5,6].

b) List of reference material The list of barley mildew phenotypes by Prof. M. Wolfe and the list of cultivars and near isogenic lines with identified genes for powdery mildew resistance by Drs. P. Kloster and J. Helms Jergensen were presented and made available to the ECP/GR Barley Working Group [7]. Some additional genebanks have included these lists in their databases for better services to their users.

c) Research results There are numerous research projects, for example in universities, which utilize germplasm. Results of those projects are published in various ways, but an identification of the material used is usually not provided. National programmes should ensure that all the useful information resulting from these researches, be added to their databases.

Institutes acting as coordinator/central database of a crop network will make this information available at an international level. They also may be instrumental in establishing agreements with editors of scientific journals, so that, for example, researchers systematically refer to the national accession numbers of the material mentioned in their publications.

Integrated conservation approach

i) Rationalization of collections

The international/regional existing crop databases have provided some factual information on the amount of redundancy which is occurring between collections. For example, persons responsible of the ECP/GR *Avena* database have shown that more than 60% of the named accessions (mainly cultivars) were replicated in different collections participating in the *Avena* Working Group (5 different accessions were replicated 17 times). Such redundancy may be financially bearable for rich countries especially in the case of inbreeders for which regeneration constraints are not so stringent. However, the duplication of efforts which is involved in holding

the same accessions among different genebanks becomes hardly justifiable in the case of outbreeders or for accessions replicated in developing countries (without mentioning the specific case of perennial crops). There is, therefore, an unquestionable need to rationalize collections, this means to consider all existing collections of a crop as a whole entity and subsequently to convince persons responsible of all these crop collections that they should share maintenance responsibilities altogether by coordinating their activities.

Each crop network will have to agree on the strategy which seems most suitable to all participants in order to reach this objective. For example, the ECP/GR barley and *Avena* Working Groups [7,8] are identifying, through their respective databases, the most original accessions within a set of named duplicates. Thereafter, these most original accessions will be a preferred source of international distribution and their holders should commit for high multiplication/regeneration standards as agreed by participants of the network. There are two prerequisites for the success of this system:

a) the confidence within the network that those original accessions will be available in a short lag of time and thus can be acquired only through practice and experience. In this relation, the collation of management descriptors such as "germination percentage" of "seed's stock", take their full justification;

b) the easy international exchange of germplasm and this is coupled with an efficient quarantine system, the existence of testing/cleaning centres for vegetative material (see section on phytosanitary aspects).

Additional technical difficulties are to be faced up for the reduction of redundancy in unnamed material (landraces, wild species) Actually, the voluntary redundancy of the same wild species accessions, which have been distributed/exchanged to several genebanks, may be sometimes desirable, because the seed's numbers being so small each genebank may have only a part of the variability of the original sample of the wild population [9] and also because of the risks of loss of the germplasm during regeneration. However, the identification of potential genetic duplicates through a carefully selected set of morphological/agronomic/allelic markers, among collections will without doubt become a priority for many clonal crops and it is already an existing practice within collections (e.g. sweet potato in CIP).

ii) Safety duplication

The reduction of involuntary redundancy has to be coupled with the insurance that every original accession is held in a long-term storage (with high viability and a sufficient number of seeds) and, in addition, duplicated for safety in another long-term storage. Vegetative material should be present in two distinct field genebanks and, in the future, cryopreserved *in vitro*.

IBPGR, since its creation, has obtained agreement from 38 Institutes to act as crop base collections for many crops. Such a system has promoted the long-term maintenance of an important percentage of the existing material, but it is now faced with some constraints due mainly to the absence of links between the designated base collection and the active collections of the same crops; this system also needs to be revised in some cases because the requirement of safety duplication between a designated base collection and another designated base collection (requirement which has been far to be achieved) does not take into account the fact that many active collections have during the last fifteen years acquired long-term storage chambers and thus are able to store their germplasm in appropriate conditions.

The improvement and, when necessary, the change of such a system, can be envisaged only if we assume i) that a central database will proceed with the inventory of the world crop collection and will identify redundancies, ii) that the mechanisms which are put in place for safety duplication are acceptable to all holders of germplasm of a crop, iii) that reasonable standards for maintenance of the germplasm (including viability thresholds at which regeneration is needed, germination test procedures and regeneration procedures) are defined and applied by all curators. Thus the action needed for the safety duplication is entirely linked with the one which is required for the rationalization of collections. Crop networks provide the best framework to fulfill the three conditions described above and to successfully reach a rational sharing of genetic resources holdings.

There is no space to enter into more technical considerations to what concerns genetic

resources with vegetative reproduction or recalcitrant seeds but the same principles as described above also apply.

iii) An integrated conservation approach

The concept of a crop world collection through sharing of commitments/responsibilities by all the curators of the crop has to be completed by a global approach involving, on one side, studies on the different conservation techniques and, on the other side, estimates on the extent of material which will have to be conserved for the future.

Conservation methods consists of cold storage for orthodox seeds, *in vitro* techniques, field conservation, e.g. orchards, and *in situ* conservation. For each genepool there is to find an optimal combination of these four methods and within each method the most appropriate management techniques. This will be achieved in consideration of investments and running costs needed for each system taking into account the existing conservation status of each genepool. A better knowledge of the diversity of each genepool is a scientific prerequisite for this optimal combination.

Similarly, a detailed knowledge of the variation between and within populations and of their ecogeographical distribution as well as the identification of the variation or the combination of variation which is really meaningful is required to start assessing the extent of germplasm which must be conserved at long-term. Many researches in the different fields, from *in vitro* techniques to genomic studies and ethnobotany have therefore to be intensified for developing the concept of an integrated conservation approach. Most of those researches will have to be undertaken in collaborative projects, or at least, there is a need for coordination to avoid duplications.

To take a simple example, the *in situ* conservation for wild populations of a crop genepool will not become a reality, unless i) systematic inventories of genetic resources occurring in national conservation areas are undertaken, ii) those inventories are compared with the knowledge of existing diversity within these wild populations and iii) surveys on impact of different conservation management systems for the relevant populations are conducted.

It is the primary responsibility of Governments to establish *in situ* reserves and to monitor them. Nevertheless, if the community of specialists concerned with a specific crop genepool does not contribute to the identification of wild populations with high diversity which should be kept *in situ* and then, if it does not provide scientific advice for their monitoring, no one else will do it, or it will be done on basis of unsatisfactory criteria.

The use of collections

i) Phytosanitary aspects

The safe accessibility of the germplasm all over the world is a prerequisite to the use of collections. This means, especially for vegetative material, that crop networks have the task to stimulate research in field disciplines such as virus indexing and to help into the establishment of guidelines for the safe exchange of germplasm. The designation or the strengthening of quarantine centres to transfer the material is not the least responsibility of those crop networks.

ii) Evaluation

The registration of available evaluation data into the central database will allow to avoid duplication of efforts, e.g. screening the same material in different parts of the world (see documentation). The genotype x environment interactions are certainly an hindrance to full exploitation of evaluation data in different environments. The adoption of reference varieties within a network, which are known for their general behaviour or for their behaviour on specific characters in different environments is of help [10]. The increase availability of evaluation data for the same material in different environments (and recorded with the same descriptors) through the crop network documentation system, will stimulate research on G x E interactions. Results of those researches, if they will not allow to predict the exact value of a character from an environment to another, will at least provide useful clues for selection of preliminary material by users in different parts of the world.

Genetic resources networks for crops which are essentially underbred may have a direct role to play in the evaluation process, in addition to the documentation aspects, e.g. the establishment

of multi-site evaluation trials, or the sharing of different screenings activities for a selected set of germplasm in relation to comparative advantages/expertise of each partner.

iii) Enhancement of collections

Comprehensive and easily accessible pertinent evaluation data may not be sufficient to encourage the use of genetic diversity present in crop collections. Potentially useful characters have to be transferred in a favourable genotype (a genotype not too far from elite breeding lines). Still more than for evaluation, crop networks have the potentialities to stimulate collaborative activities for enhancement of the germplasm from wide-crosses to pre-breeding

The core collection is certainly one of the most attractive concept to be pursued by crop networks, firstly the establishment of core collections has to be considered on a regional or international basis, secondly it implies better focusing and sharing of evaluation efforts and thirdly collaborative research for a better understanding of the genetic diversity which contributes to the development of an integrated conservation approach Another important advantage of core collections is to improve the usefulness and applicability of basic researches (e.g. RFLP or other studies) by providing different researchers all over the world with the same material for their studies.

The development of crop genetic resources networks

i) Inaugural Workshop

The convening of an inaugural Workshop is the most adequate way to stimulate the creation of crop genetic resources networks. It may be difficult for major crops to obtain a representative and fair sampling of all concerned parties which should be part of the network. In addition, the status, constraints and primary interests of curators of crop collections in different parts of the world may be very different so that the probabilities to obtain a consensus on a minimum line of action for the establishment of a network may be poor. In such cases an inaugural Workshop should be convened on a regional basis in order to create regional subnetworks, those can be merged later on into an international context or develop specific modes of interaction with other existing genetic resources subnetworks of the same crop. Preliminary working sessions or working groups composed of a few crop experts and representatives of crop collections may, of course, be necessary to explore the modalities and proposals for the establishment of a crop genetic resources network.

The membership of the Workshop should include all curators of major collections of the crop, as well as a fair number of curators of smaller collections, in order that their interests and specific problems are taken into due account. Those members will form the backbone of the future network, but obviously the further involvement of all other curators of the same crop unable to attend the Workshop has to be sought for.

The active participation of breeders, academic researchers and all other specialists concerned with the crop genepool is essential. These specialists should be selected simultaneously on two criteria: i) the relevance and quality of the scientific contribution which they can bring to the Workshop by presenting a discussion paper, ii) their status/influence within their respective circles, e g the Chairman of a crop breeding association, will have the possibility to involve his colleagues into activities of the network. The nature of such involvement will depend on the status of the crop, e g dialogue and interactions will be developed with existing breeding association when the breeding history of the crop is important, whereas more direct links can be envisaged for crops in which breeding is done by a few specialists.

ii) A minimum programme of concrete actions

Participants of an inaugural Workshop are not expected to issue a plan of action which will, for example, lead to the immediate development of an integrated conservation approach. The listing of all possible collaborative activities by participants of a Workshop, as done in the previous section of this paper will not serve the purpose of creating a network. A priority list of well-targeted objectives has to be agreed. A consensus on the strategies to be followed for reaching these priority objectives has to be obtained, and this includes commitments from participants and deadlines for each step of the agreed strategy.

Proposals for launching ambitious and long-term projects which require extra funding or any specific conditions to be fulfilled prior to their implementation should also be part of the recommendations of the Workshop. The effective and immediate collaboration on a minimum plan of action will sustain the further formulation of these long-term projects and their implementation.

A consensus on the code of conduct for sharing germplasm and information within the network is an absolute prerequisite for any further developments (refer a basic principle).

iii) One or more regional/international databases

The establishment of a crop central database is one of the compulsory requirements for IBPGR to consider its continuous support (under whatever form). The scientific role and the responsibilities of an international database within the development of a network have been outlined in section documentation. The Institute acting as central database, if not a major collection for the crop, should be widely esteemed for its crop expertise, and it should be able to dedicate staff time and expertise to pursue the objectives of the network. The continuous collation, updating and analyses of data is only one part of its duties. In short, it should play a leading role in keeping the momentum of the network.

iv) Coordinating body

The nomination of a Coordinating Committee may be desirable to support the activities of the international database, to follow-up activities as agreed and to pursue the implementation of long-term collaborative projects as recommended by the participants. The search for funds in order to develop further activities of the network (see Funding) should also be part of their responsibilities as well as the one to reconvene plenary meetings for assessing the development of the activities of the network and to propose and promote new collaborative projects.

v) Funding

Members are already involved in the expenditure of funds within the framework of their national programmes. The operation of the network should not be regarded necessarily as an additional financial commitment but rather as a mean of gaining maximum return from resources which are already committed.

It is however unquestionable that, despite growing interest in public and official circles for biodiversity, funds made available to genetic resources activities are insufficient. An international approach at the crop genepool level, targetting priorities and outlining the most urgently needed salvage actions, will be a strong incitement for national or international funds to be channelled to genetic resources activities.

vi) Institutionalization of the network

The International Databases need additional staff and funds to adequately assume their responsibilities (refer to (iii) One or more regional/international databases). Thus the commitments and responsibilities of a crop database should be fully recognized by the governing bodies of this institute to ensure the long-term viability of the network. Running costs of the database and of its coordinating activities should be included in the regular budget of this Institute like any other of its normal duties.

Such institutionalization, which is vital for the good operation of the central database, should be sought for all partners (national programmes) of a crop network to ensure the safe extension of the activities of the network. Therefore, the structures, activities and achievements of each network should be presented in an official way to governmental or political instances for obtaining some type of formal recognition. For example, short presentation to the FAO Commission on Plant Genetic Resources on activities of each network could help to serve this purpose.

vii) A basic principle

The free exchange of genetic resources and of their data is a condition for the participation in the network activities, which has to be clearly outlined at the inaugural Workshop.

However, this raises difficulties when genetic resources are defined *sensu lato*, e.g. genetic stocks and breeding lines. There may also be reluctance in some cases or, even legal obstacles in communicating evaluation data. Those constraints have to be raised up. As a basic rule, the provision of data to the central database should always mean the availability of the related materials (a temporary unavailability due to the need of multiplication before its distribution is, of course, understandable).

At an early stage, a pragmatic approach, for example, the free availability of genetic resources *sensu stricto* and of their passport data as well as of a minimum set of characterization/evaluation data may be more reasonable than statements of goodwill which will not be honoured by a large part of the participants; this is on the assumption that those restrictions are agreeable to all partners. However, the free distribution of all genetic resources and of the global related information must be a clear objective of all networks. The sharing of the workload for maintenance of the material to the exclusive benefit of a few national programmes which best have the financial resources to best exploit this germplasm, is not defendable, neither on an operational nor on an ethical point of view.

Until now all concerned parties involved in the establishment of networks have understood this basic requirement and the principles of the full sharing of all types of data have never been rejected. Nevertheless, taking into account the natural competition between different programmes, rules and codes of conduct will have to be developed within each network in accordance with the specific conditions of the crop

IBPGR's role

IBPGR acts as a catalyst in bringing together the relevant specialists to come to decisions on the structure and functions of a genetic resources network. It facilitates, in the limit of its possibilities, the development of the activities of the network.

In the framework of its assistance to national programmes, IBPGR will give priority to those who are faced up with constraints which impede them to fully participate in activities of the crop networks. Similarly the recommendations for collaborative research issued by each crop network will allow IBPGR to better focus its research programme to the most relevant needs within the genetic resources community.

It should be the vocation of all international organizations involved with genetic resources activities to facilitate the development of the activities of the networks. IBPGR, through its Regional Offices, will encourage and facilitate collaboration between all participants of the network.. Regional Coordinators, as well as staff from Headquarters, besides their obvious roles as technical advisors have also the task to promote the objectives of the networks to the upper level of the concerned Institutes or to the higher authorities responsible for the national genetic resources programmes or national breeding programmes.

In the course of the development of the networks, misunderstandings may arise. For example, some partners of a network may come to the conclusions that the leading Institute/central database is unitarilly benefitting of the common activities or, reversely, persons responsible of the central database may judge that some partners benefit of the input of the others without really bringing their due contributions. It will be the difficult responsibility of IBPGR to provide a neutral assistance and advice in order to help in the solving of this type of bottlenecks.

IBPGR is willing to financially support the inaugural Workshop as well as the first meeting(s) of the Crop Coordinating Committees, when this is necessary. However, it has no possibility for continuous funding of such event, and the networks should become quickly financially self-sustaining. IBPGR's major role will be to assist Coordinating Bodies in seeking funds to donors for the coordination and expansion of their activities.

Other collaborative approaches

The implementation of crop networks is called for major crops as well as for a number of so called minor crops, in which a minimum of collections and activities are already existing. It is yet questionable if this concept may be useful, or, at least, applicable in its actual philosophy, to all minor or neglected crops. Other approaches based, for example, on uses of the product or

on ecogeographical backgrounds, may reveal more operative, for example, in the case of medicinal crops.

Many scientific problems or technical approaches are simular for all crop genepools. For example, each international crop database, which is actually implemented, can benefit of the experience acquired in the past by previous ones and thus become operative much faster than five years ago. Working Groups, networks, Committees or any other structures as felt necessary by the documentation officers of international databases could be created to enhance further exchange and analyses of data. Similarly, Working Groups or any other collaborative structures for enhancing specific fields of research such as seed physiology, core collection, could also be most useful. As an example, IBPGR intends to organize an international Workshop on core collections.

National genebanks are more than an addition of different crop genepool collections. Indeed they have the role of integrating all approaches concerning genetic resources activities and their duties towards society go far beyond the concept of crop genepool.

Thus global collaborative structures between genebanks to share problems and improve their practices are also necessary. In Europe, the Genebank section of the EUCARPIA, which, by the way was one of the main facilitator for the creation of the ECP/GR should be created if not already existing as it gives the opportunity to discuss, study and stimulate common approaches on general issues.

Finally, and this list of different possible international approaches do not pretend to be exhaustive, the regional collaboration in a political or ecogeographical framework, should not be neglected. If in the past some failures have been registered, there are also obvious achievements through this type of collaboration, e.g. Nordic Gene Bank, Dutch-German cooperation.

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In situ conservation at the interface between crop genetic resources and nature conservation

L. Olivier[1] and M. Chauvet[2]

[1] *Conservatoire Botanique National de Porquerolles, Le Castel Sainte Claire, rue Sainte Claire, F-83400, Hyeres, France*

[2] *Bureau des Ressources Génétiques, 57, Rue Cuvier, F-75231 Paris Cedex 05, France*

Summary

The setting up of *in situ* conservation of genetic diversity, results for both geneticists and nature conservationists, in enforcing only limited and particular aspects of global biodiversity conservation. The authors, considering this problem from a geneticists point of view, point out the different steps in the organization to reach a satisfactory degree of conservation of wild crop relatives. From the example of protected areas, such as parks and reserves, originally created to protect nature, they study the biodiversity from the nature conservationists point of view. In conclusion, they recommend pragmatism in conservation actions.

The need for a global approach

Genetic conservation versus nature conservation. In spite of the growing consensus towards Biosphere conservation, this issue still looks somewhat provocative. Beyond the official statements, indeed, the current practice of geneticists and breeders on one hand, and of ecologists and nature conservationists on the other hand shows clearly that deep divergences do exist between them.

It would be wrong to think that those divergences are simply the expression of different habits or of obsolete corporatism. In fact, both approaches are firmly based on scientific postulates that look indispensable in our state of knowledge, in the lack of a unified theory on the living world. But these approaches proceed from two contrasting philosophical conceptions of the relationships between Man and Nature.

Some geneticists don't hesitate to assert that 'there is no optimal method to manage diversity; instead, according to the type of management, different types of diversity will be generated' (Gouyon 1989). Ecologists and managers of natural areas come to similar conclusions (Owen 1972).

All this leads us to think that if scientific controversies have to follow their own path, they may be stimulating if the actors of conservation are able to reach pragmatic and realistic compromises whenever it is necessary to take concrete decisions.

A lot of confusion has arisen about what may be called *in situ* conservation. Properly speaking, it deals with wild living beings let to live and reproduce freely in natural habitats. Of course, there are no dogmatic limits, and for example forage plants in permanent extensive meadows may be included. But it seems better to exclude from this contribution the case of primitive cultivars that are sown and grown in ploughed fields. Although it is theoretically interesting to think about an *in situ* conservation in that case, it would mean conserving at the same time entire agrosystems, including human populations, what looks very difficult, if not more. The case of weeds is of course intermediate. For both primitive cultivars and weeds, there would be few differences between such an *in situ* conservation and *ex situ* conservation in the field.

The first step for *in situ* conservation is to realize ecogeographical surveys, as was stressed by IBPGR (1985). Perhaps it is important to insist once more on the urgency we have to face, before many a population of potentially useful plants are irreversibly destroyed as a consequence of land management, building of roads and houses, golf areas, etc. Only with good basic surveys will we be able to reach compromises with a growing social demand towards other uses of land. From now on, nowhere on earth will it be possible, due to human demography, to ensure a long term survival of species that do not benefit from human activities, without a conscious and voluntary action plan enacted even before having had

the time to set up the strong scientific basis we would prefer.

As an urgent task, we propose to realize chorological atlases, in order to have a good information about the distribution of each taxon, putting to light the discontinuities, the presence of isolates and the distribution of infraspecific taxa or particular phenotypes that were noted by previous botanists.

Through field surveys and bibliography, the ecological amplitude of each taxon could be approached through a set of parameters such as altitude, plant communities, soil and climate parameters.

The size of populations and what is known about the ploidy level and the reproductive pattern would also help to identify the sites to be chosen.

The ways of *in situ* conservation

What is really *in situ* conservation? Wouldn't it be better to speak of various methods of *in situ* conservation, adapted to the objectives that have been decided?

In the lack of thorough surveys of each site, we may of course rely on theoretical models or common knowledge the pertinence of which is nevertheless more and more disputed. In a recent meeting held in Israel to assess the results of several years of research on the wild populations of *Triticum dicoccoides* in Ammiad, one of the rapporteurs (Namkoong 1989) stressed that the mechanisms thrown to light relating to population dynamics and genetics would in no case have been predicted by theory, and that from now on, conservation projects based on theories 'elaborated from insular models and hypothesis of random distribution of genes and phenotypes, or permanence of selection pressure' could no longer be considered valid. Thus, although 'Theory' could have been comfortable, we are obliged to recognize that it is only a partial approach of reality.

Consequently, we could add to the careful recommendations formulated by IBPGR (1985) the comment that a conservation plan must not be the consequence of a choice between neutralist and synthetic theory of evolution, but must ensure that in any case, the global diversity available be effectively preserved.

So, a conservation plan will have two objectives:

- maintain the highest number of individuals possible, at the site level as well as in the whole distribution area, in order to allow, statistically speaking, the conservation of rare and presently neutral alleles, and the emergence of a new variability,
- and at the same time, maintain the greatest diversity of habitats, confronting the taxon to the greatest number of elements of natural selection, allowing so the emergence of selected characters, or more simply a high allelic frequency for the best adapted characters, which by the way makes the breeder's task easier.

Practically, when the taxon considered is rare and its global number of individuals is reduced, it will be appropriate to conserve *in situ* all the populations known. When the taxon occurs to be more abundant, it will be appropriate to sample the conservation sites in order to maintain the highest number of 'adaptative units' (Tigersted 1989), that is to say populations permanently submitted to natural selection, ecological stresses, interspecific competition and parasite pressure. The choice will be based on a complete chorological survey and a good knowledge of the ecological amplitude. This approach will of course integrate the populations in which individual characters useful for the breeder, such as male sterility, have already been detected.

The contribution of specialists of natural habitats management coming from nature conservation agencies will be very helpful to:

- describe and characterize the habitats;
- identify evolution and management indicators;
- define the management systems to be implemented according to the objectives of conservation.

Many phytoecologists have also been concerned with rare and threatened plant species conservation, in the last décade. They elaborated a methodology of analysis of environment constraints, very simple to implement. This method is mainly based on the sigmatic approach of phytosociologists, complemented by some physical and biotic analysis.

This method allowsone to define easily the management constraints we have to implement into habitats to maintain the population of a given species. It is worth knowing and using for *in situ* conservation of wild relatives.

At the level of a population or an aggregate of populations, we could differentiate:

- 'biodiversity reserves', where the manager aims to maintain globally the population, avoiding undesired human pressures and in many cases perpetuating some traditional agricultural practices (or activities giving similar results) in order to maintain ecosystems which favour the taxon. Those ecosystems are often secondary, and cannot be left to recover a state prior to anthropization, due to the disappearance of important elements of ecosystems such as big herbivores, in Europe and other areas (Lecomte 1987).
- 'genetic reserves' *sensu stricto*, especially created or adapted to conserve a population or several populations of wild crop relatives. Those reserves would be monitored on a long term basis, and act as the framework of multidisciplinary research work. We could have so a feed-back effect on the management system, and several management modes could be implemented, compared and expertised. This would be possible of course only with adequate funding throughout many years. It would surely bring to light many scientific results, and act as models for conservation strategies in many other areas.

The role of protected areas and nature conservation

As they already have a legal status, and often some managing and scientific staff, it seems logical to try to add a new role for the areas which are protected in a way or another. In most cases, they inherited the tradition of hunters and foresters, and were created to conserve remarkable landscapes and combinations of ecosystems, and the habitats required to maintain populations of big mammifers. They nevertheless contain some diversity of habitats, allowing them to house wild crop relatives and potentially useful taxa. This is particularly the case of the protected areas which embrace extended parts of secondary ecosystems. This kind of ecosystems are more or less stable, and depend upon traditional human practices, and they are often dominant in the managed natural areas of Europe and the Mediterranean.

It is obvious that those areas were not originally created to conserve wild crop relatives, and that it falls very rarely within the direct preoccupations of their managers. Some experts (di Castri and Younès 1990) are very critical in regard with National Parks and Biosphere Reserves, as to their ability to manage biodiversity at the genetic level. The list of gaps to be found is long:

- no species inventories in most cases;
- management systems not taking into account the individual species and even less the genetic diversity;
- no detailed eco-geographic survey.

Until now, flora has been with insects the poor parent of nature protection worldwide. This is exemplified by the status of flora in European regulations. The majority of legal texts protecting the flora aim essentially at forbidding or limiting direct attacks such as gathering, felling, or pulling up, etc. The measures of habitat protection are rare and often difficult to implement (de Klemm 1989).

In fact, the inclusion of flora *per se* as a specific object of nature protection is a recent issue. Traditionally, conservation was conceived in a global way, at the level of whole ecosystems, as is the case in the US National Parks (Kushlan 1979). Many conservationists also consider that in a managed area, the only acceptable measures are those which minimize or even suppress the factors of anthropic origin, with the recognized objective to let the dynamics of the ecosystem and the animal populations act spontaneously, even if it leads to the disappearance of certain species. However, other experts have a more balanced opinion: they recommend to maintain on a given territory a mosaic of habitats belonging to the different stages of an ecological succession (concept of climacic complex, Blondel 1979).

Let us now come back to managed areas. Many specialists consider that their actual distribution doesn't allow them to respond to the requirements of biodiversity conservation, above all at the genetic level. Furthermore, in the perspective of global climatic change, the location of existing managed areas is even more questionable (di Castri and Younès 1990). European parks, perhaps due to their relatively small size, have to face with severe criticism from the viewpoint of nature protection.

Nevertheless, conservationists and genetic resources specialists should be aware that the process of area protection is a lengthy one, needing the mobilization of a considerable energy and time in order to supersede governmental and political obstacles, transform the hostility of some fractions of local populations into a favourable neutrality, and raise funds needed for management and public order. At least ten years are necessary for a project of protected area to come to an end and be enforced in the field by concrete actions. Everywhere in the world, and above all in democratic countries, creating a reserve or a park results from a compromise in the elaboration of which political and social criteria play the same role as biological criteria.

This kind of areas have always been the result of important investments made by local and regional authorities. Thus it seems wise to optimize those investments by incorporating them into a network of conservation of wild crop relatives when such plants are present.

The role of *ex situ* conservation

In this context, the role of *ex situ* conservation is easy to define. It gives the worker the advantage to have genetic diversity immediately available, and it ensures the conservation of a significant part of the diversity present in nature, as a duplicate of *in situ* conservation. It would be an illusion to think that we may conserve *ex situ* the whole array of diversity, both for scientific and financial reasons. A rational strategy would be to limit our pretention to the conservation *ex situ* of:

- a representative sample of each identified population of rare and threatened taxa;
- the genetic material necessary for the working collections of geneticists and breeders.

A good coordination between *in situ* and *ex situ* conservation will of course have to be fulfilled, probably through the designation of a coordinating agency.

Conclusion

As a conclusion, let us say that *in situ* conservation of genetic diversity is a complex issue at the interface between crop genetic resources and nature protection (Chauvet, 1989). It has to deal with all the levels of organization of the living world, from the molecular to the population level. It needs multiple approaches and the contribution of specialists from different disciplines, who are not used and not always willing to work together, and appears as a challenge of nowadays.

The moment has come to go further than mere intentions. A strong impetus needs to be given to overcome organizational obstacles (let us remind that classically, genetic resources are in the frame of agricultural research, whereas nature protection is in the frame of environment).

If real shadows do persist in scientific knowledge, particularly in population genetics, we are convinced that we know enough to set up a pragmatic strategy to conserve this part of biodiversity represented by wild crop relatives.

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Intellectual property protection and genetic resources

J.J. Hardon
Centre for Genetic Resources, the Netherlands (CGN), P.O.Box 224, 6700 AE Wageningen, the Netherlands

Summary

A brief review of Plant Breeders' Right and Intellectual Property Protection legislation is presented, with special emphasis on the actual or possible consequences for access to genetic resources. Differences between Europe and the US are pointed out. These developments are related to global developments in genetic resources conservation resulting from amongst others the FAO Undertaking on Genetic Resources and the concept of Crop Networks evolving through the IBPGR. It is argued that Intellectual Property Protection may negatively effect availability of genetic resources and that this issue requires attention. Some examples are given that illustrate the difficulties that may result from natural transfer of protected characters through outcrossing into landraces and even wild relatives in centres of diversity.

Introduction

The emergence of modern biotechnology has diffused the definition of plant genetic resources to include apart from plants also their individual constituent elements such as genes or other fragments of DNA, specific processes, plant tissue, cytoplasms, cytoplasmic organelles, enzymes, proteins and so on. Private industry plays an important role in plant biotechnological research. In the context of plant genetic resources this refers to research at the molecular and cellular level employing advanced techniques to identify, isolate and transfer carriers of genetic information in any form. A major outlet for the results of such research are plant varieties. While in the past plant breeding typically formed part of the agricultural sector, it is now more and more moving into the modern chemical industrial complex. Traditional plantbreeding evolved a moderate form of legal variety protection, Plant Breeders' Right (PBR), guaranteeing third parties free use of any protected variety for the purpose of creating other varieties. The industrial complex generally considers this form of research protection totally inadequate for their purpose and argues that it reduces the value of protection in the field of plant biotechnology to practically nil. A number of industrial countries have responded to such arguments and are considering or have started to expand patentable material to include plants or parts thereof. This represents a radical step with potentially large consequences for ownership of and access to genetic resources. In historical context it would be or is a turning point. Domestication, improvement and the movement of crops to new regions has been based on the principle of free access since the dawn of agriculture. Agriculture in the major industrial regions of the world have been main beneficiaries. European agriculture depends largely on crops introduced from elsewhere in historical times and continues to depend on genetic diversity available in centres of origin. With the advent of commercial plant breeding this principle of free availability of genetic resources rooted in the agricultural philosophy was upheld by Plant Breeders' Right legislation.

The present debate on extending Intellectual Property Protection (IPP) to include living organisms is heavily dominated by short term industrial interests motivated by market control and corporate profits rather than by the interests of agriculture and society as a whole. It appears a confrontation between a moderate agricultural and a more competitive industrial philosophy. The growing relationships of universities and public supported institutions with private industry in biotechnological research has profound effects on the directions of research, intellectual secrecy and perhaps even public accountability. It certainly effects attitudes towards intellectual property protection issues. In this article these

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issues are discussed from the point of view of plant breeding and genetic conservation and access to genetic resources in a global context.

Plant Breeders' Rights

PBR is a right granted by a government to plant breeders to exclude others from producing and selling propagating material of a protected variety for a period of 15-30 years. 'Breeders' Exemption' allowing without restriction use of the protected variety in the creation of new varieties is central to PBR. It expressed the unanimous wish to preserve free availability of genetic resources when the international convention on PBR was drawn up (UPOV, 1974). The reasons are obvious. Plant breeding is a step by step process developing better yielding varieties with improved characteristics or adapted to new environments. Current cultivars represent the sum of past achievements going back to the original landrace material. New characteristics identified, e.g. disease resistance genes, need to be bred into varieties throughout the range of distribution of the crop or where the disease occurs. Any restriction in the availability of new and useful materials was considered unacceptable in the general interest. It could restrict progress in crop improvement geographically and might stimulate undesirable monopoly situations where industrial companies could decide who would and who would not have access to improvements essentially based on products of nature. Hence PBR was not conceived in its present form because varieties could not meet the requirements of industrial patents. It was specifically designed to provide a careful balance between the interests of the plant breeders and those of producers and consumers. The patent requirement of non-obviousness was dropped. New varieties are developed rather than invented. New characters are generally discovered through evaluation of genetic resources and are not a new creation. Furthermore the characters in themselves tend to be obvious in the context of crop improvement rather than novel and unexpected. To be eligible for PBR protection a variety must be distinct from other varieties in one or more characteristics relevant to the difference, it has to be sufficiently homogeneous and stable in its essential characteristics and not yet commercialized. As a system it has worked well and allowed the evolution of a large and successful plant breeding industry in industrial countries that adopted PBR legislation.

