ICARDA
Annual Report
1998

International Center for Agricultural Research in the Dry Areas

About ICARDA and the CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based in Aleppo, Syria, it is one of 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR).

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production; and the West and Central Asia and North Africa region for the improvement of bread and durum wheats, chick-pea, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural-resource management practices. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs is offered extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and specialized information services.

The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. The CGIAR receives support from a wide variety of country and institutional members worldwide. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South-North partnership to reduce poverty and hunger.

The mission of the CGIAR is to promote sustainable agriculture to alleviate poverty and hunger and achieve food security in developing countries. The CGIAR conducts strategic and applied research, with its products being international public goods, and focuses its research agenda on problem-solving through interdisciplinary programs implemented by one or more of its international centers, in collaboration with a full range of partners. Such programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and contributing to strengthening agricultural research in developing countries.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP) are cosponsors of the CGIAR. The World Bank provides the CGIAR System with a Secretariat in Washington, DC. A Technical Advisory Committee, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

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Citation:

ICARDA 1999. ICARDA Annual report 1998. International Center for Agricultural Research in the Dry Areas, Aleppo, Syria. viii+107 pp.

ISSN: 0254-8313

AGROVOC descriptors: *Cicer arietinum*; *Lens culinaris*; *Vicia faba*; *Hordeum vulgare*; *Triticum aestivum*; *Triticum durum*; *Aegilops*; safflower; *Lathyrus sativus*; *Medicago sativa*; *Pisum sativum*; *Vicia narbonensis*; *Trifolium*; *Trigonella*; feed legumes; clover; shrubs; fruit trees; agroclimatic zones; agricultural development; dry farming; farming systems; pastures; steppes; rangelands; sheep; goats; animal feeding; international cooperation; research; training; germplasm conservation; plant collections; genetic maps; research networks; cold; temperature resistance; disease control; plant viruses; pest control; biological control; nutritive quality; irrigation systems; seed production; genetic resources; resource management; resource conservation; remote sensing; geographical information system; water harvesting; water management; tillage; stubble cleaning; soil water; watersheds; soil erosion; uses; environmental degradation; grassland management; reclamation; harvesting; mechanical methods; poverty; rural population; malnutrition; human resources; development; training; computers; biometry; diffusion of information; innovation adoption; technology transfer; biodiversity; sustainability; rapid rural appraisal; ownership; Middle East; North Africa; Ethiopia; Sudan; Pakistan; Kazakhastan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan; Armenia; Azerbaijan; Georgia; Latin America

AGRIS category codes: A50, A01, E10, F01, F30, H10, H20, H60, L01, U30

Foreword

Cooperation, sharing expertise and technology, partnerships, and access to information were the building blocks of ICARDA's achievements during a year in which strategic realignments were made with a forward-looking vision, and a new positivism injected into its program of work, in harmony with the global research continuum.

One of the major achievements was the innovative Consortium for Central Asia and the Caucasus which has, for the first time, brought nine centers of the CGIAR to work together through a program initiated and pioneered by ICARDA. The CGIAR program for Central Asia and the Caucasus (CAC) may be compared to a 'one-stop shop' for the CAC national agricultural research systems (NARS) where they can develop joint projects and benefit from the collective efforts of the centers involved in the Consortium. The emerging republics in CAC are determined to upgrade their existing research base and rebuild and refocus their agricultural economies for the free market conditions under which they now intend to operate. Populations are predicted to more than double by 2025 in at least three of the five Central Asian Republics and continue expanding rapidly in the others. Overgrazing and encroachment of rangelands for cultivation in Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan are further aggravating feed deficits. The Consortium is moving forward to serve the needs of the millions of people in CAC, who deserve immediate attention.

In line with its thrust on collective work in CAC, ICARDA, in 1998, established a Regional Program Office for CAC in Tashkent, which also hosts the CGIAR Program Facilitation Unit to liaise between CAC NARS and the Consortium of CGIAR centers.

There are many other examples of cooperation, each just as innovative in its own way. The establishment of the Agrobiodiversity Project—involving Jordan, Lebanon, Palestine and Syria, and funded by the United Nations Development Programme's General Environment Facility (GEF)—to be coordinated from ICARDA headquarters, is another pioneering effort for *in situ* conservation of landraces and the wild relatives of important crop species, and a model of cooperation between international and regional centers, donors, and national programs.

The Medium-Term Plan for 1998-2000, implemented during the year, guided the progress of ICARDA's realigned program of work, which involves several strategic thrusts to respond to the needs of NARS in a changing environment. Since water is at the heart of the overall research program, work on the conservation and efficient use of this scarce resource has been strengthened, as well as more closely integrated with crop improvement and with overall natural resource management. This is just one of the areas, along with soil management, where the application of remote sensing techniques in combination with geographic information systems (GIS) is beginning to demonstrate how considerable savings in human power and time can be made in planning and executing water harvesting schemes. Use of satellite imagery is being made to develop digital soil maps for effective utilization of natural resources. Simultaneously, increased emphasis was placed on training national partners in the use of these new tools through specialized training courses, offered both at headquarters and in countries of the region. The Center also encouraged the development and use of computer expert systems, in collaboration with the Central Laboratory for Agricultural Expert Systems, Egypt, to promote transfer of technology.

Adoption of other new scientific techniques continues apace. The application of biotech-

nology brought the Center recognition at the System-wide level when a young ICARDA scientist received the CGIAR Chairman's Award for Excellence in Science for his work on a lentil genetic-linkage map.

Despite this tangible progress during the year, ICARDA is fully aware of the enormity of the task ahead. Food and feed demand has outpaced domestic production in most dry-area countries and will continue to do so. The resource base for traditional livestock raising (native pastures and crop residues) has come under serious pressure, and large food and feed deficits are projected.

To meet these challenges, partnership, cooperation, and sharing must remain an integral and vital part of the ICARDA ethos – one that will carry the Center through 1999 to the brink of the new millennium, fully prepared to address the complex problems, arising out of degradation of the natural resource base, global warming and population explosion.

Prof. Dr Adel El-Beltagy
Director General

Dr Alfred Bronnimann
Chair, Board of Trustees

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PART ONE

Major Developments in 1998

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Major Developments in 1998

Programmatic Shifts

Two forces, globalization of agriculture and availability of new tools of research, are bringing about significant changes in the direction of international agricultural research. This is happening at a time when other global priorities are claiming an increasing share of donor support, so funding for international agricultural research is declining. Developing and implementing an agricultural research agenda in such a climate is like hitting a moving target.

To deal with this reality, ICARDA used a proactive approach in developing its program of work and budget for 1998, and made several programmatic shifts in line with the strategic thrusts of its Medium-Term Plan for 1998-2000. These included scaling down some specific research and training activities, making adjustments in staff numbers and expertise, and strengthening some of the priority areas of strategic research. Simultaneously, avenues of partnerships, which could open new doors for financial support, and enable ICARDA to spread the benefits of its work more widely, were vigorously explored.

The ICARDA Board Chairman-elect (second from left) and the Director General (third from left), accompanied by ICARDA researchers and local government officials, visited the El-Bab village, near Aleppo, to see the vetch/barley rotation technology adopted by farmers.

Water is at the heart of ICARDA's overall reasearch program. The Center strengthened its research on the conservation and efficient use of this scarce resource, and restructured its research teams to integrate the work on water with crop improvement and overall natural resource managament.

Application of molecular techniques to crop improvement gained increased momentum, with the aim of identifying genes for tolerance to such abiotic stresses as drought, heat and cold, and resistance to disease and insect pests. This research complements the integrated pest and disease management efforts of the Center, carried out in collaboration with several national partners.

The Center looked at new paradigms for conducting long-term agronomic trials, an activity that began 20 years ago. As a result, this activity is being downsized on station, but cooperation with the National Agricultural Research Systems (NARS) is being increased to conduct such trials with farming communities in their own agroecological conditions to meet their specific objectives.

Farmer participatory breeding of barley, initiated in Syria in 1995, spread to other countries in West Asia, North Africa, and the Nile Valley region. Over the years, ICARDA has made substantial achievements in improving the nutritional quality of straw, hence research in this field was scaled down. On the other hand, to respond to the needs of NARS, a program for small-ruminant breed characterization, using molecular tools, is being introduced. The objective of this research is to identify the right breeds of small ruminants to increase production of meat and dairy products, the demand for which is outstripping supply.

The year saw an increased use of geographic information systems (GIS) and remote sensing, for soil and water management. Technologies for information management and exchange were upgraded, and a major effort was made to enhance the public awareness of ICARDA's work. ICARDA produced its first CD-ROM and a new video film to share its strategy, research and training activities, and major achievements with its stakeholders and all those interested in agriculture.

In the interest of cost-effectiveness and better integration of research activities, the Farm Resource Management Program (FRMP) and Pasture, Forage and Livestock Program (PFLP) were merged into a Natural Resource Management Program. Laboratory facililities were accordingly reorganized and consolidated.

Expanding Partnerships

An office to host ICARDA's Regional Program for Central Asia and the Caucasus (CAC) was established in Tashkent, Uzbekistan. A Program

H.E. Mr Ismail Djurabekov (left), First Deputy Prime Minister of the Republic of Uzbekistan and Cabinet Minister In-Charge of the Ministry of Agriculture and Water Resources (MAWR), and ICARDA Director General Prof. Dr Adel El-Beltagy signing an agreement of collaboration in agricultural research and training.

Facilitation Unit, closely linked to this office, will provide service to the CGIAR centers carrying out collaborative activities in CAC within the System-wide Program for the region.

The Desertification Convention accorded an official place of Observer to ICARDA, which opened new avenues of cooperation in the Center's work on combating desertification. ICARDA's Director General, Prof. Dr Adel El-Beltagy, was reelected as President of the Technical and Scientific Council of the International Observatory of Sahara and Sahel (UNESCO, Paris).

ICARDA had the privilege of hosting the third meeting of the CGIAR Inter-Center Working Group on System-wide Integrated Pest Management; and the seventh meeting of the System-wide Genetic Resource Policy Committee.

The annual regional coordination meetings brought together a very large number of national researchers to address the needs of their respective regions in collaboration with ICARDA. High-level delegations visited the Center from several countries, including Iran, Iraq, Mauritania, the Palestinian Authority and Sudan, reaffirming their partnership with ICARDA.

During the year, ICARDA signed 10 agreements of collaboration with national governments, sister centers, and advanced research institutes.

Board of Trustees

The Board of Trustees played an active role in the governance of the Center throughout 1998. Their contributions to shaping the program of work, and to the Center's fundraising efforts, were particularly important. Mr Robert D. Havener, Dr Mamdouh A. Sharaf El-Din, and Dr Ismail El-Zabri joined the Board as new members for a 3-year term. Dr Toufik Ismail, host-country representative on the Board, was reelected for another 3-year term. Drs Ersin Istanbullouglu, Julie Caroll Noolan, and Joseph Casas completed their term of office in April 1998. Dr Peter S.M. Franck-Oberasprach was elected to join the Board after its August 1999 meeting.

Fundraising

Fundraising strategy was pursued with a new approach in which researchers were as active as the senior management and the members of the Board of Trustees of the Center. ICARDA teams visited key donors to present the Center's case for support, and participated in several international events, where there was a strong presence of donor representatives. Visits by donor representatives to ICARDA at its headquarters and in partner countries gave them a clearer perception of the Center's strategy and program of work.

A three-pronged strategy was used for fundraising: relations with traditional donors were further strengthened, new donors were approached, and ICARDA increasingly worked in externally-funded bilateral projects of NARS. The examples of the last category include the Matrouh Resource Management Project in Egypt, and the Agricultural Resource Management Project in Yemen, funded by the respective countries from their World Bank loans, and the additional projects in the pipeline for Central Asian Republics, the Palestinian Authority, and Mauritania. The Center was also successful in obtaining funds from non-conventional sources, such as the Global Environment Facility (GEF) for the Dryland Agrobiodiversity Project. These efforts were supported by brief concept notes that were shared with traditional and new donors, as well as NARS.

Scientists Honored

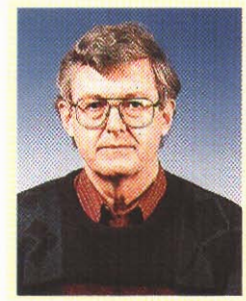
CGIAR Chairman's Science Award

ICARDA scientist Dr Imad Eujayl won the CGIAR Chairman's Science Award for Outstanding Locally-Recruited Support Staff, in recognition of his research achievements in biotechnology (see also pages 7 and 8). Using different DNA-marker systems, including RFLP, RAPD and AFLP, Dr Eujayl constructed a genetic-linkage map of *Lens* species.

Dr Imad Eujayl (center) receives the Chairman's Science Award from CGIAR Chairman, Dr Ismail Serageldin (right) and Dr Wally Falcon (left), Chairman of the Selection Committee.

The map, comprising 177 markers, is the most extensive of all genetic-linkage maps developed todate for *Lens* species.

American Society of Agronomy Award



ICARDA Senior Scientist, John Ryan, was selected as a 1998 Fellow of the American Society of Agronomy. Dr Ryan has a life long interest in soil and fertility studies in the Middle East. He first served as Soil Science Professor at Lebanon's American University of Beirut; then as Soil Fertility Specialist with the University of Nebraska in Morocco. For the past seven years he has been working as a Soil Scientist at ICARDA. Dr Ryan has published prolifically in the fields of soil fertility and soil conservation, as well as contributed to international soil science education.

Oregon State University's Award

Dr Hugo Vivar, Barley Breeder and Regional Coordinator of ICARDA's Latin America Regional Program, based at CIMMYT in Mexico, won the 1998 James and Mildred Oldfield/E.R. Jackman Team Award of the College of Agricultural Sciences, Oregon State University (OSU), USA, as a member of the Barley Stripe Rust Resistance Team. The team consists of seven researchers, of which Dr Vivar is one. The award includes a certificate and an Oldfield medal to each team member and US$3000 for the team.

The Barley Stripe Rust Resistance Team has, through individual and cooperative efforts, contributed to the development of a new value-added processing industry in Oregon.

The award was presented to the winners on the Faculty and Staff Day of the College of Agriculture of OSU on 17 September 1998.

Agroecological Characterization

Digital Soil Map

In a collaborative effort between INRA, Morocco and ICARDA, a new digital soil map of central Morocco was compiled. The map covers the area from the foot of the Rif mountain to just north of Marrakech, and from the Atlantic coast to the foot of the High Atlas. The new map presents a synthesis of early pedological studies, complemented by the interpretation of aerial photographs and satellite images, the analysis of geological maps, and limited ground surveys. This would be of help in crop growth simulation work.

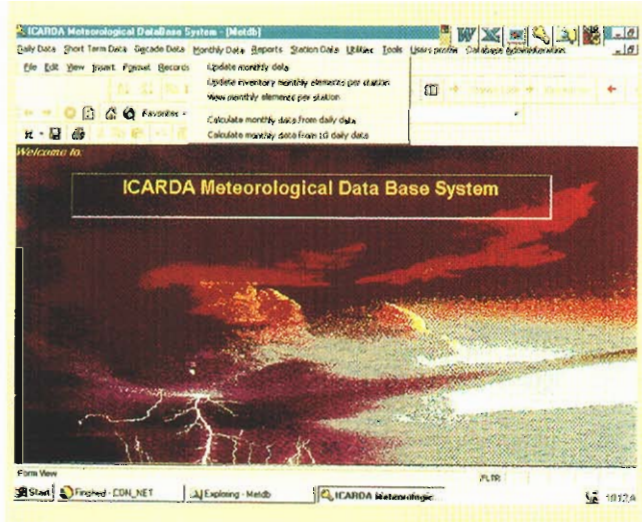
Workshop on Remote-Sensing Applications

Collaboration with the Center for Earth Observations, Yale University, was further strengthened by jointly organizing a 3-day subregional workshop on the "Use of Remote Sensing for Natural Resource Management and Environmental Assessment in Southwest Asia" at ICARDA headquarters. The USAID Linkage Fund provided financial assistance.

Remote sensing is still largely underutilized in the region as a research tool to analyze environmental and land-use trends and fluctuations over large areas, mainly because of the communication and information gap. To bridge this gap, the workshop brought together agricultural researchers and remote-sensing specialists from Syria, Turkey, Jordan and Lebanon, and from Yale University and ICARDA. Remote-sensing applications were presented in the areas of soil survey and land evaluation, natural vegetation mapping, rangeland condition assessment, land degradation and rehabilitation, identification of potential water-harvesting sites, plant diversity research, agroecological characterization, land cover/land use mapping, precision farming, regional assessment of climate, hydrology and vegetation, and impact assessment of land-use policy.

Meteorological Database

During 1998, a major effort was made to revamp the existing Meteorological Database (METDB) to improve its user-friendliness, performance, security, and program maintenance. METDB now exists as a stand-alone Windows 95/MS-Access application, programmed in Visual Basic, with data-entry forms and storage formats for monthly, 10-day, daily, and shorter-term meteorological data, similar to the CLICOM standard of the World Meteorological Organization. It also contains standard and in-house developed query and reporting facilities.



METDB currently contains more than 5 million records on a daily basis, and more than 1 million records on a monthly basis from 27,000 stations from all over the world. During 1999, transformation and data loading of all ICARDA-held meteorological records into METDB will continue.

Germplasm Conservation

Collection Mission in Uzbekistan

ICARDA, in collaboration with the Center for Legumes in Mediterranean Agriculture (CLIMA), Uzbek Research Institute of Plant Industry (UzRIPI), Andijan Research Institute of Cereals (UzARIC) and Uzbek Scientific Production Institute of Cereals in Gallaaral, conducted a two-week collecting mission

in Uzbekistan during June/July 1998. The collectors were specially interested in landraces and wild relatives of cereals and food legumes. They explored the Fergana Valley and the regions of Bostanlik, Dzizak and Samarkand (Fig. 1), and collected 206 accessions (136 cereals and 70 legumes) from 85 sites.

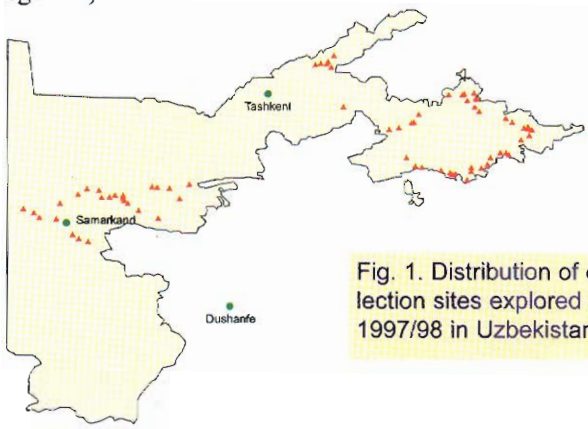


Fig. 1. Distribution of collection sites explored in 1997/98 in Uzbekistan.

GEF/UNDP Project on Biodiversity Conservation in the Near East

The GEF Board has approved a funding of US$ 8.1 million for a project on "Conservation and Sustainable Use of Dryland Agrobiodiversity of the Near East." The project, developed by ICARDA in collaboration with IPGRI and ACSAD, and the national programs of Syria, Jordan, the Palestinian Authority and Lebanon, will help strengthen the capacity for *in situ* conservation of agrobiodiversity in these countries. Innovative approaches will be tested at the local level to ensure sustainable conservation of the target species through improved habitat management, in close collaboration with the local communities. It will be supported by ICARDA's activities in agroecological characterization through the use of remote sensing and GIS, and participatory approaches in natural resource management.

Multiplication and Characterization of Germplasm from the Vavilov Institute

As part of a project supported by the Grain Research and Development Corporation (GRDC, Australia),

Dr Larisa Prilyuk (right), of the Vavilov Institute of Plant Industry (VIR), along with ICARDA's legume germplasm curator, evaluating at ICARDA the unique germplasm received from VIR.

and in collaboration with the Vavilov Institute of Plant Industry (VIR), St. Petersburg, Russia and the Center for Legumes in Mediterranean Agriculture (CLIMA), 340 faba bean, 457 lentil, 341 chickpea, 498 pea, and 207 barley accessions were brought to ICARDA for multiplication, preliminary characterization, and introduction into the germplasm collections. This germplasm mostly originated in North Africa, West Asia, and Central Asia. The pea curator from the Vavilov Institute, Dr Larisa Prilyuk, spent three months at ICARDA conducting the VIR pea germplasm evaluation trial.

Germplasm Enhancement

Farmer Preferences in Barley/Vetch Rotation Trials

Decentralized selection, defined as selection in the target environment, has been used by ICARDA to avoid the risk of useful lines being discarded because of their relatively poor performance at the experiment stations. Decentralized selection is a powerful methodology to fit crops to the physical (climate and management) environment. However, crop breeding

based on decentralized selection can still miss its objective if it does not utilize farmers' knowledge of crops and the environment.

ICARDA has implemented these concepts in a participatory breeding project entitled "Farmer Participation and Use of Local Knowledge in Breeding Barley for Specific Adaptation," supported by BMZ (Federal Ministry for Economic Cooperation, Germany). The project is conducted in nine villages in Syria.

At one of the project sites, El-Bab, where the participating farmers have introduced common vetch (*Vicia sativa*)—a forage legume—in the rotation, the trial was planted in two different fields: barley after barley, and barley after vetch.

Farmers at El-Bab in Syria recording their preferred barley lines in barley-barley and vetch-barley trials.

As expected, the trial planted after vetch had a higher grain and total biological yield than that planted after barley (Fig. 2). Also, plants were taller, with a higher harvest index and larger kernels.

The effect of rotation on farmer preferences was analyzed by comparing the 5% most preferred lines by the farmers under the two rotations, using an index of preference, which includes both the score given to each line and its ranking. The index can take a value between 1 (high preference) and 0 (low preference).

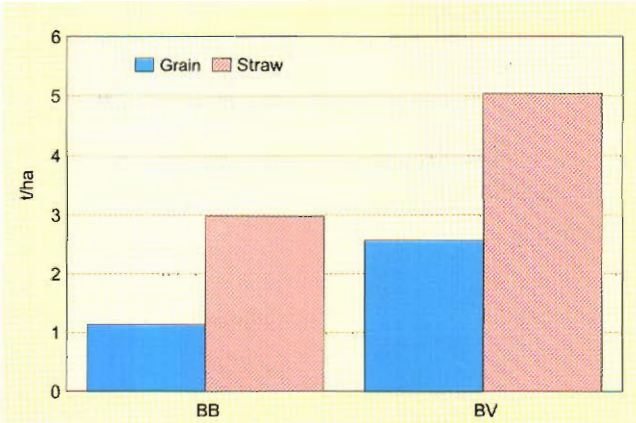


Fig. 2. Mean grain and straw yield (t/ha) in the same barley trial planted after barley (BB) and after vetch (BV).

The 5% most preferred lines in the barley-barley trial were all different from the 5% most preferred in the vetch-barley trial. The most preferred lines in the barley-barley trial had a low index of preference in the vetch-barley trial (from 0.05 to 0.54); the line with 0.54 as index of preference ranked seventh in vetch-barley trial, and was the one with best combination of preferences in the two trials. Similarly, the most preferred lines in the vetch-barley trial had preference indexes ranging from 0.09 to 0.26 in the barley-barley trial.

These results illustrate an additional advantage of participatory breeding—that of farmers rapidly adapting the breeding material to the changes in agronomic practices and farming systems of the target environments.

Enhanced Yellow Rust Resistance in Spring Bread Wheat

Bread wheat production in the WANA region is highly variable and generally not enough to meet the ever-increasing demand. The joint CIMMYT/ICARDA wheat program addresses the problems associated with increasing bread wheat production in the region. Of these, foliar diseases (yellow rust, leaf rust, stem rust, and septoria leaf blotch) can cause particularly severe yield losses.

In the past few years severe yellow rust epiphytotics have resulted in serious yield losses in bread wheat in some of the WANA countries, for example,

Egypt, Iran, Lebanon, and Syria. It was found that a new race of yellow rust caused the damage. The new race is virulent on Yr9, the yellow rust resistance gene associated with the 1B/1R translocation commonly found in the major cultivars grown in the region.

The CIMMYT/ICARDA wheat program, therefore, increased its efforts to widen the genetic base of yellow rust resistance in the wheat germplasm by including different sources of genes in the crossing program, and using the doubled-haploid technique for generation advance.

Frequency distribution of the level of yellow rust resistance was studied in 270 advanced yield trial lines assembled in the wheat key location (WKL) nursery, 470 preliminary yield trial lines assembled in the wheat preliminary disease (WPD) nursery, and 197 lines of Aleppo wheat crossing block (WAC). The results showed that 50% of the WKL lines were resistant. Many of the new bread wheat lines possess multiple resistance to major foliar diseases in WANA.

Broadening Durum Genetic Base

Mediterranean landraces possess several desirable traits, such as resistance to drought and cold, early plant vigor, long peduncle and high tillering, not found in materials from other regions. Besides landraces, wheat wild relatives, such as *Triticum dicoccoides*, *Triticum monococcum*, and *Aegilops* species can provide valuable sources for widening the genetic base of durum wheat.

Introgression of Genes from Landraces. Improved lines were crossed with landraces resistant to diseases, wheat stem sawfly, and Hessian fly. Landraces from the Middle East region are used for enhancing tolerance to drought and terminal heat stress; from Turkey and Algeria, for cold tolerance; from the Morocco-Iberian region for resistance to root rot and Hessian fly; and from Ethiopia for leaf rust resistance.

Introgression of Genes from Wild Emmer. Crosses between dryland adapted durum genotypes and *T. dicoccoides* were made to improve grain quality and resistance to *Septoria tritici* and yellow rust. In the segregating populations, plants were selected for resistance to drought, heat, yellow rust, and leaf and stem rust. In the advanced populations, crosses with *T. dicoccoides* showed high levels of resistance to tan spot, heat, and cold. Several lines from these crosses are now included in the international trials.

Introgression of Genes from Wild Relatives. Crosses were made with *T. monococcum* to increase earliness, rust resistance, and early plant vigor in durum wheat. Crosses were also made with different *Aegilops* species, earlier selected for resistance to yellow rust, Hessian fly, and Russian wheat aphid (RWA). Several of these crosses are showing promising performance in advanced yield trials under dry-area conditions.

Lentil Genetic-Linkage Map

Advances in molecular genetics have provided important tools, such as DNA markers, which can increase the efficiency of crop breeding by using closely linked markers to select for traits such as wilt and cold resistance in the absence of the trait expression. *Fusarium* wilt is economically the most destructive disease of lentil and can cause total yield loss. Cold tolerance is an important trait for winter lentil cultivation at high elevations.

Different DNA-marker systems including RFLP, RAPD, and AFLP were used to construct a genetic-linkage map of *Lens* species. A population was chosen for producing F_6-derived F_8 recombinant inbred lines (RILs) and used as perpetual mapping population. The population of 86 RILs was genotyped with 257 morphological, RFLP, RAPD, and AFLP markers. A genetic-linkage map comprising 177 markers was constructed and seven major linkage groups were identified (Fig. 3). The map, spanning 1073 cM of the lentil genome, with markers spaced at an average distance of 6.0 cM, provides a framework linkage map of lentil. The map was constructed using stringent linkage criteria. It is the most extensive genetic linkage map of *Lens* species to date.

The second part of the study was a practical exploitation of the genetic linkage map to identify markers linked to *Fusarium* wilt resistance and radiation-frost tolerance. The population was evaluated for two seasons for radiation-frost injury

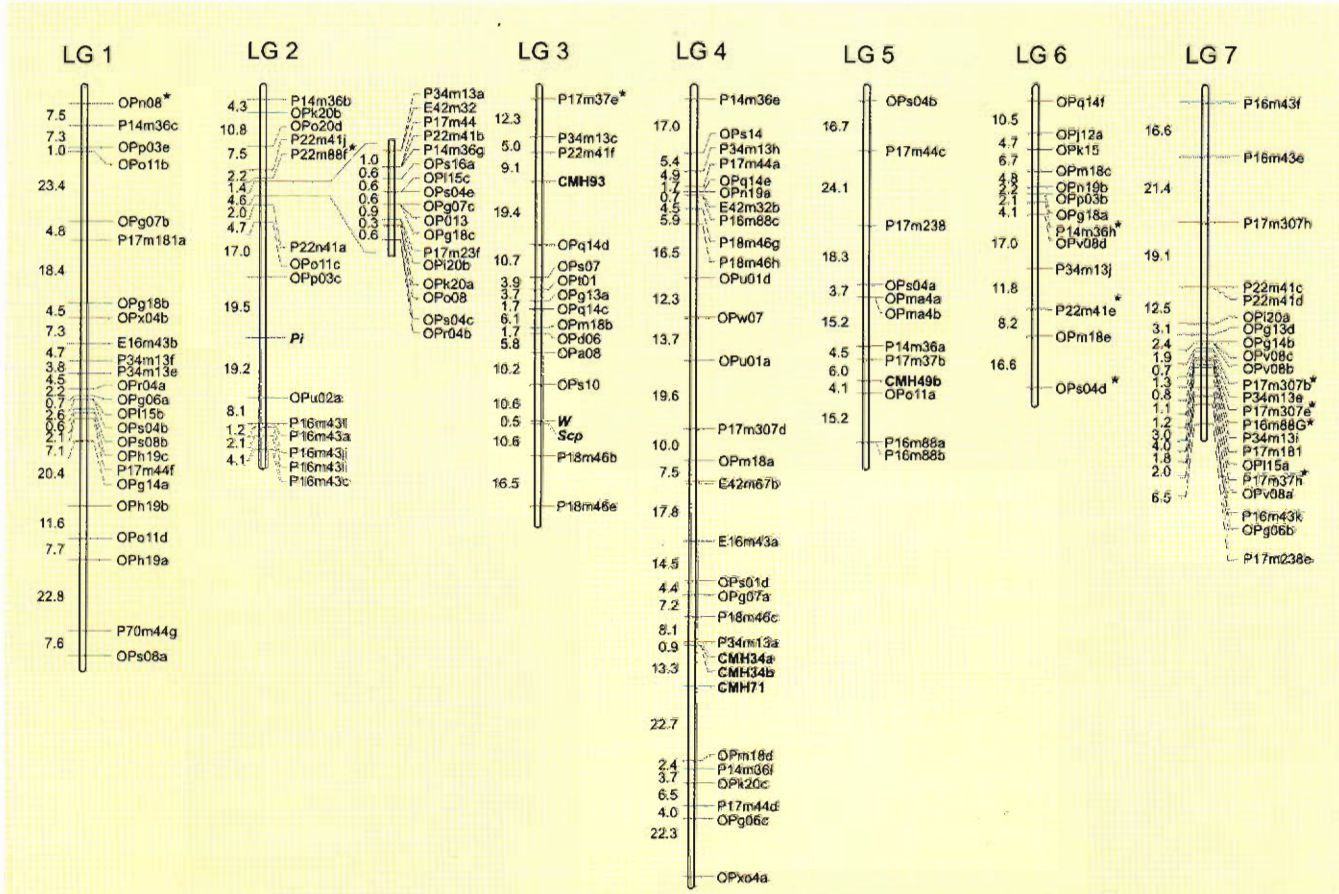


Fig. 3. Genetic-linkage map of lentil showing the distribution of morphological, RFLP, RAPD and AFLP markers. Linkage groups are named *LG1* through *LG7*. The markers in bold are "anchor" loci to previous lentil maps.

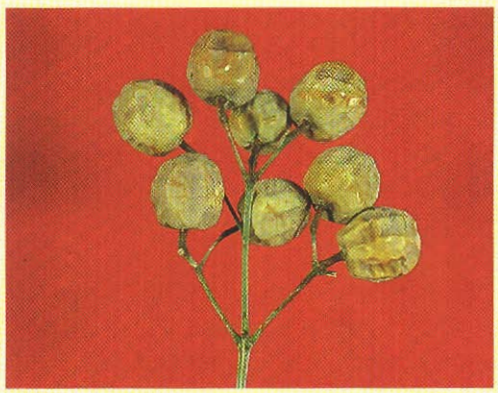
and three seasons for *Fusarium* wilt. Both traits were monogenically inherited. Four RAPD markers, linked to the *Fusarium* wilt resistance locus, were identified and located in the present map. Likewise, one RAPD marker was linked with the radiation-frost tolerance locus. The fact that the current map is based on RILs population is providing a framework that can be used to develop a high-resolution map and identify quantitative traits loci.

This study was recognized as an outstanding contribution to biotechnology research at ICARDA through an award for Excellence in Science from the Chairman of the CGIAR, Dr Ismail Serageldin, at the International Centers Week in October 1998 in Washington, D.C. Dr Imad Eujayl of ICARDA's biotechnology group, won the award for Locally-Recruited Scientific Support Staff (see also page 3).

Effect of *Melia azederach* Seed Oil Extract on Chickpea Insect Pests

Melia azedarach L., a tree native to the Middle East, is widely distributed in Asia, Mediterranean basin, Africa, and South America. Leaf and fruit extracts of this tree have been shown to have some anti-feeding characteristics against insects and mites. There are no previous studies on the effect of *Melia* extracts on lentil and chickpea insect pests.

An experiment was carried out in the plastic house at ICARDA in 1997/98 to study the effect of naturally extracted oil of *Melia* on *Sitona crinitus* feeding and *Liriomyza cicerena* mining. These two insects are, respectively, the main pests of lentil and chickpea in West Asia and North Africa. Three dosages (0.25%, 0.5%, 1%) of *Melia* oil, naturally



Fruits of *Melia azedarach*.

extracted from dry seeds, were tested in comparison to Mastrin 50% EC (Deltamithrin). The results showed significant effect ($P<0.05$) of the three dosages of *Melia* on leaflet damage by *Sitona* adults and leaflet mining by leafminer larvae in treated plants compared to untreated plants. Because of these promising results, further studies will be carried out to determine the effect of *Melia* seed extracts on the major insect pests of legume crops, as well as beneficial insects.

A *Melia* oil treated (0.5%) healthy chickpea plant (left) and the control (right) showing leaflet mining caused by chickpea leafminer.

Breeding and Selection of Non-Shattering Vetch

Loss of seeds from maturing pods (pod shattering) is common in leguminous forage crops such as common vetch (*Vicia sativa*), and constitutes a serious economic problem, when common-vetch is used in rotation with cereals. Therefore, a breeding program to develop non-shattering erect cultivars suitable for mechanical harvesting was initiated using three wild non-shattering mutants of common vetch.

The genetics of pod shattering was studied following hybridization between the non-shattering mutants and pod-shattering but otherwise promising lines. The non-shattering character was found to be conditioned by a single recessive gene. Incorporation of this gene into promising but shattering lines gave rise to a range of non-shattering *Vicia sativa* cultivars, which are now grown widely in West Asia, North Africa, and Australia. Non-shattering *Vicia sativa* No.715 was released as 'Baraka' in Jordan, Iraq, and Lebanon.

Shattered pods (left) and non-shattering pods (right) of common vetch.

The practical benefits of developing non-shattering and erect types of common-vetch include increased grain yield from a mechanized harvest, reduced problem of volunteers in subsequent cereal crops, and increased flexibility in timing of harvest.

Supporting the Development of Small Seed Enterprises

ICARDA is actively involved in seed policy issues in the region as many countries embark on a process of opening up their seed industry and encouraging greater participation by the private sector. However, the existing large seed-companies do not find the

supply of many crop seeds financially attractive unless there are hybrid varieties available. For most of the ICARDA crops and most of the WANA region, there are serious problems in commercializing the seed supply, especially in the more remote areas, because of the high costs involved and the low margins of profit.

One approach to this problem is to encourage increased seed production and marketing at the local level, which would reduce costs and might also enable the supply of locally adapted varieties which could not be marketed nationally. This is an attractive concept but there is very little practical information available about small seed-enterprises to assist those who might wish to start them.

To promote this concept, ICARDA organized a workshop on the management of small seed-enterprises in October 1998 in Addis Ababa, Ethiopia. The purpose was to gather information from those who have already been involved in such ventures and to raise awareness of the opportunities and risks for others who may be thinking along these lines. The workshop attracted 49 participants from 14 countries; there were over 20 formal presentations in addition to group discussions and a field visit. The workshop succeeded in maintaining a clear focus on the financial and management issues, which will hold the key to the establishment of viable seed enterprises. The proceedings of the meeting are expected to be published in 1999.

A grower, Ato Zerfu Woldegiorgis (third from right), explains the construction of a local seed storage facility during a field visit of the workshop participants to Hitosa in the Arsi zone, Ethiopia.

Seed Health Laboratory

The laboratory continued to monitor the in-coming and out-going seed samples for seedborne pathogens. It provided the inoculum necessary for screening faba bean germplasm collections from China and Ecuador for resistance to chocolate spot and *Ascochyta* blight.

Some of the durum recombinant inbred lines (ICARDA/CIMMYT) were identified with a high level of resistance to both black point and wheat gall nematode in JK/Cham 1 and Krf/*T. dicoccoides*//Krf crosses.

Resource Management and Conservation

Water Conservation and Management in the Dry Areas

ICARDA's research on water management and conservation was greatly strengthened in 1998 with the appointment of three new scientists. They are working in the areas of marginal-quality water management, soil-water-plant relations, and hydrology. This development came in response to the adoption of the Medium-Term Plan for 1998-2000, which places increased emphasis on research on water in the dry areas, including those in Central Asia. A "Working Group" on water issues was formed to coordinate research among various projects of the Center. The Group includes, besides water specialists, soil scientists, agronomists, and socioeconomists.

On-Farm Water Husbandry in WANA

After two years of launching an ecoregional initiative on "On-Farm Water Husbandry in WANA," the impact of this project on national programs is beginning to show. Preliminary results of research, conducted by the eight countries participating in this initiative, showed that proper planning, selection and implementation of water-harvesting techniques, and

Micro-catchment water-harvesting system of semicircular bunds at a project site in Syria.

closely involving farmers in the process, can successfully improve agriculture in the drier environments. The initiative currently includes Syria, Jordan, Pakistan, Iraq, Egypt, Libya, Tunisia and Morocco, but Iran and Yemen are likely to join soon. Jordan, Iraq, Morocco, and Syria were particularly happy with the two-year results and are incorporating water-harvesting research into their national research plan.

The most striking success story was in Syria. The project provided the Syrian national program with an implement to make a microcatchment water-harvesting system of semicircular bunds. The trials were implemented mechanically in the Mahasseh steppe area near Palmyra, where the mean annual rainfall is less than 150 mm. The harvested water was enough to support over 90% of the newly planted shrubs. The Syrian national program has decided to transfer this technology to other dry areas on a large scale.

Potential of Supplemental Irrigation in Iraq, Turkey, and Syria

Wheat production under supplemental irrigation in Iraq, Turkey, and Syria has continuously increased over the last decade. At the same time the need for improving water-use efficiency is also increasing. ICARDA has had collaborative research in Iraq, Turkey, and Syria for several years on improving productivity and water-use efficiency of wheat under supplemental irrigation. Parameters considered have included levels and timing of irrigation in relation to planting dates, levels of fertility, and varieties.

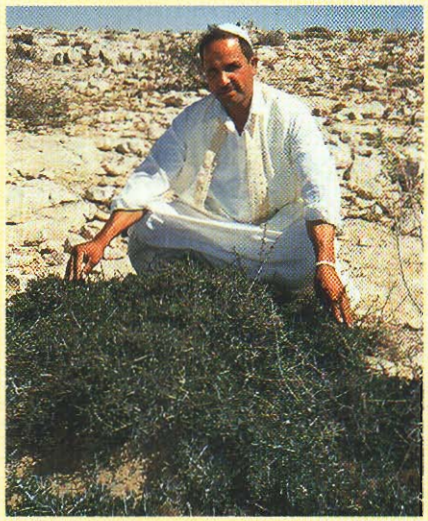
The results show that supplemental irrigation can double the yields in most of the years with the application of relatively small amounts of water. The practice proved most efficient if water was applied at levels between half and two-thirds of the full crop irrigation requirements. Methodologies for optimizing this practice under different levels of water scarcity and management options were developed and published.

ICARDA's collaborative research in Iraq, Turkey, and Syria has demonstrated that strategically applied small doses of supplemental irrigation can substantially increase and stabilize cereal yields.

