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ICARDA's Genetic Resources Unit

Conserving Genetic Diversity

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Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 18 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is a consortium of over 40 countries, international and regional organizations, and private foundations.

ICARDA focuses its research efforts on areas with a dry summer and where precipitation in winter 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 their associated farming systems.

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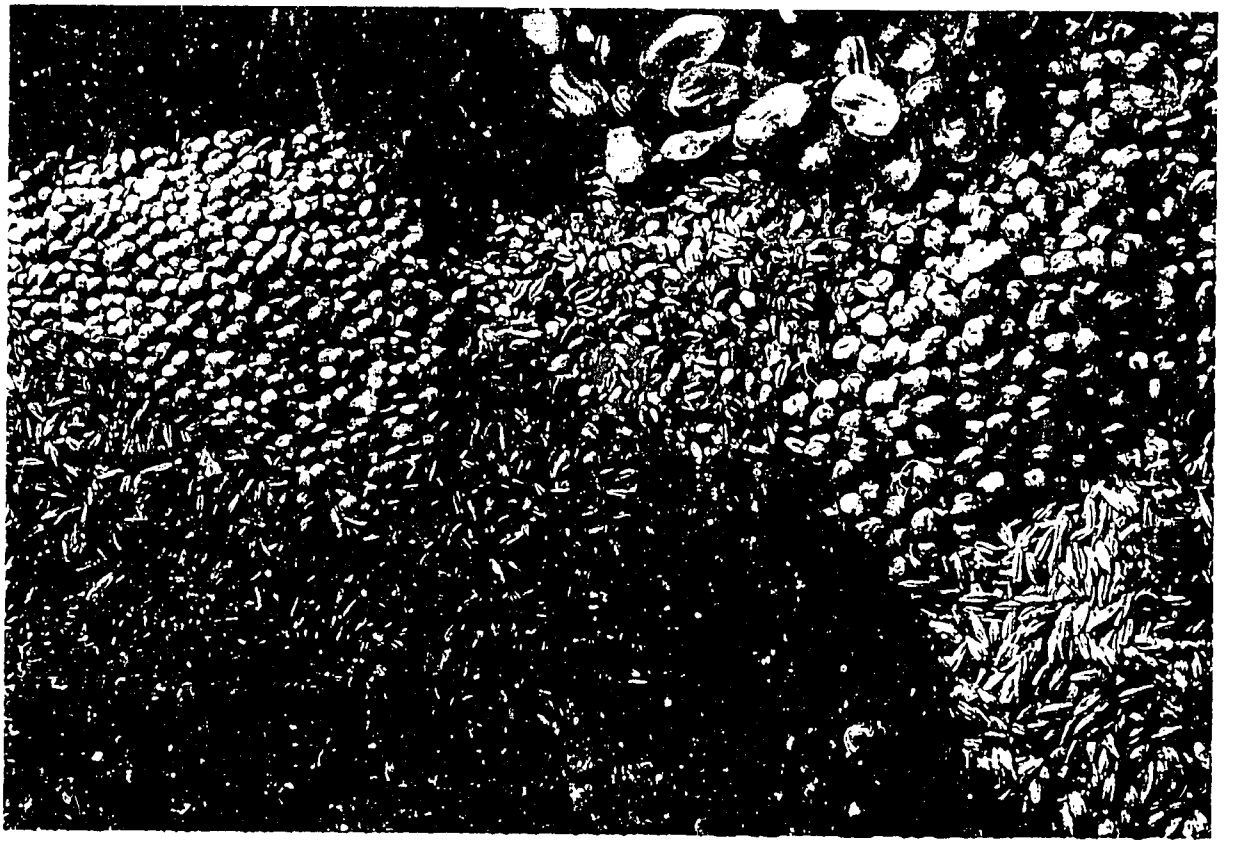
Crop Germplasm — a Precious Resource

Genetic diversity of crop plants is one of the world's most precious resources. The principal aim of preserving genetic resources of our crop plants in genebanks is to prevent the extinction of some of our oldest crop varieties and their wild relatives. These genetic resources are available to breeders now and in the future as scientists search for genes to combat new production constraints.

Several landraces (old crop varieties that are well adapted to specific local environmental conditions) were lost as they were replaced by newly developed, better-yielding cultivars or were destroyed by natural or man-made calamities. This has led to increased attention on collecting and preserving seeds (germplasm) of threatened landraces and other germplasm. Gradually, as improved varieties became available, conservation of plant genetic resources has become a crucial task of fundamental and strategic importance. A large proportion of germplasm needed for crop improvement in the future will be from genebanks such as the one operated by the Genetic Resources Unit of the International Center for Agricultural Research in the Dry Areas (ICARDA) near Aleppo, Syria.

