ICARDA



Annual Report 2004



ICARDA

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 one of 15 centers supported by the CGIAR. ICARDA's mission is to improve the welfare of poor people through research and training in dry areas of the developing world, by increasing the production, productivity and nutritional quality of food, while preserving and enhancing the natural resource base.

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 Central and West Asia and North Africa (CWANA) region for the improvement of bread and durum wheats, chickpea, pasture and forage legumes, 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, regional and international agricultural research and development systems.

The Consultative Group on International Agricultural Research (CGIAR) is a strategic alliance of countries, international and regional organizations, and private foundations supporting 15 international agricultural Centers that work with national agricultural research systems and civil society organizations including the private sector. The alliance mobilizes agricultural science to reduce poverty, foster human well being, promote agricultural growth and protect the environment. The CGIAR generates global public goods that are available to all.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD) are cosponsors of the CGIAR. The World Bank provides the CGIAR with a System Office in Washington, DC. A Science Council, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

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International Center for Agricultural Research in the Dry Areas

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Contents

Foreword

In 2004, ICARDA began strategic visioning, driven by the global focus on achieving the Millennium Development Goals and the realignment of the CGIAR System priorities by the Science Council. It involved, among other actions, a consolidation of the 19 research projects into six mega-projects for better integration of the Center's multidisciplinary teams, and an increased use of new tools of science in addressing the problems of poverty and degradation of natural resources. The new, poverty-focused research portfolio, scheduled to be implemented from 1 January 2005, encompasses a number of new avenues including improved income generation from high-value crops and adding value to staple crop and livestock products; rehabilitating agriculture in countries affected by conflict; and closer alignment of agricultural research with mainstream development programs through research-for-development applications.

Implementation of research projects under the Challenge Program on Water and Food got off to a good start, with activities in Eritrea on barley improvement and in the Kerkheh river basin in Iran on water productivity. In addition, ICARDA continued to play a leading role in international fora on issues related to the development of agriculture in dry areas.

Working with ICARDA, at least 13 countries released more than 35 improved cereal and food and feed legume varieties in 2004. The key traits of the improved varieties include better yields, resistance to pests and diseases, and tolerance to cold and drought.

ICARDA continued its work to rebuild agricultural systems in Afghanistan. During the year, under the Research in Alternative Livelihoods Fund (RALF) projects, supported by DFID (Department for International Development, UK), the Center started work on developing and promoting innovative alternative livelihood options for rural Afghans who are currently economically dependent on opium poppy. The Center also strengthened its activities on technology transfer, established village-based seed enterprises, and introduced protected agriculture in Afghanistan under the Rebuilding Agricultural Markets in Afghanistan (RAMP) program, funded by the United States Agency for International Development (USAID).

The Center was privileged to host the inaugural meeting of the CGIAR Science Council, and the annual meetings of the CGIAR Center Board Chairs Committee (CBC), and Center Directors Committee (CDC) in May 2004.

ICARDA enters 2005 with a sharpened focus on contributing to the Millennium Development Goals, especially halving poverty and hunger by 2015. The Center's Board of Trustees, Management and Staff thank all of ICARDA's donors and partners for their continued support, without which the activities and achievements summarized in this Annual Report would not have been possible.

Margaret Catley-Carlson
Chair, Board of Trustees

Adel El-Beltagy
Director General

Highlights of the Year

In 2004, ICARDA began strategic visioning. The exercise focused on a systematic review of global and regional externalities in the socioeconomic and political/institutional context, opportunities emerging from new science and technology, environmental trends, and lessons learned by the Center. Integral to this strategic visioning exercise was a review of the Center's research project portfolio, against the backdrop of the agricultural research priorities in the Central and West Asia and North Africa (CWANA) region, identified during the priority setting exercise undertaken by ICARDA with its partners in 2002/03. As part of this process, ICARDA redesigned its research portfolio and consolidated its 19 research projects into six coherent mega-projects, focused on human welfare, agricultural productivity, economic growth, and protection of the environment in the dry areas. The new portfolio will come into effect from 1 January 2005.

As in previous years, ICARDA continued to promote partnerships with national research systems (NARS) and advanced research institutes. The collaborative research led to the release of 35 varieties of cereal and food and forage legume crops in 13 countries of the CWANA region. During the year, a Center-Commisioned External Review of ICARDA's integrated gene management activities was conducted. The year also saw continued active participation of the Center in global and regional initiatives related to agricultural research and development in dry areas. Efforts to rebuild agriculture in Afghanistan continued, and new initiatives were taken to support agricultural research and infrastructure development in Iraq and Palestine. The work of some of the staff members earned honors and awards.

Key Events

ICARDA hosted the Science Council's inaugural meeting in May. The issues discussed at the meeting included the changing trends in global agricultural research, monitoring and evaluating the change process in the CGIAR, external reviews, and a report of the study on biosafety. The Center also hosted the CGIAR Center Board Chairs Committee (CBC), and Center Directors Committee (CDC) meetings in May. The agendas of the meetings included Center reports, evaluation of the CGIAR Board Orientation Program, CGIAR structure and membership, donor performance assessment, updates from the task forces of the CDC and Future Harvest, and lessons learned from the Challenge Programs.

Dr Per Pinstrup-Andersen (right), Chair, Science Council, addressing the inaugural meeting of the Science Council, at ICARDA headquarters in Aleppo, 12 May 2004.

Prof. Dr Adel El-Beltagy, Director General, participated in an international conference on "Living with the Desert" held in Tokyo, Japan. The aim of the conference was to review global research on managing dryland natural resources and anthropogenic adaptation to the desert. He made a keynote presentation on "Harnessing New Science to Combat Desertification," in which he described the need for a holistic approach which focuses on technological interventions that address land, water, and food security problems.

The Second International Conference on Sunn pest was held at ICARDA in July on the theme "Enhancing International Cereal Production for Food Security." The conference attracted more than 130 participants, who made 50 oral and 30 poster presentations on a variety of topics including the socioeconomics, integrated management, and biology and ecology of Sunn pest.

ICARDA was well represented at the 2004 Annual General Meeting (AGM04) of the CGIAR, held in Mexico in October. The Center organized a special luncheon meeting for the CGIAR Program for Central Asia and the Caucasus, and co-hosted with ICRISAT a meeting on Desertification, Drought, Poverty and Agriculture.

An international workshop on "Grass Pea as a Food and Feed Crop" was held at ICARDA in November. It aimed to establish partnerships for research and development on grass pea, share knowledge on grass pea as a food and feed crop, and develop a project proposal to scale-out low-toxin grass pea technologies to improve food security and soil productivity in Africa and Asia. Participants came from Africa, Asia, Australia, Europe, and the United States of America.

Members of the CBC and CDC and other participants who attended the Science Council, CBC, and CDC meetings at ICARDA.

Luncheon meeting on Desertification, Drought, Poverty and Agriculture at AGM04. Left to right: Dr Ali Ahoonmanesh, Deputy Minister of Agriculture and Head of AREO, Iran; Dr William Erskine, ADG (Research), ICARDA; Prof. Dr Adel El-Beltagy, DG, ICARDA; Dr Douglas Wholley from IFAD; and Dr Barry Shapiro from ICRISAT.

ICARDA established a country office in Islamabad, Pakistan, to further strengthen the Center's long-standing partnership with the country and fulfill its commitment to improve productivity of crops and livestock, and alleviate rural poverty in the dry areas. The new office was inaugurated by H.E. Mr Sikandar Hayat Khan Bosan, Federal Minister of Food, Agriculture and Livestock, Pakistan, and Prof. Dr Adel El-Beltagy, Director General of ICARDA, on 8 November 2004.

Fostering Development of Dry Areas

- Focusing on the poor in Sub-Saharan Africa (SSA), ICARDA continued its collaborative research in Sudan, Ethiopia and Eritrea on enhancing food security through the generation of sustainable production technologies for cereals and cool-season food legumes. In Eritrea, a new project on "Improving Water Productivity of Cereals and Food Legumes in the Atbara River Basin," within the Challenge Program on Water and Food, was launched. A collaborative project with Mauritania on natural resource management started in 2004. This is complementing activities initiated with the Canada-for-Africa funding, which is also being used for specific interventions in Eritrea, Ethiopia, and Sudan.

- ICARDA is providing major support to integrated research on dryland resource management in Pakistan within the IFAD-funded Barani Village Development Project.

- In 2004, the Minister of Agriculture of Bangladesh recognized the impact on lentil production in Bangladesh of new cultivars at a "BARI/ICARDA Day, held in Dhaka." Strong links with NARS in germplasm improvement of cereals (barley and wheat) and food legumes (lentils, kabuli chickpea, faba bean and low-neurotoxin grass pea) continue through germplasm exchange and training activities in Bangladesh, India, Nepal and Pakistan, and to a lesser degree in Bhutan, China, South Korea, Sri Lanka, and Vietnam.

Prof. Dr Adel El-Beltagy, ICARDA DG, unveiling the foundation plaque during the inauguration of ICARDA's country office in Islamabad, Pakistan. Looking on (left to right): H.E. Mr Sikandar Hayat Khan Bosan, Federal Minister of Food, Agriculture and Livestock; Dr Badaruddin Somroo, Chairman, PARC; Mr Mumtaz Ahmed, Additional Secretary, Ministry of Food, Agriculture and Livestock, Pakistan; and Dr Adel Aboul Naga, Senior Advisor to the DG, ICARDA.