Range Biodiversity and Development in Marsa Matrouh, Egypt

Since 1997, ICARDA has been supporting the rangeland component of the Marsa Matrouh Resource Management Project. Several missions were completed to organize an adaptive research program with Egyptian colleagues. ICARDA's main contribution has been in the diversification of native and exotic shrubs and trees to be used in the low-rainfall area of Marsa Matrouh (less than150 mm mean annual rainfall).

The species worth noting include a small tree *Rhamnus oleoides*; *Periploca angustifolia*, once on the plateau and now taking refuge in the wadis; *Ephedra aphylla* (a medicinal plant) hanging from the cliffs; and *Retama retam* (a valuable legume shrub producing some good fuel wood and fruits which are good forage).



Rhamnus oleoides, a small tree abundant in Marsa Matrouh but rare elsewhere in the region.

A valuable fodder shrub and a perennial Crucifer with fleshy leaves, *Moricandia nitens* is likewise found all around and grows as tall as 1.5 meter on top of the cliff of Wadi Abu Grouf.

Abundant and unexpected also is the presence of *Dactylis glomerata* (var. *hispanica*), the famous cooksfoot pasture grass at the edge of the plateau and hiding in the wadi's steep slope, and *Oryzopsis miliacea* (a very palatable bunch grass which reaches a height of 2 meters), and *Hyparrhenia hirta* growing on sand stones in the very eastern tip of wadi Remel.

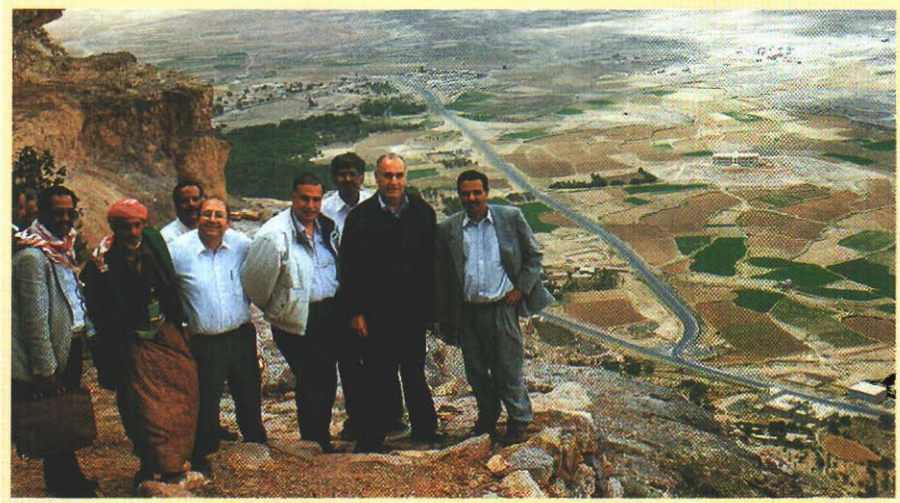
The project experts now have a valuable range of plant material. Seeds are collected and seedlings grown in the project's nursery before being transplanted to the grazing units implemented with the local farmers and pastoralists.

Impact of Land Tenure and other Socio-economic Factors on Mountain Terraces in Yemen

A study, financed by IDRC (International Development Research Center), was conducted in 1997/98 in the western escarpments of Yemen in collaboration with the University of Sana'a and Agricultural Research and Extension Authority (AREA). The highlands of Yemen are characterized by their stone-wall terraces, which were built with indigenous knowledge and local resources. These terraces represent over 25 percent of the country's arable land and provide employment and livelihood for the rural population. Farmers have diligently managed these mountain terraces and developed complex farming systems. However, the dramatic social and economic changes over the last 30 years following the revolution, the oil boom in the Gulf region, the improvement of roads, and the increasing job opportunities in the rapidly growing urban centers and overseas have led to the migration of people from rural to urban areas of Yemen. Reliance on the land for food supply has declined due to availability of subsidized food grain, particularly wheat.

These factors led to the abandonment of terrace agriculture. The restoration of many degraded terraces may not be economically feasible under the prevailing conditions. But the good agricultural land that still remains on the mountain terraces of Yemen could be sustainably used for long-term benefits.

General information about the area including land ownership, customary tenure systems, and crop shares was collected through informal interviews



Yemeni colleagues and farmers, and ICARDA researchers take a close look at the rugged environment of Yemen. Farming is not easy in these harsh conditions, and per capita income is low; ICARDA is working with the Yemeni national program to find solutions.

with farmers and key figures in local communities, and local administration officials, in group discussions and individual interviews using open-ended questions. Formal surveys were administered to collect data on holding size, land fragmentation, land property rights, tenure arrangements, crops, and sharecropping arrangements. Data on degraded and broken terraces, farmers' perceptions of constraints to terrace maintenance, and sources of finance for terrace repair were collected.

There are private, state, and endowment (*waqf*) cultivated land ownerships, and communal land representing the vast mountain slopes used as rangelands. However, there is no agricultural land registration and the figures for different land properties are only estimates. At the local (sub-district or *Uzla*) level, a trusted person, locally known as *amin*, keeps records of land transactions. Private land is mainly cultivated by owners (about 70%), but it is also rented out to tenants under sharecropping arrangements. State and *waqf* lands are cultivated by tenants under sharecropping. More than one-third of the cultivated land in the sample was sharecropped.

The study found that customary tenure systems in Yemen are flexible and can accommodate investment in land improvement by tenants. This flexibility, however, was influenced by the expectations of returns on the investment, i.e., it is more likely to apply where high value crops, such as *qat* and coffee are cultivated, and less so where rainfed food crops are cultivated. Nevertheless, food crops were found to be more frequently cultivated than *qat* or coffee on the reclaimed land for the last five years, which were mainly self-financed by farmers.

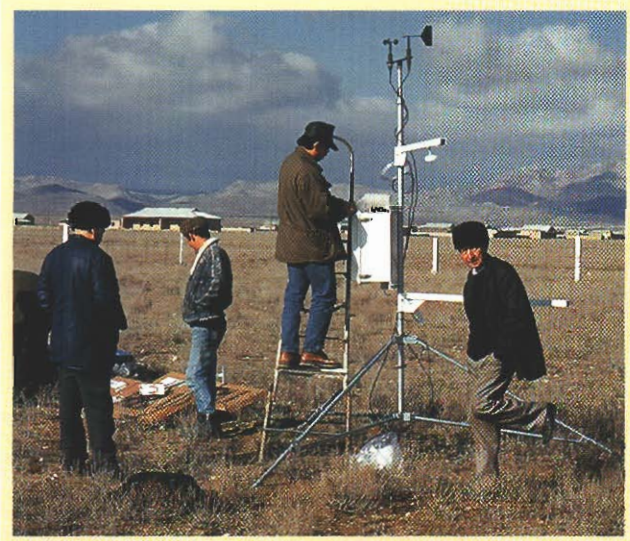
Terraces cultivated by landowners had lower number of broken walls per hectare than those cultivated by tenants under sharecropping arrangements. Lack of clearly defined responsibility between tenants and landowners for the maintenance and cost sharing was the main reason for this. Although these responsibilities are defined in the customary rules of land use, there are no effective enforcement mechanisms. Farmers stated that proper enforcement of the customary rules would significantly increase the investment in land improvement and, particularly, terrace maintenance. However, tenants are relatively in a weaker position to seek enforcement of these rules.

The results of this study indicate that government support is needed for local institutions to strengthen land registration and documentation of sharecropping contracts, increased agricultural credit services that target land improvement, and improved technology and information for farmers. The study also suggests that, if returns on investment are increased, for example, through better price policy and improved agricultural technology, customary tenure systems can support private investment in land improvement.

Establishment of the Carbon-dioxide Flux Measurement Equipment in Uzbekistan

The first station for carbon-dioxide (CO_2) measurement on Central Asian rangeland was established in Karnap (Uzbekistan) as a cooperative project between ICARDA, ARS-USDA (Logan-Utah, USA), and the Samarkand State University.

Karnap rangeland is located at the southern end of the Tim village, within walking distance from the last houses of the village, and on a very large foothill *Artemisia* range. Dr Nassirov is responsible for the operation and maintenance of the equipment on site and in Uzbekistan. Measurements began in spring of 1998.



Installation of a carbon-dioxide Bowen Ratio Equipment at a site near Samarkand in Uzbekistan.

Reorienting Small-Ruminant Production Systems in Central Asia

Reorientation of a number of production systems in WANA and Central Asia is becoming necessary to exploit the opportunities offered by the emerging global open-market economy. In 1998, ICARDA started a collaborative research project with the Karakul Sheep Research Institute of Uzbekistan in Central Asia. An early-weaning and fattening study was conducted as a means not only to offer new alternatives to generate income for Karakul sheep producers but also to reduce overgrazing. Sheep production in Uzbekistan, as well as in other Central Asian countries, confronts critical problems in view of the new emerging market options under a global open-market economy. Research institutions in the past were oriented to serve production lines with little or no possibilities to make use of the open-market scenarios involving the sale of pelts and wool. In fact, farmers in Uzbekistan are keen on selling the pelts they produce.

One of the reorientation strategies successfully demonstrated by ICARDA involved a simple management change to accelerate the weaning and fattening of lambs. Lambs survived and reached desirable weights as stipulated. With average weight gains of 180 g/day, this trial raised the interest of farmers in exploring additional alternatives to generate income.

Sheep production in Central Asia needs reorientation to take advantage of the options offered by the new open-market economy.

Socioeconomic Studies and Impact Assessment and Enhancement

Food and Feed Prospects to 2020 in Central and West Asia and North Africa

Food and feed demand has outpaced domestic production in most WANA countries and will continue to do so. The resource base for traditional livestock raising (native pastures and crop residues) has come under serious pressure, and large feed-deficits are projected. Differences are so great among the WANA countries that aggregating their prospects indiscriminately can be seriously misleading. Sub-aggregates of the WANA countries are proposed to distinguish these differences in prospects.

With populations projected to more than double by the year 2025 in three of the Central Asian Republics (Tajikistan, Turkmenistan, and Uzbekistan), and to continue to increase rapidly in Kyrgyzstan and Kazakhstan as well, expanding deficits in food and feed grain production are projected for all Republics but Kazakhstan. Livestock numbers and feed resources, in aggregate, have expanded in the past 20 years, except in the case of Kazakhstan where feed production has fallen. Moreover, all the Central Asian Republics (with the exception of Kazakhstan) are in feed-deficit situations now. And, with the exception of Kyrgyzstan and Uzbekistan in the highest crop-growth scenarios, all other Republics are projected to plunge into far greater deficits in coming decades, assuming constant current per capita livestock inventories. The likely result will be increased pressure on the rangelands of the four feed-deficit Republics in the form of overgrazing and cultivation.

Policy Research for Improved Productivity and Income in the Low-Rainfall Areas

Joint ICARDA/IFPRI (International Food Policy

Research Institute) policy research with national partners has focused on the development of agricultural policies and analyzes the impact of policy reforms and their effects on income, prices, supply, and demand by agroecological zones and social groups. A multi-market modeling framework was applied to four representative countries (Tunisia, Morocco, Iraq, and Jordan) based on a database used to estimate behavioral parameters for production, consumption, and trade. The impact of nationally relevant policy reform scenarios has been simulated and the results of these simulations support the claim that trade liberalization and domestic price reforms in the Mashreq & Maghreb countries tend to decrease welfare in the low-rainfall areas if mitigation measures are not taken simultaneously. Market liberalization reforms should probably include some exceptions for farmers in arid zones. However, protecting the low-rainfall areas by means of subsidies and/or tariff protection has a high cost on the environment since these instruments tend to increase pressure on marginal lands and rangelands.

Research was conducted in three communities—*Ait Ammar* (Morocco), *Nouayel* (Tunisia), and *Falha* (Jordan)—using bio-economic community models to evaluate the effects of policy reforms and technology packages on community welfare. The results of the simulations, which corroborate sector-level findings and income distribution and environmental sustainability, suggest that trade liberalization policies while enhancing welfare at the national level do not necessarily improve the well-being of farming communities in the low-rainfall areas. Similarly, domestic price reforms tend to reduce farmers' welfare but yield a more equitable income distribution between rich and poor farmers. The effects of these reforms on natural resources tend to be site-specific. However, the introduction of new technologies (new barley cultivar) was found to improve farmers' welfare, enhance crop livestock integration, and reduce pressure on natural resources without necessarily worsening income distribution. This result underscores the importance of technology transfer and agricultural research as an alternative to broad-based price support and feed subsidies in achieving efficiency, equity, and environmental sustainability in low-rainfall areas.

The Cereal/Vetch Rotation Technology Takes Off in Syria

ICARDA started to develop the cereal/vetch rotation in the El-Bab area, in northwest Syria, in 1986. At that time, continuous wheat and, especially, barley cropping was exhausting the land, and causing an unbroken cycle of pests and diseases. Both these factors were contributing to a decline in yields.

The work started in 1985/86 by establishing on-farm trials in cooperation with farmers. The objective of the trials was to quantify the benefits of using common vetch (*Vicia sativa*) to replace the fallow year in the barley-fallow rotation or to introduce common vetch into continuous barley monoculture.

The on-farm research has demonstrated that vetch is well adapted to the farming systems of northwest Syria. Weaned lambs grazing vetch in spring gained 150-200 kg live weight per hectare. Even more significant were the benefits that farmers saw in their barley when forage crops interrupted the barley monoculture and prevented the perpetuation of gall nematode that has become quite widespread in recent years. Barley yield was up, too. In the 1997/98 season, in what was generally not a good year for cereals in Syria, Mr Yagen, a farmer in El Bab, obtained a yield of around 3.4 t/ha from his barley fields following vetch, against 2.8 t/ha obtained by his neighbors who did not follow this practice. In

A farmer in El-Bab harvests vetch for seed, using a cutterbar mower. The availability of mowers has added to farmers' enthusiasm for growing vetch.

general, he has been seeing 20% higher yields than those of his neighbors in recent years.

These results made vetch attractive to farmers. Vetch seed production was, however, a bottleneck to the wide adoption of vetch. Hand harvesting is not economical because labor is both scarce and expensive. To tackle the problem ICARDA started to test locally constructed rollers to make an even seedbed and mowers to cut and swath the mature crop. The availability of the rollers and mowers added to farmers' growing enthusiasm about vetch. The number of farmers growing vetch increased in 1998 to 200 in 20 villages, with an area of about 500 hectares. And farmers are investing themselves.

Human Resource Development

During 1998, ICARDA offered training opportunities to 865 national researchers from West Asia and North Africa (WANA), Africa (excluding North Africa), Asia and the Pacific region (excluding West Asia), and Europe. Of these, 18% were women. In addition, 64 national scientists from both developing and industrialized countries have been conducting their graduate research training for MSc and PhD degrees through arrangements between ICARDA and agricultural universities.

ICARDA continued its strategy to gradually decentralize its training activities. In 1998, there were 13 headquarters training courses and 35 in-country, regional, and subregional courses.

The Center also facilitated and coordinated implementation of the training needs for several externally-funded projects: the Southern Regional Agricultural Development Project in Syria; the Matrouh Resource Management Project (MRMP) in North-West Egypt; and the Agricultural Sector Management Support Program (ASMSP) in Yemen.

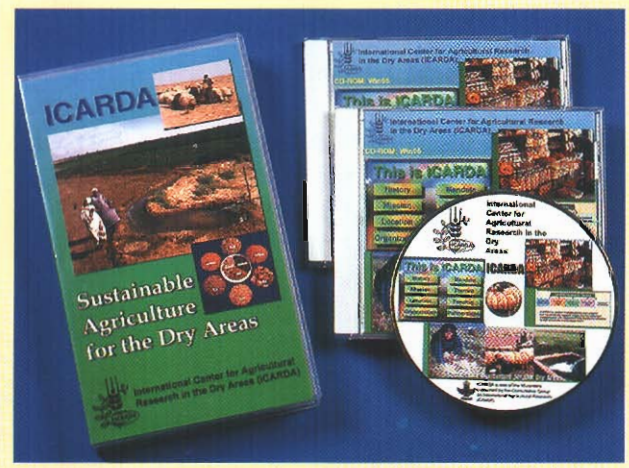
Collaboration in offering training courses was further strengthened with NARS, as well as with several sister regional and international agricultural research and training institutes including ACSAD, AOAD, ACIAR, API, CIHEAM, CIMMYT, CLAES, FAO, EICA, IFPRI, ILRI, IPGRI, and UNDP. Three training courses were jointly offered with CIHEAM and two with IPGRI. Inter-Center collaboration was also strengthened through participation in the Inter-Center Group, and exchange of the ICARDA training database with other sister centers.

Information Dissemination

The year saw the establishment of an electronic library on the Intranet. This enabled users at headquarters to access from their PCs a large number of databases including AGRIS, AGRICOLA, Plant Gene, Water Resources Abstracts, World Development Indicators, a few electronic journals, and the proceedings of the CGIAR meetings. The electronic library received about 220 hits per month during the year. ICARDA staff can also now access the electronic version of *The Week* (both English and Arabic) on the Intranet. The Information Unit's homepage also features video clips of important events held at ICARDA during 1998.

A self-learning laboratory, with three stations, was established. This facility provides access to important self-learning videos and CD-ROMs, covering the software programs used at ICARDA, to the Center staff and trainees.

A new ICARDA video, based on the Center's MTP for 1998-2000, was released in English and



As part of its increased thrust on public awareness, ICARDA produced a new video and a first CD-ROM in 1998.

Arabic. The Center also produced its first interactive, multimedia CD-ROM in-house, which provides information about ICARDA's mandate and mission, its research themes and projects, its partnerships, and its future vision. A journalist from the U.K. visited the Center and broadcast stories about ICARDA's work twice on BBC. ICARDA featured on satellite channels frequently in the region. Over 53 stories about the Center's activities were published in the media. The Center participated in several regional/international book fairs.

Technology upgrades and improvement in staff skills in the Information Unit helped the Center scientists to improve the quality of their presentations. Three training courses in scientific writing were offered, one each in Morocco, Qatar, and Yemen. A headquarters training course in information management was organized on 18-29 October. Ten information professionals from Algeria, Ethiopia, Jordan, Lebanon, Libya, Morocco, Oman, Sudan, Syria, and Yemen participated. A new component of the course was the introduction to the PC version of MINISIS, which allows the use of Internet technologies. The Director of MINISIS from IDRC offered this component of the course.

The key publications produced included the corporate Annual Report for 1997, crop newsletters (Rachis, FABIS and LENS), workshop proceedings, *Caravan*, and *The Week at ICARDA*. Two titles, "This is ICARDA" and "Central Asia and ICARDA" were also produced in Russian.

Computer and Biometric Services

There was only a limited upgrading of the computer facilities during 1998 owing to budget limitations. The computer local-area network was extended to more buildings at Tel Hadya. The standardization on Office 97 PC software was completed. A local-area computer network was designed and installed for the ICARDA International School.

Statistical analyses for evaluating productivity and sustainability of cropping systems were carried out on 14 years of data from barley-legume rotations, and 10 years of data from continuous barley cropping. Modeling of plot error covariance structures in long-term rotation trials in barley was done on data from the two-course barley rotations conducted for 14 years and the other with continuous barley conducted for 10 years each at two locations in northern Syria. The data indicated that accounting for heterogeneity in error variances provides a highly significant improvement over the assumed uncorrelated errors with a constant variance. This can be used in evaluating effects of rotation and other input factors in crop rotation trials.

During 1998 the MIS team migrated all the six modules of Oracle Financials on VAX-4500 from release 9.3 to 10.6. Users were trained, both in Arabic and English, to benefit from this.

The Project Management System was converted to Windows NT environment and loading of projects data was initiated.

The ICARDA Intranet use expanded, with 150 connections, ushering in the WEB culture at ICARDA.

A total of 55 NARS personnel were trained in biometrics, data management and presentation in both in-country and regional courses. Over 211 ICARDA staff were trained in 24 courses covering various software packages.

International Cooperation

ICARDA's Regional Programs continued to provide a major mechanism for sustaining the research continuum with the national agricultural research systems (NARS). Besides enhancing linkages and exchange of technology and germplasm between ICARDA and NARS, these Programs help promote the development of intra- and inter-country linkages, coordination, and effective networking. They also provide feedback on NARS' needs to reorient ICARDA's research agenda and Medium-Term Plan.

North Africa Regional Program

The North Africa Regional Program (NARP) continued to place special emphasis on enhancing ICARDA's partnership with the NARS of Algeria, Libya, Morocco and Tunisia; in addition, it initiated a first collaborative program with Mauritania.

Collaborative Research

Within the framework of collaborative projects, several activities continued with the national research institutions. These included the Regional Program on Development of Integrated Crop/Livestock Production Systems in Low-Rainfall Areas of the Mashreq and Maghreb Regions – Phase II (known as the Mashreq/Maghreb Project), funded by AFESD and IFAD; the West Asia and North Africa Dryland Durum Wheat Improvement Network (WANADDIN), supported by IFAD; and the Farmer Participation in Barley Breeding, supported by IDRC. In addition, collaborative programs continued in on-farm water management, water harvesting, and the improvement of cereals and food legumes. Collaborative research on resistance and biotype characterization of the Hessian fly, resistance to Russian wheat aphid and to barley stem gall midge, outsourced by ICARDA to Morocco, continued to make good progress.

Coordination Meetings, Workshops, and Training

Annual National Coordination Meetings, involving scientists from NARS and ICARDA, were held in Algeria, Libya, Morocco, and Tunisia to evaluate the progress made in collaborative research in 1997/98 and develop workplans for 1998/99. The sixth North Africa/ICARDA Regional Coordination Meeting was held in October in Tunisia to discuss problems of common interest, particularly in cereal and food legume improvement, with emphasis on participatory breeding, agroecological characterization, integrated pest and disease management, and water-use efficiency.

Three workshops were held: (i) WANADDIN Socioeconomics Workshop; (ii) Workshop on Policy and Property Rights within the Mashreq/Maghreb Project; and (iii) Durum Wheat Traveling Workshop in Morocco. Three regional training courses contributed to the enhancement of capacity building and human resource development in North Africa: (i) Scientific Writing; (ii) Processing and Economics of Seed Production; and (iii) On-Farm Experimental Station Operation and Management.

NARP, in collaboration with INAT-Tunisia, contributed to interregional cooperation by organizing three training courses/study tours in Tunisia for colleagues in the Matrouh Resource Management Project (MRMP) of Egypt, in which ICARDA is implementing the research component through NVRSRP.

Collaboration with Mauritania

In March 1998, a Mauritanian delegation, headed by the Minister of Rural Development and Environment, visited ICARDA at the invitation of the Director General. To follow up on the discussions, an

Participants in the Mashreq/ Maghreb Project Technical Coordination and Planning Meeting for Phase II, held in Tunisia.

ICARDA team visited Mauritania in April and November 1998, to develop a collaborative research program. Based on NARS priorities and field missions, seven research concept notes were jointly developed on irrigated agriculture, rainfed agricultural systems, agro-sylvopastoral system, oasis production system, technology transfer and impact analysis. Collaborative research in these areas is expected to be initiated in 1999.

Nile Valley and Red Sea Regional Program (NVRSRP)

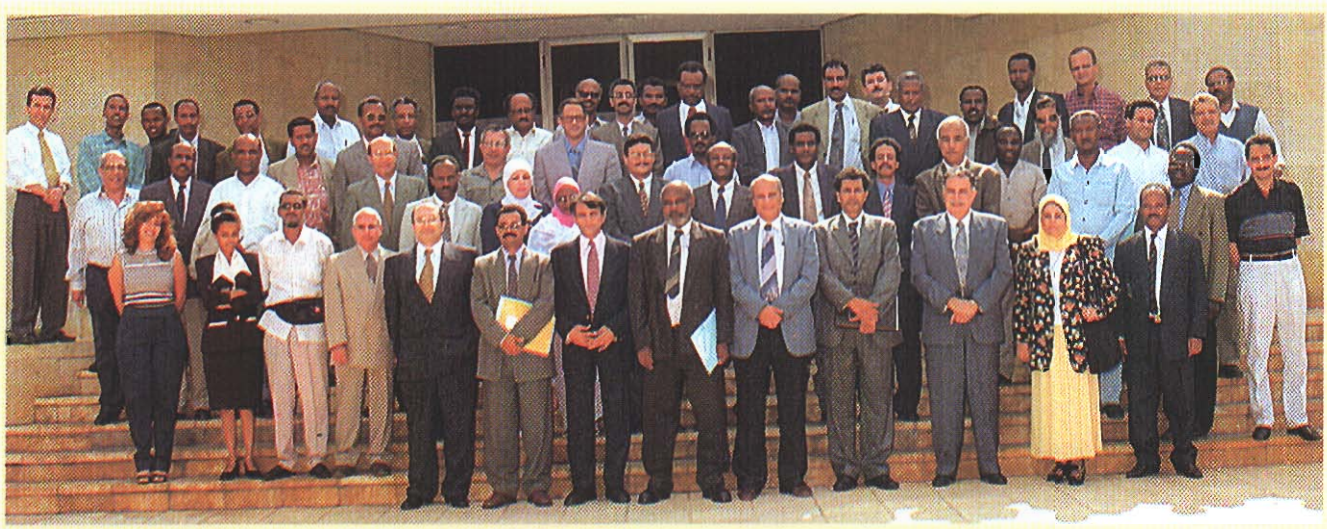
Collaborative Research

The Nile Valley and Red Sea Regional Program (NVRSRP) continued the implementation of several major collaborative projects at the national and regional levels: in Egypt, the projects on cereals, food legumes and natural resource management, funded by the EU and Egypt; on weed control (particularly wild oats), funded by the EU and Egypt; the Matrouh Resource Management Project (MRMP), supported by the Egyptian Government through a World Bank loan; in Ethiopia, the project on pulses improvement, funded by the Netherlands; and in Yemen, the Agricultural Sector Management Support Project (ASMSP), supported by the Yemeni Government through a World Bank loan. This is in addition to the Problem-Solving Regional Networks Project involving Egypt, Ethiopia, Sudan and Yemen, and supported by the Netherlands. The first phase of this project (1995-98) reached completion on 31 December 1998. A proposal for a second phase was submitted to potential donors.

Coordination Meetings, Workshops, and Training

Annual National Coordination Meetings were held in Ethiopia, Sudan, Egypt, and Yemen to discuss the achievements of collaborative research in the 1997/98 season and develop workplans for 1998/99. These were followed by a Regional Coordination Meeting involving all partners (the four countries and ICARDA), which was held at ICARDA headquarters. The meeting focused on regional problem-solving networks and other areas of common interest, such as wheat rusts, wilt/root rots of food legumes, viruses/aphids in cereals and food legumes, thermotolerance in wheat, drought tolerance and water-use efficiency, and socioeconomic studies.

The Rapid Impact Program (RIP) of ASMSP in Yemen continued to disseminate improved technology to farmers in different agroecologies. Two Research Review Workshops were held in Yemen to review the RIP in the Coastal Area and the Eastern Plateau. Based on the success achieved in ASMSP, ICARDA was requested by the Yemeni Government



Participants in the Regional Coordination Meeting of NVRSRP held in Aleppo in September 1998.

to join the World Bank Mission to develop the terms of reference for the National Agricultural Research Project (NARP) for Yemen.

Three Regional Traveling Workshops were organized in 1998 to enhance regional cooperation and interaction among scientists, extension workers and farmers in Egypt, Ethiopia, Sudan, and Yemen: (i) Wheat in Sudan, (ii) Food Legumes in Egypt, and (iii) Barley in Ethiopia. To enhance coordination and cooperation at the national level, national workshops were also held on Lentil and Chickpea in Ethiopia; Resource Management, Data Handling and Computer Applications in Egypt; and Cereals in Yemen.

In human resource development, regional and in-country training courses in 1998 covered integrated management of aphids and viruses, methodologies of socioeconomic impact and gender analysis, wilt and root rot diseases, and AGROBASE software. During the year, 84 scientists from the four countries, involved in the Regional Networks Project, participated in short training courses (16), visiting scientists program (10), and regional workshops and coordination meetings (58). In bilateral projects, a total of 355 and 123 scientists from Egypt and Ethiopia, respectively, were involved in various human resource development and capacity building activities. In degree training, one Ethiopian and one Yemeni graduate student completed their MSc, and 16 Yemeni students continued their MSc and PhD studies in various specializations.

ICARDA Director General, Prof. Dr Adel El-Beltagy, visited Yemen in June 1998 to meet the Prime Minister, the Ministers of Foreign Affairs, Planning and Agriculture, as well as other distinguished officials; in addition to visiting the Agricultural Research and Extension Authority (AREA) and field activities of the collaborative ASMSP Rapid Impact Program. It was agreed to jointly mobilize the resources for agricultural research in Yemen.

West Asia Regional Program

Collaborative Research

The West Asia Regional Program (WARP) focuses on improving and sustaining the productivity of farming systems in low-rainfall areas (200-400 mm) of Cyprus, Jordan, Iraq, Lebanon, Syria, southern Turkey (low lands), and the Palestinian Territories. Major developments in collaborative projects included the extension of the Mashreq & Maghreb Project on the Development of Integrated Crop/Livestock Production Systems of Mashreq (Jordan, Iraq, Lebanon, and Syria) and Maghreb (Algeria, Libya, Morocco, and Tunisia) for a second phase through the continued support of AFESD and IFAD. IDRC partly supports the policy and property rights (PPR) studies in Phase II of this Project.

Substantial technical input continued to be provided to other collaborative research projects on water harvesting in WANA, improvement of barley in dry areas, and production of multipurpose fodder crops. ICARDA also continued to provide technical backstopping to the IFAD-funded projects on Agricultural Research Management and the Newlands Agricultural Services as well as the EU-funded Jordan Arid-Zone Productivity Project.

Coordination Meetings, Workshops, and Training

Four national coordination meetings were jointly organized in Cyprus, Jordan, Iraq, and Syria to further strengthen the ICARDA/NARS partnership. For Cyprus, this was the first national coordination meeting. A new agreement of cooperation was signed between Cyprus and ICARDA, which extends the collaborative research with Cyprus from an earlier agreement. The Regional Technical Planning and Coordination Meeting and the Steering Committee Meeting of the Mashreq & Maghreb Project, involving all partners (eight countries, ICARDA, and donor representatives from AFESD and IFAD), were held in Tunisia. These meetings marked the beginning of Mashreq & Maghreb Phase II. Workplans and budgets were approved at these meetings to enhance complementarity in research and capacity building, as well as leadership at the national and regional levels.

Cooperation was initiated with ESCWA on increasing the efficiency of on-farm water use in the region. A Regional Workshop on Policy and Property Rights (PPR) in West Asia and North Africa was

organized jointly with NARS and IFPRI to consolidate the PPR findings in Mashreq & Maghreb Phase I on community development, collective property rights, policies, and market liberalization. Human resource development activities included in-country and regional training courses on water harvesting, water-use efficiency, and modern techniques in improved intensive agricultural systems. This was in addition to training of national scientists/technicians at ICARDA.

Arabian Peninsula Regional Program

After the formal opening of the Arabian Peninsula Regional Program (APRP) Office in Dubai in January 1997, the Program was further strengthened in mid-1998 with the recruitment of two scientists specialized in protected agriculture and irrigation. The major collaborative project in APRP is on "Strengthening Agricultural Research and Human Resource Development in the Arabian Peninsula," supported by AFESD and IFAD. The Project covers four main research themes: (i) rangeland, shrubs, irrigated forages and livestock; (ii) abiotic stresses; (iii) on-farm water use and irrigation management; and (iv) protected agriculture.

Coordination Meetings, Workshops, and Training

The Regional Technical Coordination Meeting and the Regional Steering Committee Meeting were held in Bahrain. The meetings were attended by the National Program Coordinators and selected scientists from all seven Arabian Peninsula countries (Bahrain, Kuwait, Qatar, Saudi Arabia, the Sultanate of Oman, the United Arab Emirates, and Yemen) and ICARDA, in addition to a representative from AFESD. The meetings evaluated progress and developed the 1998/99 workplans and budgets, which were approved by the Steering Committee.

An international workshop on "Protected Agriculture in the Arabian Peninsula" was held in Qatar. It covered state-of-the-art of major components of protected agriculture in the Arabian Peninsula and the world. The recommendations from this workshop formed the basis for the immediate and long-term strategies for protected agriculture development in the Arabian Peninsula. The workshop was funded by AFESD and IFAD, with technical contribution from FAO. It was organized by the Ministry of Municipal Affairs and Agriculture in Qatar in cooperation with ICARDA. Fifteen national scientists and 12 regional and international experts participated.

Improving on-farm water-use efficiency and irrigation management is a key component of ICARDA's collaborative research in the Arabian Peninsula. Here, ICARDA DG (fourth from left) is seen with national researchers at a collaborative research site in the UAE.

Five regional training courses were held in the region: Field Plot Techniques, Data Analysis and Data Presentation and Scientific Writing (Qatar), Germplasm Collection and Maintenance (UAE), Irrigation and Fertigation (Saudi Arabia), Seed Technology and Production (Oman), and Insect Taxonomy and Integrated Pest Management (Oman).

The courses were given both in Arabic and English. A total of 83 national scientists were trained.

Highland Regional Program

The Highland Regional Program (HRP) continued to strengthen partnerships with Turkey, Iran, Pakistan, and Central Asia and the Caucasus (CAC) (until the establishment of a separate CAC Regional Program in September 1998).

Collaborative Research

Collaborative research projects in Turkey covered crop improvement (durum and bread wheat, barley, lentil, chickpea, and feed legumes), crop diversification and on-farm technology adoption, supplemental irrigation, rangeland rehabilitation, and sheep improvement.

The Iran-ICARDA project, funded by the Iranian Government, continues to further strengthen the ties between the two partners, particularly in crop improvement (wheat, barley, chickpea, lentils) and human resource development. A Wheat Rust Trap Nursery was assembled and dispatched in cooperation with Iran to partner countries within CWANA. Cereal research results of the Dryland Agricultural Research Institute (DARI) for the period 1994-1997 were published.

Upon the request of Pakistani Government and IFAD, ICARDA contributed to the development of the research component of the Barani Village Development Project of Pakistan. ICARDA is being considered as the implementing agency for this Project, expected to start in 1999.

Officials of the Southeastern Anatolia Project-Regional Development Administration (GAP-RDA) of Turkey and ICARDA exchanged visits and discussed collaboration for the improvement of agricultural research and development in the GAP Region. A Memorandum of Understanding (MOU) between GAP-RDA and ICARDA was signed in Sanliurfa on 26 June 1998, by GAP-RDA President and ICARDA Director General. The MOU calls for collaboration in research, technology transfer, and strengthening human resources for rural and agricultural development in the GAP Region.

The Turkey-CIMMYT-ICARDA International Winter Wheat Improvement Program (IWWIP) established an expanded Seed Unit and started to develop a Seed Health Laboratory at Konya to ensure the dispatch of healthy wheat seed from Turkey to the CWANA region. The coordination of IWWIP is streamlined with the establishment of a Working Group and a Steering Committee, with members from GDAR/Turkey, CIMMYT, and ICARDA. The Steering Committee met twice to review the implementation of program activities in 1998, and develop the plan of work for 1999.

The GAP team sees ICARDA experiments. Left to right: Mr A. Mekin Tuzun, Mr Hamidi, Ms Berrin Basak, Ms Zerrin Oztimur, Mr Erkan Alemdaroglu, ICARDA faba-bean breeder Dr Shabban Khallil, and Germplasm Program Leader Dr Willie Erskine.

Meetings, Workshops, and Training

ICARDA scientists visited Iran during the crop season and at the annual Iran-ICARDA coordination meeting. Human resource development included: (i) two in-country courses on seed processing and biotechnology, (ii) individual

training of 13 researchers at ICARDA on durum wheat improvement, barley breeding, chickpea improvement, water-use efficiency, biotechnology, integrated pest management, seed health, and experimental station management, and (iii) MSc/PhD degree training for eight scientists. Scientists from Iran participated in meetings, workshops and conferences in Niger, Central Asia, Canada, and Turkey. Twenty-four decision-makers involved in agriculture and 100 progressive farmers visited ICARDA during the season to get acquainted with the Center's research facilities and methodologies.

A senior scientist from National Agricultural Research Council, Pakistan visited the IWWIP in Turkey to participate in winter wheat selection, and to discuss collaboration with ICARDA. Turkish scientists were supported to participate in scientific meetings, workshops, conferences and training at ICARDA, and in Canada, UK, and Central Asia.

Establishment of ICARDA's Regional Office in Central Asia

ICARDA's Regional Program for Central Asia and the Caucasus (CAC) was formally established in Tashkent, Uzbekistan in response to an invitation from the Republic of Uzbekistan (RU). An Agreement of Cooperation between the RU and ICARDA was signed in May 1998. The program will serve Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan in Central Asia, and Armenia, Azerbaijan and Georgia in the Caucasus.

Collaborative Research

In 1998, collaborative activities in the CAC region were further strengthened in genetic resources collection, conservation and documentation (in collaboration with IPGRI), sheep and range development (in collaboration with USDA/ARS), wheat improvement (in collaboration with CIMMYT), and germplasm exchange in barley and food, feed and forage legumes. New collaborative activities included socioeconomic surveys of rangelands/livestock in three regions of Kazakhstan, conducted in collaboration with GL–CRSP/University of California, Davis, USA. A new regional ACIAR-supported project on "Collection, Evaluation and Conservation of Cereals and Legumes in the CAC," in which ICARDA is actively involved, was initiated in Uzbekistan with a collection expedition jointly organized with the Plant Industry Institute of Uzbekistan and CLIMA of Australia.

ICARDA also actively participated in study missions in CAC, including participation in the World Bank supported mission in Kyrgyz Republic, to prepare a final report on the Seed Component of the Agricultural Support Services Project. ICARDA was also a partner in a "Seed Sector Study in Kazakhstan," which was jointly implemented by COWI of Denmark and the Ministry of Agriculture and the National Academic Center for Agricultural Research (NACAR) of Kazakhstan.

Coordination Meetings and Workshops

A Regional Traveling Workshop on winter/facultative wheat was organized in collaboration with CIMMYT and three CAC NARS from 13 to 20 June. Scientists from the eight CAC Republics, as well as from Iran, Turkey, ICARDA and CIMMYT participated and visited the national wheat programs of Uzbekistan, Kyrgyzstan, and Kazakhstan.

The second Regional Coordination Meeting for CAC was organized in collaboration with NACAR in Almaty, Kazakhstan, 21-24 September 1998. The meeting, attended by 34 scientists from the eight CAC Republics and 11 from ICARDA, provided an excellent opportunity for scientific interaction. During the meeting, participants discussed results of the 1997/98 collaborative activities and developed collaborative workplans for 1998/99.

CGIAR Collaborative Research Program for CAC

Nine CG Centers—CIMMYT, CIP, ICARDA, ICRISAT, IFPRI, IIMI, ILRI, IPGRI, and ISNAR—are participating in this Program, which has been formulated on the basis of CAC NARS priorities and approved at the first Program Steering Committee Meeting held in Tashkent, 28-29 September 1998.

The Program addresses five main themes corresponding to the five main activities within the CGIAR's approved research agenda: (i) productivity of agricultural systems; (ii) natural resource conservation and management; (iii) conservation and evaluation of genetic resources; (iv) socioeconomics and public policy, and (v) strengthening national programs. "Seed money" was provided by the CGIAR Finance Committee to support three main projects on crop improvement and diversification (CIMMYT, CIP, ICARDA, ICRISAT and IPGRI), soil and water (ICARDA) and research management (ISNAR), in addition to supporting the development of other research proposals relevant to NARS priorities.

The implementation of the CGIAR collaborative research is supported by a Program Facilitation Unit (PFU), which is located in ICARDA's Regional Office for CAC in Tashkent, since ICARDA serves as the focal point for the CGIAR activities in CAC.

Latin America Regional Program

The Latin America Regional Program (LARP), based at CIMMYT in Mexico, emphasizes on barley-breeding activities. During 1998, three new varieties were released, derived from germplasm bred in the ICARDA/CIMMYT Barley Program. The El Nino effect, with its associated severe rainstorms, put to test the disease-resistance of barley varieties being promoted in the dry Andes in southern Ecuador. Farmers involved in a seed production project sponsored by the National Research Institute (INIAP) and ICARDA's barley program harvested 2 t/ha, which is almost three times the national average.

ICARDA has initiated the process of strengthening its Latin America Regional Program, by expanding its action domain in collaboration with CIP (International Potato Center), in Lima, Peru. In addition to the present efforts in crop improvement, problems related to natural resource management, including small ruminants, will be addressed.