PBR is a national legislation. International harmonization is achieved through the International Convention for the Protection of New Varieties of Plants (UPOV Convention), initially in 1961 adopted by 5 European countries. Since 1978 also non-European countries have joined raising the number of member-states to 19 including most industrial countries. The primary objective of PBR is to stimulate private investment in plant breeding. This assumes the presence of a private seed industry or an official policy aimed at stimulating plant breeding in the private sector. As it is, in most developing countries plant breeding is mainly done in public institutions, while the international institutes of the Consultative Group on International Agricultural Research (CGIAR) have led to a total open and obviously successful public financed system of plant breeding. Key characteristics are free exchange of breeding materials in all stages of development and international cooperation in multi-locational testing of such materials. It is difficult to see how such a system can be made compatible with national PBR legislation. Furthermore there is some concern that PBR legislation as formulated under the UPOV convention could make it difficult for a national seed industry to develop in competition with large international companies. This could lead to dependency situations in basic seed supply which most countries do not find acceptable.

Strengthening PBR systems

Private breeding companies, both in Europe and the US have felt for some time that adjustments were required in PBR. A major revision of the UPOV Convention is under way. At the same time the E.C. Commissions' Directorate General for Agriculture (DG VI) has prepared a 'Draft Council Regulation on Community PBR' in 1989, taking note of the proposed changes in the UPOV Convention. With regard to the availability of genetic resources, a main change considered is to restrict the interpretation of the 'Farmers Privilege' to limit farmers practice to safe seeds of protected varieties for future sowing.

Furthermore modifications are proposed in the principle of 'Breeders' Exemption' to increase the so-called minimal distance between varieties eligible for PBR protection. It is meant to curb cosmetic breeding, only changing one or more characters to satisfy present distinction criteria. It is proposed to introduce a classification of 'derived variety', providing for joint protection together with the original parent variety. The EC draft proposal also contains a modified definition of what is considered a variety to be: 'any group of plants as well as parts of those plants as far as they comprise of more than a cell or cell line and are usable for the production of plants'.

Patent protection

A patent is a right granted by a government to inventors to exclude others from imitating, manufacturing, using or selling a patented process or product for commercial use for a period usually 17-20 years. In return for a patent the inventor discloses how the invention works so that knowledge is available to the public. To obtain a patent, the subject matter has to be novel and inventive, ie not obvious to a person skilled in the art. Patent law, as PBR contains a provision known as 'research exemption' which however allows others only to study the protected subject matter. Hence, unlike PBR reproducing or multiplying it in any form is not allowed.

Internationally the Paris Convention for the Protection of Industrial Property provides for a universal treaty. Establishing equal rights for nationals as well as for residents of its member countries under the national laws regulating industrial property rights. At present 100 countries are members. A United Nations specialized agency, the World Intellectual Property Organization (WIPO) is charged with the administration.

Variation in intellectual property protection

In spite of the various international conventions and agreements, there still is considerable variation in procedures of granting and in the interpretation of requirements in both PBR and in industrial patents Such differences exists specifically between Europe and the US reflecting differences in their legal and political systems. Aspects relevant to genetic resources are briefly reviewed.

The differences in PBR between Europe and the US are mainly procedural The actual nature of the protection is largely comparable as far as it affects genetic resources.

In patents the situation is more complicated. European patent laws are harmonized through the Strasbourg Convention of 1963 and subsequently by the European Patent Convention (EPC) of 1973. However also within the EPC there still is considerable diversity. The European Patent Bureau can issue patents for one or more of the 14 member countries. However the actual protection provided is still determined by national laws and may differ from country to country. Since not all EC-member states are members of the EPC, the European Community has drawn up a Community Patent Convention (CPC) providing for unitary patents within the Community. However it is not expected to become operational before 1992.

In essential aspects with regard to patenting biological material there is considerable agreement within Europe. All European patent laws contain provisions by which certain subject matter is explicitly excluded from patent protection. The EPC under Art.53(b), and thus the patent laws of all EPC member states, exclude from patent protection plant or animal varieties or essential biological processes for the production of plants and animals. US patent law does not contain any exclusions. Here the extent to what is patentable is determined by case law.

In Europe considerable emphasis is placed on the criteria of non-obviousness whereby the invention should be a technical problem plus the solution to that problem, or is a teaching for a technical operation (Bent *et al.* 1987). In the US a patent may be granted to whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter or any new and useful improvement thereof. The criteria of non-obviousness is less stringently applied and need only be 'sufficiently different from the prior art'. In the US patents are granted for parallel cases even when the underlying problem has been solved

already. In Europe this is much more difficult. This is a very fundamental difference, specifically with regard to patenting biological material.

Patenting in plants

Industrial patenting in biological materials has become a matter of intense debate since new developments in biotechnology are starting to have an impact on industrial, agricultural and environmental processes. In plants intellectual property protection is not anymore restricted to varieties developed by plant breeding, but also concerns independently products and processes in plants including genes and gene products (enzymes, proteins, etc.), cytoplasm, cytoplasmic organelles transferred across natural biological barriers and so on. Through sequencing and appropriate probes precise identification of transferred segments of DNA has become possible. Similarly, genetic resources now not only cover plants but also include any DNA fragment isolated and transferred from any type of living organism to improve a variety. Much of this research and its application is done outside traditional plant breeding in industrial companies.

In line with industrial practices, private industry argues that patent protection should be extended to include 'inventions' in biotechnology without restrictions when basic requirements of patent protection can be satisfied. They consider PBR to provide totally inadequate protection.

So far, patenting of biotechnological inventions have progressed based on legal interpretation of patent law. More fundamental aspects such as what consequences it may have for plant breeding in general or for genetic resources in particular do not seem to have had the same attention.

Some recent developments

The USA

In the US the system of case law resulted in a ruling by the court on a genetically engineered bacteria that 'the relevant distinction was not between living and inanimate things, but between products of nature, whether living or not, and man-made inventions' (Sasson 1988). This was followed in 1985 by a ruling in the 'Hibberd case' that a maize variety containing an increased level of tryptophan constituted patentable subject matter under US patent law. The conclusion is that genes, plant parts, plants, plant varieties, and processes for developing new varieties and hybrids constitute patentable subject matter under US law (OTA 1989). The maize-tryptophan patent in essence means that any maize variety with a tryptophan level above the stated level would fall under the patent regardless of how this level has been achieved. It thus discourages any further breeding or improvement of tryptophan in maize at least in the US. It contributes to genetic uniformity and nullifies one of the most important objectives of patenting, to stimulate further research and development. The US system is based on the assumption that adopted rulings can be challenged in court and juris prudence will take effect. It seems likely that this will happen in the present case. In fact it appears that the US Board of Patent Appeals and Inferences has already raised the criteria for patents in living organisms significantly (Shands, pers.com.). Mean while the ruling stands and has far reaching consequences also outside the US leading to a multitude of patent applications.

Europe

In Europe the EPC allows patenting of micro-organisms but does not allow patent protection for plant and animal varieties and essentially biological processes (Art.53(b)). However strong pressures from private industry, arguing that without parity in patenting Europe would be left behind in biotechnology, led the EPO to grant in first instance patents on several plants. Legal justification put forth was that while plant varieties were excluded in the EPC this would not necessarily apply to plants as such. This somewhat liberal interpretation is still disputed in the EPO Court of Appeals. It, in a way suggests that EPO

is attempting to adopt US procedures of circumventing existing legislation through case law.

Fundamental changes in the EPC will require a lengthy process of renegotiation. However within the EC national patent laws can be changed more rapidly through directives by the European Council. The 'Proposal for a Council Directive on the Legal Protection of Biotechnological Inventions' (Commission of the EC 1988) is meant to do just that. In its draft form the patentable subject matter is defined to include ultimately plants and animals, the offspring of these plants and animals, and products of protected biotechnological processes, even plant and animal varieties. Hence almost anything biological becomes patentable subject matter. The most remarkable, almost outrageous proposal is the reversal of proof. If on a product or process a patent is issued, any 'inventor' of an alternative genetic solution must provide the evidence that it differs from the former solution. Not surprisingly these proposals received strong support from especially large pharmaceutical and chemical companies in Europe. On the other hand plant breeders backed by agricultural organizations and UPOV are concerned that such patents will de-facto limit the free availability of varieties for further breeding and undermine thereby a basic principle of PBR. Added to this is a general concern that patenting in living organisms may result in the 'privatization of life' which has profound ethical consequences. Resolution of this controversy will obviously be extremely difficult.

Developing countries, centres of diversity

Patenting in plants has come at a time when the whole issue of access to and ownership of genetic resources has become a matter of global debate. Partners in this debate are developing countries, some harboring still existing centres of diversity of crops and industrial countries requiring such diversity for their crop improvement including biotechnology. Through the FAO Undertaking on Plant Genetic Resources (FAO 1985) developing countries sought recognition for their sovereignty over their natural wealth while accepting the basic principle that genetic resources should be seen as a 'Heritage of Mankind'. Initial misunderstandings over the nature of protection provided in industrial countries by PBR were resolved and balanced by a proposed 'Farmers' Right'. Farmers' Right is meant as a recognition of the input of many generations of farmers in the development of landraces. Unlike PBR a Farmers' Right can however seldom be attributed to a specific farmer or even a farmer community. The notion that specific landraces have evolved in a particular locality over long periods of time is generally not realistic. Landraces tend to be replaced and moved around, introgressed and so on in a dynamic system of genetic change. It does not provide a stable situation. Hence, while landraces are undoubtedly of great value as a genetic resource for plant breeding, it is difficult if not impossible to define individual landraces, assign a specific or relative value to them and decide who is the owner. An interpretation of Farmers' Right accepted by the FAO Commission on Genetic Resources sees it as an expression of the principle of global international responsibility to conserve landraces and thereby insure their availability. At present approximately 125 countries, including most industrial countries are members of the FAO Commission on Genetic Resources while around 90 countries accepted the Undertaking in principle.

However the possibility of patenting individual genes or gene products has added a new complication with potentially far reaching consequences for the basic principle of unrestricted availability of genetic resources. It not only threatens genetic diversity as a free resource. If countries in centres of diversity will respond by extreme interpretation of national sovereignty over their genetic diversity, conservation itself may be endangered as it becomes the sole responsibility of national governments often lacking the necessary financial resources.

Discussion

Unrestricted availability of plant genetic resources for further crop improvement has been a basic principle in agriculture since the dawn of agriculture and was upheld in modern plantbreeding.

There is no argument that any meaningful input in crop improvement should be adequately rewarded in order to stimulate such progress. Such rewards should benefit the inventor but take into account the interests of society as a whole. In plantbreeding the general interest is obvious; to provide farmers with the best material available for their particular farming systems and at the same time to insure overall availability of food to a growing world population at affordable prices and there were the food is needed. To satisfy these objectives, any monopoly situation is inappropriate.

Biotechnology is clearly making significant contributions to plantbreeding through a better understanding of gene action and the ability to manipulate genes across natural crossing barriers It will increase the tools available to speed up introgression of alien germplasm into breeding populations and cultivars and provide techniques that will improve selection progress. The suggestion often made that it will revolutionize conventional plantbreeding seems somewhat exaggerated. Plantbreeding is more than adding small segments of DNA to a cultivar. Most characters of agricultural value are regulated by numerous inter-acting gene complexes. Hence crop improvement will probably continue to depend largely on conventional plantbreeding for some time to come. Forms of rewards provided to biotechnological research should therefor not have a negative effect on plantbreeding in general. This issue seems so far to have had curious little attention.

The World Industrial Property Organization (WIPO) recognizes three categories of inventions related to biological materials (WIPO 1986).

- 1 Inventions relating to an organism or material *per se* (products).
- 2 Inventions relating to a process for the creation of a living organism or the production of other biological material.
- 3 Inventions relating to the use of an organism or material.

Categories '1' and '3' are relevant to the present discussion as they cover plants and parts of plants. Any form of patent protection which does not stipulate free use of a plant for further breeding restricts access to it as a genetic resource. It has been argued that therefor patent protection of any isolated gene should be exhausted when such a gene is incorporated in a plant. Obviously this view is hotly contended by private industry involved in biotechnology. This is understandable as it would make the invention freely available as soon as such plants are commercialized. It has been suggested that through licensing, varieties containing patented genes can be made available for further breeding, although apparently compulsory licencing so far is rejected by biotechnological companies. Another alternative would be for the owner of a patented gene and its construct to transfer the patented system for a fee at the request of interested plantbreeders. The cost and time involved in backcrossing such a character in other varieties would than determine the price that could be asked for such a service. This alternative might present an acceptable compromise when the basic criteria for rewarding a patent, to be an 'invention' and not a 'discovery' and to be 'non-obvious', are stringently applied. Most biologist would argue that these criteria should make it exceedingly difficult for genes or gene products to qualify for patent protection. A finite set of plant-enzyme systems are regulated by essentially similar DNA sequences across taxa. Secondly surely the identification of a specific gene or biological process is generally a 'discovery' and not an 'invention'. Using an existing 'product' in a novel and concrete application may satisfy patent requirements However if that requirement is interpreted in biological rather than in legal terms, it may raise the threshold for what is patentable to a level that makes biological sense and is acceptable to plantbreeders.

Regardless of patent requirements, enforcing such patents might prove difficult. In regions were landraces or open pollinated varieties are still common, introgression of a patented character will undoubtedly take place. In fact introgression between modern varieties and landraces and among landraces is the rule in such situations. It forms part of the informal system of crop improvement enriching the gene pools of local material. Can the owner of the patented character claim his rights on such introgressed materials and thereby de facto control their use. It is hard to imagine that an inability of a patent holder to control the transfer of a gene through natural outcrossing would give him added rights on all the materials affected. What will happen if such landraces are collected by genebanks unaware

of the presence of the introgressed character and are distributed to plant breeders who may be primarily interested in other than the patented character. What are the obligations if such a plant breeder only finds out later that he has unwittingly included the patented character in his new variety without necessarily wanting it. Can he ask the owner of the patent to remove his property or sue for damages. As introgression through natural means can often not be ruled out, how than does one differentiate between bona fide and illicit transfer of genes. What happens if patented characters introgress into wild relatives of crops, a not unlikely situation. All this would seem to suggest that common industrial patent protection is not very suitable for self-reproducing organisms. It will lead to almost unsolvable and endless legal procedures, increasing the costs of plant breeding and seriously complicating if not restricting the free availability of genetic resources.

What can be the legal implications for crop networks. A crop network assumes open exchange of materials and information. Free exchange of genetic resources is embedded in the FAO Undertaking on Plant Genetic Resources, presently signed by over 85 countries. Reservations made by some countries pertain to genetic materials that can be reasonably classified as 'private property' under national law, such as breeding lines and PBR protected varieties and so on. Most genebanks do not normally consider breeding lines as a resource that needs to be conserved. Preference is given to the original parent material. PBR protected varieties do not cause serious problems, since their use as a genetic resource for further breeding is not restricted. More problematic could be materials containing patented subject matter. Various options might be considered:

- Patented materials are stored in genebanks and upon distribution to users, mention is made of the patent.
- Patented materials are not included in genebanks until he patent expires. The assumption is that the patent holder will keep or has available for sale the material for the duration of the patent and upon request will negotiate conditions for its release.

Actually, even the entry in genebank collections of PBR protected varieties is still in discussion. The argument against is, that the holder of the right is obliged to maintain the variety and has stock for sale, hence there is no danger of loss until the right expires. However for practical reasons CGN does include PBR protected varieties in its collection if they are of sufficient interest as a genetic resource.

In summary, the problem is that so far there does not seem to be an objective debate on the various consequences of IPP when applied to biological materials. Decisions are made in courts of law based on legal interpretation often looking for loophoies in a legislation that was not developed for biological materials. The research community is increasingly dependent on contracts from private industry which seriously erodes their critical intellectual and independent role in passing judgement on such matters. In fact many public institutions see patents as a promising way of solving their financial problems and increasingly become motivated by self interest and not by objective standards of the general interest of society.

The specter of varieties becoming covered by a variety of patents requiring complicated legal negotiations before they can be used for further breeding, may be attractive to lawyers but will seriously hamper plant breeding as we know it

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Central crop databases in collaborative genetic resources management

Th. Hazekamp and Th.J.L. van Hintum
Centre for Genetic Resources, the Netherlands (CGN), P.O.Box 224, 6700 AE Wageningen, the Netherlands

Summary

By coordinating activities between genetic resources programmes and sharing responsibilities, the effectiveness of these programmes can be increased enormously. Coordination of activities can be organized for a given crop or group of crops in a crop network. With the recent developments in information technology, new approaches for coordination have become available. The central crop database is an important example, it combines information on the accessions in several germplasm collections of a given crop or group of crops. Considering the conservation of genetic diversity, two tasks can be distinguished: the compilation of germplasm collections and the maintenance of these collections. Coordination, and the availability of a central database can help to avoid unnecessary duplication of efforts for both tasks. In compiling collections a central database can reveal whether material that is missing in a specific collection is available elsewhere, thereby avoiding duplication of collecting efforts. The maintenance of collections is severely hindered by the high degree of duplication between and within collections. Analysis of duplication, using central crop databases, makes it possible to set priorities for the rejuvenation of the material, and to reduce the duplication. Also safety duplication can be properly organized. If the information on the material in the network collections is easily available, it will become much easier to supply the user with the material he is looking for. Apart from passport information, a central database can also be a source of information on evaluation activities. It could serve as a repository for the actual evaluation data gathered within the network, or could limit itself to providing summarized information, describing what kind of evaluations are performed on which type of material. To promote utilization of collections several new concepts are being applied or developed, central crop databases support these activities with the necessary information.

Introduction

The main objectives of genetic resources programmes are to conserve genetic diversity and to stimulate its utilization. The need to improve the effectiveness of these programmes has been the driving force behind collaborative activities. By coordinating activities between genetic resources programmes and sharing responsibilities, the effectiveness of the programmes can be increased enormously. Usually coordination of activities is organized for a given crop or group of crops in a crop network. In particular the smaller programmes can benefit of collaboration, since task sharing allows them to make a more effective use of their limited resources

Since it is obvious that genetic resources conservation is a responsibility shared by all, and too great a task to be taken care of by one country alone, activities have always been coordinated to some extend. With the increased availability of computer hard- and software, and the recent developments in information technology, new approaches to coordinate collaborative structures have become available. Within crop networks, the central crop database concept is an important example of such a new approach. In this paper we will discuss its potential role in collaborative genetic resources management.

Central crop databases

The central crop database concept of pooling information over collections, is aiming at a more efficient usage of information to coordinate genetic resources activities. The notion

that this should also be accompanied by the creation of large centralized seed collections, like in base collections, has been abandoned. A central crop database combines information on the accessions in several germplasm collections of a given crop or group of crops. Usually it is created and operated by a centre with special interest and expertise in a particular crop. The type of information that is included in such a database differs per case. In general at least passport information of the individual accessions is included, since these data act as the main point of entry into collections for users (Withers *et al.* 1990). Central crop databases can be used as a powerful tool in collaborative genetic resources management for both conservation and utilization of germplasm. The effectiveness is determined by its ability to provide users with the required information. Obviously, the information inputs, both quantitative and qualitative, and the ability of the database manager to handle crop related issues using information management techniques, are important factors.

Central crop databases and conservation of genetic resources

Considering the conservation of genetic diversity, two tasks can be distinguished: the compilation of germplasm collections and the maintenance of these collections. Coordination, and the availability of a central database can help to avoid unnecessary duplication of efforts for both tasks.

Compilation

When compiling germplasm collections, the scope of the collections have to be defined and priorities in collecting have to be set. Following the identification of blank spots, decisions have to be made on how and when to supplement the collection. Priorities for additional collecting activities can be set when it is known what kind of material is or is not available in *ex situ* collections, and possibly what kind of *in situ* diversity still exists. While the *ex situ* collections can largely be analyzed using their documentation, *in situ* diversity is more difficult to assess. The documentation of *in situ* diversity is often very limited and above all very transient, since natural populations are in constant interaction with their environment and tend to evolve.

By using the information gathered in central crop databases, duplication of collecting efforts can be avoided. Besides, the crop network can be used to feedback information to the network members about upcoming collecting activities, thereby improving the overall planning of activities.

Maintenance

In maintaining collections, central crop databases can also contribute to a more effective management. It is known that substantial duplication exists between and even within collections. Plucknett *et al.* (1987), e.g., estimates that two-thirds of the world's wheat germplasm are duplicated. The conservation of such redundant germplasm unnecessarily burden genebank facilities. By reducing this type of duplication waste of the limited genebank resources can be avoided. Analysis of duplication, using central crop databases, makes it possible to set priorities for the rejuvenation of the material, and possibly in time discard superfluous material. Also safety duplication can be properly organized.

Since central crop databases pools information from different collections, it can be used to indicate the most suitable location for maintaining or rejuvenating accessions, thereby taking into consideration environmental factors like day-length and soil, the availability of crop specific expertise or specialized technical facilities to name just a few. In this way optimal use can be made of local facilities within the crop networks.

To use central crop databases for a more rational compilation and conservation of collections, the need for adequate passport information is evident. Also information is needed about the availability of the material, since utilization is the ultimate goal of germplasm collections.

Central crop databases and utilization of genetic resources

Considering the objective of genetic resources programmes to stimulate the utilization of germplasm, the accessibility of the collections is an important aspect. Based on information

about what kind of material is available in the joint collections, it will become much easier to locate the material the user is looking for. This would have to be done on the basis of passport data, possibly extended with data on the availability.

A central database could also be a source of information on evaluation activities. It could hold data-files containing the complete evaluation sets, gathered from different locations. Alternatively it could limit itself to a short and comprehensive summary, describing what kind of evaluations have been performed at the different locations. Both options would help answering trait specific requests.

To promote utilization of germplasm, many new concepts are being developed or applied. Diversity studies resulting in the compilation of core collections will provide a basis for more efficient search strategies. Pre-breeding and the creation of bulked base populations will make the incorporation of new germplasm more attractive to breeders. Coordination between collections is essential for these initiatives, central crop databases support the activities with the necessary information.

It can be concluded that passport data is the common type of information in central crop databases. This information can be extended with data on the availability and/or the seed quality, and evaluation data or summary information on evaluation data (meta data).

Implementation of central crop databases

As argued, central crop databases can play an important role in coordinating activities in crop networks to improve the effectiveness of genetic resources programmes. To illustrate what kind of implications the use of central crop databases will have, some aspects need to be discussed in more detail.

Network support

Central crop databases provide a technical basis to enhance collaborative activities within crop networks. A central database can only add a new dimension to these activities if the participating network members fully support the central database with sufficient and accurate data.

- The data have to be submitted regularly. Especially data on availability and seed quality are very dynamic and need frequent updating, but also passport and other information need periodic updating.
- Secondly, the data have to be reliable. The reliability is a general problem in the use of information on germplasm. It should be a constant effort to improve the quality of this information.

Central crop databases are the result of a joint effort. If support is too limited within the network, a central database may even be counterproductive, since decisions based on inadequate information could turn out to be worse than no decisions at all. On the other hand, if adequate support exists, the benefits for individual members and the network as a whole are evident.

Compatibility

Another issue strongly related to the concept of central crop databases is compatibility. Data have to be exchanged and incorporated in a single central system. Hardware compatibility is hardly a problem anymore, conversion procedures are available. The only problem on this level are data that haven't been computerized yet, but this problem will solve itself in time.

Logical compatibility remains a more serious problem. Structures of germplasm information systems differ, because genebanks differ. The use of different coding conventions and taxonomical classification systems complicate a correct interpretation and comparison of information. Conversions from one structure or system to another usually are labor intensive, and cause loss of information.

Continuity

In general genetic resources programmes pursue long term objectives. Continuity of activities is therefore vital and deserves a prominent role in the discussion on crop networks.

Since central crop databases support these long term activities a few basic requirements have to be met.

- The organization responsible for compiling and operating the database has to be sure it can support these activities for a reasonable period of time.
- A certain capacity will have to be reserved for the activities on the database. This capacity could possibly be financed externally to offer some compensation for services rendered. The same applies for expenses on hard-and software. The genetic resources community or other interest groups have to provide financial backup for these activities to secure their continuity.

Technical set up

There are several options for the technical set up of a central database. Most of the existing central databases are off-line systems, where every few years data are gathered from the contributing collections, transformed in a common structure and format, and combined in one system. The 21 international central databases, compiled as part of the European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources (ECP/GR) are good examples of this approach (e.g. Knüpffer 1988; Frese & van Hintum 1989). The structures, in which the data are combined, can vary from a simple ASCII file to a sophisticated relational database management system. The way the resulting data are distributed to the user can also vary from printed catalogues to CD-ROM discs.

An alternative to the off-line systems is an interactive on-line system, like the national 'Germplasm Resources Information Network' of the USA (Perry *et al.* 1988). In an interactive on-line system the users/contributors can directly access the data, via computer networks or ordinary telephone lines. The obvious advantage of an interactive on-line system over a off-line system, is the direct accessibility of the data, and the resulting possibility to keep the information available for the user up to date. A number of problems associated with using interactive on-line database services can be expected.

- On-line interactive access completely bypasses the database manager. To effectively access the database, either the database has to be very user friendly, or potential users must have a very clear idea of the structure of the system to get hold of the proper information.
- A direct line between the information contributor and the database leaves little space for transformation of the structure and format of the data to be included in the database. Either the user has to supply data with a common structure and format, or the system must be able to hold all kinds of structures, resulting in a complicated system, with the obvious disadvantages. This problem could be avoided by keeping the data input off-line.
- Computer networks are fast, but at present these networks have their limits. Especially when using databases, often large amounts of data will have to be transported through the network, creating a substantial network load. Besides, genetic resources networks, and especially central crop databases, should service a widespread international user community. Until now, it not possible to establish on-line connections if you are not directly connected to the same network. These factors can easily slow down network operations and turn on-line access into on-line agony. On top of all this, an on-line system is technically much more complicated to create and maintain, considering user friendliness, security, etc. A third option could be a file- or list-server system. These servers offer two types of services.

File-server

A file-server acts as a shared repository for data-files, so called archives, from which network users can retrieve files or submit them. Files can be submitted or retrieved interactively or by electronic mail. File-servers could be used to make information contained in central databases available to users. These systems enable fast data access even from other networks, which is important for central crop databases servicing a large international community. Fast data access could become more relevant in genetic resources activities, if

dynamic data, like seed availability, are incorporated in central databases. Contrary to on-line database systems, the database manager is not by-passed, but acts as an intermediary, between users and the database, enabling a more structured support of users.

Distribution lists

Besides file archives, used to store data-files, list-servers support electronic bulletin boards. On these bulletin boards, specific discussion lists enable people with shared interests to communicate. Questions, remarks and announcements can be submitted to a discussion list and are automatically distributed to all subscribers of the specific list. It offers a possibility for more direct, and less formal, communication, compared to conventional methods.

Although, until now, only few genebanks have direct access to international computer networks, this number will surely increase in the near future. National data networks are operational or under construction in many countries, and can be used to link up to the international networks. Especially since more and more networks are to be interconnected, it seems worthwhile to investigate their application in genetic resources activities.

Duplication

Duplication of accessions is a central issue in the discussion on the possible applications of central crop databases.

In the narrow sense genebank duplicates can be defined as genetic identical genebank accessions, 'identical duplication'. This definition is only of very limited use. Only for material that hasn't been rejuvenated, material that is completely homogeneous, or vegetatively propagated, it can be useful. In a broader sense genebank duplicates can be defined as populations derived from a common parental population, with all alleles in common. This can be mixtures of lines, with differing genotype frequencies, or random mating populations with the same alleles, but differing allele frequencies.

In tracing duplicates within and between germplasm collections several problems have to be faced. First the probable duplicates have to be identified. Complicating factors are the errors and omissions in the passport information. These are due to omission of important information, errors in interpretation, typing, translation and transcription errors, and difficulties due to taxonomical (re)classification. These errors can be avoided by handling information carefully, and possibly using standardized systems for transcription and classification. But unfortunately the material in most germplasm collections has a long history, many mistakes might have occurred in the past.

Tracing probable duplication between and within collections can only to a very small extend be done automatically. Manual screening must be supported by an appropriate interface, allowing multi field searches, different types of wildcards, searches on phonetic resemblances etc.
Knupffer (1988) and Frese & van Hintum (1989) showed some of the complications faced while tracing duplicates in a central database.

Once probable duplicates are identified, it is not at all certain if they are actual duplicates. Genebank accessions are not always what they are supposed to be, the genetic identity sometimes changes in time. This is mainly due to random genetic drift and natural selection during rejuvenation, and unintentional selection, contamination and switching of seed lots during rejuvenation and seed handling. Reducing the number of rejuvenations, and organizing the rejuvenations and seed handling properly, will reduce the changes of the genetic identity. But unfortunately, also here, changes might have occurred in the past.

These considerations show that the subject of duplication has to be handled with care. A central crop database is essential in the first step of tracing duplicates, it can help to locate probable duplication, and no more.

Discussion

Several developments can be observed that will increase the effectiveness of central crop databases.

Given the standardization of the computer hardware, and the increasing power and user friendliness of the computer software, the technical problems of data exchange have practically disappeared.

Ways of improving the accessibility of central databases will become available. Some alternatives have been discussed. The application of expert systems to support users in selecting material may be another future improvement.

To allow better analyses of the representation of *in situ* genetic diversity, central crop databases could be linked to *in situ* databases, as far as they are available.

Given the need for rationalization of global genetic resources management in a collaborative approach, the central databases will have to be used as a management tool. Technical problems can be solved easily, given some minimal requirements like trained staff and hardware. Organizational problems can also be solved as soon as the importance of a collaborative approach is recognized by the genetic resources community. Serious problems that will remain are logical compatibility and the low quality of the information in germplasm documentation systems. These problems will possibly decrease as soon as the information actually has to be used, and the genetic resources managers realize that you can not know what to do if you do not know what you've got.

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The core collection concept

T. Hodgkin
International Board for Plant Genetic Resources (IBPGR), Via delle Sette Chiese 142, 00145 Rome, Italy

Summary

A core collection has been described as a collection which contains, with a minimum of repetitiveness, the genetic diversity of a crop species and its wild relatives. Such a collection is not intended to replace existing genebank collections but to include the total range of genetic variation of a crop in a relatively small and manageable set of germplasm accessions.

It has been argued that the development of core collections will improve management and utilization of crop plant genetic resources and provide a guide to future germplasm collecting activities. However, concern has also been expressed that the information needed to develop core collections is not available for most crop species and that accessions with desirable characters will be omitted from the core collection. Core collections of okra, wild *Glycine* spp. and winter wheat have already been described. An IBPGR survey has shown that projects to develop core collections of a number of cereal, legume, forage, vegetable and fruit crops are also in progress. These projects should provide much needed information on the different approaches being investigated, the data needed to develop such collections, the most effective sampling methods and the extent to which the collections have captured the required genetic diversity.

The development of core collections is likely to involve a number of features of direct importance to those concerned with developing new concepts for collaborative genetic resources management. These include collaboration between genebanks in identifying unique sets of accessions that represent the total available resources of a crop, cooperation between genebanks and researchers in the investigation and analysis of the genetic diversity present in a crop genepool and collaboration between genebanks and germplasm users to identify sets of accessions that contain most of the genetic diversity of species.

Introduction

The concept of a core collection which would contain with a minimum of repetitiveness the genetic diversity of a crop species and its wild relatives (Frankel, 1984), has already had a considerable impact on plant genetic resources work. As with crop networks, the underlying ideas are conceptually simple, have considerable scope for development and appear to offer opportunities for significantly improving germplasm management and utilization. Originally proposed by Frankel (1984) the core collection concept was further developed by Frankel and Brown (1984) and by Brown (1989a). The latter argued that if plant germplasm collections were to be used more extensively they would have to be better collections, rationalized, refined and structured around a small, well-defined and representative 'core'. There was no suggestion that a core collection should replace existing collections. The objective was to identify a set of accessions which would represent and cover the major kinds of genetic diversity known to be present in the crop species and its wild relatives. This 'core' would provide genebank managers, plant breeders and research scientists with a manageable number of accessions for their work. It would become the focus for the search for desirable new characters, for detailed evaluation and for work on the application of new techniques. Brown (1989a) also stated that there should be a hierarchical relationship between the core collection and the rest of the accessions so that the core fraction would provide efficient access to the whole collection.

The need to improve accessibility and hence utilization of plant genetic resources is widely recognized (Brown *et al*, 1989) and the size of some collections has been cited as a barrier to increased utilization (Holden, 1984). There are currently estimated to be over

250,000 *Hordeum* and 345,000 *Oryza* accessions in genebanks throughout the world. While many of these accessions are duplicates, the number of unique accessions of major crops is now so great that they could only be screened for simply expressed characters, even by the largest breeding organizations.