- ICARDA continued to lead the CGIAR Ecoregional Program for Sustainable Agricultural Development in Central Asia and the Caucasus (EP-CAC), in partnership with CIMMYT, CIP, ICRISAT, IFPRI, ILRI, IPGRI, ISNAR, IWMI, IRRI, AVRDC, and ICBA. The program is organized under five broad themes: (1). Productivity of Agricultural Systems, (2). Natural Resource Conservation and Management, (3). Conservation and Evaluation of Genetic Resources, (4). Socioeconomic and Public Policy Research, and (5). Strengthening National Programs. These themes provide the overall framework in which specific projects are developed and implemented in partnership between NARS and participating Centers.

- ICARDA continued to participate in six Systemwide Programs: SGRP, SLP, SP-IPM, CAPRi, SWNM, PRGA, and the Comprehensive Assessment of Water Management. The Center is an active partner in six of the IT-KM projects, and leads the project on "Utilization of Intelligent Information for Plant Protection."

Mr Mohammad Abdul Sattar (center), a lentil farmer in Pabna, Bangladesh, was honored for his contributions to technology adoption and dissemination. Left to right: Dr William Erskine, ADG (Research), ICARDA; Prof. Dr Adel El-Beltagy, ICARDA DG; Mr Omar Ali, Pulse Agronomist, BARI; Dr M.S. Islam, BARI DG; and Dr M.M. Rahman, Director of Research, BARI.

- ICARDA continued to participate in three pilot Challenge Programs:
  Water and Food: ICARDA has received funding for three projects through the competitive grants program: two for the Karkheh River Basin, Iran project, and one for the Nile River Basin project within Eritrea.
  HarvestPlus: ICARDA is responsible to identify barley and lentil germplasm with high concentration of β-carotene, iron, and zinc.
  Generation: ICARDA is a full member of this Challenge Program and is involved in a series of commissioned research and one competitive grant project.

- ICARDA is co-convener with ICRISAT of a Challenge Program pre-proposal on Desertification, Poverty and Drought (DDPA), which is evolving into a Consortium mode.

- ICARDA is currently convener of the INRM group of CDC. The Center is also an active partner in the Consortium for Spatial Information (CSI) and the International Crop Information System (ICIS) network.

- ICARDA leads the Future Harvest Consortium to Rebuild Agriculture in Afghanistan (FHCRAA) and has formed a similar Consortium to Rebuild Agriculture in Iraq.

- ICARDA's cooperation in Latin America has focused on the provision of germplasm of its global mandate crops. A barley breeder operates from CIMMYT, Mexico, for the genetic improvement of barley for the Andean region and for favorable environments globally. The State of Mexico released a variety of faba bean in 2004, derived from ICARDA germplasm, with tolerance to chocolate spot.

- An IFAD-funded project on strengthening institutional capacity to improve marketing of small ruminant products and income generation in dry areas of Latin America was started in partnership with FAO and NARS.

Participants of the workshop on "Capacity Building for Combating Desertification" in front of the Central Dome of the Arid Land Research Center (ALRC), Tottori University, Japan. The workshop followed an international conference on "Living with the Desert," held in Tokyo on 19-20 May 2004. ICARDA made major scientific contributions to both activities.

Awards for Excellence in Science

Prof. Dr Adel El-Beltagy, Director General, received an honorary doctorate and the academic status of Honorable Professor from the Azerbaijan Agricultural Academy, in recognition of his contributions to promoting agricultural research and development in Azerbaijan.

Prof. El-Beltagy also received the Sahara and Sahel Observatory (OSS) Honorary Medal for his valuable contributions to OSS since its inception.

Dr Mohan C. Saxena, Assistant Director General (At-Large), received an honorary doctorate degree from the Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India, for his outstanding contributions to agricultural research.

Dr Rajendra S. Paroda, Regional Coordinator, Regional Program for Central Asia and the Caucasus (CAC) and Head of the Program Facilitation Unit of the CGIAR, received the following honors and awards in recognition of his contributions to agricultural research and development in developing countries:

- Honorary doctorate degree from the Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India.
- Diploma of Honorary Professorship of Samarkand State University, Uzbekistan.
- Honorary doctorate degree from the Azerbaijan Agricultural Academy.

Dr John Ryan, Soil Fertility Scientist, won the 2004 International Service in Agronomy Award of the American Society of Agronomy (ASA). He was also appointed member of the International Crop Science Committee (ICSC) for a three-year term by the Crop Science Society of America (CSSA).

Dr Shibani Ghosh, a PhD student at ICARDA, won first place for her poster on 'Growth Status of Children in North-West Syria: A Comparison of Three Rural Livelihood Groups' at the 7th annual student poster presentation at the School of Public Health and Health Sciences at the University of Massachusetts, USA.

Working to Restore Agricultural Systems in Conflict-Affected Areas

ICARDA contined its work to rebuild agricultural systems in Afghanistan. Under the Research in Alternative Livelihoods Fund (RALF) project, the Center is working to develop and promote innovative alternative livelihood options for rural Afghans currently economically dependent on opium poppy. ICARDA is also working on improving technology transfer, establishing village-based seed enterprises, and introducing protected agriculture in Afghanistan under the Rebuilding Agricultural Markets in Afghanistan (RAMP) program. RALF is funded by DFID, and RAMP by USAID.

The Center is also helping to rebuild Iraq's agriculture. ICARDA held meetings with Iraqi officials to develop collaborative projects on human resource development and capacity building; participation in regional and international scientific conferences and workshops; exchange of adapted germplasm and improved varieties; and organization of demonstration trials and farmer field days and study tours.

Important Visitors to ICARDA

ICARDA hosted a number of distinguished visitors from various countries during 2004. H.E. Honorable Kim Chance, the Western Australia Minister of Agriculture, led a delegation to the Center in February.

The delegation met with ICARDA senior management and discussed research projects funded by Australia and potential areas for future collaboration.

The Center hosted a delegation from the Belgian Parliament, also in February. The delegation was led by Honorable Senator Anne-Marie Lizin, President, Senate Commission for Foreign Affairs and Defense, who was particularly interested in the Center's work in enhancing the sustainable use of limited water resources in the region and in the collection and use of genetic resources for the development of agriculture in the dry areas.

The Assistant Director General of the FAO, Dr Henri Carsalade, visited ICARDA in April. He reviewed the past and present collaborative activities between the FAO and ICARDA, including participation in various Technical Cooperation Programs, (TCP), regional networks, and work in Afghanistan, Pakistan, and Iraq.

Mr Lennart Båge, President of the International Fund for Agricultural Development (IFAD), visited ICARDA in May. He was accompanied by Dr Abdulmajid Slama, Director of the Near East and North Africa (NENA) Division of IFAD; Dr Abdelhamid Abdouli, Country Portfolio Manager for NENA Division; and Ms Farhana Haque Rahman, Coordinator, Communications Special Program of IFAD. The delegation had the opportunity to get a first-hand view of the physical facilities and research that resulted from their partnership with the Center. Prof. Dr El-Beltagy expressed ICARDA's gratitude for IFAD's generous support for the construction of the Administration and Training Building of the Center. He also acknowledged IFAD's continued support for research on improving the livelihoods of rural communities in the dry areas.

Prof. Dr Adel El-Beltagy (left), Director General, briefing Mr Lennart Båge (right), President of IFAD, and H.E. Prof. Dr Adel Safar, Minister of Agriculture and Agrarian Reform in Syria, on their visit to ICARDA in May 2004.

The Director General, Prof. Dr Adel El-Beltagy (right) with the Western Australia Minister of Agriculture, H.E. Mr Kim Chance (center) and his wife, who led an Australian delegation to ICARDA in January 2004.

New crop varieties released in 2004

Globa Mandate Crops	
Barley	'Athroh,' 'Yarmouk,' and 'Muta'a', in Jordan; 'Furat 6' in Syria
Lentil	'Tershale' and 'Alem Tina' in Ethiopia; 'Chaouina' and 'Abda' in Morocco
Faba Bean	'San Isidro' in Mexico
Regional Mandate Crops	
Durum	'Gidara-2' in Turkey; 'Cham 7,' 'Bohouth 9,' and 'Bohouth 11' in Syria
Winter and Facultative Bread Wheat	'Azibrosh,' 'Jamin,' and 'Zubkov' in Kyrgyzstan
Spring Bread Wheat	'Azametly-95,' and 'Nurlu-99' in Azerbaijan; 'Cham 10,' and 'Douma 2' in Syria
Chickpea	'Habru,' and 'Chefe' in Ethiopia; 'Kimberley Large,' 'CLIMA kabuli 1,' 'CLIMA kabuli 2,' and 'CLIMA kabuli 3' in Australia; 'Arman' in Iran; 'Beja 1' in Tunisia
Forage Legumes	'ALI-BAR' in Kazakhstan; 'Oguz-2002,' 'Anadolu pembesi-2002,' 'Segmen-2002,' 'Baydurbey-2002,' 'Gürbüz-2001,' and 'Tarman-2002' in Turkey

ICARDA's Research Portfolio

ICARDA has adopted a project-based system since 1998, outlined in this chapter, of conducting and administering its research and training activities.