Conservation of plant genetic resources has become a crucial task of fundamental and strategic importance.



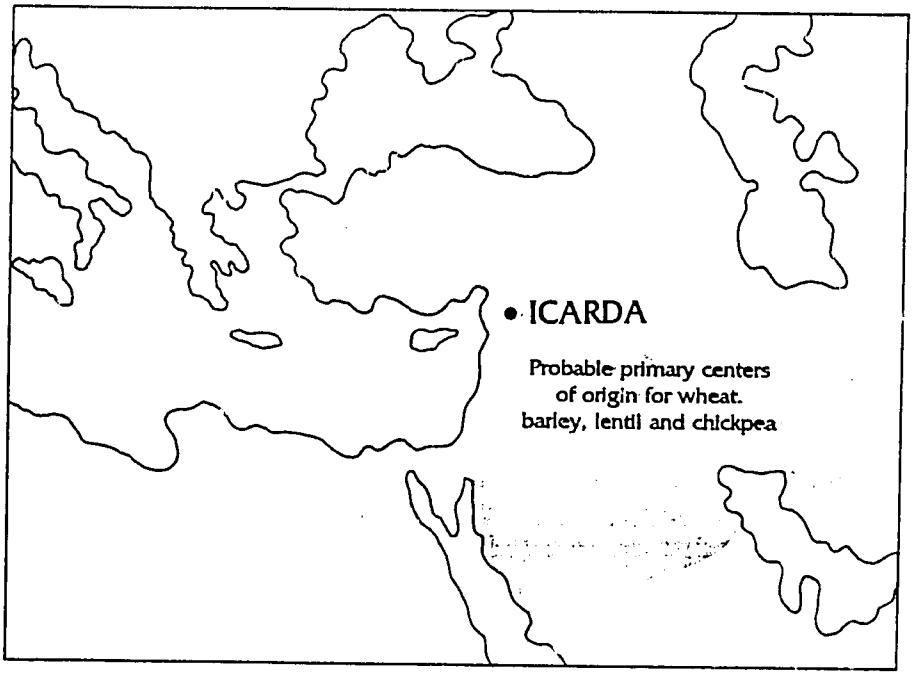
The Genetic Resources Unit serves the West Asia and North Africa (WANA) region as a repository for a world collection of ICARDA's mandate crops and their wild relatives. The International Board for Plant Genetic Resources (IBPGR) has designated ICARDA as a center for holding a global base collection of wheat and barley, chickpea, faba bean and lentils, including their wild relatives. The Center thus holds the various germplasm collections in trust for the benefit of the world community.

ICARDA holds a global-base collection of barley, wheat, chickpea, faba bean and lentil, including their wild relatives.