A first requirement for the effective management and utilization of plant genetic resources is the collection and collation of characterization and evaluation data describing the variation found in the material. But, increasingly it is being realized that another key to effective management and utilization lies in a better understanding of the way in which the variation or genetic diversity of a species is distributed in the genebank and in nature. The core collection concept focusses on the extent and distribution of genetic diversity in a species and should involve investigations that would result in the identification of accessions that optimally represent the available genetic diversity in a species.

Both the theoretical and the practical aspects of developing core collections raise a number of problems. Information on the genetic diversity present in a collection is required, the size of the core needs to be determined and sampling methods have to be developed which maximise the genetic variation present in the core. Brown (1989a, b) has discussed these issues from a largely theoretical point of view and proposed procedures that maximise the genetic diversity in a core collection and should achieve the objective of retaining over 70% of the alleles present in the whole collection. This paper describes some current work on core collections and outlines a number of issues in need of further study and research. Possible links between work on core collections and the development of crop networks will also be suggested.

Current core collection projects

At the end of 1989 IBPGR conducted a survey on the extent of work on core collections. This survey revealed that there was widespread interest in the development of such collections, particularly in developed countries and in the CGIAR Commodity Centres. Over 20 projects directly concerned with setting up core collections and four established core collections were identified.

The projects reported involved cereal, legume, forage, fruit and vegetable crops and ranged from individual initiatives based on the germplasm holdings of a single national genebank to collaborative programmes involving considerable international cooperation. Wide differences in approach were found with respect, for example, to the criteria used to differentiate groups of accessions from which to select the core, to the sampling procedures used and to the practical aspects of developing and maintaining a core. Four projects involving wild *Glycine* spp., okra, barley and wheat are described here to illustrate these different approaches.

Perennial *Glycine* species

One of the earliest core collections to be described was that of perennial *Glycine* (Brown, Grace & Speer, 1987) which was derived from the collection of 1,400 accessions of 12 species held in Canberra, Australia and recognized by IBPGR as the world base collection for perennial *Glycine*. The accessions included in the core were chosen so as to ensure:

- the inclusion of at least a few accessions of each species to provide replication at the species level;
- geographic coverage of each Australian State with as broad a range and scatter of habitats as possible;
- the inclusion of any known morphological, cytological and isozyme variation within species;
- that accessions already used in research or known as authentic first hand collections were given preference.

Once adequate representation of each species had been obtained ecogeographic factors were used to select the core entries. A total of 111 accessions were included in the core collection, slightly less than the 10% proposed by Brown (1989a). As might be expected the

proportion of accessions selected from each category (species x state) varied dramatically from <5% to 100% in order to achieve some representation of each category. Although guidelines for modification of the core collection were developed, it was stated that alteration of the core collection would be relatively infrequent in order to build up a substantial body of information on the core accessions.

Okra

The development of an okra core collection was outlined by Hamon and van Sloten (1989) as part of their work on characterization and evaluation of West African accessions of the crop. The selection of 189 accessions for the core collection from the 2,283 accessions in the ORSTOM/IBPGR okra collection was based on passport, characterization and evaluation data with the deliberate inclusion of some rare types. The number of accessions chosen was determined primarily by the need to have a manageable collection scaled down to the needs of the breeder and/or other user and by the desire to include the widest possible range of variability. Characterization and evaluation data were obtained from a single trial involving all the available accessions and data on qualitative descriptors (e.g. stem colour, leaf shape, fruit position) and quantitative descriptors (e.g. plant height, date of flowering, number of internodes) were analysed to determine the correlation between variables and the geographic distribution of variability using a range of univariate and multivariate techniques.

More recently, Hamon (1990) has investigated the procedures that might be used to develop a core collection using quantitative data on crop characters. Using multivariate analysis procedures, selection of accessions for the core is carried out in such a way as to maximise the variation in the core collection relative to the original collection. The proportion of variability to be included is decided by the operator without specifying a fixed percentage of accessions. As Hamon notes the procedure results in a tendancy to include extremes of expression and takes no account of the heritability of the characters included.

Barley

A working group nominated by the Barley group of the European Cooperative Programme for Conservation and Exchange of Crop Genetic Resources (ECP/GR) has been considering the development of a barley core collection since September 1989. The working group report (von Bothmer *et al*, 1990) proposed that a core collection of not more than 2,000 accessions be established and that it should include cultivars (500-800 accessions), landraces (approx. 500 accessions), Hordeum spontaneum (up to 150 accessions), other wild *Hordeum* spp. (approx. 80 accessions) and genetic stocks. A clear definition of the barley core collection was formulated and the objectives were described as increasing the efficiency of evaluation and utilization, providing a manageable and representative selection of germplasm and providing standard material for scientific work.

No attempt was made in the report to select accessions although the use of sampling procedures in which genetic variation is considered to have a hierarchical structure was recommended. Essentially, the accessions would be classified on the basis of agreed characters and a dendogramme of variation created. Selected accessions are considered to represent the terminal groups of the dendogramme. Some of the characteristics that might be used in constructing the dendogramme were listed. For the cultivar category the characteristics included phylogenetic group (occidental or oriental) growth habit (winter or spring barleys), genetic differentiation, ear type and pedigree data For landraces ecogeographical data, the agricultural system practised and end-use were considered important while, for *H. spontaneum*, the use of ecogeographic data was specifically mentioned.

The working group report discussed the organization and operation of the core collection in considerable detail. The collection is to be established as a result of international collaboration and, in order to ensure its continued integrity, it was recommended that, as far as possible, selected accessions should be homozygous. In order to achieve this, single seed selection to obtain homozygous lines was suggested wherever initial accessions were

found to be heterozygous. Different phases in the establishment and operation of the core collection were described so as to ensure it could be maintained by genebanks cooperating on a voluntary basis. Interestingly, in order to increase the value of the core collection to those involved in research, it was proposed that genetic and cytogenetic marker stocks be included in the core collection.

Wheat

The approach taken by Mackay (1986, 1988), in using the core concept for improved evaluation and utilisation of wheat in the Australian winter cereals collection, differs considerably from the other examples given. Initially (Mackay, 1986), a core collection was to be established by breaking the collection into ecogeographical and other major groupings using ploidy, type of accession (cultivar, breeding line, wild species, etc), growth habit and maturity. It was anticipated that the core would contain about 3,000 accessions and provide a reasonably sized group of genotypes for extensive evaluation. Latterly it appears that this approach has been modified. Mackay (1988) reported that germplasm to be evaluated was selected on the basis of ecogeographical data in order to include a reasonable amount of genetic variation. This procedure is complemented by a specific attribute programme for which the genebank and potential user make predictive decisions about the origin of germplasm which might possess the desired character in terms of soil type, climate, maturity, etc This is used to identify sets of accessions which are likely to contain maximum variation for the character in question. While this may seem quite different from the other core collection projects cited, it is similar with respect to the concern to clarify the structure of genetic diversity in the crop and to identify a small number of accessions with the maximum possible genetic diversity.

Areas for investigation

The studies described above illustrate the wide range of approaches chosen by workers on core collections. Thus, the collections may be based on a single genebank as in okra, winter wheat and *Glycine* or may involve international collaboration. The accessions identified may be physically separated, simply marked on a genebank's database or reselected for each objective required. Many related species may be involved or only a single crop and genetic stocks may or may not be included. Differences also exist with respect to the data used to select the core collection. In okra, emphasis was placed on characterisation and evaluation data from a wide range of characters, whilst in other crops ecogeographic data has been given much greater emphasis so that in wheat, ecogeographic aspects largely determine the choice of accessions to be included in specific evaluation exercises. In part this may reflect the availability of data and the scale of the undertaking, but characteristics of the crop species that effect the nature and distribution of genetic diversity, such as breeding system and ploidy level are also likely to affect the approach used. Thus, the methodology adopted for clonally propagated crops may differ substantially from that used for seed propagated ones.

While many of the features of the core collections described reflect the characteristics of the crops involved and the nature of the projects, issues of a more general nature can also be identified. The extent to which passport data or ecogeographic considerations can be used to maximuse the diversity in a core collections needs to be established. Many studies have shown that country of origin is a major factor when variation in a set of accessions is partitioned (e.g. Spagnoletti Zeuli & Qualset, 1987; Peeters, 1989). However, in crop plants this may result from social and political factors as much as from ecological ones and there remains a large amount of variation unnaccounted for in such analyses. Furthermore, adaptation to a particular set of environmental conditions may result from the action of different genes and, where this involves adaptation to stress environments, plant breeders may wish to have access to all the different adaptive genes for their breeding work.

While multivariate analysis procedures have become common, the methods by which genetic diversity can be usefully summarised from analysis of passport, characterization and evaluation data still need to be investigated. The relative advantages and disadvantages

of the different analytical techniques for the analysis of genetic diversity in crop genepools need to be described so that those with access to the data can make a more informed choice of the analysis procedure most appropriate for their requirements. Together with an improved knowledge of the significance of ecogeographic data, and suitable methods for partitioning observed differences to identify genetically related groups of accessions, more information is required on the way in which sampling for the core collection is to be carried out. Brown (1989b) has investigated this on sample data sets but much more extensive studies are required before final conclusions can be drawn. High levels of residual genetic variation within accessions have been reported in a number of studies (e.g. Tostain & Marchais, 1989; Jaradat, 1989) and any sampling method based on grouping accessions will tend to limit the amount of this variation that can be included in a core collection.

Core collections will be largely selected from genebank collections and can only contain the diversity present in the genebanks used. Collaboration between genebanks will increase the amount of diversity that can be included in the core, but the material held in genebanks is often unrepresentative of the total diversity of a species. For many crop species a large number of more or less uniform cultivars are held in genebanks and many of these may be related The presence of some cultivars may be required in a core collection for utilization purposes, although the diversity they contain may also be found in landraces of the same crop. Landraces may present a particular problem in the development of core collections. Indeed, their maintenance in genebanks can cause problems with rapid changes in allele frequencies over succeeding multiplications (IBPGR, 1990). In many genebanks landraces are divided into different accessions based on variation for visible characters and sampling for the core collection will need to take account of this.

Once a core collection has been established it is thought desirable that its constitution should remain fairly stable to enable a body of knowledge to be accumulated on the collection. However, it is important to ensure that a core collection adequately represents the diversity in the genebank(s) from which it was derived. To this end validation procedures are required involving comparisons between the core and the source collection.

It is therefore desirable that comparisons should be made of the amount of genetic variation in the two collections using isozymes or RFLP markers. More generally, criteria which a core collection should meet need to be developed. Thus, Hamon (pers. comm.) has suggested that intercrossing within a core collection should, in theory, generate that range of variation found in the original collection from which it was derived. Other criteria which can be used to test whether a core collection is adequate have been given by Brown (1989b) in terms of its utility and genetic representativeness and methods need to be developed to establish the extent to which a collection satisfies these.

Core collections and crop networks

Ultimately, the success of core collections will depend on the use that is made of them. This suggests that users requirements must play a considerable part in the selection of the core. Differences are apparent between some of the projects in progress which reflect the extent to which they are influenced by plant breeders perceived needs rather than genetic considerations. The desire to include maximum genetic diversity in core collection also implies that collaboration between different genebanks, between genebanks and users and between genebanks and research workers is likely to be important to their success. In this sense the development of core collections is closely linked to the development of crop networks. The inputs required for a core collection include an assessment of genebank holdings to identify unique accessions and improve their documentation, adequate evaluation of accessions, the study of genetic diversity and a clear definition of users needs. Many, or all of these objectives are expected to be achieved by crop networks which may therefore provide the stimulus needed to develop further core collection work. The reverse is also true. The development of a core collection may be one of the more important concrete objectives which crop networks could undertake and, such work could materially help the development of effective crop networks by focussing collaborative work on a specific objective.

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The role of the Commission of the European Communities in germplasm conservation

K. Beese
Commission of the European Communities, Directorate-General for Science, Research and Development (XII), Directorate Biotechnology (F/2), 200, Rue de la Roi, Brussels 1049, Belgium

Summary
A possible future role for the EC Commission was discussed by the European Conference "Biological Diversity: A Challenge to Science, the Economy and Society", held in Dublin, 1987. Since general conditions have not changed remarkably, the recommendations from this conference can be considered as still valid. The Conference Scientific Committee recommended that the CEC should take steps to: better organize and make available information on biological diversity; promote research on the subject; create international and multi-disciplinary teams and networks; integrate knowledge in policies; coordinate the exploration, assessment and conservation of biological diversity; and increase public awareness regarding the subject. Several Community programmes and services have considered these aspects in past and recent activities. To better coordinate the different approaches, to develop policies and to improve cooperation with other international programmes an inter-service group has been set up (secretariat: DG XII F/2). Services involved are DG VI (agriculture), DG VIII (development), DG XI (environment), DG XII (research: CUBE, Biotechnology, ECLAIR/FLAIR, FOREST, STEP, STD) and DG XIV (fishery). A joint DG XII/DC VI expert meeting in July 1990 was held in order to identify research priorities and to discuss the feasibility of Community coordination of national crop germplasm programmes. The expert group on plants identified the following priority research objects for the Community Biotechnology programme (3rd RTD Framework Programme, 1990-1994): rapid methods for genetic screening; taxonomic information systems combining molecular data with other data; strategies for combination of different conservation methods; and identification of markers of regeneration potential of cryo-preserved samples of forest tree species. As requested by the Council of Ministers on Agriculture in March 1990, possibilities for EC coordination of national crop germplasm conservation programmes are now under discussion.

The role of the Commission of the European Communities in germplasm conservation can be presented in two different ways :

1. the potential role of the Commission as requested by breeders, scientists, germplasm curators, officials responsible for species conservation programmes etc.;
2. current Community approaches aimed at granting this request.

I will try to consider both aspects, desirable engagement and practical steps which have been undertaken to meet these requirements. Considering the balance between the requests and expectations compared to practical steps already initiated, 95% of my presentation should consider the first aspect. I will try to upset this balance and overstress recent Commission activities.

The most important EC initiative to identify needs and to define a Community role in the framework of national and international programmes in biodiversity conservation, was the organization of the European Conference 'Biological Diversity - A Challenge to Science, the Economy and Society', Dublin 1987. The Conference Scientific Committee - some of its members are also present here, e.g. Prof. Dieter Bommer and Dr. Jaap Hardon - formulated

a number of recommendations which concern the future role of the EC Commission. The Commission was urged to

- better organize and make available existing information on biological diversity and to promote research on the subject. Revival of taxonomy was explicitly mentioned in this context;
- better integrate results of research in the field of biological diversity into agricultural, industrial, environmental and development cooperation policies;
- coordinate, at European and international levels, the exploration, assessment and conservation of biological diversity in order to concentrate on the most urgent actions and to make effective use of limited available financial resources;
- harmonize at European and international levels, regulations concerning conservation and the commercial use of wild genetic resources, and finally
- increase the general awareness about biological diversity through European campaigns of information and education aimed at decision-makers and the general public.

Similar recommendation were formulated by a European workshop of national plant germplasm coordinators, organized by the German-Dutch Commission for Agricultural Research in Bonn in 1989. The EC Commission was asked

- to develop a work-sharing cooperation of crop genetic resource centres in the member states;
- particularly through a European Committee for crop genetic resources;
- to increase public awareness about genetic erosion;
- to improve the information basis and
- to promote interdisciplinary cooperation.

These suggestions are in line with the role of the EC as identified in the German national conception on plant genetic resources, elaborated by Prof. Bommer. This conception, which is now in the implementation stage, says that an EC-wide strategy for plant genetic resources has to be elaborated. The objective would be to bring about a reasonable division of work and concentration. First step is the establishment of a Europe based collaboration for important crop plants. A corresponding request of the EC Council of Ministers of Agriculture was expressed in the early spring of 1990.

To consider these manifold requests, an informal internal interservice group was initiated at the EC Commission in order to :

- identify those Community programmes which, in principle, can contribute to research into biodiversity assessment, conservation and use;
- harmonize the different approaches;
- intensify research in this field;
- improve cooperation with international organizations and
- discuss, at a later stage, policy implications.

Even the first step, to identify relevant programmes and services, is not easy, even for an insider. Of course, it is much more complicated to identify opportunities from the outside. Therefore as the secretary of our group I invite you to contact me if you have any questions or suggestions. Our group forms a useful platform to distribute information, invite discussions and to make contacts.

A number of services are now involved, mainly from research programmes in DG XII, the Directorate-General for Science, Research and Development :

- The secretariat is held by the Biotechnology Division,
- CUBE, the Concertation Unit for Biotechnology in Europe,
- ECLAIR and FLAIR, the programmes for Agro-Industrial and Food Technologies,
- STEP, standing for Science and Technology for Environmental Protection,
- STD, the DG XII programme for Science and Technology for Development, and
- FOREST, now part of the broader programme 'Raw Materials', for aspects of forest resources.

But not only DG XII has activities in genetic resources assessment, conservation and utilization. The major contributions in the field that we are discussing here, have come from agricultural research programmes in DG VI, the Directorate-General for Agriculture.

Possibilities of how to consider the request from the Agricultural Council are now being discussed in the Committees responsible. It goes without saying that activities in environment protection by DG XI (Environment, Nuclear Safety and Civil Protection) have far-reaching importance for genetic resources conservation. The same is true for programmes in fishery resources as managed by DG IV (Fishery), although this is not directly related to the issue we are discussing here. Some important programmes on information networks like MSDN, the Microbial Strain Data Network, were promoted by DG XIII, the Directorate-General for the Information Market Innovation. Projects on genetic diversity assessment and conservation related to development are part of DG VIII (Development) activities. One example is the contribution of this service to the Tropical Forestry Action Plan.

In our group, we are now discussing cooperation with other international organizations. For this purpose we have prepared a list of relevant organizations and are now trying to get the responsible EC units involved in our interservice group. The most important organizations for collaboration are obviously IBPGR, FAO, UNESCO, UNEP, GIBiP, EUCARPIA, IUCN and a number of others. Furthermore, services responsible for relevant policies (plant variety rights, plant health, crop products marketing, veterinary legislation etc.) are kept informed about our discussions and can participate in our group.

To fulfill another recommendation of the conference in Dublin, we are now discussing means to inform the public about the problem of genetic diversity erosion and Community approaches to assess, conserve and use genetic material.

You can see from this presentation that first initiatives have been started to consider the suggestions from the Dublin Conference. The interest to reinforce activities in genetic resources conservation in corresponding Commission programmes is evident. Therefore, there seems to be good reason to expect that more funding will become available for corresponding programmes in the future.

The requests which concern CEC activities in genetic resources conservation are two fold :

1. the coordination of national activities and inputs from the EC in order to develop an EC infrastructure, including the establishment of EC based collections for important crop plants;
2. to provide funding for research into biodiversity assessment, conservation and utilization.

Some of the previous speakers have already mentioned the urgency in respect of the first aspect, infrastructure and coordination. However, at the present stage, it is more suitable for me in this presentation to give more attention to research aspects. Since the objectives of the research framework programmes change frequently, it is difficult to establish the responsibility for long-term coordination tasks in units responsible for research programmes. On the other hand, new areas of Community activities can rapidly picked up by the research programmes. As a representative of DG XII, the Directorate for Science, Research and Development, I am not willing to determine beforehand the role of the EC in the field of coordination, but I will give you some information on opportunities in Community research activities. DG VI, the Directorate-General for Agriculture, has accepted the notion of discussing CEC opportunities for coordination in the crop field.

At the beginning of this year, the EC Council of Ministers approved a new Framework Programme for Research and Technological Development which will last until 1994. For the first time 'conservation of genetic resources' has explicitly been mentioned as a priority area for a research programme. This programme is the biotechnology programme, working title BIOTECH. The corresponding Commission proposal for the specific programme was presented in May this year. Conservation of genetic resources is still a minor part of the programme, about 15% of the total budget of 164 Million ECU will probably be dedicated to the 3rd area, including biosafety and germplasm conservation research. Therefore it was obvious that a clear-cut definition of the objectives of this programme had to be found. The purpose will not be to finance long-term maintenance of germplasm collections but to overcome technical problems in order to reach efficient conservation strategies and effective use. The text of the Commission proposal for the programme particularly mentions the assessment of genetic diversity in order to improve knowledge about the amount of existing genetic diversity and the degree of genetic erosion. Support to the decentralized collections

and cooperation with international organizations is considered as important.

To define the objectives of the research area more clearly, we organized an expert meeting in July 1990. Discussions took place in separate working groups on plants, animals and microorganisms. Another working group, invited by DG VI, was to discuss possibilities of the CEC to become involved in the support and coordination of national crop germplasm programmes. The 'plants' working group identified 4 priority objects:

- Highest priority was given to the development of rapid molecular genetic screening methods for the analysis of genetic distances and identification of samples bearing economically interesting genetic traits.
- The development of taxonomic information systems, which integrate molecular genetic data with other data was identified as second priority.
- Research into alternatives to conventional approaches to store genetic material was considered as third priority, however premature for direct research funding. A study in order to develop a strategy of combining the different methods was seen as more adequate.
- The identification of markers for regeneration potential of cryopreserved forest tree samples was identified as fourth priority.

The recommendations from the experts do not bind the Commission in any way, but have to be considered as a basis for discussion. The objects of the programme will be clearly defined in the technical annex of the so-called 'call for proposals'. This call for proposals will be launched not earlier than in Spring 1991. First contract research could then start in Summer 1992. The whole programme will be implemented in three phases.

The Commission can finance :

- cost shared research, that means that at least 50% of the costs must be provided by funding bodies other than the Commission;
- concerted actions, this means that the CEC's role is only concerned with the coordination of work and the exchange of results;
- feasibility studies, before being involved in direct research funding.

Parts of research in the area, 'conservation of genetic resources' will be implemented as concerted actions and studies, shared cost contracts will be the exceptions. New areas are generally more difficult to introduce than to continue with others which are well-known to the members of the advisory committees. Therefore, in the beginning, no major contributions from the EC can be expected for the new topic 'conservation of genetic resources'. This situation may change in future programmes. The strongest argument to reinforce the contribution allocated to a part of a programme is the receiving of a high number of high quality proposals. However, it would be unrealistic to expect, at present, the establishment of a whole programme on crop germplasm conservation. Therefore, to be practical, one must consider the different priorities of the various existing Community programmes.

The overall budget of the Community Biotechnology programmes has increased considerably in the past, combined with a shift from industrial/bioprocessing technology towards more fundamental biology research.

Coming back to the coordinating role of the EC Commission and contribution to infrastructure, we must consider:

1. the opportunities and limitations of EC involvement;
2. the activities of other international organizations, particularly the European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources (ECP/GR) coordinated by IBPGR.

In view of the growing necessity to involve Eastern Europe countries and to link European programmes to global approaches, I would like to question whether we need another European coordination of national crop genetic resources programmes, limited on EC member states and, at least partly, interfering with IBPGR responsibilities. I would like to stress the importance of clearly concentrating on original EC Commission responsibilities and possibilities and the consideration of other international programmes when requesting EC activities in this field. This has to be seen as an essential prerequisite for profitable use of financial resources.

The role of ICARDA in genetic resources conservation

J. Valkoun
International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria

Summary
The West Asia and North Africa (WANA) region where ICARDA is operating includes the primary centres of diversity of wheat, barley, chickpea, lentil and a number of pasture and forage species. The goal of ICARDA's work in germplasm conservation is to explore, collect, safeguard and enhance the utilization of the germplasm of crops for which the Center has a mandate.

ICARDA has global responsibility for preserving genetic resources collections of barley, durum wheat, wheat wild relatives, kabuli chickpea, lentil and faba bean within the IBPGR-coordinated base collection network. The total number of accessions exceeded 88000 in 1990, and further efforts are being made to collect locally adapted populations of ICARDA-mandated crops and their wild relatives. Since ICARDA's research focuses towards drier areas, priorities are given to the collection of landraces and wild relatives of the mandated crops from insufficiently explored regions, including dry (150-350 mm rainfall) areas and highlands, and where native germplasm is being threatened by genetic erosion. Cooperation with the IBPGR and other IARC's within the CGIAR system as well as with the National Agricultural Research Systems (NARS) belongs to the guiding principles of ICARDA's policy on genetic resources activities. The Center participates in the crop collaborative networks but a regional approach may be more appropriate in the developing world.

The Consultative Group on International Agricultural Research (CGIAR) has given high priority to crop genetic resources activities since its foundation in 1971 and, recently, this position was reinforced in the 'CGIAR Policy on Plant Genetic Resources' (IBPGR 1989). ICARDA, as one of the 10 CGIAR Centers involved in plant genetic resources conservation, included all key principles of the CGIAR Policy into its own position paper 'Availability of Genetic Resources from Collections Held in the ICARDA Genetic Resources Unit' (ICARDA 1989). In addition, CGIAR is now developing a position paper on plant breeders' and farmers' rights.

As at the other International Agricultural Research Centers (IARCs) within the CGIAR system, objectives and conditions of genetic resources work at ICARDA differ in several aspects from those at gene banks and germplasm centres in developed countries, and some of them are specific to the Center. The role of ICARDA in genetic resources conservation, therefore, will be discussed in the above context.

The following are major determinants of ICARDA's genetic resources activities:

- Regional mandate in developing world.
- Multiple crop mandate.
- Proximity to the centres of origin of its mandate crops.
- Importance of indigenous germplasm for crop improvement in the region.
- Possession of comprehensive germplasm collections.
- Location in a typical West Asia and North Africa (WANA) semi-arid environment.
- Research and breeding back-up from the Center's commodity programs.
- Advanced information and documentation service.
- Intensive involvement in training.
- Limited development of most national genetic resources programmes in the WANA region.
- Well-established infrastructure for cooperation with National Agricultural Research Systems (NARS) in the mandate region.
- Cooperation with institutions and organizations outside WANA (IBPGR, other IARCs, FAO Commission, other gene banks and advanced institutions).

Established in 1977, ICARDA focuses its research efforts on areas with dry summer and where precipitation ranges from 200 to 600 mm. The Center has a world responsibility for the improvement of barley, lentil, and faba bean, and a regional responsibility, in West Asia and North Africa, for the improvement of wheat, chickpea and pasture and forage crops and the associated farming systems. In the mandated area a harsh, stressful and highly variable environment, which is under increasing pressure of the rapidly growing human population, predominates. On the other hand, this area has been the natural habitat of the ICARDA's mandate crops, since barley, durum and bread wheat, lentil, faba bean, kabuli chickpea and a number of annual forage species originated in the WANA region.

In the primary centres of diversity, crop progenitors and other wild relatives have been evolving under continuous pressure of the stressful environment and, as a result, have become well-adapted to the region. Archeological evidence from the Near East indicates that the first cultivated cereals, emmer wheat and barley, appeared about 10 000 years ago, and that food legumes were brought into cultivation approximately 1000 years later (Renfrew 1973). Thus, the traditional landraces of both cereals and food legumes developed from their ancestral forms during thousands of years of cultivation and man-assisted selection in constant interaction with the environment. As a result, their genetic make-up and population structure acquired high level of adaptation to agroecological conditions of the WANA region.

The importance and value of this adaptation became obvious when improved exotic germplasm was introduced into these semi-arid environments at the beginning of the 'Green Revolution'. The new germplasm, so successful in other parts of the world, proved to be insufficiently adapted to rain-fed agriculture in semi-arid environments, particularly in low-input marginal areas. Consequently, breeders at ICARDA in cooperation with sister Centers CIMMYT and ICRISAT and national programs, focused their attention on the indigenous genepool, i.e. cultivated landraces, primitive forms and wild relatives of crops.

However, these valuable genetic resources are threatened by genetic erosion due to several factors. Therefore, their exploration and *ex situ* conservation receives high priority among the activities of the Genetic Resources Unit (GRU) at ICARDA. In close collaboration with the NARSs, ICARDA conducts annually 6 to 8 joint collection missions mainly in WANA but also in other areas with ecogeographic conditions relevant to the ICARDA mandate region. The plant material collected in the missions is shared with the respective NARS and if the national programme has no adequate facilities for seed conservation, GRU/ICARDA maintains the germplasm to be repatriated later when the necessary facilities for genetic resources conservation are available. Arrangements are being made to duplicate all the original germplasm in other IARCs or major gene banks of the IBPGR-coordinated base collection network. However, since most of the ICARDA germplasm was donated by other institutions, its duplicates exist there.

ICARDA has a global responsibility for genetic resources collections of barley, durum wheat, wheat wild relatives, kabuli chickpea and faba bean within the IBPGR network of base collections. The GRU active collections, over 90 000 accessions, are the major source of germplasm for the Centre's crop improvement programmes and breeders in WANA countries supplying them with around 15 000 seed samples every year.

One of the most important components of the genetic resources work is germplasm evaluation. Being located between the Syrian desert and the higher-rainfall coastal region in a typical semi-arid environment, classified as CSa or IV1 climate zone (Mueller 1982), with cold winters and elevated temperatures in spring, the Center has favourable ecogeographic conditions for the identification of germplasm with a breeding potential for crop improvement programs. In response to the needs of breeders, more attention is paid to preliminary evaluation of traits related to adaptation and stress tolerance, and less to morphological characterization.

In-depth evaluation and germplasm enhancement are conducted in ICARDA's crop improvement programmes and/or in cooperation with NARS. Interaction with ICARDA breeders and feed-back from commodity programmes provide a valuable stimulus to the GRU activities.

The participation of national programmes in joint evaluation of GRU germplasm has started more recently, and in the 1990-91 season a large number of accessions will be evaluated with the national programmes of Jordan, Morocco, Tunisia and Turkey.

Evaluation data and passport information on GRU germplasm are processed and stored in the GRU documentation system. The data are published in crop catalogs or provided to NARS on request as printouts or on diskettes. ICARDA also participates in international databases on barley and annual *Medicago* germplasm and maintains databases of passport data on wheat wild relatives and annual forage legume species which were developed with support from IBPGR

In recent years training of the national staff in genetic resources activities has substantially increased at GRU/ICARDA since a higher level of expertise and awareness in the NARS are being considered as the basis for strengthening the national programs. This year, for example, a regional in-country training course in Jordan was attended by 13 participants from West Asia. In addition, 7 national staff members from different WANA countries received individual training at ICARDA headquarters in Aleppo, Syria. The training also has an important social component which creates a favourable atmosphere for future collaboration in the region.

Some of the WANA countries have already established national programmes which coordinate and/or conduct genetic resources conservation, evaluation and utilization, but most of them are modest, often understaffed and limited in funds and facilities. There is an urgent need for international support and collaboration and a network could be one of the avenues.

Considering the specific situation in WANA the regional approach seems to be appropriate because countries in which genetic resources programmes are in the initial stage, or do not exist, might be more efficiently assisted through a regional network and the cooperation could be extended to all crops of major interest. Such a network may later develop commodity sections: cereals, food legumes, forages, industrial crops, horticultural crops.

In relation to agroecological conditions the WANA region can be divided into several subregions: North Africa, Nile Valley, Ethiopia, Arabian Peninsula, Near East and West Asia Highlands. Accordingly, similar subdivisions could be created within the network to emphasize the ecogeographic aspects of genetic resources conservation, evaluation and utilization and also to facilitate the cooperation between ecologically and geographically related countries.

ICARDA could play a coordinating role in the network since its infrastructure for international cooperation is well established in the region. The headquarters in Syria and its regional offices in Jordan, Turkey, Morocco, Tunisia, Egypt and Pakistan maintain close interaction with national programmes and may thus serve as sub-regional bases for the WANA genetic resources network.

This does not mean, however, that ICARDA should limit the international cooperation exclusively to the WANA region. On the contrary, the Center wishes to be more involved in those crop networks which deal with crops mandated to ICARDA. Furthermore, the cooperation with IBPGR, other IARCs, FAO Commission on Plant Genetic Resources, gene banks and advanced institutions outside WANA will remain among the leading imperatives of ICARDA's work.

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The CGIAR collaborative system on plant genetic resources

R. Reid and E. Bettencourt
International Board for Plant Genetic Resources (IBPGR), via delle Sette Chiese 142, 00145 Rome, Italy

Summary

Ten of the 13 international agricultural research centres established since 1971 by the Consultative Group on International Agricultural Research concern themselves with plant genetic resources, especially the International Board for Plant Genetic Resources in Rome. The nine commodity centres hold, between them, over 460,000 accessions of crop germplasm accounting for approximately 14% of the world's resources. Much of this large collection is kept under long-term storage conditions in purpose-built facilities.

Introduction

Since its founding in 1971, the CGIAR system has grown to comprise a network of 13 international agricultural research centres, of which ten are concerned with plant germplasm. One centre, IBPGR is dedicated entirely to activities related to plant genetic resources, while the nine other institutions, namely CIAT, CIMMYT, CIP, ICARDA, ICRISAT, IITA, ILCA, IRRI and WARDA also make major contributions to the field. The work of the centres has resulted in significant agricultural advances by producing improved varieties of major food crops and forages. The purpose of CGIAR support for work on plant genetic resources is to ensure that the diversity of germplasm is safely maintained and made available for use in programmes of research and crop improvement for the long-term benefit of all people (IBPGR, 1989).