Barley is grown as part of the complex crop-livestock systems in the Andean region. Potato-based crop rotations include barley and faba bean as secondary but essential crops to maintain soil fertility and minimize potato-associated diseases. Barley and faba bean are staple crops and their straw is used as fodder. In some parts of the Andean region, shortage of water and low temperatures limit crop production to less than 150 days per year. The management of flooded grasslands, or *bofedales*, above 4000 m, is crucial for the sustainability of potato-based agriculture and agropastoral systems. The *bofedales* function as a living sponge and regulate the water flow to the inter-Andean valleys—crucial for soil erosion control—and represent a valuable source of forage for sheep and camelids. Property rights, water harvesting, storage and irrigation at critical times–to maximize the value of scarce water -are areas of research that complement gains in crop improvement. Supplemental irrigation of faba bean in the dry valleys of Bolivia, coupled with research on disease resistance, biotechnology, soil fertility and marketing, are avenues suggested by the national programs to broaden ICARDA's activities. Likewise, research towards the improvement of water and range management of the dry coastal plains of Peru and Chile could offer high payoffs.

ICARDA/CIMMYT Barley Program is collaborating with Oregon State University in developing head-scab-resistant barley lines. Here, Ann Corey from the U.S. and Ariel Castro from Uruguay observe new doubled-haploids resistant to head scab in ICARDA/CIMMYT barley nurseries at El Batan Experiment Station in Mexico.

PART TWO

Research and Training Overview

Contents

Research and Training Overview

Research and Training Overview

ICARDA serves the entire developing world for the improvement of barley, lentil and faba bean; and dry-area developing countries for the on-farm management of water, improvement of nutrition and productivity of small ruminants (sheep and goats), and rehabilitation and management of rangelands. In the Central and West Asia and North Africa (CWANA) region, ICARDA is responsible for the improvement of durum and bread wheats (in collaboration with CIMMYT), chickpea (in collaboration with ICRISAT), pasture and forage legumes, and farming systems; and for the protection and enhancement of the natural resource base of water, land, and biodiversity. Much of ICARDA's research and training activities are carried out in collaboration with National Agricultural Research Systems (NARS). For certain specialized areas of research, the Center has established linkages with several advanced institutions in industrialized countries (see Appendix 7). The Center has identified seven integrative activities central to its current research program. These are: agroecological characterization, germplasm conservation, germplasm enhancement, resource management and conservation, training and networking, information dissemination, and impact assessment and enhancement. Each activity is a multidisciplinary effort with well-defined objectives and program of work, designed to contribute to the Center's overall goal of achieving sustainable increases in crop and livestock productivity, while protecting the environment and alleviating poverty.

At its headquarters at Tel Hadya, about 35 km southwest of Aleppo, Syria, ICARDA conducts research on a 948-ha farm. The Center operates three additional sites in Syria and two in Lebanon (see Table 9, p. 69). The report that follows represents only a selection of important results achieved in collaboration with NARS and advanced research institutes (ARIs) during the 1997/98 cropping season. Progress in transfer of technology and strengthening partnerships with NARS is summarized under "International Cooperation."

The Weather in the 1997/98 Season

Favorable weather prevailed across North Africa during the 1997/98 season and cereal yields were generally higher than the previous year and above the long-term average. In the Maghreb countries, this was due to a good moisture supply, while in Egypt crops did not suffer from the excessive heat and dust of the previous year. In East Africa, the rainfall during the spring of 1998 was lower than average. This affected especially Somalia, where spring is the main rainy season; while in Ethiopia, where spring is the minor rainy season, crop yields reached near-average levels in the north and were even higher in the south of the country. In southern Sudan, the picture was equally varied with some areas suffering from drought and others from flooding. The summer period, which is the main rainy season across East Africa, except for Somalia, brought ample rainfall and a generally good harvest, with only some patches of drought in eastern Ethiopia.

The rainfed areas of Yemen received adequate moisture supply; and the irrigated crops in Saudi Arabia and the Gulf countries were not hit by excessive heat stress. In the Mashreq countries too, precipitation during the winter was above average. Yields in general were higher than in the previous year in spite of a period of warm weather during April and May in Syria (Fig. 1) and parts of the neighboring countries.

The winter was quite wet and snowy across Turkey, Iran, Afghanistan, and western Pakistan. In Turkey and Iran, floods caused some damage to crops, but the harvest was generally above average. The favorable weather helped Afghanistan to produce its largest cereal crop since the late seventies. Favorable weather also prevailed over most of Central Asia and the Transcaucasian Republics and the harvest was good in spite of localized problems

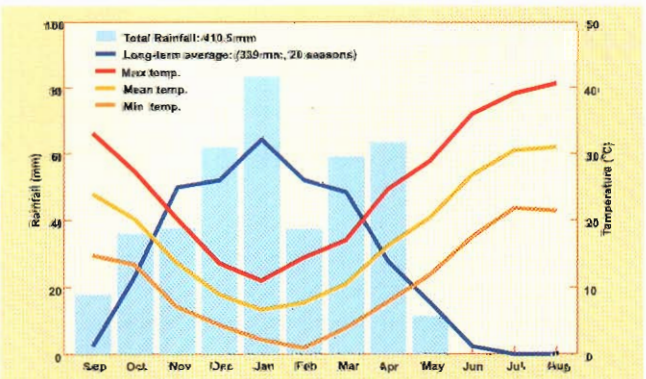


Fig. 1. The weather conditions at Tel Hadya, ICARDA's main research station, during 1997/98.

of cold spring and flooding. It was only in Kazakhstan that a significant part of the cropped area was affected by exceptionally high temperatures causing crop failure and a reduction in cereal production.

Agroecological Characterization

Agroecological Atlas of Syria

ICARDA, in cooperation with the Syrian national program, has started work on assessing Syria's natural resources with the objective of developing a land-resource information system (LARIS) for use in land-use planning and targeting of research.

LARIS will contain geo-referenced data sets on climate, land forms, soil, water resources, land cover, land utilization and farming systems, as well as derived data sets on agroecologic zones, land suitability and water requirements for different crops, and land-use recommendations. These data sets will be integrated into a Geographic Information System (GIS) and made available royalty-free on CD-ROMs to potential users.

The first results from this project are expected to become available in mid-1999 in the form of a CD-ROM-based digital Agroecological Atlas, being developed jointly with Texas A&M University, USA. In its first version, this country-level GIS will contain layered information on climate, soil, land forms, geology, water resources, and land cover/land use in Syria.

Germplasm Conservation

Germplasm Collection in the United Arab Emirates and the Sultanate of Oman

Germplasm collection missions were carried out in the United Arab Emirates (UAE) and the Sultanate of Oman for the major indigenous forage grasses, legumes, shrubs and trees of the region. The objective is to identify promising material for rehabilitation of degraded rangeland, and for irrigated fodder (alfalfa and Rhodes grass) production with less water than currently used. The missions were also aimed at training colleagues from the Ministry of Agriculture and Fisheries, UAE, and the Directorate of Agricultural Research, Oman, in germplasm collection techniques.

The mission in the UAE, 12–19 March 1998, targeted the higher rainfall zones, which occur north of the Abu Dhabi to Al-Ain main road. Prior to the mission, target taxa had been prioritized in consultation with farmers, local botanists, and an international consultant on rangeland development. In total, 114 accessions were collected, representing 22 taxa from 27 sites (Table 1). The locations of collection sites are shown in Fig. 2.

In the Sultanate of Oman, 20 March–6 April

Table 1. Number of accessions of rangeland species collected in the United Arab Emirates and the Sultanate of Oman in March 1998.

Species	No. of accessions	
	UAE	Oman
Asphodelus tenuifolius	-	2
Calligonum comosum	-	1
Calligonum crinitum arabicum	1	1
Cassia italica	1	-
Cenchrus ciliaris	11	7
Cenchrus setigerus	-	1
Coelachyrum piercei	5	-
Crotalaria aegyptiaca	-	5
Cyperus conglomeratus	-	2
Dichanthium foveolatum	5	5
Dipterigium glaucum	8	5
Farsetia aegyptiaca	1	-
Farsetia linearis	-	1
Heliotropium kotschyi	2	1
Indigofera articulata	1	-
Indigofera intricata	-	2
Indigofera sp.	2	-
Jaubertia aucheri	-	2
Kohautia retrorsa	-	1
Lasiurus scindicus	9	8
Leptadenia pyrotechnica	1	-
Lotus garcinii	-	1
Ochradenus arabicus	-	1
Ochradenus aucheri	-	4
Ochtochloa compressa	-	1
Panicum turgidum	18	3
Pennisetum divisum	19	6
Polygala erioptera	-	1
Rhanterium eppaposum	1	-
Savignya parviflora	1	-
Sphaerocoma aucheri	2	-
Sporobolus ioclades	2	2
Sporobolus spicatus	5	1
Stipagrostis plumosa	15	1
Stipagrostis sp.	2	-
Tephrosia apollinea	-	1
Ziziphus spina-christi	-	2
Unidentified	2	-
TOTAL	114	68

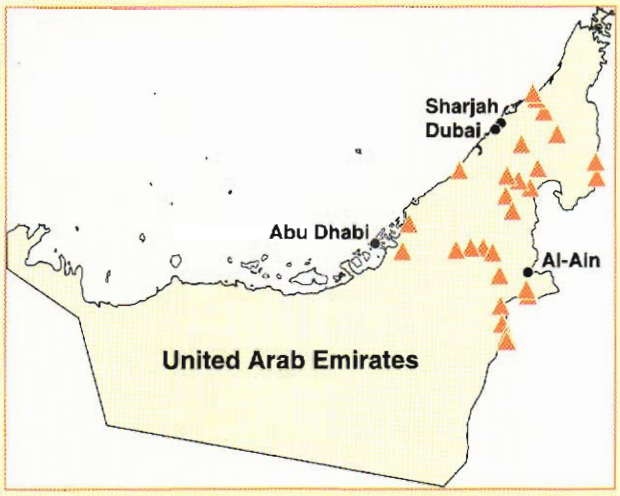


Fig. 2. Location of germplasm collection sites in the United Arab Emirates.

1998, the mission targeted the northern regions including the northern and eastern coastal plains, Wahiba Sands, the northern and eastern interior plains, and the Hajar mountains. In total, 68 accessions were collected, representing 27 taxa (Table 1), from 18 sites (Fig. 3). In addition, discussions were held with farmers to collect indigenous knowledge and prioritize species for rangeland rehabilitation and for use as fodder crops.

During both expeditions, herbarium specimens were taken to identify unknown species which may be of interest for animal browsing, and to define the distribution of target species for which seed was not available. At each site, soil samples were taken to determine the ecological preferences of each species. All samples have been analyzed by the appropriate authority in each country. The seed collected was stored in the gene bank of ICARDA until suitable storage facilities become available within the Arabian Peninsula. Two scientists from the UAE and six from the Sultanate of Oman were trained in germplasm collection techniques.

A database has been compiled of all collection passport data and a photographic flora produced to assist in rangeland species identification. In addition, a database of 152 rangeland plants, which were brought to the mission's attention by farmers, herders, and scientists, has been developed. This includes information on biological characteristics of the plants and their potential use in forage production and rangeland rehabilitation. These databases have been used to produce a 'target species' list. The list includes 27 species of high priority, 39 of medium priority, 60 of low priority, and 26 of unknown potential.

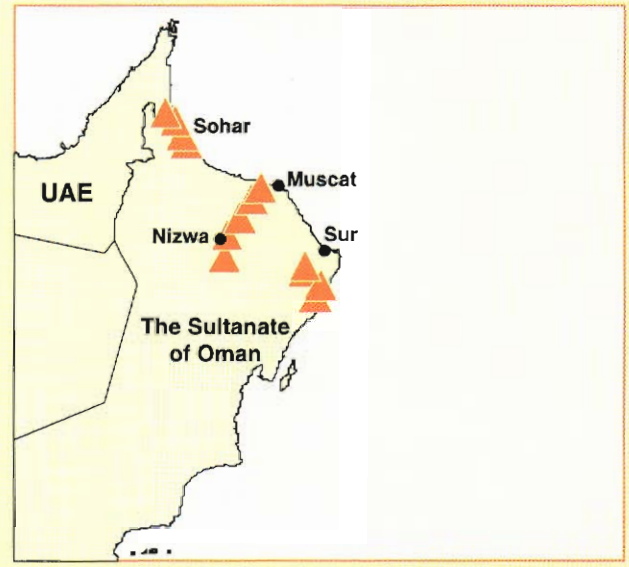


Fig. 3. Location of germplasm collection sites in the Sultanate of Oman.

Bulk seed samples were also collected of *Panicum turgidum, Pennisetum divisum, Lasiurus scindicus, Cenchrus ciliaris, Dipterigium glaucum, Dichanthium foveolatum, Rhanterium eppaposum, Stipagrostis plumosa, Coelachyrum piercei,* and *Calligonum comosum* from locations identified during the collection missions. This seed will be used in experiments in the following seasons.

Implementation of Genetic Resources Program in Yemen

ICARDA played a major role in 1998 in the implementation of the Genetic Resources Sub-program component of the UNDP project "Sustainable Environmental Management Program in Yemen Arab Republic." The following achievements were made in collaboration with Yemen:

1. The existing cold storage facilities were upgra-

ded, furnished, and put into operation.

2. The existing germplasm material was deposited in medium-term storage.

3. Most of the equipment needed for running the genetic resources activities was purchased and delivered to the Agricultural Research and Extension Authority (AREA) of Yemen.

4. Consultancy on plant genetic resources conservation strategy, including *in situ* conservation, was provided to NARS in Yemen. A discussion paper on plant agro-biodiversity conservation was developed to facilitate the deliberations of a national workshop to be held in 1999.

5. Most of the germplasm originating from Yemen and previously held in ICARDA collections was returned to AREA.

6. The genetic resources staff members of AREA were trained in seed processing.

Molecular Characterization of Wheat and Barley Germplasm

The recently developed molecular-marker systems based on DNA amplification have facilitated and enhanced germplasm characterization. Two well-established methods, RAPD and AFLP, were used for molecular characterization of gene bank materials and natural populations of crop wild relatives and farmers' varieties (landraces). Populations of wild wheat—*Triticum urartu*, *T. turgidum* subsp. *dicoccoides* (= *T. dicoccoides)* and *T. monococcum* subsp. *aegilopoides* (= *T. baeoticum*)—from Syria and Lebanon, and landraces of barley from Ethiopia, Eritrea and Yemen have been analyzed by RAPD techniques. Moreover, genetic diversity among and within populations was studied using AFLP fingerprinting by both methylation-sensitive and insensitive methods. The results provided useful information on the geographical pattern of genetic diversity and its distribution among and within natural populations or landraces. This new knowledge will help to optimize collection and *in situ* conservation strategy.

New Durum Wheat Genes from Wide Crosses

More than 2000 BC_2 and F_1BC_1 plants, derived from crosses of durum wheat cultivars 'Haurani' and 'Cham 5' with wheat wild progenitors and close relatives, were evaluated in the field for disease resistance under severe natural epidemics of both yellow and leaf rusts. The initial crosses of the durum wheat with *Triticum urartu, T. baeoticum, T. dicoccoides,* and *Aegilops speltoides* were produced in the 1994/95 season and the subsequent backcross generations were produced in the plastic house. In the 1997/98 season, the wide hybridization products were first exposed to biotic and abiotic stresses in the field. The hybrid plants displayed a wide range of phenotypic variation in comparison with the respective durum wheat parent for a number of agronomically important traits, e.g. plant height, tillering capacity, and spikelet number per spike. Fully fertile plants with a gene(s) conferring high resistance to yellow rust were detected in crosses of 'Cham 5' with *T. dicoccoides* ICWT 601116 and ICWT 600117, originating from southern Syria. Yellow rust resistant and fully fertile plants were also found in crosses of durum wheat with wild diploid wheats: 'Cham 5' with *T. baeoticum* ICWT 500647 and 'Haurani' with *T. urartu* ICWT 500530. This is, to the knowledge of ICARDA, the first transfer of yellow rust resistance from diploid to tetraploid cultivated wheat. Leaf rust resistance was also identified in two durum wheat crosses with wild diploid wheat: 'Haurani' with *T. baeoticum* ICWT 500652 and 'Cham 5' with *T. baeoticum* ICWT 500647. In the latter cross, plants with resistance to both yellow and leaf rusts were identified, which may be of particular interest to breeders. Some BC_2 plants from the crosses of 'Cham 5' and *Ae. speltoides* were immune to yellow and leaf rusts, as well as to powdery mildew and stem rust. However, all the *Ae. speltoides* derivatives were sterile and had to be further backcrossed to the durum wheat parent.

Disease Resistance in Newly Collected Faba Bean Accessions

Chocolate spot resistance of germplasm collected in Ecuador and in the administrative regions of Sichuan

and Yunnan in China in 1996 was reconfirmed in the 1997/98 season. Among the germplasm from Ecuador there were many accessions with resistance to chocolate spot, as opposed to little resistance to this disease in the germplasm collected from China. The germplasm from Yunnan was less susceptible than that from Sichuan. The germplasm from Ecuador collected in 1996, compared with previous sources of resistance to chocolate spot, showed a much larger range in flowering dates. Some lines flowered earlier than 90 days as compared with the check variety which flowered in 110 days. This will facilitate development of cultivars for intensive cropping.

Database on Microbial Genetic Resources of the CGIAR

Within the framework of the System-wide Genetic Resources Program, ICARDA has compiled a database on 8670 accessions of nitrogen-fixing organisms maintained in its own gene bank and those of CIAT, IITA, ILRI, and IRRI. In addition to data gathering, verification and compilation, a user-friendly software was developed to use the database. The use of the software was demonstrated during the CGIAR's Genetic Resources Policy Committee Meeting, held at ICARDA in April 1998.

Germplasm Enhancement

New Varieties Released by National Programs

A number of collaborating countries released new varieties of ICARDA-mandated crops during 1998. These are listed in Appendix 2.

Farmer Participation in Barley Breeding in Syria

Participation of farmers in the initial stages of a breeding program, when the large genetic variability created by the breeders is untapped, can help to better exploit the gains from breeding for specific adaptation through decentralized selection by adding farmers' perception of their needs and knowledge of the crop.

The BMZ-funded barley-breeding project in northern Syria has now completed two cycles of contrasting types of selection—decentralized-participatory and centralized non-participatory—and the results provide useful information. The composition of the initial population of 208 entries is shown in Table 2 with regard to germplasm types such as two row *versus* six row, modern or landraces, fixed or segregating, and seed color.

The total number of entries left after two cycles of decentralized participatory selection was double the number of entries left after two cycles of centralized non-participatory selection at Breda (a dry site near Aleppo) and triple that at Tel Hadya (ICARDA's main research station in Aleppo).

The reduction in the total number of entries does not give a full picture of the decrease in diversity associated with centralized selection. In fact, both at Tel Hadya and Breda, some types of germplasm disappeared after two cycles of selection. This was the case with landraces and black-seeded types at Tel Hadya, and with six-row types at Breda.

The disappearance of some germplasm types also occurs in decentralized participatory selection, but different germplasm types disappear in different locations. For example, two cycles of decentralized participatory selection led to the disappearance of six-row types in all sites except Ibbin and Ebla, but to an increase in the frequency of six-row types in wet sites from 24% in the original population to 50% in Ibbin and 56% in Ebla (Fig. 4 shows the example of Ibbin—a wet site—and Bylounan—a dry site).

Table 2. Number (and fraction of the original population) of different types of germplasm after two cycles of decentralized participatory selection and centralized non-participatory selection (at two different research stations) using 208 barley entries.

	Initial population	Decentralized participatory	Centralized non-participatory	
			Tel Hadya	Breda
Total	208 (1.00)	52 (0.25)	17 (0.08)	26 (0.13)
Two row	158 (0.76)	42 (0.81)	12 (0.71)	26 (1.00)
Six row	50 (0.24)	10 (0.09)	5 (0.29)	0 (0)
Modern	100 (0.48)	23 (0.44)	17 (1.00)	10 (0.38)
Landraces	108 (0.52)	29 (0.56)	0 (0)	16 (0.62)
Fixed	100 (0.48)	27 (0.52)	10 (0.59)	17 (0.65)
Heterogeneous	108 (0.52)	25 (0.48)	7 (0.41)	9 (0.35)
White	161 (0.77)	38 (0.73)	17 (1.00)	16 (0.62)
Segregating	19 (0.09)	5 (0.10)	0 (0)	0 (0)
Black	28 (0.14)	9 (0.17)	0 (0)	10 (0.38)

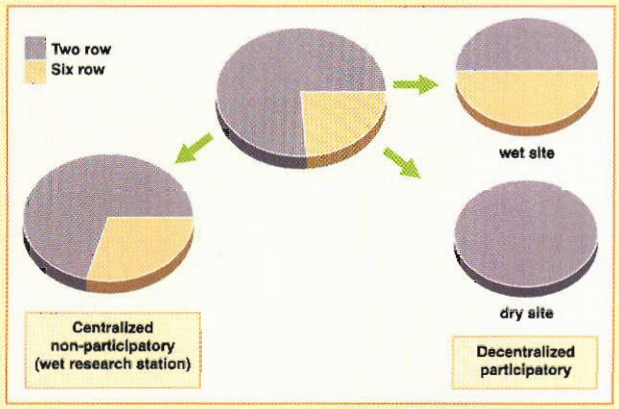


Fig. 4. Change in the frequency of two- and six-row types of barley after two cycles of centralized non-participatory selection at Tel Hadya (wet research station) and two cycles of decentralized participatory selection at Ibbin (wet) and Bylounan (dry) in Syria.

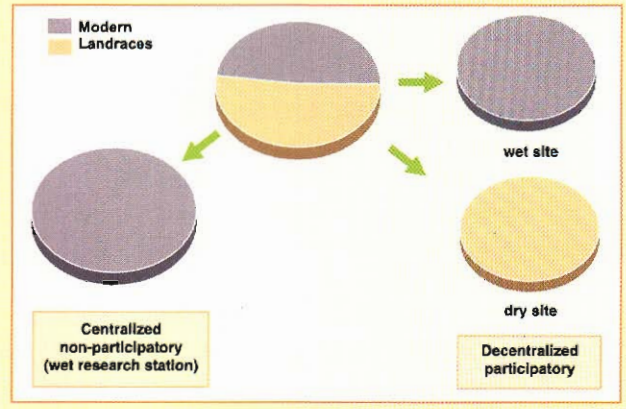


Fig. 5. Change in the frequency of modern cultivars and landraces after two cycles of centralized non-participatory selection at Tel Hadya (wet research station) and two cycles of decentralized participatory selection at Ebla (wet) and Melabya (dry) in Syria.

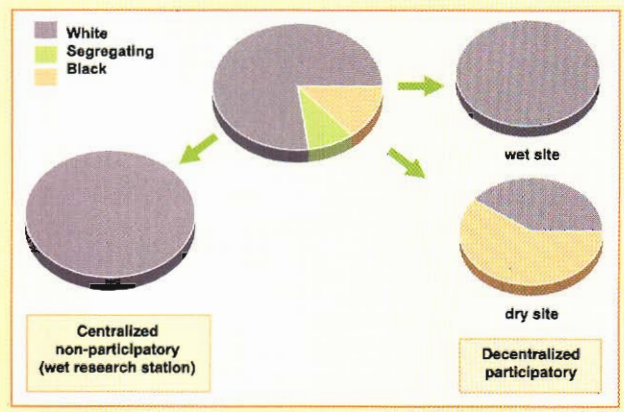


Fig. 6. Change in the frequency of black-seeded and white-seeded entries and of entries segregating for seed color after two cycles of centralized non-participatory selection at Tel Hadya (wet) and two cycles of decentralized participatory selection at Ebla (wet) and Jurn El-Aswad (dry) in Syria.

The frequency of landraces, which changed in opposite directions depending on whether centralized non-participatory selection was conducted at Tel Hadya or Breda, also changed in opposite directions in decentralized participatory selection depending on whether the location was dry or wet.

Fig. 5 shows the case of Ebla, where two cycles of decentralized participatory selection led to the disappearance of landraces, like in the centralized non-participatory selection in the wet research station, while in Melabya two cycles of decentralized participatory selection led to the disappearance of modern germplasm.

Decentralized participatory selection had the same effect as centralized non-participatory selection in the wet research station on the black-seeded types leading to their disappearance (Fig. 6 shows the example of Ebla). This also happened in Sauran and Bari Sharki, where farmers have a strong preference for white-seeded types. However, in dry sites the frequency of black-seeded types increased almost two-fold in two cycles of selection, as at Jurn El-Aswad (Fig. 6). In one extreme case (Bylounan), the population of entries resulting from two cycles of decentralized participatory selection consisted of only black-seeded types and entries segregating for seed color in equal proportions.

Farmer-Participatory Barley Breeding in Tunisia and Morocco

Farmer participation in barley breeding is spreading rapidly among NARS, mostly as special-funded projects. One of these is the program in Tunisia and Morocco entitled "Increasing the Relevance of Breeding to Small Farmers: Farmer Participation and Local Knowledge in Breeding Barley for Specific Adaptation to Dry Areas of North Africa," funded by the International Development Research Centre (IDRC). The project is being run in collaboration between INRA in Morocco, IRESA in Tunisia, and ICARDA.

In Morocco, the project is being carried out in seven farmer-fields and at two experiment stations (Merchouch and Jemaa Shaim). The farmer-fields are

located at Merchouch, Zhiliga, Smaala and Oued Zem in the semi-arid zone, at Beni Khloug and Jemaa Shaim in the arid zone, and at Tanant in the mountainous areas. In Tunisia, the project is being carried out in: (i) Tejerouine (in Kef Governorate), which represents the semi-arid region, and is characterized by low rainfall, cold winter, and early spring drought; (ii) Foussana (in Kasserine Governorate), which represents the small-size farms located in the semi-arid region, and is characterized by very cold winter, early *sirocco* (hot winds), very hot summer and low rainfall, where barley is the most adapted crop, and the only reliable cereal, even though yields are relatively low; and (iii) Fahs (in Zaghouan Governorate), which represents the semi-arid regions with mild winters and relatively high rainfall.

There were large differences between the selections made by the farmers in their fields and those made by the breeder in experiment stations in Morocco (Fig. 7). Local varieties were still preferred by the majority of farmers at both tillering and maturity. This finding strongly suggests the importance of local varieties as key parents in the crosses made for Moroccan farmers. In fact, the Moroccan local variety 'Merzaga 077' (Me) received the highest selection score across five farmer-sites and was selected at least once by all the participating farmers. The two-row improved variety 'Aglou' (Ag) was the least selected. Only a few lines were selected more frequently than the local varieties 'Merzaga 077' and 'Arig 8' (Ar). Varieties such as 'Tichedret' (T) and 'Martin' (M) were selected frequently by farmers, but discarded by breeders.

Similarly, the most frequently selected lines by farmers in Tunisia (Fig. 8) were derived from crosses between the local landrace and 'Rihane-03'. Only two of the 25 lines were selected by both the farmers and the breeders. The lines most frequently selected by the farmers (1, 8 and 12, see Fig. 8) have a yield potential similar to or higher than that of the widely adopted improved cultivar 'Rihane-03' (Fig. 9) across 10 environments (years and locations) in Tunisia.

The criteria used by Moroccan farmers during visual selection are shown in Table 3. At the tillering stage, all farmers considered the importance of tillering ability, early vigor, erect types,

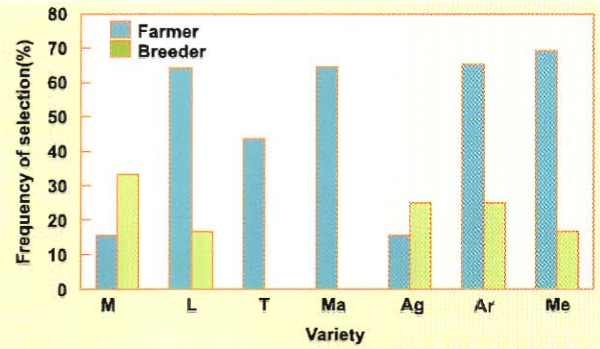


Fig. 7. Frequency of selection of seven barley varieties by the breeder on station and the farmers in their fields in Morocco.

M = 'Manal'; L = 'Lannaceur'; T = 'Tichedret'; Ma = 'Martin'; Ag = 'Aglou'; Ar = 'Arig 8'; Me = 'Merzaga'.

and large leaves as possible indicators of good forage and straw productivity and suitability for grazing. Many of the farmers were interested in dual-purpose barley varieties combining good forage and grain productivity. Dark-green leaves, tolerance to drought, and resistance to disease were cited as selection criteria by only a few farmers. Most of the farmers believe that the development of foliar diseases depends on favorable climatic conditions and this project showed them the differences in reactions between genotypes.

At maturity, farmers use a larger number of selection criteria. Across sites most of the farmers preferred lines with good grain filling, long spikes, and tall plants with good tillering ability. The few winter barley lines included in the trials were systematically discarded by them. Based on their visual appreciation

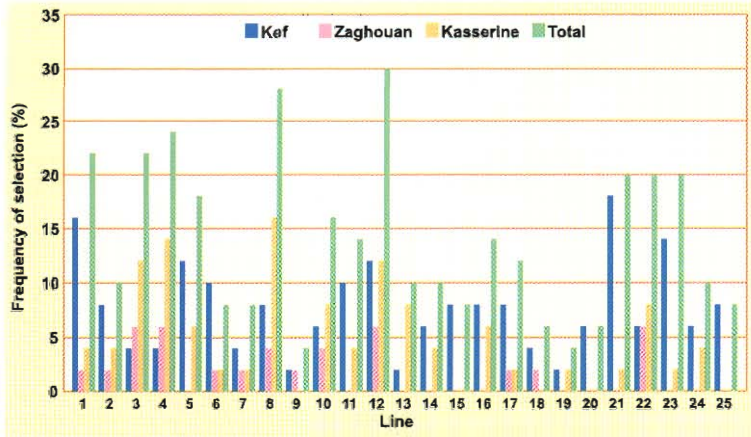


Fig. 8. Frequency of selection of 25 barley varieties by farmers at three locations in Tunisia.

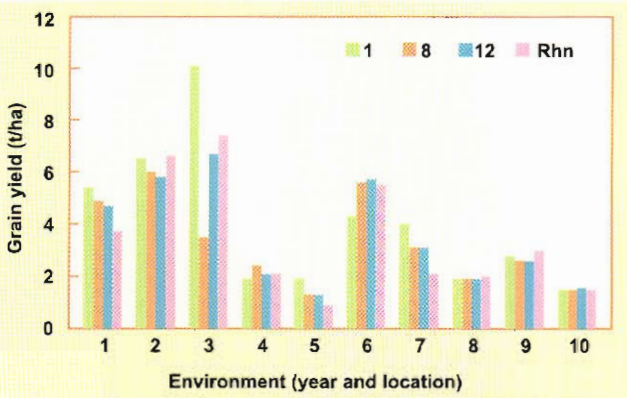


Fig. 9. Grain yield of the lines most frequently selected by Tunisian farmers (shown in Fig. 8) compared with the widely adopted cultivar 'Rihane-03' (Rhn).

Table 3. Selection criteria used by farmers at the tillering stage at four sites in Morocco.

Criterion	Beni Khloug	Jemaa Shaim	Smaala	Oued Zem
Large leaves	8	2	-	3
Dark-green leaves	1	1	-	4
Erect plant	7	0	-	4
Tillering ability	19	3	9	14
Forage type	2	1	-	10
Lodging resistance	23	1	-	-
Disease resistance	2	3	-	2
Drought resistance	1	3	-	-
Earliness	3	3	3	7
Overall score	6	7	4	5

of grain and straw yields, they identified the best two to three lines in the trial. All the farmers selected at least once the landrace 'Merzaga 077', except at Merchouch where it was severely lodged. Few farmers based their selection on tolerance to drought or heat, or resistance to foliar diseases. The straw and grain qualities were also seldom cited as selection criteria. These findings show the importance of considering straw yield and grain filling under drought and heat stresses in the breeding program. Consequently, all the parental barley material from Montpellier, France, which was considered as elite germplasm in the past, seems to be of limited use in the future crossing program. These parents have good general appearance and good disease tolerance but they are highly affected by drought and heat during grain filling. The landraces were among the few lines that filled their grains well under late drought.

The project's findings stress the importance of extending the selection and evaluation of breeding material in as many contrasting environments as possible, and the need to apply at the experiment stations fewer inputs in order to simulate the farmer-field conditions. Since the ranking of lines at experiment stations was quite different from that at farmers' sites, selection at farmers' sites is the most appropriate way to search for and develop barley varieties adapted to the environments where they will be grown by farmers.

Gene Mapping of the Quantitative Trait for Improved Barley Plant Height under Drought

The wild progenitor of barley, *Hordeum spontaneum*, can contribute useful genes for several characters, such as disease resistance, earliness, biomass, grain yield, grain protein, and tolerance to salinity and drought. One of the most useful traits of *H. spontaneum* in relation to stress tolerance is its plant height under drought. This is important because one of the most evident effects of drought is a reduction in plant height making harvest by combine difficult or impossible. In addition, not only grain but also straw is important for farmers in WANA.

The introgression of genes for plant height under drought from *H. spontaneum* into cultivated barley has been a long and difficult process. This is because *H. spontaneum* has a number of undesirable traits such as brittle rachis, low kernel weight, and rough awns. An additional difficulty is that the improvement of plant height under drought often causes a reduction in tillering, and hence in both grain and straw yield.

It was evident that, to fully exploit the potential of crosses between cultivated barley and *H. spontaneum*, a large number of recombinant lines derived from each cross should be evaluated. In addition, the identification of molecular markers closely linked to QTLs of agronomic interest or to negative traits can greatly facilitate the use of *H. spontaneum* as a parent.

ICARDA developed a population of 494 F_7 random inbred lines (RILs) derived by single-seed

descent from the cross 'Arta'/*H. spontaneum* 41-1. 'Arta', a pure line selected from the Syrian landrace 'Arabi Abiad', is well adapted to Syrian conditions and is high yielding, but produces short plants under dry conditions. *H. spontaneum* 41-1, a pure line selected for its adaptation to severe drought stress conditions, combines earliness with acceptable cold tolerance and plant height under drought.

At least six characters are expected to segregate from this cross: rachis brittleness, awn roughness, peduncle extrusion, plant height, tillering, and kernel size.

The main objective of this cross was to develop lines combining grain yield and tillering ability from 'Arta' with the plant height and adaptation to severe drought stress conditions of *H. spontaneum* 41-1.

Thirty-six entries were promoted to preliminary yield trials. Eleven selections from the cross had higher grain and biological yields than 'Arta', with improved plant height under drought, and no reduction in tillering. Only two lines had a 1000-kernel weight of 30 g or more. No line with seed size similar to that of 'Arta' was identified. The promising lines have been included in the crossing program for 1999.

A subset of 92 lines was selected for mapping. Genetic mapping was carried out using Amplified Fragment Length Polymorphic (AFLP) markers and microsatellite-based markers. AFLPs usually provide high numbers of polymorphic, although mostly dominant, markers. Microsatellite-based markers are usually codominantly-inherited PCR markers and are useful because they map to identical linkage groups in different genetic backgrounds. Therefore, they are useful to anchor linkage groups developed by dominant markers (here AFLPs) to chromosomes. For 84 markers (11 microsatellite markers, 73 AFLP markers) segregation analysis was performed on the F_5-derived F_7 recombinant inbred lines. Using a stringent LOD of 4.0 and an excluding threshold for linkage relationships of 0.25, 62 markers were grouped into 11 linkage groups using MAPMAKER 3.0 software (Table 4).

The microsatellite-based markers identified linkage groups belonging to chromosome *1, 2a, 2b, 4a,*

Table 4. Linkage map developed in recombinant inbred lines of 'Arta' × *H. spontaneum* 41-1 for their ability to maintain plant height under drought.

Chrom *1*		Chrom *2a*		Chrom *4a*	
Marker	Distance	Marker	Distance	Marker	Distance
63 P71M885	23.4 cM	77 HVBKASI1	4.9 cM	52 P71M845	32.6 cM
66 P71M888	23.0 cM	78 HVBKASI2	8.9 cM	11 P71M8211	7.4 cM
33 P81M836	20.6 cM	32 P81M835	11.7 cM	10 P71M8210	34.8 cM
65 P71M887	25.4 cM	58 P71M8411	1.7 cM	46 P81M8311	9.0 cM
4 P71M824	5.0 cM	57 P71M8410		42 P82M837	10.0 cM
22 P71M425	15.9 cM		27.3 cM	27 P71M4210	24.9 cM
82 HVM41	0.6 cM	Chrom *2b*		72 P71M8814	9.6 cM
83 HVM42	12.2 cM	39 P82M834	8.2 cM	74 HVM62	7.0 cM
61 P71M883	6.4 cM	75 HVCSG1	3.6 cM	73 HVM61	
6 P71M826	8.1 cM	76 HVCSG2	11.8 cM		135.3 cM
3 P71M823		36 P71M341		Chrom *4b*	
	140.6 cM		23.6 cM	80 HVM401	4.3 cM
				81 HVM402	
					4.3 cM

Unassigned linkage groups					
Link 1				Link 3	
54 P71M847	13.8 cM			41 P82M836	16.1 cM
19 P71M422	19.4 cM			1 P71M821	23.6 cM
67 P71M889	5.0 cM	Link 2		69 P71M8811	
5 P71M825	20.2 cM	15 P71M8215	0.0 cM		39.7 cM
2 P71M822		16 P71M8216	6.8 cM		
	58.4 cM	14 P71M8214	3.9 cM	Link 4	
Link 6		48 P71M841	1.9 cM	40 P82M835	21.1 cM
35 P81M838	7.3 cM	49 P71M842	8.4 cM	15 P71M8215	18.1 cM
12 P71M8212	2.3 cM	59 P71M881	16.7 cM	43 P82M838	
21 P71M424	4.4 cM	55 P71M848	3.9 cM		39.2 cM
51 P71M844	29.6 cM	56 P71M849	14.7 cM		
24 P71M427	14.6 cM	8 P71M828		Link 5	
28 P81M831	21.0 cM		56.4 cM	37 P82M832	10.2 cM
64 P71M886	6.8 cM			71 P71M8813	11.3 cM
53 P71M846				26 P71M429	
	86.1 cM				21.5 cM

and *4b*. Another six linkage groups (link 1–6) have not yet been anchored.

The major objective of this work was to see whether markers could be identified for brittle rachis and plant height under drought from *H. spontaneum* and for yield. For brittle rachis, the evaluation at Breda in 1997 and 1998 showed in both cases linkage to the same AFLP marker 52P71M845 on chromosome *4a* (Table 5).

Table 5. Identified marker-trait linkages in the RILs of 'Arta' ˜ *H. spontaneum* 41-1 by simple regression analyses (trait = dependent variable, marker allele = independent variable, N = number of progenies analyzed).

Trait	Marker	Chrom.	N	Source	F-value	R^2
RachisBR97	52P71M845	Chrom *4a*	87	*H. spont.*	30.30	0.263
RachisBR98	52P71M845	Chrom *4a*	88	*H. spont.*	23.17	0.212
PHTH97	81HVM40b	Chrom *4b*	91	*H. spont.*	10.58	0.106
	14P71M8214	Link 2	80	*H. spont.*	10.54	0.119
	48P71M841	Link 2	90	*H. spont.*	12.85	0.127
PHBR98	46P81M8311	Chrom *4a*	91	*H. spont.*	9.31	0.095
PHBR97	63P71M885	Chrom *1*	91	*H. spont*	7.40	0.076
	15P71M8215	Link 4	92	*H. spont.*	5.66	0.059
	16P71M8216	Link 2	92	*H. spont.*	3.94	0.042
BYTH97	52P71M845	Chrom *4a*	88	Arta	34.81	0.288
BYTH98	52P71M845	Chrom *4a*	88	Arta	20.97	0.196
GYTH97	52P71M845	Chrom *4a*	88	Arta	62.33	0.420
GYTH98	52P71M845	Chrom *4a*	88	Arta	43.98	0.338

For plant height under drought stress, quantitative trait loci (QTLs) with major effects were found only at Tel Hadya (81HVM40b on chromosome *4b*, 14P71M8214 on link 2, and 48P71M841 on link 2 with R^2 = 0.106, 0.119, and 0.127, respectively). At Breda, in 1997, three QTLs (63P71M885 on chromosome *1*, 15P71M8215 linkage group 4, and 16P71M8216 linkage group 2 with R^2 = 0.076, 0.059, and 0.042, respectively), and in 1998, one QTL (46P81M8311 on chromosome *4a* with R^2 = 0.095) with smaller effects were identified. The absolute values for the trait measured were 79.89 and 105.00 cm for 'Arta' and *H. spontaneum*, respectively, at Tel Hadya in 1997, and 29.43 and 51.9 cm on average for both years at Breda. A range of 31.9 to 64.5 cm for Breda and 83.5 to 115.1 cm for Tel Hadya was recorded for the analyzed lines in 1997. Different genes seem to be responsible for this trait at Tel Hadya and Breda.