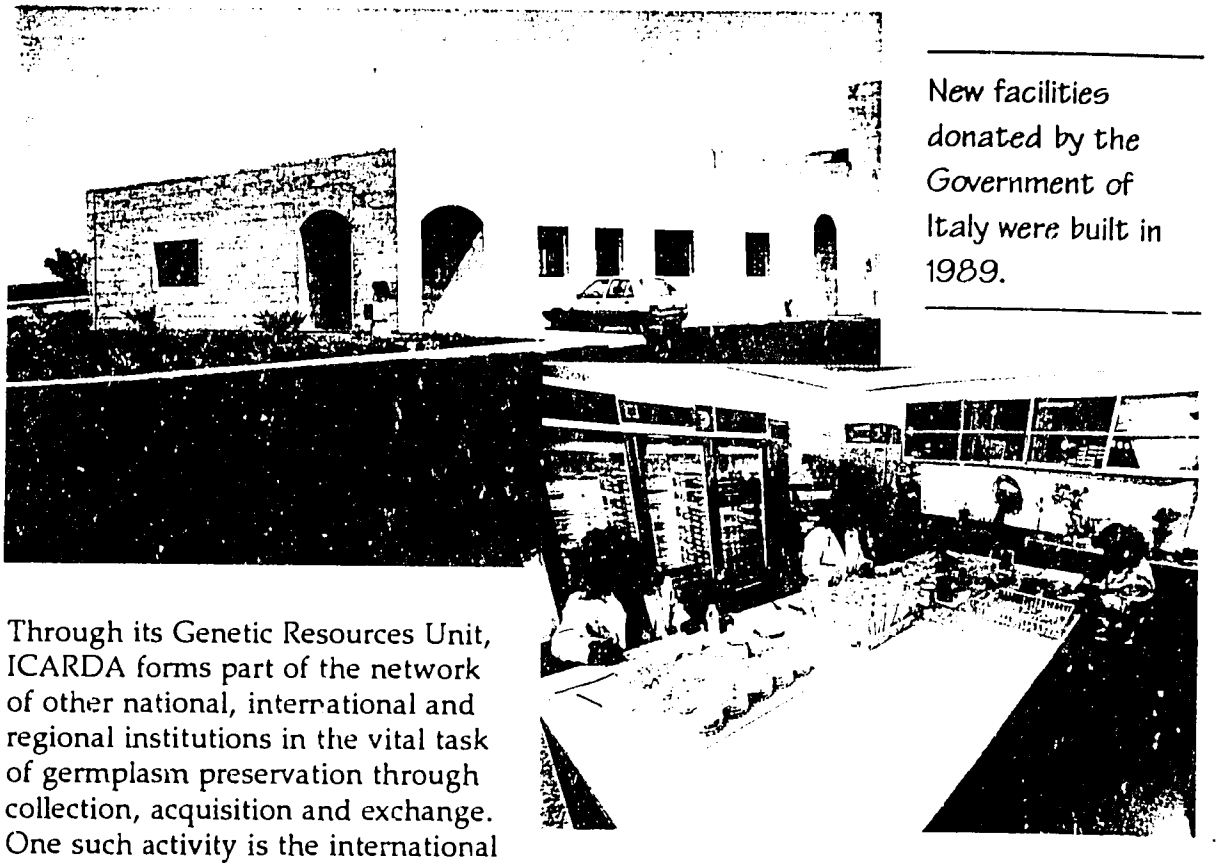
ICARDA's Crop Mandate

Barley (*Hordeum vulgare*)
Durum wheat (*Triticum durum*)
Bread wheat (*Triticum aestivum*)
Chickpea (*Cicer arietinum*)
Lentil (*Lens culinaris*)
Faba bean (*Vicia faba*)
Forage legumes (*Medicago* spp., *Pisum* spp., *Trifolium* spp., *Vicia* spp., *Lathyrus* spp.)

ICARDA's location in the center of origin of most of its mandate crops provides a unique opportunity to explore, collect, conserve and evaluate germplasm. Two of the Genetic Resources Unit's major tasks are documenting the acquired information, using the most modern methods, and making it readily available to scientists in national programs of the countries ICARDA serves.



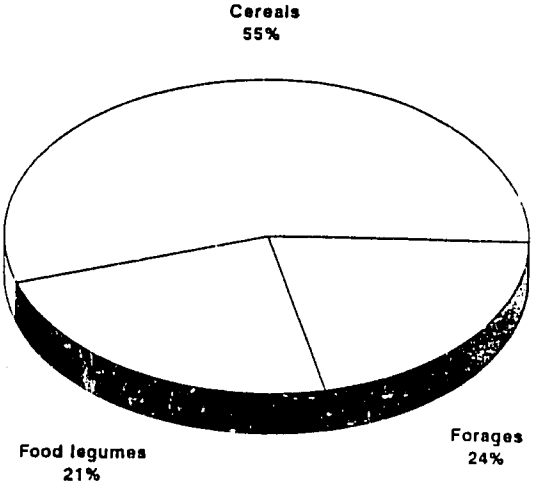
In addition to the continuing support by the Consultative Group on International Agricultural Research (CGIAR), the United Nations Development Program (UNDP) and other donor agencies, a substantial financial contribution to construct and operate a new genebank and strengthen the Genetic Resources Unit at ICARDA has come from the Government of Italy.



New facilities donated by the Government of Italy were built in 1989.

Through its Genetic Resources Unit, ICARDA forms part of the network of other national, international and regional institutions in the vital task of germplasm preservation through collection, acquisition and exchange. One such activity is the international network of genetic resources conservation programs in the WANA countries.

At the beginning of 1992 the accessions of ICARDA's mandate crops and their wild relatives numbered 89,000, representing germplasm from 90 countries. They include 49,000 cereals, 19,000 food legumes and 21,000 forages. Major sources of germplasm so far have been the Germplasm Institute, Bari, Italy; the USDA National Small Grains Collection, Aberdeen, Idaho, USA; and several other national institutions. In 50 germplasm collection missions organized by ICARDA, 17,000 accessions were collected.



Assembling a Collection

Assembling a comprehensive genetic resources collection has been a challenging task. The most critical requirement for achieving our objectives is to explore and collect the germplasm most threatened with replacement by modern bred varieties or by genetic erosion caused by such phenomena as rapid urbanization.

Collecting activity continues in areas of substantial genetic diversity as well as in the relevant underexplored areas in WANA. Areas generally covered by collecting missions include those with unique climate, ecology, crop history and cultural practices, which may endow the indigenous germplasm with certain traits that could be very useful to future crop improvement programs. These traits could be tolerance to drought and extremes of temperatures, disease resistance and good industrial quality.