Activities

Activities supported by the CGIAR in connection with the conservation of plant genetic resources include exploration, collection, characterization, multiplication, evaluation, storage, data management, information services, and the supply of germplasm to plant breeders and other research workers. Where appropriate these activities are supported by research and training.

There has of course been a positive working relationship among plant genetic resource workers of the centres for a considerable time. Successful joint missions by ICRISAT and ICARDA to collect germplasm of chickpeas, the agreement between WARDA and IITA for the collection and preservation of West African rice germplasm or the IBPGR-CIP collaboration for the collecting of sweet potato germplasm can be cited as representative example from a much longer list of inter-centre collaboration on plant genetic resources. IBPGR has naturally developed special relationships with all other centres and has played a role in facilitating plant genetic resource acitivities throughout the system.

Status

The centres have built up the world's largest collections of plant genetic resources - some 460,000 individual accessions accounting for approximately 14% of the global holdings.

CIAT has received 26,330 accessions of *Phaseolus* beans from 64 countries. These include five domesticated species and 28 wild species, of which the most important is the common bean (*Phaseolus vulgaris*). In addition, CIAT now holds more than 20,000 accessions of tropical pasture germplasm with potential for acid soils adaptation, including more than 100 different genera, mostly legumes that have been collected in tropical areas of Central and South America, Africa and Asia. The cassava collection has more than 5,000 entries, consisting mostly of domesticated clones of *Manihot esculenta* collected in the primary

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centres of domestication in South and Central America. CIAT also holds a collection of wild *Manihot* from 32 species.

CIMMYT maintains two principal collections, one for wheat and the other for maize. The former contains more than 60,000 accessions, comprising bread wheats, durum wheats, triticale, primitive wheats, and wheat wild relatives. The centre's main concern until recently has been to conserve germplasm developed by CIMMYT breeders. However, in 1988, the wheat programme acknowledged the importance of conserving genetic resources on a wider scale and has agreed to share wheat germplasm conservation responsibilities with ICARDA. To this end CIMMYT is maintaining a base collection of hexaploid wheat and triticale, along with duplicates of ICARDA's holdings as a backup.

The CIMMYT maize programme has some 10,700 accessions which includes the world's largest collection of landraces, as well as teosinte and *Tripsacum*, which are wild relatives of maize. The active collection of teosinte is maintained through seed collecting during *in situ* monitoring tours conducted annually in Mexico and Guatemala, and that of *Tripsacum* at one of the centre's experimental stations.

The CIP programme has collected more than 900 accessions of wild potato species in their natural habitats. These accessions comprise a representative sample of the total genetic diversity of approximately 100 wild species. The cultivated germplasm collection, assembled at CIP originally comprised more than 15,000 samples collected in nine countries. The identification of duplicate accessions has reduced that number to almost 3,500 representing about 90% of all cultivated potato varieties.

Since 1985, CIP has been involved in assembling a sweet potato genebank in Latin America. In close collaboration with IBPGR, numerous collecting trips have been carried out in in Latin American countries. At present, the CIP collection holds more than 3,400 *Ipomoea* accessions. They comprise 10 wild species, two new hybrids, two new natural hybrids and a new wild species in section *Batatas*; 49 *Ipomoea* species from other sections; and more than 2,800 accessions of *I. batatas*.

A total of 75,258 accessions has been assembled in ICARDA's genetic resources collection, to date about 60% of which has been multiplied, evaluated and preserved in active collections. The collections have been extensively utilized by breeders, both at ICARDA and in national programmes. This has resulted in the release of more than 100 cultivars of different crops in its mandate areas. Landraces and wild species have received special attention, both because they are in particular need of rescue, and because they are best suited to providing breeders with germplasm adapted to harsh environments.

Besides working with its mandate crops of sorghum, pearl millet, chickpea, pigeonpea and groundnut, ICRISAT has also accepted responsibility for six minor millets (foxtail, finger, kodo, proso, little and barnyard millets). The collection contains just over 96,500 accessions from 134 countries.

Since its inception in 1975 the Genetic Resources Unit of IITA has organized 53 plant exploration missions in 29 African countries and has collected over 20,000 germplasm samples of different crop species and their wild relatives. This systematic exploration has been carried out in collaboration with IBPGR and with national scientists. Over 31,000 accessions are maintained by IITA in seed storage, and the centre's tissue culture laboratory maintains *in vitro* collection of cassava, yam, sweet potato and plantain.

The ILCA genebank holds more than 10,000 accessions from 840 species of 227 genera. About 40% of this germplasm was collated by ILCA in cooperation with institutes in nine African countries. The remaining germplasm has been donated to ILCA by other major forage research institutes, especially CIAT and CSIRO in Australia.

The acquisition, multiplication and preservation of rice germplasm were initiated by IRRI in 1961. As high yielding varieties replaced traditional varieties in irrigated areas, IRRI began, in cooperation with Asian and African countries, a campaign to collect landraces in irrigated, rainfed, wetland, upland and deepwater areas. IBPGR, IITA and WARDA joined in these activities. Some 41,000 seed samples were gathered from tropical Asia and 6,000 from Africa and many of these landraces no longer exist in farmers fields. Collecting has focused on wild relatives offering multiple tolerance or new potential for rice improvement.

The WARDA programme focuses on the need to acquire, collect, and conserve West African indigenous rice cultivars, landraces and wild species. In addition to these collections, WARDA seeks to maintain samples of important commercial varieties and promising cultivars in West Africa in short-term storage; and whilst mounting its own collecting mission in West Africa, it has given administrative and logistic support to IRAT/ ORSTOM and IITA missions in the region.

Inter-centre collaboration

To ensure that strong and positive working relationships are maintained between the various plant genetic resources workers throughout the CGIAR system, the centre Directors established an Inter-centre Working Group in 1987. This group has met on three occasions and made recommendations on a number of topics with the aim to increase inter-centre collaboration. Amongst the many topics discussed, four are expanded as examples to improve the collaborative system; namely, strategic research on bottleneck problems, the improvement of documentation/information systems on wild species, the necessity of further duplication efforts particularly in wild species and the long-term security of some collections.

Strategic research on bottleneck problems has been confirmed as very appropriate for collaboration and includes topics such as:

a) non-destructive methods of testing seed viability
b) cryopreservation techniques
c) germplasm diversity studies including their distribution in different agroclimatic zones
d) core collection for duplicate storage
e) distribution of diversity and factors underlying genetic variation under traditional farming conditions, including introgression between genepools
f) characterization of landraces and wild species populations in order to enhance their efficient evaluation and utilization
g) safety, viability and genetic stability
h) genetic and cytogenetic studies of newly observed variants
i) genetic erosion during germplasm conservation, and;
j) germplasm regeneration.

Some of these various areas of research collaboration have been underway for some time, whilst others are still essentially in the planning stage. A number of examples of the former can be cited. Most of the crop germplasm held by the centres is conserved as seed. However there are important exceptions (cassava, potato, sweet potato, yam and *Musa*) for which some of the germplasm at least must be conserved in vegetative form in field genebanks and/or *in vitro*. In these cases quite different considerations apply to duplication. One such technique, cryopreservation has great promise in providing stable, long-term *in vitro* conservation. In a collaborative project IBPGR and CIAT are working with cassava shoot-tips and have found that there is a loss of viability at intermediate temperatures. The ability to regenerate plants is lost at a higher temperature (-20°C) than cell survival (-50°C). Other explants are being tested in cassava as subjects for cryopreservation, including the very freeze-sensitive callus and somatic embryos, and seed Comparing the different explants should provide insights into the causes of lethal cryoinjury in cassava and indicate means of overcoming it. Once such technologies as cryopreservation have been developed sufficiently for base conservation of vegetative material to be routine, it should be possible to apply similar procedures to the safety duplication of vegetative materials as now apply to orthodox seeds.

The great value of developing the core collections concept as an aid to the better management and utilization of germplasm collections has been emphasized by germplasm curators in recent years (Brown, 1989). A number of initiatives are already underway within the CGIAR on this topic e.g. CIMMYT, working closely with Latin American National Programmes, is examining the possibility of a core collection in maize and IRRI is establishing core subsets of wild *Oryza*.

The allocation of funds to the collection, conservation, documentation and evaluation of the wild relatives of crop genepools is often seen as a diversion of existing resources from more important plant genetic resources activities e.g. the work involving obsolete, more recent cultivars and landraces in particular. Further there are claims that the use of germplasm collection by breeders is inadequate, particularly as such an activity is unlikely to result in the speedy incorporation of wild genetic material into cultivars in the immediate or even medium-term future. However, because such claims are long standing this does not necessarily mean that they are valid (Marshall, 1989).

Recent advances in the use of *in vitro* techniques, the utilization of haploids and 2n gametes, the rapid current advances in the use of restriction fragment length polymorphisms (RFLPs) as well as the development of a whole array of new germplasm enhancement techniques have rendered some of the traditional arguments against the use of wild species obsolete. An example of this can be seen in the work of CIP on sweet potato, where the utilization of a collection of wild *Ipomoea* species, considered impossible until 3-4 years ago, clearly demonstrates the use of wild germplasm to improve an important staple crop. Thus, it is argued that continued emphasis must be put on the exploration, collection, evaluation and utilization of wild species since they are promising genetic resources in crop improvement work and many are threatened due to environmental degradation.

Further it is recognized that in some centres mandated crops and in many others dealt with by IBPGR this will continue to be a difficult task as many species would have to undergo a process of domestication before they can be properly maintained, evaluated and utilized. In only a few cases could a centre fully maintain and easily grow out the wild genepools. Other problems in handling germplasm which are often amplified in the case of wild material, such as, storage methodology, the resolution of taxonomic confusion, the high cost of seed production/propagation and administrative points relating to accessibility and recognition of responsibility for the maintenance and duplication of collections, are all being studied in varying degress by the respective centres (their activities are summarized in Appendix I).

An important principle of germplasm conservation is to ensure that any given collection be securely duplicated in at least another institute; this provides insurance not only against loss, but also against the temporary unavailability of material. centres that agree to accept responsibility for maintaining a base collection also undertake to make arrangements for the duplication of their collection. The level of duplication of many of these collections appears to be surprisingly low, but varies between centres, and between the different crops in each centre; and only in a few cases does it appear that an entire holding has been duplicated.

Without access to the records on the individual accessions, it is not possible to know whether the stated level of duplication represents a maximum value or whether some accessions are duplicated more than once and others not duplicated at all. The latter is perhaps more likely to be true, as those accessions which have been duplicated are likely to be those for which large quantities of seed were available, in which case, samples would probably have been sent to more than one other institute.

The problems of obtaining accurate information are well known. From IBPGR's Directories of Germplasm Collections it is clear that many centres have sent small parts of their holdings to a large number of countries, often "repatriating" material to national programmes, but this could hardly be described as the planned duplication of a collection. The very fact that the picture is unclear suggests that organized and systematic duplication has not been given as high priority as it might.

The long-term security of the germplasm collections held by the respective centres is a matter of the utmost importance. IBPGR has developed and published acceptable and preferred scientific standards and procedures for seed storage in genebanks, and it continues with its efforts to monitor their implementation. To avoid expensive and sometimes difficult regeneration of germplasm accessions, it is preferable that they be kept in long-term condition i.e. storage temperature of -18°C or lower and a seed moisture content of about 5%. Less stringent conditions are acceptable for active collections, from which

TABLE I. STATUS OF THE MAINTENANCE OF THE COLLECTIONS OF THE IARCs

IARC	CROPS	LONG-TERM				MEDIUM-TERM				SHORT-TERM				OTHER TYPE MAINT.
		T°C	%RH	%MC	Container	T°C	%RH	%MC	Container	T °C	%RH	%MC	Container	IV/F
CIAT	*Phaseolus*; Tropical forages	-20		6/8		5/8	30		D					
	Manihot esculenta													IV/F
	Manihot spp.(wild)													IV
CIMMYT	*Hordeum; Triticum*					2	30	9	B					
	Zea	-15	25/30	6/8	B	0	30/35	8/10	B					
CIP	*Solanum* (wild & cultivated)	-15		5	A	0		5	A					IV
	Ipomoea	-15		5	A	0		5	A					
ICARDA	*Aegilops*	-22		5.5/6.5	A	2±2	25	6.5	G					
	Cicer					2±2	25	6.5	G					
	Hordeum	-22		5.5/6.5	A	2±2	25	6.5	G					
	Lathyrus	-22		5.5/6.5	A	2±2	25	6.5	G					
	Lens					2±2	25	6.5	G					
	Medicago	-22		5.5/6.5	A	2±2	25	6.5	G					
	Pisum	-22		5.5/6.5	A	2±2	25	6.5	G					
	Triticum	-22		5.5/6.5	A	2±2	25	6.5	G					
	Vicia	-22		5.5/6.5	A	2±2	25	6.5	G					
	Vicia faba					2±2	25	6.5	G					
ICRISAT	*Arachis*; *Cajanus*; *Cicer*; Millets; *Sorghum*	-20	30	4/6	A	4	20	6/8	A					
IITA	*Dioscorea*													IV/F
	Glycine	-20	<30	6/7	B	5	30/35	6/7	B					
	Ipomoea													IV/F
	Manihot					5	30/35	6	B					IV/F
	Musa													IV/F
	Oryza	-20	<30	5	B	5	30/35	9	B	15	20	8	B	
	Vigna	-20	<30	5	B	5	30/35	9	C	15	20	8	B	
	Zea	-20	<30	6/7	B									
ILCA	Forages(grasses, legumes and browse)	-20		4/6	A					8	35	4/6	A	IV/F
IRRI	*Oryza* (wild and cultivated)	-10	27	6	B	2	40	6/8	B/C	20	50	10	E	
WARDA	*Oryza*(wild and cultivated)					0/5	65/75	9/11	D	5/10	65/75	9/11	D	

IV, *in vitro*; F, field; A, aluminium laminated foil packets; B, cans; C, glass jars, D, plastic bags/bottles; E, paper bags; G, cotton bags

samples are used for characterization, evaluation, regeneration and distribution. The maintenance conditions of the seeds held by the centres are summarized in Table I.

It should be noted that seven of the centres maintain some or all of their collections under long-term seed storage conditions. However, the base collections at ICRISAT and WARDA are not yet stored under long-term conditions, although the transfer of material to such conditions commenced at ICRISAT in 1989. At WARDA, the humidity and seed moisture contents are both relatively high. In addition, the large wheat and barley collections at CIMMYT are currently held in medium-term storage.

Conclusions

The nine commodity centres of CGIAR hold, between them, over 460,000 accessions of crop germplasm accounting for approximately 14% of the world resources. The maintenance conditions for much of this large collection are generally satisfactory, with the material mostly being kept under long-term storage conditions in purpose-built facilities.

Acknowledgements

We wish to thank all the curators of the respective CGIAR centres who gave freely of their time in providing the relevant data. Dr. Lyndsey Withers of IBPGR prepared the Appendix and this is gratefully acknowledged.

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Appendix I: A summary of CGIAR centre activities on wild species germplasm

Centre	Crop	Activity
CIAT	*Cassava*	33 wild *Manihot* species held (only a few accessions per species). *In vitro* methodology for management of wild cassava germplasm, developed with IBPGR support, is under refinement. A field genebank of wild cassava is being developed for cultivar improvement, focussing on crossability over the next 3 years.
	Phaseolus	Each of 5 cultivated species has its own wild form (GB-1B by the definition of Harlan). Efforts have concentrated on the use of the wild form of common bean (*P. vulgaris*) for improvement of this, the most important cultivated species. A jointly published CIAT-IBPGR catalogue contains *ca.* 800 accessions some of which have already been evaluated. Resistance to the most important storage pest, bean weevil (*Zabrotes subfasciatus*), found in two Mexican accessions has successfully been transferred into advanced breeding lines which are now under extensive evaluation by some national programmes. The other 4 cultivated species are less important in terms of world-wide acreage but, being adapted to different agroecological conditions, contain valuable traits that are missing or poorly expressed in the primary genepool of the common bean (e.g. drought and heat tolerance from *P. acutifolius*; *Ascochyta* resistance from *P. coccineus*). Use of RFLP markers is planned to check efficiency of introgression in wide crosses with the common bean.
	Tropical pastures	Practically all forage species (comprising 22,000 accessions) are wild species (noncultivated). Activities include all aspects of genebank management. Studies are being carried out into the reproductive biology of key pasture species.
CIMMYT	Maize	5-year project to collect, characterize, conserve, evaluate and use *Tripsacum*; also used in wide cross programme.
	Wheat	Wide cross project is attempting to move genes from the following species into cultivated forms: *Thinopyrum bessarabicum, Th. junceiforme, Th. intermedium, Th. scirpeum, Th. distichum, Th. curvifolium, Th. trichophorum, Elymus giganteus, Aegilops variabilis, Ae. umbellata, Ae. squarrosa, Ae. ropens, Ae. desertorum, Psathrostachys juncea, Haynaldia villosa, Triticum tauschii.*
CIP	Potato	1. Collection and biosystematic classification: A multi-volume work on research into new species by Professor Carlos Ochoa, Taxonomy Consultant to CIP is in preparation (first volume to appear during 1990). 2. Maintenance: Includes transfer of odd-ploids and other species that do not form seeds to *in vitro* storage, as well as maintenance of botanical seeds. 3. Germplasm enhancement: Several projects to enhance wild species for resistances, tolerances and adaptive complexes. Material is then used in complex germplasm enhancement schemes to make useful characteristics accessible to breeders. About 15% of 200 known wild species have entered germplasm enhancement programmes.
	Sweet potato	1. Collection and classification: New species have been and are being discovered. 2. Basic research on accessibility of wild *Ipomoea* species: Crossability of the series *Batatas*, the taxonomic series most closely related to the cultivated forms have recently been completed Through complex crossing schemes, this series can be made genetically accessible to sweet potato breeders. Resistances to most important sweet potato pests have been identified. 3. Germplasm enhancement: Highly successful work has been carried out with the wild species *Ipomoea trifida* as a source of resistance to the sweet potato weevil, an insect pest of world-wide importance. *I. trifida* is also a source of high dry matter content. This research is being followed up in a PhD thesis at the University of Birmingham, UK.

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Appendix I : A summary of CGIAR Centre activities on wild species germplasm *continued*

Centre	Crop	Activity
IBPGR	General	In collaboration with the CGIAR commodity centers, IBPGR is maintaining a record of existing *ex situ* collections of wild species of relevant crops. Similar activities are being carried out in collaboration with National Programmes for wild relatives of other crops, and are planned with IUCN for wild relatives of crop germplasm maintained in botanic gardens. These efforts should facilitate the channelling of requests for seed and appropriate location of research. IBPGR is, with the benefit of ongoing taxonomic revisions and links to botanic gardens, assembling data on the distribution (at the GP1 and GP2 levels) of wild species of interest to the IBPGR Programme. The resultant databases will provide information to CGIAR Centers and National Programmes in the planning of germplasm exploration in the future, and to national and international agencies in the planning of *in situ* conservation efforts.
	Allium	Ecogeographic survey recently carried out in Southeast Asia.
	Mango, Citrus	Ecogeographic survey recently carried out in Southeast Asia.
	Triticeae	Current ecogeographic survey in northern China. Taxonomic study commissioned for *Thinopyrum*.
	Cucurbitaceae	Current ecogeographic survey for the main cucurbits and wild relatives in Central America.
	Pulses	Current ecogeographic survey for major pulses such as pea, chickpea, lentil and vetch (Vicieae) in the southern USSR. Complementary study to develop molecular markers for *Phaseolus* and *Vigna*. (Note, when appropriate, selected collecting is carried out on all ecogeographic surveys).
ICARDA	Wheat	Taxonomic studies and evaluation of wheat wild relatives, mainly *Aegilops* spp.
	Food legumes	Evaluation studies of a large number of species including *Lens* spp. and *Cicer* spp. (the latter jointly with ICRISAT).
	Forages	Wild species are under investigation for potential use as forage crops in the Mediterranean region.
ICRISAT		Details not supplied on going to press
IITA	*Vigna*	Exploration and collecting have been carried out in Africa (15 collecting missions in last 5 years); germplasm has also been assembled from elsewhere. In all, the collection comprises more than 1500 accessions of over 40 species. Research includes biosystematic studies (crossability between species and classification); agrobotanical variability of species within section *Cajan* and other species of interest to crop improvement objectives; interspecific hybridization between cowpea and wild *Vigna* to identify potential bridging species to introduce genes for resistance to post-flowering insect pests; screening for resistance to major insect pests; cowpea enhancement involving crosses between cowpea and closely related species within section *Cajan*. IITA collaborates with several institutes in Italy and the University of Purdue on various areas of research including biotechnological innovations to exploit the genepool of wild *Vigna*, e g cell and protoplast culture, protein electrophoresis, nutritional studies, screening for insect resistance.
	Cassava	Resistance genes against cassava mosaic virus and bacterial blight have been transferred from *M. glazovii* into improved cassava populations and clones. Many wild species including *M. tristis* with suitable characteristics have been assembled to improve cassava resistance to mealy bug and green spider mite. 66 accessions of wild cassava from 26 species, mainly from Brazil, are preserved in the field genebank and *in vitro*. This material has also been screened for low cyanide content and drought tolerance. New approaches to cassava improvement include the production of spontaneous sexual and asexual poly hybrids and the exploitation of apomixis for the production of improved clonal genotypes that can be distributed by seed.

Appendix I :
continued

Centre	Crop	Activity
IITA *(cont.)*	*Dioscorea*	Collecting and biosystematic studies have recently been initiated. Conventional techniques and RFLP of chloroplast DNA are being used to investigate the *D. rotundata-D. cayenensis* complex, including wild species. This will enable breeders to use the wild species for yam improvement. Wild *Dioscorea* has been surveyed and collected in Nigeria. Further collecting from West and Central Africa is planned for the future.
	Rice	IITA maintains 335 accessions of wild *Oryza* species indigenous to Africa. Species belonging to the AA genome, closely related to cultivated rice have been screened for resistance to rice yellow mottle virus; good sources for rice improvement have been found.
ILCA	Forages	(Note: all forages are, in effect, wild species). 1. Acquisition, conservation, regeneration and distribution of forage germplasm. 2. Database management of forage germplasm: passport, inventory, breeding systems, taxonomy. 3. Research on: i) Breeding systems and regeneration of *Trifolium* species and *Sesbania sesban*. ii) Use of *in vitro* culture techniques for collecting, conservation, multiplication and distribution of grasses (*Digitaria* and *Cynodon*) and browse (*Faidherbia albida* and *Erythrina brucei*). iii) Methodology and strategy for characterization of forage germplasm.
IRRI	Rice	1. Since 1987, 20 collecting missions, primarily aimed at collecting wild rices, have been undertaken in cooperation with 12 Asian and Pacific countries netting about 700 samples of 11 species. 2. National parks and reserves where wild relatives of rice are conserved *in situ* have been identified and the information published. 3. Core subsets of wild *Oryza* have been established and are used for some current evaluations at IRRI. 4. Distribution of samples of wild rice to scientists both within IRRI and in National Programmes has increased about four fold in recent years. Biotechnology workers are the principal clients. 5. IRRI scientists have been screening wild rices for insect pests for many years and results have been published. More recently, IRRI researchers have intensified evaluation of wild rices for major rice pathogens such as tungro and bacterial leafblight. 6. An active wide hybridization programme at IRRI has now successfully crossed rice cultivars with many wild species of *Oryza* Promising lines have been derived from crosses involving *Oryza nivara* and *O. officinalis*. Varieties with resistance to grassy stunt virus derived from *O. nivara* have been released since the mid-1970s, but their usefulness has been reduced by the emergence of grassy stunt virus biotype 2 in the early 1980s.
WARDA	Rice	Although work on wild rice has not been carried out in the past or included in the Center's current medium-term plan, WARDA is keeping informed of related work at IRRI for possible applications to West Africa.

The VIR network: problems of mobilization and conservation of plant genetic resources; the concept of international collaboration

V.A. Dragavtsev and S.M. Alexanian
N.I. Vavilov All-Union Institute of Plant Industry (VIR), 42, Herzenstreet, 1
90000 Leningrad, USSR

Summary

The N.I. Vavilov All-Union Institute of Plant Industry (VIR) was organized in 1894. The basic tasks of the VIR are: collecting the world plant resources; preserving the collected materials viable; studying plant germplasm, preserved in the collections; supplying breeding centres of the USSR with germplasm for breeding programmes; conducting theoretical and methodological research. To accomplish these goals there are specialized scientific departments and 18 experimental stations in the different climatic zones of the country within the Institute. There 53 collecting missions were organized and carried out in 1990, covering 55 various regions in the USSR and abroad. In 1991 VIR distributed 3,107 samples from its collection to various countries of the world, nearly half of them to countries in Europe. Experts of each experimental station, scientific department and laboratory examine definite aspects of the life of plants. This allows to obtain maximum information about the value of accessions preserved in the collection, which by August 1990 numbered more than 350,000 samples belonging to 155 botanical families, 304 genera and 2,539 species. The entire collection can be divided into 4 groups: genetic diversity from Vavilov's centres of origin; landrace populations of folk breeding; modern breeding varieties, and genetic lines, introduced mutants and other new forms obtained experimentally. In 1975 a genebank was established at the Kuban Experimental Station of VIR, where 190,000 seed accessions are now stored in sealed containers at between 1°C and 4°C. The Institute also preserves more than 250,000 herbarium samples of cultivated plants and their wild relatives. All scientific work of the VIR can not be carried out without a wide international collaboration. Nowadays the Institute maintains close scientific and technical ties on various aspects of plant genetic resources with Bulgaria, Hungary, Poland, Czechoslovakia, Germany, the Netherlands, Mexico, the USA, and with IARC's, IBPGR, FAO, etc.

The N.I.Vavilov All-Union Institute of Plant Industry (VIR) originated as the Bureau of Applied Botany, which was organized in 1894. This Bureau was reorganized in 1924 into the All-Union Research Institute of Applied Botany and New Crops, and in 1930 it was renamed the Research Institute of Plant Industry.

The basic tasks of scientific research and practice at the VIR include:

- collecting the world plant resources - varieties, forms and hybrids of agricultural crops and their wild relatives;
- preserving the collected materials viable;
- studying the collected material;
- supplying breeding centres with the initial material for plant breeding; and
- conducting theoretical and methodological research.

To accomplish these goals, specialized departments and experiment stations were organized within the Institute. An important department is the Department of Plant Introduction. Its principal task is to organize the exploration and collection of germplasm, exchange and quarantine testing of received material.

In 1990 The Institute carried out 40 collecting missions covering 55 various regions of the USSR territory. As a result of these missions, the collection was replenished with 34,000 seed accessions of various useful plants.

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This year VIR organized 5 joint missions with foreign scientists on the territory of the country: Soviet-American for fruits; Soviet-Australian for legumes; Soviet-Dutch for *Beta*; joint COMECON-countries mission for forages; VIR - Southampton University (UK) - Israel's Hebrew University of Jerusalem joint mission under the auspices of IBPGR for wild legumes.

Territories of 13 countries of the world have also been explored by VIR experts in 1989-1990, namely Peru, Poland, China, Côte d'Ivoire, Bolivia, Butan, Equador, USA, Mongolia, Syria, Bulgaria, Vietnam and Columbia. As a result of these missions, more then 7,500 accessions of different crops and wild relatives were collected.

Along with the introduction of foreign materials, in 1990 VIR distributed 3,107 samples from its collection to various countries of the world, nearly half of them being countries of Europe.

All the materials that come to the Institute, including seeds, seedlings, tubers and bulbs, undergo registration in the Department of Plant Introduction. Each accession acquires its permanent introduction number, under which it remains further on.

Materials, coming from abroad, undergo quarantine testing at one of the seven introduction quarantine nurseries. After quarantine testing the materials are handed to the Departments of Plant Resources. These departments are organized according to the principle of closely related crops. For example, wheat and triticale are studied in the Department of Wheats, maize, rice, buckwheat, sorghum, etc. in the Department of Maize and Small Grains; clover, alfalfa, timothy and other grasses in the Department of Fodder Crops, and so on.

Experts of each department carry out primary evaluation of these materials and hand them over to methodological laboratories engaged in studying plant immunity, physiology, cytology, molecular biology, biochemistry and genetics. By the results of these studies, the most promising accessions are selected.

To study materials from different countries in the most appropriate climatic and soil conditions, the Institute operates a network of experiment stations. They are spread from the Kola Peninsula (the Polar Region) to the Caucasus (the subtropics), and from the European part of the USSR to the Far East. At these experiment stations the collection accessions undergo evaluation, which is conventionally divided into two stages:

- field evaluation of the material, and
- laboratory evaluation.

While assessing materials in the field, the VIR experts study peculiarities of plant biology and morphology, that is, phenological phases of vegetation, duration of vegetation period, yielding ability, resistance to diseases and pests, heat and frost resistance, resistance to draught and excessive moisture, and to other environmental factors. Morphological description of plants is made afterwards. All this work is carried out using appropriate methods and against the background of commercial (standard) varieties. In the end, every accession acquires a passport, where all most important biological and morphological characters are registered, as well as the differences from the standard, i.e., its positive and negative characters.

Experts of each experiment station, department or laboratory examine definite aspects of the life of plants, corresponding to their field of research. This allows to obtain maximum information about the value of accessions preserved in the collection, that is, to extend the passport data accumulated by the experts from the Departments of Plant Resources.

The studied materials are further handed over to breeding centres and used in breeding programmes of the USSR. Thus, as a result of primary evaluation, during 1989 and the first half of 1990 around 3,000 sources of valuable breeding characters have been selected, and genetical studies revealed 77 sources, including 27 of resistance to pathogens of wheat, barley, oats, peas etc., 9 of early maturing of oats, maize and sunflower. Fifty-one new sources have been created. Within the same period of time varieties based on the VIR collection have been cultivated on 63 million hectares.

By August 1990, the collection of the Institute numbered 349,460 accessions belonging to 155 botanical families, 304 genera and 2,539 species (Table 1).

Table 1. Germplasm Collection of the N.I. Vavilov Institute of Plant Industry for 1990

Wheat	59,603	Cotton	6,068
Aegilops	3,302	Sunflower	2,131
Triticale	4,193	Flax	5,256
		Hemp & bast crops	1,670
	67,098	Southern oil crops	3,510
		Other industrial crops	5,761
Rye	3,001		
Barley	25,131		24,396
Oat	12,950		
		Potato & other tubers	10,472
	41,082		
			10,472
Sorghum	12,560		
Millet & relatives	14,967	Cabbage	3,641
		Carrot & radish	6,113
	27,527	Tomato	6,444
		Cucumber	3,407
Maize	19,309	Onion & garlic	3,936
Rice	6,377	Pepper & eggplant	3,977
Buckwheat	2,290	Beet	2,964
		Greens	3,003
	27,976	Cucurbits	10,783
		Other vegetables	4,175
Clover	6,754		
Alfalfa	3,713		48,443
Top grasses	6,728		
Bottom grasses	4,183	Fruit plants	29,631
Agropyron & *Leymus*	2,264	Ornamentals	5,258
Other fodder crops	3,933		
			34,889
	27,575		
Pea	7,437		
Phaseolus	9,987		
Soybean	6,618		
Lupin	2,472		
Lentil	3,075		
Vetch	3,030		
Other legumes	7,383		
	40,002	Total No. of Accessions	349,460

The most important task of the Institute is to preserve the entire collection which can be broken into 4 groups:

- genetic diversity from the centres of origin;
- landrace populations of folk breeding;
- modern breeding varieties, and
- genetic lines, introduced mutants and other new forms obtained experimentally.

The Institute has a special Laboratory of Seed Testing, which controls seed germination and viability, and a genebank at the Kuban Experiment Station of VIR, where 190,000 seed accessions are now stored in sealed containers at between +1°C and +4°C. The experts on long-term storage pursue the task of raising the level of investigations for the further improvement of storage techniques, and, ultimately, increasing the safety of the genepool under storage I would like to name several problems for further investigation. These are:

- technologies of progenies multiplication with due regard to the mode of pollination and principles of taking an average sample for long-term storage;
- development of express methods for seed drying (cold drying);
- development of express methods for determining seed viability;
- evelopment of seed aging diagnostics.

Thus, with the accumulation of our knowledge in the sphere of longterm storage of seed, the better preservation of the world's diversity of cultivated plants and their wild relatives will be provided.

The Institute also preserves more than 250,000 herbarium samples of cultivated plants and their wild relatives.

Our current priorities for collecting are:

- wild populations subjected to agro-ecological influence and acute genetic erosion;
- disappearing landraces, which are sources of resistance to diseases and abiotic factors;
- modern cultivars possessing a complex of valuable genes.

Priority collecting regions: major regions of formation of cultivated plants and those subjected to severe genetic erosion on the territory of the USSR; the Mediterranean area, South-Eastern, Eastern and Southern Asia, Latin America.