Most interesting is the QTL for biological and grain yield for Tel Hadya in 1997 and 1998 identified by AFLP marker 52P71M845 on chromosome *4a* which showed for the biological yield an R^2 of 0.288 in 1997 and R^2 of 0.196 in 1998, and an R^2 of 0.42 for grain yield in 1997 and R^2 of 0.338 in 1998. In all cases, the responsible chromosome segment originates from 'Arta'. For grain yield, an average difference of 976 kg/ha (for *H. spontaneum*) and 1186 kg/ha for 'Arta' was recorded for Breda, and 3157 kg/ha (*H. spontaneum*) and 4665 kg/ha ('Arta') for Tel Hadya. However, due to brittle rachis, the range was from 632 to 4504 kg for the analyzed lines for Tel Hadya and 573 to 1666 kg for Breda. The huge effect of the marker trait association might therefore better characterize the brittle rachis trait than the yield, as the chromosomal region is identified by the same marker linked with the brittle rachis trait.

Other interesting traits for which markers were identified and which might be useful in a marker-assisted selection program were: several markers linked with the growth habit of 'Arta' in linkage group 2, markers for days-to-heading from 'Arta' on chromosome *1*, (125–127 days *versus* 116–120 days for *H. spontaneum*), and markers against cold damage introduced by *H. spontaneum* on linkage groups 1 and 6.

Exploiting Genetic Variability in Wheat Landraces in Iran

Wheat crop in most of the highlands of WANA faces severe abiotic and biotic stresses. Research in these areas is relatively recent, and farmers still use old cultivars, or landraces, such as 'Sardari' in Iran, 'Local White' in Pakistan, and 'Achoure' and 'Kirik' in Turkey. Over the years, these landraces have adapted themselves well to their respective environments, but their yield is low and further threatened by new races and biotypes of plant pathogens and pests. A three-year study in Iran jointly conducted with ICARDA using 'Sardari', grown on more than half-a-million hectares in rainfed areas of western Iran,

examined the possibility of improving the productivity of this landrace without sacrificing its genetic variability.

Individual spikes of 'Sardari' were randomly picked in 1995 from a farmer's field in the Maragheh region of western Iran. They were increased as head rows in 1996 at the Dryland Agricultural Research Institute (DARI) in Maragheh. No selection was made, except for the elimination of a few heterogeneous families, leaving a total of 106 families that were evaluated in 1997 and 1998 for the following traits: reaction to cold, plant height, lodging, days to heading, reaction to yellow rust, number of tillers/plant, spike length, spikelets/spike, kernels/spike, spike color, seed color, 1000-kernel weight, protein content, and grain yield.

Significant variation was observed among the 106 families for most of the traits. 'Sardari' is a winter mid-tall wheat cultivar, with white chaff and grain, and a weak straw. Its photothermal characteristics enable it to go dormant throughout the winter, grow actively in the spring, once the frost risk is over, and rapidly fill the grain, a major advantage in the dry highlands of WANA. However, it is very susceptible to yellow rust (*Puccinia striiformis* f.sp. *tritici*) under favorable environmental conditions such as those of the early 1990s in WANA. It is moderately susceptible to severe cold.

A relatively high frequency of yellow rust resistance or moderate resistance was unexpectedly observed among the 106 pure lines (Table 6). The variability among the landrace-derived lines was confirmed in field tests at Maragheh in Iran and Tel Hadya in Syria at both seedling and adult plant stages. This was unexpected as the mother 'Sardari' population is usually scored very susceptible (90S or higher) under favorable disease conditions, both in Iran and Syria.

Divergence from the typical 'Sardari' type was also observed for most of the other traits. This within-landrace variability may explain the plasticity of such a population under variable growing conditions, a characteristic of the highlands and cold areas with a Mediterranean-type climate. Cluster analysis of the 106 families did not show a dominant type and there was no cluster that grouped all desirable types, i.e. yellow rust resistant, white kernelled, non-lodging, early, cold tolerant, and high yielding. Therefore, it seemed possible to take advantage of the desirable attributes identified in certain lines by intercrossing

Table 6. Characteristics of 106 random pure lines extracted from the wheat landrace 'Sardari' in Iran.

Trait	Parameter				
	Mean	Standard deviation	Maximum	Minimum	Frequency (of desirable type)
Cold (winter survival %)	86	16.6	100	35	77 (resistant)
Yellow rust (1–5)					
Field test	1.9	1.38	5	1	58 (resistant)
Seedling test	3.0	1.50	5	1	40 (resistant)
Plant height (cm)	79.0	7.5	100	66	56 (mid-tall)
Lodging (1–5)	2.2	1.09	4	1	31 (resistant)
Days to heading	33	3.6	41	28	50 (early)
Tillers/plant	3.3	0.88	6	2	39 (high)
Spike color (1–2)	1.4	0.49	2	1	61 (white)
Spike length (cm)	9.6	0.97	12.3	7.7	27 (high)
Spikelets/spike	13.6	1.60	19.5	10.0	30 (high)
Seeds/spike	30.4	5.60	47.5	21.0	24 (high)
Seed color (1–2)	1.4	0.48	2	1	64 (white)
1000-kernel weight (g)	43.9	4.80	52	33	38 (high)
Grain yield (t/ha)	2.6	0.36	3.2	1.7	11 (≥ 3)
Grain protein (%)	13.2	0.87	15.9	11.5	18 (≥14)

Variability of reaction to yellow rust among pure lines derived from the Iranian winter wheat 'Sardari'.

such lines or crossing them to other germplasm with complementary traits. The second procedure was applied by the breeders at DARI, and three new advanced lines were developed that possess the earliness of 'Sardari' and disease resistance and increased yield potential of other cultivars.

The study suggested that wheat landraces such as 'Sardari' should not be discarded because of their disease susceptibility or low yield potential under certain conditions. Such populations should be preserved and simultaneously used to improve and develop new and diversified cultivars for different environments to avoid the erosion of genetic variability.

Interspecific Hybridization in Chickpea

The cultivated chickpea (*Cicer arietinum* L.) belongs to the genus *Cicer*, which comprises an additional eight wild annual species. The wild *Cicer* species, in general, possess higher levels of tolerance to many key biotic (ascochyta blight, fusarium wilt, nematodes, bruchids, leaf miner, pod borer) and abiotic (cold, heat, drought) stresses than the cultivated species. At ICARDA, researchers have successfully crossed the domesticated with the two most-closely-related wild *Cicer* species: *C. reticulatum* and *C. echinospermum*. This has allowed the transfer of high levels of cold and cyst nematode tolerance from these wild species to the cultigen. The other wild *Cicer* species of interest are *C. bijugum*, *C. pinnatifidum* and *C. judaicum*, which possess high levels of tolerance to various biotic and abiotic stresses (ascochyta blight, bruchids, leaf miner, nematodes, drought, and cold). Earlier attempts at ICARDA to produce viable interspecific hybrids involving these wild species (*C. bijugum*, *C. pinnatifidum*, *C. judaicum*) and kabuli chickpea were not successful. During the 1997/98 season, desi chickpea was included in hybridization with the wild types. The interspecific crosses using these wild species generally resulted in very low seed set. Seed set was more among the crosses between the cultigen and *C. judaicum* than the crosses between the cultigen and either *C. pinnatifidum* or *C. bijugum*. Further joint research with Italian institutions on crossability barriers between the cultigen and *C. judaicum* and *C. pinnatifidum* showed the absence of any pre-zygotic barrier to the incompatibility in hybridization. To overcome the post-zygotic incompatibility barriers, different hormones were used at various stages of plant growth. An application of a hormone solution [gibberelic acid (8 mg/l) + kinetin (5 mg/l) + naphthalene acetic acid (25 mg/l)] after pollination led to ovules from which embryos could be rescued. The seeds from these interspecific crosses are now being tested for their fertility and multiplication.

Survey of Lentil and Chickpea Viruses in Ethiopia

Upon the request of the Ethiopian Agriculture Research Organization (EARO), scientists from ICARDA, Ethiopia, Egypt, and Yemen conducted a survey of virus diseases affecting chickpea and lentil in Shewa province of Ethiopia in November 1998. The survey covered 33 randomly selected chickpea and 32 lentil fields. Virus disease incidence was determined based on laboratory examination of 100- 200 randomly collected samples from each field against antisera of 12 viruses. Over 9000 chickpea and lentil samples were tested, using the tissue-blot immunoassay procedure at Debre Zeit Research Center. In chickpea fields, beet western yellows virus (BWYV) and soybean dwarf virus (SbDV) were the most common. Five chickpea fields had a virus disease incidence of 21% or higher (Fig. 10). In lentil fields, pea seed-borne mosaic potyvirus (PSbMV) was the most common, followed by BWYV and

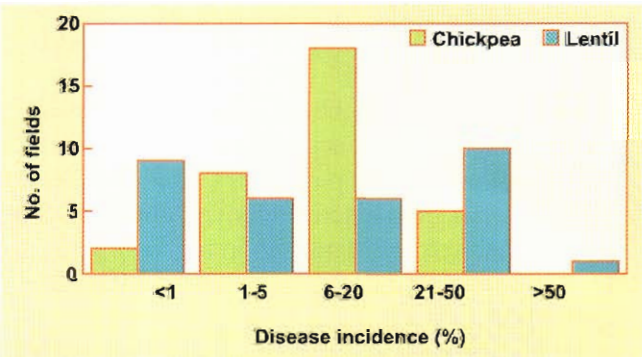


Fig. 10. Virus incidence in chickpea and lentil fields based on laboratory testing of randomly collected samples in Ethiopia, November 1998.

SbDV. Eleven lentil fields (34% of the fields surveyed) had a virus disease incidence of 21% or higher. The highest virus disease incidence in a single field was 58.5% in lentil (PSbMV) and 41.3% in chickpea (BWYV). Other viruses, though rare, found during the survey included the faba bean necrotic yellows nanovirus (FBNYV) and broad bean wilt fabavirus (BBWV) in chickpea; and FBNYV, broad bean stain comovirus (BBSV), bean yellow mosaic potyvirus (BYMV), and cucumber mosaic cucumovirus (CMV) in lentil.

Management of Lentil Vascular Wilt

Lentil vascular wilt, caused by *Fusarium oxysporum* f.sp. *lentis*, is a widespread and devastating disease in most countries where lentil is grown. It sometimes causes complete crop failure, especially in a warm and dry spring.

ICARDA annually screens, under well-established "sick-plot" conditions, germplasm and breeding lines for sources of resistance to wilt. The wilt-resistant material is then distributed to national programs. As a result, 'Talya 2' is being grown by farmers in Lebanon; a wilt-resistant line ILL 5883 is a candidate for release in Syria; and NARS scientists in Ethiopia, Sudan, and Egypt have also identified resistant sources from ICARDA-supplied material.

To increase the durability and reliability of the management of the disease, host-plant resistance was integrated with other components including soil solarization, adjustment of planting date, and chemical seed treatment. Results showed that early planting in November gave a higher economic yield than late planting in December and January in wilt-infested soil. Even with moderately resistant genotypes, early planting combined with soil solarization provided 74% more seed yield than unsolarized late sowing. Soil solarization is also a means to control weeds, which are more severe in early sowing. Seed treatment with the fungicide benomyl (Benlate) showed no effect on reducing wilt infestation and may not be useful in the integrated management of the disease.

Clearly, integrated management of lentil vascular wilt is agronomically possible. It allows lentil cropping in fields previously abandoned for lentil due to soil wilt infestation either by using resistant varieties in early sowing or moderately resistant ones with soil solarization. However, the economics of soil solarization needs further investigation before formulating recommendations for farmers.

Entomopathogenic Fungi, a Potential IPM Component for Sunn Pest Control

Sunn pest (*Eurygaster integriceps* Puton) is one of the most damaging insect pests of wheat and barley in West Asia, where over US$ 42 million is spent annually for its control. Yield loss caused by Sunn pest is estimated at 20–30% in barley and 50–90% in wheat. An integrated pest management (IPM) package is being developed to replace the existing chemical control strategy.

Entomopathogenic fungi of Sunn pest were collected in southern Turkey and southeastern Syria in January 1998. The collection team consisted of scientists from ICARDA, University of Aleppo, University of Cukorova, Plant Protection Research Institute of Adana, and University of Vermont. Adult Sunn pests were collected from their overwintering habitats, which varied depending upon geographic location. In cereal fields, surrounded by mountains, the insect was found on steep slopes beneath the litter at the base of bushes. At lower elevations, where mountains

An adult Sunn pest killed by entomopathogenic fungi.

were absent, Sunn pest was found under the litter of bushes or at the base of Eucalyptus and Mediterranean pine trees. All dead individuals and pieces of dead individuals were carefully collected.

A total of 1063 Sunn pest specimens were collected; 84 of these were dead on collection. From these, a total of 104 fungal isolates were made. The most common entomopathogenic isolates belonged to the genus *Beauveria*. Also, representatives of *Paecilomyces* were found. This last one is considered moderately entomopathogenic, but instances have been recorded where certain strains of the fungus were very pathogenic. From these, pure cultures of 45 isolates were prepared. These are now being subcultured and multiplied for pathogenicity trials against Sunn pests at ICARDA.

Dry Pea as a Potential Crop in WANA

Although dry pea was domesticated in West Asia and the crop has been cultivated in the ICARDA region for millennia, yields are low because of lack of high-yielding and stable cultivars and efficient crop-management practices. Therefore, research on dry-pea improvement was initiated at ICARDA in 1986. Building on the extensive research on the improvement of dry pea in both industrialized and developing countries, ICARDA identified lines adapted to the farming systems of WANA. The Center's research focused on: (i) assembling enhanced germplasm from various sources and testing its adaptation at ICARDA sites in Syria and Lebanon, (ii) increasing the seed of adapted lines and sharing the promising materials with NARS in and beyond WANA through the Legume International Testing Network, and (iii) developing suitable production technology at ICARDA and transferring it to NARS.

ICARDA investigated management practices for pea production under low- to medium-altitude Mediterranean environments in WANA. Mid-November to early December is the optimum sowing time for peas in the region. Peas fix about 75 kg N/ha in a season and, therefore, are comparable with other cool-season food legumes (lentil, faba bean, and chickpea) in the region. Sowing peas at a population density of 36 plants/m^2 for traditional types and 50 plants/m^2 for semi-leafless types gave optimal seed yield. The trials at Tel Hadya, Syria, revealed that preemergence application of a combination of propyzamid (0.5 kg a.i./ha) and methabenzthiazuron (2.5 kg a.i./ha) or propyzamid (0.5 kg a.i./ha) plus cyanazine (0.75 kg a.i./ha) was effective in controlling the weeds.

Since cold stress is common during the winter months, the introduced materials were evaluated for cold tolerance under Tel Hadya conditions using the same technique as for chickpea. This technique involved early planting (late September or early October) of pea materials and their evaluation in January or February when the susceptible check-cum-indicator rows were killed by cold. This resulted in the identification of a good number of cold-tolerant lines. Some of the lines found tolerant to cold across a number of years are listed in Table 7.

Table 7. Pea lines found tolerant to cold across a number of years at Tel Hadya.

Acc. No.	Name	Origin	Acc. No.	Name	Origin
77	K129	Greece	199	D-166-1-15-1W	USA
85	506-V2	Afghanistan	205	D-166-1-24-6W	USA
86	603-V2	Afghanistan	206	D-166-1-4-2W	USA
186	D166-3-1	USA	346	PIMOS 12069	USA
190	D166-3-1	USA	354	PIMOS 12077	USA
197	D200-4-3	USA	470	WIR-1878	CIS

ICARDA distributed a large number of elite lines to NARS through its Legume International Testing Network. The evaluation results of these lines across various countries demonstrated that yield levels of some of the improved cultivars were comparable with other cool-season food legumes (including chickpea, lentil, and faba bean). In certain countries the location means for seed yields were as high as 2500 kg/ha in some years.

From these elite cultivars, a large number of lines have been identified by NARS for multilocation or on-farm testing or prerelease multiplication. Some NARS have released pea cultivars, namely, PS210713 ('Contemenos') in Cyprus; 061K-2P-2192 in Ethiopia; 'Collegian', MG102703, and A0149 and 'Syrian Local' in the Sultanate of Oman; and 'Krema -1'

Variability in pea germplasm collected from various sources at Tel Hadya, Aleppo.

and 'Ballet' in Sudan, for general cultivation. Results from 12 years of research on dry pea have demonstrated that this crop has good potential to replace fallow areas (under wheat–fallow or barley–fallow rotation in the region). Research on dry pea was discontinued at ICARDA in 1998 for budgetary reasons.

Seed Activities

The Seed Unit's activities in the CWANA region involve training, networking, research, and consultancies, either directly with the national seed programs or through ICARDA's regional programs.

Training: During the year, the Seed Unit organized five training courses, two at Tel Hadya and three in other countries, for a total of 103 trainees. As in previous years, a course on variety description, maintenance, and breeder seed production was held in response to the continuing need of many national programs to strengthen the management of varieties and ensure regular supply of high-quality early-generation material for further multiplication. The regional course on seed production and technology was the first to be held in the Arabian Peninsula.

Workshop on small seed enterprises: The viability of small seed enterprises is a topical issue in the context of many governments wanting to open up their seed industries to private enterprise and remove subsidies on seed production. A workshop on "Financial Management of Small Seed Enterprises" drew 49 participants from 15 countries, including 5 from sub-Saharan Africa. Some 20 presentations were made, dealing mostly with general financial management procedures or country-specific experiences, each followed by useful discussion.

Information networking: The WANA Seed Network, which has 18 countries as members, serves as a major vehicle for regional activities of the Seed Unit including information exchange. Work on five publications was completed in 1998. The first of these, the "Catalogue of Crop Varieties," was published in December 1998; the remaining four will follow early in 1999. Two issues of the regular Network newsletter "*SeedInfo*" were published in January and July; the January issue was the first to be published also in Arabic. Two more country studies—featuring Ethiopia and Oman—in the series "Focus on Seed Programs" were also published.

Production of forage and pasture seed: During 1998, the Seed Unit collaborated with the Arabian Peninsula Regional Program (APRP) in preliminary work on producing seed of local forage species which are favored by livestock and have a much lower water requirement than the introduced species. Collections of native species were made during the early months of 1998 when natural seed production was good, following an unusually wet winter season. Laboratory tests were done to establish their germination/dormancy characteristics, and seed-cleaning techniques appropriate to these species were explored. Later in the year, mechanical processing of the collected seed was organized in Sharjah, and local staff trained in seed-cleaning procedures. The seed produced will be vital for establishing large-scale plots both to evaluate the potential of these species as forage and to investigate the techniques required for seed production.

Seed production at Tel Hadya: During 1998, the Seed Unit produced 36 tonnes of seed from its own fields, mostly for distribution to NARS for research or further multiplication. The seed-processing facility of the Unit handled 229 tonnes of seed of 10 species on behalf of all the research programs of the Center. In addition, over 11,000 samples were cleaned for supply to breeders or to the Genetic Resources Unit

of ICARDA. Besides, over 5000 samples were quality tested, either for research purposes or for routine monitoring of seed stocks.

The Unit has also used data from its variety plots in recent years to prepare a bilingual descriptive manual of the main cereal varieties in use in Syria in collaboration with the General Organization for Seed Multiplication (GOSM). The manual may well serve as a model for use by other countries in the region.

Seed activities in Central Asia: The Unit continued to participate in seed activities in Central Asia by offering consultancy for the seed component of the Agricultural Support Services Project for the Kyrgyz Republic. ICARDA was part of the World Bank mission which followed the launch of this project. In October, the Unit, in association with ICARDA's Central Asia office in Tashkent, undertook a major review of the seed sector in Kazakhstan with the Danish consultancy company, COWI. The study presented options for the revival and strengthening of the seed sector in that country.

Resource Management and Conservation

Land and Water Management in the Khanasser Valley, Syria

Land-use systems, being complex and multidimensional, require both a holistic approach and active participation of land users to stabilize and improve fragile degraded areas.

The Khanasser Valley, located 70 km southeast of Aleppo, is a typical dryland area in the transitional rainfed agriculture/rangeland zone. It has been adopted by ICARDA as a first integrated study site to address a range of problems characteristic of marginal drylands. With the first phase of baseline studies completed, the project will now embark on participatory adaptive research aimed at environmental stabilization of the area and improved technologies for sustainable land use.

The area falls within the winter-rainfall zone of 200–250 mm per year, which means it is marginal for cereal production. Rainfed barley is the dominant field crop. High densities of human and animal populations create enormous pressure on the land resources of the area, and soil degradation is serious.

In the flat Valley floor, the soils are deep and moisture-retentive. Whenever water for irrigation is available, farmers grow wheat and, sometimes, cotton. Over the past 15 years, farmers have dug many wells for exploitation of groundwater resources. Field studies have established that the aquifer is inadequate to support full irrigation of the Valley and that salt-water intrusion from the nearby Jabul Salt Lake would deteriorate the groundwater quality, if pumping continues at the present rate.

On the overgrazed and denuded Valley slopes, the soil resources are quite limited. Most of the topsoil has been eroded and natural vegetation survives only in small niches between stones and rocks. Large pockets of soil, though, lie preserved under the stones.

While the current land use results in low productivity on the slopes, potential exists for fruit-tree and shrub plantations with appropriate soil- and moisture-conservation measures and nutrient management.

Three of the main activities in the area were: a comprehensive groundwater survey, launching of a ground-cover and plant-biodiversity monitoring program on the highly degraded grazing lands, and establishment of fruit-tree plantations on the Valley slopes.

Groundwater Quality

As a first approximation, the electrical conductivity (EC) of the water has been used as a measure for the salinity hazard of the groundwater used for irrigation in the Valley. According to international water-quality standards, irrigation water with EC values up to 1 mS/cm is safe for all crops and between 1 and 3 mS/cm is acceptable, but values higher than 3 mS/cm restrict the use of water for many irrigated crops.

During the year, an extensive well monitoring program was implemented to study the spatial distribution of groundwater salinity (Fig. 11). EC of the groundwater is high in the central part of the Valley. In the north of the Valley, near the salt lake, EC reaches a maximum of 23 mS/cm; in the south, it decreases to 4 mS/cm. Measurements in 1964, when

there was no irrigation practiced in the area, showed average salinity values of only 3.2 mS/cm. The increase in EC values could be the result of the introduction of irrigated agriculture to the area.

Preliminary data analysis suggests that the increase in EC could be the result of two processes: (1) from water penetrating from the salt lake into the unconfined aquifer, and (2) from irrigation return flow. Field surveys show that, presently, water from the salt lake only reaches the wells in the northern part of the Valley. With increased groundwater pumping, this process may be accelerated and more salt water from the lake might penetrate the aquifer. The increase of salinity of the water in the south is most likely the result of irrigation return flow.

In the western part of the Valley, EC values are much lower. Here, they range between 1 and 4 mS/cm. This area has the highest groundwater level and is therefore currently not influenced by saltwater intrusion from the salt lake. Observation of the water table in the Valley has also shown that there is a freshwater recharge flow from the west and the east to the center.

The study will continue with the aim of developing options for the use of groundwater that will reduce the soil salinization hazard in the area.

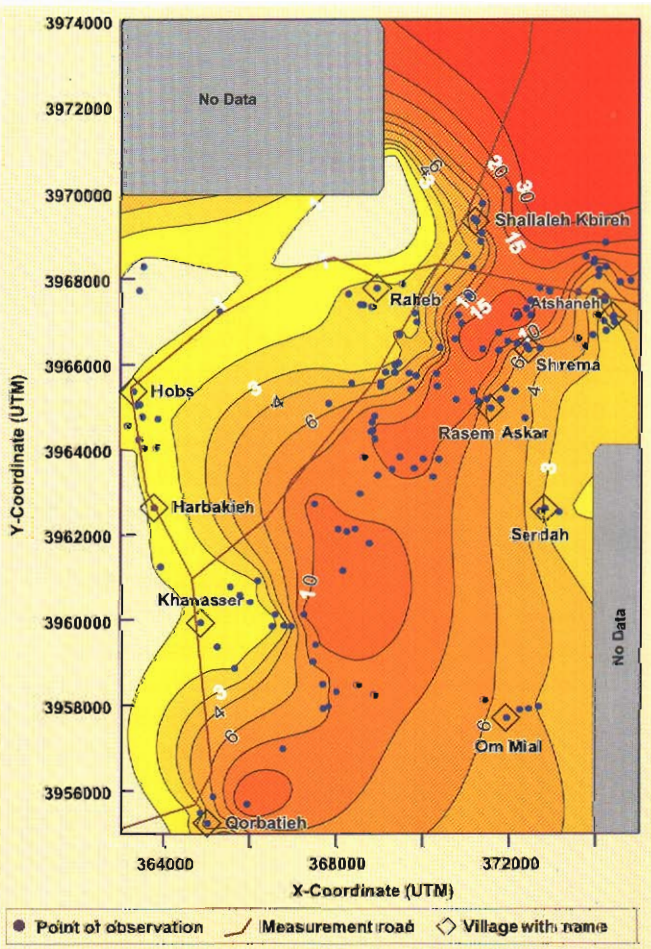


Fig. 11. Electrical conductivity (mS/cm) contour map of the shallow groundwater in the Kanasser Valley, Syria.

Plant Diversity and Ground Cover on the Grazing Land

Overgrazing has had disastrous consequences in the Khanasser Valley: natural vegetation is much depleted, both in terms of plant diversity and degree of plant cover, yet many plants manage to survive only in small niches, often inaccessible to animals. Differences in plant diversity and degree of ground cover between protected (fenced) and unprotected (open) grazed plots—after one or two seasons of study—will indicate the potential short- and long-term regenerative capacity of the land, and the extent of investments required to rehabilitate it.

Six sites were selected on the western and eastern slopes of the Valley to study their regenerative capacity. At each site, one protected (fenced) plot and three open plots were monitored for plant diversity and ground-cover development.

First results showed that, even during the first rainy season, plant diversity and plant cover on the protected plots were significantly better than on the grazed plots. And within the first season of the monitoring program, plant cover was found much better on the fenced plots compared with the open plots. On the fenced plots, the vegetation cover could regenerate over the season, while on the open plots, the degree of ground cover showed a downward trend because of continued heavy grazing.

In all, 71 plant species were identified at the monitoring sites with a maximum of 41 species at one site. On average, 75% of all the species identified at the site were found on the protected plots, whereas, on the grazed plots, only 32% of the species were found.

After a longer period, the protected plots are likely to show site-specific plant diversity under undisturbed conditions. It is assumed that this will then be the maximum possible protective plant cover which can reestablish on its own, under the present natural conditions in the area.

Protected plots may also serve as plant diversity pools (*in situ* plant diversity conservation) and seed multiplication sites for both annual and perennial species.

Fruit Trees on Barren Slopes and Farmer Participation

ICARDA is actively encouraging farmers to take up cultivation of fruit trees on barren slopes where rainfall and soil resources are limited. In the villages Om Mial and Mgerat, farmer-participatory observation and demonstration trials with different fruit trees were established to demonstrate how fruit trees will develop and produce under such constraints. On small plots belonging to two farmers, trees of six different types (olives, grapes, cherries, almonds, pistachios and pomegranates) were planted.

In cooperation with ICARDA researchers, the farmers prepared the plantations themselves using simple principles of water concentration to assure runoff collection for the trees during the wet season. For each tree, a terrace-like area of about 2m x 2m was cleared of stones. At the spots where the trees were planted, small holes (0.5 m x 0.5 m x 0.5 m) were excavated and refilled with a mixture of soil and sheep manure. During the dry season, the trees were watered (half-a-bucket) by hand every two weeks. The fact that most trees survived the critical dry period without costly regular irrigation, prompted other farmers in neighboring villages to try out fruit-tree growing as well, although it is a relatively long-term investment for them.

With ICARDA's help, the farmers have also learned how to lay out and construct simple tree terraces and small structures to collect rainwater from the surrounding slopes, skills increasingly important in a dry environment with limited water resources.

Recently, the teachers of a local primary school have shown keen interest to learn more about terracing and moisture conservation. This is a very good development, because some of the students will be the farmers of tomorrow. They will learn new ideas and skills, and will therefore find it easier to adapt to the fast changes in their environment than did their parents.

A proud farmer, Asri Da'bool, with one of the first olive trees growing in his terraced tree garden in the Khanasser Valley in Syria.

Spate-Irrigation Systems of Balochistan, Pakistan

Pakistan's Water Resources Research Institute and ICARDA are conducting research in hill-torrent areas to assess users' needs in watershed management and introduce suitable technological innovations. In the dry mountainous areas of Pakistan, the area under *sailaba* (hill-torrent spate irrigation) agriculture has expanded to meet the food and fiber needs of the rural population. *Sailaba* agriculture entails the management of torrential water flows in time and space. Both technical and socioeconomic factors determine the performance of the system. While water and vegetation management determines soil-erosion rates, and flood irrigation can increase and stabilize crop yields, this is subject to large variations in water availability in semi-arid environments.

In the Musa Khel and Barkhan districts of Balochistan, for instance, farmers grow wheat in the *rabi* (winter) season and mungbeans, mashbeans, and sorghum in the *kharif* (summer monsoon) season. Three cropping patterns are practiced: mixed sorghum, mungbeans/mash-

beans–wheat (M–W); fallow–wheat (F–W); and mixed sorghum, mungbeans/mashbeans–wheat–fallow–fallow (M–W–F–F) cropping pattern. In the M–W cropping pattern, half of the landholding is assigned for *kharif* crops and the other half for *rabi* crops with 100% cropping intensity (cropped-to-cultivated area ratio on a yearly basis). In the F–W cropping pattern, the monsoon rainfall and runoff is stored to ensure wheat monoculture with 100% cropping intensity. The M–W–F–F cropping pattern is different from the M–W cropping pattern in that one-year fallow in both the *rabi* and *kharif* seasons is required.

About 63% of farmers follow the M–W cropping pattern, 25% the F–W cropping pattern, and only 12% the M–W–F–F cropping pattern (Fig. 12). The majority of farmers in the top and middle of the mountainous areas practice the M–W cropping pattern, whereas 32% in each of the middle and foot of the mountains follow the F–W cropping pattern. One year cropping and one year fallow is normally practiced at the foot of the area by about 33% of farmers aiming to conserve soil moisture and runoff water, as well as soil fertility. The mix of *kharif* season crops is commonly grown by farmers located at upstream reaches (head and middle), indicating that more water is available to farmers in the head and the middle reaches than those in the areas below. Evapotranspiration in wheat is lower than in sorghum, mashbeans, and mungbeans. Therefore, the majority of farmers in the lower areas practice a pattern based on either wheat only or one year cropping and one year fallow.

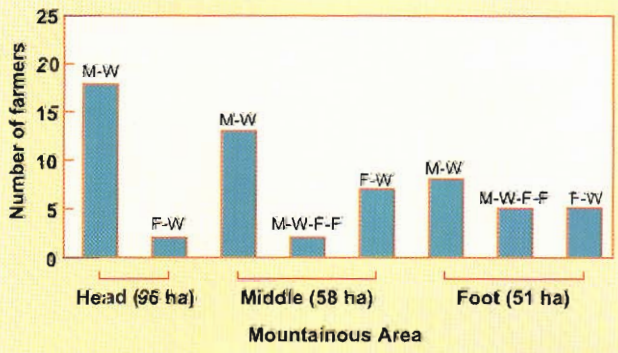


Fig. 12. Number of farmers, area, and cropping patterns practiced by farmers in spate-irrigation systems in Musa Khel and Barkhan districts of Balochistan, Pakistan.

M-W = mixed sorghum, mungbeans/mashbeans–wheat; F-W = fallow–wheat; M-W-F-F = mixed sorghum, mungbeans/mashbeans–wheat–fallow–fallow.

The cropping pattern followed at the head, middle, and foot of the area shows an asymmetric distribution of water availability to farmers. The cropping pattern of mixed sorghum, mungbeans– wheat is practiced by farmers who normally have more assured supply of water as the area under this cropping pattern and the proportion of farmers declines from head to lower areas (Fig. 13). Inequity in water availability might arise during a low-flow season because of difficulties in distribution of water since the flow depth might be insufficient for farmers in the middle or lower areas. Achieving equity would require the design and construction of channels which can perform better under both small and high water flows. High flows also create problems of channel erosion, requiring more maintenance as breaches become common. Water in small systems is more equally distributed.

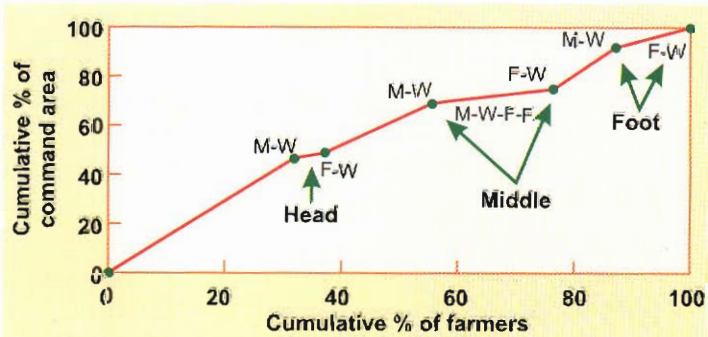


Fig. 13. Cumulative percentage of the area and cumulative percentage of farmers with respect to cropping patterns and the position in the watercourse in spate-irrigation systems in Musa Khel and Barkhan districts of Balochistan, Pakistan.

Research in spate-irrigation systems in Pakistan is potentially applicable to 1.5–2.0 million hectares to help reconcile food security with natural resource management. Productive use of water for grain crops, vegetable and fruit gardening, livestock operations, and domestic uses under extreme conditions of water scarcity compound the complex water management decisions made by the households. Quantification of socioeconomic variables with resource endowments is under way at two sites to help understand the mechanics of decision making for natural resource management and investment in land development.

Integrated Watershed Development in Mihassa, Syria

The Government of Syria established the Mihassa Research Center in 1989 as part of the Integrated Watershed Development Project. The Project's main focus is to develop and encourage use of sustainable water-harvesting and water-spreading techniques under arid conditions for enhancing forage yields and improving grazing and rangelands. The Project is under the aegis of the Directorate of Irrigation and Water Use (DIWU) of the Syrian Ministry of Agriculture and Agrarian Reform.

The Project includes a socioeconomic research component that seeks to integrate the knowledge, perspectives, and aspirations of land users into resource-management strategies formulated for the target area. ICARDA, in collaboration with DIWU, and with financial support from IDRC, carried out a socioeconomic research project in the Mihassa area in 1995/96. The research had two major components: (1) *ex ante* economic assessment of the proposed technical innovations, and (2) socioeconomic analysis of the transhumant pastoral production system practiced by the land users in the Mihassa watershed, including their own perspectives and understanding of the feasibility of the proposed development strategies.

More specifically, the objectives of the socioeconomic study were to: (1) determine the number of families and livestock that used watershed in good, average and dry years, and develop estimates of grazing periods; (2) document gender roles and responsibilities in resource management; (3) develop an economic assessment of present land-user livestock operations; (4) provide estimates of supplemental feeding in forms and quantities during the year; (5) collect local explanations for the cases of range degradation and suggestions for improvement; and (6) identify preferred shrub species for animal grazing.

Fieldwork for these studies was completed during 1995/96, and two draft reports were prepared: (1) Economics of water harvesting and storage in the Mihassa watershed, and (2) Socioeconomic study of land users in Mihassa watershed. These reports provide useful information and indicate that further research should look at the relationships among land users and if they could collectively manage the watershed. Also, the perceptions and suggestions of land users with regard to the arrangement that would best facilitate sustainable use of the Mihassa watershed need to be understood.

Diagnostic Study of Soil Erosion in the Hilly Areas of Syria

Soil erosion causes degradation of land in the hilly areas of Syria where olives are widely cultivated on the hill slopes. Conservation measures, though, are completely lacking in these fragile lands. A diagnostic study, supported by INIA, Spain and ICARDA, was carried out in 1997/98 in collaboration with Aleppo University to assess the incidence of soil erosion, analyze farmers' awareness of the problems and solutions, and determine the socioeconomic factors affecting farmers' decisions on land conservation.

The study covered some 530 households located in Hazarim village in the typically hilly Idleb province. The village has 1244 hectares of agricultural land, 86% of it arable and the rest uncultivable rocky land and rangelands. About 90% of the cultivated area is covered with trees, predominantly olives. The study area receives about 500 mm of annual rainfall.

Participatory techniques were employed to understand farmers' perceptions and knowledge of soil erosion and conservation measures. The farmers, the study revealed, were aware of the problem of soil erosion, though its intensity was seen to vary from severe to moderate. Changes in land use and introduction of modern agricultural practices, such as the use of tractors in place of animal power, were given as reasons for increased soil erosion. Though aware of its ill-effects, the majority of farmers (67%) did not take any conservation measures and attributed this to lack of resources. Asked about solutions, some farmers saw soil erosion as a natural process and thought that nothing could be done about it. Some others said they adopted short-term solutions, such as spreading soil under trees where topsoil has been mostly eroded. All farmers, considered digging of diversion ditches as most effective in reducing soil erosion on very steep slopes. However, their solu-

tions for soil erosion on moderate slopes varied, and included plowing across the slope and leveling.

Farmers in the area believe that intercropping of field crops with trees reduces soil erosion and the formation of rills and gullies as compared with land with tree cover but without field crops. Since this practice is seen to affect mature trees negatively, it is applied only when the trees are young, below 5–6 years old. Some farmers, though, still practice intercropping with full-grown trees for economic reasons.

Farmers' criteria for land valuation included soil color, soil depth, stoniness, steepness of the slope, age of trees, distance from the village, and type of subsurface rock. Average values of scores for some of these criteria are given in Table 8. Analyses revealed that while the steepness of the slope and degree of land degradation were good predictors of land values—as perceived by farmers—soil depth was not; it appears that farmers in the study area do not necessarily prefer deep soils for trees, particularly olives. This is because in the study area, under the topsoil lies a layer of soft, white rock which could inhibit root growth. This partly explains why farmers in the area are largely indifferent to soil erosion; lack of information on technological options and on supportive government policy are the other contributing factors.

Based on this diagnostic study, simple experiments/demonstrations of soil-conservation measures were established in collaboration with farmers. Farmers mainly preferred to grow field crops to increase soil cover. While some of them chose legumes for green-manure application to improve soil fertility, others opted to harvest. The effects of intercropping on income, tree performance, soil fertility, and soil loss will be monitored.

Table 8. Farmers' land quality assessment criteria and average scores for different land categories, Hazarin, Syria, 1998.

	Most frequent soil characteristics					
Farmers' land type	Color	Avg. depth (cm)	Slope	Erosion	Bedrock	Stoniness
Best	Red	125	Flat	No erosion	White soft	All parcels were considered to have no stones. Stones are normally collected from fields.
Good	Red	76	Moderate to flat	Moderate to no erosion	White soft	
Moderate	All colors	57	Moderate	Eroded to moderate erosion	White soft	
Worst	White	48	Very steep	Highly eroded	White soft	

Enhanced Agricultural Sustainability Using Forage and Pasture Legumes

Sustaining productivity while preserving the already limited agricultural resource base is a major concern in the WANA region where micro-economic considerations have often led to more erosive crop rotations.

To monitor long-term trends in cropping systems in WANA, ICARDA undertakes both on-station and on-farm research. In this context, a trial was established in 1985/86 at Tel Hadya for comparing the productivity of cereals, with and without nitrogen, in rotation with grazed medic, vetch, lentil, clean fallow, and watermelon. Soil analyses for total mineral nitrogen (N) and organic carbon (C) were done annually, with a final measurement of labile and biomass N and C forms.