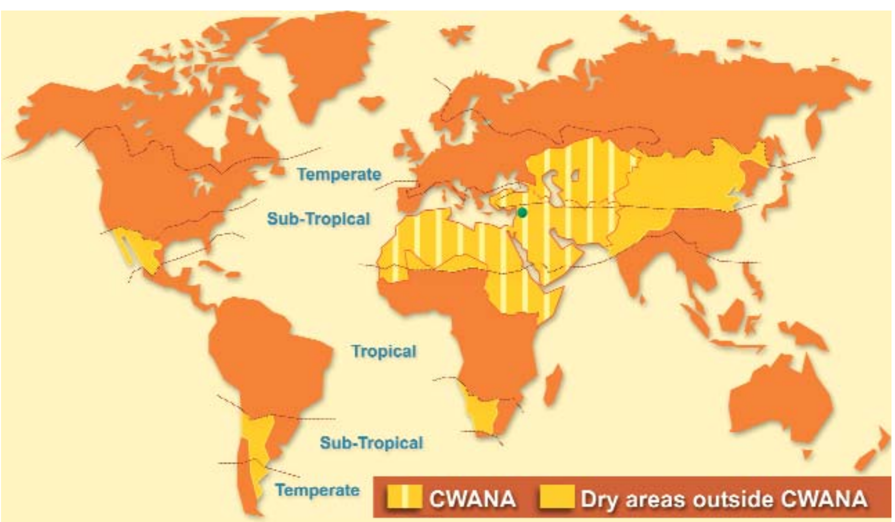
While detailed descriptions of all projects can be found at ICARDA's website (www.icarda.org), the pages that follow present some key achievements made in each project during 2004.

Agricultural systems in the dry areas are dynamic. Global linking of national economies and urban market development are creating new, more intensive, and more diverse demands on agricultural producers. The demographic pressure on the land combined with the need to produce more food from a limited resource base is forcing producers to follow practices that maximize short-term returns at the expense of long-term sustainability.

Environmental resource degradation and human poverty are most pronounced in low-potential agricultural environments, particularly those with low and uncertain rainfall, in mountainous areas, and in the rangelands. Rural to urban, as well as international migration, is widespread, particularly in the Mediterranean region, and threatens social, political, and economic stability.

To deal with the challenges of poverty, food insecurity and resource degradation, ICARDA's research agenda is built around five general themes:

1. Crop Germplasm Enhancement
2. Production Systems Management
3. Natural Resource Management
4. Socioeconomics and Policy
5. Institutional Strengthening



The eco-geographic mandate of ICARDA's research covers the countries of Central and West Asia and North Africa (CWANA), as well as other developing countries with subtropical and temperate dry areas. The term 'dry areas,' in the context of ICARDA's research program, refers to those areas where the length of the crop growing period is less than 180 days because of the limitation of rainfall.

Theme 1. Crop Germplasm Enhancement

This theme includes six projects, each developed around a particular crop or group of crops. The overall goal of the projects is to steadily increase yield and stability through genetic improvement and water-use efficiency, with special emphasis on less favored environments and low external-input systems. The strategy is to produce cultivars with stable year-to-year yield adapted to the environments in which they will be grown. The projects are multidisciplinary, with research targeted to specific dry-area farming systems. As such, they integrate genetic improvement with production systems, resource management, and socioeconomic and policy considerations. ICARDA is an active partner in the CGIAR Challenge Program on Biofortified Crops for Improved Nutrition. "Harvest Plus." It is also a partner in the "Generation Challenge Program."

The following projects are in operation under this theme:

Project 1.1. Barley Germplasm Improvement for Increased Productivity and Yield Stability

Project 1.2. Durum Wheat Germplasm Improvement for Increased Productivity, Yield Stability, and Grain Quality in West Asia and North Africa

Project 1.3. Spring Bread Wheat Germplasm Improvement for Increased Productivity, Yield Stability, and Grain Quality in West Asia and North Africa

Project 1.4. Winter and Facultative Bread Wheat Germplasm Improvement for Increased Yield and Yield Stability in Highlands and Cold Winter Areas of Central and West Asia and North Africa

Project 1.5. Food Legume (Lentil, Kabuli Chickpea, and Faba Bean) Germplasm Improvement for Increased Systems Productivity
Project 1.6. Forage Legume Germplasm Improvement for Increased Feed Production and Systems Productivity in Dry Areas

Theme 2. Production Systems Management

Production systems management draws together all the components of research into a farming systems perspective. This approach enables site-specific results to be blended into recommendations that can be applied to broader target areas. Long-term experiments on the productivity of farming systems, particularly those integrating crops and livestock, and the management of soil and water resources, are geared to optimize cropping sequences and the development of appropriate ways to intensify production in the dry areas. Optimizing soil water use is a particularly important area in which ICARDA is a co-convener with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), of the Optimizing Soil Water Use (OSWU) Program, within a "CGIAR Systemwide Soil Water and Nutrient Management (SWNM) Consortium."

Management of crop pests and diseases is increasingly handled in an integrated fashion in order to reduce the environmental and economic impact of chemical interventions. ICARDA views pest and disease management as a dimension of the entire farming system rather than as one component of the production practices for a single crop. ICARDA participates in three sub-programs of the "CGIAR Systemwide Integrated Pest Management Program."

The following projects are in operation under this theme:

Project 2.1. Integrated Pest Management in Cereal- and Legume-based Cropping Systems in Dry Areas
Project 2.2. Agronomic Management of Cropping Systems for Sustainable Production in Dry Areas
Project 2.3. Improvement of Sown Pasture and Forage Production for Livestock Feed in Dry Areas
Project 2.4. Rehabilitation and Improved Management of Native Pastures and Rangelands in Dry Areas
Project 2.5. Improvement of Small-Ruminant Production in Dry Areas

Theme 3. Natural Resource Management

ICARDA's research on natural resource management aims to promote efficient, integrated, and sustainable use of resources for improved productivity and alleviation of poverty. The Center's research plan responds to the vision expressed at the Lucerne meeting in Switzerland 9-10 February 1995 and to recommendations in TAC's 1995 report, "Priorities and Strategies for Soil and Water Aspects of Natural Resource Management Research in the CGIAR," and the Maurice Strong report on "Systemwide Review, 1999." ICARDA is an active partner in the CGIAR Challenge Program on "Water and Food." While water and its availability are the key issues in the dry areas and are accorded the highest priority, soil, agricultural biodiversity, and land use are all closely linked. ICARDA maintains a strong Genetic Resources Unit with a holding of 132,831 accessions and participates in the "Systemwide Genetic Resource Program."

ICARDA is responding to the urgent need for higher productivity using less water by substantially increasing its research investment on improved and sustainable water-use efficiency at the farm level. The Center leads the work in this field and contributes to the "CGIAR Systemwide Program on Water Management," coordinated by the International Water Management Institute (IWMI). In this program, on-farm water management is integrated in an overall water-basin perspective.

The following projects are in operation under this theme:

Project 3.1. Water Resource Conservation and Management for Agricultural Production in Dry Areas
Project 3.2. Land Management and Soil Conservation to Sustain Rural Livelihoods of Dry Areas
Project 3.3. Agrobiodiversity Collection and Conservation for Sustainable Production
Project 3.4. Agroecological Characterization for Agricultural Research, Crop Management, and Development Planning

Theme 4. Socioeconomics and Policy

Socioeconomic and policy research provides gender, market, cultural and end-user perspectives that can help in promoting the adoption of new technologies and enhance the impact and benefits of ICARDA's research. Particular emphasis is placed on participatory research methods for problem identification, technology evaluation and selection that complement the formal analytical methods already in use. The strategy is to build upon the knowledge, perspectives, and innovative capacities of farmers and local communities in finding solutions to production and resource-management problems.

As part of its new strategy, ICARDA is devoting increased attention to natural resource management, especially water, formal methods of resource and environmental economics, and farmers' participatory research to understand how resource degradation, productivity, and conservation are related. Operational guidelines on resource use for farmers, pastoralists, extensionists and policy makers are being identified. Development of local institutions is being investigated and institutional innovations that mitigate natural resource degradation and enhance collective action are being promoted.

The following projects are in operation under this theme:
Project 4.1. Socioeconomics of Natural Resource Management in Dry Areas
Project 4.2. Socioeconomics of Agricultural Production Systems in Dry Areas
Project 4.3. Policy and Public Management Research in West Asia and North Africa

Theme 5. Institutional Strengthening

ICARDA has a strong program of technical assistance to National Agricultural Research Systems' (NARS) seed-production efforts. While supporting this essential activity, the Center emphasizes the needs of the informal seed sector to stimulate improvements that are not adequately met by existing services. These include partnerships with government agencies, farming communities and NGOs, and opening up the possibility of new initiatives by the private sector.

The following project is in operation under this theme:
Project 5.1. Strengthening National Seed Systems in Central and West Asia and North Africa

Training

Training is an integral part of ICARDA's research projects. The Center's research partnerships with NARS are strengthened implicitly by colleague-to-colleague training. Increasingly, the Center is out-sourcing its training activities to make the best use of the expertise that is becoming available in NARS. Training focuses on improved quality and effectiveness, and on achieving multiplier effects through training the NARS trainers. ICARDA encourages greater participation of women scientists from NARS in its training programs.

Key Features of ICARDA's Research Stations

ICARDA operates two experimental station sites in Syria, including the main research station at Tel Hadya, near Aleppo, and two sites in Lebanon. These sites represent a variety of agroclimatic conditions, typical of those found in the CWANA region.