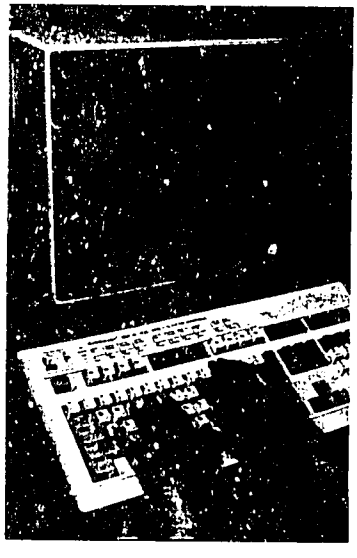
The GRU has promoted cooperation between ICARDA and national programs through joint participation in exploration and collection activities.

The Genetic Resources Unit has promoted a high degree of cooperation between ICARDA and national programs through joint participation in exploration and collection activities. A Genetic Resources Committee has been established at ICARDA comprising breeders from the commodity programs and genetic resources scientists to provide a consensus on the need to observe certain traits during evaluation and to determine future collecting strategies for the mandate crops.

Cooperation with the IBPGR is also sought, when needed, for joint collecting and training activities. Subsets of samples collected by all missions conducted by ICARDA are shared with national programs and left for study and conservation in the source country.

Documentation and Evaluation of New Germplasm

All seed material brought to ICARDA is examined closely by the national plant quarantine authorities and undergoes seed health laboratory inspection before it is admitted and registered at the Genetic Resources Unit. Information on all accessions held at the Genetic Resources Unit is stored in a computer data bank. The material is then characterized by growing it during the next available season. The new germplasm is subsequently observed for a certain number of stable traits and evaluated for characters of current interest to breeders. The IBPGR descriptor lists are followed with regard to methodology of character scoring and format for data recording only.



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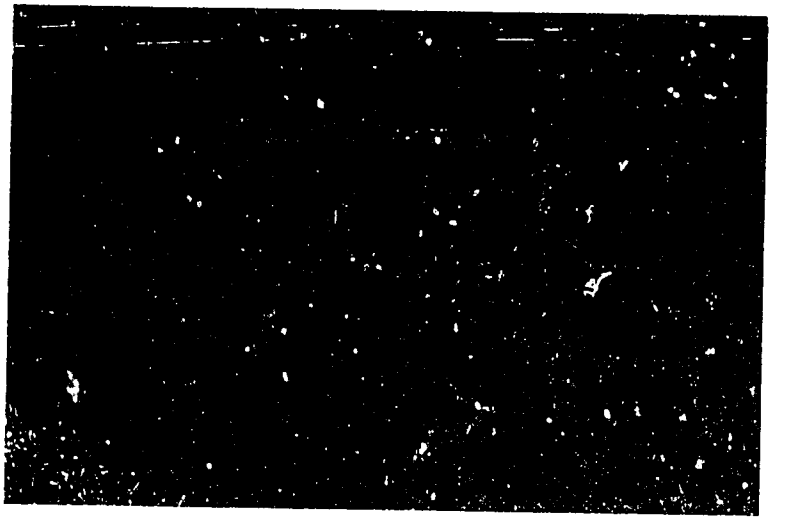
Examples of some major identifiable traits are early growth vigor, number of days to flowering, plant height, number of days to maturity, number of seeds per head or pod, seed color, tolerance to biotic and abiotic stresses and seed yield per plant. Each accession is then multiplied as a bulk seed sample and/or distinct individual lines, if many distinct morphotypes exist in a population sample.

Germplasm collections are taxonomically classified and evaluation data and information of origin as well as the collection site are recorded and stored in ICARDA's Data Management and Retrieval System.



After systematic registration, computerized documentation, characterization and conservation, selected germplasm samples are evaluated in depth by an interdisciplinary team of scientists that includes pathologists, entomologists, physiologists, seed quality specialists and scientists from national programs. The main aim of this work is to assess the full potential of the germplasm for future breeding work.

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Information on passport and evaluation data is published regularly in germplasm catalogs. The catalogued information is increasingly being made available on floppy diskettes which can be read on personal computers.

The Genetic Resources Unit also supports two international data bases, one on wild wheat, including *Aegilops*, and one on forages from the Mediterranean basin; which was initially created through collaboration with the IBPGR.

A number of trainees from national programs have benefitted by participating in this evaluation exercise; it gives them an opportunity to identify superior germplasm from a sea of diversity.