It is obvious from the above, that all this voluminous work in the sphere of plant genetic resources cannot be carried out without a wide international collaboration. It is the mutually beneficial collaboration that makes part and parcel of VIR' activities: each year more than 600 people from various parts of the world visit the Institute as members of around 100 delegations. Joint collecting missions aimed at exploring certain territories and collecting various plants are carried out; training courses for scientific cadre from genebanks of the developing countries are conducted; scientific workshops and symposia are organized. At present time 10 foreign post-graduate students are working on their PhD programmes at VIR.

Signing of the Agreement between VIR and IBPGR in June, 1990 and incorporation of VIR into ECP/GR are important landmarks in the international scientific collaboration. The issue of the Institute joining FAO activities in the sphere of PGR is being discussed at a high governmental level.

Nowadays VIR maintains close scientific and technical ties based on Agreements on various aspects of study and utilization of PGR with Poland, Bulgaria, Hungary, Czechoslovakia, Germany and the Netherlands. Joint scientific research is being carried out together with such international centres as ICARDA, CIMMYT and ACSAD; closer joint activities are planned for 1991 together with CIP and ICRISAT.

Two representatives from VIR participate in the International Keystone Dialogue on PGR, the plenary sessions of which helped 126 countries adhering to the FAO Undertaking on PGR to come to understanding of many previously disputable questions.

Signing of the Memorandum between VIR and ARS USDA and of the consequent Communique on further joint activities in the field of collection, preservation and utilization of PGR received positive international response. These most important steps in joining together two largest collections of germplasm can have positive effect on the entire international collaboration in the field, as efforts of both parties are concentrated on the maximum conservation of PGR, the world's treasure, and it will provide ample opportunities for all interested organizations, persons, institutes, farmers and scientists to obtain collection accessions and related information from the United States and the USSR. This collaboration will be based on a joint database for the collections of plant germplasm. Moreover, this joint database will make core of the Global Center for PGR, which is being developed by the Institute de la Vie of Prof. Maurice Marois. The Center is meant to unite all the information on PGR accumulated in the world. The first organizational meeting on the establishment of the Center took place in Beltsville (USA) in May 1990.

It is impossible to embrace all aspects of international activities of VIR in this report, but it would have been incomplete if we did not use the opportunity to describe our plans of collaboration in Europe.

It is well known to many plant genetic resources experts, that multilateral cooperation of Bulgaria, Hungary, the GDR, Mongolia, Poland, the USSR and Czechoslovakia on PGR was established in 1964. In fact, it was the first regional programme in this field. The years of cooperation have resulted in the following: rich experience of joint research has been accumulated; national programmes and genebanks have been established in all the above-mentioned countries; long-term storage for nearly a half of the total accumulated genepool has been organized. It is hard to overestimate these achievements. In September of 1990 the Meeting of the Scientific and Technical Council in Bulgaria summarized the results of cooperation for the period from 1986 to 1990. From our point of view, it is reasonable to

continue this cooperation, having modified it in accordance with the present-day situation in the world.

Participants of the Meeting signed an Appeal to FAO, proposing the creation of a Regional Program for Eastern Europe under the aegis of FAO and IBPGR. The given Program would not duplicate ECP/GR, but unlike the latter would concentrate on the continuation of more profound collection, preservation and study of PGR from Europe and other parts of the world.

The above mentioned Appeal was handed over to the FAO Secretariat, and in April of 1991 it will be discussed at the next Meeting of the FAO Working Group. VIR invites all the interested parties to make comments and suggestions on the establishment of this Program, which can be joined by any country. If FAO comes to a positive decision on the issue, VIR proposes to hold in Leningrad the Organizational Meeting, aimed at the development of the Working Plan and the Agreement.

I would like to sum up the report by reminding the audience the words of Academician N.I Vavilov, spoken more than 50 years ago:

"Crises do not exist in scientific work. On the contrary, scientific problems show themselves every day, and they are to be solved both from the theoretical and the practical points of view. Those problems are endless, and they can be solved on the basis of the international scientific collaboration only."

The NGB system

M. Niklasson
The Nordic Gene Bank (NGB), P.O.Box 41, S-23053 Alnarp, Sweden

Summary
The Nordic Genebank (NGB) is at present decreasing the collecting activities in advantage of characterization and evaluation of the material. The work on investigating *in situ* preservation and establishment of an automatic delivery of new cultivars to NGB is progressing. Our information efforts focus on making the germplasm data available in crop catalogues and databases. NGB's international project together with the SADCC-countries, on establishing a regional genebank in Lusaka, Zambia, is now completing the development of an infra-structure and moves towards a phase of implementation and education. The constituent and financier of NGB is the Nordic Council of Ministers, which is an executive assembly under the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden). NGB is governed by a board with one full and one deputy member from each country. The chairmanship is circulating between the countries. The board has a Technical Advisory Committee with national sections. Subordinated to the Director, NGB has now nine Crop Working Groups with members from the countries concerned. They are our expert organ and implementors in respective countries. NGB is situated in the south of Sweden at Alnarp. The 11 staff members are occupied in any of three departments or with administrative functions The different departments deal with plant material, information related to the material and international projects. The mandate of NGB is to preserve agricultural and horticultural species and their wild relatives in the Nordic countries. The number of endemics in this area is small and none of the species are under the commission of NGB. At this moment about 100 species are preserved *ex situ* at the genebank. About 70 of these are indigenous and the rest are introduced species that have been cultivated in this area for such a long period of time that new genotypes adapted to the very various Nordic conditions have evolved. The Nordic material also comprises genetic stocks, i.e. material originating from research projects and breeding programmes. Information on that kind of material is Nordic and often comprehensive. NGB preserves genetic stocks of the genus Pisum and cereals. To fulfill the different obligations of the genebank, preservation of *ex situ* material is divided into three categories. The Base Collection is maintaining maximum genetic integrity and quality. The Active Collection satisfies the availability of the material for investigation and characterization. The Safety Collection is stored at an other location and is independent of constant artificial energy supply. This accedes the demand of security in case of accidental loss at the Nordic Genebank. The vegetatively propagated species are in the future supposed to be kept at two different locations. The characterization and registration of data is decentralized to the countries involved. At NGB the different national databases are transformed and developed into Nordic databases. This then constitute the basis for the catalogues. The catalogues and databases are distributed to users. The staff of NGB also utilize the evaluation data from these databases in search for requested material.

Introduction

The Nordic Gene Bank for Agricultural and Horticultural Plants (NGB) was established 12 years ago. The institution was initially located at Lund, Sweden, but moved in 1984 to its present location at Alnarp, Sweden.

Organization

NGB is an institution under the Nordic Council of Ministers. The Nordic Council of Ministers is an executive assembly under the five Nordic countries, Denmark, Finland,

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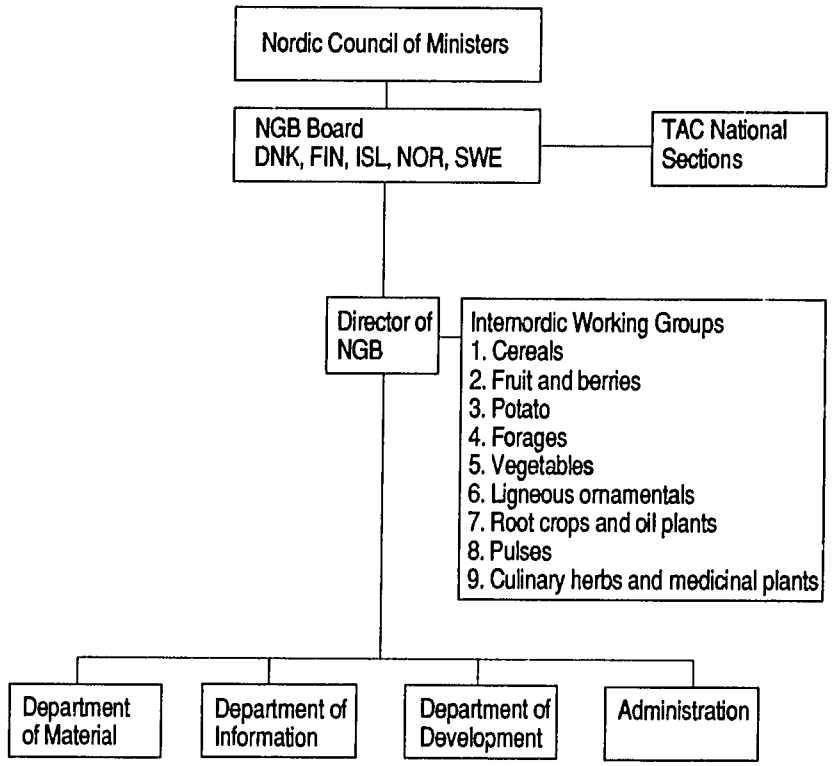

Fig. 1. The Working Group structure of NGB

Iceland, Norway, and Sweden (Fig.1). The aim of the Nordic Council of Ministers is to encourage cooperation between the Nordic countries.

NGB is governed by a board. The board of NGB consists of one full and one deputy member from each of the Nordic countries. The chairmanship is circulating between the countries and the term of office is two years.

The board has a Technical Advisory Committee (TAC) with national sections. The members of the committee represent different interested parties and they cover as broad competence as possible The national sections gather needs and views from respective country to be able to act as an advisory body to the board. The TAC sections also constitute a platform for genebank matters and serve as an information organ in their own country.

NGB has three departments. The Department of Material deals with plant material and keeps four persons busy. The Department of Information handle information related to the plant material and the Department of Development takes care of international projects, these two departments both have two employed each. NGB has also two administrators. The director as well as the rest of the staff are contracted for a period of four years.

Working groups

Subordinate to the director, NGB has internordic crop working groups. The working groups are initiated by the board. At present there are nine working groups (Fig.1) all initiated between 1981 and 1985. The working groups are NGB's expert organ and the members act as implementors in their own country.

The working group structure is flexible. One working group, the permafrost Working Group, ceased to exist when the safety store was inaugurated in 1984. There has also been

one consolidation. The working group for Cereals started as two working groups, one for self-pollinated small grains and one for cross-pollinated small grains. In the future the working group structure may be as follows. Two fusions will probably take place. The Working Group for Fruit and Berries and the Working Group for Ligneous Ornamentals already have their meetings in common. The members of the Working Group for Root Crops and Oil Plants and the Working Group for Pulses are almost the same. A new Working Group for *in situ* preservation will probably be formed.

The staff at head quarters represents a minority of NGB. There are many people involved in the work of preservation of genetic resources and they are spread over the entire area. About 100 persons are in some way involved in genebank tasks in the working groups, in the Technical Advisory Committee, in the board or with some special projects.

To strengthen the cooperation between NGB and its working groups a staff member of NGB is permanent secretary of a working group. NGB attends a working group meeting with two persons, the director and the secretary for that particular working group. The working groups usually have a meeting once a year to aid in drawing short- and long-term work plans.

This year a meeting attended by the chairmen of the different working groups was held at the genebank for the first time. This vertical cross section through the working groups improved the information flow in other directions than the connection between NGB and the working groups through the secretary. The chairmen meeting will also constitute a forum for fundamental questions in the future.

Mandate

The aim of NGB is to preserve and document the genetic variation of valuable material of Nordic agricultural and horticultural plants and their wild relatives. As a service institution NGB shall provide stored material and documentation. NGB shall also take part in international cooperation regarding genebank activities.

Preservation

To fulfill the different obligations of the genebank the material preserved *ex situ* is kept as three different collections.

- The *Base Collection* keeps maximum genetic integrity and quality. The number of rejuvenations are kept at a minimum. It is a seed source for the Active Collection in case that the germinability has decreased for an accession. The case collection is kept at long-term storage. The seeds have been dried to 3-6% moisture and they are stored in glass-bottles at -20°C.
- The *Active Collection* meets the demand for availability. It is distributed to users for characterization and other purposes. It is also used for initial multiplication. The only difference in the storage of this collection compared to the Base Collection is that the samples are put in aluminum foil bags.
- The *Safety Collection* is a safeguard against accidental loss. This collection is partly a duplicate of the Base Collection and it is stored at another location. The maintenance requires no artificial input of energy. The Safety Collection is stored in a mine with permafrost at Svalbard. The samples are handled the same as the other collections. The seeds are put in glass ampoules and the temperature is between -3 and -4°C.

The size of the collections kept at Alnarp is roughly 20,000 accessions distributed on 100 species. The Safety Collection comprises about 4000 accessions.

Documentation

NGB has databases on different levels of information. Some accessions have only passport data, but for most accessions there is some additional characterization and evaluation data. On gene-level we have information on peas and some cereal collections, but it is largely lacking. The method used at NGB, is that registration is done at the different national institutes which accomplish the characterization or evaluation. At NGB a summary of the different databases is created into Nordic crop databases. This summary makes the documentation easier to use.

As well as for the material, availability comprises documentation. It is distributed as databases or crop catalogues to users. The documentation is also used by the staff of NGB for finding requested material. Some programming for special purposes is done e.g. to display pedigrees.

Databases have been created to facilitate the daily work. These databases make the seed store maintenance and correspondence easier. They also give opportunities to get statistics over different activities e.g. requests.

Department of development

NGB has one international project. NGB acts as management consultant to the Nordic development agencies. This project is a case of regional cooperation. A regional genebank for the SADCC countries has been established at Chalimbana east of Lusaka, Zambia. The SADCC (Southern African Development Coordination Conference) corresponds to our Nordic Council. The Countries involved are Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia and Zimbabwe.

Plant genetic resources conservation programme in Poland, a multi-institutional collaboration

Z. Bulińska-Radomska, W. Podyma and S. Góral
Plant Breeding and Acclimatization Institute, Radzików, 05-870 Bonie, Poland

Summary

The National Genetic Resources Conservation Programme in Poland is based on multi-institutional input and cooperation. Altogether there are over 50,000 accessions of 57 genera in our genetic preservation programme. The broad range of plant material (cereals, forages, root and tuber crops, horticulture, vegetable, industrial, medicinal and herbal plants) imposed the need to utilize crop-related breeding and scientific centres for genetic resources activities. Seven universities, 7 branch institutes, 3 plant breeding stations, the Botanical Garden and the Institute of Plant Genetics of the Polish Academy of Sciences carry the responsibility for evaluation, regeneration and multiplication of crop collections. Introduction, documentation and storage services are handled centrally by the Plant Breeding and Acclimatization Institute at Radzików, which provides introduction, documentation and controlled storage (+4°C and -15°C) facilities for all genetic resources collections. The programme is coordinated by the National Department of Plant Genetic Resources at the Plant Breeding and Acclimatization Institute in Radzików. As coordinator the department organizes training which provides updates on genetic resources developments for the staff members of the cooperating institutions. It also organizes collecting missions and facilitates participation of genetic resources personnel in similar expeditions at home and abroad. The National Department of Plant Genetic Resources maintains scientific collaboration with the Jagiellonian University in Kraków regarding ecogeographical distribution in Poland of wild species of potential agricultural and economic importance, with the Institute for Soil Sciences in Pulawy on phytochemical research in some Fabaceae plants, and with the Agricultural University at Olsztyn on the physiological basis of seed ageing.

Introduction

The magnitude of the National Genetic Resources Conservation Programme in Poland requires multi-institutional cooperation. There are 57 genera (over 50,000 accessions) which represent a broad range of plant categories such as: cereals, forages, root and tuber crops, horticultural plants, vegetables, spices, medicinal, fibre and industrial plants; all of which have been covered by genetic resources activities (Table 1). The key role in directing, and

Table 1. Genera covered by genetic resources activities

Crops	Genera
Cereals	*Triticum Hordeum Triticale Panicum Avena Zea Fagopyrum Secale Setaria*
Legumes	*Pisum Lupinus Vicia Lens Glycine Phaseolus Medicago Trifolium Lotus Ornitophus Melilotus Onobrychis*
Grasses	*Alopecurus Agrostis Bromus Poa Arrhenatherum Cynocurus Dactylis Festuca Lolium Phleum Phalaris Beckmania*
Oil & fibre plants	*Brassica Helianthus Papaver Linum*
Root & tuber plants	*Solanum Beta*
Industrial plants	*Humulus Nicotiana*
Vegetables	*Licopersicon Allium Brassica*
Horticultural plants	*Malus Prunus Ribes Vaccinium Fragaria*
Ornamental plants	*Gladiolus Lilium Narcissus*
Spices & medicinal plants	*Betonica Potentilla Arnica Adonis*

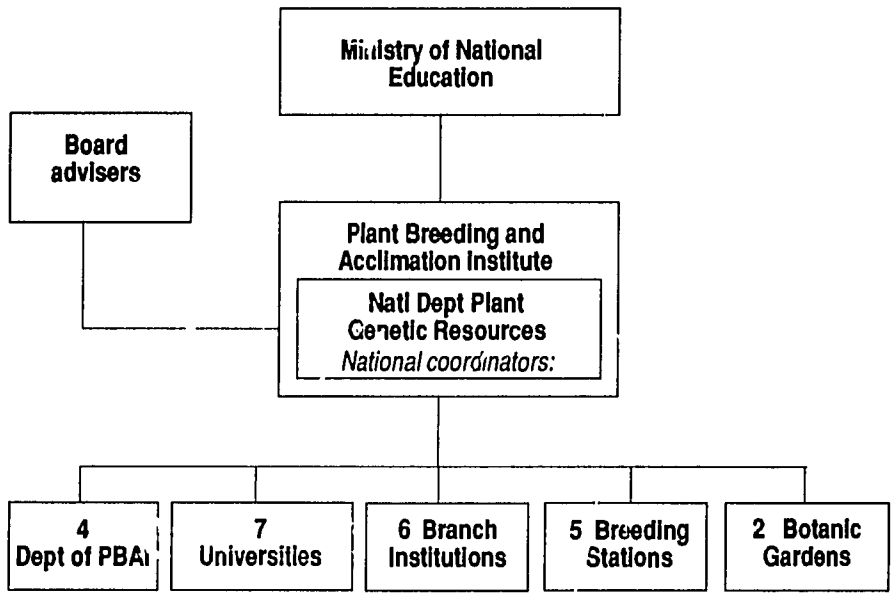

Fig. 1. Organizational framework of the Polish National Programme of Plant Genetic Resources

implementing the programme is played by the National Department of Plant Genetic Resources (NDPGR) of the Plant Breeding and Acclimatization Institute (PBAI) located at Radzików, which coordinates genetic resources activities of the collaborating institutions. The Department is assisted by the Board of Advisors which meets annually to assess progress and consult on policy matters.

Collaborating institutions perform two different roles. First there are institutions which carry out identification, characterization, evaluation, multiplication and regeneration of plant germplasm, therefore fulfilling the role of collection curators. The second group of institutions contribute to the programme through undertaking relevant research projects.

The programme is financed by the Ministry of National Education. Figures 1 and 2 show the organizational framework of the programme.

The role and responsibilities of National Department of Plant Genetic Resources

The role of the National Department of Plant Genetic Resources is threefold:

- coordinator of collaborative activities;
- centre providing services and facilities;
- national representative on genetic resources bodies.

As a **coordinator** the department has the following responsibilities:

- *to define objectives*
  Objectives are expressed in the title of the programme which states 'Collection, characterization, evaluation and preservation of crop plant germplasm for plant breeding and genetic research'.
- *to identify and include in the programme, crop plants for which genetic resources have to be collected and preserved*
  This is done according to two criteria: importance for the Polish economy and the danger of germplasm extinction.
- *to identify and include in the programme institutions with technical capacity and expertise to manage appropriate collections*
  Usually the responsibility for the collections is assigned to the institutions which are

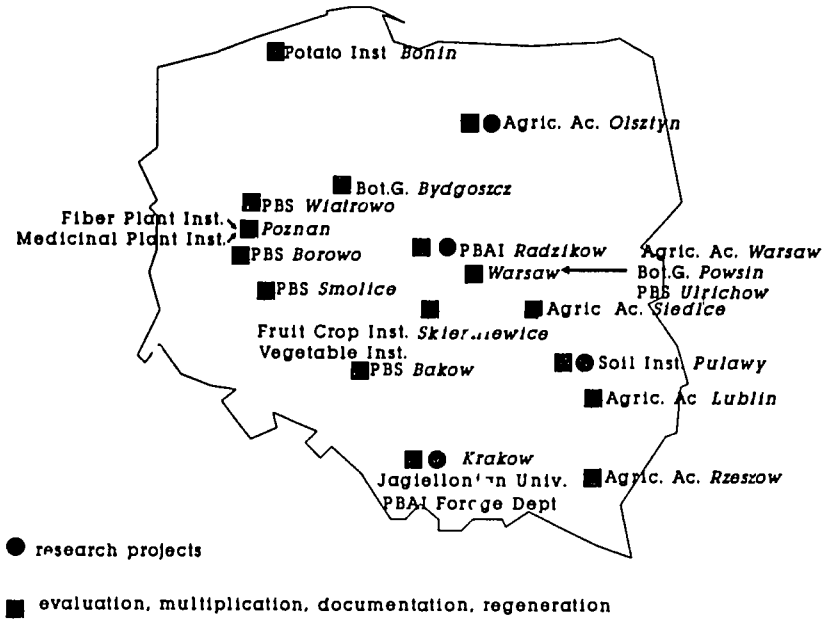

Fig. 2. Collaborating institutions in Poland and their contribution to the genetic resources programme

breeding stations or research centres dealing with these crops. This can be exemplified by the pea collection curated by the Plant Breeding Station (PBS) at Wiatrowo, a centre for breeding and research of this crop or the potato collection managed by the Potato Institute at Bonin.

to identify needs for research projects relevant to major issues of the programme and to employ appropriate institutions to carry out such research projects

In the last few years projects in the three following areas have been undertaken:

1. *Systematics and evolution*, including research on *Lupinus, Trifolium, Melilotus, Lotus, Trigonella, Medicago*, performed at three different institutions namely PBS in Wiatrowo, the Institute for Soil Science in Puawy, and the Plant Breeding and Acclimatization Institute at Radzików.

2. *Plant geography*, leading to determination of distribution of wild or semi-wild counterparts of crop plants in Poland. This project is run by the distinguished scientists of the Jagiellonian University in Kraków and will provide background for *in situ* conservation programme in Poland.

3. *Seed physiology*, aiming at identification methods preventing loss of seed viability. This research project initiated 2 years ago has been successfully carried out by the Agricultural University in Olsztyn

-to supervise activities of collaborators

This is usually done by visiting collaborating institutions during the course of their activities and by evaluating their progress reports.

-to secure necessary funds for realization of the programme (salaries, equipment, service)

This is done on a five year basis but because of high inflation annual corrections are made.

The second important role played by the department is *to act as a centre* providing the following service and facilities:

-germplasm introduction service

Although curators use their own means to acquire plant material, NDPGR has an obligation to provide plant germplasm material on request from the curator and to

Table 2. Countries visited and main groups of plants collected during 1981-1991 expeditions

Country	Crops
Poland	cereals legumes grasses wild *Trifolium*
Soviet Union	cereals legumes grasses *Aegilops* onion garlic wild relatives
Bulgaria	cereals legumes *Aegilops*
Czechoslovakia	legumes grasses
Morocco	cereals legumes *Aegilops*

initiate expedition missions in order to obtain local and exotic germplasm (table 2 lists the countries explored and germplasm collected in last 10 years).

- *central documentation facilities and service*

Each collection curator has an obligation to transfer both passport and evaluation data to the central file in PBAI, which together with information on storage such as initial moisture content, viability, year of sample deposition, sample size etc. form a data base for the collection. A uniform structure of passport data files has been adopted for all collections. Structures of evaluation data files are crop specific. The same character fields have the same code and size in all crop data files. Data are available on request for those who are interested. The percent of all accessions in plant categories which entered the documentation system is illustrated in Fig. 3.

- *controlled storage facilities and service*

PBAI provides controlled storage facilities at its location at Radzików for all seed collections. There are 2 chambers with -15°C and four with 4°C, 168 m³ each. The proportion of germplasm in crop categories deposited in cold storage is shown in figure 4. When seed samples from the curators arrive at NDPGR, they are screened with respect to quality prior to storage. In case of loss of seed viability during the course of storage or diminishing sample size, an accession goes back to the appropriate curator for regeneration and multiplication.

- *training to provide updates on genetic resources problems*

Training addressed to all collaborators in the plant genetic resources conservation

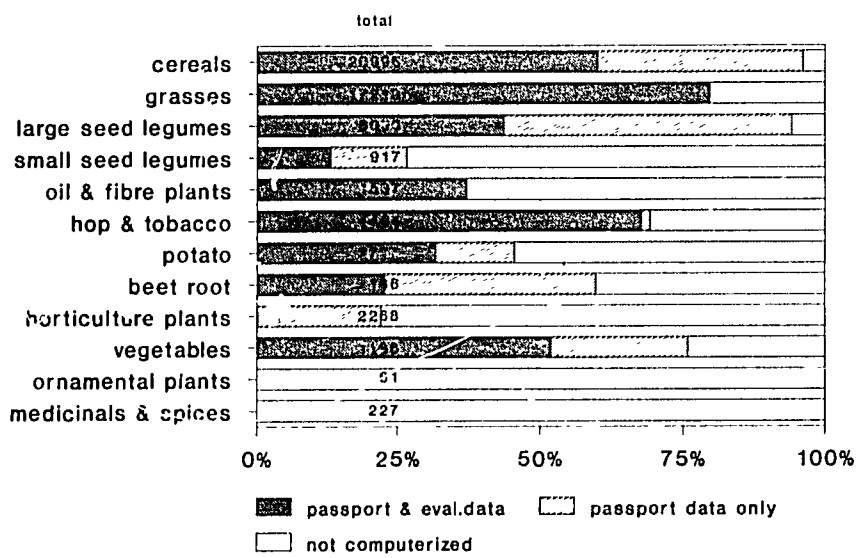

Fig. 3. Computerized documentation of plant genetic resources in Poland

programme has been organized on an annual basis since 1986. They present information on the current status and problems of genetic resources activities at home and world wide and forms a platform for personal contacts and interaction between people who have the same goal.

The third role performed by the department involves representation of Polish genetic resources interests in organizations, networks and undertakings abroad such as the Gene Bank Technical Advisory Committee for Eastern European Countries, Technical Consultative Committee (TAC), European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources (ECP/GR) and the EUCARPIA Gene Bank Committee.

Responsibilities of plant collection curators

Finally, to complete the picture of internal relations among institutions collaborating in plant genetic resources conservation one has to discuss the responsibilities that are placed on the curators of the collections. These are:

- *acquisition of plant germplasm*

In most cases curators take good care to enhance the variability of the curated plant collection. However the majority of germplasm comes from exchange. Plant collecting is the less popular method although much encouraged by the coordinator.

-*identification, characterization, evaluation, multiplication and regeneration of plant material*

These steps are the core of curator activities and therefore most of the collections are well evaluated and documented. Some curators go beyond the standard requirement for evaluation. This is the case of the rye collection managed by PBAI and the pea collection, which are subject to genetic research. Regeneration or multiplication are done at the location of the curator upon the request of gene bank personnel or at the time of evaluation.

-*provision of passport and evaluation data to central documentation file in PBAI*

Plant collection curators collaborate with the personnel of the documentation unit at PBAI on the final version of documentation information of the curated germplasm. Data are supplied by the curator in form of floppy disks.

-*provision of seeds to central seed storage in PBAI*

The seed material is usually transferred by the curators to PBAI for storage after the evaluation and multiplication procedures have been completed.

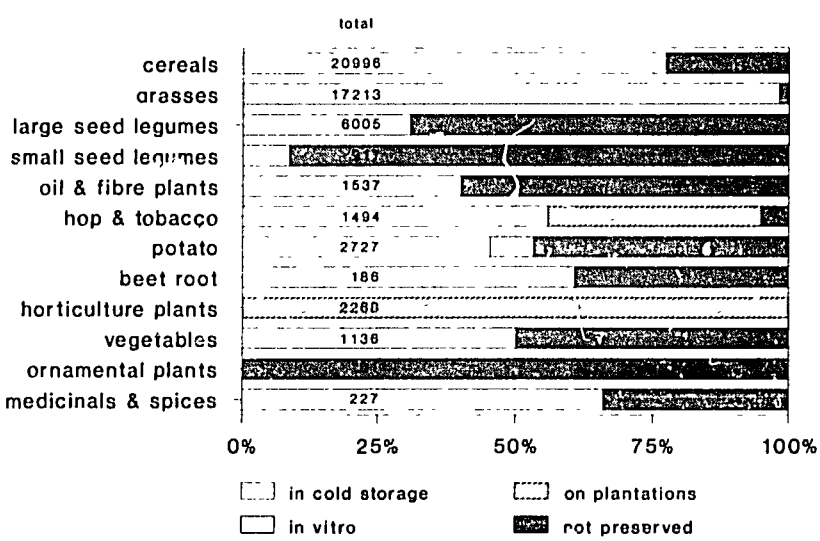

Fig. 4. Status and preservation of plant genetic resources in Poland

-consulting NDPGR on modification of the activities
This condition is imposed to enhance control over the collaborators' activities to ensure that they fulfill the role with which they have been entrusted.

Advantages and disadvantages of the Collaborative System

To conclude our discussion of inter-institutional links we would like to list some advantages and disadvantages that this system of collaboration carries.

Advantages:

Easy access to genetic resources germplasm by the breeders.
It is self explanatory as the majority of the collections are managed by the breeders.
Involvement of crop experts in evaluation, multiplication and regeneration.
Only institutions possessing good expertise on particular crop germplasm are entrusted with the management of the collection.
Reduction of expenditures on staff and equipment.
Personnel involved in genetic resources work are usually full time employees of the collaborating institutions. Therefore the financial requirements for their input is much lower than they would be for full time genetic resources personnel. To carry out genetic resources activities, collaborating institutions often use equipment bought for their own projects.
Flexibility to modify programme (selection of collaborators).
In case the collaborating institution is not fulfilling its role, the agreement on cooperation can be terminated.

Disadvantages:

Too much breeding material.
As breeders prefer to work with breeding material they also tend to limit their collection to this kind of germplasm.
Danger of losing plant material.
Practically no sanction can be imposed if a collaborator refuses to terminate an agreement on cooperation and refuses to hand over the germplasm collection, which has not been yet deposited in cold storage.
Slow down of exchange of material and information.
This is a usual problem of communication and efficiency of collaboration.

The present economic and political situation in Poland may have a dramatic effect on genetic resources activities in the next few years. The movement towards commercialization in almost every area of life may lead to limiting certain genetic resources activities. If this is the case then the extent of the evaluation programme will suffer the most. This would in turn impose the need to restructure the organizational framework of the programme.

European System of Cooperative Research Networks in Agriculture (ESCORENA): a model for regional cooperation

H. Ölez
Food and Agriculture Organization (FAO), Regional Office for Europe, via delle Terme di Caracalla, I-00100 Rome, Italy

Summary

Following the recommendations of the European Commission on Agriculture (1972) and the 7th and 8th Regional Conferences for Europe (1970 and 1972), the European System of Cooperative Research Networks in Agriculture (ESCORENA) was established by the FAO Regional Office for Europe (REUR). The cooperative research networks and working groups and the year of their establishment are as follows: 'Olive production' (1974), 'Sunflower' (1975), 'Pesticides and their impact on the environment' (1975), 'Maize' (1976), 'Durum wheat' (1976), 'Soybean' (1976), 'Animal waste utilization' (1976), 'Trace elements' (1977), 'Pasture and fodder crops' (1978), 'Sheep and goat production' (1979), 'Cotton' (1988), 'Flax' (1989), 'Nuts' (1990), 'Rice' (1990). The main objectives are: promotion of voluntary exchange of information and experimental data in the selected subject matters; joint applied research on selected subject matters of common interest according to an accepted methodology, agreed division of tasks and timetable; exchange of germplasm, as far as possible; establishment of close links between European researchers working on the same subject; and the fostering of a spirit of cooperation to stimulate interaction. The networks have a simple and efficient organizational set-up and their activities are basically self-regulated. Each participating institute defrays the necessary expenses (staff, laboratory, field equipment, etc.) involved in contributing to the implementation of the joint programme. FAO sponsors and promotes the establishment and development of the networks, in close cooperation with the national institutions. FAO also provides some basic financial resources, from Regular Programme funds reserved for European regional activities, for the organization of network consultations, printing and distribution of consultation documents, reports and research bulletins.

Background

Since the early 1960s FAO has promoted and supported the network system. It has, within its field of competence, used networks to foster research and technical cooperation, upgrade national research capabilities, facilitate exchange of information and transfer of technology. The system has taken various forms and approaches, depending on the problems to be solved, the capacities and capabilities of the institutions involved and the method of funding.

The establishment of the European System of Cooperative Research Networks in Agriculture (ESCORENA) was based on the principle that in a period of rapid technological and scientific development it is difficult, if not impossible, for any one institution or country to undertake all the necessary scientific research on any subject matter. Therefore, well-defined cooperation among interested national institutions would have a multiplying effect on the work of each one since each cooperating institution would rely not only on its own activities but would benefit from the results achieved and the experience gained by all.