ICARDA and the Lebanese Agricultural Research Institute (LARI) now share the use of the sites in Lebanon. ICARDA uses these sites for commodity research trials in winter, and for off-season advance of breeding material and for rust screening in cereals in summer.

ICARDA Sites in Syria and Lebanon

Sites	Coordinates		Approx. elevation (m)	Area (ha)	Rainfall data for 2002/03		Rainfall data for 2003/04	
	Latitude	Longitude			Total precipitation (mm)*	Long-term average (mm)	Total precipitation (mm)*	Long-term average (mm)
SYRIA								
Tel Hadya	36.01° N	36.56° E	284	948	492.0	349.2 (25 seasons)	400.2	351.6 (26 seasons)
Breda	35.56° N	37.10° E	300	95	386.4	274.2 (23 seasons)	303.4	275.4 (24 seasons)
LEBANON								
Terbol	33.49° N	35.59° E	890	23	994.8	537.0 (23 seasons)	549.8	537.5 (24 seasons)
Kfardane	34.01° N	36.03° E	1080	11	868.7	454.1 (9 seasons)	539.0	462.6 (10 seasons)

Note: The rainfall data reported in the ICARDA Annual Report for 2003 was for the 2003/04 season, not for the 2002/03 season. For clarity, data for both 2002/03 and 2003/04 seasons are reported in the table above.

Theme 1

Crop Germplasm Enhancement

Project 1.1.

Barley Germplasm Improvement for Increased Productivity and Yield Stability

Barley, *Hordeum vulgare* L., was probably the first cereal crop cultivated for human consumption in the Fertile Crescent thousands of years ago. Archaeological evidence suggests that barley was once more popular than wheat in North Africa. Today, barley is widely grown for animal feed, and for making malt. However, it is still an important staple food for many of the world's poor living in regions of high altitude and low rainfall. In 2004, high-yielding, drought-resistant lines derived from wild barley performed well on farm. Quantitative trait loci (QTLs) for useful agronomic traits in a wild × cultivated barley cross were mapped to improve breeding efficiency. In Ethiopia and Eritrea, wild barley accessions resistant to different leaf blights were identified for use in breeding programs. Researchers also found 45 new sources of resistance to the Russian wheat aphid. In on-farm trials in Iraq, improved barley varieties outyielded locally used varieties. In addition, in Eritrea, researchers identified new barley lines that yielded well individually and in traditional barley-wheat mixtures. Promising barley lines were shared with national partners for the benefit of farmers in dry areas.

One of the new drought-tolerant barley lines planted in Hassakeh province, Syria.

New drought-resistant barley lines

To breed high-yielding barley cultivars for low-rainfall areas (250 mm per year or less), selection needs to be conducted in the target environment and must be based on locally adapted landraces and wild relatives. Since 1987, ICARDA has been working to exploit the drought tolerance of *Hordeum spontaneum*, the wild progenitor of cultivated barley, by crossing it with local landraces.

In 2004, five improved barley lines were tested on 10 farms in Syria. These lines were chosen because they performed well during a serious drought in 2000, when they produced 300-500 kg/ha of grain and 500-3000 kg/ha of biomass (see ICARDA Annual Report 2000, p. 11). Four of these lines were derived from crosses between *H. spontaneum* × local landrace. Local extension services distributed the five lines to 10 farmers (one to each farmer) in Hassakeh province in northeast Syria. One line and one local landrace were compared per farm. The 10 farms fall within two of the driest barley-growing zones in Syria (zones 3 and 4[1]), making drought resistance a high priority in these areas.

Less than 200 mm of rain fell during the season, and yields ranged from less than 400 kg/ha to slightly more than 1000 kg/ha (Fig. 1). One of the farmers (Farmer 8) experienced complete crop failure; and five farmers were only able to harvest the new drought-resistant lines. However, four farmers harvested both the local landrace and

[1] Zone 3: Average annual rainfall over 250 mm. Zone 4: Average annual rainfall between 200 and 250 mm.

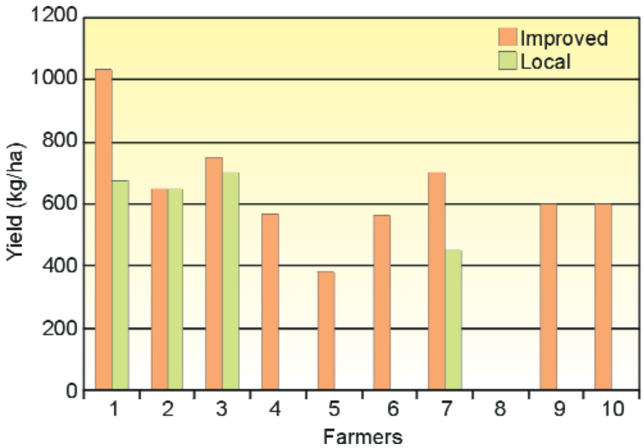


Fig. 1. Grain yield of new drought-tolerant barley lines and local checks in 10 farmers' fields. Because of drought, the local check failed to produce grain in six fields.

the new drought-tolerant line. In these cases, the new lines yielded 7-50% more than the local landraces. In 2005, extension services will disseminate more seed to farmers in the province to allow them to plant larger areas with these high-yielding, drought-resistant lines.

QTLs for straw traits identified in recombinant inbred lines of the cross 'Arta' x *Hordeum spontaneum* 41-1

The objective of this study was to identify trait-marker linkages in a population of recombinant inbred lines (RILs) of a cross between the *H. vulgare* cv 'Arta' and *H. spontaneum* 41-1 using the QTL approach. Of particular interest was to analyze straw characteristics and determine the locations of the genes involved in their control.

One hundred and ninety-four RILs were used to construct a genetic linkage map (Fig. 2). Total genomic DNA was extracted and genetic mapping was carried out using Amplified Fragment Length Polymorphic (AFLP) markers and microsatellite-based markers. The linkage map based on the 'Arta' x *H. spontaneum* 41-1 population originally contained 189 marker loci, including 1 morphological marker locus (*btr* = brittle rachis). For the purpose of the QTL analysis, a reduced map was constructed containing 129 marker loci. The Join Map v. 2.0 software package was employed for map construction and recombination fractions were converted to centiMorgans (cM) according to the Kosambi's mapping function. The QTL analysis was performed using Windows QTL Cartographer v. 2.0. The LR-value of the locus originates either from Multi Trait Analysis or from composite interval analysis. The effect and the explained phenotypic variance were estimated by Multi Interval Mapping.

F_7 RILs, derived by single seed descent from the cross between the *H. vulgare* cv 'Arta' and *H. spontaneum* 41-1, were planted with the parents in the cropping seasons 1996/97 and 1997/98, at ICARDA's research stations located near Tel Hadya and near Breda in Syria and 184 of the RILs evaluated for the straw traits. Straw samples were milled and analyzed by NIRS. The traits measured were: acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin (LIG), dry organic matter digestibility (DOM), voluntary intake (DMI), crude protein (CP), and ash percentage (ASH).

Ten QTLs were detected for ADL, but none of them was common between the environments. The QTLs detected in *Br97* explained in total 18.6% of the phenotypic variation and the ones found in *Th97* explained 19.2%. For NDF, one QTL was detected being common to two environments (1H-1: *Br98* and *Th98*). Eleven QTLs were localized for LIG. One of them was common to two environments (6H-7 in *Br97* and *Br98*). For DOM, 12 QTLs were localized; one of them was common to *Br98* and *Th98* (on 5H-4). Twelve QTLs were localized for DMI, one of which common to *Br97* and *Th98* (on 1H-8) and one to *Br98* and *Th98* (on 5H-5). Only for these two QTLs, the *H. spontaneum* line contributed the allele with the higher value, while for all other QTLs detected for this trait, the higher allele was found in 'Arta.' Specific QTLs for DMI were detected in *Br97*, *Br98*, and *Th98*. No QTLs were found in *Th97*. The phenotypic variance explained was about 30 %. For CP, no QTLs were found in *Br97*, while one QTL was common to *Th97* and *Th98* (on 5H-5) and three additional specific QTLs were localized. Like in the case of LIG, DOM and DMI, the origin of the allele with the higher value for the locus on 5H-5 was opposite to the rest of the QTLs: in this case, it was the only QTL where the *H. spontaneum* line contributed the allele leading to the higher value of the trait. QTLs for ASH were found only in *Br98*. Five QTLs were identified, explaining together 25.8 % of the phenotypic variance. Some of the QTLs identified would be good candidates for exploitation by marker-assisted selection.