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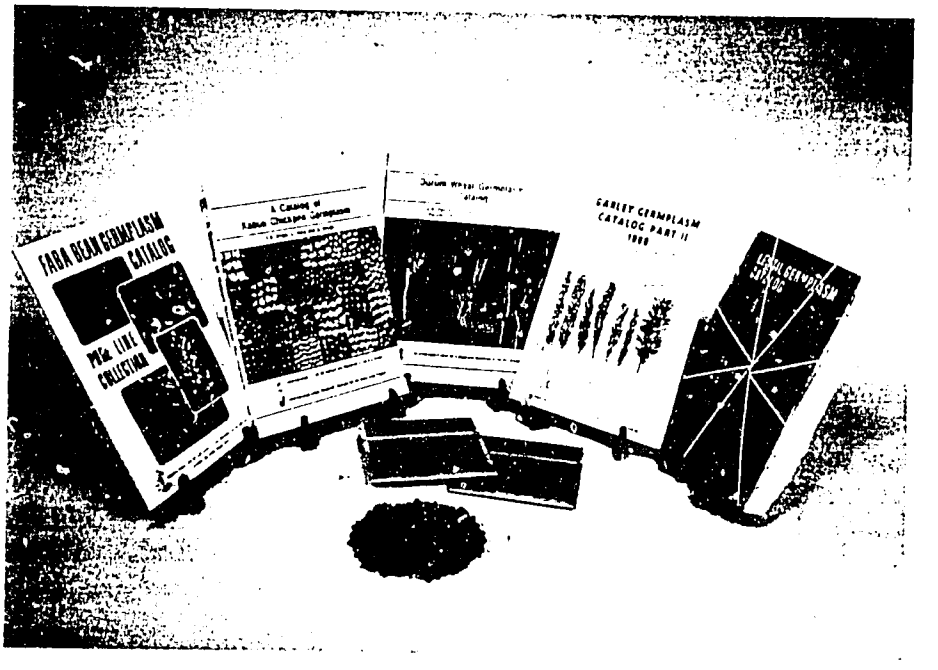
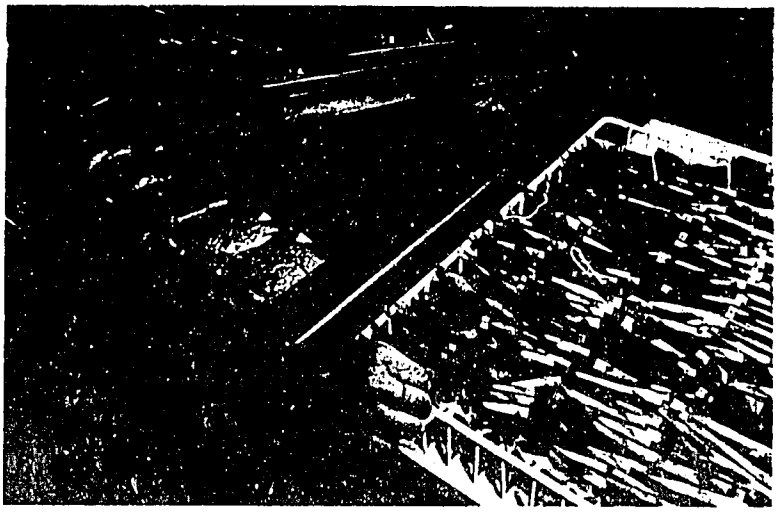


Conserving Germplasm



Systematic and careful preservation of germplasm, stored as seeds, eliminates frequent growing out of the collection for rejuvenation, which is a time-consuming and expensive process. It also avoids the dangers of contamination, outcrossing, unwanted selection pressures and human error during rejuvenation, which can nullify the value of a sample. In the Genetic Resources Unit at ICARDA, controlled environmental storage—low temperatures and low relative humidity—is used for medium and long-term conservation.

After drying, the seeds are packed in plastic containers and stored in the medium-term storage, which at ICARDA's genebank operates at 0° C and a controlled relative humidity of 15-20%. In this way seeds of most mandate crops can maintain their viability for 20 to 30 years. In the long-term cold store, seeds are dried to contain only 5-6% moisture content and hermetically vacuum-sealed in fabricated aluminum foil packets; they can be preserved for about 50-100 years at a storage temperature of -22° C.

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Safety Duplication of Germplasm

Genetic resources stored in the genebank at ICARDA are safe. Standby electricity generators are available in case of failure of power supply. However, an important aspect of long-term preservation of germplasm is having a duplicate set of samples stored in another genebank with standard controlled-environment conditions. ICARDA has taken concrete steps to duplicate its long-term base collection of unique samples at other locations and institutions. For example, wheat and barley samples are preserved in the genebank at the International Maize and Wheat Improvement Center (CIMMYT), Mexico.

An important aspect of long-term preservation of germplasm is having a duplicate set of samples.