The introduction of legumes into rotation increased cereal yield. Over the last five years (1993–1998), barley yields were lowest after continuous barley (1.39 t/ha), intermediate after lentil (2.11 t/ha), and similar with fallow (2.51 t/ha), medic (2.63 t/ha), and vetch (2.69 t/ha). Organic matter and total mineral N were highest with vetch and medic, and lowest with continuous cereal. Organic matter and total N showed a gradual increase with medic over the years (Fig. 14). Labile C and N were higher with medic (Fig. 15).

Legumes, such as *Medicago* and vetch, can increase soil organic matter and total soil N, thus enhancing soil quality. The C and N buildup can reduce N needs for the alternating cereal crop and improve soil structure.

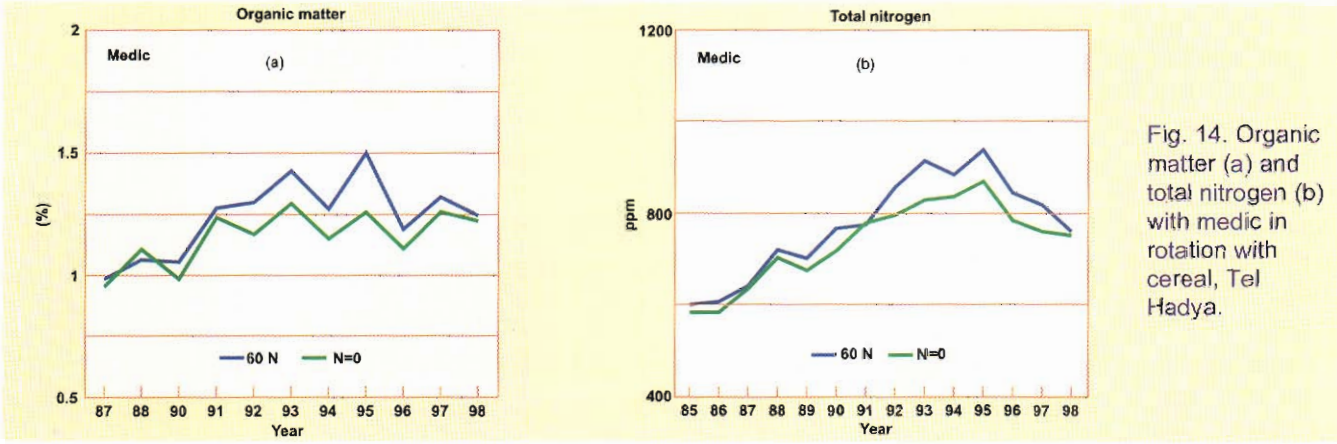


Fig. 14. Organic matter (a) and total nitrogen (b) with medic in rotation with cereal, Tel Hadya.

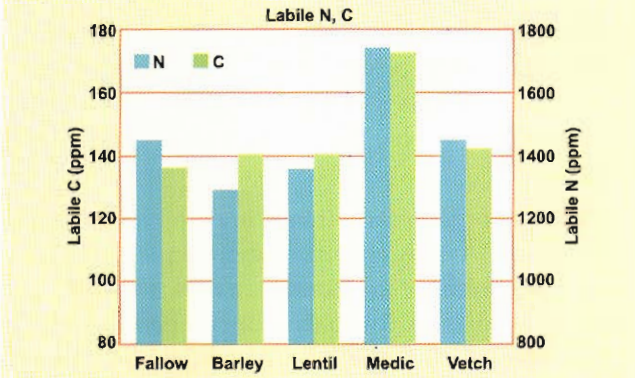


Fig. 15. Labile carbon (C) and nitrogen (N) with medic in rotation with cereal, Tel Hadya, Syria.

Integrating Forage Shrubs and Cereal Stubble into Animal Feeding Systems

Cereal stubble, though an important feed resource for small ruminants in WANA particularly during their breeding season, is low in protein. Various drought-tolerant shrub species are being incorporated in range areas of WANA both as a means to reduce land degradation and for use as fodder during times of feed shortage. ICARDA is conducting a series of trials to determine the suitability of shrubs in small-ruminant production, particularly how they complement cereal stubble feeding.

Re-orienting Small-Ruminant Production Systems in Central Asia

New production strategies for small ruminants hold the key to augmenting income of sheep farmers in Uzbekistan and other Central Asian countries confronted with the challenge of reorienting themselves to a market-led economy. Pelts and wool, for instance, no longer command the kind of market they did earlier. In 1998, under a collaborative research project with the Karakul Institute, Uzbekistan, ICARDA demonstrated how a simple change in management involving accelerating the weaning and fattening process in lambs, could help sheep farmers in their quest for alternative sources of income. With average weight gains of 180 g/day, the trial evoked a strong interest among the farmers.

Early weaning and artificial rearing of lambs in improved sheep production systems.

Survey of Sheep Fertility in the WANA Region

As part of the Mashreq/Maghreb Project, a series of on-farm surveys were conducted in Iraq, Jordan, and Syria to assess the reproductive performance of

sheep-production systems. The survey revealed low—less than 70%—flock lambing rates, suggesting that fertility problems are widespread and require urgent attention. While the impact of low reproduction rates is yet to be quantified, it is likely that they have negative consequences for sheep breeders in economic terms. The study further revealed that the potential for intensifying the flock's reproduction performance was depressed, with the incidence of twining not exceeding 3%.

As a follow-up to these findings, research on improving reproductive performance of sheep flocks in Jordan is planned.

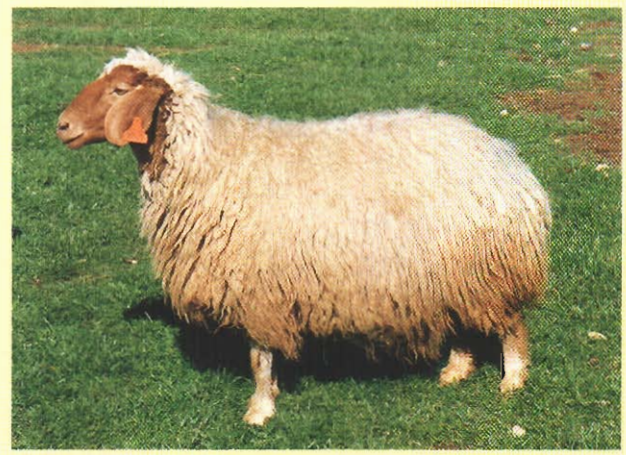
Improved Flock Management in Syria

Besides working with farmers on various aspects of animal husbandry, ICARDA advises farmers on flock management. Amin Yagen from El Bab in northwest Syria typifies a farmer who has benefited from ICARDA's guidance. Adopting a set of recommended practices—growing forage as a source of animal feed, breeding animals by selection within the flock, cultivating improved genotypes, and protecting the animals against disease by vaccination—he has managed a twinning rate of 21% as opposed to the regional norm of 5–10%. Besides, earlier lambing reduces mortality and the animals, plump and healthy, reach their sale weight—about 40–50 kg—at a time in spring when such lambs are in short supply and their price is high.

Improved flock management allows the improvement of fertility rates.

Genetically Improved Small Ruminants to Enhance Productivity

ICARDA has been collecting improved genotypes of native small ruminants from the region with the objective of studying how effective they are in enhancing productivity in a range of environmental conditions, particularly in areas involving livestock/crop interactions.



Improved Awassi genotype from Turkey

A flock of Syrian Awassi ewes, originally acquired from Syrian sheep-improvement centers, was augmented with improved Awassi animals imported from Turkey. Preliminary observations indicate that under similar conditions, Turkish ewes produce 25% more milk than their Syrian counterparts. On-farm evaluations of the improved germplasm will follow the on-station evaluations.

A small, improved herd of Shami goats was also acquired from the Syrian Goat Research Station in Damascus to study their suitability for intensive production systems where feeding resources are less limited.

Future research on these improved genotypes will focus on milk traits and the conversion of milk into cheese and yogurt.

Impact Assessment and Enhancement

Property Rights on Croplands and Rangelands

How do policy reforms on property rights affect rangeland farmers' investment behavior? What is their impact on household income? Do existing property-rights systems strike the right balance between individual and social interests? An ICARDA/IFPRI team, working in collaboration with national partners, investigated some of these issues in Algeria, Jordan, Lebanon, Morocco, Syria, and Tunisia.

Results of the econometric analysis of household and plot-level data in Jordan, Morocco, Syria, and Tunisia revealed that property rights do matter in determining farmers' management and investment behavior. Also, land rights do not prevent farmers from making long-term investments because even those with incomplete ownership rights—excluding individually or state-leased lands—have strong use-rights. In the low-rainfall areas, the study concluded, farmers'rights on croplands are not secure.

In rangelands, existing property rights systems were found to be failing to provide the right balance between individual and social interests. Land disputes, for instance, were found to be related to the exclusion of local communities from control and management of common pastures (e.g. Jordan), or in the inability of tribal institutions, whose ownership rights were recognized and sometimes titled (e.g. Morocco), to respond to the growing demands of their members. The management of common rangeland resources is a crucial issue in these low-rainfall areas. New approaches that favor greater participation of local communities are being initiated or implemented in the M&M countries.

Adoption and Impact of Fertilizer Application on Rainfed Barley in Syria

Barley is the most common crop in the dry rainfed areas of Syria. It is grown using traditional practices and materials, and is an important source of income in the rural areas. Production and yields, however, show wide fluctuations due to the variability in rainfall within and between seasons. ICARDA's research has shown that, in addition to low rainfall, shallow soils prevent efficient use of rainwater thereby limiting yields. Farmers in Syria still perceive fertilizer use on rainfed barley as a new idea. This is because fertilizer in the past was primarily used for high-value crops, such as cotton and vegetables. Research-station trials by ICARDA, however, clearly established that barley responds significantly to fertilizer application, especially of phosphate, even under low-rainfall conditions. Fertilizers were found to increase water-use efficiency by about 75% through more rapid development of crop cover and quicker completion of the growth cycle.

In order to assess the biological responses and economic viability of fertilizer use on barley in dry areas, ICARDA and the Soils Directorate of the Syrian Ministry of Agriculture and Agrarian Reform initiated multiple-season, multiple-location trials in farmers' fields, using a farming systems approach. Results of the trials, conducted over four years, confirmed those from the earlier research-station trials. Economic analysis showed that fertilizer use on rainfed barley is profitable at the farm level, with a positive impact at the national level in terms of production and net revenue besides being non-risky under variable rainfall and price conditions. In addition, fertilizer is simple to incorporate into the current barley/livestock farming system, easy to experiment with on a limited basis, compatible with farmers' beliefs, and environmentally sustainable. It is thus an appropriate technology for farmers of rainfed barley.

Impact of New Wheat Production Technologies in Syria

Syria was self-sufficient in wheat some 40 years ago, and a net exporter until the 1950s. But wheat production could not keep pace with increasing domestic demand triggered by population growth. The country therefore started importing wheat and wheat flour. Emphasis on production of vegetables, fruits and commercial crops was another contributory factor. Between 1985 and 1989, wheat production met only 72% of the requirement.

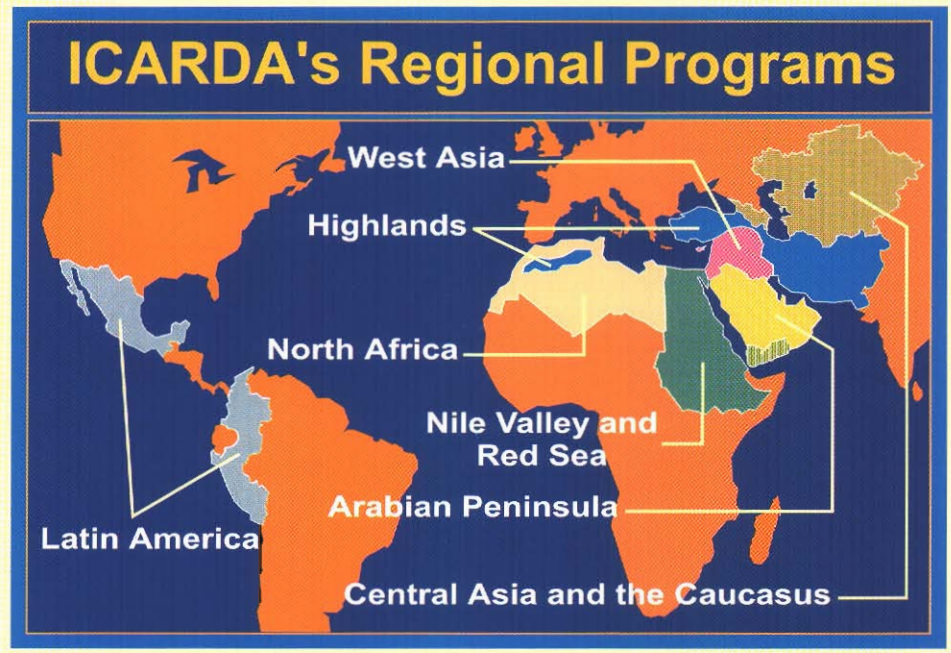
Since 1990, though, there has been a shift in policy with focus on enhancing productivity of wheat through use of high-yielding varieties, chemical fertilizers, and pest-control measures suited to local conditions. Irrigation infrastructure has improved, extension and credit institutions have become available, and farm mechanization is being encouraged. Consequently, wheat production in Syria has exceeded demand since 1993. An indication of wheat production trends in Syria can be had from the fact that between 1977-78 and 1995-97, the average area under wheat increased by 11% annually and the yield per unit area by 145%, with the two taken together contributing to increasing production by 170%. These percentages are based on wheat yields computed for three-year periods.

The ICARDA/CIMMYT Wheat Improvement Program for WANA has contributed significantly to enhancing wheat productivity in Syria through development of high-yielding, drought-resistant varieties of both durum and bread wheat suited for cultivation under rainfed and irrigated conditions. It also had a role in effective crop management. In its research and training endeavors in wheat and other crops, ICARDA collaborates with the Syrian Ministry of Agriculture and Agrarian Reform. As a result of the collaborative efforts, the wheat varieties 'Cham-1', 'Cham-2', 'Cham-3', 'Cham-4', and 'Cham-5' have been widely adopted by farmers in Syria. In fact, it is estimated that currently these varieties account for over two-thirds of the area under wheat in the country.

Interestingly, benefits of modern technologies in wheat have accrued to all farmers—small, medium and large—in contrast to the experience in many other countries where large farmers tended to benefit the most.

International Cooperation

ICARDA's international cooperation is driven by its Regional Programs, which provide the major mechanism for sustaining the research continuum between the Center and the national agricultural research systems (NARS). Besides enhancing linkages and exchange of technology and germplasm between ICARDA and NARS, these Programs permit the development of intra- and inter-country linkages, coordination, and effective networking within each region they serve. They also provide ICARDA with feedback from NARS, which contributes to the development of the Center's research agenda and medium-term plans in order to serve best its ultimate clients, the farmers.



In 1998, a major development in ICARDA's International Cooperation was the establishment of the Central Asia and the Caucasus Regional Program (CACRP) to enhance collaboration with the Central Asian Republics, namely, Kazakhstan, Kyrgyzstan, Tadjikistan, Turkmenistan and Uzbekistan, and the Caucasus, namely, Armenia, Azerbaijan, and Georgia. CACRP is now operational from ICARDA's Regional Office in Tashkent, Uzbekistan. The other six Regional Programs continued to enhance ICARDA's partnerships in North Africa, the Nile Valley and Red Sea, West Asia, the Arabian Peninsula, the Highland Region, and Latin America. Partnership and cooperation in the various regions were strengthened in 1998 at national and regional levels through the implementation of collaborative projects involving the exchange of technical expertise and germplasm, technical visits, participation in coordination meetings and workshops, and human resource development. What follows here is a summary of activities on strengthening partnership with NARS at national and regional levels, while the results of collaborative research with NARS are reported under the relevant sections of this Annual Report.

North Africa Regional Program

The North Africa Regional Program (NARP), which serves Algeria, Libya, Morocco and Tunisia, placed special emphasis in 1998 on establishing a collaborative program with the NARS of Mauritania. An official agreement is expected to be signed with the Government of Mauritania in the near future.

Cooperative Research Activities

Close collaboration between ICARDA and NARS of the region contributed to the selection of a number of promising cereal and food legume lines combining higher and more stable productivity with better resistance/tolerance to biotic and abiotic stresses prevailing in the target environments of the region. Germplasm enhancement activities are carried out through a decentralized approach whereby leading NARS are given greater regional responsibility.

The pioneering ICARDA/NARS collaborative research on Hessian fly resistance, especially with Morocco, resulted in the development of durum wheat germplasm (e.g., 'TelSet 2', 'TelSet 3' and 'HFR') combining this trait with drought tolerance.

These lines are now undergoing intensive on-farm testing. Encouraging preliminary results on Russian wheat aphid resistance have been obtained. Furthermore, durum wheat germplasm (e.g., 'Zeina' and 'Outrob 4') with resistance to *Septoria tritici* has been identified in Tunisia. Also, a bread wheat variety ('BW 2750') and a barley variety ('Barley 119'), particularly adapted to semi-arid areas, are expected to be released in 1999.

Throughout the cropping season, considerable effort was deployed for strengthening food legume programs of the region, especially in germplasm conservation and varietal improvement and screening for disease resistance (ascochyta blight of chickpea and lentil rust). A large number of nurseries of ICARDA-enhanced germplasm were evaluated by NARS breeders. Research on faba bean is mainly conducted within the Maghreb Faba Bean Research Network (REMAFEVE), which is in the process of evolving into a full-scale Maghreb Food Legume Network (REMALA).

Mashreq/Maghreb Project

The 1998/99 cropping season marked the first year of Phase II of the Mashreq/Maghreb Project, financed by AFESD, IDRC and IFAD. The project includes technology development and transfer, and policy and institutional research in collaboration with IFPRI.

The first Regional Technical Coordination and Planning (RTCP) Meeting and the Steering Committee Meeting of Phase II were held in October in Hammamet, Tunisia. ICARDA offices in Tunis and Amman jointly organized the meetings. The National Coordinators and scientists from each NARS involved in the project (Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, and Tunisia) attended the RTCP Meeting in which ICARDA was represented by 10 scientists. The Steering Committee Meeting was attended by the eight National Coordinators, donor representatives (IFAD and AFESD), and IFPRI and ICARDA management.

A policy and property rights workshop was held in November 1998 in Hammamet, Tunisia, and was attended by key scientists from participating NARS and representatives of IFPRI and ICARDA. At the workshop, results from Phase I of the project were reviewed.

WANADDIN

North Africa plays a leading role in the regional West Asia and North Africa Dryland Durum Improvement Network (WANADDIN), funded by IFAD. The Network involves five NARS (Algeria, Morocco, Syria, Turkey, and Tunisia) and two international centers (CIMMYT and ICARDA). WANADDIN's objective is to develop durum germplasm incorporating high and stable productivity, better quality, and resistance to main abiotic (drought, cold) and biotic (Hessian fly, septoria, root rot, tan spot, powdery mildew) stresses prevailing in dry areas of the region. Transfer of technology activities and socioeconomic studies were strengthened in 1998, especially assessment of on-farm traditional durum processing techniques (for *couscous*, *frike*, *burgul*, and bread).

The socioeconomic sub-network of WANADDIN held its first seminar in January 1998 in Tunis to present results of on-farm surveys undertaken, review the progress of economic impact assessment of durum improvement research in the five participating NARS, and develop a two-year (1998 and 1999) workplan.

The last Research Advisory Committee (RAC) and National Steering Committee (NSC) Meetings of the first phase were held in December 1998 in Zaragoza, Spain, on CIHEAM campus.

Other Collaborative Projects

ICARDA collaborates with Morocco and Tunisia in developing a farmer-participatory approach to barley breeding. The project, financed by IDRC, involves farmers in marginal areas in the evaluation and selection of early breeding material with a view to developing cultivars that are specifically adapted to marginal conditions and that meet farmers' desired characteristics. Libya, Morocco, and Tunisia participate in the Ecoregional Program on On-Farm Water Husbandry, implemented by ICARDA. Information on available water resources has been collected. Indigenous water-harvesting techniques (cisterns, underground channels, contour terracing, levees) have been investigated and recommendations made for their improvement.

Collaboration with Mauritania

The year witnessed the initiation of collaboration with Mauritania. In March 1998, a Mauritanian Delegation, headed by the Minister of Rural Development and Environment, visited ICARDA at the invitation of the Director General. Two ICARDA missions visited Mauritania in April and November 1998 to develop a collaborative research program. Based on NARS priorities and field missions, research concept notes were developed by NARS and ICARDA scientists on irrigated agriculture, rainfed agricultural systems, agro-sylvipastoral systems, oasis production systems, technology transfer, and impact analysis. Collaborative research is expected to be initiated in 1999.

Coordination Meetings, Workshops, and Training Courses

The main activities undertaken during the year were reviewed during the Annual ICARDA/NARS Coordination Meetings, held in September in Libya, Algeria, Morocco and Tunisia, and the ICARDA/ North Africa Regional Coordination Meeting, held in October in Hammamet, Tunisia. At these Meetings, the major changes in emphasis in research programs outlined in ICARDA's 1999-2001 MTP were discussed to develop plans for implementation. Eleven ICARDA scientists and representatives of the NARS of the four countries attended the Regional Coordination Meeting. Dr A. Alaoui, ICARDA BOT member, attended the opening and closing sessions of the Morocco meeting. The Annual Coordination Meetings were a good opportunity for presenting and discussing ideas for project proposals to be developed and submitted to potential donors. New areas of collaboration were identified, including biotechnology, water and natural resource management, gender issues, community approach, and biodiversity conservation.

Potential projects were presented and thoroughly discussed, including those on sustainable management of the agro-pastoral resource base in the Oujda region (Morocco) in collaboration with the Swiss Agency for Development and Cooperation (SDC); the Oat and Vetch Network (REMAV); rural development projects in Morocco (Rif and Ifrane); a regional IPM project on cereal and food legume pests in North Africa; Hessian fly management through biological control and host-plant resistance; integrated management of *Septoria* spp. on wheat in North Africa; and two biotechnology projects: development of biotechnological resources in the Arab States, and development of biotechnological research in North Africa.

Two workshops were held in Tunis: a WANADDIN Socioeconomics Workshop in January and the Mashreq/Maghreb Policy and Property Rights

Participants in the North Africa/ICARDA Regional Coordination Meeting.

Workshop in November. A Durum Traveling Workshop (WANADDIN) was held in Morocco in April, and training courses on Scientific Writing (WANADDIN) in February, Processing and Economics of Seed Production in March/April, and On-Farm Experimental Station Operation Management in October.

Three training courses/study tours were conducted in Tunisia, in collaboration with INAT, for the World Bank/Egyptian Government Matrouh Resource Management Project (MRMP) staff, on Arid Zones Agricultural Development, Rainfed Orchards Establishment and Production, and Water Harvesting in Dry Areas.

Other activities included participation in the following regional events in Tunisia: INAT Symposium on Prospects for Sustainable Agricultural Development; FAO Regional Meeting of Plant Protection Scientists from North Africa; UNESCO Biodiversity Workshop; Regional Expert Group Meeting on the Promotion of Arab Cooperation in the Protection of Biodiversity, organized by the Arab League Educational, Cultural and Scientific Organization (ALECSO); and the Conference on the Role of Agricultural Development in Improving the Industrial Sector in Arab Countries in Libya.

Nile Valley and Red Sea Regional Program

The Nile Valley and Red Sea Regional Program (NVRSRP), operating from ICARDA's Regional Office in Cairo, Egypt, is based on tripartite collaboration among the NARS of the Nile Valley and Red Sea countries (Egypt, Eritrea, Ethiopia, Sudan and Yemen); ICARDA; and donors (the European Union, the Netherlands, and the World Bank). It covers major cool-season food legumes and cereals in these countries. Resource management is an important component of the activities in Egypt. A Regional Networks Project aims to strengthen basic and applied research to solve problems of common interest to the countries of the region. NVRSRP is also involved in adaptive research and in integrating research with development through the Matrouh Resource Management Project (MRMP) in Egypt and the Agricultural Sector Management Support Project (ASMSP) in Yemen.

Regional Networks

Wheat Rusts Network. Forty-nine leaf rust and 57 stem rust pathotypes have been identified during the past six growing seasons in Egypt, Ethiopia, Sudan, and Yemen. The most effective leaf rust resistance genes at the seedling and adult stages have also been identified. Stem rust gene Gt^t was the most effective at both stages, while three other genes were effective only at the seedling stage.

Wilt and Root-Rot Diseases Network for Cool Season Legumes. Eight isolates belonging to one race were identified in Sudan. Three races were determined in different parts of Egypt and three in Ethiopia. Screening of chickpea for wilt/root rots resulted in the identification of two lines that proved resistant across the three countries. Promising results were obtained on the integrated management of wilt/root-rot diseases. Application of fungicide with early sowing and a resistant variety gave significantly higher crop yields in Egypt and Sudan. Use of Rizolex/Benlate (tolochofos-methyl/benomyl) reduced damping-off in faba bean, chickpea, and lentil. Frequent irrigation reduced disease inocula. In Sudan, delayed sowing reduced disease incidence, and seed dressing with fungicide was effective in the control of wilt and root rots of chickpea.

Aphids/Viruses Network. Twelve lines of wheat from two different crosses proved to be resistant to *Schizaphis graminum* under greenhouse conditions. Environmentally safe chemicals, including jojoba oil, exhibited high effectiveness in controlling *Rhopalosiphum padi* aphids in wheat in Egypt. In Ethiopia, two sprays of Pirimor (primicarb) at the rate of 0.1% effectively controlled *Acyrthosiphon pisum* in field pea and increased yield. Gaucho (imidacloprid) 70% and *neem* seed extract were also effective. The economic threshold level (ETL) for *Aphis craccivora* in faba bean variety 'Giza 2' in Egypt was determined at 43 aphids/shoot. In Ethiopia, three years' results showed that ETL for *A. pisum* in field pea variety 'Arsi' was 40-45% infestation level. Twenty-two bread wheat genotypes and 20

barley genotypes were found tolerant to barley yellow dwarf virus (BYDV) in Egypt. Resistance to FBNYV in faba bean has been elusive so far, but roguing, sowing in early November, and insecticide spraying decreased infection.

Thermo-Tolerance in Wheat Network. About 350 wheat crosses were made to accumulate desirable genes for heat tolerance in commercial cultivars. Segregating populations were distributed and evaluated in collaborating countries (Egypt, Sudan, and Yemen). Promising lines were selected for further evaluation. A wheat screening nursery for heat tolerance consisting of 110 entries of advanced lines and released varieties in Egypt and Sudan was evaluated. Promising material was further tested in yield trials in 10 environments in Egypt, Sudan, and Yemen. Seven genotypes gave mean yields greater than those of the checks across all environments. The results from morpho-physiological character studies indicated that grain yield under heat stress is highly associated with high biomass production, canopy temperature depression, number of heads per unit area, kernel weight, and slightly later maturity.

Drought and Water-Use Efficiency Network. A screening nursery consisting of 110 wheat genotypes assembled from the national programs' advanced lines and released cultivars was evaluated at eight locations in Upper Egypt, Sudan, and Yemen. Promising lines were further tested in a regional yield trial across locations. Seven genotypes proved to be tolerant to moisture stress. Their grain yields ranged from 6 to 6.8 t/ha in Egypt, 2.2 to 2.6 t/ha in Sudan, and 2.4 to 2.8 t/ha in Yemen.

Socioeconomic Studies Network. Adoption studies revealed that farmers' adoption rates of the proposed technologies were moderate to high depending on the technology component, and that productivity was highly related to the level of technology adoption. Main constraints limiting farmers' adoption are related to farmers' lack of access to inputs; socioeconomic factors, such as age, education, and importance of the crop to farmers; and lack of feedback to researchers; or to the performance of different technology components under alternative field conditions. Impact assessment studies showed that the proposed technologies contribute considerably to the improvement of rural community income and national food security as a result of the good yield gains realized, to farmers' higher incomes, and to higher national production of target crops, which would result in lower imports and higher self-sufficiency ratios.

Policy analysis indicated that proposed technologies were economically efficient under the open market changes which the four countries are experiencing. There is a tendency towards a more rational use of some inputs, especially chemicals in Egypt. Gender analysis revealed that women play a considerable role in agricultural production, suggesting that research and technology transfer should take account of possible gender differentiation in specific agricultural activities.

Collaboration at National and Regional Levels

To enhance coordination at the national level, several national workshops were conducted. These covered lentil and chickpea in Ethiopia, and resource management, data handling and computer application in Egypt. Annual National Coordination Meetings were held in Ethiopia in May, Sudan in August, and Yemen and Egypt in September.

To enhance inter-regional cooperation, four regional traveling workshops were organized in 1998. The one on wheat was held in Sudan in February, and participants visited farmers' fields in the northern and central parts of Sudan. A regional cereals traveling workshop was held in Yemen in March, in which participants from Egypt and ICARDA, accompanied by their Yemeni colleagues, visited farmers' fields in the northern, central, and southern highlands and observed the heavy infection of yellow rust as well as the improved entries which showed a high level of resistance to the disease. A regional traveling workshop on food legumes was organized in Egypt in March with participants from Ethiopia, Sudan, Yemen, and ICARDA; they visited demonstrations in farmers' fields and research conducted at the stations, and observed interesting newly released materials

such as the chocolate spot resistant lines 'Giza 461' and 'X-843', and the newly released early-maturing faba bean line 'Giza 716' to precede cotton in rotation. Another workshop was conducted in Ethiopia in October with participation from Egypt and ICARDA. Visits covered the major production areas east and southeast of Addis Ababa and included visits to farmers' fields and research stations.

Sudanese farmers in their wheat field, where the recommended production package has been successfully implemented.

The NVRSP Regional Coordination Meeting was held at ICARDA headquarters in Aleppo, Syria, in September with participation of over 75 scientists from the four countries. The meeting gave an opportunity for the scientists to see the recent developments at ICARDA, visit its facilities, and interact with scientists at the Center. Exchange of scientific visits within the Problem Solving Regional Networks Project aimed at exchanging experience, evaluating germplasm, and developing future strategy of the project.

Human Resource Development

Several national and regional training workshops, courses, and individual training were organized. Regional training courses included IPM of aphids and viruses, impact assessment methodology and gender issues, wilt and root rot diseases, and training in the use of AGROBASE software with participation from North African countries. Eighty-four scientists from the four countries involved in the Regional Networks Project participated in these activities, 16 in short training courses, 10 as visiting scientists, 32 in meetings and conferences, and 26 in workshops. Out of the 123 Ethiopian scientists involved in the project activities, 72 attended in-country training courses, 50 participated in meetings and conferences, and one completed an MSc degree. In Egypt, 355 researchers from different disciplines, including cereals, food legumes and resource management, participated in these activities. In Yemen, 120 researchers attended various short-term training courses and 14 are receiving MSc and PhD degree training under ASMSP.

The first issue of the NVRSRP Newsletter was published for enhancing regional cooperation and exchange of research results and methodology.

ICARDA-Yemen

ICARDA continued its collaboration with the Agricultural Research and Extension Authority (AREA), Yemen, in the Research Component of the Agricultural Support Management Sector Project (ASMSP), funded by the Yemeni Government through a World Bank loan. A major component of the work was the technical assistance in implementation of research, particularly through the participatory farming systems approach, to strengthen researcher–extensionist–farmer linkages thereby accelerating the development and adoption of technologies.

Progress was made in revitalization of agricultural research activities in Yemen. The Agricultural Research Strategy document was finalized and published during the year, but implementation of the new strategic vision required several organizational adjustments to make agricultural research more effective, efficient, and nationally coherent. For the transition period, the ICARDA team assisted AREA in preparing a Medium-Term Research Plan (MTRP) for implementation during 1998–2000 by the regional research stations.

Adaptive research through the Rapid Impact Program (RIP) was expanded to the Generalized Rapid Impact Program (GRIP) to transfer improved technologies to farmers and create rapid impact on farmers' productivity and income. Ninety technologies were tested/demonstrated on farmers' fields during 1998. A problem-solving and farmer-participatory farming systems approach was followed for the implementation of GRIP activities. This promoted

community participation in technology testing and evaluation, facilitating quicker adoption. In 1998, farmers adopted some of the technologies introduced during 1997 on a wider scale. Faba bean varieties selected from ICARDA material, which AREA has recently released, gave more than 150% yield increase and most of the farmers in the area decided to adopt these varieties next season. Visiting policy-makers and donors have greatly appreciated the success of GRIP, which has renewed their confidence in AREA. The program is also generating feedback for researchers to improve their on-station research agenda.

Significant progress has been made in the use of Participatory Rural Assessment (PRA) methods. Researchers have used, with assistance of ICARDA team, various techniques in diagnosis of farmer problems, planning, implementation and evaluation of research activities. Most of the on-farm trials were conducted under farmers' management conditions, and the full methodological cycle of a farming systems approach to research and extension has been initiated at three pilot sites.

As part of research capacity building, a series of consultative meetings, workshops and in-country training workshops were conducted on various themes and disciplines, including statistical design and analysis of agricultural experiments, scientific writing, and participatory farming systems approach methodology, and long- and short-term training and study tours were organized for key AREA personnel. Fourteen researchers are receiving MSc and PhD training.

ICARDA continues to support AREA in research on the management of mountain terraced farming systems. Indigenous technical knowledge and farmers' innovations in the Central Highlands have been documented.

ICARDA continued to provide technical assistance for systematic genetic resources conservation under the UNDP Sustainable Environment Management Project. A draft strategy paper for plant biodiversity conservation in Yemen was prepared. ICARDA was also involved in strengthening the seed sector in Yemen and played a major role in linking Yemen to the Cereals and Legume Asia Network (CLAN) coordinated by ICRISAT.

West Asia Regional Program

The West Asia Regional Program (WARP) promotes regional cooperation in research, training, and information dissemination in Cyprus, Jordan, Iraq, Lebanon, Syria, and the lowlands of southern Turkey. The major emphasis of the Program is on the improvement of farming systems in the 200–450 mm rainfall zone. The region is characterized by a limited agricultural resource base, shortage of water with highly erratic rainfall over time and space, and high population growth.

Collaborative Projects

The regional adaptive research program for the development of integrated crop/livestock production (the Mashreq/Maghreb Project), funded by AFESD, IFAD, and IDRC was extended for a four-year second phase starting in July 1998. The 1997/98 season was a transitional period, bridging Phase I of the Project with Phase II. In Phase II, greater integration of the research will be achieved through a shift in the scale of technology testing to the community level. Technology transfer, socioeconomics, and policy and property rights issues will be integrated across agroecological zones and disciplines within a community approach.

Substantial support was also provided in areas of critical importance to the West Asia countries through other projects such as water harvesting in WANA, improving barley under dry conditions, and producing and using multi-purpose fodder shrubs and trees.

Collaboration at National and Regional Levels

Four coordination meetings were organized with the national programs of Syria, Jordan, Iraq, and Cyprus. ICARDA held its first coordination meeting and signed a new agreement with Cyprus. Cooperation with Lebanon was reviewed with a view to further strengthen it. As part of Phase II of the Mashreq/Maghreb Project several meetings were held: (1) two in Lebanon where more than 100 farmers and sheep herders participated, in addition to national researchers from various collaborating institutions, high officials, policy-makers, and exten-

sionists, (2) two in Iraq in which 70 farmers and researchers from IPA and ICARDA attended, and (3) three in Syria, which were attended by the Mashreq/Maghreb project team and a number of farmers. In all these meetings, farmers interacted with the researchers, extensionists, and policy-makers and expressed their views on a number of technical issues and their relationship with policy and property rights. A national traveling workshop was held in Iraq in which more than 100 farmers and technicians participated. Several topics, including the use of vetch in rotation with barley as a feed source for sheep, were discussed and large-scale on-farm demonstrations were conducted. Some of the farmers have started to produce vetch seed and were willing to share it with other farmers in the area.

The Mashreq/Maghreb Project in Lebanon conducted a traveling workshop in north Lebanon, which was attended by 45 individuals representing farmers, technicians and scientists from ICARDA, ARI, and UNIRDP Baalbeck–Hermel project. Participants visited the trial and demonstrations and witnessed the advantages of the technology package for barley improvement developed by the project. Farmers also participated in the evaluation of the different barley lines introduced by the project and by the joint ARI/ICARDA collaborative program.

A workshop on policy and property rights research was organized in July at IPA Agricultural Research Center in Baghdad, Iraq. The workshop was attended by the Minister of Agriculture; scientists from ICARDA, the Ministry of Agriculture, IPA Agricultural Research Center, Higher Commission for Agriculture, and Universities of Baghdad and Mosul; and high-ranking officials from the Ministry of Agriculture. The workshop discussed the impact of domestic price reforms on agricultural sector, market liberalization in WANA and its impact on low-rainfall areas, effect of property rights in the low-rainfall areas of WANA, and impact of GATT on the agriculture sector in the Arab World.

Collaboration between countries in the region included exchange of germplasm, technical meetings, as well as visits and participation in workshops on seed production, technology impact, livestock production under climatic uncertainties, conservation and sustainable use of plant genetic resources, and water use.

To start implementing of the second phase of the project and develop workplans, National Coordination Meetings were organized in the Mashreq countries (Iraq, Jordan, Lebanon, and Syria) for the project teams and several farmers. This participatory approach is one mechanism for the implementation of project activities. The first Regional Technical Planning and Coordination Meeting and the Steering Committee Meeting for Phase II, held in Hammamet, Tunisia, were attended by researchers from the countries involved and ICARDA. During these meetings, which marked the start of Phase II, workplans were presented with a view to enhancing integration between the countries and the regionality of the project.

Collaboration between West Asia and North Africa was strengthened through the Mashreq/Maghreb Project. Cactus production technologies developed in the Maghreb countries are now being transferred to the Mashreq countries. Farmers as well as scientists and the DG of the National Center for Agricultural Research and Technology Transfer (NCARTT) in Jordan visited Tunisia in order to get acquainted with this technology. Jordan is now promoting cactus cultivation as a means to secure alternative feed sources, and at the same time combating land degradation. Linkages were developed with the Arabian Peninsula region through exchange of visits and experience on crop/livestock integration and production.

Collaboration with Other Organizations

A program of cooperation on the Technical and Economical Assessment of On-farm Water Use Efficiency in the region was initiated with the Economic and Social Commission for Western Asia (ESCWA). Technical backstopping in the form of short consultancies continued to be provided to the Jordan Arid Zone Productivity Project (JAZPP) and to the IFAD-funded Agricultural Research Management Project in Jordan. Collaboration with IFPRI continued through the Mashreq/Maghreb Project.

Human Resource Development

Researchers and technicians from national programs participated in various regional training courses organized in the region and/or at ICARDA headquarters. Five graduate students from West Asia are working for their MSc degree under joint supervision of ICARDA and NARS scientists. Furthermore, ICARDA has been outsourcing and/or subcontracting national expertise to provide targeted training to other national programs. In this regard, young scientists, extensionists and farmers from the IFAD-supported project in Egypt, Newlands Agricultural Services, are being trained by local experts at NCARTT in Jordan on modern irrigation techniques in improved intensive agricultural systems.

Arabian Peninsula Regional Program

The ICARDA Office of the Arabian Peninsula Regional Program (APRP) in Dubai, which was formally opened in January 1997, was further strengthened in 1998 with the recruitment of a protected agriculture specialist and a water/irrigation specialist. APRP has four main research themes: (i) rangeland, shrubs, irrigated forages and livestock; (ii) protected agriculture; (iii) abiotic stresses; and (iv) on-farm water-use and irrigation management.

The Regional Technical Coordination Meeting (RTCM) and the Regional Steering Committee Meeting (RSCM) were held in Manama, Bahrain, in May. All the Steering Committee members from each of the seven Arabian Peninsula countries (Bahrain, Kuwait, Qatar, Saudi Arabia, the Sultanate of Oman, the United Arab Emirates, and the Republic of Yemen) attended, as well as technical staff, scientists and management personnel from ICARDA, in addition to a representative from AFESD, the major donor. Results of the work from the past season were presented and evaluated at the meetings, and the 1998/99 workplans and budgets were developed and subsequently approved by the Regional Steering Committee.