The feeding value of barley straw is of great importance. In years with favorable rainfall the feeding value is generally poor, but high straw yields permit the straw

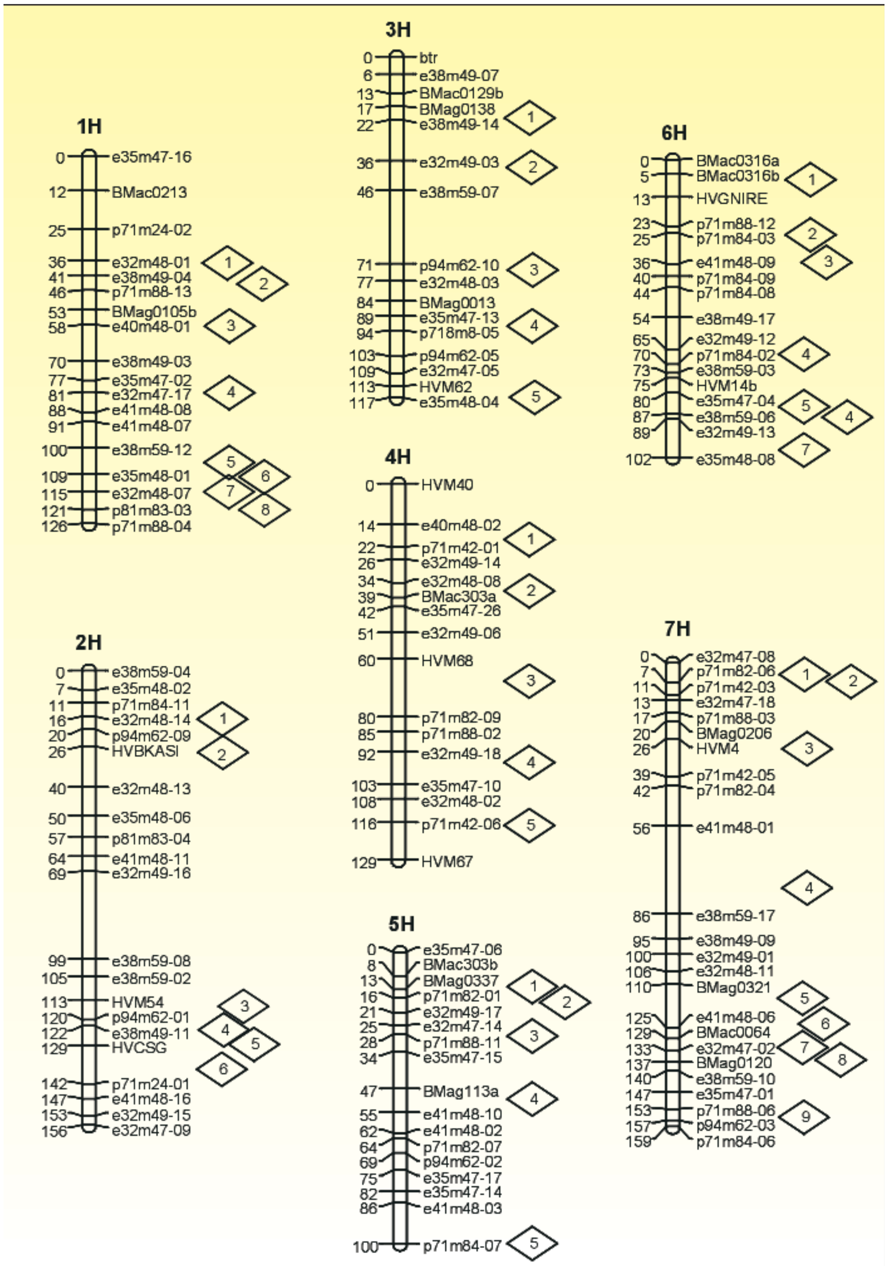


Fig. 2. Linkage map of the cross 'Arta' x *H. spontaneum* 41-1 with positions of QTLs on the right side of the chromosomes.

to be stored for future years. Conditions likely to decrease grain yield tend to increase the feeding value of straw, such as low winter minimum temperature, low rainfall during vegetative growth, and high temperature during grain maturation. Precipitation before January affects the yield of grain and straw but has little effect on the feeding value of straw. Two negative correlations between feeding value and agronomic traits were found: with plant height under drought, and with lodging resistance. These factors would compromise yield and harvestability in dry and wet conditions, respectively.

Searching for resistance to barley leaf blights

Barley is an important crop in the Horn of Africa, especially in Ethiopia and Eritrea, where it is used to produce food, traditional drinks, and animal feed, as well as bedding for animals and thatch for buildings. However, different diseases reduce the quantity and quality of the barley produced, and can cause the crop to fail. ICARDA is breeding leaf blight resistant barley cultivars for the area. However, because leaf blight pathogens can adapt and overcome host-plant resistance, researchers constantly have to identify new resistance genes. An important source of such genes is the wild progenitor of barley, *Hordeum spontaneum*, which co-evolved with these pathogens.

To characterize and exploit this rich pool of agronomically important traits, ICARDA researchers tested 350 accessions of *H. spontaneum* for resistance to scald, bacterial stripe, powdery mildew, and the net and spot forms of net blotch. Testing was carried out under natural and artificial infection in the field, in glasshouses using seedlings, and in the laboratory using detached leaf tests.

Field tests in Eritrea showed adequate levels of qualitative resistance to the net form of net blotch (31%), the spot form of net blotch (8%), and bacterial stripe (17%). More than 50% of the accessions showed quantitative resistance to the above diseases. Under natural infection at Tel Hadya, Syria, in 2003, 27% of the accessions tested were moderately resistant to powdery mildew, while 45% were highly resistant.

The same accessions were also tested for their reaction to two Ethiopian scald pathotypes, one with very high virulence and the other with very low virulence, in a controlled environment. Researchers found that 47% of the accessions were resistant to the high-virulence pathotype and 57% to the low-virulence pathotype; 12% of the accessions showed combined resistance to both pathotypes. Separate tests using the detached-leaf testing method showed that 86% of the accessions were resistant to Syrian isolates of net blotch.

Screening barley lines for resistance to Russian wheat aphid (RWA). Lines showing poor growth are susceptible to RWA.

New sources of resistance to Russian wheat aphid

Host-plant resistance is the most economical and practical method of controlling Russian wheat aphid (*Diuraphis noxia*), an important pest of barley in Algeria, Ethiopia, Morocco, Tunisia, Turkey and Yemen. ICARDA screened thousands of barley entries from different origins for resistance to this pest at its Tel Hadya research station.

Entries were first screened in the field in hill plots (10 seeds per hill), with a susceptible check being planted after every tenth entry. At the tillering stage, each plant was infested with 10 aphids. Once symptoms were clearly visible on the susceptible checks, entries were evaluated for leaf rolling using a scale of 1-3, and for leaf chlorosis using a scale of 1-6. Promising entries were then grown in a greenhouse for confirmation. Individual plants were infested with 10 aphids at the one-leaf stage and then evaluated.

Forty-five entries scored 1 on the leaf-rolling scale and less than 3 on the leaf-chlorosis scale, which indicated a good level of resistance. Of these resistant entries, 18 were *H. spontaneum* accessions from Jordan and 22 landraces from Afghanistan. The final five were landraces from Armenia, Kyrgyzstan, Russia, Turkmenistan, and Uzbekistan. These resistant lines will be used to widen the genetic base of resistance to the aphid and develop new resistant varieties.

Improved barley varieties for Iraq

ICARDA is working with the national program of Iraq to rebuild the country's agricultural sector, improve rural livelihoods, and reduce the country's dependence on imported food. Since the early 1990s, several barley varieties have been tested and released in Iraq. 'Rihane-03' was particularly successful, and within three years of its release in 1993 was being grown on 250,000 hectares. In 2004, 'Rihane-03' was further tested for its performance against a local check and an improved variety 'Furat-1,' which was released in Syria. 'Rihane-03' outyielded the local check by 58% and the Syrian variety by 37%, proving its usefulness in Iraq's moderate-rainfall areas. Nineveh's State Board of Agricultural Research began disseminating 'Rihane-03' more widely in Iraq.

In 2004, two other ICARDA barley varieties, 'Tadmor' and 'Zanbaka,' performed well in Iraq's driest areas. Both these lines are descendents of the black-seeded Syrian landrace Arabi Aswad, which is widely cultivated in most of northeast Syria and is similar to Iraqi Black, the landrace traditionally grown in Iraq. Both 'Tadmor' and 'Zanbaka' proved to be well-adapted to the dry areas of Nineveh province, outyielding the local check by 47% and 26%, respectively, under a wide range of stress conditions (Fig. 3). Both these varieties are now being distributed by Nineveh's State Board of Agricultural Research.

Increasing water productivity in Eritrea through participatory plant breeding

War, droughts, and famine in Eritrea have caused food production to fall by around 60% over the last decade. In 1997, two-thirds of the population was undernourished and 40% of children under the age of five suffered from malnutrition.

With the support of the CGIAR's Challenge Program on

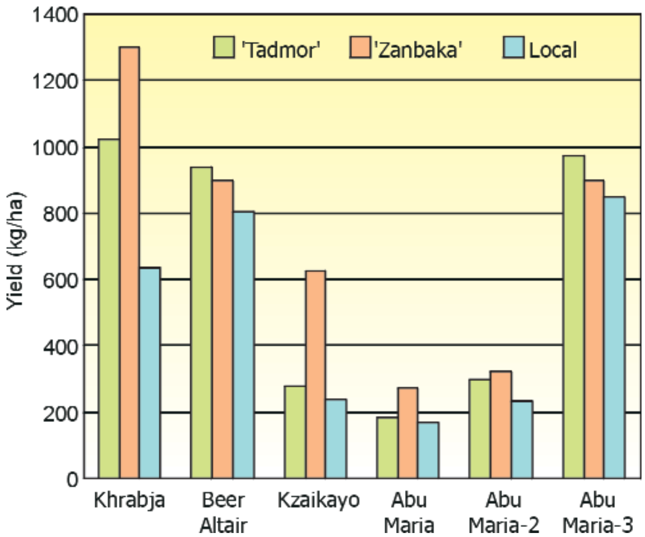


Fig. 3. Evaluation of ICARDA barley varieties 'Tadmor' and 'Zanbaka' at six low-rainfall sites in Iraq.