The chickpea collection is duplicated at ICRISAT, the faba bean collection is duplicated at the Austrian national genebank, and the lentil collection is duplicated at the National Bureau of Plant Genetic Resources (NBPGR), India. In addition, as national programs assumed greater responsibilities with upgrading of facilities in recent years, ICARDA repatriated large collections of cereals, forages and food legumes to their countries of origin, to be conserved by national genetic resources units and to be available for utilization by national breeding programs.

Utilization of Genetic Resources for Crop Improvement

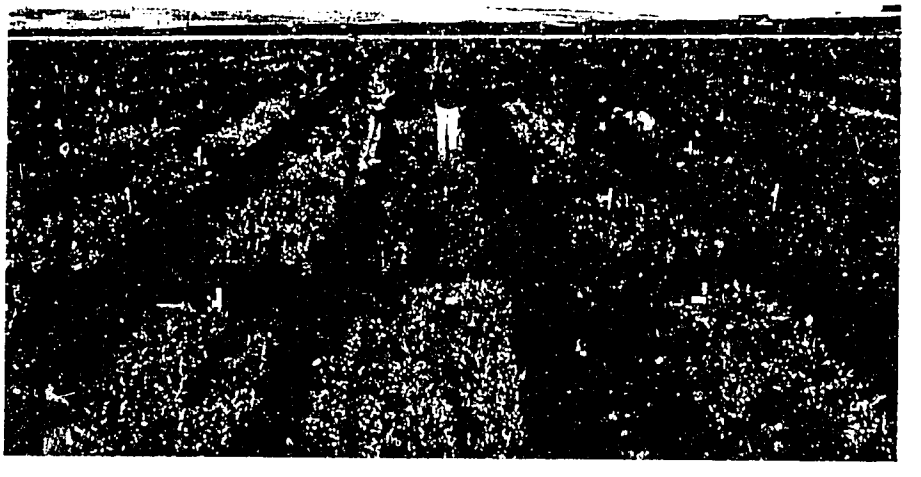
Drought is the most important of all environmental constraints on wheat production in West Asia and North Africa. Nearly 75% of land under wheat production in this region is under either partial or complete stress conditions. However, moisture stress does not have to be catastrophic to constitute a serious problem. Short periods of drought during critical periods of crop growth can cause a substantial reduction in crop yield. The genetic modification of crops for increasing tolerance to periods of drought and high temperatures through targeted crosses and selection may be the only practical solution to this problem. To encourage utilization of genetic resources, a short-list of accessions with desirable traits for drought tolerance is provided to breeders.

Direct use of accessions or selection within adapted landraces for high-yielding lines has provided varieties suitable for specific growing conditions.

Food and feed legume genetic resources have been instrumental in providing a base for new breeding programs. In testing programs, direct use of accessions or selection within adapted landraces for high-yielding lines has provided varieties suitable for specific growing conditions. Forty-eight varieties released by ICARDA breeding programs have been direct utilizations or selections from landraces.

Over 8,000 germplasm accessions of chickpea have been screened for resistance to ascochyta blight.

Another major use of genetic resources of legumes has been for selection of sources of resistance to major diseases and insect pests. Over 8,000 germplasm accessions of chickpea have been screened for resistance to ascochyta blight by the ICRISAT/ ICARDA breeding project with excellent sources identified and used. This has enabled the breeding program to move chickpea to winter planting, which provides more than double the yield of spring planting. In lentil, germplasm has been selected for tolerance to drought, and wild species have been used to screen for resistance to abiotic and biotic stresses in *Lens* and *Cicer*.



Accessions have been identified for use in mixtures to set up self-regenerating pastures.

Medicago species have been screened for their adaptation, productivity and persistence and accessions have been identified for further research on the use of annual self-regenerating pastures in ley farming systems. Much use has been made of passport accession data of the agroecology of the collection site to select accessions from environments similar to the target environment for further characterization and evaluation. Accessions have been identified for use in mixtures to set up self-regenerating pastures.

There is a considerable increase in requests from scientists for wheat and barley germplasm tolerant to salinity. The processes that limit plant growth due to drought or salinity are similar. One constraint to improving the yield of crops exposed to salinity in the field is that both the timing and the intensity of exposure can influence yield in various ways.

Screening germplasm for salinity tolerance in a controlled environment has been attempted.

Because of the variability in seasons from year to year it is very difficult to obtain consistent results by making selections in a salinized field; the ranking of lines changes from year to year as different characters become more or less important with different types of exposure. Hence, a move to screen germplasm for salinity tolerance in a controlled environment has been attempted as we foresee a greater demand for salt-tolerant cereal germplasm from the National Agricultural Research Systems in the future.