An International Workshop on Protected Agriculture in the Arabian Peninsula was held in Doha, Qatar, which covered state-of-the-art of the major components of protected agriculture, including greenhouse design, structure and covering materials; growing systems in relation to water-use efficiency, fertigation and postharvest technology; integrated plant production and protection; and regional networking for the exchange of experience and information. The recommendations of this Workshop formed the basis for both immediate and long-term strategies for protected agriculture development in the Arabian Peninsula. The Workshop was funded by AFESD, IFAD and FAO, and was organized locally by the Ministry of Municipal Affairs and Agriculture in Qatar and ICARDA. Fifteen national scientists and 12 regional and international experts participated. A regional protected agriculture network, using a home page on the Internet, has been developed to maximize collaboration among researchers, scientists and extension staff.

To enhance human resource development in agricultural research, five regional training courses were conducted on Field Plot Techniques; Data Analysis and Presentation and Scientific Writing (Qatar); Germplasm Collection and Maintenance (UAE); Irrigation and Fertigation (Saudi Arabia); Seed Technology and Production (Oman); and Insect Taxonomy and Integrated Pest Management (Oman). All five specialized training courses were given both in Arabic and English by ICARDA scientists and other regional and international experts. A total of 83 national scientists were trained.

Following a training program on germplasm collection and gene bank management in March in the Sharjah Emirate, plant and seed collection missions were undertaken in the UAE, Oman, and Yemen. A major objective of the collection missions was the training of counterparts from the Ministry of Agriculture and Fisheries, UAE, and the Directorate of Agricultural Research, Oman, on germplasm collection techniques. The seed of 182 accessions collected from UAE and Oman is currently stored in the gene bank at ICARDA headquarters due to the lack of adequate in-country facilities. The accessions from Yemen are stored in the recently developed gene bank at AREA. A database and herbarium specimens were also prepared. Several additional days were spent in the UAE collecting bulk seed samples of

important forages for storage and multiplication. Finally, a small gene bank was developed in the UAE for these seeds, which will be used in experiments in the following seasons.

Collaboration with the Faculty of Agricultural Sciences at the UAE University in Al-Ain involves measurement of the nutritive value of five of these indigenous forages *in situ*. The water-use efficiency of current forage systems is being measured in Kuwait, Oman, UAE, and Yemen.

A survey of all seven Arabian Peninsula countries was completed by an ICARDA agroclimatologist and his review "Status of Agroecological Characterization in the Arabian Peninsula" was published and presented at the RTCM in Bahrain in May.

Highland Regional Program

The Highland Regional Program (HRP), with its regional office in Ankara, Turkey, coordinates and promotes activities on research, training, and information dissemination in the highland areas (over 700 meters above sea level) of West Asia (Afghanistan, Iran, Pakistan, and Turkey) and North Africa (Algeria, Morocco, and Tunisia). The regional program for Central Asia and the Caucasus (CAC) assumed responsibility for the highland areas of the CAC region in July 1998 (see page 64).

Collaborative research and training activities were jointly carried out for the highland areas with NARS from Turkey and Iran. Collaboration was also maintained with NARS in Pakistan, Afghanistan, and Morocco.

Turkey

Thirteen research activities were jointly conducted by NARS researchers in Turkey and their ICARDA partners. These involved crop improvement, with emphasis on cold tolerance (for durum and bread wheat, barley, lentil, chickpea, vetch, and chickling), crop modeling, crop diversification and on-farm technology adoption, supplementary irrigation, range rehabilitation and management, seed production, and sheep improvement. The information generated through these joint activities is used by the NARS to develop improved technologies for Turkish farmers, to adopt and by ICARDA scientists to further improve their germplasm for specific traits.

Central Research Institute for Field Crops (CRIFC)/ICARDA Collaboration. Work continued within the joint project, launched in 1995, for the rehabilitation and improved management of communal rangelands in Central Anatolia. Successful rehabilitation of rangelands has been achieved, within the last three years, in one village. The project yielded a wealth of information on plant diversity and dry-matter yield increase (by 200–300%), and on social and economic aspects of the communal pastures. The project has direct relevance to a new law in Turkey for rangeland rehabilitation and utilization, which provides for the establishment of a special fund to support rangeland development projects in the country.

Collaboration between researchers of CRIFC and ICARDA led to the testing of annual forage legumes in different growing conditions in Central and Eastern Anatolia. Hungarian vetch and hairy vetch were found to be particularly adapted to cold environments. Seed of improved breeding lines is being shared with interested CAC countries. Work continues on further improvement of cold-tolerant species for earliness to ensure good yields in drier environments.

A disease survey in different areas of Turkey was organized by HRP and CRIFC in June 1998. The major disease observed throughout the survey was yellow rust on bread wheat and, to a lesser extent, on durum wheat. Septoria blotch on wheat and scald on barley were also serious diseases. Symptoms of root rot were observed on both wheat and barley, and symptoms of cereal cyst nematodes were evident in a few fields. Ascochyta blight was severe on early-planted chickpea.

Turkey/CIMMYT/ICARDA International Winter Wheat Improvement Program (IWWIP). The program continued to strengthen partnership between the three involved institutions, and with collaborating NARS in the CWANA region. Germplasm is developed in Turkey and Syria, and testing is largely done in Turkey before it is dispatched to a large number of sites in the region. Five international nurseries were

sent to around 30 cooperators within CWANA for *in situ* testing and selection by NARS. The germplasm is shared with cooperators on the basis of a CGIAR Materials Transfer Agreement. The three partners of IWWIP established an expanded Seed Unit and started the preparation of a Seed Health Laboratory at Konya Agricultural Research Institute to ensure healthy wheat seed for the international nurseries sent from Turkey to the CWANA region.

WANA Dryland Durum Improvement Network (WANADDIN). Within this IFAD-funded project, Turkish researchers tested durum wheat germplasm in different environments of the highlands in Turkey, with particular emphasis on germplasm improvement for drought and cold tolerance and for grain quality. Seven advanced breeding lines were identified for future registration. Socioeconomic surveys were carried out, involving farmers in Central, North-Central, and Southeastern Anatolia, to investigate problems related to farm size, farm income, available technology, and use of production inputs. Seed was distributed in five districts to farmers who planted their seed in demonstration fields totaling 258 ha. Results showed a consistent superiority of the new cultivars 'C-1252' and 'Kiziltan 91' over the older cultivars 'Kunduru 1149' and 'Cakmak 79', with a yield advantage varying between 12% and 100%.

Southeastern Anatolia Project (GAP). This project aims at sustainable development of the southeastern region of Turkey, including the diversification and improvement of agriculture and welfare of the rural communities in the GAP region. A team of GAP officials and scientists visited ICARDA headquarters in April 1998 to observe research/training activities and facilities, followed by a visit of GAP President to ICARDA to discuss collaboration. In June, a team of ICARDA scientists visited GAP Regional Headquarters at Sanliurfa to observe irrigated and rainfed agriculture activities and visit the GAP research station at Koruklu and the Ceylanpinar State Farm. A Memorandum of Understanding (MOU) between GAP-RDA and ICARDA was signed between GAP and ICARDA in June 1998. The MOU calls for collaboration in research, technology transfer, and strengthening human resources for rural and agricultural development in the GAP region.

Human Resource Development. Sixteen researchers from Turkey attended specialized training courses in different research areas, e.g. water resources management, seed health, seed production, and food legume breeding and pathology. Two others pursued their PhD research programs on durum wheat breeding and biotechnology in Turkish universities. Seven scientists were sponsored to attend workshops, conferences and scientific meetings in Central Asia, Niger, Canada, and UK. Visitors to Turkey from other cooperating institutions observed germplasm of ICARDA mandate crops, attended conferences, delivered training, provided consultancy and advice, and conducted collaborative research, disease surveys, or insect collection in Turkey.

A traveling workshop on winter wheat improvement was organized in Uzbekistan, Kyrgyzstan, and Kazakhstan in June 1998, with the participation of 22 scientists from CWANA and 12 from ICARDA, CIMMYT, the World Bank, and the USA. Workshop participants visited laboratories, research plots, and farmers' fields in the three countries; exchanged scientific views and information on breeding, agronomy, and pathology; and discussed strategies and actions for strengthening regional collaboration for the improvement of wheat productivity in the participating countries.

Iran

Iran/ICARDA Collaborative Project. International nurseries of ICARDA-mandated crops were sent to different research centers/institutes in Iran. Three wheat breeding lines were proposed for release in the cold-winter, rainfed areas of the country. The new cultivars possess better resistance to yellow rust and bunt, and have higher than or equivalent grain yield to the widely grown local cultivar 'Sardari.'

Surveys of chickpea and lentil diseases in the drylands of Iran were conducted in the 1997/98 season. Surveys on ascochyta blight and fusarium wilt were conducted in East and West Azerbaijan provinces in 65 and 88 farmers' fields in each region,

respectively. Both diseases need special consideration in breeding programs. The incidence and severity of the diseases were determined and summarized by province or region, as appropriate. Disease-hot spots, especially for fusarium wilt, were identified for use in field screening.

Research on oilseed crops showed good potential for introducing sunflower, safflower, and rapeseed in rainfed areas of Iran. Sunflower cultivars were identified that have good performance in the Gachsaran area, where they could be successfully grown. As in cereals, substantial yield increase of rapeseed was obtained with one irrigation at planting time in the Sararood area.

Human Resource Development. Two in-country training courses were conducted in June: one on seed processing and seed quality, attended by 13 researchers; and another on the application of molecular marker technology, attended by 18 researchers. Long-term training at ICARDA (4 months) was offered to two researchers. Eleven researchers were trained at ICARDA in specialized disciplines. Nine Provincial Directors General of Agriculture visited ICARDA for one week. Fifteen Directors of Production visited ICARDA to get acquainted with new technologies and the mechanisms of their transfer to farmers. One-hundred progressive farmers visited ICARDA to see new production technologies for dry farming. One researcher visited Turkey to select cereal materials. Five Iranian scientists attended international workshops/meetings in Central Asia, Niger, and Canada. ICARDA scientists attended the Iran-ICARDA annual planning meeting at DARI Center in Maragheh, Iran.

Two Iranian researchers completed their PhD thesis research at ICARDA under the supervision of ICARDA scientists. Another four researchers are working for their PhD degree: two in India, one in the UK, and one in Canada. Two researchers completed their MSc studies.

The project helped Iranian researchers in scientific writing of research results; several articles were published in journals/conference proceedings.

Pakistan, Afghanistan, and Morocco

Wheat, barley, chickpea, and barley nurseries were supplied to Pakistan for testing in target areas of the country. A special effort was made to initiate research in the northern highlands of the country. A senior scientist from NARC visited the winter wheat project in Turkey to participate in germplasm selection and to prepare a joint project on cereal improvement for the northern highlands of Pakistan. Two researchers from Pakistan received training at ICARDA on seed health, and experimental station management.

Leaders of the Iranian national program with Syrian farmers and ICARDA colleagues at ICARDA's research farm at Tel Hadya, in Aleppo in a plot where mechanized harvesting of vetch was demonstrated.

Collaboration with Afghanistan continued through Afghan researchers working with FAO, SIDA, and a number of NGOs operating from Peshawar, Pakistan. Nurseries of wheat, barley, chickpea, and lentil were provided. As a result of this collaboration, seven wheat and two barley cultivars were identified for their good performance and their seed was increased and supplied to farmers for cultivation in Afghanistan.

Although cultivars grown in the lower altitudes of the Atlas Mountains in Morocco have been identified, they are generally not well adapted to the higher elevation areas. Therefore, special wheat germplasm has been recently supplied in modest quantity to NARS for testing in high elevation (1800–2300 meters above sea level) sites, where the risk of frost and cold damage is high. Initial results are encouraging and collaboration in this area will be strengthened.

Central Asia and the Caucasus Regional Program

The year was a landmark for ICARDA in its collaboration with NARS in Central Asia and the Caucasus (CAC) region. ICARDA's Regional Office for CAC was formally established in Tashkent, collaborative activities were intensified, and a CGIAR Collaborative Program for Strengthening Agricultural Research in CAC was initiated.

Establishment of ICARDA's Regional Office. ICARDA's Regional Office for the CAC Republics (Kazakhstan, Kyrgyzstan, Tadjikistan, Turkmenistan and Uzbekistan in Central Asia; and Armenia, Azerbaijan and Georgia in the Caucasus) was formally established in Tashkent, Uzbekistan, effective 1 July 1998, and a Regional Coordinator, who in the past was operating from ICARDA's HRP Office in Ankara, was formally appointed. This was done in response to an invitation from the Republic of Uzbekistan. An agreement was signed between Uzbekistan and ICARDA in May 1998.

Strengthening Ongoing Collaborative Activities

During the year, the ongoing ICARDA collaborative activities in CAC were further strengthened in the areas of genetic resources collection, conservation and documentation (in collaboration with IPGRI), sheep and range development (in collaboration with USDA/ARS, Dubois, Idaho, and the GL–CRSP/University of California, Davis), wheat improvement (in collaboration with CIMMYT), and germplasm exchange in barley and food and forage legumes.

Initiation of New Collaborative Activities

New collaborative activities were initiated during the year. These included socioeconomic surveys of rangelands/livestock in three regions of Kazakhstan (in collaboration with GL–CRSP/University of California, Davis, USA). A new regional ACIAR-supported project on collection, evaluation and conservation of cereals and legumes germplasm in CAC was initiated in Uzbekistan with a collection mission jointly organized with the Plant Industry Institute of Uzbekistan and CLIMA of Australia.

ICARDA actively participated in study missions in the region. This included participation of two scientists in the World Bank supported mission in Kyrgyzstan to prepare a final report on the Seed Component of the Agricultural Support Services Project. Also, ICARDA was a partner in a Seed Sector Study in Kazakhstan, which was jointly conducted by COWI of Denmark, the Ministry of Agriculture, and the National Academic Center for Agricultural Research (NACAR) of Kazakhstan.

Workshop and Coordination Meeting

A traveling workshop on winter/facultative wheat was organized in collaboration with CIMMYT and three CAC NARS in June. Scientists from the eight CAC Republics, Iran, Turkey, ICARDA, and CIMMYT participated in the workshop, and visited

the national wheat programs of Uzbekistan, Kyrgyzstan, and Kazakhstan.

The second Regional Coordination Meeting for CAC was organized in collaboration with NACAR in Almaty, Kazakhstan in September. The meeting was attended by 34 scientists from the eight CAC Republics and 11 from ICARDA. During the meeting, the participants discussed results of the 1997/98 collaborative activities and planned collaborative activities for the next cropping season (1998/99).

Initiation of the CGIAR Collaborative Research Program for CAC

Another landmark activity in 1998 for the CAC Republics was the initiation of a research program for Strengthening Collaborative Research for Sustainable Agricultural Development in CAC. The program, initiated by the CGIAR at the request of the eight CAC Republics, aims to contribute to achieving the overall goal of food security, economic growth, environmental sustainability, and poverty alleviation in those Republics. Nine CG Centers (CIMMYT, CIP, ICARDA, ICRISAT, IFPRI, IIMI, ILRI, IPGRI, and ISNAR) participate in this program. The program, formulated on the basis of CAC NARS priorities and approved by the first Steering Committee Meeting held in Tashkent in September, addresses five main themes corresponding to the activities within the CGIAR-approved research agenda: productivity of agricultural systems, natural resource conservation and management, conservation and evaluation of genetic resources, socioeconomic and public policy, and strengthening national programs.

ICARDA serves as a focal point for CGIAR activities in CAC, and program implementation is supported by a Program Facilitation Unit, which is hosted by ICARDA's Regional Office for CAC in Tashkent. A head of the Unit and a visiting scientist were appointed to facilitate activities of this multi-Center program.

Latin America Regional Program

ICARDA's Latin America Regional Program (LARP), based at CIMMYT in Mexico, works on barley improvement and breeding for high yield and multiple disease resistance for areas with higher precipitation than in the WANA region. LARP works closely with the national programs in the region and with advanced research institutions. Barley germplasm developed by the program has been widely accepted by NARS in Latin America and around the world.

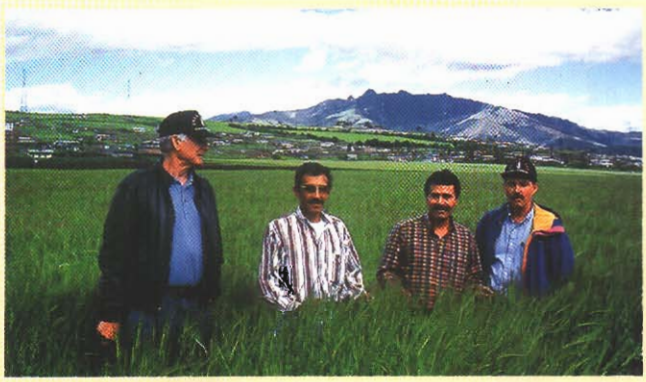
Cooperative Research

BYDV-tolerant lines resulting from four years of screening were sent to Colombia, Ecuador and Tunisia, where the disease is a serious problem. At

CAC NARS and CGIAR representatives who participated in the first CAC Research Program Steering Committee Meeting in Tashkent.

Sta. Catalina Experiment Station in Ecuador, a few entries were tolerant to BYDV with good adaptation to the station's acid soils. Selected lines were sown at the Chuquipata Experiment Station in southern Ecuador for seed increase.

Latin American Barley Network (RECLA). High rainfall creates an optimum environment for the development of diseases that cause yield losses to barley growers. Since 1993, head scab has become more important in Latin America and additional breeding efforts are required to develop fusarium-resistant germplasm. At the second meeting organized by FAO in Chile, participants agreed to continue efforts for transferring head-scab resistance using barley cultivars adapted to Brazil and Uruguay. A doubled-haploid (DH) set of 125 from RECLA was developed by Oregon State University, USA, and sent to Mexico for testing against head scab in the greenhouse, using artificial inoculation. Data on the reaction of the lines to primary infection by the fungus and to its further spread in the spike were recorded in 1998. At the same time, seed of the DH series was increased at El Batan Experimental Station for distribution to barley programs in eight South American countries.



'Atahualpa' hull-less barley field in Ecuador. Left to right: Paul Marko from the World Bank (retired), Fernando Paredes and Dr Oswaldo Chicaiza from INIAP, and Dr Pat Hayes from Oregon State University.

Mexico. In 1998, the first forage barley variety, 'Capuchona,' was released in Mexico, and is rapidly expanding to several Mexican states such as Chihuahua and Aguas Calientes. Ranchers allow animals to graze the barley fields 40 days after planting, since early maturity is the main characteristic of this variety. 'Capuchona' was sown twice by a farmer in the same 4-ha field near Toluca. Early grazing allowed the second planting of the variety in spite of the short growing season that in the past permitted only one crop a year.

In Patzcuaro in the state of Michoacan, a barley line with excellent adaptation to local conditions was identified among 12 scab-resistant lines previously screened at Toluca. A scientist from the Mexican National Research Organization (INIFAP) identified and is increasing seed of a barley line (Arupo/K8755//Mora) with excellent head-scab resistance. The line is being tested for a second year and is showing good adaptation to the area. The same line was previously selected in Chile for its high yield (over 10 t/ha).

Colombia. Hull-less barley lines resistant to PAV, MAV and RPV barley yellow dwarf biotypes were sent from Mexico to a Colombian scientist to be tested for their adaptation to Nariño conditions in southern Colombia. Farmers growing peas on 9,000 ha in the region are looking into hull-less barley as a new crop for rotation with legumes. Colombia is already at the final testing stage of two hull-less barley lines, and soon may join five other Latin American countries that have released hull-less barley varieties. A scientist from Colombia's NARS, CORPOICA, was invited to visit Ecuador to observe large-scale hull-less barley cultivation.

Forty-eight improved pea lines developed by CORPOICA were sent to the National Research Institute (INIAP) of Ecuador for testing. Officials in both countries considered a pea–barley rotation as the most suitable agronomic practice for small farmers to reduce the cost of nitrogen fertilization of the cereal crop.

Ecuador. A mini-workshop was conducted for agronomy students at Loja University, Ecuador. Breeding for disease resistance, hull-less barley breeding, and the use of molecular markers in barley breeding were topics presented at the workshop. After presentations, participants visited the Saraguro barley seed project conducted by INIAP. The main barley variety,

'Shyri,' sown by farmers in the area has been extensively studied at Oregon State University to map resistance genes for six different diseases. Yields obtained by farmers in their fields were almost three times the national average (700 kg/ha), despite heavy rains caused by El Niño.

Average barley yields have remained low in Ecuador for decades. Recently, an approach that aims to achieve yield increases and a rapid adoption of new barley varieties by farmers was implemented by INIAP. A key element of the system was providing farmers with credit in kind, fertilizer, herbicide, and certified seed at the farm gate before the planting season. Harvesting has changed dramatically with the use of stationary threshers leased to farmers by the project, eliminating the traditional and costly harvest operation using draft animals. An additional result observed was the high level of loan repayment during the last four years.

China. Two new barley varieties introduced from ICARDA/CIMMYT barley germplasm were released under the names 'S500' and 'V06' in Yunnan province, a location where these materials show good adaptation.

Funding and Information Exchange

The Antarctica Beer Company Saõ Paolo, Brazil, donated funds to INIAP of Ecuador. The money will be invested in purchasing fertilizer to be used by small farmers growing barley in southern Ecuador. In exchange, Antarctica will receive data on head-scab testing conducted in Mexico and seed of resistant doubled haploids from RECLA.

Since 1995, when project activities were initiated in Ecuador, its operational activities have been financed by small contributions from ICARDA, CIMMYT, two American universities (Oregon and Colorado), and the Antarctica Beer Company. Canada has agreed to finance the project for three years, beginning next year. The scope of the project has been expanded to benefit 2,000 farmers by the end of the century.

Resources for Research and Training

Finance

In 1998, ICARDA's grant revenue from donors amounted to USD 23.944 million (including CGIAR Finance Committee's one-time contribution of USD 1.6 million). Combined with other income of USD 1.241 million, the total revenue for the year was USD 25.185 million. The operating expenses for 1998 were USD 23.570 million, resulting in a surplus of USD 1.615 million (see Appendix 11) and a net positive operating balance of USD 0.605 million as against a negative operating balance of USD 0.808 million in the beginning of the year.

The surplus was the result of programmatic changes in the work plan, prudent financial management of core and non-core expenditure, reduction in the work force, and increase in the other income.

Staff

During 1998, the following internationally-hired P-level staff members joined ICARDA: Dr Michel Chenost, Animal Nutrition Scientist; Dr Faisal Maya, Director of the Office of the Government Liaison; Dr Ian Mccan, Water/Irrigation Management Specialist (Dubai Office); Dr Ahmed T. Mustafa, Protected Agriculture Specialist (Dubai Office); Ms Verity Stiff, Personnel Officer; Dr Adriana Bruggeman, Agricultural Hydrology Specialist; Dr Amor Yahyaoui, Senior Cereal Pathologist; Dr Christoph Studer, Plant Water Soil Specialist; Dr Fawzi Karajeh, Marginal-Quality Water Management Specialist; and Dr Luis Iñiguez, Senior Small-Ruminant Scientist.

The following internationally-hired P-level staff members, already on board, moved to higher positions in 1998 through the normal recruitment process of the Center: Dr William Erskine, Leader, Germplasm Program; Dr Richard Tutwiler, Leader, Natural Resource Management Program; Dr Stefania Grando, Barley Breeder; and Dr Mekhlis Suleimenov, Deputy Head of ICARDA's Regional Office for Central Asia and Caucasus.

Dr Tidiane Ngaido, Property Rights Specialist, and Dr Nabil Chaherli, Policy Economist were seconded to ICARDA from IFPRI.

Dr S.P.S. Beniwal, was transferred from the Highland Regional Program, Turkey to Tashkent as Regional Coordinator, Central Asia and the Caucasus Program (CACRP) and Head of the CGIAR Program Facilitation Unit for CAC; and Mr Nicholas Thomas, GIS Analyst, from the Computer and Biometrics Services to the Natural Resource Management Program.

Four internationally-hired, RA-level staff members also joined during the year: Ms Azusa Fukuki, Research Fellow; Dr Kamel Chabane, Biotechnologist; Dr Heinz P. Wolff, Visiting Scientist (Cairo Office); and Dr Zakir Khalikulov (Tashkent Office) as Consultant.

The following P-level staff members left during 1998: Mr David Martone, Personnel Officer; Dr Michael Jones, Barley Systems Agronomist; Dr Tom Nordblom, Agricultural Economist; Dr Ahmed T. Osman, Pasture Ecologist; Dr Euan Thomson, Consultant; Mr John Noisette, Director of Finance/Administration; and Dr Larry Robertson, Legume Germplasm Curator.

The following RA-level staff members also left during 1998: Mr Gerard van Eeden, Scientific Data Base Senior Analyst Programmer; Ms Christine Kalume, Mr Guy Manners, and Mr Michael Robbins, Science Writers/Editors; Mr Bijan Chakraborty, Scientific Applications Team Leader; Mr Peter Eichhorn, Vehicle Farm Machinery Supervisor; Mr Issam Nagi, Agronomist; Mr Nerses Nersoyan, Research Associate; Mr Alain Mayoux, System Programmer; Mr Faik Bahhady, Consultant; Mr Farouk Jabri, Consultant (Food and General Services); Mr Soren Jorgensen, Junior Professional Officer; Dr Hailu Gebre, Visiting Scientist-Coordinator (Cairo Office); Dr Mustafa Labhilili, Dr Wafa Choumane, Dr Hala Toubia-Rahmeh, and Mr Seid Kemal, Post-Doctoral Fellows; and Mr Sobhi Dozom and Mr Asaad Mousa, Research Associates. Mr Khaldoun Wafaii, Civil Engineer, passed away on 15 May.

The Farms

ICARDA operates four sites in Syria (including its main research station at Tel Hadya, near Aleppo) and

two in Lebanon (Table 9). These sites represent a variety of agroclimatic conditions, typical of those prevailing in the WANA region.

Table 9. ICARDA sites in Syria and Lebanon.

Site	Coordinations		Area (ha)	Approximate elevation (m)	Average precipitation (mm)*
SYRIA					
Tel Hadya	36° 01′ N	36° 56′ E	948	284	410
Bouider	35° 41′ N	37° 10′ E	6	268	279
Breda	35° 56′ N	37° 10′ E	95	300	229
Maragha	35° 33′ N	37° 40′ E	10	370	213
LEBANON					
Terbol	33° 49′ N	35° 59′ E	50	890	526
Kfardane	34° 01′ N	36° 03′ E	50	1080	429

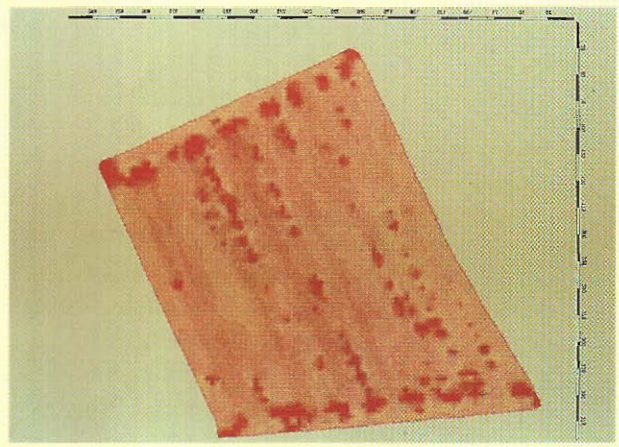
* For the 1997/98 season.

At the Tel Hadya site, rainfall during the 1997/98 season was above average, and cereal and grain legume yields were good.

Grain legume production, as a cover after cereal experiments, looked promising with chemical control of *Orobanche* spp. in lentils. Tests indicated good control with two different herbicides. The results will be confirmed next season.

Replacing legumes in *Orobanche*-infested fields by cumin (*Cumimum cyminum)* proved successful, if planting was done in the second week of February or later. A test planting of cumin in January showed infestation with parasitic weed *Orobanche aegyptiaca.*

The Center received its first combine equipped with a DGPS orientation system and yield monitor, which is mainly used to harvest cover crop cereals and grain legumes. The system will be used to document field homogeneity. It may help in identifying soil- or management- related yield differences. The use of this system will also help in selecting the most uniform fields for such research applications as yield trials. In many cases spatial variation in yield will be documented to increase accuracy of research planning.



Combine-generated yield map of a field showing management-related yield differences in durum wheat cover crop. The yield level is reflected by the level of darkness of the red color—darker the spot, higher the yield. The field was used for lentil seed increase in the previous year (1996/97) with alleyways. The dark red high-yield strips are where the alleyways were in the last season. Therefore, the differences are management influenced.

Appendices

Contents

Appendix 1

Precipitation (mm) in 1997/98

	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL
SYRIA													
Tel Hadya													
1997/98 season	18.1	36.3	37.9	62.3	83.6	37.6	59.3	63.7	11.7	0.0	0.0	0.0	410.5
Long-term average (20 seasons)	2.5	23.5	50.0	52.1	64.4	52.2	48.5	27.9	15.5	2.4	0.0	0.0	339.0
% of long-term average	724	154	161	120	130	72	122	228	75	0.0	10.0	0.0	121
Breda													
1997/98 season	17.8	18.0	10.8	29.4	47.2	17.0	38.6	39.2	9.4	0.0	0.0	0.0	227.4
Long-term average (41 seasons)	2.1	14.8	29.8	39.3	48.8	40.3	34.0	29.3	16.0	0.0	0.0	0.0	264.4
% of long-term average	848	122	36	60	97	42	114	134	59	0.0	0.0	0.0	86
Bouider													
1997/98 season	4.4	30.8	34.4	41.8	57.0	24.4	35.2	34.0	10.8	0.0	6.4	0.0	279.2
Long-term average (25 seasons)	0.7	18.4	27.6	37.2	44.7	37.9	30.4	19.5	9.9	0.0	0.0	0.0	226.3
% of long-term average	629	167	125	112	128	64	116	174	109	0.0		0.0	123
Maragha													
1997/98 season	1.0	10.0	21.6	52.6	48.2	26.2	23.0	27.2	2.8	0.0	0.0	0.0	212.6
LEBANON													
Terbol													
1997/98 season	7.2	7.6	37.8	173.6	120.8	62.2	140.6	19.9	1.4	0.0	0.0	0.0	571.1
Long-term average (18 seasons)	1.9	5.5	22.1	107.1	53.8	90.7	106.8	50.6	11.8	0.0	0.0	0.0	450.3
% of long-term average	379	138	171	162	225	69	132	39	12	0.0	0.0	0.0	126
Kfardan													
1997/98 season	4.2	17.0	24.0	86.2	117.4	60.6	100.1	17.6	6.2	0.0	0.0	0.0	433.3

Note: For area and elevation of these sites, please see Table 9 on page 69.

Appendix 2

Cereal and Legume Varieties Released by National Programs

Barley

Country/year	Variety
Algeria	
1987	Harmal
1992	Badia
1993	Rihane-03
Australia	
1989	Yagan
1991	High
1993	Kaputar, Namoi
Bolivia	
1991	Kantuta
1993	Kolla
1994	San Lorenzo
Brazil	
1989	Acumai
Canada	
1992	Seebe
1993	Falcon
1994	Tukwa
1995	Kasota
Chile	
1989	Leo/Inia/Ccu, Centauro
China	
1988	Zhenmai 1
1989	V-24, Api/CM67//B1, CT-16
1998	S500, V06
Cyprus	
1980	Kantara
1989	Mari/Aths*2
1994	Mia Milia, Achera
1995	Lefkonoiko, Sanokrithi-79, Lysi
Ecuador	
1989	Shyri
1992	Calicuchima-92, Atahualpa-92
Egypt	
1993	Giza 125, Giza 126, Giza 127
1994	Giza 128
Ethiopia	
1973	Beka
1975	IAR/H/485
1979	Holkr
1980	Ardu 12-60B

Barley (contd.)

Country/year	Variety
1985	HB-42
1986	HB-120
1994	Shege
1996	Misratch
1998	Abay
Iran	
1986	Aras
1990	Kavir, Star (Makui)
1996	Ezeh
1997	Sahand (= Tokak), Ganub
Iraq	
1993	Rihane-03
1994	IPA 7, IPA 9, IPA 265
Italy	
1992	Salus, Digersano
Jordan	
1984	Rum
Kenya	
1984	Bima
1993	Ngao
Lebanon	
1989	Rihane-03
1997	Assy, ER/Apm
Libya	
1992	Wadi Kuf, Wadi Gattara
1997	Borjouj, Maknosa, Ariel, Irawen
Mexico	
1986	Mona/Mzq/DL71
1998	Capuchona
Morocco	
1984	Asni, Tamelat, Tissa
1988	Aglou, Arrnal, Tiddas
1991	Laannaceur
1997	Igrane, Safia
Nepal	
1987	Bonus
Pakistan	
1985	Jau-83
1987	Jau-87, Frontier 87
1993	Jau-93
1995	AZRI-95

Barley (contd.)

Country/year	Variety
1996	Soorab-96, Sanober-96
Peru	
1987	Una 87, Nana 87
1989	Buenavista
1994	Una-94
1996	Una-96
Portugal	
1982	Sereia, Enxara, Campones
1983	CE 8302
1990	Ancora
Qatar	
1982	Gulf
1983	Harma
1989	Harma 88
Saudi Arabia	
1985	Gustoe
Spain	
1990	Resana
Syria	
1987	Furat 1113
1991	Furat 2
1994	Arta
Tanzania	
1991	Kibo
Thailand	
1987	Semang 1, Semang 2, BRB-8
Tunisia	
1985	Taj, Faiz, Roho
1987	Rihane-03
1992	Manel 92
Turkey	
1993	Tarm 92, Yesevi
1995	Orza
USA	
n.a.	Poco, Micah
Vietnam	
1989	Api/CM67//B1
Yemen	
1986	Arafat, Beecher

Country/year	Variety
Durum Wheat	
Algeria	
1982	ZB//Fg/Loukos
1984	Timgad
1986	Sahl, Waha
1991	Korifla
1992	Om Rabi 6
1993	Belikh 2, Haider, Kabir 1, Om Rabi 9
Cyprus	
1982	Mesaoria
1984	Karpasia,
1994	Macedonia
Egypt	
1979	Sohag I
1988	Beni Suef, Sohag II
1990	Sohag III
Greece	
1982	Selas
1983	Sapfo
1984	Skiti
1985	Samos, Syros
Iran	
1996	Seimareh = Om Rabi 5,
1997	Korifla
Iraq	
1996	Waha Iraq
1997	Om Rabi 5, Korifla
Jordan	
1988	Maru = Cham 1, Petra = Korifla, Amra = N-432, ACSAD65 = STK
Lebanon	
1987	Belikh 2
1989	Sebou
1993	Waha = Cham 1
Libya	
1985	Baraka, Fazan, Ghuodwa, Marjawi, Qara, Zorda
1991	Zahra 1
1992	Khiar 92
1993	Zahra 3, Zahra 5 = Korifla
1995	Zahra 7, Zahra 9
Morocco	
1984	Marzak
1991	Tensif
1992	Brachoua, Om Rabi 5
1994	Anouar, Jawhar
1997	Telset
Pakistan	
1985	Wadhanak
Portugal	
1983	Celta, Timpanas
1984	Castico
1985	Helvio
n.a.	TE 9204
Saudi Arabia	
1987	Cham 1
Spain	
1983	Mexa
1985	Nuna
1989	Jabato
1991	Anton, Roqueno
Sudan	
1996	Cham 1
1997	Waha
Syria	
1984	Cham 1
1987	Bohouth 5, Cham 3
1993	Om Rabi 3
1994	Cham 5
Tunisia	
1987	Razzak
1993	Khiar, Om Rabi 3
Turkey	
1984	Susf bird
1985	Balcali
1988	EGE 88
1990	Sam 1 = Cham 1
1991	Kiziltan
1994	Aydin, Firat 93
1997	Haran = Omrabi 5
1998	Altin 98, Ankara 98
Bread Wheat	
Algeria	
1982	Setif 82, HD 1220
1989	Zidane 89
1992	Nesser = Cham 6, Sidi Okba = Cham 4, Rhumel = Siete Cerros, Alondra = 21AD, Soummam = DouggaXBJ, ACSAD 59 = 40DNA
1994	Mimouni, Ain Abid
Egypt	
1982	Giza 160
1988	Giza 162, Giza 163, Giza 164, Sakha 92
1991	Gammeiza 1, Giza 165
1993	Sahel 1
1994	Sids 1, Sids 2, Sids 3, Giza 166, Giza 167, Benesuef-3
1995	Sids 4, Sids 5, Sids 6, Sids 7, Sids 8
Greece	
1983	Louros, Pinios, Arachthos
Iran	
1986	Golestan, Azadi
1988	Darab, Sabalan, Quds
1990	Falat
1995	Tajan, Mahdabi, Darab 2
1996	Gaher, Zagross, Nicknejad
1997	Alrand, Atrak, Alement, Chamran, Zareen
1998	Azar 2
Iraq	
1989	Es14
1994	Hamra, Adnanya, Abu Ghraib
1998	Vee 'S'
Italy	
1996	Sibilla
Jordan	
1988	Nasma = Jubeiha, L88 = Rabba, Petra, Cham 1
1990	Nesser
Lebanon	
1990	Seri
1991	Nesser = Cham 6
1998	Towpe
Libya	
1985	Zellaf, Sheba, Gerina

Country/year	Variety
Bread Wheat (contd.)	
Morocco	
1984	Jouda, Merchouch
1989	Saba, Kanz
1996	Massira
1998	Aguilal, Arrihane
Oman	
1987	Wadi Quriyat 151, Wadi Quriyat 160
Pakistan	
1986	Sutlej 86
1996	Azri-96, Sariab-96
Portugal	
1986	LIZ 1, LIZ 2
Qatar	
1988	Doha 88
Sudan	
1982	Debeira
1987	Wadi El Neel
1990	El Neilain
1992	Sasaraib
1996	Nessr
Syria	
1984	Cham 2, Bohouth 2
1986	Cham 4
1987	Bohouth 4
1991	Cham 6, Bohouth 6
Tunisia	
1983	T-DUMA-D6811-INRAT
1987	Byrsa, Salambo
1992	Vaga 92
1996	Tebica 96, Utique
Turkey	
1979	Gerek 79
1985	Atay 85
1986	Dogankent-1 (Cham 4)
1988	Kaklic 88, Kop, Dogu 88, Genç-88
1989	Es14
1990	Yuregir, Karasu 90, Katia 1
1991	Gun 91
1994	Dagdas 94, Kutluk 94
1995	Sultan 95, Kasifbey 95, Basribey 95 F//68.44NZT/3/CUC'5'
1996	Ikizce 96, Pehlivan 96

Country/year	Variety
Bread Wheat (contd.)	
1997	Kinaci 97, Palandoken 96, Suzen 97
1998	Aytin 98, Mizrak 98, Turkmen 98, Uzunyayla 98, Yildiz 98
1999	Genç-99
UAE	
1995	Cham 2, Seyhan 95, Kirgiz 95
Yemen	
1981	Ahgaf
1983	Marib 1
1988	Mukhtar, Aziz, Dhumran
1992	Alswiri
1995	Radfan
1998	Seiyun
Kabuli Chickpea	
Algeria	
1988	ILC 482, ILC 3279
1991	FLIP 84-79C, FLIP 84-92C
China	
1988	ILC 202, ILC 411
1993	FLIP 81-71C, FLIP 81-40WC
1996	ILC 3279
Cyprus	
1984	Yialousa
1987	Kyrenia
Egypt	
1994	Giza 88
1995	Line 95
1999	Giza 3
France	
1988	TS1009, STS1502
1992	Roye Rene
India	
1996	Pant G88-6
Iran	
1995	ILC 482, ILC 3279, FLIP 84-48C
Iraq	
1991	Rafidain, Dijla

Country/year	Variety
Kabuli Chickpea (contd.)	
Italy	
1987	Califfo, Sultano
1995	Pascia, Otello
Jordan	
1990	Jubeiha 2, Jubeiha 3
Lebanon	
1989	Janta 2
1993	Baleela
1998	Al-Wady
Libya	
1993	ILC 484
Morocco	
1987	ILC 195, ILC 482
1992	Rizki, Douyet
1995	Farihane, Moubarak, Zahor
Oman	
1988	ILC 237
1995	FLIP 87-45C, FLIP 89-130C
Pakistan	
1992	Noor 91
Portugal	
1992	Elmo, Elvar
1998	Elite
Spain	
1985	Fardan, Zegri, Almena, Alcazaba, Atalaya
1995	Athenas, Bagda, Kairo
Sudan	
1987	Shendi
1994	Jebel Marra-1
1996	Atmor
1998	Salawa, Wad Hamid, Matama-1
Syria	
1986	Ghab 1, Ghab 2
1991	Ghab 3
Tunisia	
1986	Amdoun 1
1987	Chetoui, Kassab,
1991	FLIP 84-79C, FLIP 84-92C
Turkey	
1986	ILC 195, Guney Sarisi 482

Country/year	Variety
Kabuli Chickpea (contd.)	
1991	Akcin
1992	Aydin 92, Menemen 92, Izmir 92
1994	Damla, Aziziye
1997	Gokce
USA	
1994	Dwelley, Sanford
Lentil	
Algeria	
1987	Syrie 229
1988	Balkan 755, ILL 4400
Argentina	
1991	Arbolito
Australia	
1989	Aldinga
1993	Digger, Cobber, Matilda
1995	Northfield
1998	Cumra, Cassab
Bangladesh	
1993	Barimasur-2
1995	Barimasur-4
Canada	
1989	Indian head
1994	CDC Redwing, CDC Matador
Chile	
1989	Centincla
China	
1988	FLIP 87-53L
1998	C 87
Ecuador	
1987	INIAP-406
Egypt	
1990	Precoz
1998	Giza 370, Giza 4, Giza 51, Sinai 1
Ethiopia	
1980	R 186
1984	Chalew, Chikol
1993	FLIP 84-7L
1995	Gudo, Ada'a

Country/year	Variety
Lentil (contd.)	
Iran	
1999	ILL 6212
Iraq	
1994	Baraka
Jordan	
1990	Jordan 3
Lebanon	
1988	Talya 2
1995	Toula
Lesotho	
1998	FLIP 87-21L, FLIP 84-78 L
Libya	
1993	El Safsaf 3
Morocco	
1990	Bakria (Precoz)
Nepal	
1989	Sikhar
New Zealand	
1992	Rajah
Pakistan	
1990	Manserha 89
1995	Masur 95
1996	Shiraz-96
Portugal	
1999	Beleza, Cinderela
Sudan	
1993	Rubatab 1 (ILL 813), Aribo 1
1998	Nedi
Syria	
1987	Idleb 1
Tunisia	
1987	Neir, Nefza
Turkey	
1987	Firat 87
1990	Erzurum 89, Malazgirt 89
1991	Sazak 91
1996	Sayran 96

Country/year	Variety
Lentil (contd.)	
USA	
1991	Crimson
Faba Bean	
Egypt	
1994	Giza Blanca
1995	Giza 429, Giza 461, Giza 643, Giza 674, Giza 714, Giza 716, Giza 717
1997	Giza 2, Giza 3,
1998	Giza 40, Giza 843
Iran	
1986	Barkat
Portugal	
1992	Favel
Sudan	
1990	Sellaim-ML
1991	Shambat 75, Shambat 104
1993	Shambat 616, Basabeer, Hudeiba 93
Syria	
1991	Hama 1
Peas	
Cyprus	
1994	Kontemenos
Ethiopia	
1994	061K-2P-2192
Lesotho	
1997	Local Sel 1690, Mg 102469, Syrian Aleppo
Oman	
1995	Collegian Dry Pea, MG 102703 Dry Pea, A 0149 Dry Pea, Syrian Local Dry Pea
Sudan	
1989	Krema-1
1994	Ballet

Country/year	Variety
Forage Legumes	
Australia	
1998	*Lathyrus cicera* Chalus
Cyprus	
1998	*V. narbonensis* acc. 568
Jordan	
1994	*Vicia sativa* IFLVS - 715, *L. ochrus* IFLLO-185,
Forage Legumes (contd.)	
	V. villosa ssp. *dasycarpa* IFLVD 683
Lebanon	
1997	*V. sativa* Baraka, *V. ervillia* Amara, *L. cicera* Jaboulah
Morocco	
1990	*V. sativa* ILFVS-1812
1992	*V. villosa* ssp. *dasycarpa* IVLVD-2053
1994	*V. narbonensis* IFLVN-2387, *V. narbonensis* IFLVN-2391, *V. sativa* IFLVS-709
Pakistan	
1997	*V. villosa* ssp. *dasycarpa* Kuhak-96

Appendix 3

Publications

The following list covers, as of the time of going to press, journal articles published by ICARDA researchers—many of them in collaboration with colleagues from national programs. A complete list of publications, including book chapters and papers published in conference proceedings, is published separately and is available on request from ICARDA.