Male and female farmers selecting barley lines in Tera'emni, Eritrea.

Water and Food, ICARDA is working to increase the water productivity (yield per unit of water used) of the country's crops. In 2004, a multi-disciplinary team of researchers from ICARDA, the CGIAR System-wide Program on Participatory Research and Gender Analysis, Eritrea's Ministry of Agriculture, Asmara University, and other development agencies conducted research on water-use efficiency of barley, an important staple crop in Eritrea's highlands. In these areas, barley and wheat are often grown together in a mixture known as *hanfetse*, which is less vulnerable to disease and produces better tasting bread.

Barley and wheat field trials were established at Halhale research station, as well as on five farms in Tera'emni, Dekemhare, Serejeka, Adiguadad, and Mendefera. The trials used local germplasm from the National Agricultural Research Institute's genebank and the best performing barley and wheat entries from a previous participatory program.

Data were collected on early vigor, days to heading and maturity, plant height, spike length, kernel size, and grain and biomass yield.

Genotype × Environment interactions were large, varying from around 60% in barley to nearly 70% in wheat. At Serejeka, the local checks outyielded all the new barley and wheat germplasm. However, at all other locations, the new germplasm outyielded the local checks—by up to 159% in barley (Fig. 4) and 40% in wheat. The yield gains achieved were much larger at Halhale research station than in farmers' fields. The project also organized field days at the trial sites in Tera'emni, Serejeka, and Dekemhare.

At Tera'emni, Serejeka, and Adiguadad, researchers also tested *hanfetse* barley–wheat mixtures, using all 16 possible combinations of four popular wheat varieties ('Manna,' 'Pavon 78,' 'Kenya,' and

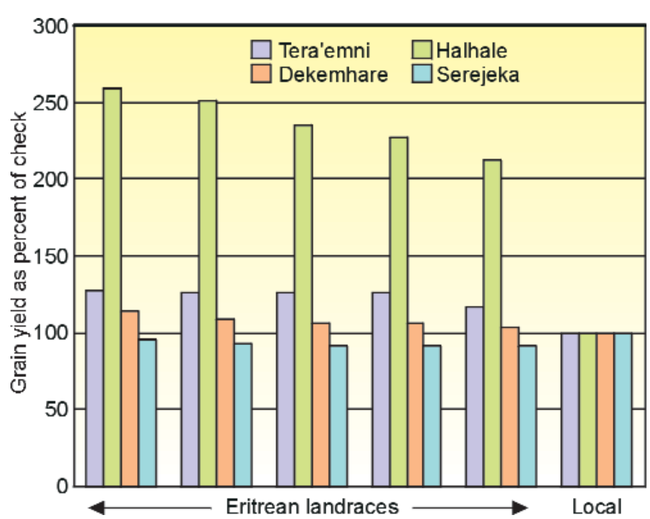


Fig. 4. Grain yield of five Eritrean landraces of barley in four locations, expressed as a percentage of the grain yield as percent of the local check.

'HAR1685') and four barley varieties ('Kulih,' 'Yeha,' 'Atsa,' and 'Kunto'). These were compared with locally grown *hanfetse*. At Serejeka and Adiguadad, the new mixtures outyielded the local mixtures by 20% or more. However, at Tera'emni, the local *hanfetse* outyielded the new mixtures (Fig. 5). At all three locations, barley–wheat mixtures yielded more than barley and wheat varieties grown separately; 'Yeha'–'Pavon 78' was always the highest yielding new mixture. However, when grown individually, the most productive varieties were 'Pavon 78' (wheat) and 'Atsa' (barley).

At Serejeka, researchers also assessed which mixtures and varieties male and female farmers preferred. Twenty-seven farmers (20 men and 7 women) participated by assigning scores to each variety: high scores indicated a strong preference. The preferences of men and women were similar, as there was a strong positive correlation between their scores (r = 0.805). However, the women's scores were more closely correlated with grain yield than the men's. Men and women strongly preferred short plants, early heading, and early maturity in both the barley and the wheat components of the *hanfetse*, and long spikes in the barley component. A number of the new *hanfetse*, such as 'Kulih'–'HAR1685,' 'Atsa'–'HAR1685,' and 'Yeha'–'Pavon 78,' were preferred by both the men and women. Another, 'Kulih'–'Kenya,' was chosen as one of the best mixtures by the men but not by the women.

The data collected on yields and farmers' preferences will be used by the participatory breeding program to develop improved barley, wheat, and *hanfetse*, and increase the water productivity and sustainability of Eritrea's agricultural production systems.

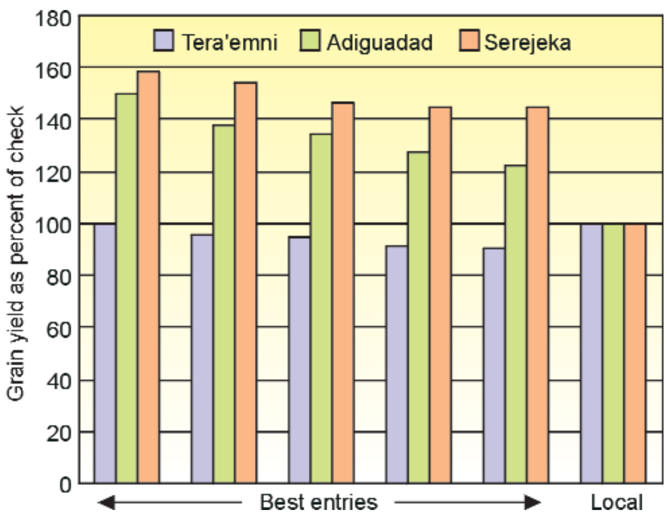


Fig. 5. Grain yield of the highest yielding wheat and barley mixtures (*hanfetse*) tested in three locations, expressed as a percentage of the yield of the local mixtures.

Wheat-and-barley-mixture (*hanfetse*) plots at Serejeka, Eritrea.

Researchers from the National Agricultural Research Institute in Eritrea in a wheat trial planted at Halhale research station.

Project 1.2.

Durum Germplasm Improvement for Increased Productivity, Yield Stability, and Grain Quality in CWANA

Over the years, ICARDA has made steady progress in breeding durum wheat for increased productivity, yield stability, and grain quality. Selection based on morpho-physiological traits has already improved drought tolerance in durum. In 2004, researchers used chlorophyll-fluorescence screening techniques to identify durum lines that photosynthesize efficiently under drought and extreme temperatures. Research has already begun to find molecular markers linked to chlorophyll-fluorescence parameters for use in marker-assisted selection to improve yields and yield stability in dry areas.

Breeding for drought resistance using physiological tools

Over the last two decades, ICARDA studies have shown that selection based on morpho-physiological traits can improve durum wheat yields under dryland conditions. Mediterranean landraces of durum wheat have played an especially important role, providing valuable genes for such traits as tolerance to drought, heat, and cold.

Researchers have identified the traits that contribute most to increased durum grain yields in the Mediterranean region. These include early growth vigor, biomass at the vegetative-growth stage, carbon isotope discrimination (indicating water-use efficiency), and the number of fertile tillers produced.

'Fadda-98,' a drought-tolerant durum variety grown in Morocco, seen here at Tel Hadya, Syria. .

The ability to escape the damage caused by moisture and heat stress by developing quickly is very important, as these stresses become more intense later in the growing season. Breeding for early vigor involves manipulating the relationship between the plant's development and its environment (phenology). ICARDA's breeding program has been exploiting this trait to ensure relatively stable yields under terminal stress.

Some of the traits associated with drought tolerance, including early growth vigor, canopy waxiness, and erect leaf posture, are relatively simple to measure because they can easily be evaluated visually. Generally, drought-tolerance traits are associated with conserving available moisture by reducing soil water loss through evaporation and radiation load to the canopy. However, ICARDA's recent research has highlighted the important role photosynthesis plays in moisture-limited areas. To enhance efforts to breed for higher yields and yield stability, ICARDA is working to identify genetic material that can continue to photosynthesize under drought conditions.

Researchers are using chlorophyll fluorescence screening to detect the stress caused by drought and temperature extremes. This is done using pulse amplitude modulated (PAM) fluorometry, which uses a range of flashing (pulsed) lights of different intensities to measure photosynthetic activity. In photosynthesis, light energy is harvested by chlorophyll molecules in the leaf and converted into chemical energy. If the light falling on the plant is too intense, or if the plant is stressed, it cannot use all the available energy and gives up the excess as light or heat. The light produced causes the chlorophyll molecule involved to fluoresce, and this can be measured.

When a leaf is kept in the dark, the amount of fluorescence is small (F0). If that leaf is then flashed with a bright light, the fluorescence signal will increase to a maximum (Fm), as the plant cannot use all the available energy. The difference between these two fluorescence values is known as variable fluorescence (Fv). The ratio Fv/Fm is one of the most common parameters used in fluorescence studies, and is called the optimum quantum yield or photochemical efficiency ratio. It represents the proportion of light being used for photosynthesis—usually about 80%, as healthy leaves have an Fv/Fm value of 0.832. Low Fv/Fm values indicate stress. To discover how chlorophyll fluorescence parameters link with grain yield, yield stability, and grain quality traits, ICARDA researchers studied 112 different lines within the mapping population 'Lahn' × 'Cham 1.'