The Genetic Resources Unit receives monthly requests for germplasm from around the world, including scientists at ICARDA. In 1991, 24,000 accessions were distributed world-wide from the ICARDA collections. After testing, all seed consignments are provided with phytosanitary certificates issued by the Syrian authorities. The Seed Health Laboratory takes particular care to ensure that only healthy seed is dispatched to users and that only seed free from quarantine diseases is imported into Syria.

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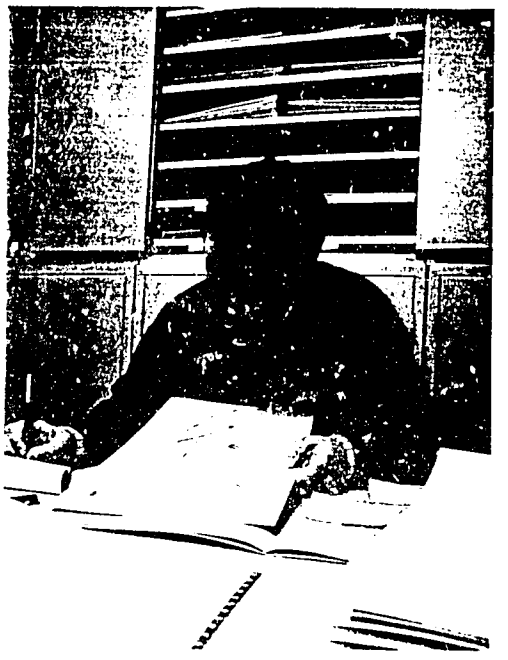
Several hundred lines of germplasm supplied to scientists around the world have been used as desirable sources of disease resistance, drought and agronomic traits for crop improvement. Some accessions have even been identified as superior genotypes and directly released as varieties in certain countries of WANA.

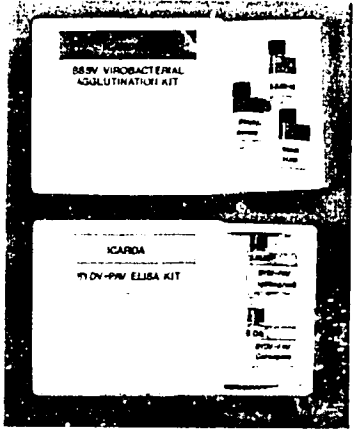
The Herbarium

A small herbarium section was established at the Genetic Resources Unit in 1989. Its purpose is two-fold. First, it acts as a reference collection for all groups of crop plants (genera, species, varieties) that are studied at ICARDA, and second, it provides a means for trainees to study the plants when they are not readily available for observation in the field. Before an exploration mission, germplasm collectors use the herbarium to better acquaint themselves with the target plants, especially the wild relatives. All the taxa of ICARDA's mandate crops are represented in the collection, which comprises 1,100 specimens of cereals and 1,300 of forage legumes.

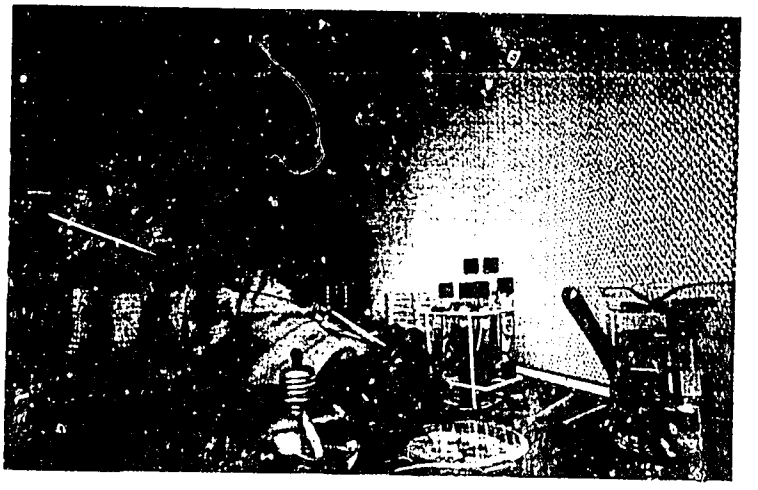


Virology Laboratory

The Virology and Seed Health Laboratories are attached to the Genetic Resources Unit. The two laboratories underwent considerable renovation and upgrading during 1990. The Virology Laboratory tests germplasm for seed-borne virus infections. Kits for diagnosing several cereal and legume viruses including barley yellow dwarf (BYDV), broad bean stain, broad bean mottle and broad bean wilt viruses have been developed. These kits provide enough reagents for testing at least 2,000 samples, and are available to national programs on request. In addition, the Virology Laboratory conducts surveys for virus diseases of cereal and legume crops in WANA jointly with scientists from national programs. The laboratory also evaluates germplasm accessions for resistance to the economically important viruses affecting ICARDA's mandate crops and has been engaged in the development of certified virus-free collections.