Journal Articles

Serret, M.D., S.M. Udupa and F. Weigand. 1997. Assessment of genetic diversity of cultivated chickpea using microsatellite-derived RFLP markers: implications for origin. Plant Breeding 116: 573–578.

Al Hakimi, A., P. Monneveux and M.M. Nachit. 1998. Direct and indirect selection for drought tolerance in alien tetraploid wheat × durum wheat crosses. Euphytica 100: 287–294.

Araus, J.L., T. Amaro, J. Casadesus, A. Asbati and M.M. Nachit. 1998. Relationships between ash content, carbon isotope discrimination and yield in durum wheat. Australian Journal of Plant Physiology 25: 835–842.

Araus, J.L., T. Amaro, J. Voltas, H. Nakkoul and M.M. Nachit. 1998. Chlorophyll fluorescence as a selection criterion for grain yield in durum wheat under Mediterranean conditions. Field Crops Research 55: 209–223.

Bayaa, B., S.G. Kumari, A. Akkaya, W. Erskine, K.M. Makkouk, Z. Turk and I. Ozberk. 1998. Survey of major biotic stresses of lentil in South-East Anatolia, Turkey. Phytopathologia Mediterranea 37: 88–95.

Bort, J., J.L. Araus, H. Hazzam, S. Grando and S. Ceccarelli. 1998. Relationships between early vigour, grain yield, leaf structure and stable isotope composition in field grown barley. Plant Physiology and Biochemistry 36(12): 889–897.

Ceccarelli, S., S. Grando and A. Impiglia. 1998. Choice of selection strategy in breeding barley for stress environments. Euphytica 103: 307–318.

El-Beltagy, A. and A. Rodriguez. 1998. The agro-alimentary systems in the middle eastern countries. Economia Agro-Alimentare 3(2): 53–64.

El-Bouhssini, M., O. Benlhabib, M.M. Nachit, A. Houari, A. Bentika, N. Nsarellah and S. Lhaloui. 1998. Identification in *Aegilops* species of resistant sources to Hessian fly (Diptera: Cecidomyiidae) in Morocco. Genetic Resources and Crop Evolution 45: 343–345.

El-Bouhssini, M., J.H. Hatchett and G.E. Wilde. 1998. Survival of Hessian fly (Diptera: Cecidomyiidae) larvae on wheat cultivars carrying different genes for antibiosis. Journal of Agricultural Entomology 15(3): 183–193.

El-Bouhssini, M., S. Lhaloui, J.H. Hatchett and N. Naber. 1997. Nouveaux gènes de resistance efficaces contre la mouche de Hesse (Diptere: Cecidomyiidae) au Maroc [New genes for resistance to Hessian fly (Diptera: Cecidomyiidae) in Morocco. Al Awamia 96: 55–63.

Erskine, W., S. Chandra, M. Chaudhry, I.A. Malik, A. Sarker, B. Sharma, M. Tufail and M.C. Tyagi. 1998. A bottleneck in lentil: widening the genetic base in South Asia. Euphytica 101: 207–211.

Eujayl, I., M. Baum, W. Powell, W. Erskine and E. Pehu. 1998. A genetic linkage map of lentil (*Lens* sp.) based on RAPD and AFLP markers using recombinant inbred lines. Theoretical and Applied Genetics 97: 83–89.

Eujayl, I., W. Erskine, B. Bayaa, M. Baum and E. Pehu. 1998. Fusarium vascular wilt in lentil: inheritance and identification of DNA markers for resistance. Plant Breeding 117: 497–499.

Ferguson, M.E., B.V. Ford-Lloyd, L.D. Robertson, N. Maxted and H.J. Newbury. 1998. Mapping the geographical distribution of genetic variation in the genus *Lens* for the enhanced conservation of plant genetic diversity. Molecular Ecology 7: 1743–1755.

Ferguson, M.E., H.J. Newbury, N. Maxted, B.V. Ford-Lloyd and L.D. Robertson. 1998. Population genetic structure of *Lens* taxa revealed by isozyme and RAPD analysis. Genetic Resources and Crop Evolution 45: 549–559.

Ferguson, M.E., L.D. Robertson, B.V. Ford-Lloyd, H.J. Newbury, N. Maxted. 1998. Contrasting genetic variation amongst lentil landraces from different geographical origins. Euphytica 102: 265–273.

Franz, A., K.M. Makkouk and H.J. Vetten. 1998. Acquisition, retention and transmission of faba bean necrotic yellows virus by two of its aphid vectors, *Aphis craccivora* (Koch) and *Acyrthosiphon pisum* (Harris). Journal of Phytopathology 146: 347–355.

Garabet, S., J. Ryan and M. Wood. 1998. Nitrogen and water effects on wheat yield in a Mediterranean-type climate. II. Fertilizer-use efficiency with labelled nitrogen. Field Crops Research 58: 213–221.

Goodchild, A.V., F.J. El Haramein, A. Abd El Moneim, H.P.S. Makkar and P.C. Williams. 1998. Prediction of phenolics and tannins in forage legumes by near infrared reflectance. Journal of Near Infrared Spectroscopy 6: 175–181.

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Appendix 4

Graduate Theses Produced with ICARDA's Assistance

Master's

1997

AU The University of Western Australia

Fahim Ghassali (SY). Rehabilitation of degraded Mediterranean grasslands under on-farm conditions in north Syria. 121 pp.

1998

FR Université de Nantes

François Delaroque (FR). Elaboration d'un système d'information géographique comme outil d'aide au développement des parcours de la région de Marsa Matrouh, côte nord ouest de l'Egypte [Use of a geographical information system to identify potentialities of range improvement in the Wadi Tips: region of Marsa Matrouh, northwest coast of Egypt]. 129 pp. (In French).

LB Lebanese University

George Frayfer (LB). Movement of the wilt pathogen *Fusarium oxysporum* f.sp. *Lentis* in different lentil genotypes and a preliminary study on its biological control. 77 pp. Graduation project in partial fulfillment of requirements for the Diploma of Agricultural Engineer.

SY University of Aleppo

Said El-Hassan (SY). Biological control of lentil wilt in Syria. 109 pp. (In Arabic, English summary.)

George Ghandour (SY). Study of relative efficiency of different chickpea genotypes for drought tolerance. 235 pp. (In Arabic, English summary.)

TR University of Cukurova

Mohamed Izzat Ghannoum (SY). Sources of resistance in durum wheat (*Triticum durum*) and its wild relatives *Aegilops* spp. to Russian wheat aphid [(*Diuraphis noxia* (Mordvilko) (Homoptera: Aphididae)] and use of random amplified polymorphic DNA (RAPD) analysis to detect genetic variability in RWA. 73 pp.

Doctoral

1998

TR University of Cukurova

Mustafa Darwich (SY). Economics of crop/livestock systems in the Abdul Aziz mountain area of Hassakeh province, northeast Syria. (in Turkish). 136 pp.

FI University of Helsinki

Imad Ahmad Mahmoud Eujayl (SD). Use of DNA markers for genetic linkage mapping and analysis of biotic and abiotic stresses in lentil. 55 pp.

GB University of Birmingham

Morag E. Ferguson (GB). Studies of genetic variation within the genus *Lens*. 200 pp.

* Country codes:
AU, Australia; FI, Finland; GB, England; LB, Lebanon; SY, Syria; TR, Turkey

Appendix 5

Agreements

Agreements of Cooperation with International Organizations in 1998

CIHEAM/IAM Bari (Centre International de Hautes Études Agronomiques Méditerranéennes/ Institut Agronomique Méditerranéen de Bari)

18 February 1998. Memorandum of Understanding between Centre International de Hautes Études Agronomiques Méditerranéennes/Institut Agronomique Méditerranéen de Bari (CIHEAM/IAM Bari) and ICARDA.

IAEA (International Atomic Energy Agency)

9 January 1998. Memorandum of Understanding between the International Atomic Energy Agency (IAEA) (based in Vienna, Austria) and ICARDA.

16 April 1998. Agreement between the International Atomic Energy Agency (IAEA) (based in Vienna, Austria) and ICARDA.

IFPRI (Internationl Food Policy Research Institute)

1 December 1998. Memorandum of Understanding between the International Food Policy Research Institute (IFPRI) (based in USA) and ICARDA.

ILRI (International Livestock Research Institute)

7 March 1998. Memorandum of Understanding between the International Livestock Research Institute (ILRI) (based in Nairobi, Kenya) and ICARDA.

IPGRI (International Plant Genetic Resources Institute)

25 June 1998. Memorandum of Understanding between the International Plant Genetic Resources Institute (IPGRI) (based in Rome, Italy) and ICARDA.

Agreements of Cooperation with National Governments and Institutions in 1998

BANGLADESH

25 October 1998. Memorandum of Understanding between the Bangladesh Agricultural Research Institute (BARI) and ICARDA.

CYPRUS

30 October 1998. Agreement between the Agricultural Research Institute (ARI), Cyprus, and ICARDA.

IRAN

10 May 1998. Agreement of Cooperation between the Faculty of Agriculture, Ferdowsi University of Mashhad, Islamic Republic of Iran, and ICARDA.

PAKISTAN

22 June 1998. Memorandum of Understanding between ICARDA and the University of Arid Agriculture, Rawalpindi (UAAR).

TURKEY

26 June 1998. Memorandum of Understanding between the Southeastern Anatolia Project Regional Development Administration (GAP-RDA), Turkey, and ICARDA.

UZBEKISTAN

8 May 1998. Agreement between the Government of the Republic of Uzbekistan and ICARDA.

Appendix 6

Restricted Projects

ICARDA's research program is implemented through 19 research projects, as detailed in the Center's Medium-Term Plan. Restricted Projects are those activities that are supported by restricted funding that is provided separately from the Center's unrestricted core budget. Restricted funding includes restricted core funding, donor directed core funding (core funds directed by the donor to specific activities) and project specific grants. The financial contributions by the respective donors are reported in Appendix 11. The reports on the activities listed are encompassed in the appropriate sections of the body of this Annual Report. During 1998, the following Restricted Projects were operational.

AUSTRALIA

ACIAR (Australian Centre for International Agricultural Research)

Improvement of drought and disease resistance in lentils in Nepal, Pakistan and Australia

Improvement of faba beans in China and Australia through germplasm evaluation, exchange and utilization

Near isogenic lines for the assessment of pathogenic variation in the wheat stripe (yellow) rust pathogen

Pulse transformation technology transfer

Improvement of lentil and grasspea in Bangladesh

Development and conservation of plant genetic resources from the Central Asian Republics and associated regions

Development and use of molecular markers for enhancing the feeding value of cereal crop residues for ruminants

GRDC (Grains Research and Development Corporation)

Faba bean germplasm multiplication

International durum wheat improvement cooperation

Preservation and utilization of the unique pulse and cereal genetic resources of the Vavilov Institute

International selection, introduction and fast tracking of kabuli chickpea with large seed size, high biomass, yield and Ascochyta resistance

AFESD (Arab Fund for Economic and Social Development)

Technical assistance to ICARDA's activities in Arab countries (Postgraduate Research Training and Visiting Scientist Program)

Development of integrated crop/livestock production systems in low rainfall areas of the Mashreq and Maghreb regions - Phase II

Arabian Peninsula Regional Program - Phase II

Development of biotechnological research in the Arab States

CANADA

IDRC (International Development Research Centre)

Scientific support to dryland resource management research in the highlands of Yemen

Water harvesting (Jordan)

Integrated watershed development (Syria)

Farmer participation in barley breeding - North Africa

Supplemental irrigation with brackish water in Syria

Community-level impacts of policy, property right and technical options in the low rainfall areas of Morocco, Tunisia and Syria

Dryland Pasture, Forage and Range Network Newsletter

CGIAR Systemwide Programs

CGIAR Collaborative Program for Central Asia and the Caucasus

Program Facilitation Unit

Germplasm conservation, adaptation and enhancement for diversification and intensification of agricultural production in Central Asia and the Caucasus

On-farm soil and water management for sustainable agricultural systems in Central Asia and the Caucasus

Systemwide Genetic Resources Program (SGRP)

Supporting national plant genetic resource programs in Central Asia

Development of a discussion paper on the N-fixing organism collections held in CGIAR Centers

Management and characterization of animal genetic resources in WANA: Development of a regional research program

Systemwide Livestock Program (SLP)

Production and utilization of multi-purpose fodder shrubs and trees in West Asia, North Africa and the Sahel

Systemwide Water Resources Management Programme (SWIM)

On-farm water use

Systemwide Program on Soil Water and Nutrient Management (SWNM)

Optimizing soil water use

EC (European Commission)

Nile Valley Regional Program - Egypt Phase II

Nile Valley Regional Program Wild Oats Project - Egypt. Wild oats control in cereals and other winter crops

Analyzed climatology of rainfall obtained from satellite and surface data for the Mediterranean basin. A version for the Eastern Mediterranean region

EC donor directed core funding: CGIAR undertakings in Protecting the Environment, Biodiversity and Information Dissemination.

EGYPT

Matrouh Resource Management Project

ESCWA (United Nations Economic and Social Commission for West Asia)

Water use in agriculture

FAO (Food and Agriculture Organization of the United Nations)

Analytical review of NARS in West Asia and North Africa

Regional cooperation programme on protected agriculture in the Arabian Peninsula

Publication of proceedings "The Origins of Agriculture and Crop Domestication"

Dryland Pasture, Forage and Range Newsletter

FORD FOUNDATION

Support to gender analysis in the agricultural systems of WANA

GERMANY

DNA marker assisted breeding and genetic engineering of ICARDA mandated crops

QTL analysis by molecular markers of agronomically important characters of barley for dryland conditions

Integrated disease management in cereal and legume based cropping systems of the West Asia and North Africa region

Farmer participation and use of local knowledge in breeding barley for specific adaptation

IFAD (International Fund for Agricultural Development)

Development of integrated crop/livestock production systems in low rainfall areas of the Mashreq and Maghreb regions - Phase II

West Asia and North Africa dryland durum wheat improvement network

Arabian Peninsula Regional Program - Phase II

Technical backstopping support programme to ongoing IFAD-financed projects in the Near East and North Africa

IMPHOS (Institut Mondial du Phosphate)

Phosphorus fertilizer use efficiency for increased crop production in West Asia and North Africa

IRAN

ICARDA/Iran scientific and technical cooperation

ITALY (Donor-Directed Core Funding)

Durum wheat germplasm improvement for increased productivity, yield stability and grain quality in West Asia and North Africa

Barley germplasm improvement for increased productivity

Food legume germplasm improvement for increased systems productivity: chickpea improvement

JAPAN (Donor-Directed Core Funding)

Rehabilitation and improved management of native pastures and rangelands in dry areas

Improvement of small ruminant production in dry areas

NETHERLANDS

Strengthening research and transfer of technology for sustained barley production in Ethiopia

Strengthening client-oriented research and technology dissemination for sustainable production of cool-season food and forage legumes in Ethiopia

Problem-solving regional networks involving cool-season food legumes and cereals in the Nile Valley countries and Yemen

Training in seed technology

NORWAY (through United Nations Environment Programme)

Wind erosion in Africa and Western Asia - Problems and control strategies

OPEC Fund for International Development

Devolution of barley breeding to farmers in North Africa

SPAIN

Incorporating resistance to drought and upgrading the grain quality in durum wheat for Ibero-Maghreb region

Race identification of *Fusarium oxysporum* f.sp. *ciceri* in chickpea in the Mediterranean region

Exchange of fodder, pasture and range plant germplasm

Stabilization of marginal steeplands in northwest Syria

SWITZERLAND

Arid margins of Syria

Sustainable management of the agro-pastoral resource base in the Oujda Region (Morocco)

UNDP (United Nations Development Programme)

Technical assistance to agricultural investment in the Southern Region - Phase II

Yemen: Sustainable environment management

UNITED KINGDOM (Donor-Directed Core Funding)

Integrated pest management in cereal- and legume-based cropping systems in dry areas

Agronomic management of cropping systems for sustainable production in dry areas

Land management and soil conservation to sustain the agricultural productive capacity of dry areas

UNITED STATES OF AMERICA

USAID (United States Agency for International Development)

GL-CRSP (Global Livestock Collaborative Research Support Program) Assessment Team: GIS modelling tools to predict regional trends of rangeland production in Central Asia

Adaptation of barley to drought and temperature stress using molecular markers

Inheritance and mapping of winter hardiness genes in lentil

Use of entomopathogenic fungi for the control of Sunn pest

Feasibility study of use of remote sensing and image analysis for land use mapping and evaluation

Simulation of phosphorus dynamics in the soil–plant system

Nutrition, food systems and poverty

USAID Agricultural Technology Utilization and Transfer Project (ATUT)

Leveraging an integrated expert system/crop modelling for farm level wheat crop management

Application of molecular genetics for development of durum wheat varieties possessing high yield potential, rust resistance, stress tolerance, and improved grain quality

Development of high yielding, long spike bread wheat cultivars possessing high tiller number, rust resistance and heat tolerance facilitated by microsatellite DNA markers

USDA/ARS (United States Department of Agriculture, Agricultural Research Service)

Central Asian range and sheep evaluation

WORLD BANK

Genetic transformation of barley for improved stress resistance at the All-Russian Research Institute of Agricultural Biotechnology

REPUBLIC OF YEMEN

Agriculture Sector Management Support Project (ASMSP), Yemen

Appendix 7

Collaboration in Advanced Research

The following are ICARDA's collaborative activities with advanced research institutions regardless of funding source.

International Centers and Agencies

ACSAD (Arab Center for the Studies of Arid Zones and Dry Lands)
- Joint workshops, conferences and training.
- Exchange of germplasm.
- ICARDA provides ACSAD with plant pathology back-stopping.
- ACSAD is participating in the ICARDA/CIMMYT Durum Wheat Network for WANA.
- Cooperation between ICARDA, ACSAD and AOAD in developing a joint research program proposal on on-farm water management.
- Cooperation with ACSAD in formulation of research programs for the UN Convention to Combat Desertification (CCD) Sub-Regional Action Program on Combatting Desertification and Drought in Western Asia.

CIAT (Centro Internacional de Agricultura Tropical)
- ICARDA is participating in the Systemwide Program on Soil Water and Nutrient Management and in the Systemwide Program on Participatory Research and Gender Analysis for Technology Development, both coordinated by CIAT.
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database.
- Cooperation in joint project on development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants.

CIHEAM (International Center for Advanced Mediterranean Agronomic Studies)
- Joint training courses and information exchange.
- Collaboration in an analytical review of NARS in WANA.
- Study of the tolerance of ICARDA mandate crops to salinity at CIHEAM-Bari.

CIMMYT (International Center for the Improvement of Maize and Wheat)
- CIMMYT/ICARDA Joint Dryland Wheat Program.
- CIMMYT has seconded two wheat breeders to ICARDA.
- ICARDA has seconded a barley breeder to CIMMYT.
- CIMMYT's outreach program in Turkey and ICARDA's Highland Regional Program share facilities in Ankara, Turkey, and collaborate in a joint facultative and winter wheat improvement program.
- ICARDA and CIMMYT jointly coordinate a durum wheat research network encompassing WANA and southern Europe.

FAO (Food and Agriculture Organization of the United Nations)
- ICARDA participates in the Inter-agency Task Forces convened by the FAO-RNE (FAO Regional Office for the Near East).
- ICARDA and FAO are co-sponsors of AARINENA.
- ICARDA participates in FAO's AGLINET cooperative library network, AGRIS and CARIS.
- ICARDA participated in the Regional Workshop for Training Near East National Coordinators in Management of Animal Genetic Resources.
- Collaboration in an analytical review of NARS in WANA.
- ICARDA and FAO-RNE conduct research and training on water policy.
- Joint training courses and exchange of information.

IAEA (International Atomic Energy Agency)
- Management of nutrients and water in rainfed arid and semi-arid areas for increasing crop production.

ICLARM (International Center for Living Aquatic Resources Management)
- ICARDA and ICLARM share offices in Cairo.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)
- ICARDA and ICRISAT cooperate in a joint kabuli chick-pea improvement program.
- ICARDA and ICRISAT maintain the Global Grain Legume Drought Research Network.
- ICARDA and ICRISAT are co-convenors of the theme "Optimizing Soil Water Use within the Systemwide Program on Soil Water and Nutrient Management."
- ICARDA is collaborating with ICRISAT on insect pests of grain legumes within the Systemwide Program on Integrated Pest Management.
- Cooperative task force on wind erosion in Africa and Western Asia.

IFPRI (International Food Policy Research Institute)
- ICARDA collaborates with IFPRI in the Systemwide Program on Property Rights and Collective Action.
- Collaboration in policy and property rights research in WANA: ICARDA hosts two joint ICARDA/IFPRI appointed Research Fellows.

IITA (International Institute of Tropical Agriculture)
- ICARDA is collaborating with IITA on parasitic weeds within the Systemwide Program on Integrated Pest Management.
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database

ILRI (International Livestock Research Institute)
- ICARDA is the convening center, in collaboration with ILRI and ICRISAT, for a program on Production and Utilization of Multi-purpose Fodder Shrubs and Trees in West Asia, North Africa and the Sahel, as part of the Systemwide Livestock Program on Feed Resources Production and Utilization, coordinated by ILRI.
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database.
- Cooperation in joint project on development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants.
- ICARDA and ILRI initiated efforts to start cooperative work on small ruminant health.

IPGRI (International Plant Genetic Resources Institute)
- ICARDA hosts and services the IPGRI Office for West Asia and North Africa.
- ICARDA participates with other CG Centers in the Systemwide Genetic Resources Program, coordinated by IPGRI.

IRRI (International Rice Research Institute)
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database.

ISNAR (International Service for National Agricultural Research)
- ICARDA and ISNAR cooperate in research management for NARS in WANA.

IWMI (International Water Management Institute)
- ICARDA is the convening center for a project on Efficient Use of Water in Agriculture within the Systemwide Water Resources Management Program coordinated by IWMI.

UNEP (United Nations Environment Programme)
- Cooperative Task Force on Wind Erosion in Africa and West Asia.

WMO (World Meteorological Organization)
- Cooperative Task Force on Wind Erosion in Africa and West Asia.

AUSTRALIA

Australian Winter Cereals Collection, Tamworth
- Development and conservation of plant genetic resources in the Central Asian Republics.

Australian Temperate Field Crops Collection, Horsham
- Development and conservation of plant genetic resources in the Central Asian Republics.

University of Adelaide, CRC for Molecular Plant Breeding, Waite Campus
- International collaboration in barley research.

Charles Sturt University, NSW
- Soil physical characteristics in relation to infiltration and surface evaporation under conventional and no-till operations.

CLIMA (Centre for Legumes in Mediterranean Agriculture)
- Improvement of drought and disease resistance in lentils from the Indian subcontinent.
- Improvement of lentil and grasspea in Bangladesh.
- Faba bean germplasm multiplication.
- Germplasm testing and assessment of anti-nutritional factors: *Lathyrus* spp. and *Vicia* spp.
- International selection, introduction and fast tracking of kabuli chickpea.
- Development and conservation of plant genetic resources in the Central Asian Republics.
- Preservation of the pulse and cereal genetic resources of the Vavilov Institute.
- Pulse transformation technology transfer.

La Trobe University
- Development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants.

NSW Agriculture, Agricultural Research Centre
- Durum wheat improvement.
- Improvement of faba beans in China.
- Selection of legume germplasm for virus disease resistance.

Plant Breeding Institute, University of Sydney
- Near-isogenic lines for the assessment of pathogenic variation in the wheat stripe (yellow) rust pathogen.

University of Western Australia
- Whole-farm modelling of pasture, cereals and livestock (with CLIMA).
- Collection, evaluation and ecology of subterranean vetch (*Vicia sativa* ssp. *amphicarpa*).

Victorian Institute for Dryland Agriculture
- Improvement of drought and disease resistance in lentils from the Indian subcontinent.
- Improvement of lentil and grasspea in Bangladesh.

AUSTRIA

Federal Institute for Agrobiology, Linz
- Safety duplication of ICARDA's legume germplasm collection.

BELGIUM

University of Ghent
- Assessment of *Vicia sativa* and *Lathyrus sativus* for neurotoxin content.

University of Leuven
- Participatory agroecological characterization.

CANADA

Canadian Grain Commission, Winnipeg
- Development of techniques for evaluating the quality of barley, durum wheat, and food legumes.

Concordia University, Montreal, and University of Moncton
- Development of an optimization model for water harvesting in Jordan.

University of Guelph, School of Rural Development and Planning
- Gender and property rights.

McGill University
- Collaborative project on the use of brackish water in supplemental irrigation in Syria.

University of Saskatchewan, Saskatoon
- Information services on lentil, including publication of *LENS Newsletter*.
- Evaluation of chickpea germplasm and their wild relatives.

DENMARK

Royal Veterinary and Agricultural University, Copenhagen
- Diversity in barley landraces.

Risoe National Laboratory, Plant Biology Biogeochemistry Department
- Use of DNA markers in selection for disease resistance genes in barley.

FRANCE

Institut National de la Recherche Agronomique (INRA)
- Association of molecular markers with morphophysiological traits associated with constraints of Mediterranean dryland conditions in durum wheat (with École Nationale Supérieure d'Agronomie (ENSA), Montpellier, and ENSA-INRA, Le Rheu).
- Studies on genetic markers in blood and milk of Syrian goats (Laboratoire de Génétique Biochimique et de Cytogénétique, INRA, Joy en Josas).
- Water balance studies in cereal–legume rotations in semiarid Mediterranean zone (with Bioclimatology Research Unit of INRA, Thiverval-Grigon).

Institut Francais de Recherche Scientifique pour le Développement en Coopération (ORSTOM)
- Cooperation in the establishment of a network on water information.

Maison de l'Orient Méditerranéen, Université Lyon
- History of agricultural and pastoral production systems and the management of agricultural and pastoral resources in the Middle East and North Africa.

Université Paris-Sud, Labo Morphogénèse Végétale Experimentale
- Production of double haploids in durum wheat.

GERMANY

University of Bonn
- Ecology and biology of cereal cyst nematodes.

Giessen University
- Sustainable management of a Mediterranean type agroecosystem: Results from crop simulation studies.

University of Kiel
- Assessment of information needs for development of water management models.
- Institutions of supplemental irrigation.

University of Frankfurt am Main
- Development and use of DNA molecular markers for indirect selection in chickpea.
- Characterization of *Ascochyta rabiei* and mapping of geographical distribution in WANA.

University of Göttingen
- Development of wheat germplasm with multiple disease resistance.
- Use of chemical stimulants to improve drought tolerance in lentil.

University of Hannover
- Development of transformation protocols for chickpea.

University of Hohenheim
- Barley market studies and economic assessment of grain and straw quality and morphological traits.
- Straw quality: breeding and evaluation methods (near-infrared reflectance and histochemistry).
- Simulation studies on the sustainability of Mediterranean cropping systems.

University of Karlsruhe
- Use of remote sensing and GIS for identification of water harvesting sites.

Technical University, Munich
- Use of DNA markers in selection for disease resistance genes in barley.

ITALY

Institute of Nematology, Bari
- Studies of parasitic nematodes in food legumes.
- Studies on salinity tolerance in lentil.

Catania University
- Developing a decision support system for mitigation of drought impacts in Mediterranean regions.

University of Genova
- Analysis of the climatology of rainfall obtained from satellite and surface data for the Mediterranean basin.

University of Naples
- Development of transgenic chickpea resistant to *Ascochyta* blight.

University of Naples; ENEA, Rome; Stazione Sperimentale di Granicoltura per la Sicilia, Caltagirone; Istituto Sperimentale per la Patalogia Vegetale, Rome
- Development of chickpea germplasm with combined resistance to *Ascochyta* blight and *Fusarium* wilt using wild and cultivated species.

University of Tuscia, Viterbo
- Enhancing wheat productivity in stress environments utilizing wild progenitors and primitive forms.
- Diversity of storage proteins in durum wheat.

University of Tuscia, Viterbo; Germplasm Institute, Bari; ENEA, Rome
- Evaluation and documentation of durum wheat genetic resources.

JAPAN

Japan International Cooperation Agency (JICA)
- Collaborative research on small ruminant health.

Japan International Research Center for Agricultural Sciences (JIRCAS)
- Resource management: mapping of soil loss, feed resources, and vegetation loss in crop/range/livestock system of northeastern Syria.

Gifu University, Faculty of Agriculture
- Assessment of the adaptive role of plant color and chlorophyll a/b ratio in barley.

NETHERLANDS

ISRIC (International Soil Reference Information Centre)
- Collaboration on modelling soils in GIS.

Royal Tropical Institute, Amsterdam
- *Orobanche* control.

PORTUGAL

PORTUGAL

Estacão National de Melhoramento de Plantas, Elvas
- Screening cereals for resistance to yellow rust, scald, Septoria, and powdery mildew.
- Developing lentil, faba bean, chickpea, and forage legumes adapted to Portugal's conditions.

RUSSIA

Krasnodar Lukyanenko Research Institute
- Development of winter and spring barley for the continental highlands of Central Asia and the Eastern States of the former Soviet Union.

All Russian Institute of Agricultural Biotechnology, Moscow
- Establishment of barley transformation system.

SPAIN

INIA (Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria)
- Barley stress physiology (with University of Barcelona).
- Improvement of drought tolerance and semolina and pasta quality of durum wheat (with University of Córdoba; Jerez de la Frontera; University of Barcelona; Centre Udl-IRTA, Lleida).
- Race identification of *Fusarium oxysporum* f.sp. *ciceri* in chickpea in the Mediterranean region (with University of Córdoba).
- Exchange of fodder, pasture and range plant germplasm.
- Reclamation of marginal soils.
- Stabilization of marginal steeplands.

SWITZERLAND

University of Bern, CDE (Center for Development and Environment)
- WOCAT Network (World Overview of Conservation Approaches and Technologies).

Institut Universitaire d'Études du Développement (IUED), Geneva
- History of agricultural and pastoral production systems and the management of agricultural and pastoral resources in the Middle East and North Africa.

Station Fédérale de Recherches Agronomiques de Changins (RAC)
- Duplication of *Lathyrus* genetic resources and data.

UNITED KINGDOM

University of Birmingham
- Botanical surveys and assessment of communal pastures in Turkey.

Bristol University
- Analysis of the climatology of rainfall obtained from satellite and surface data for the Mediterranean basin.

University of Bristol, Long Ashton Research Station
- Molecular characterization using AFLP techniques.

University of Reading
- Gender analysis in the agricultural systems of WANA.
- Adaptation of lentils.

Scottish Crop Research Institute
- Use of microsatellite markers to characterize barley genetic resources of WANA.

Silsoe College
- ICARDA is providing consultancies in support of the Jordan Arid Zone Productivity Project implemented by Silsoe College.

UNITED STATES OF AMERICA

University of California, Riverside
- Biodiversity of wheat wild relatives.

University of California, Davis
- GL-CRSP (Global Livestock Collaborative Research Support Program): rangeland production and utilization in Central Asia.
- Developing chickpea cultivars with resistance to *Ascochyta* blight.

Colorado State University
- Testing for stripe rust in barley.

Cornell University, Ithaca
- Use of molecular markers for genome mapping and marker-assisted selection for stress resistance in durum wheat.

University of Massachusetts, Amherst
- Child nutrition in rural areas of Syria.

Michigan State University, East Lansing, Michigan
- Simulation of phosphorus dynamics in the soil-plant system.
- Integrated expert systems/crop modelling of wheat crop management.

North Dakota University
- Head scab of barley.

Oregon State University
- Molecular mapping of barley within the North America Barley Genome Mapping project.
- Identification of molecular markers associated with resistance to diseases of barley.

Texas A&M University, Blacklands Research Center (BRC-TAMU), Temple, Texas
- Development of an Almananc Characterization Tool (ACT) for Syria.

Texas Tech University, Plant Molecular Genetics Laboratory, Lubbock, Texas
- Adaptation to drought and temperature stress in barley using molecular markers.

USDA/ARS (US Department of Agriculture, Agricultural Research Service), National Germplasm Resources Laboratory
- Production of PCR primers for detection of viruses.

USDA/ARS Beltsville Agricultural Research Center, Beltsville, Maryland
- Development of bread wheat cultivars facilitated by microsatellite DNA markers.

USDA/ARS Range Sheep Production Efficiency Unit (RSPEU), Dubois, Idaho
- Central Asian rangeland and sheep evaluation.

USDA/ARS Forage and Range Research Laboratory (FRRL), Logan, Utah
- Central Asian rangeland and sheep evaluation.

USDA/ARS Grain Legume Genetics and Physiology Research, Washington State University
- Gene mapping of economic traits to allow marker-assisted selection in chickpea and lentil.
- Exploitation of existing genetic resources of food legumes.

USDA/ARS Western Regional Plant Introduction Station, Pullman, Washington
- Conservation of temperate food, pasture and forage legume biodiversity.

Utah State University
- GL-CRSP (Global Livestock Collaborative Research Support Program): rangeland production and utilization in Central Asia.

University of Vermont
- Use of entomopathogenic fungi for the control of Sunn pest in West Asia.

Washington State University, Pullman, Washington
- Mapping economic genes of lentil.
- Adaptation of peas for Mediterranean environments.
- *Ascochyta* blight resistance in chickpea.
- Genetics of winter hardiness and adaptation of lentil to cold highland areas.
- Utilization of cropping systems simulation model for generalization of site-specific trial results for wider areas with known environmental characteristics.

University of Wisconsin, Land Tenure Center, Madison
- Livestock and rangeland policy and property rights in Central Asia.

Yale University, Center for Earth Observations
- Feasibility study of use of remote sensing and image analysis for land use mapping and evaluation.