Each line was grown for four seasons in four environments with different moisture regimes. Based on the yield data obtained, the lines were then sorted into two groups: (i) the highest yielding lines with the greatest yield stability, and (ii) the lowest yielding lines with the lowest yield stability. The phenological and fluorescence parameters of the lines in the two groups were then compared.

The values recorded for leaf water potential and the fluorescence parameters F0, Fm, Fv, Fv/Fm, and Tfm (the time required to reach maximal fluorescence) were higher in the higher yielding group than in the lower yielding group (Fig. 6). The higher yielding lines also developed more quickly, having lower values for days to heading (DH) and days to maturity (DM). The values obtained for quenching were lower in the higher yielding lines, which means that photo-inhibition was lower. All these differences between high and low yielding lines were significant (Table 1), which demonstrates the importance of breeding for stable photosynthesis under dry conditions.

Cluster analysis showed that fluorescence parameters (F0, Fm, Fv, Tfm, and the ratio Fv/Fm) were strongly linked with durum grain yields under dry conditions (Fig. 7). Grain yield, yield stability, and test weight (kernel plumpness) clustered closely with the fluorescence parameters and leaf water potential. By contrast, the quenching parameter, which reflects photoinhibition, clustered with the grain quality parameters, protein content, sedimentation test, yellow pigment, and kernel size.

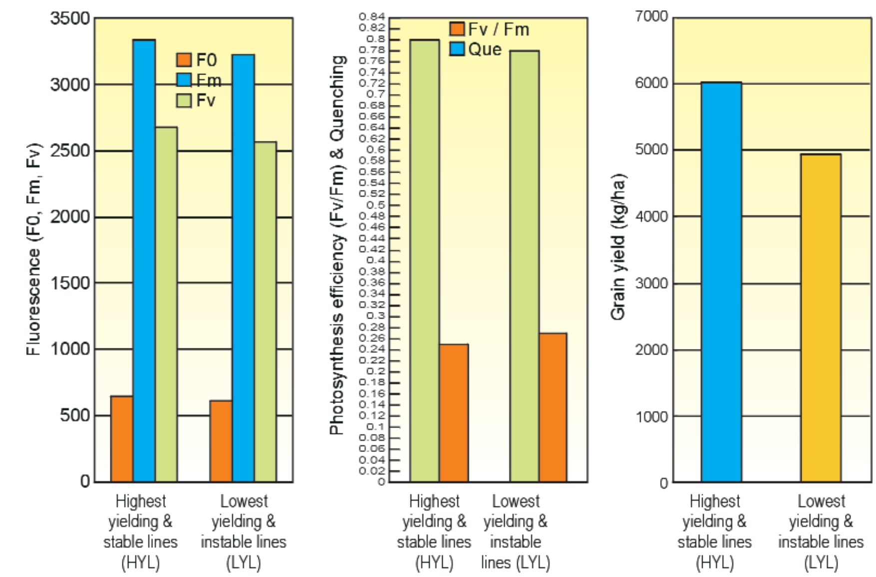


Fig. 6. Relationship between grain yield and chlorophyll-fluorescence parameters, which represent photosynthetic activity and drought stress.

Table 1. Phenological and physiological traits of durum wheat lines with the highest yield and yield stability (HYL) and lines with the lowest yield and yield stability (LYL) in the 'Lahn' × 'Cham 1' mapping population. Summary of results from Breda, Tel Hadya (dry and irrigated), and Terbol stations for four seasons (2000-2004).

Trait	Highest yielding & stable lines (HYL)	Lowest yielding & least stable lines (LYL)	Difference between means of HYL & LYL groups	Significance level	Parent 1: 'Lahn'	Parent 2: 'Cham 1'
Grain yield	6021.89	4940.48	1081.41	***	5700.5	5788.3
Stability	121.16	57.70	63.46	***	76.5	100.0
DH	124.09	127.83	-3.74	*	126.9	120.9
DM	166.76	168.43	-1.72	*	168.9	164.5
F0	644.70	616.28	28.42	*	672.8	667.8
Fm	3332.26	3216.46	115.81	**	3247.8	3331.1
Fv	2676.21	2560.92	115.29	**	2619.5	2708.4
Tfm	414.99	321.37	93.63	*	456.0	527.2
Fv/Fm	0.80	0.78	0.01	*	0.8	0.8
Que	0.25	0.27	-0.01	*	0.2	0.2
LWP	5.16	4.96	0.21	*	5.1	5.4

DH = days to heading; DM = days to maturity; F0, Fm and Fv = initial, maximal, and variable fluorescence; Tfm = time required to reach maximal fluorescence; Fv/Fm= optimum quantum yield (photochemical efficiency ratio); Que = quenching (F0/Fv); LWP = Leaf water potential (Fm/F0).

These preliminary results show the potential of using fluorescence techniques to study the mechanisms underlying photosynthetic efficiency under drought and extreme temperatures. Research aiming to link the fluorescence parameters with molecular markers in different durum mapping populations has already begun. Researchers are working to identify quantitative trait loci (QTLs) that can be used in marker-assisted selection within the durum breeding program at ICARDA.

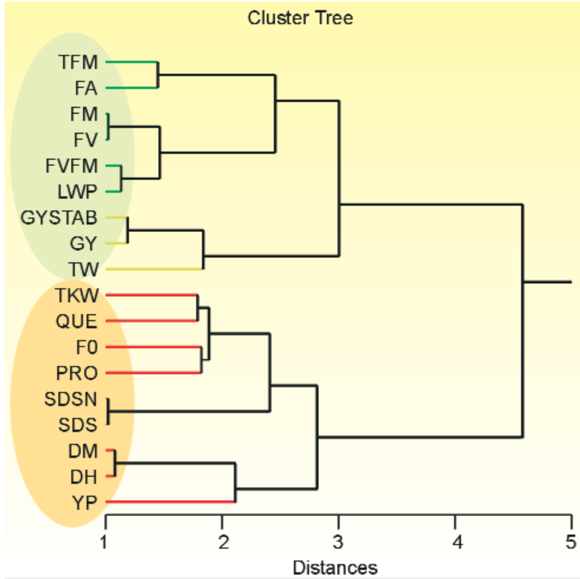


Fig. 7. Relationship of chlorophyll fluorescence parameters with grain yield, stability, and grain quality in durum wheat ('Lahn' × 'Cham 1' mapping population).

TW = test weight; GY = grain yield; GYSTAB = grain yield stability; TKW = 1000-kernel weight; SDS = sedimentation test; SDSN = SDS index; Pro = protein content; DH = days to heading; DM = days to maturity; YP = yellow pigment; F0, Fm and Fv = initial, maximal, and variable fluorescence; Tfm = time required to reach maximal fluorescence; Fv/Fm = optimum quantum yield (photochemical efficiency ratio); LWP = leaf water potential (Fm/F0); Que = quenching (F0/Fv); FA = fluorescence area (area between F0 & Fm, relates to the pool size of photosystem II electron-transport acceptors).

Project 1.3.

Spring Bread Wheat Germplasm Improvement for Increased Productivity, Yield Stability, and Grain Quality in West Asia and North Africa

Bread wheat is the principal food source for most people in CWANA. The average consumption of 185 kg of bread wheat per person per year in CWANA is the highest in the world. However, yields per hectare are extremely low. ICARDA is working with the national program of Iran to produce improved spring wheat germplasm for use in CWANA's lower latitudes. This new multidisciplinary project, begun in 2004, has the potential to vastly increase the spring wheat production in CWANA's irrigated and high-rainfall areas.

Enhancing sustainable wheat production in CWANA's low latitudes

NARS in CWANA consider wheat to be their major research priority, as it provides more than half the daily calories consumed by people in the region and up to half their daily protein intake. CWANA accounts for the largest wheat-growing area in the world, and most of its 13 million hectares of irrigated spring wheat area falls within the region's lower latitudes, between 13°N and 30°N. However, overall productivity is low in comparison with other regions, such as South Asia, East Asia, and the Southern Cone of South America. In fact, CWANA's irrigated areas currently yield only 2 t/ha on average, around 25 million tonnes of wheat per year, when they could produce more than 4 t/ha, or around 50 million tonnes per year.

In 2004, Iran's Agricultural Research and Education Organization (AREO) and ICARDA launched a multidisciplinary spring wheat germplasm enhancement program for CWANA's low latitudes. Known as the AREO-ICARDA International Spring Wheat Improvement Program (AIISWIP), this project aims to develop spring wheat germplasm suitable for the low-latitude, irrigated, high-rainfall areas of CWANA, where winters are mild. The project's activities will include varietal improvement and deployment throughout CWANA, integrated pest management and monitoring, training and human resource development, and the transfer to farmers of input-use-efficient production technologies such as bed planting systems.

The breeding materials used by the program will come from the jointly planned crossing program undertaken by ICARDA and AREO's Seed and Plant Improvement Institute (SPII). Breeding experiments and the selection of segregating generations (F_2-F_7) will be undertaken at SPII's Dezful research site in southern Iran, using material shuttled to and from other locations in Iran, such as Moghan, Gorgan, Shiraz, and Kalardosht (Fig. 8). The Dezful site was chosen because conditions there are suitable for developing and testing wheat germplasm that combines high yield potential with high water-use efficiency, heat tolerance, resistance to multiple diseases, and good bread-making qualities.