Following the recommendations of the European Commission on Agriculture and the Regional Conference for Europe in 1972, the European System of Cooperative Research Networks in Agriculture (ESCORENA) was established by the FAO Regional Office for Europe (REUR).

Table 1. Cooperative research networks and working groups, the year of establishment and number of participating countries

Olive	1974	21 countries
Sunflower	1975	19 countries
Pesticides	1975	26 countries
Maize	1976	17 countries
Durum wheat	1976	19 countries
Soyabean	1976	19 countries
Animal waste utilization	1976	27 countries
Trace elements	1977	20 countries
Pastures and fodder crops	1978	21 countries
Sheep and goats	1979	27 countries
Mushrooms	1987	10 countries
Cotton	1988	11 countries
Flax	1989	14 countries
Nuts	1990	17 countries
Rice	1990	13 countries

The cooperative research networks and working groups, the year of their establishment and the number of countries participating are shown in Table 1.

The activities of ESCORENA consist of collaborative research projects, documentation and publication of network bulletins, meetings and workshops of working groups and sub-networks, network consultations. Whenever a need arises and financial resources are available, other cooperative activities such as training courses, study tours and exchange of material or experts could be undertaken through mutual agreement.

Objectives

The main objectives of ESCORENA were identified as follows:

- promotion of voluntary exchange of information and experimental data in the selected subject matters;
- joint applied research on selected subject matters of common interest according to an accepted methodology, agreed division of tasks and timetable;
- exchange of germplasm;
- establishment of close links between European researchers working on the same subject, and fostering of a spirit of cooperation to stimulate interaction.

Membership and participation

Cooperation in the ESCORENA research networks is voluntary, and each network develops its own programme and the manner of its implementation, draws up its own applied research programme, organizes the exchange of information on the latest scientific experience, prepares methods of work best suited to its specific requirements and divides the tasks among cooperating institutions in accordance with their interests, capabilities and fields of specialization. Cooperating institutions are free to choose the subject-matter on which they cooperate and exchange information.

Institutional framework

The organizational structure of ESCORENA consists of:

- Coordinator and Coordination Centre;
- Coordination Board;
- Liaison Officers and Liaison Centres;
- Working Groups;
- National Liaison Centre (when more than one institution from a country participates in the same network/sub-network/working group, a National Liaison centre is designated to serve as the focal point).

The networks have a simple and flexible organizational set-up and their activities are basically self-regulated. Their decisions are generally taken by consensus. Each

network carries out research on a few well-defined subjects and not on a complete inventory of topics drawn from the respective fields of activity. For each topic, in which a sufficient number of countries have expressed interest, a sub-network and/or working group is established. The working groups with specific tasks and life span are easier to convene and to terminate upon completion of their tasks. The actual cooperation takes place in the sub-networks or working groups.

The coordinators and the coordination centres of the networks, the liaison officers and the chairmen of the working groups are nominated and elected at the network consultations, generally for a renewable period of four years. The network coordinators are responsible for the implementation of the agreed work programme and collaborate with FAO in convening workshops, technical meetings and network consultations and in organizing coordination board meetings. The liaison officers and the working group chairmen follow-up the implementation of the adopted programmes and organize workshops, as well as publication of reports, proceedings, studies and guidelines. The Coordination Board, consisting of the coordinator of the network and the liaison officers, meets every two years to review the progress achieved, problems encountered and future programme of activities, and discusses appropriate means of expansion and improvement of cooperation.

To review past activities and results, and prepare future programmes, a consultation is convened for each network. The consultation also designates the coordination and liaison centres and may establish or suppress sub-networks. During the consultation, separate meetings are held by national institutions belonging to the same sub-network to examine the latest aspects of research on the topics handled by the sub-network. Lectures are given, and participants have the opportunity of exchanging information and experience

The activities and the progress made by the networks and their respective sub-networks and working groups are reviewed every two years by the ECA Executive Committee and the network coordinators.

FAO sponsors and promotes the establishment and development of the networks, in close cooperation with the national institutions. REUR plays the pivotal role of coordinating for the ESCORENA system. It systematically informs member governments of the results achieved by the networks. FAO also provides some basic financial resources, from Regular Programme funds reserved for European regional activities, for the organization of network consultations, printing and distribution of consultation documents, reports and research bulletins. It also finances the coordination centres' follow-up activities in the form of visits to the liaison centres of each sub-network, and those of the liaison centres to the institutes cooperating in their respective sub-networks.

In assisting the networks to implement their research programmes and other activities, the Regional Office for Europe cooperates with the technical divisions concerned, as well as with interested international and non-governmental organizations.

As far as financial implications are concerned, each participating institute defrays the necessary expenses (staff, laboratory, field equipment, etc.) involved in contributing to the implementation of the joint programme. At the same time, this contribution enables the institute to benefit from the overall achievements of its respective network

Past performances

ESCORENA has so far proved to be a useful, efficient and inexpensive system in promoting cooperation in agricultural research among national institutions, and has served as a model for scientific and technical cooperation. The achievements resulting from the work of cooperating institutes are relevant and often conclusive. Considerable production increases have occurred in Europe in those crops studied by the cooperative research networks and this clearly indicates that the choice has been in line with national priorities. Progress has also been made in the solution of problems analyzed by the networks on animal waste utilization, trace elements, etc.

Another constructive aspect of this cooperation is the gradual involvement of an increasing number of national institutions from developing countries who participate in

joint research programmes, and exchange scientific information and experience with European institutions. They have benefitted from achievements already made, and perhaps even strengthened their own research capabilities. ESCORENA members realize that the network is a meeting point which enables research workers from very distant countries to become acquainted, to obtain information on their respective work, to exchange information, material and technologies and to generate reciprocal esteem.

Adjustments and reorientation

ESCORENA system is in a continuous dynamic change, the research focus and participating institutions change with time. Adjustments are made in the network/sub-network programme of activities when:

-expected results are achieved;
-activities are no longer relevant;
-other priorities emerge, and/or
-the network activities are carried out by other organizations outside ESCORENA.

A majority of the networks have undergone reorientation and modifications since their establishment due to the above listed factors. The Durum Wheat Network was phased out in 1986 after having fulfilled its objectives and its continued existence was, therefore no longer justified. In addition, the Maize Network was converted to an *ad hoc* working group on maize genetic resources and breeding for disease resistance. The Pesticides Network was first converted to an *ad hoc* research group, and then phased out.

ESCORENA has already obtained some good results in a relatively short period of time. However, the difficulties faced should not be underestimated. The problems encountered are both structural and financial, and to solve them, political support is required from member countries.

The main problem is, of course, the human factor. It is clear that not all the networks were equally successful in achieving their objectives. There is a direct link between the competency of a leader and the results of his group, as well as the efficiency of the network regardless of other resources.

There are some organizational weaknesses, mainly in the sub-networks. Some of the liaison centres have not been able to fully carry out their tasks of follow-up and guidance; in some sub-networks the joint programme is not sufficiently detailed and the division of work has not been clearly defined.

Recently, a European Research Networks Advisory Committee (ERNAC) was established within REUR as a part of an adjustment and reorientation plan. ERNAC is expected to conduct periodic analysis of ESCORENA and to advise on the creation of new or suppression of existing networks. The committee aims to improve the organization and operation of the system, and to advise on the feasibility and interest of topics suggested for new networks/working groups.

Activities on plant genetic resources within ESCORENA

ESCORENA crop networks (olive, sunflower, soyabean, maize, fodder crops, cotton, flax, nuts, rice and mushroom) have a component of different extent dealing with genetic resources, like:

- improvement of olive plant material (olive);
- sunflower genetics and breeding; evaluation of morphophysiological and biochemical characteristics and taxonomical aspects of wild species (sunflower);
- collection, study and exchange of initial breeding material (soyabean);
- maize genetic resources (maize);
- forage shrubs and trees; herbaceous Mediterranean species (fodder crops);
- flax genetic resources and breeding (flax);
- cotton breeding, variety trials (cotton);
- germplasm, breeding and selection (nuts);
- rice breeding (rice);
- international bank for saprophytic mushrooms (mushroom).

In some cases, like in sunflower, ESCORENA Sunflower Network and ECP/GR Sunflower Working Group are composed of the same scientists, and have almost the same objectives. Joint meetings of these groups saved time and resources. Consideration should be given to consolidate these efforts.

Conclusions

The ESCORENA system has considerably expanded since it started in 1974 from one network to 10 networks and 3 working groups at present. The increased interest shown by member institutions provides an indication of its potential usefulness and impact. More concrete results of the various networks are in practical use in several countries. The success of the system can be attributed to a large extent to:

- the enthusiasm for voluntary cooperation on the part of the participating institutions;
- the simple and flexible framework of the network structure and operation,
- the constant evolution and updates of its programmes; and
- FAO's continuing support in promoting cooperation and communication within and between the networks.

FAO cooperates with the regional, international and non-governmental organizations operating in Europe and interested in the activities of the networks; apart from being represented at the meetings and receiving publications, these organizations occasionally contribute towards overhead administrative costs for network operations.

Despite its relatively long history, ESCORENA has yet to evolve into an independent and self-supporting system. It depends on the sponsorship of the Organization and may not continue without continued financial and technical assistance.

Possible roles for educational establishments in genetic resources conservation networks

H. Cachon, C. Foury and M. Mitteau
Institut National de la Recherche Agronomique (INRA), Ecole Nationale Supérieure d'Horticulture, 4, rue Hardy, F-78009, Versailles Cedex, France

Summary

The French School of Horticulture proposes involving secondary and higher educational establishments in an in-depth pluri-disciplinary study, using the onion, *Allium cepa*, as the model, in terms of preserving and developing genetic resources for the future. Such a collaborative effort involving various sectors is seen to offer advantages to each.

Aims and methods

The conservation of genetic resources is, by its nature, a complicated matter since:

- adequate techniques are not necessarily fully available for all species;
- its aims may appear ambiguous and open to controversy; and
- its theorization consequently remains insufficient in terms of doctrine and methodology for every case.

The collection, evaluation and conservation of material in the form of seeds or plants is laborious and delicate, and the use of collections is not easy. To have the best chance of succeeding and obtaining practical results, it requires the assiduous collaboration of specialists from at least five disciplines: botany, genetics, physiology, general agronomy and ethnology. However, it appears preferable not to subordinate too narrowly the management to the use of the genetic resources. Thus it would be advisable to have structures specific to the former. Their form is still under discussion, but in order to spread the risks and responsibilities, networks would be more desireable than centers. In any case, the considerable costs need to be justified by the most extensive and intensive pluri-disciplinary studies possible (Cauderon 1984).

The stakes for this action, so widely conceived, are high. Not only does this appear to be an indispensable prerequisite to plant culture diversification, notably by the constitution of parent lines to accelerate and optimize breeding and selection (Bannerot & Foury 1985), but an immense scientific (Cauderon 1984), agronomic (Cauderon 1985; Marchenay & Lagarde 1987), and cross-cultural (Bush 1989; Cauderon 1989; Chauvet 1985; Marchenay & Lagarde 1987) learning opportunity.

The complexity of the task, the means and the ends, incite us to reflect upon the use of the potential in this domain in educational establishments (Herve 1987; Mitteau & Foury 1984) and on the mutual benefits to be derived.

Benefits to educational establishments

The nature of the most suitable educational structures to be associated with such an endeavor undoubtedly varies according to the country considered. In France, the professional agricultural colleges (Ecoles Nationales Supérieures Agronomiques) and their associated laboratories would surely play a leading role but secondary establishments should also be integrated into the network to better deal with the complexity already mentioned by multiplying the support base throughout the territory and also de-centralizing national funding throughout the regions.

This effort would serve the establishments of higher education by improving their participation in research, their teaching opportunities, and their regional, national, and international relations.

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Research

The harmonious development of a research programme based on the protectior improvement of living resources can only contribute to the drawing together o biological sciences and technology, within the institution and in its relations witl outside. Such pluri-disciplinary efforts can only lead to better agricultural applicatio the scientific findings, especially in terms of a better understanding of the whole plant. S it is based on concrete practice, the participation of students is an elegant and efficient m of acquainting them with the numerous techniques now available, and how, in practi use the results. Acquiring competence in sampling and investigation methods, and b observant are necessary attributes, especially in biological prospecting. The descriptior evaluation of the collections implies not only physical and biochemical measurement the following up of the plants in the field, that is, the application of culturing techniques controlling pests.

The inherent cohesiveness of this domain makes the work easy to organize, whil diversity of approaches offers the student a wide range of options.

Teaching

Student participation in all of the operations, even if in a discontinuous manner important pedagogic consequences. A wide appeal for students to help with a stud *Allium cepa* L. will be launched by the Ecole Nationale Supérieure d'Horticulture (EN as part of the European IBPGR network, and financed by the Ministry of Agriculture. knowledge acquired in this project will go much further than just the genetic resources will ultimately be applicable to the entire domain of agriculture. This collaboration a various steps of the programme should give a sense of the concrete and a taste for anal and help put every problem into its proper perspective, and lead to better decision-mak This manner of approaching an in-depth study of the biology of a whole plant and its se as well as grasping the diversity of the species, is primordial in the training of agronom whatever their future sector of activity. However, many programmes and teaching metl today either bypass these aspects, or approach them too theoretically, even dogmatic This more global method we suggest also influenced the choice of model species, the or made by ENSH for this study. Although many other possibilities exist, the diversity, anc complexity of the behavior of ornamental and edible bulb plants make them good mo for teaching purposes.

Extra-mural relations

Most of the operations envisaged, and notably the biological prospecting, c students, but also teachers and researchers, numerous occasions for dialogue in whic learn to understand the problems of others, and undoubtedly a certain humility. This cc well help to offset a few of the more negative tendencies in our current educational syst but also, and especially, to promote a more natural, ecologically aware, and hum approach to agriculture. Without in any way neglecting the acquisition of scien knowledge, this wider attitude appears essential to future leaders in agriculture.

The potential benefits to the networ'

If the operations involved in the conservation of genetic resources may be benefi to the educational establishments even to the point of modifying their teaching method return, the schools may be of very great help to the project. First, the broad experienc teachers from various disciplines, and the 'cross-fertilization' of joint efforts and w ranging interests, plus the enthusiasm of students, constitutes a potential that it woul a shame not to tap into. Generally speaking, educational establishments offer hig favorable conditions for the creation of a network and International connections. T aggregation permits diversification in funding sources: the educational establishme professional organizations, and possibly private enterprise, in association or not. Howe at least one institutional (governmental) source is needed to assure the continuity of

project. It would be better to separate the conservation and study functions from those of the exploitation of the resources, in order to guarantee unrestricted public and private access to the gene banks created. As opposed to research institutes directly engaged in plant breeding, or the professional organizations, the educational establishments can ensure this total independence. Aware of these problems, an association of plant breeders has asked ENSH and its associated national agricultural research laboratory, to supervise a collection of *Pelargonium*, as well as to undertake fundamental studies on floral biology and on the possibilities of interspecific hybridization.

Conclusions and prospects

All in all, the students may be both central figures in the research and the beneficiaries of an eminently educational activity. However, despite the obviousness of the reasoning, the project is up against considerable difficulties. Doubtless, the efforts to constitute a network remain inadequate, but it is equally important that the 'member units' be of a sufficient size, and be well-structured, and have a truly functional hierarchy. It is possible that the fundamental re-organization currently underway in France, in agricultural research as well as teaching departments, may provide a suitable framework for this project. In addition, it will be equally important to establish appropriate mechanisms for making the results of this work available to those who need them.

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The European Barley Database

H. Knüpffer
Institut für Genetik und Kulturpflanzenforschung, Corrensstraße 3, D-O-4325 Gatersleben, Germany

Summary

The European Barley Database (EBDB) of the European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources (ECP/GR) is maintained at the Institut für Genetik und Kulturpflanzenforschung at Gatersleben. The EBDB contains passport data of 55,369 accessions from 35 barley collections in 26 countries. A catalogue, the European Barley List, was published in 1987. The EBDB will be transferred from dBASE II to dBASE III Plus to improve its structure and performance. The projected development of the database includes the incorporation of data on new accessions, the identification of duplicates between the European genebanks, and the detection of geographical gaps in the representation of the material. It is intended to build up links with other major databases of barley genetic resources within the framework of an International Barley Network coordinated by IBPGR. The services of the EBDB and computer-readable copies of the data are offered to potential customers.

Introduction

The European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources (ECP/GR) was initiated by UNDP (United Nations Development Programme), FAO (Food and Agriculture Organization) of the United Nations and European governments. ECP/GR became part of operations of the International Board for Plant Genetic Resources (IBPGR) in 1983 (Perret 1985; IBPGR 1990). The main aim of the ECP/GR is to document existing genetic resources and to promote the exchange of material for breeding and research purposes (FAO/UNDP 1980).

Six crop-specific working groups were established by the ECP/GR, including the Barley Working Group. The former Zentralinstitut für Genetik und Kulturpflanzenforschung (ZIGuK) of the Academy of Sciences of the German Democratic Republic at Gatersleben, now Institut für Genetik und Kulturpflanzenforschung (IGK), was designated to establish and maintain the European Barley Database (EBDB) (UNDP/IBPGR 1983).

The objectives of the EBDB are as follows (cf. UNDP/IBPGR 1983 1986 1989):

- to catalogue the barley genetic resources in European collections;
- to provide information on the barley germplasm available;
- to identify duplicates to avoid duplication of efforts on collections;
- to identify gaps in European barley collections to elaborate strategies for further collecting.

The EBDB will also play an important role in the establishment of an International Barley Network (IBPGR 1989) and of a Barley Core Collection (BCC) (Bothmer *et al.* 1990).

In this paper we briefly present the EBDB. For more details, see the Reports of the Barley Working Group (UNDP/IBPGR 1983 1985 1986 1989), the Introduction to the European Barley List (Knüpffer 1987, Vol. 1) and other publications (Knüpffer *et al.* 1988; Knüpffer 1988 1989).

Present state of the EBDB

Until 1985 Stig Blixt (now at Nordic Genebank, Sweden) gathered data from European genebanks and processed them on a Wang computer. The data were transferred to ZIGuK in 1985, and the EBDB was built up on an NGB IRS-83, an 8-bit microcomputer kindly provided by IBPGR. This computer was equipped with a 32 MByte hard disk. The file management system dBASE II was used under the operating system CP/M. In 1987 the

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Table 1. Genebanks contributing to the European Barley Database

Country (Genebanks)	Number of Accessions
Germany (Gatersleben)	10266
Great Britain (Cambridge, Kew)	9472
Germany (Braunschweig)	8274
Ethiopia (Addis Ababa)	5335
Netherlands (Wageningen)	2912
France (Clermont-Ferrand, La Minière)	2547
Poland (Radzików; Warszawa)	2437
Hungary (Tápiószele)	2207
Czechoslovakia (Kromeriz; Prague-Ruzyne)	2158
Sweden (Svalöv)	186[illegible]
Italy (Bari)	1242
Spain (Madrid)	1004
Nordic Genebank (Alnarp, Sweden), including data from Denmark (Copenhagen), Finland (Jokioinen and Hyrylä) and Norway (Ås)	968
Other countries: Greece (2), Belgium (3), Switzerland, Turkey, Yugoslavia, Bulgaria, Austria, Israel, Portugal, Cyprus, Ireland	4659
Data from Arias *et al.* (1983)	5142
Total:	60511

European Barley List with more than 60,000 data records and more than 800 pages was produced, using this equipment. In 1988 the identification of duplicates using a KWIC (Key Word In Context) index was started. However, it appeared that the necessary sorting of the data and storage of auxiliary files would be impossible on the available equipment. During these processes the limitations of the hardware and software were felt very hard, and an International Barley Working Session held in spring 1989 agreed that funding for new equipment would be essential to improve the performance of the database (IBPGR 1989). It was only recently that we received a Compaq 386/20e from IBPGR, and the EBDB will be transferred to and processed on this more powerful computer.

At present the EBDB contains passport data of 55,369 accessions from 34 barley collections in 25 countries participating in the ECP/GR and from the Ethiopian Genebank (Table 1). In addition, information on 5142 barley cultivars and lines extracted from the Directory of Barley Cultivars and Lines (Arias *et al.* 1983) was incorporated for reference.

Since 1987 several genebanks sent updates of their data. Due to the problems mentioned with computing facilities, the updates have not yet been included in the database. Recently the Soviet Union signed its participation in the ECP/GR, and another 25,000 accessions will have to be included in the database.

The European Barley List

A first draft of the European Barley List (EBL) with 37,478 accessions was prepared in 1986 (Knüpffer 1986). A new edition was issued in 1987 (Knüpffer 1987). It consists of two volumes. The actual barley data (23 descriptors as listed in table 2) are printed in Vol. 2. The barley genetic resources are classified into three categories. Accordingly, the data are tabulated in three parts:

Part 1 contains 23,418 accessions of cultivars, lines and special resources of *Hordeum vulgare* L. s.l. as well as the information extracted from Arias *et al.* (1983). The data are sorted alphabetically by (1) Accession Name, (2) Country of Origin, (3) Genebank/Accession Number.

Part 2 contains 29,166 collected and unnamed accessions of *H. vulgare*. The sorting order is by (1) Country of Origin (subheadings in the list), (2) Geographical Information (Province/ Site), (3) Accession Name, (4) Genebank/Accession Number.

Part 3 contains 2785 accessions of wild species and hybrids of *Hordeum*. They are presented in alphabetical order of (1) Scientific Name (subheadings in the list), (2) Country of Origin, (3) Geographical Information (Province/Site), (4) Accession Name, (5) Genebank/ Accession Number.

Vol. 1 contains the introduction, tables of acronyms and summary information. An alphabetical index allows one to find quickly material appearing in Parts 2 and 3 by accession name.

Brief survey of barley germplasm in European collections

The material comprises 52,584 cultivated (*H. vulgare*) and 2,785 wild barley accessions. Their provenance is shown in Knüpffer (1988). Amongst the 40,303 accessions with information on seasonality, 83.2% are spring, 15.2% winter, and 1.6% intermediate forms.

The database gives scientific names below the species level for nearly half of the *H. vulgare* material. The frequencies of the convarietates (Mansfeld 1950) are shown in table 3. The great morphological variation of the material is reflected by the presence of 219 different varietates (botanical varieties), excluding synonyms. According to the names of the varietates, there are 16,222 accessions of covered barley (114 varietates) and 2,150 of naked barley (80 varietates) (cf. Knüpffer 1988).

The secondary and tertiary genepool of the genus *Hordeum* are represented by 2,785 accessions of 33 wild species with 27 infraspecific taxa and 20 different interspecific and intergeneric hybrid combinations (Knüpffer 1988). Approximately two thirds of these accessions belong to the Scandinavian Hordeum Collection maintained at the Swedish Agricultural University at Svalöv.

Descriptors

The original data provided by the contributing genebanks show a great variation in layout and completeness. They contain more than 70 descriptors with partly overlapping definitions (Blixt 1985). A subset of 23 descriptors (Table 2) was chosen for the pooled database and for presentation in the European Barley List (Knüpffer 1987). Several descriptors have been standardized prior to inclusion into the database, e.g., Country of Origin, Genebank, Donor, Breeder, Expedition/Collector, Scientific Name.

The descriptor numbers in Table 2 refer to the IBPGR descriptor list for barley (IBPGR 1982) where their definitions may be found. In the following we provide definitions for additional descriptors and give some further remarks on descriptors from the IBPGR list and their acronyms.

Table 2. Descriptors presented in the European Barley List

Descriptor in EBL	IBPGR Descriptor Number	Descriptor in EBL	IBPGR Descriptor Number
1. EBL Number	-		
2. Genebank	-	13. Subspecies	1.5.3
3. Accession Number	1.1	14. Convarietas	-
4. Donor	1.2	15. Varietas	1.5.4
5. Donor's Number	1.3	16. Subvarietas	-
6. Seasonality	4.1.1	17. Expedition/Collector	2.2
7. Row Number	4.2.2	18. Collector's Number	2.1
8. Country of Origin	2.4	19. Province	2.5
9. Accession Name	1.6	20. Site	2.6
10. Breeder	-	21. Latitude	2.7
11. Other Numbers	1.4	22. Longitude	2.8
12. Species	1.5.2	23. Altitude	2.9

The descriptor numbers refer to the IBPGR descriptor list for barley (IBPGR, 1982). For definitions of descriptors without an IBPGR number and for further remarks, see text

EBL Number. A unique number assigned to each accession in the EBDB, mainly for internal use and reference, e.g., identification of duplicates.
Genebank. Acronym of the genebank holding the material. Acronyms for institutions dealing with plant genetic resources were developed for the ECP/GR framework by Serwiski *et al.* (1987). In agreement with the recommendations of the ECP/GR Workshop on Exchange of Information (UNDP/IBPGR 1984), these acronyms consist of up to ten letters, the first three being the IBPGR country acronym (see under Country of Origin), followed by an abbreviation of the institution's or person's name. They are used for the descriptors Genebank, Donor, and Breeder (Knüpffer 1987, Vol. 1, Appendix 4)
Accession Number. Meaningful in connection with the respective genebank acronym only.
Donor. Acronym (see under Genebank); occasionally only 'Country of the Donor' (3 letters, see under Country of Origin).
Donor's Number. Usually meaningful in connection with the donor acronym only.
Seasonality. Codes: A, spring form; H, winter form; I, intermediate form; P, perennial form.
Row Number. Redundant with the convarietas name in *H. vulgare.*
Country of Origin. Abbreviated by three-letter acronyms proposed by IBPGR (Anon. 1982), with additions for geographical regions, e.g. North Africa (AFN) (Knüpffer 1987, Vol. 1, Appendix 3).
Accession Name. Often contains information actually belonging to other descriptors, e.g. collection site, donor number, other numbers like CI or PI, expedition and collection number, scientific name.
Scientific Name. Species, subspecies, convarietas, varietas, subvarietas, including authority. To resolve problems regarding the synonymy, author names and spelling, the relevant literature (e.g. Mansfeld 1950, for *H. vulgare*) and experts were consulted (cf. Knüpffer 1988).
Expedition/Collector. Acronym of the expedition, collector or collecting institute. An accepted standard for acronyms was not available. Therefore, we developed our own set of acronyms (cf. Knüpffer 1987, Vol. 1, Appendix 6).
Collector's Number. Meaningful in connection with the expedition/collector acronym only.

Services of the EBDB

Searches in the EBDB are carried out on request of genebanks, breeders and scientists. The genebanks holding the specified germplasm may be identified, and related passport data may be provided.

Complete or summarized information from the database is available on request in form of printouts or on magnetic media.

Future development of the database

The following activities will have to be undertaken in the future (UNDP/IBPGR 1986):
- Transfer of the EBDB to dBASE III Plus / dBASE IV
Including transformation of the flat files into a relational structure.
- Correction and completion of the existing data
The printouts or files to be disseminated to European barley specialists for checking will be of two types: by contributing genebanks and by countries of origin.
- Registration of additional passport data
It was recommended to include the descriptors Year of Registration or Release (for cultivars) and Principal Attribute. New collections, e.g. VIR Leningrad, will also have to be incorporated.
- Inclusion of certain characterization/evaluation descriptors
In general, the EBDB will register summary information on characterization and evaluation, whereas the national genebanks will keep the detailed data. Each genebank should select five of the most important descriptors and provide the corresponding data for the unique material to the EBDB (UNDP/IBPGR 1986).
- Identification of duplicates
The Barley Working Group repeatedly stressed the need to identify duplicates in the database (UNDP/IBPGR 1983 1985 1986 1989). This is aimed at a rationalization in maintenance, characterization and evaluation of the material. A list of unique accessions and

Table 3. Old French winter barley varieties resistant to Y1 BaYMV in 1988, 1989 and 1990

Variety	Maule 1988	Gembloux 1989	Gembloux 1990
Franka (control)	1	1	1
Express (control)	1,5	1	1
Marne*	1	1	1
Ile de Re	1,5	1	1
Escourgeon de Beauce	1,5	1-5**	-
Hatif de Grignon	1,5	1-5**	1
Comte de Serre	1,5	1	1
Escourgeon de Champagne	1,5	1	1
Escourgeon Nouveau	1,5	-	1**
Superchampenois	1	1	1
Demi-hatif des Tourettes	-	1	1
susceptible varieties	4-5	5-6	5-6
Hatif du Moulin	-	-	6

1=resistant, 9=highly susceptible
Locations: Maule in France and Gembloux in Belgium
*Escourgeon de la Marne : BaYMV resistance previously reported
**Segregating for resistance or seed purity unsatisfactoryN. Rajanaidu

their duplicates with indication of a 'best representative' of each duplicate group would help to give recommendations for the maintenance of unique material and deposition of safety duplicates. A technique suitable for the identification of duplicates in international databases of plant genetic resources is illustrated by Knüpffer (1988). It is based on a KWIC (Key Word In Context) index applied to different descriptors containing names and/or numbers.

- Recommendations for further collecting

After the identification of duplicates, more realistic estimates on the number of unique accessions from each particular country or geographical region will be derived. Such information will be of great value for further collecting strategies.

- Establishment of an International Barley Network

An International Barley Working Session in 1989 recommended to build up an International Barley Network (IBPGR 1989). This requires closer links and the definition of data exchange channels between the EBDB and other international barley databases.

- Barley Core Collection

The Barley Working Group set up a subgroup to work out the concepts of a Barley Core Collection (BCC) (IBPGR 1989; UNDP/IBPGR 1989). Since September 1989 this subgroup met three times, and a special workshop on this topic will be held during the VIth International Barley Genetics Symposium at Helsingborg, Sweden, in 1991 (Botmer *et al.* 1990). The EBDB will be the basis for selecting the actual accessions for the BCC once the criteria for selecting them will have been established.

Conclusions

The EBDB with its over 60,000 accessions is by far the largest database amongst the crop-specific databases of the ECP/GR. It is followed by the databases for *Pisum* (22,000 accessions) and *Avena* (17,000) (IBPGR 1990).

The establishment of the European Barley Database showed that it is possible to maintain a relatively large passport database of plant genetic resources on an 8 bit microcomputer, if a sufficient hard disk and a good file management system are available.

However, the hardware constraints caused severe problems. The pooled files of the EBDB containing just the 23 selected descriptors occupy more than 50% of the 32 Mbyte disk. The storage capacity did not allow to access the whole database on the disk directly, and large parts had to be kept on diskettes. Therefore, the transfer to a more powerful system is essential.

The EBDB and the European Barley List are valuable sources of information for barley

breeders and other customers. In numerous cases it was possible to provide the desired information. Requests for searches in the database should be directed in written form to the Genebank of the Institut für Genetik und Kulturpflanzenforschung (IGK). Computer-readable copies of the data files (the 23 descriptors as listed in table 2) on IBM PC diskettes or magnetic tapes may be requested from IGK.

ECP/GR is interested in extending the EBDB by inclusion of passport data from other European barley collections (genebanks, breeder's collections, botanical gardens) willing to exchange seed material free of charge. Before mailing any data, preferably in computer-readable form, please, contact the author for details of diskette or tape format, file structures, descriptors and preferred coding schemes.

It would be highly desirable to link the European Barley Database with other national and international databases on barley genetic resources (cf. Chapman 1988), this will be one of the main tasks for an International Barley Network (IBPGR 1989), and with barley cultivar inventories as the Directory of Barley Cultivars and Lines (Arias *et al.* 1983) and the Barley Register (Baum *et al.* 1985). The former would add information for non-European barley collections and allow one to complete and improve the geographical survey and to identify duplicates world-wide, whereas the latter would provide valuable additional data, like breeder, pedigree, year of release, etc. A comparison of these databases would reveal cultivars and lines which do not exist any more as living material in genebanks.

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The world *Beta* network

L. Frese
Centre for Genetic Resources, The Netherlands (CGN), Institut für Pflanzenbau und Pflanzenzüchtung (FAL), P.O.Box 224, 6700 AE, Wageningen, the Netherlands

Summary

This paper describes the history and organization structure of the world *Beta* network. The network, founded in 1989, integrates beet experts from genebanks, research institutes and breeding companies from Europe, the USA, the USSR, West Asia, India, China and Japan. The common goal of the *Beta* network is to make maximum use of the often limited funds for genetic resources conservation programmes by task-sharing in the fields of collection, maintenance, evaluation and documentation. In addition, the network tries to promote the utilization of collections in breeding and to stimulate research on biosystematics and related fields. The establishment of the International Data Base for *Beta* (IDBB) and the inventory of the world *Beta* holding can be regarded as the first and crucial output of the international working group. The IDBB has received passport and partly seed stock data from 19 different national holdings. Since these data are stored in a central database the user's access to *Beta* germplasm has been improved considerably. Within the network the IDBB can be employed to coordinate collecting missions, to guide the process of systematic safety duplication and to rationalize and improve the maintenance of accession. There is a general agreement that international cooperation in the field of *Beta* genetic resources in the medium to long term will substantially benefit breeding programmes. Network members are also strongly convinced that the network can effectively stimulate research on genetic resources and promote the utilization of collections. Uncertain financial support of the network activities has been identified as the major constraint to continuous operation of the network organization.