Appendix 8

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions Involved	Donor Support
International & Regional Networks				
Cereal International Nursery	Dissemination of barley, durum wheat and bread wheat advanced lines, parental lines and segregating populations developed by ICARDA and CIMMYT and by national programs themselves. Feedback from NARS assists in developing adapted germplasm for national programs and provides a better understanding of genotype ˜ environment interaction and of the agroecological characteristics of major cereal production areas.	Germplasm Program	50 countries worldwide, CIMMYT	ICARDA core funds
International Legume Testing Network (ILTN)	Dissemination of genetic material to NARS for evaluation and use under their own conditions. Permits multilocation testing of material developed by NARS and ICARDA and helps in developing better understanding of genotype ˜ environment interaction as well as agroecological characterization of legume production areas. Includes lentil, chickpea, dry pea, vetches and chickling.	Germplasm Program	52 countries worldwide, ICRISAT	ICARDA core funds
SEWANA (Southern Europe and WANA) Durum Wheat Research Network WANADDIN (WANA Dryland Durum Improvement Network)	Durum breeder and crop improvement scientists from southern Europe, West Asia and North Africa (SEWANA) complement each other's activities in developing techniques and breeding material of durum wheat adapted to the Mediterranean environment and with high grain quality.	Germplasm Program	Algeria, Jordan, Lebanon, Morocco, Tunisia, Turkey, Syria, France, Greece, Italy, Spain, Canada, USA	ICARDA core funds, France, Italy, IFAD
Soil Fertility Network	To standardize methods and exchange information and results from research on soil fertility, soil management, and fertilizer use.	Natural Resource Management Program	Algeria, Cyprus, Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Pakistan, Syria, Tunisia, Turkey, Yemen	ICARDA, IMPHOS

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions Involved	Donor Support
Dryland Pasture and Forage Legume Network	Communication linkages among pasture forage and livestock scientists in WANA.	Natural Resource Management Program	WANA, Europe, USA, Australia	ICARDA, CIHEAM, CLIMA, FAO-RNE, IDRC, USAID (CRSP)
WANA Plant Genetic Resources Network (WANANET)	Working groups will specify priorities in plant genetic resources; identify and implement collaborative projects; implement regional activities.	IPGRI Regional Office for WANA, ICARDA Genetic Resources Unit	WANA countries, IPGRI, FAO, ACSAD	IPGRI, ICARDA, FAO
Faba Bean Information Services (FABIS)	Collection and dissemination of worldwide information on faba bean, chickling and vetch to facilitate communication between research workers. FABIS Newsletter; specialized bibliographic journals; research workers' directory.	Germplasm Program; Communication, Documentation and Information Services	Worldwide	ICARDA core funds
Lentil Experimental News Services (LENS)	Collection and dissemination of worldwide information on lentils to facilitate communication between research workers. LENS Newsletter; specialized bibliographic journals; research workers' directory.	Germplasm Program; Communication, Documentation and Information Services	Worldwide	ICARDA core funds
RACHIS	Collection and dissemination of worldwide information on wheat and barley to facilitate communication between research workers. RACHIS newsletter; specialized bibliographic journals; research workers' directory.	Germplasm Program; Communication, Documentation and Information Services	Worldwide	ICARDA core funds
WANA Seed Network	Encourages (1) stronger regional seed sector cooperation, (2) exchange of information, (3) regional consultations, and (4) inter-country seed trade.	ICARDA Seed Unit	Algeria, Morocco, Iraq, Cyprus, Turkey, Jordan, Syria, Egypt, Sudan, Libya, Yemen	ICARDA, Germany (GTZ), Netherlands
Agricultural Information Network for WANA (AIN-WANA)	Improving national and regional capacities in information management, preservation and dissemination.	Communication, Documentation and Information Services	WANA countries, CIHEAM, ISNAR	ICARDA

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions Involved	Donor Support
Global Grain Legume Drought Research Network (GGLDRN)	Establishing integrated global efforts on enhancing and stabilizing grain legume production in drought-affected environments through provision of information. Characterizing and mapping types of drought using GIS. Quantifying yield losses using existing data or through experimentation. Identifying priority areas for research. Extending available technologies to target regions.	ICRISAT, ICARDA	Worldwide, ICRISAT, FAO	ICARDA, ICRISAT, FAO
Sub-Regional Networks				
Networks operating under the North Africa Regional Program (NARP):				
North African Faba Bean Research Network	ICARDA provides technical support to this network coordinated by GTZ and Morocco. The network provides for continued availability of ICARDA enhanced faba bean germplasm and runs regional trials and nurseries including *Orobanche* resistance nursery, joint evaluation visits, and regional training courses.	GTZ, INRA/Morocco	Algeria, Libya, Morocco, Tunisia	GTZ
Networks operating under the Nile Valley and Red Sea Regional Program (NVRSRP):				
Sources of Primary Inoculum of Stem and Leaf Rusts of Wheat: Their Pathways and Sources of Resistance	Determine disease development of leaf and stem rusts in relation to weather data. Identify prevailing races and the pathways of pathogens. Identify wheat germplasm with effective resistance genes. Identify primary sources of inoculum. Contribute to overall breeding strategy.	ARC/Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA	Netherlands (DGIS)
Management of Wilt and Root Rot Diseases of Cool Season Food Legumes	Identify sources of resistance to wilt and root rots. Incorporate resistance into germplasm with suitable characteristics. Provide segregating populations to NARS to select under their own conditions. Develop strategy for multiple disease resistance. Identify races in Fusarium wilt pathogens. Studies on other components of integrated disease management.	AUA/Ethiopia	Egypt, Ethiopia, Sudan, ICARDA, ICRISAT	Netherlands (DGIS)

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions Involved	Donor Support
Integrated Control of Aphids and Major Virus Diseases in Cool-Season Food Legumes and Cereals	Assess the potential for and implement biological control of aphids. Identify and incorporate sources of resistance to, and improve chemical control of aphids. Develop improved diagnostic methods to identify virus diseases, and assess their spread and relative importance. Identify germplasm for virus resistance. Develop integrated pest management program.	ARC/Egypt, ARC/Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA	Netherlands (DGIS)
Thermo-tolerance in Wheat and Maintenance of Yield Stability in Hot Environments	Identify physiological and morphological traits for improving wheat adaptation to heat; verify these traits in collaboration with breeders. Identify improved management strategies through a better understanding of development and growth. Describe the physical environment and characterize promising genotypes for development of computer simulations of crop growth. Characterize photothermal and vernalization responses of selected commercial lines.	ARC/Sudan	Egypt, Sudan, Yemen, ICARDA, CIMMYT	Netherlands (DGIS)
Drought and Water-Use Efficiency in Wheat	Develop and identify wheat cultivars requiring less water and tolerant to moisture stress. Identify irrigation regimes that meet crop-water requirements. Improve soil management practices for soil moisture conservation. Develop improved production packages.	ARC/Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA	Netherlands (DGIS)
Socioeconomic Studies on Adoption and Impact of Improved Technologies	Monitoring and evaluation of technology transfer to farmers with respect to adoption levels and identification of factors influencing adoption; impact of improved technology on farm-income levels and production; effect of policy and institutional factors on technology transfer and adoption.	ARC/Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA	Netherlands (DGIS)

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions Involved	Donor Support
Barley Networks operating under the Latin America Regional Program (LARP):				
Development of Stripe Rust Resistant Barley	To produce barley resistant to stripe rust using double haploid method (DH). DH lines produced by Oregon State University, field tested in Mexico, and superior cultivars distributed to NARS.	LARP Regional Coordinator	Oregon State Univ., Latin American NARS, CIMMYT	ICARDA & CIMMYT core funds
Development of Hull-less Barley	Develop high-yielding hull-less cultivars and improve their nutritional value, producing cultivars with high energy and low fiber.	LARP Regional Coordinator	CIMMYT, Canada, Australia, Colombia	ICARDA & CIMMYT core funds
Development of Barley Yellow Dwarf (BYD) Resistant Lines	ELISA testing of barley lines. Field testing of identified resistant lines in Latin America. International testing in Chile, Ecuador and Kenya where disease has reached epidemic proportions.	LARP Regional Coordinator	CIMMYT, Chile, Ecuador, Kenya	ICARDA & CIMMYT
Development of Germplasm Resistant to Scab and Barley Yellow Mosaic Virus (BYM)	Development of scab-resistant barley with tolerance to BYM for China.	LARP Regional Coordinator	CIMMYT, China	ICARDA & CIMMYT core funds
Development of Barley Lines Resistant to Spot Blotch Caused by *Helminthosporium sativum*	Crossing sources of resistance identified in Thailand and North America. International field testing in Thailand, Vietnam, Uganda.	LARP Regional Coordinator	CIMMYT, Vietnam, Uganda, Thailand	ICARDA & CIMMYT core funds
Development of Leaf Rust Resistant Barley	Network of researchers investigating leaf rust resistance.	LARP Regional Coordinator	Virginia Tech, North Dakota State, CIMMYT, Latin American NARS	ICARDA & CIMMYT core funds

Appendix 9

ICARDA International School of Aleppo

The ICARDA International School of Aleppo (ISA) is a co-educational day school sponsored by ICARDA. ISA offers a high quality, internationally acceptable program, primarily for the children of ICARDA employees. Currently, there are 278 students enrolled in grades K–12 representing 37 countries. Approximately one-third of the students are ICARDA-sponsored, with the remainder coming from the Aleppo community.

The School is housed in what is called Office One on four hectares located at the edge of Aleppo, shared with the residence of the Director General and the ICARDA Sports and Social Club. The School facilities include two former mansions and two purpose-specific buildings. Athletic facilities are shared with the Sports Club.

The School is fully accredited by the Middle States Association (MSA) of Colleges and Schools of the United States and is affiliated to the International General Certificate of Secondary Education (IGCSE) and the International Baccalaureate (IB). All students work towards a US-style secondary diploma and approximately two-thirds of the students also attempt the IB diploma.

Highlights for the year included students receiving the highest IGCSE and IB scores in the history of the School. Within the IB, the School had a 100% pass rate for all students sitting the diploma, with an average score increase of six points (27 to 33) over the previous year. The School expanded its academic program, adding courses in business, psychology, geography, art, multimedia, music, yearbook, and pre-IGCSE mathematics at the secondary level. At the elementary level the School added support resource room services for students needing extra assistance.

The School's extracurricular program continued to grow as an expanded number of athletic teams participated in a local league as well as internationally through the International Schools Activities Conference (ISAC).

The campus was expanded with the second purpose-specific building opened on 4 October 1998. This facility added three larger classrooms and a much-needed auditorium. The entire campus was also wired to create a Local Area Network (LAN) in anticipation of future Internet connections. The School library and the computer laboratories were combined to create a student research center. A secondary-student social area was created behind the secondary building with a new patio, a shaded area formed by a grape arbor, and a pond which will also be used for biological studies. The soccer pitch, which is shared with the Sports Club, received extensive work with the installation of an underground irrigation system.

The School Management Committee (SMC), which is appointed by the Director General and oversees the School's operation, completed an entire rewrite of its policy manual. Tighter fiscal management allowed the School to finish with a small operational surplus.

Appendix 10

Visitors to ICARDA

In 1998, the Center received 2495 visitors in 294 groups from all over the world; 76% from WANA, 10% from Europe, 9% from areas in Asia and Africa other than WANA, and 5% from the USA, Australia and Canada. The visitors included ministers of agriculture, parliament members, ambassadors, senior government officials, representatives of donor organizations, media personnel, researchers, extension specialists, farmers, representatives of farmers' union, trainees, and students.

Among the distinguished visitors during 1998 were the ministers of agriculture of the following five countries:

H.E. Assa'ad Moustafa, Syria
H.E. Abdul Elah H. Mohamed, Iraq
H.E. Abdul Jawad Al-Saleh, the Palestinian Authority
H.E. Nafie Ali Nafie, Sudan
H.E. Abdel Rahman Kazzaz, Mauritania

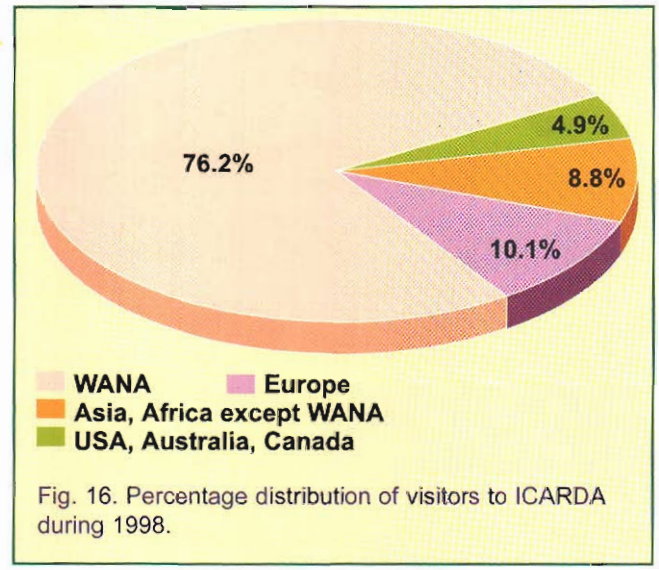


Fig. 16. Percentage distribution of visitors to ICARDA during 1998.

Appendix 11

Statement of Activity

For the Year Ended 31 December 1998 and 1997 (x 1000 US$)

	1998	1997
REVENUE		
Grants	23,944	22,877
Exchange gains/(losses) - net	433	(220)
Interest income	294	327
Other income	514	367
	25,185	23,351
EXPENSES		
Research	17,596	20,515
Training	2,060	2,526
Information services	689	918
General administration	2,996	2,771
General operations	1,207	1,772
	24,548	28,502
Recovery of Indirect Costs	(978)	(868)
	23,570	27,634
EXCESS OF REVENUE OVER EXPENSES	1,615	(4,283)
ALLOCATED AS FOLLOWS:		
Capital invested in property, plant and equipment	202	318
Capital fund	-	4
Operating fund	1,413	(4,605)
Surplus/(Deficit)	1,615	(4,283)

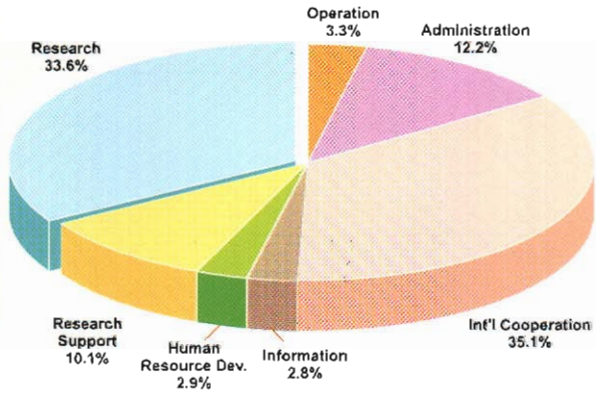
Statement of Grant Revenue, 1998

(x 1000 US$)

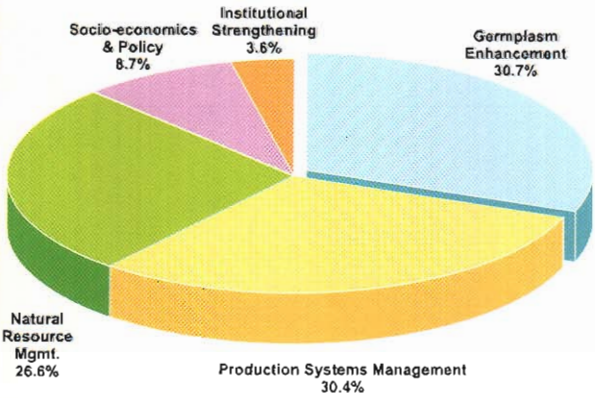
Donor	Amount	Donor	Amount	Donor	Amount
		France	194	South Africa	30
Arab Fund	1,294	Germany	1,348	Spain	224
Australia	565	IMPHOS	8	Sweden	448
Austria	30	IBRD (World Bank)	2,000	Switzerland	118
Canada	420	IDRC	134	United Kingdom	758
China	10	IFAD	1,051	UNDP	202
CGIAR*	2,308	Iran	1,280	Univ. of California-Davis	46
Denmark	609	Italy	525	USAID	1,545
Desertification trust fund	1,248	Japan	535	USDA	143
European Commission	2,808	The Netherlands	1,649	Yemen	750
Egypt	1,052	Norway	533	Miscellaneous	2
Ethiopia	24	OPEC	53	Total	23,944

* Includes US$ 1.6 million one-time contribution from CGIAR Finance Committee.

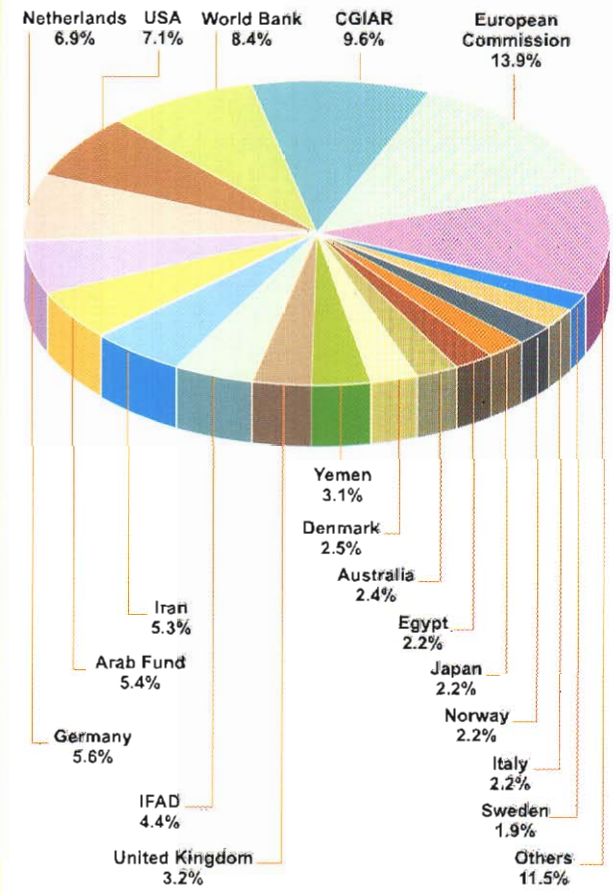
Statement of Activity
Taking a Closer Look



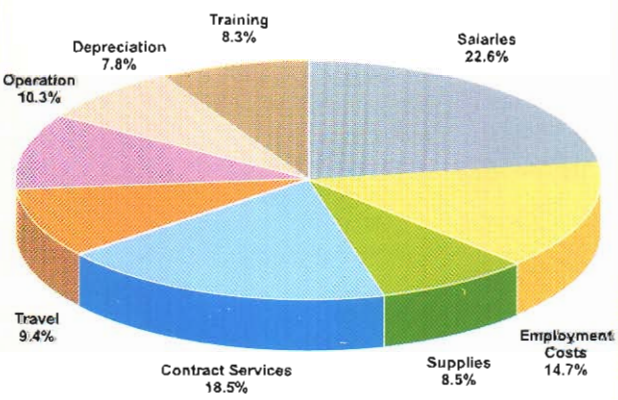
Expenditure (US $ 24.5 million) by Activities for 1998



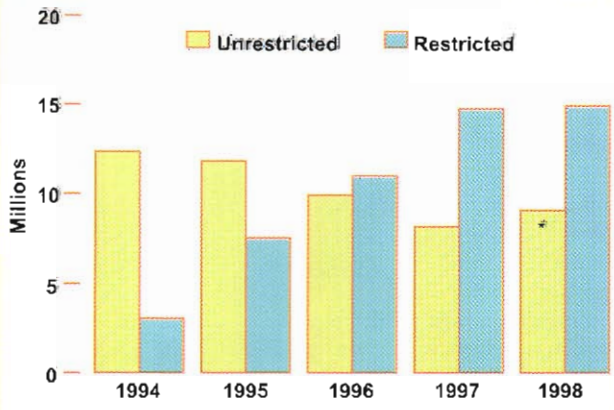
Expenditure by Medium-Term Plan Themes for 1998



Grant Revenues for 1998



Expenditure by Expense Category for 1998



Funding Trend 1994-1998

*Includes US$1.6 million one-time contribution from the CGIAR Finance Committee

Appendix 12

Board of Trustees

At its extraordinary meeting on 21 February1998 in Cairo, Egypt, the Board of Trustees (BOT) appointed Mr Robert D. Havener, Dr Mamdouh A. Sharafeldin, and Dr Ismail El-Zabri as members for a 3-year term starting from the April 1998 meeting.

Drs Ersin Istanbulluoglu, Julie Caroll Noolan, and Joseph Casas completed their term of office in April 1998. At its annual meeting held on 22–23 April 1998 at ICARDA, Aleppo, the Board expressed its appreciation for their valuable contributions to the progress of ICARDA. The departing Trustees had joined the Board in 1993.

Dr Toufik Ismail, host country representative, after completing his second 3-year term on the Board, was re-elected for a third 3-year term starting immediately after the 1998 annual Board meeting. Drs Raoul Dudal and Luigi Monti completed their first 3-year term on the Board and were re-elected for a second 3-year term also starting immediately after the 1998 annual Board meeting.

At the April BOT meeting, Mr Robert Havener was elected as Chairperson Designate of the Board to take office for a term of two years immediately after the 1999 annual meeting of the BOT.

Mr Robert D. Havener

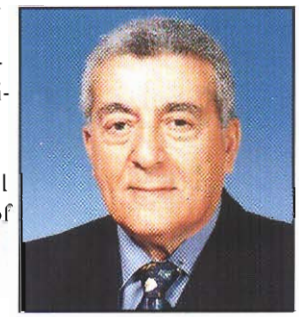
Mr Robert D. Havener received his BS (1952) and MS (1958) in agriculture from Ohio State University, and M.PA. (1972) from the Kennedy School of Government, Harvard University. Mr Havener is not new to the CGIAR system; through the Arid Lands Agricultural Development (ALAD) Program of the Ford Foundation, he was Co-project Development Officer for ICARDA in 1975–1976, and was a member of ICARDA's Board of Trustees in 1976–1978. He was also Director General of CIMMYT (1978–1985) and Interim Director General of CIAT (1994–1995), and has served on the Board of Trustees of IRRI (1977–1978), CIMMYT (1978–1985), and CIAT (1992–1998).

Besides the CGIAR Centers, the organizations in which he has gained his major work experience in the past three decades include the Ford Foundation (Program Advisor, Agriculture, Pakistan, 1966–1971; Program Officer, New York, 1971–1972; Director, ALAD Program, Beirut, Lebanon, 1972–1976; and Program Advisor, Agriculture, Asia and the Pacific Region, 1976–1978); Winrock International Institute for Agricultural Development (President and CEO, 1985–1993); and Rockefeller Foundation (Senior Consultant, 1993–1994). He has also been a Board member of numerous national and international organizations.

In addition to his numerous awards and professional achievements, including President Emeritus and Honorary Member of Winrock International; National Award for Agricultural Excellence, National Agri-Marketing Association; and Distinguished Alumni Award, College of Agriculture, Ohio University, he has contributed more than 25 invited papers to conferences, seminars, and workshops.

Dr Mamdouh A. Sharafeldin

Dr Mamdouh A. Sharafeldin is currently Technical Counselor to the Ministry of Agriculture and Land Reclamation of Egypt; Professor of Animal Sciences at Cairo University, Egypt; and Chairperson, Livestock, Poultry and Fisheries Research Council of the Egyptian Academy of Scientific Research and Technology. His responsibilities at the Ministry include coordinating activities of the public and private livestock and poultry sectors and supervising all the animal and veterinary science institutes of the Agricultural Research Center, of which he is a Board member. He is also Coordinator of the EU Steering Committee and Food Sector Development Program (FSDP), Chairman of the Board of Trustees of FSDP, and Coordinator of the World Bank's Matrouh Resource Development Project in Egypt.

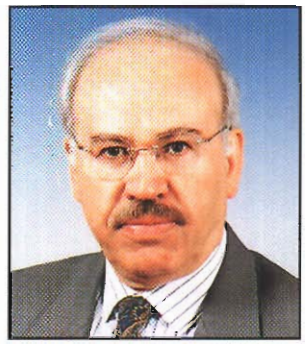


Dr Sharafeldin served from 1971 to 1988 with FAO, where his most recent position was Senior Technical Advisor to the Ministry of Agriculture of Saudi Arabia. In addition to teaching animal sciences at the university level, his professional experience includes planning and implementation of integrated agricultural development projects and management of bi- and multi-lateral projects. He has 17 years of experience with international organizations, and was awarded "Le grade d'officier du merite agricole" by the Government of France in 1996.

Dr Sharafeldin's specialization is in animal breeding, with notable activities in livestock improvement and conservation of genetic material; livestock production systems, particularly nomadic and transhumant systems; and agricultural development. He has published 40 articles in both international and national journals on animal breeding, wool technology, sheep production, and animal behavior, and several FAO publications on agricultural development.

Dr Ismail El-Zabri

Dr Ismail El-Zabri has been working with the Arab Fund for Economic and Social Development (AFESD), Kuwait, since 1977. With a background in agricultural economics, he is currently Director of the Technical Department, where his duties include managing technical operations, assisting Arab countries in formulating their development plans, formulating regional and country development strategies and programs geared to guiding AFESD's lending and technical assistance programs, and organizing seminars and workshops on major issues of Arab economic development.



Dr El-Zabri's previous assignment after he received his PhD from the University of Illinois, Urbana-Champaign (1968), was with FAO, where he was Chief, Near East and North Africa Group. His duties included supervision and technical backstopping of agricultural economists assigned to UNDP/FAO projects in countries of the Near East and North Africa region; economic analysis of food and agriculture conditions, problems and policies at country and regional levels, and review of performance of the agriculture sector; preparation of country studies (for Egypt, Iran, Jordan, Pakistan, and Sudan); and lending advisory assistance to countries in agricultural plan preparation.

Full Board, 1998

On 31 December 1998, the membership of ICARDA's Board of Trustees was as follows:

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Board Meetings, 1998

Cairo, Egypt

20 February	Extraordinary Nomination Committee Meeting
20–21 February	Extraordinary Board of Trustees Meeting

Aleppo, Syria

23–24 April	Board of Trustees Meeting
21–22 April	Program Committee Meeting
22 April	Nomination Committee Meeting

Washington DC, USA

2–3 November	Executive Committee Meeting

Appendix 13

Senior Staff
(as of 31 December 1998)

SYRIA (Aleppo: Headquarters)

Director General's Office

Prof. Dr Adel El-Beltagy, Director General
Dr M.C. Saxena, Assistant Director General
Dr John Dodds, Assistant Director General (Research)
Dr Mahmoud El-Solh, Director of International Cooperation
Dr Elizabeth Bailey, Project Officer
Mr V.J. Sridharan, Internal Auditor
Ms Houda Nourallah, Administrative Officer to the Director General and Board of Trustees

Government Liaison

Dr Faisal Maya, Director

Finance

*Mr John E. Noisette, Director of Finance and Administration (until July 1998)
Mr Suresh Sitaraman, Acting Director of Finance (from July 1998)
Mr Edwardo Estoque, Finance Officer, Financial Reporting
Mr Issam Abdalla Saleh A. El-Nagga, Accountant

Mr Mohamed Samman, Treasury Supervisor

Natural Resource Management Program

Dr Richard Tutwiler, Program Leader

Dr Aden Aw-Hassan, Coordinator, Dryland Resource Management Project
Dr Adriana Bruggeman, Agriculture Hydrology Specialist
Dr Nabil Chaherli, Policy Economist (seconded from IFPRI)
Dr Eddy DePauw, Agroclimatologist
Dr Michael Chenost, Scientist
Dr Gustave Gintzburger, Range Ecology and Management Scientist
Dr Luis Iniguez, Senior Small-Ruminant Scientist
Dr Fawzi Karajeh, Marginal-Quality Water Management Specialist
Dr Tidiane Ngaido, Property-Rights Specialist (seconded from IFPRI)
Dr Theib Oweis, Water Harvesting/Supplemental Irrigation Specialist
Dr Mustafa Pala, Wheat-based Systems Agronomist
Dr Abelardo Rodriguez, Agricultural Economist
Dr John Ryan, Soil Fertility Specialist
Dr Christoph Studer, Plant, Water and Soil Specialist
Dr Michael Zöbisch, Soil Conservation and Land Management Specialist

Dr Mustafa Bouneimate, Consultant, Feed Legumes Production
Mr Wolfgang Göbel, Agroclimatologist
Dr Ahmed Mazid, Agricultural Economist
Mr Nicholas Thomas, GIS Analyst

Dr Heping Zhang, Post-Doctoral Fellow

Ms Azusa Fukuki, Research Fellow
Ms Shibani Ghosh, Research Fellow
Ms Trine Nielsen, Junior Professional Officer
Dr Safouh Rihawi, Research Associate
Mr Farouk Shomo, Research Associate
Ms Monika Zaklouta, Research Associate

Germplasm Program

Dr William Erskine, Leader

Dr Osman Abdallah, Pathologist (seconded from CIMMYT)
Dr Ali M. Abd El Moneim, Forage Legume Breeder
Dr Chrysantus Akem, Plant Pathologist
Dr Michael Baum, Biotechnologist
Dr Mustafa El Bouhssini, Entomologist
Dr Salvatore Ceccarelli, Barley Breeder
Dr Stefania Grando, Barley Breeder
Dr Khaled Makkouk, Plant Virologist
Dr Miloudi Nachit, Durum Wheat Breeder (seconded from CIMMYT)
Dr Victor Shevtsov, Barley Breeder
Dr Amor Yahyaoui, Senior Cereal Pathologist

Dr R.S. Malhotra, International Trials Scientist

Dr Ashutosh Sarker, Post-Doctoral Fellow, Lentil Breeding
Dr S.M. Udupa, Post-Doctoral Fellow, Pathogen Analysis

Mr Fadel Afandi, Research Associate
Ms Bianca van Dorrestein, Visiting Research Fellow
Dr Bruno Ocampo, Research Associate

Genetic Resources Unit

Dr Jan Valkoun, Head

Dr Kamel Chabane, Biotechnologist
Mr Jan Konopka, Germplasm Documentation Officer

Ms Siham Asaad, Research Associate
Mr Bilal Humeid, Research Associate

Communication, Documentation, and Information Services

Dr Surendra Varma, Head

Mr Moyomola Bolarin, Multimedia/Training Material Specialist

* Proceeded on terminal sabbatic leave on 15 July.

Mr Nihad Maliha, Library and Information Services Manager

Human Resources Development Unit

Dr Samir El-Sebae Ahmed, Head

Mr Mohamed A. Hamwieh, Administrative Officer (Visitors Services)

Computer and Biometrics Services

Dr Zaid Abdul-Hadi, Head

Dr Murari Singh, Senior Biometrician

Mr Awad Awad, Data Base Administrator
Mr Michael Sarkisian, Senior Maintenance Engineer

Mr C.K. Rao, Senior Analyst/Programmer

Seed Unit

Dr Michael Turner, Head

Dr Samuel Bockari-Kugbei, Seed Economist

Mr Zewdie Bishaw, Assistant Seed Production Specialist
Dr Lahcen Grass, Training Officer

Mr Abdul Aziz Niane, Research Associate

Personnel

Ms Verity Stiff, Personnel Officer

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Dr Jürgen Diekmann, Farm Manager

Mr Bahij Kawas, Senior Horticultural Supervisor
Mr Ahmed Shahbandar, Assistant Farm Manager

Engineering Services Unit

Mr Ohannes Ohanessian, Electrical/Electronic Engineer

Purchasing and Supplies

Ms Dalal Haffar, Manager

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Mr Marwan Mallah, Administrative and Security Officer/ Consultant

International School of Aleppo

Dr Thomas Taylor, Principal

Mr Anthony Brown, Deputy Principal

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Mr Abdul Karim El Ali, Administrative Officer

Beirut Office, Lebanon

Mr Anwar Agha, Executive Manager/Consultant

Terbol Research Station, Lebanon

Mr Munir Sughayyar, Engineer, Station Operations

Regional Programs

North Africa Regional Program

Tunis, Tunisia

Dr Abdul Razzak Belaid, Socioeconomist

Rabat, Morocco (Camp Office)

Nile Valley and Red Sea Regional Program

Cairo, Egypt

Dr Nasri Haddad, Regional Coordinator

Dr Scott Christiansen, Grazing Management Specialist/ International Facilitator

Dr Abdul Bari Salkini, Agricultural Economist

Dr Heinz Peter Wolff, Visiting Scientist/Natural Resources Management Economist

Dhamar, Yemen

Dr S.V.R. Shetty, Team Leader

Dr Mohamed Zainul Abedin, Farming Systems Specialist

West Asia Regional Program

Amman, Jordan

Dr Mohamed Habib Halila, Regional Coordinator

Arabian Peninsula Regional Program

Dubai, United Arab Emirates

Dr John Peacock, Regional Coordinator

Dr Ian McCann, Water/Irrigation Management Specialist
Dr Ahmed Tawfik Mustafa, Protected Agriculture Specialist

Highland Regional Program

Ankara, Turkey

Dr Habib Ketata, Acting Regional Coordinator

Tehran, Iran

Dr Muhammed Tahir, Plant Breeder, and Coordinator, Iran/ICARDA Project

Central Asia and the Caucasus Regional Program

Tashkent, Uzbekistan

Dr S.P.S. Beniwal, Regional Coordinator

Dr Mekhlis Suleimenov, Deputy Head
Dr Zahir Khalikulov, Consultant Scientist

Latin America Regional Program

CIMMYT, Mexico

Dr Hugo Vivar, Barley Breeder and Regional Coordinator

Consultants

Dr Bassam Bayaa, Lentil Pathologist
Dr Ahmed El Ahmed, Seed Pathologist
Dr Wafa Choumane, Biotechnologist
Dr Edward Hanna, Legal Advisor (Beirut)
Mr Tarif Kayali, Legal Advisor (Aleppo)
Dr Shaaban Khalil, Faba Bean Breeder
Dr Nour-Eddine Mona, Syrian National Coordinator
Dr Hisham Talas, Medical Consultant (Aleppo)

Appendix 14

Acronyms

ACSAD	Arab Center for the Studies of Arid Zones and Dry Lands (Syria)
ALESCO	Arab League Educational, Cultural and Scientific Organization (Tunis)
AREA	Agricultural Research and Extension Authority (Yemen)
AFESD	Arab Fund for Economic and Social Development (Kuwait)
APRP	Arabian Peninsula Regional Program (Dubai, Yemen)
ARI	Agricultural Research Institute (Lebanon)
ASMSP	Agricultural Sector Management Support Project (Yemen)
BOT	Board of Trustees
BMZ	Federal Ministry for Economic Cooperation (Germany)
CAC	Central Asia and the Caucasus
CACRP	Central Asia and the Caucasus Regional Program (Tashkent, Uzbekistan)
CIAT	Centro Internacional de Agricultura Tropical (Colombia)
CIHEAM	Centre International de Hautes Etudes Agronomiques Mediterraneennes (France)
CIP	International Potato Center (Peru)
CGIAR	Consultative Group on International Agricultural Research (USA)
CIMMYT	International Maize and Wheat Improvement Center (Mexico)
CLIMA	Center for Legumes in Mediterranean Agriculture (Australia)
CRIFC	Central Research Institute for Field Crops (Ankara Central Anatolia, Turkey)
CWANA	Central and West Asia and North Africa
DARI	Dryland Agricultural Research Institute (Iran)
EARO	Ethiopian Agriculture Research Organization (Ethiopia)
EC	European Commission
ESCWA	Economic and Social Commission for Western Asia (Lebanon)
FAO	Food and Agriculture Organization of the United Nations (Italy)
GAP-RDA	Southeastern Anatolia-Regional Development Administration (Turkey)
GATT	General Agreement on Tariff and Trade (USA)
GIS	Geographic Information System
GL-CRSP	Global Livestock-Collaborative Research Support Program (USA)
GRDC	Grain Research and Development Corporation (Australia)
HRP	Highland Regional Program (Ankara, Turkey)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
IDRC	International Development Research Centre (Canada)
IFAD	International Fund for Agricultural Development (Italy)
IFPRI	International Food Policy Research Institute (USA)
ILRI	International Livestock Research Institute (Kenya)
INIAP	Agricultural National Research Institute (Ecuador)
INRA	Institut National de la Recherche Agronomique (Morocco)
IPGRI	International Plant Genetic Resources Institute (Italy)
ISNAR	International Service for National Agricultural Research (The Netherlands)
IWMI	International Water Management Institute (Sri Lanka)
IWWIP	International Winter Wheat Improvement Program (Turkey)
LARP	Latin America Regional Program (Mexico)
MRMP	Matrouh Resource Management Program (Egypt)
NACAR	National Academic Center for Agricultural Research (Kazakhstan)
NARC	National Agricultural Research Center (Pakistan)
NARP	North Africa Regional Program (Tunis, Tunisia)
NARS	National Agricultural Research Systems
NCARTT	National Center for Agricultural Research and Technology Transfer (Jordan)
NVRSRP	Nile Valley and Red Sea Regional Program (Cairo, Egypt)
UNDP	United Nations Development Programme (USA)
UNIRDP	United Nations Integrated Rural Development Programme (Lebanon)
USAID	United States Agency for International Development (USA)
USDA/ARS	United States Department of Agriculture/Agricultural Research System (USA)
WANA	West Asia and North Africa
WANADDIN	WANA Dryland Durum Improvement Network
WARP	West Asia Regional Program (Amman, Jordan)

Appendix 15

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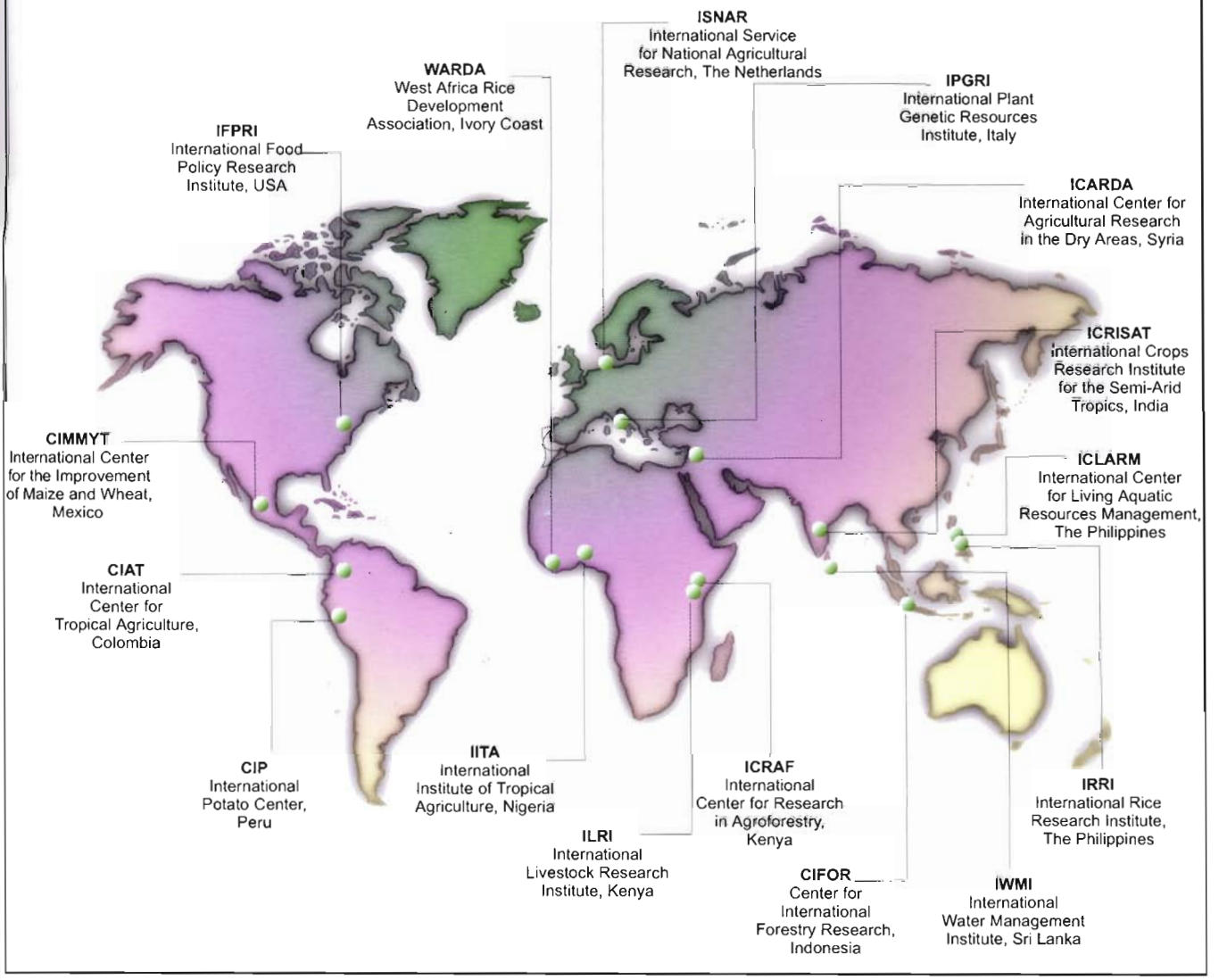
CGIAR Centers



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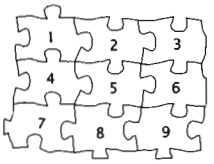
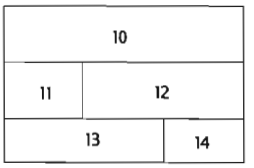


Back cover



1. Understanding why terrace farming in Yemen is being abandoned, and helping to restore it, can greatly contribute to increased food production and combating soil erosion.
2. Demonstration of farm production of winter-sown chickpea in Syria.
3. Biodiversity holds the key to future food security.
4. The farming systems in the WANA region are complex, and their improvement requires a holistic approach.
5. A simple water-harvesting technique being promoted by ICARDA.
6. Farmer participation guides the development of ICARDA's research agenda.
7. Improved-quality durum wheat is becoming popular in WANA for village-level pasta making.
8. ICARDA places a major emphasis on training national partners in the use of modern research tools.
9. Rangeland rehabilitation by ICARDA is providing good-quality feed for livestock.
10. A Roman-time water-harvesting system still in use in Syria.
11. Discussion of a work plan between ICARDA and Central Asian researchers for implementation.
12. An improved variety of barley, developed by ICARDA, has become popular in China.
13. Farmers in Latin America are now increasingly growing ICARDA-developed barley varieties.
14. A farmer in Rajasthan, India where the agroecological conditions and the problems of agriculture are similar to those in several dry areas of WANA.

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ICARDA-014/5000/October 1999