Seed Health Laboratory

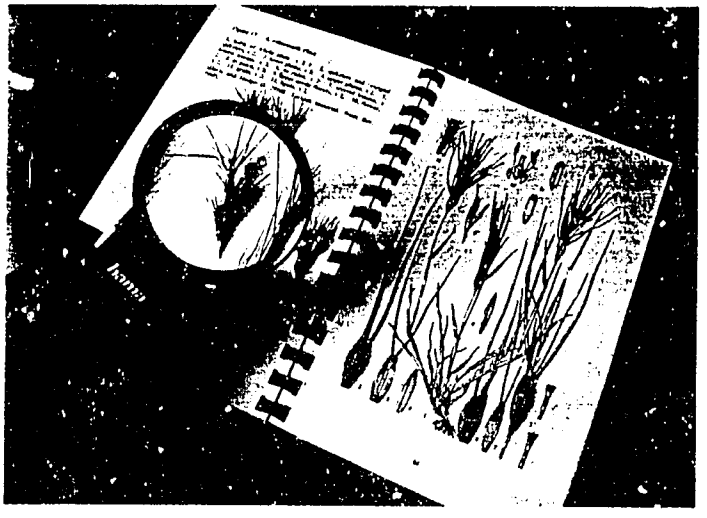


The activities of the Seed Health Laboratory have increased in recent years with the addition of modern facilities and space. The principal concerns at the Laboratory are to prevent inadvertent introduction or exportation of pathogens/pests with incoming and outgoing seed shipments by conducting seed-health testing programs, regular field inspections and seed treatment. ICARDA routinely receives germplasm from over 40 countries and exports seed material to over 76 countries. The second, and very important, aspect of the Laboratory is to provide training to staff from national programs. In addition, the Seed Health Laboratory also conducts research on fungal seed-borne pathogens related to their epidemiology, importance, seed treatment, economical tolerance limit of seed infection, and development of rapid and accurate techniques of pathogen detection in collaboration with advanced institutions.

Training

The training of scientific personnel from national programs forms a major part of the activities of the Genetic Resources Unit. The acute shortage of trained manpower limits the task of germplasm conservation in the region. Short training courses (2-3 weeks) are regularly conducted at ICARDA's main experimental farm as well as in other countries of the region, often in collaboration with the IBPGR and national programs. Young scientists from several countries have been trained in all aspects of conservation work and many have used their research to support an award of a higher university degree.

Research on Genetic Resources



In addition to the normal activities of a gene bank, scientists at the Genetic Resources Unit also engage in research involving taxonomy, crop diversity, crop enhancement through pre-breeding and production of pure lines, biochemical characterization and *in situ* conservation.

A concise and unambiguous taxonomic system is important for a gene bank because it enables researchers to be certain about the form of material they will be receiving. With the inventory of the *Aegilops* collection completed, the norms of taxonomy and nomenclature in this wild wheat genus have been determined at the Genetic Resources Unit.

Diversity studies using biochemical markers such as storage proteins have been conducted at the Genetic Resources Unit. This research may lead to identification of sites of special genetic interest and eventually the development of guidelines for research on *in situ* conservation.

One such group of sites already has been identified in the Sweida province of Syria on a high basaltic plateau where genera of wild wheat and barley were found growing in swarms that included some hybrids with cultivated species.

Germplasm of wild and primitive forms is being utilized for a pre-breeding program which seeks to infuse desirable genes from the wild or primitive parent into the cultivated form through crossing and selection. This work will create stable lines which can be utilized by breeders without fear of undesirable characteristics becoming linked to those that are sought from the wild or primitive parent.

Long-term Impact of Genetic Resources Conservation

The Genetic Resources Unit at ICARDA is a solid component of the CGIAR system and is staffed by highly motivated and experienced scientists from seven different countries. Since 1983, plant breeders, academic institutions, other scientists and general users from over 150 countries have requested germplasm from ICARDA and have received over 100,000 seed samples without restrictions.

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The Unit welcomes donations and exchanges of unique germplasm, responds quickly to bona fide requests, and addresses an ever-increasing demand for its services.

The most noteworthy impact of the Genetic Resources Unit is in conserving the vanishing germplasm of ICARDA's mandate crops and making this diverse material readily available for use to crop improvement programs catering to the dry areas and other regions of the world.

The Genetic Resources Unit of ICARDA is devoted to the free and unrestricted exchange of germplasm with all nations. The Unit welcomes donations and exchanges of unique germplasm, responds quickly to bona fide requests, and addresses an ever-increasing demand for its services as the need for conserving, evaluating and utilizing germplasm of the world's most important crops grows.

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