Introduction

International efforts to preserve wild, primitive and cultivated types of beets were initiated by Williams and Ford-Lloyd who in 1972 performed a first systematic exploration in Turkey. IBPGR sponsored these collecting missions, later the collection of germplasm was carried on by national institutions. Since then much has been achieved in the field of conservation and evaluation of beet germplasm.

In September 1986 a joint *Beta* genetic resources programme* was established at the Centre for Genetic Resources, The Netherlands. How this new *Beta*-programme at international level could add value to existing activities was one of the concerns of the CGN. The offer of IBPGR to establish and implement a central database for *Beta* within the framework of the ECP/GR programme came therefore right in time and moreover met the interest and expertise of the CGN. When the CGN had accepted to act as an information centre for *Beta* fast progress was achieved. During summer 1987 the European *Beta* Data Base (EBDB) was established and introduced during a workshop held in October 1987. Since datasets from outside of Europe were later added to the EBDB in 1989 the name was changed into International Data Base for *Beta* (IDBB). A second and extended workshop was organized by IBPGR in February, 1989. During this workshop the IBPGR launched the concept of crop network organizations and the participants agreed to establish the world *Beta* network organization (IBPGR 1989).

*The Dutch-German programme on *Beta* genetic resources is a cooperative project between the CGN and the Institute for Crop Science and Plant Breeding of the FAL (Braunschweig-Völkenrode) within the framework of the German-Dutch Board for Plant Genetic Resources.

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Structure and objectives

General principles

During the workshop in 1989 the general principals and objectives of the network were formulated. The function of the network is to bring together beet experts to work in close cooperation for their mutual benefit. Since continuous funding of various kinds of crop specific networks is beyond the financial prospects of IBPGR it was stressed that the *Beta* network had to become self-sustaining within a short time. In 1989 it was assumed that the necessary funds could be raised from national bodies or from breeding companies.

Organization

The network is a voluntary association of representatives from genebanks, research institutes and breeding companies which will meet once in two years. The *Beta* Coordinating Committee (BCC), elected by the network participants for a period of two years, assists the working group in implementing the joint work plan. It will function as a central link between the network participants but also maintain contacts towards the IBPGR and other national or international organizations such as the International Institute for Sugarbeet Research (IIRB). The responsible for the IDBB is a permanent member of the BCC and acts, as practice has shown, as the secretary of the group.

Objectives

The common goal of the *Beta* network is to make maximum use of the often limited funds for genetic resources conservation programmes by task-sharing in the fields of collection, maintenance, evaluation and documentation. In addition, the working group tries to promote a more systematic use of collections through pre-breeding and to stimulate biosystematic research.

Achievements

An essential requirement for the continued operation of a viable network is a central database which collates, analyzes and disseminates information. The International Data Base for *Beta* (IDBB) functions as such a central information unit within the *Beta* network. This information system can be used for various purposes.

Inventory of the world Beta *holding*

About 26 *Beta* holdings are existing worldwide. 19 genebanks or research units of countries in Europe and overseas have transmitted their *Beta* passport and partly their seed stock data to the IDBB since February 1987 (Frese & van Hintum 1989). Within short the passport data of the Vavilov *Beta* collections will be added to the data set. Then, the inventory of the world *Beta* holding will be almost accomplished. The IDBB currently stores passport data information on 7317 accessions and seed stock data on 3152 accessions.

Rationalization of seed increase programmes

In the past the exchange of germplasm between national collections has led to large numbers of redundant material within the world *Beta* genetic resources stock. By means of identical collection numbers or the similar sound of variety names duplicated material has been identified within each of the national collections (Table 1). Currently, the total stock of *Beta* germplasm consists of 5296 accessions of unique material (sample category: 'MOS') and different kinds of duplicates and other sample categories (2121 accessions).

The sample category 'MOS' indicates the first priority for regeneration. If the seed stock table of the IDBB were complete priorities could also be defined based on the seed quantity and quality. Then it would be rather easy to compile an international priority list ('red list') of most original samples requiring urgent regeneration. Collaborative actions in this field would help to save funds since curators could put priority on the maintenance of their 'MOS' samples knowing that duplicates within their collection will be seed increased elsewhere.

Table 1. Number of accessions per holding and sample category

Beta holding		Sample category						Total
		MOS	SDS	SDA	PRD	NOG	NOC	
001CHN	(China)	44			6			50
AISBRC	(Ireland)	13			2			15
ARARI	(Turkey)	114						114
BARCPI	(USA)	1813			124	11	2	1950
BIRDPB	(UK)	818			197	9	1	1025
BLOBAI	(Poland)	46				50		96
DYOSAP	(France)	8			37			45
GGB	(Greece)	679			61		1	741
INRALR	(France)	14						14
MERRVP	(Belgium)	45				28	53	126
NEDBEG	(Netherlands/FRG)	1106	328	224	111	20	333	2131
NGB	(Sweden)	25				2	2	29
NVRS	(UK)	50			28		1	79
NYONRA	(Switzerland)	56			10			66
OLORBI	(Czechoslovakia)	122			65	1		186
PRAGGR	(Czechoslovakia)	75			27	75		177
TAPRCA	(Hungary)	75			22	13		110
ZARAEE	(Spain)				1	110		111
ZIGUK	(GDR)	193			56		1	250
Total		5296	328	224	777	345	338	7317

MOS: most original sample, SDS: security duplication sample not in the active collection, SDA: security duplicate sample in active collection, PRD: probable duplicate, NOG: not within the responsibility of genebanks (e.g. triploid hybrid varieties), NOC: no longer in the collection.

Though joint activities in the field of regeneration seem to be very attractive virtually little progress has been achieved. A lack of readily available computerized seed stock data at the national level appears to be the major reason. Obviously, the service offered by the IDBB does not meet the database management facilities at the local level. This hampers the rapid flow of information from the local units to the central database.

A better coordination of seed increase activities could also include mutual help to overcome structural (unsuitable climatic condition for seed production of particular species) or momentary short-comings (serious backlog in regeneration). Bilateral contacts between network members were recently established and appropriate action is taken to solve such problems.

Management of safety duplication

The IDBB can also manage the safety duplication of collections. A central database can note the genebank holding the most original sample and the genebank storing the safety duplicate. Since genebanks can freely choose where to store duplicates there is no need for central base collections. In fact, Braunschweig as one of the *Beta* base collections has never really been accepted. The USDA/ARS, the USSR and Turkey for instance care for their own safety duplicate collection and did never make use of the base collection in Germany or in Greece. Table 1 gives an indication of the degree of safety duplication (sample category 'SDS' and 'SDA') in the world *Beta* collection which is about 10% of the most original samples while the percentage of total duplication (SDS, SDA and PRD) is about 25% of the most original samples.

Agency for germplasm acquisition

If a user is interested in specific germplasm he can address to CGN which will help to obtain the samples from the world *Beta* seed stock. Since its establishment the IDBB has treated a number of very specific requests for germplasm which could only be satisfied by making

use of the seed stock of 2 or 3 of the national *Beta* holdings. This information system would become even more attractive if characterization and evaluation data were added.

Planning of collecting missions

A central database can assist in developing guidelines for future collecting missions. The IDBB for example forwarded to the Turkish genebank a list of passport data of all the material previously collected in Turkey. This information was used in 1990 to purposefully recollect seed samples of *Beta* populations. A recent analysis of the geographic data has shown that major geographic gaps are still existing within the world *Beta* holding. This information has been used by the network members to decide upon priorities for further collecting missions. The CGN for example explored in 1989 Portugal and southern Spain, because none of the national collections contained *Beta* germplasm originating from this region. Similarly, major geographic gaps were identified in Egypt, Morocco, Yugoslavia, Bulgaria, the Caucasus region, Iran, northwestern India and possibly China. The necessary actions to fill up these gaps have already been taken and partly successfully accomplished.

Current constraints

The momentum IBPGR has given to *Beta* genetic resources activities through momentary financial support of the working group could now be used to further develop this new association. There are no doubts that many of the network participants have a vivid interests to cooperate. However, while the willingness to cooperate is readily available the necessary structural funds for basic activities are not. Amongst the participants of the last *Beta* workshop there is a general agreement that the uncertain financial support is the major constraint to frictionless function. The network will only continue to operate as it was started by IBPGR if financial means will become available for the basic activities which are

- maintenance, extension and use of the IDBB,
- coordination of the network,
- meetings of the *Beta* Coordinating Committee (BCC), and
- meetings of the network.

The CGN has committed itself to maintain the database and to extend it according to the recommendations of the *Beta* network organization. In addition, it will care for user's service in its broadest sense as described before. The CGN within the Dutch-German cooperation on plant genetic resources currently does not intend to cease this support. However, it must be stressed that with this kind of cooperative structure on the long run the success or failure of a crop network is too much bound to the momentary interests and facilities of the central unit.

While the function of the central unit is secured the meetings of the BCC and the network are not. Colleagues from West European countries and the USA will presumably be able to raise funds for their participation in network meetings from national bodies or from the European Community. Colleagues from less wealthy countries, however, may face greater difficulties. Without support of these colleagues the world *Beta* network will undergo a shrinking process which at the end may result in a limited cooperation on *Beta* genetic resources between West European countries and their close allies.

Perspectives

Within a short time the *Beta* network will face its first verification as a more or less self-sustaining organization. The second world *Beta* network meeting planned for June, 1991 will certainly reveal some of the difficulties of a comparatively small working group consisting of representatives from very different and distant countries.

Utilization

Intensified and successful use of germplasm in breeding programmes is one important mean to promote the *Beta* network. This in turn could facilitate to raise the funds needed for the operation of the network. Progress in sugarbeet breeding based on introgression of wild

or primitive germplasm would confirm the usefulness of collections and emphasize the need for an efficient and rational genetic resources conservation and utilization programme. In late 1989 a group of plant breeders from institutes and companies initiated therefore an European Community (EC) research project which is currently being evaluated by an EC expert group.

Biosystematic research

During the workshop meeting in 1989 the group also decided to stimulate more research in the field of biosystematics. Further investigations on genecology in wild beets, on species relationships and on the evolution of the genus *Beta* are needed for the development of more scientifically based sampling and conservation strategies. The necessary expertise in classical taxonomy as well as in more sophisticated research methods like isozyme and RFLP analysis is available at various research institutes. The network's function would be to create a forum for discussion, to associate the experts and to initiate joint research projects. Such projects would facilitate the exchange of ideas and methods between specialists and improve the fundamental knowledge on the structures of genetic diversity of beets.

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Allium networks in Europe and in the tropics

D. Astley[1] and L. Currah[2]
[1] Genetic Resources Unit, Horticulture Research International*, Wellesbourne, Warwick, CV35 9EF, United Kingdom
[2] Natural Resources Institute, Chatham Maritime, Kent ME4 4TB, United Kingdom

Summary

The European Cooperative Programme *Allium* Working Group developed the European *Allium* database with passport data from 20 countries. These data have been distributed widely via catalogues and computer diskettes. The Group has expanded the ECP passport descriptor requirements and formulated a minimum list of characterization and evaluation descriptors for crop groups (onion, garlic & leek) and their relatives for crop inclusion in the database. National curators are encouraged to collect, conserve and document their germplasm passing data to the ECP database. The taxonomy of the genus is under revision. A practical taxonomic workshop is planned by the ECP *Allium* Working Group in 1991.

There is an increasing need to develop a global strategy for the conservation and utilization of *Allium* via links with other interested parties (NRI Tropical Onion Network, IBPGR, International Institutes, USDA, etc). The Natural Resources Institute in UK has promoted the formation of a network of contacts with interests in onions in the tropics. The network now numbers over 400 confirmed members. It is being maintained through the NRI-sponsored publication 'Onion Newsletter for the Tropics', the first two numbers of which appeared in 1990. The Newsletter covers all aspects of onion production and storage in the tropics, and includes an annually updated list of commercially available short-day onion varieties and the seed firms which supply them. In the 1991 Newsletter, the research interests of network members will be published, thus potentially allowing breeders and those interested in genetic conservation to arrange exchanges of germplasm of short-day adapted onions. Information on the genetic resources of onions in the tropics was collected by questionnaire in 1986-9 and is published in the NRI Bulletin, 'Onions in Tropical Regions'. Cultivar lists published in the Bulletin show where land-races and local cultivars of onion and shallot are grown and indicate where farmers still largely depend on their own resources for onion seed. We are inviting interested parties in these regions to offer seed of their local onions to the Vegetable Gene Bank at IHR Wellesbourne. The seed stored there will be available for distribution through the *Allium* Genetic Resources network.

Introduction

The *Allium* Working Group of the European Cooperative Programme met for the first time in Tapioszele, Hungary in 1984 (Anon. 1984). The Group objectives were to collect passport data using standardized descriptors on all european *Allium* collections in order to:

- define gaps in the total genetic resources collections;
- direct the collection of germplasm to fill gaps;
- conserve material in long-term seed stores or field genebanks; and
- reduce unnecessary duplication in collections.

These objectives continued to evolve with the production of the ECP European Catalogue of *Allium* (Astley 1988) and through subsequent meetings of the ECP *Allium* Working Group (Anon. 1986 1988):

*Correspondence address: HRI, Wellesbourne, Warwick, CV35 9EF, UK

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- characterize accessions using a minimal number of descriptors;
- include characterization data in database;
- improve taxonomic knowledge;
- assess variation e.g. ecogeographic, intra- and inter-specific;
- encourage utilization and evaluation;
- link with other collections.

Has this working group/network approach been successful?

A distillation of comments from Group members reveals a surprising consensus on both positives and negatives.

The development of the European *Allium* database and catalogue of passport data provided a common goal and a sense of linked commitment. The database is viewed as a success by the data donors and has been valuable in identifying source material for users. -Strangely, the natural extension of the work through subsequent objectives for collection and characterization within national programmes has not provided such a feeling of cohesion. Individuals active in collection and characterization have complained of isolation and limited contact between other group members. Communication has been limited to essentials with the database holder and secretariat and less between the members. Bilateral programmes such as between Bulgaria/Netherlands are the exception. On-going coordination is very difficult to achieve without regular discussion meetings.

All agree that a minimal newsletter distributed to group members would go some way to countering this isolation and provide the basis for more constructive discussion of future objectives. However, few participants report their activities, e.g. expeditions, visits, characterization, evaluation, etc., to the Chairman for inclusion in such a newsletter.

A functional secretariat is essential to continued activity in coordinating regular meetings (bi- or triennial) to reaffirm commitment and objectives, to publish and distribute reports, and to act as a vehicle for funds which would not otherwise be allocated to genetic resources within national programmes.

Objectives defined as inputs-in-kind within national programmes frequently rely upon the expenditure of limited resources allocated to an institute or individual scientist rather than being supported by specific additional funds directed by the signatory government. Any move towards self-supporting groups would need the continuing support of an international organization such as ECP to monitor national commitments to additional financing of the necessary inputs-in-kind to the group. (This is particularly poignant because of the ECP Technical Consultative Committees definitions of the requirements of working group Chairmen and national crop representatives within Phase IV. The expected inputs for collaborators in ECP Phase IV are considerable and will only be achievable if signatory governments recognize their responsibilities.)

There is disagreement between members on links with other groups; some feel we should consolidate the activities on the broader european front; while others look to the ECP Group having a shared responsibility within a global network.

There are certain conclusions that we can draw from the comments of my ECP *Allium* Working Group colleagues :

- A group/network is only as good as its component parts.
- The Chairman has the responsibility to coordinate the group and encourage activity and dialogue. ECP Phase IV requires a more active role from database holders and country coordinators.
- Common goals bind a group together, but a number of parallel activities in member countries may not be perceived by members as shared commitment to reach a common objective.
- Communication within the group is essential.
- A Secretariat offers distinct advantages in the coordination of a group's activities.
- Money enables activity at all levels e.g. Secretariat, meetings, inputs-in-kind funded by national programmes, etc. A loss of funds at any level will have serious consequences for the group's activities.

The tropics

The Natural Resources Institute (NRI), part of the Overseas Development Administration in UK, took the initiative in the mid 1980s in promoting the formation of a network of individuals with interests in onion growing and storage in the tropics. The basis of the scheme was NRI's continuing interest in problems of onion storage in tropical climates, and the need to relate storage problems to the characteristics of the cultivars grown. Onions suitable for the tropics are exclusively of the short day-length response type, and prior to the NRI survey, knowledge of the cultivars or landraces grown and of the variations between regions of the tropics in cultivar availability was fragmentary. Initially, the project aimed to collect information on this aspect, so as to establish a factual basis for future development work. Storage problems were addressed in some detail. Later, the possibility developed of encouraging direct links and information exchange between onion workers in the tropics.

Informal contacts provided by individuals in the UK were developed from NRI (F.J.Proctor) by sending out a questionnaire on onions to many of these contacts during 1986. Further questionnaires in English, French and Spanish have since been distributed. Over 80 replies have been received from countries of the tropics and sub-tropics. The questionnaire asked for information on the onions grown: the cultivar or land-race names, bulb skin and flesh colour, shape, average local yield, estimated storage life and liability to common defects such as doubling or thick-necks. This information is published in NRI Bulletin 35, 'Onions in Tropical Regions'. The full information from the questionnaires, which includes details of harvesting methods and storage, is available at Horticulture Research International (HRI).

From a genetic resource viewpoint, the cultivar lists published in the Bulletin show where in the tropics local landraces and cultivars of onion and shallot are still grown, and indicate where farmers largely depend on their own resources for onion seed. Regions identified in this way are clearly those where efforts are needed in genetic conservation. They include India, Pakistan and Bangladesh, Sudan and the West African countries of the Sahel region. International seed companies are increasing their activities in the tropics, and once improved cultivars become widely available, many local onion landraces are likely to disappear. In some parts of the tropics, only imported seed is used.

Many countries also reported that tropical red shallots are grown. These types of *Allium* are little known outside the tropics and may contain interesting genes, for leaf disease resistance for example, which might be useful in breeding improved bulb onions for the tropics.

Interested parties in the regions where local onion strains are still found are being invited to offer seed to the Vegetable Gene Bank at HRI Wellesbourne. The seed stored there will be conserved and some will be available for distribution through the *Allium* Genetic Resources network.

Starting from the onion questionnaire contacts and others who contributed to the Bulletin, an information network is now being maintained and expanded through the 'Onion Newsletter for the Tropics', the first two numbers of which appeared in 1990. Over 400 readers have confirmed their interest in receiving the Newsletter. The Newsletter is intended to cover all aspects of onion production and storage in the tropics, including genetic resources. It includes an annually updated list of commercially available short-day onion varieties and the seed firms which supply them.

In the third issue of the Newsletter, the research interests of network members will be published, thus potentially allowing breeders and those interested in genetic conservation to arrange exchanges of germplasm of short-day adapted onions.

Is there any way of monitoring the success of the NRI onion network project? The Newsletter is still at an early stage of development, but already many appreciative letters have been received from network members. The second issue, which contained a large number of contributions from within the tropics, was evidence of a keen wish to share information on onions and shallots within the tropical regions of the world. Some contacts made through the questionnaires and newsletters have led to the setting up of collaborative

trials on commercially available onion cultivars. It is hoped to publish the results of these trials eventually in the Newsletter. In this way information about the performance of modern cultivars in a variety of well-defined environments can be shared.

The future of the Newsletter and the network will depend on obtaining financial backing for the third and subsequent numbers, and if possible for the reprinting of the first and second numbers, for which demand is continuing. The long-term sustainability of the network, including the Newsletter, and its funding need to be reviewed within the next year by ODA/NRI.

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Cereal genetic resources networks in France

J. Koenig, A. Le Targa-Le Blanc, L. Jestin, J. Legouis and A. Bouguennec
Institut National de la Recherche Agronomique (INRA), Station d'Amélioration des Plantes, Domaine de Crouelle, F-63039 Clermont-Ferrand Cedex, France

Summary

Cereal genetic resources networks have been developed in France during the 10 last years. The INRA (Institut National de la Recherche Agronomique) and cooperative networks with private firms are described as well as some evaluation work for wheat and barley

Introduction

Cereal Genetic Resources is not a new topic for INRA researchers or private breeders: collections have been maintained since a long time, the problem being that they were only locally enhanced; no catalogue was published except for the Clermont-Ferrand wheat collection. For this reason, genetic variability of french wheat cultivars has decreased, the breeders having crossed only a few well known genitors (Branlard & Le Blanc 1985). Networks were established for inventory and evaluations of INRA wheat and barley collections. These inventories have been extended to the collections of private breeders and a new network was created. We will describe successively both networks.

The INRA wheat and barley networks

In our institute, several laboratories located in different part of our country are dealing with cereal research. They maintain collections in relation with their main research topics summarized for wheat in Table 1.

The collections are divided in two parts:

-Genitors, possessing particular traits, which might be integrated in breeding programs.

-Reserve collections for wheat presenting no actual interest but preserved for later.

In addition, each location evaluates new cultivars or lines from foreign countries which are afterwards added to one of the two groups or eliminated.

The INRA cereal working group, who federates these laboratories, decided to realize an inventory of the entries maintained in the INRA locations and to publish catalogues with passport and evaluation data. The first edition was published in 1987 for wheat 1989 for winter barley and led to an important sample distribution in France and foreign countries. Databases according to the ERGE system (Guillon & Le Targa 1990) are being set up in each location.

A wheat network has been organized to evaluate every year about 80 genitors issued from the different laboratories. The best performing ones are utilized as breeding parents. Other specific evaluations have been realized recently. A collection of 117 old french cultivars or landraces issued from several laboratories, and belonging to different groups (Table 2) has been evaluated for agronomical, morphological, technological and biochemical characters (electrophoresis of gliadins and HMW glutenins). Genetic distances calculated from agro-morphological characters and glutenin patterns, and parentage coefficient allowed to distinction of several groups according to origin. New alleles have been revealed; some old varieties had a good cold tolerance (Automne rouge barbu, Barbot, Rouge de St Ciergue). Some had a good technological value ('Rouge de Bordeaux' from prospection, Blé du Lot, Blé du Jura). The description of old cultivars was compared with the description published by Vilmorin-Andrieux (1880, 1900); only very slight differences could be revealed. In general, old cultivars seem to be more diverse as recent cultivars are more homogenous. This study should be extended to other old varieties or to foreign groups.

For barley, a similar work has been developed on 70 old french varieties (1988-1990), which were derived directly from landraces or had predominantly such material in their ancestry. Apart from the 2 row spring vs 6 row winter contrast, the morphological and agronomical diversity of this collection was relatively limited. However, interesting

Table 1. Main research topics of INRA wheat laboratories

Location	Main research topics
Clermont-Ferrand	technological value
Dijon	cold tolerance
Gis-Moulon	use of haploidy in breeding
Montpellier	durum wheat; adaptation of bread and durum wheat to mediterranean conditions
Rennes	disease tolerance: powdery mildew, septoria, fusarium, eyespot
Versailles	disease tolerance: viruses, rusts

reactions of BYMV (Barley Yellow Mosaic Virus) resistance were found in 1988 in some old winter 6 row cultivars, and confirmed in 1989 and 1990 in France and Belgium (Table 3). The polymorphism of this material has been studied for 6 isoenzymatic groups. Overall 33 alleles were distinguished for the 16 loci involved. Only 10 of these loci were polymorphic. Among the old French barley, 29 allozymes were described; individual alleles showed no marked regional groupings. Two of the 29 alleles had not been reported earlier: one slow aconitase ACO1, and a rapid NADH dehydrogenase NDH2. This work has been partially supported by an IBPGR grant.

French cereal inventory and evaluation networks with breeders

In 1988, the following partners were joined in a project we describe later:

- the Ministry of Agriculture,
- O.N.I.C. (National Cereal Office),
- I.N.R.A. (National Institut for agronomical research),
- B.R.G. (Genetic Resources Board),
- I.T.C.F. (Technical Institute for Cereals and Forage),
- S.P.S.S. (Breeder Union).

A direct and indirect (tasks, services, etc.) financial participation from these organizations made possible the engagement of a coordinator based in the Clermont-Ferrand I.N.R.A. location to work out an inventory of cereal genetic resources from the private firms in France. This work led to a national thought about the creation of a central unit for cereal genetic resources and to the coordination of genetic resource evaluation networks grouping public and private sectors.

Cereal genetic resource inventory in France

The curators of the French private firms were visited during the year 1988. The purpose of these visits was to inform personally about the inventory of the cereals project and to collect the questions and suggestions of everybody in order to define how to finally constitute a national collection open to all interested users (gathering public and private sectors). Twenty six cereal private breeders agreed to contribute to a national inventory; they undertook: to give the lists of the genotypes maintained in their collection that they considered as exchangeable and available; in a second step, to give the description of these materials in order to load a data base; and finally to transmit to the future central unity genetic resource sample from which they are the only holder in France.

Firstly, a few quantitative data on inventory: we made the inventory of 3464 wheat genetic resources in the private collections from which 1232 were already known and maintained by I.N.R.A.; concerning barley, 2500 genotypes were inventoried from which only 806 were already described in I.N.R.A. collection. Moreover, among the about 5900 inventoried genetic resources, about 3500 are represented by only one sample.

Besides the great number of genetic resources not included in the public collections, this inventory revealed a great number of genetic resources which are maintained in only one site in France; the importance of these genotypes as genetic resources is still to be proved

Table 2. Different groups and main cultivars studied

Group	Period of cultivation or introduction date	Genotypes
T.turgidum (T)	19th century	Aubaine blanche
		Milanais de Limagne
		Nonette de Lausanne
		Pétanielle noire de Nice
		Poulard d'Australie
		Poulard d'Auvergne
		Taganrock barbu
Old landraces (A)	before 1870	Automne rouge barbu
		Bladette de Besplas
		Herisson brun
		Précoce du Japon
		Rouge de St.Clergue
		Saissette de Provence
		Saumur (2 types)
Noé group (N)	1833	Noé
	1897	Gros bleu
	1892	Japhet
	1870	Melbor
	1860	Rouge de Bordeaux
English landraces (GB)	1850	Victoria d'Automne
		Browick
		Chiddam (3 types)
		Shireff blanc barbu
		Teverson
Recent. prospected landraces (P)		Barbot
		Barbu du Finistère
		Blé de Haute Loire
		Blé du Jura
		Blé du Lot
		Blé de Redon (2 types)
		Prospected "Rouge de Bx"
Bred cultivars (C)	1909	Alliés
	1931	Cappelle-Desprez
	1883	Dattel
	1950	Etoile de Choisy
	1933	Florence Aurore
	1907	Hybride hatif inversable
	1924	Hybride du Joncquois
		Institut Agronomique
	1945	Nord-Desprez
	1943	Petit Quinquin
	1927	PLM (3 types)
Recent cultivars (R)	1977	Arminda
	1980	Camp Rémy
	1964	Capitole
	1974	Courtot
	1982	Festival
	1978	Fidel
	1962	Moisson
	1983	Pernel
	1983	Thésée

though it is very difficult to define some criteria. In the meantime, even if some are related or similar, I.N.R.A. was appointed to collect samples of each of them to ensure the safeguard of these potential resources.

About the description of the materials, all the curators agreed on 20 descriptors in addition to a few passport data. For this agreement, we submited the list of the about 80

descriptors of our genetic resource data bases to the private and public curators and breeders; these descriptors were coming from the wheat and Barley descriptor lists edited by IBPGR. A first provisional catalogue was edited in 1989. It showed that many genotypes could not have been described completely or just for some characters.It enhanced the necessity of further evaluations. In this field, I.N.R.A. had already proposed to set up such networks, in order :

-to gain a better knowledge of the genetic resources or recently introduced genotypes;
-to improve the accessibility of the genetic resources for the breeding firms;
-to stimulate the use of genetic resources in breeding programmes.

Evaluation networks between public and private breeders

Almost all French cereal breeders expressed their interest in participating in the genetic resources networks. They represent in 1990 20 sites for barley and 25 sites for wheat. Considering that some breeders work on wheat as well as barley, it represents 37 different sites among which 6 are I.N.R.A. (Clermont-Ferrand, Rennes, Versailles, Dijon, Montpellier and Avail; the latter being only represented by rented field where the BYMV can be well observed).

Organization

The genotypes

For the moment, most of the proposed genotypes are issued from I.N.R.A. collections or foreign countries; some genotypes coming from private collections within the context of the inventory were added to this pool after one year of evaluation and multiplication in I.N.R.A.. It has been agreed that the greatest part of the genotypes in the network should be adapted material. Only a few less adapted genotypes should be introduced in the network list because of particular characters.

The evaluations

The characters observed in each site are not fixed but it is recommended to carry out a minimum of two evaluations per site, according to the most striking features expressed (i.e. a good disease development for example). Some descriptors like growth habit, heading date or plant height have no priority because they are well known and it has been decided that it is the responsibility of the central unit to describe the genetic resources for such stable characters. In any case, the material is at once pre-evaluated and multiplied by I.N.R.A. in Clermont-Ferrand.

The results

The evaluations are collected in August so that the results are available before the next sowing. This process includes the data for each descriptor or disease in each site, with the mean, standard deviate, maximum and minimum. About twenty standards are included in order to allow a better comparison of the evaluation results at the different sites.

Presently, each collaborator receives a written synthesis but we intend to send each one a microcomputer diskette while waiting to give direct access to the general database (by MINITEL for example, or computer network). Actually, these data will be incorporated in the future in a database named ERGE (Guillon & Le Blanc 1990), firstly in annual series (as test) and then, for the genotypes which are or will be introduced in the national genetic resource collection, in the main database. In this database evaluations are stored year after year, with multi-site means for each descriptor.

Conclusion

In conclusion, we wish to stress our gene bank conception: it will be, beside the grocer's shop aspect and the necessary conservation of national inheritance, a dynamic structure inside the breeders' world, inside the breeding problems. It has to set up the evaluation networks, to centralize and summarize the results, to include them in databases and to

provide the information. Moreover, one of its roles could be to introduce foreign genotypes or breeding lines and to make some primary crosses. It must be as close as possible to the breeders' preoccupations and it must stimulate the use of the diversity which it maintains.

We will end this communication with two questions :

-Why not an european wheat database and network as for barley, oat, rye, etc., and

-When ?

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Oil palm genetic resources - public and private sector collaboration

N. Rajanaidu
Palm Oil Research Institute of Malaysia (PORIM), P.O.Box 10620, 50720 Kuala Lumpur, Malaysia

Summary

PORIM has assembled the largest oil palm genetic resources in the world. The activities of genetic resources involve collection, establishment, evaluation, conservation and utilization. Collaboration between PORIM (public) and the plantation companies (private) begins from the initiation of a project until utilization of the elite genetic material found in the collection. PORIM is funded solely by the private sector for its research needs. Having identified the research priorities of the industry, PORIM allocates sufficient funds for collection, evaluation, conservation and utilization programmes. The PORIM's base collection is augmented continuously through the collaboration with various public, private both local and overseas and including international bodies such as IBPGR for funds and assistance in collection. The oil palm genetic resources are evaluated at various ecological niches of the country and the private sector provides sufficient suitable land to lay down trials to detect and quantify genotype x environment interaction. The close collaboration between public and private is further demonstrated at the time of utilization of oil palm genetic resources. The elite material from the collection is distributed to the industry without any delay. The materials are used to create new foundation stocks or to introgress the new genes into the existing stocks to broaden the genetic base of current breeding material which has extremely narrow genetic base.

Introduction

The collection, evaluation, conservation and utilization of genetic resources are largely funded by public bodies through national and international programmes. It is likely that funds for genetic resources activities will be limited in future. Hence, it is important to formulate new methods of collaboration in this field especially between the public and private sector. The private sector will be playing an important role in the food production and it is expected that private sector should be more involved in the genetic resources programme from the start. The main aim of genetic resources programmes is to increase the food production and it is imperative that the private sector is actively involved in the genetic resources programme from funding to utilization.

The oil palm (*Elaeis guineensis* Jacq.) has become a major source of vegetative oil. World production of major oils and fats in 1989 was 76.7 million tonnes (mt). Of this soyabean oil accounted for 19.5% and palm 13.4%. World exports of major oils and fats amounted to 25.5 mt in 1989 and exports of palm oil accounted 31.3% and soyabean oil 14.9%. Total world production of palm oil was 10.3 mt in 1989 and exports of palm oil amounted to an estimated 7.9 mt. Malaysia is the world's largest producer (58.8%) and exporter (70%).

The oil palm is a perennial, tree crop which is cross-pollinated. The palm oil is obtained mainly from the mesocarp of oil palm fruits of *tenera* fruit form. These *tenera* hybrids palms yield 4-5 t of palm oil (PO) and 0.5 t palm kernel oil (PKO) and 0.6 t palm kernel cake meal ha-1yr-1. The main application of palm oil products is for edible purposes such as cooking and frying oils and in the manufacture of margarine, vanaspati (vegetable ghee), ice cream, and cocoa butter equivalents all of which derive from PO. PKO can be used to produce soaps, confectionery fats, coffee whitener, oleo-chemicals such as fatty alcohols and glycerols. The palm kernel meal is an important source of animal feed.

The genetic base of current oil palm breeding programme is extremely narrow (Arasu & Rajanaidu 1975; Hardon & Thomas 1968). The bulk of the current planting material is based on 4 palms planted at Bogor Botanical Gardens in 1848. The need of an adequate

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genetic base for effective selection in a breeding programme is well known. It is generally recognized that the narrowness of effective gene pools has been a major obstacle to rapid selection progress. It was concern generated by this situation that provided the initial impetus for prospection for new oil palm genetic materials (Hardon 1974).

This paper outlines the experience of Palm Oil Research Institutes of Malaysia (PORIM) which has been involved in the management of oil palm genetic resources for the past twenty years. The collaborative efforts of PORIM and private in the management of genetic resources will be highlighted.

Palm Oil Research Institute of Malaysia and funds for genetic resources

PORIM is a public body which was established in 1979. The funds are provided mainly by the palm oil industry through a research cess levied on crude palm oil and palm kernel oil produced. For instance in 1989, Malaysia produced 6 million tonnes of palm oil and the industry contributed US $10 million as a research cess. Of this, US $.5 million was allocated for oil palm genetic resources activities (Fig.1).

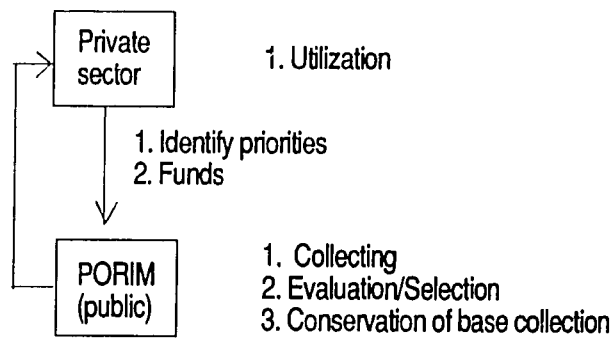

Fig. 1. Management of oil palm genetic resources at PORIM

The research priorities of the Institute is vested in the Board which comprises representatives mainly from the oil palm industry.

The Board is assisted in its decision-making by Programme Advisory Committee, a consultative body which scrutinizes PORIM annual research programme and makes recommendations to the Board. Most of the members are from the overseas specialized in various disciplines.

The Technical Advisory Committee (TAC) consists of senior research personnel from the Malaysian oil palm industry and local universities. TAC advises the Director-General on the selection and priority of research projects. In addition, details of the projects and utilization of genetic resources are discussed at PORIM Breeders Committee which is represented by industry and PORIM oil palm breeders.

Public/private sector collaboration in genetic resources activities

Collection

PORIM has assembled the largest oil palm germplasm collection in the world. In 1973, 180,000 seeds had been collected in Nigeria at 45 sites with the cooperation of Nigerian Institute of Oil Palm Research (NIFOR). In 1984, *E. guineensis* germplasm was collected in Zaire in collaboration with Unilever; collected 369 samples from 56 sites. PORIM and Unilever jointly collected 95 samples from 36 sites in the western and eastern regions of Cameroon. *E. guineensis* genetic collection was also carried out in 1986 in Tanzania and Madagascar with the cooperation of Departments of Agriculture in Tanzania and Madagascar with a partial financial assistance from IBPGR. Sixty samples from 13 sites were collected in Tanzania and 17 samples from 4 sites in Madagascar.

Table 1. Genotype x environment interactions in the oil palm

Source	DF	Yield	Bunch No.	Bunch Wt.
Sites (S)	2	120169***	3557.52**	1125 296***
Blocks (B) within sites	3	4313**	19 22	5.175
Families (F)	49	23189***	175.45***	191.605***
F x S	98	2215***	31.15**	7.268
F x B	147	1322	21.17*	7.189**
Between plants	1317	1122	16.49	5.584

A related species to oil palm, *Elaeis oleifera* germplasm was sampled in Colombia, Costa Rica, Honduras, Nicaragua, Panama and Suriname with the cooperation of Departments of Agriculture and private and public bodies in the above countries.

In 1989, PORIM with the cooperation of Instituto Colombiano Agropecuaria (ICA) collected germplasm of *Jessenia* and *Oenocarpus* in various parts of the country.

Maintenance, evaluation and conservation

The oil palm genetic materials collected in the above countries were maintained to conserve the germplasm as a base collection and to evaluate the germplasm. A part of the collection was distributed to the industry as a working collection to be evaluated at different parts of Malaysia in various ecological niches. At the same time, the genetic resources should also be readily available for utilization which, after all, is the motivating force behind any conservation efforts (Ooi & Rajanaidu 1979).

Evaluation of oil palm genetic resources at a very early part of the testing at different sites provided valuable information on genotype x environment interaction (Table 1).

The primary objective of maintenance is long-term conservation. However, we organized the experiments in proper statistical experimental designs so that it would be possible to evaluate potential of the material (Fig. 2)

The oil palm, being a fairly big plant, is planted at 148 palms ha^{-1}. This makes the maintenance efforts expensive. The collection from Nigeria alone occupies more than 200 hectares. Hence, the cooperation of the industry is vital to obtain land to test and conserve genetic materials. The private sector owns plantations throughout the country and every year about 5% of the land is replanted. Hence, it is possible to get suitable land for experimentation.

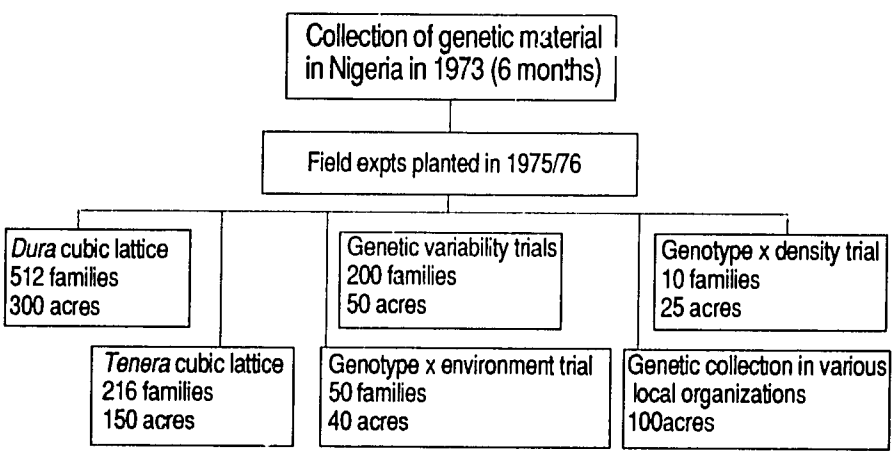

Fig. 2. Method of conservation of oil palm genetic resources collected in Nigeria in 1973

Preservation of collection through storage of seeds is not practical as the seeds can be stored for only two years (Reef 1960; Mok 1970). The oil palm can only be stored for three years. Genetic conservation through tissue culture and cryopreservation is being investigated but has not been fully developed. One great advantage of a living collection of palms is that the material is readily available for breeding purposes. Seed/pollen and tissue culture techniques are cheaper to conserve. However, it may require more than six years to evaluate and utilize the material. Eventually a method has to be devised to conserve oil palm genetic resources in the form of living collections and seed storage/tissue culture/pollen/cryopreservation tecnniques.

The genetic material laid down in various trials at PORIM and the private sector was evaluated for yield, bunch analysis, vegetative, physiological and fatty acid composition parameters. Records are taken on individual palms and data are stored electronically. Some of the characters scored are:

-Yield (Fresh fruit bunches = FFB)
-Bunch number
-Average bunch wt
-Mean nut wt
-Fruit/bunch (%)
-Mesocarp/fruit (%)
-Oil/dry mesocarp (%)
-Oil/wet mesocarp (%)
-Oil/bunch (%)
-Kernel/fruit (%)
-Shell/fruit (%)
-Mean fruit wt
-Frond production
-Rachis length
-Leaflet number
-Palm height
-Leaf area
-Bunch index = Bunch dry matter/Total dry matter
-Conversion efficiency (e) = Total dry matter/Theoretical total dry matter
-Leaf area ratio (LAR)
-Iodine value (I.V.)

Utilization of genetic resources by the private sector

The elite oil palm germplasm is being utilized by the industry in a number of ways for crop improvement. They are:

Direct selection of individuals

About 3% of the *tenera* in the Nigerian germplasm collection had oil yields comparable to current planting materials. A third of these palms had an annual height increment significantly less than current commercial DxP materials. Attempts are being made to clone these 1% palms by tissue culture technique by PORIM and the industry. The performance of selected *tenera*'s are given in Table 2. Data showed that the outstanding families and individual *tenera*'s are normally found in the East Central State of Nigeria.

Progeny-testing of Nigerian elite palms

Some of the extremely outstanding Nigerian *teneras* listed in Table 2 were progeny-tested with a range of *Deli duras* available in the industry and PORIM. The TxD or DxT hybrids and

Table 2. High-yielding and dwarf Nigerian *Tenera* palms

Trial No.	Family	Palm No.	Oil (p/yr - kg)	Oil (ha/yr - t)	Height (cm/yr)
0.149	28.17	12 724	83.34	12.18	23.1
0.149	19.11	12 279	75.94	11.24	21.5
0.149	13.05	12 094	76.27	11.29	24.0
0.150	16.21	4 352	70.39	10.42	24.9
0.150	19.13	3 759	71.54	10.59	22.5
Current planting material				5.0	45-75.0

their *dura* and *tenera* parents are being selfed simultaneously. The aim of the crossing programme is to progeny-test the Nigerian *tenera*'s to study their combining ability. The selfs will be used for seed production following the procedure of reciprocal recurrent selection (Jacquemard *et al.* 1981).

Broadening the genetic base of Deli dura's *and* tenera's

The overall genetic variability of current *Deli dura*'s and *tenera*'s could be broadened by crossing *Deli dura*'s with Nigerian *dura*'s, and *tenera*'s such as AVROS, La Me, Yangambi, URT, and 27B could be mated to Nigerian *tenera*'s or *pisifera*'s. These intro-gressed populations, with increased amounts of heritable variation for desired traits, will be the basis for further selection and breeding. Careful choice of the germplasm at this stage will increase selection efficiency and the probability of obtaining desirable segregants. Such selected palms can be expected to possess one or a combination of the following traits:

High bunch yield

It had been shown that outcrossing *Deli dura*'s with African palms gave marked increases in the additive variance for bunch yield and, especially, its components, and weight and bunch number per palm. The Nigerian germplasm palms gave relatively high yields. The main collection as a whole, covering 165 hectares on inland soils, gave FFB yields 23-24 tonnes (ha/yr) in the 8-10th year from planting. On coastal soils yields have been in excess of 25 tonnes (ha/yr) in the 8th year. Hence it is not at all surprising to find high yielding populations and individuals. Clearly the introgressing of such palms into existing breeding populations will maintain the yield potential, if not raise it, whilst broadening the selection base.

Superior oil and kernel content

Some Nigerian germplasm *dura*'s and *tenera*'s possess fruit characteristics matching the best *Deli dura* or best current *tenera*. The kernel content and O/B of some of the germplasm palms are also generally higher. Kernel-to-fruit ratios in excess of 20% are not uncommon in contrast to the 5-15% found in *Deli dura*'s and current *tenera*'s. Significantly, many germplasm palms with favourable bunch characteristics are off-spring of apparently mediocre *tenera*'s and *dura*'s. This would suggest the inherent presence of superior genes, in at least some populations, and should be considered in any programme of introgression.

Reduced height

Rapid stem growth is of major concern in oil palm plantations because harvesting costs escalate steeply as palms grow taller. Table 3 gives the height increment of the different populations in the germplasm collection and two current progenies commonly used. A

Table 3. Height growth of Nigerian germplasm population, measured on 7 year old palms

Pop	1	2	3	4	5	6	7	8	9	10	11	12	13
HI	-	14.7	17.3	17.3	17.9	22.2	20.1	20.6	20.0	15.4	17.4	-	12.7
Pop	14	15	16	17	18	19	20	21	22	23	24	25	26
HI	4.1	15.0	15.4	16.1	17.6	15.4	22.0	19.1	18.8	22.1	-	20.9	17.3
Pop	27	28	29	30	31	32	33	34	35	36	37	38	39
HI	19.4	18.1	18.7	19.1	20.6	19.7	19.9	-	20.3	19.4	17.0	-	21.1
Pop	40	41	42	43	44	45							
HI	19.7	19.4	17.7	14.6	15.9	14.6							

Pop: Population number
HI: Height increment (in cm/year)
Commercial progenies (measured on 8 year old palms) *Deli* x Yangambi - 49.0, *Deli* x La Me - 45.0
Source: FELDA Agric Services Corp. D x P planting materials handbookN. Rajanaidu

Table 4. Fatty acid composition of Nigerian material

Traits	Nigerian population		Current breeding material	
	Mean	Range	Mean	Range
C16:0	38.99	27.40 - 54.35	44.53	35.3 - 52.4
C18:0	6.14	2.50 - 12.60	4.51	2.9 - 7.9
C18:1	41.50	30.02 - 54.30	37.98	31.3 - 45.8
C18:2	10.76	6.60 - 16.50	11.36	6.0 - 15.7
IV	54.19	42.94 - 69.75	52.21	45.2 - 59.5

C16:0 = palmitic, C18.0 = stearic, C18:1 = oleic, C18:2 = linoleic, IV = iodine value

number of families in certain populations have particularly low values for both mean and variance. The germplasm palms will be able to contribute greatly in this respect. Selected short *dura*'s, *tenera*'s and *pisifera*'s from such families would be utilized in outcrossing current tall breeding palms.

Superior oil quality

The fatty acid composition of palm oil produced from current planting materials limits its share of the liquid and salad oils market. More than 3000 palms from the Nigerian collection were individually screened for their fatty acid composition to examine variation and the potential for exploitation. The mean composition and range are given in Table 4 along with the composition of present Malaysian palm oil. Many individual palms had iodine values (IV), in excess of 60.

In addition, the glycerides distribution for some germplasm palms was also examined. Interestingly, relatively enhanced levels of C52 and C54 triglycerides have been found in some palms whilst other traits are being examined to explore the possibility of developing palms yielding specialty oils (Rajanaidu & Tan 1983).

Foundation breeding programmes

The germplasm palms will also be used to initiate entirely new breeding programmes with the objective of producing superior alternatives to the *Deli dura*'s and modern breeding *tenera*'s. The presence of *tenera*'s comparable to the best of current materials but arising from Nigerian *dura* x Nigerian *pisifera* suggests that such alternative do occur. A judiciously selected range of *dura*'s and *tenera*'s will be involved in designs that encourage fixation of genes, for superior DxP combination, in *dura* and *tenera* populations.

International oil palm genetic resources network

The International Board for Plant Genetic Resources (IBPGR) convened a Working Group on Oil Palm Genetic Resources on 19-21 September 1984. Representatives from the public and private sector attended the meeting to review all aspects of oil palm genetic resources. The present IBPGR Working Group should be strengthened to play to a meaningful and effective role in the collection, conservation and utilizing of oil palm genetic resources, especially *in situ* conservation where PORIM has a large volume data pertaining to genetic structure of natural populations.

Future role of public and private sector in oil palm genetic resources management

At present the public sector is mainly involved in the collection, evaluation and conservation of oil palm genetic resources. The development of planting material is with private sector. In future, it may be necessary to develop collaborative programmes between public and private sector from the beginning. It is effective if the team consists of both scientific and business skills. Any successful venture could be marketed readily and arrangements could be made in such a way that the profits are shared between the public and private bodies in an equitable manner.

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Global warming: the case for European cooperation for germplasm conservation and use

M.T. Jackson
Plant Genetics Group, School of Biological Sciences, The University of Birmingham, P.O.Box 363, Birmingham B115 2TT, United Kingdom

Summary

Two premises underpin the ideas presented in this paper. First, CO_2 emissions will result in climatic change, as a result of global warming, although the rate and magnitude of change cannot be predicted with certainty. Secondly, germplasm evaluation is an activity which is an integral component of genetic resources conservation and utilization programmes. Global warming will have important consequences for two aspects of genetic conservation, namely *in situ* conservation and regeneration of germplasm. *In situ* conservation of wild species based on present eco-geographical distribution patterns will become an unrealistic strategy if climate belts shift northwards as has been predicted from the various general circulation models (GCMs). The regeneration of germplasm must be given greater consideration under global warming, particularly for outbreeding species, since changed environmental conditions might lead to differential fertility between parents. Steps must be taken to reduce the loss of genetic variability. Global warming will bring about additional stresses in the agricultural environment which must be faced by plant breeders. Since such warming will transcend national boundaries, there are sound reasons for closer collaboration between germplasm programmes across Europe via crop networks. Arguments will be presented for continent-wide germplasm trials, to obtain estimates of genotype x environment interaction. In Europe, north to south and west to east, there is a wide range of climatic conditions at present, particularly in terms of temperature gradients which approximate to conditions predicted to occur under a future 2 x CO_2 climate. Barley will be used as an example, since there are many collections of this crop throughout Europe, many of which are already linked through the European Barley Database.

Introduction

It is my intention in this paper to raise a number of issues related to the conservation and utilization of plant genetic resources which I hope will stimulate discussion amongst plant breeders and genetic conservationists. First of all I shall present a brief discussion of some of the widely accepted predictions of climate change in Europe which will result from global warming caused by the so-called 'Greenhouse Effect'. I shall then go on to discuss two aspects of germplasm conservation, namely *in situ* conservation and regeneration strategies which might be affected directly by global warming. Finally, I shall evaluate some ways in which germplasm specialists and plant breeders might respond to the threat of global warming, and which are linked to the theme of the EUCARPIA/IBPGR symposium on crop networks.

Global warming and climatic change

The first question we need to ask is whether global warming is something about which we should actually worry? Certainly there has been a lively debate in the scientific and popular press, for and against the likelihood of global warming. Whilst this controversy will continue unabated, a consensus does appear to be emerging amongst scientists that global warming is a phenomenon which mankind must face over the next 40-70 years. This

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certainly was the message which came from the Second World Climate Conference held in Geneva at the end of October 1990.

Causes of global warming Global warming will be caused by an increase in atmospheric concentrations of radioactively active gases, which will continue to increase unless measures are taken to curb emissions. The greenhouse gas which has been changed most by man in terms of its potential effect on climate is CO_2. The increase in CO_2 starting in the eighteenth century has been partly due to man's effect on the earth's vegetation, notably deforestation, and increasingly to fossil fuel burning. Other greenhouse gases include methane (CH_4) and CFCs. Contributions of CO_2, CH_4 and CFCs to the greenhouse effect are estimated at about 60, 30 and 10% respectively (Rowntree 1990).

At the present time there are sound theoretical reasons, according to Rowntree (1990) for anticipating a change in climate larger than any the world has experienced since the end of the last Ice Age, over 10,000 years ago. Temperatures are predicted to rise to higher levels than any experienced during the last several hundred thousand years. Most estimates of future climate change are derived from results of experiments with general circulation models (GCMs) because these at the present represent the best means of estimating the climate of the future. One broad type of scenario is that derived from 2 x CO_2 equilibrium experiments, that is a situation under which there is an increase in greenhouse gases equivalent to a doubling of atmospheric CO_2. This doubling has been estimated at 460 ppm by about 2030, and represents an approximate 60% increase over pre-industrial levels (IPCC 1990).

Critical uncertainties One of the principal problems with using GCMs, is that although they agree in the general climatic trends which can be anticipated, the rate and magnitude of changes cannot be predicted yet with any certainty, and confidence in any one prediction of changes at the regional scale, particularly of rainfall, must be regarded as low. Despite these constraints, should we ignore the probability of climatic change, as some undoubtedly will suggest, or should we look at some of the predicted changes and then evaluate any responses? I favour this second approach.

Predictions of the effects of future climatic change range from wild exaggerations in terms of sea level rises, for instance, to more conservative estimates of temperature increases. One recent publication gives a reasoned account of the probable effects of climate change on world agriculture (Parry 1990). Under one 2 x CO_2 scenario, mean temperatures in the mid-latitudes (30-60°N and S) are estimated to rise by 2-4°C, but smaller rises of 1.8°C are predicted for low latitude regions, although semi-arid regions may warm more. There are great uncertainties about future changes in precipitation. In the higher northern mid-latitudes (45-60°N) an increase of 5% in summer and as much as 15% in winter could occur. An increase in potential evapo-transpiration can be expected in the order of at least 5% per degree of warming (IPCC 1990).

Climatic change in Europe How will such climatic changes affect Europe? In broad terms, the northern countries of Scandinavia are expected to gain from global warming more than any other region of the world. In Finland, for example, the equilibrium 2 x CO_2 climate is predicted to be wetter than present and about 4°C warmer. In northwest Europe, conditions would allow the extension northwards by perhaps several hundred km of crops which are barely profitable at present, such as maize and sunflowers (Parry *et al.* 1989).

In the Mediterranean region quite substantial decreases in productive potential could occur if the GCMs are correct in predicting decreases in soil moisture in the summer, and possibly also in the winter months. Under the U.K. Meteorological Office BMO 2 x CO_2 climate, with a 4°C warming and with annual rainfall reduced by >10%, biomass potential in Italy and Greece is projected to decrease by 5% and 36%, respectively (Santer 1985). There may therefore be a striking contrast between northern and southern Europe in terms of biomass potential, suggesting a northward shift of agricultural potential.

In the Alps, a temperature increase of only 1°C would raise climatic limits to cultivation by about 150 m (Balteanu *et al.* 1987), and should an increase of 4°C be reached, then climatic zones in the Alps might be raised by 450-650 m, similar to those which currently exist in the Pyrenees which lie 300 km south of the Alps.

C_3 and C_4 plants It is also important to consider the different responses of C_3 and C_4 plants to enhanced CO_2 levels. For C_3 plants, a doubling of ambient CO_2 on productivity has been shown to be beneficial, through the so-called 'fertilizing effect' of CO_2, and a 10-50% increase in dry matter can be expected under some circumstances (IPCC 1990). However, interactions with other environmental conditions are critical in determining the net effect of increased CO_2 (Morison 1988). Future warming clearly depends on the warming we are already 'committed' to and on future trends in greenhouse gas concentrations.

In situ conservation

It is clear that *in situ* conservation has received greater attention in recent times, but such strategies cannot be applied to crop plants with any degree of security for their long-term conservation. *In situ* conservation methods are those that maintain germplasm in wild populations by paying due regard to the natural ecosystems in which the conserved populations are a part (Ingram & Williams 1984). Since species are preserved in their natural habitats, they have the potential for continued evolution. The important question to ask, however, is 'To what extent is *in situ* conservation a viable component of a genetic resources programme under global warming?'. Conservation of ecosystems does not ensure continuing adaptive change unless the genetic base of the species is sufficiently wide (Frankel 1970). Williams (1990) has raised a number of issues related to climatic change and conservation strategies. Wild species survive in the field because they are adapted to particular environments. Some have a much wider environmental tolerance. Clearly the ability to survive will depend upon the potential of plant populations to adapt to environmental change. Yet the time-frame envisaged for a doubling of atmospheric CO_2, and consequent warming is only about 40-60 years, clearly a very short time span for such adaptation to occur.

The example of forest tree conservation If *in situ* conservation of annual species is problematical, what are the implications for long-lived perennials, such as forest trees? There are some data of the effect by man on forest tree populations and as Hattemer and Gregorius (1990) have pointed out, man-made atmospheric change adds a new environmental factor to those already exerting an influence on the evolution of populations. Forest geneticists in Germany have studied the effect of gaseous pollutants on conifer clones. Individual adult trees in environmentally stressed stands were damaged to different extents, and the variation between tolerant and susceptible trees could be attributed to genetic causes. By analogy it should also be possible to use these data to predict what might happen to forest trees and other species populations under climatic change.

Hattemer and Gregorius (1990) have recognized three different goals which may be achieved by conserving gene resources:

- preserving the potential of desired trait expressions;
- preserving genetic adaptability;
- preserving unrecognized genetic variation.

Whilst these points apply broadly to all genetic conservation strategies, they are particularly relevant to consider in terms of *in situ* conservation stands for forest trees. Trait expressions are unique to present environmental conditions, and an assessment of economic value relates only to current market situations. In terms of genetic adaptability, this depends on the range of diversity within populations. If we cannot predict accurately what future climatic conditions will be, then this goal of genetic conservation becomes more important. The third point disregards actual or potential use in favour of conservation of the widest range of genetic variation, without taking into consideration either present economic value or adaptation to past environmental change. *In situ* conservation is a dynamic process (Guldager 1975). It can be argued for long-lived perennials such as trees, which will be expressed to heterogeneous environments both in space and time, that populations which are conserved by static methods would display severe lack of adaptation when exposed to changed environmental conditions, even if static methods were completely feasible. Consequently, this indicates that dynamic conservation aimed at the preservation of

adaptability should be given priority under global warming (Gregorius 1989).

The sort of environmental changes which are expected as a result of global warming will be selective. Some changes like increased CO_2 will be advantageous in one respect, because of the fertilizing effect of increased atmospheric CO_2, but this is expected to reduce foliar nitrogen content. It is anticipated that this will alter the dynamics of host-parasite relationships, as pests consume greater quantities of leaf material to obtain the same nutritive value as a smaller quantity at current CO_2 levels (Hattemer & Gregorius 1990).

The adaptability of species populations The adaptability of plant populations to colonize new areas must also be evaluated when considering *in situ* conservation strategies. Peters and Darling (1985) and Peters (1988) have outlined some of the consequences of the design and implementation of *in situ* reserves under a changing climate. It is likely that the present ecogeographical ranges of some species will be altered (Grime 1990). Species which have a narrow distribution are under greater threat than those which are more widely distributed. Furthermore, the establishment of *in situ* reserves today at one location may become inviable after climate belts have shifted. In addition, whether or not plant species have the capacity to migrate from refuge sites, there remains the intractable problem that migration will need to take place over a short period of time. What's more, mankind has created what might be considered as a desert over which colonization will be extremely difficult, since natural ecosystems have been transformed to agriculture, or landscapes have been covered with concrete and tarmac. Under these circumstances plant migration will be slow and hazardous (Peters 1988).

It is important therefore that due consideration be given to these problems across Europe, and that those concerned with either natural ecosystem preservation or genetic conservation begin a dialogue to evaluate what possible responses to global warming might be, and how cooperation can be established.

Regeneration of germplasm

In terms of germplasm regeneration strategies there are just a few points relevant to consider in terms of global warming. Gale and Lawrence (1984) have evaluated the decay of variability, particularly in outbreeding species over successive generations of a genetic conservation programme. Since genetic conservation is normally achieved with relatively small populations, the chances for genetic erosion to occur are quite high unless steps are taken to avoid this. Gale and Lawrence (1984) point out that a population under conservation may lose variability owing to natural selection, which is likely to lead to a deterioration in the economic qualities of a crop. Natural selection will be minimized if plants are raised under optimum conditions, and if the genetic contribution of different parent plants to the next generation is made equal.

Environmental change due to global warming might increase the relative pressure on particular populations. Differential fertility between parents during regeneration brought about by lack of adaptation will increase the probability of some loss of variability over time. Whether regenerating material under present climatic conditions or under a future 2 x CO_2 climate, the arguments for avoiding open pollination in outbreeding species remain the same, and steps should be taken to maximize the maintenance of variability. It may be necessary to give greater consideration to careful cross pollination when regenerating seed lots than perhaps is economically feasible at present.

In Europe the consequences of climatic change for germplasm conservation *ex situ* are perhaps less immediate than elsewhere in the world, where changes in precipitation patterns for example would seriously limit the field multiplication of some crops, at some gene bank sites. Nevertheless, germplasm collection curators should be aware of the implications of climatic change for this aspect of *ex situ* germplasm conservation.

Evaluation and utilization of plant genetic resources

Faced with the threat of climatic change how should plant breeders and germplasm specialists respond? Should we, as some have suggested bury our heads in the sand so to speak and ignore the issue, or should we examine the strategic options for a worst case scenario?

Responses to climatic change

There are several questions which should be asked. First, is it possible to breed for climatic change? Assuming that this is feasible, do plant breeders already have sufficient genetic variation to fulfil this breeding objective, and what will be the role and importance of plant genetic resources collections? Finally, what sort of characters should be studied, and in what ways can germplasm be identified that will increase adaptation to new environments?

Analogue regions

One response to climatic change has been described by Parry and Carter (1990) as the identification of 'analogue regions', which have a present-day climate that is analogous to the future climate estimated for a study area. Analogue regions could be effective in illustrating the magnitude of climatic change within a region in terms of the present day differences between regions. Furthermore, it is suggested that present day farming types in analogue regions are a useful indicator of the adaptive strategies likely to be required to retune agriculture to altered climatic resources. There are of course several difficulties with this approach. In terms of the use of germplasm and crop improvement, one of the most important general difficulties with respect to crop growth is the variation of daylength with latitude. Crop varieties at high latitudes are bred for short growing seasons with high photoperiods, so although the shift of crop varieties from current lower warmer latitudes to higher latitudes would make sense from a climatic point of view, these varieties may not be adapted to the long daylengths.

Utilization of relevant genetic resources could be simplified if it can be assumed that the future climates of a region have previously occurred elsewhere. Even in temperate regions many of the new climates met under greenhouse warming will not be copies of present-day climates in warmer regions (Rowntree 1990). This is because the solar radiation regime and often the rainfall will continue to be controlled largely by latitude. Thus climates will be created which have no precedent. For example, winter temperatures similar to those of northern Spain will occur in a more northern land where the days are shorter than previously observed with such temperatures. Similarly, northern continents will experience summer warmth with longer days than previously were associated with such temperatures.

Screening germplasm for temperature and photoperiod sensitivity Richard Ellis and his colleagues from the Plant Environment Laboratory at the University of Reading have conducted many experiments aimed at studying the relations between temperature and crop development. Gene expression for many characters is quantitative. The results of research with diverse genotypes in several contrasting crops have shown that although the actions of temperature and photoperiod ultimately result in the same event, namely flowering, responses to these factors are independent. Ellis *et al.* (1990) therefore suggest that these factors could be selected for separately, and that it would be prudent to anticipate these problems in screening germplasm collections in crop improvement strategies which need to have more distant time horizons than current breeding programmes

How might this be achieved? Germplasm response to an elevated CO_2 atmosphere can only be carried out under controlled environment conditions, which are probably beyond the scope of most germplasm programmes. However, throughout Europe, from north to south, from Scandinavia to North Africa and west to east, from Ireland to the Soviet Union, there already exists a wide range of climates, many of which have the temperature characteristics similar to predicted future climates. Obviously it is necessary to ignore the actual direct effect of elevated CO_2 concentrations, which are assumed to be positive, and the combination of higher temperatures with longer photoperiods.

A European network of field trials There is one way perhaps in which collaboration between germplasm collections might be initiated, through the establishment of regional field trials across Europe to evaluate the magnitude of genotype x environment interactions. In this way it should be possible to evaluate germplasm for both temperature sensitivity and photoperiod response, and at the same time test the validity of analogue regions, for which there has been no experimental work.

Barley would seem to be an excellent candidate crop as a model for such collaboration. As an autogamous diploid, it can be expected to be weakly buffered genetically such that

genotypic responses to environment should be more easily detected. Secondly, the concept of a crop network for barley is quite well established, and a core collection for this crop is being formulated. Furthermore, a European barley database has already been compiled (Knüpffer 1988).

In the most recent IBPGR directory of cereal germplasm collections, Bettencourt and Konopka (1990) list 68 institutes which maintain collections of barley in Europe and North Africa. I believe that these collections should begin to collaborate to evaluate barley germplasm systematically in a network of field trials in which both improved varieties and landraces from each collection would be included, and trialed extensively throughout Europe to obtain estimates of G x E. Trials such as these are already routine for the international centres such as CIMMYT and IRRI, with their international nurseries for wheat and maize, and rice respectively. The International Potato Center undertook some research some years ago with scientists from Agriculture Canada, based on field trials of the same varieties in different countries, in an attempt to predict the performance of different potato varieties under different environmental regimes (Young & Tai 1983).

Plant breeders in Europe have perhaps never been faced before with a challenge such as climatic change which will require a response transcending national boundaries. Through the establishment of crop networks, it should be possible to develop different research strategies, in which germplasm evaluation must be an important component, to generate practical responses to the environmental changes which will be brought about by global warming.

The link between genetic conservation and global warming

One last point I should like to raise concerns the importance of germplasm evaluation per se. I believe that in due course, say in the next five years, we may have to justify why large sums of money are being spent on germplasm conservation. Since we are not concerned with establishing museum collections of germplasm, we shall have to demonstrate the importance of plant genetic resources for plant breeding. This may be difficult, since the actual utilization of germplasm collections is perhaps not as high as we might expect.

Climatic change is an environmental issue that is now clearly on the political agenda in many countries in Europe. Since the use of germplasm can be considered as one strategic response to global warming, it is important to stress the link between genetic resources conservation and this issue, in order to ensure continued support for genetic resources activities.

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