Bed-planted wheat in Iran. Photos: Dr K. Sayre, CIMMYT, Mexico.

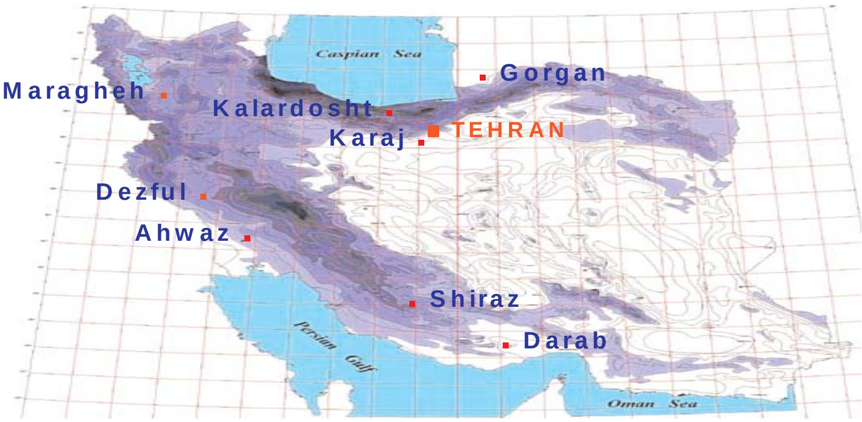


Fig. 8. Main agricultural research stations in Iran.

Project 1.4.

Winter and Facultative Bread Wheat Germplasm Improvement for Increased Yield and Yield Stability in Highlands and Cold Winter Areas of Central and West Asia and North Africa

The production of facultative and winter bread wheat, grown predominantly in developing countries, is not enough to meet demand. ICARDA is working in partnership with CIMMYT and Turkey's national agricultural research system to improve yields. As a result, CWANA's NARS released four new varieties of winter and facultative bread wheat in 2004. All are high-yielding, early maturing, and adapted to local agroecological conditions. They are also resistant to various diseases, including yellow rust—the most damaging disease of wheat in CWANA.

High-yielding, disease-resistant wheat varieties for CAC

Wheat is the most important crop in CWANA's cold, dry highlands, which include areas in Afghanistan, Iran, Pakistan, Turkey, North Africa, and Central Asia and the Caucasus (CAC). At least 40% of CWANA's wheat is grown in these areas on 16.4 million hectares. However, average yields of rainfed winter wheat are comparatively low because investment in breeding improved varieties has only started recently.

The winter and facultative wheat variety ‘Bitarap,’ released for irrigated and high-temperature areas in Turkmenistan.

In CAC countries, most of which aim to be self-sufficient in food production, yellow rust is a major problem. Most of the wheat varieties being grown were released or introduced more than a decade ago and have become susceptible to this disease. Improved, high-yielding varieties of winter and facultative wheat are, therefore, urgently needed.

In 2004, three winter and facultative bread wheat varieties were released: ‘Jamin,’ ‘Zubkov,’ and ‘Azibrosh’ in Kyrgyzstan; and ‘Bitarap’ in Turkmenistan. These varieties were selected by NARS breeders from Turkey/CIMMYT/ICARDA nurseries. During the last four years of trials, all four varieties demonstrated good resistance to various diseases, including yellow rust, as well as adaptability to local agroecological conditions. All have a high yield potential and mature early, an important trait in highland areas where growing seasons are short. Seed production of these varieties began in 2002 at research institutes and in farmers’ fields, with technical support from ICARDA.

The facultative wheat variety ‘Jamin’ was released in Kyrgyzstan’s mountainous provinces of Issyk-Kul and Naryn. This variety has a potential yield of about 6 t/ha and is resistant to yellow rust. It is, therefore, likely to replace the country’s dominant wheat variety ‘Intensivnaya,’ which was released in 1998 and is now susceptible to yellow rust. About 70 tonnes of ‘Jamin’ seed are expected to be produced in 2004 for dissemination to farmers.

In Turkmenistan, the bread wheat variety ‘Bitarap’ was released in 2004 for use in irrigated and high-temperature areas. Over the last five years, this disease-tolerant variety outyielded the local check, ‘Skifianka,’ by 18%, on average, in trials. ‘Bitarap’ has the potential to yield 6.5 t/ha. In 2004, the Turkmen Research Institute of Grains produced 1200 tonnes of elite and super-elite ‘Bitarap’ seed.

In May 2004, a delegation of high-ranking officials from Kyrgyzstan visited ICARDA’s headquarters. During a field visit, members of the delegation expressed their interest in rainfed winter wheat production. Seed samples were taken back to Kyrgyzstan for evaluation.

A parliamentary delegation from Kyrgyzstan visiting winter and facultative wheat demonstration plots at ICARDA’s headquarters in May 2004.

Project 1.5.

Food Legume (Lentil, Kabuli Chickpea, and Faba Bean) Germplasm Improvement for Increased Systems Productivity

Lentil, chickpea, and faba bean are important cool-season food legumes in CWANA. In addition to being a major source of dietary protein, particularly for the poor, they play an important role in maintaining and improving soil fertility, thus contributing to the sustainability of farming systems. In 2004, ICARDA identified high-yielding chickpea cultivars suitable for planting in both winter and spring. In the CAC region, many promising chickpea lines were identified as high-yielding, disease-resistant, and adapted to local conditions. Three cultivars were submitted for registration. Efforts to breed leaf-miner-resistant chickpea continued using a new field-screening technique and many large-seeded resistant lines were identified. In Nepal, new large-seeded, disease-resistant, and high-yielding lentil lines were selected, and production techniques were developed and disseminated to farmers. Researchers mapped new QTLs for winter-hardiness in lentil and identified candidate molecular markers for use in marker-assisted selection programs. New large-seeded, high-yielding faba bean hybrids were developed by crossing lines resistant to chocolate spot and *Ascochyta* blight.

Boosting lentil production in Nepal

Nepal is one of the six largest lentil-producing countries in the world. Grown in rice- or maize-based cropping systems, lentil enhances soil fertility through symbiotic nitrogen fixation. Currently, 95% of Nepal's lentil is grown in the lowland *Terai* region. More lentil could be grown in the cooler hilly areas, where growing seasons are longer and lentil productivity higher; however, Nepalese lentil landraces are low yielding and susceptible to various biotic and abiotic stresses, including intermittent drought, wilt root rot, *Stemphylium* blight, and *Botrytis* blight.

Farmers in mid-hill areas (Bhaktapur district) in Nepal have started growing lentil variety 'Shekhar', where no lentil was grown in the past.

To improve lentil production, ICARDA has supplied genetic materials, and technical, and human-resource-development support to the Nepal Agricultural Research Council (NARC). Two improved varieties derived from ICARDA-supplied germplasm, 'Shekhar' and 'Sital,' have already been released. Both were developed using South Asian germplasm adapted to local conditions and growing seasons, and yield around 1.2-1.5 t/ha. They were readily adopted by farmers because they produce larger seeds than local cultivars and are resistant to wilt root-rot complex.

ICARDA's decentralized breeding strategy for South Asia's short-season environments has produced more promising lines that are awaiting official release. Of these, ILL 4402, ILL 7723, ILL 7982, ILL 7537, and ILL 6829 have been tested on research stations and in farmers' fields. These high-yielding (1.9-2.9 t/ha), large-seeded lines are resistant to multiple diseases. ILL 7723 shows considerable promise for relay cropping in rice fields and is spreading very quickly through the western *Terai* region. Similarly,

A progressive farmer in Betahani village in western *Terai* in Nepal grew ILL 7723 lentil in his field, which is good for zero tillage conditions and is awaiting release.

ILL 6829 and ILL 7982 have been adopted by farmers in the mid-hills region, where lentil was not widely grown previously. As a result, lentil has now become a major source of dietary protein in this area. The national program has also identified sources of resistance to various stresses, and accessions with valuable morphological and phenological variability, which have been conserved in the national genebank for future use.

ICARDA is working with NARC and the Australian Center for Legumes in Mediterranean Agriculture (CLIMA), on an Australian Center for International Agricultural Research (ACIAR)-funded project, to develop new production technologies. Priming lentil seeds before sowing by immersing them in water for 12 hours and then air-drying them for 2 hours, improved plant establishment, reduced emergence times, and increased seed yield by around 40%. Researchers showed that the optimum sowing time for lentil grown as a relay crop with rice is 10-20 days before the rice harvest, in lowland rainfed conditions. The recommended sowing rate is 40-50 kg seed/ha, depending on soil moisture levels. Farmers have already adopted these technologies and are now achieving higher yields.

ICARDA is working with other organizations to multiply seed of promising varieties for dissemination to farmers. The Center is also using participatory approaches to improve technology development and dissemination, in collaboration with NGOs such as the Forum for Rural Welfare and Agricultural Reform for Development (FORWARD) and Local Initiatives for Biodiversity Research and Development (LI-BIRD).

These efforts have significantly improved the incomes of small-scale farmers, and made more lentil available for everyday consumption, providing nutritional security for the country's poor. They have also benefited agroindustries, traders, exporters, and the country's economy as a whole. Since 1996, new production technologies and the adoption of improved varieties has increased production by a total of 131,701 tonnes—worth around US$ 45 million.

Nepal has also recently been included in an ICARDA-led program which aims to develop lentil cultivars high in micronutrients. This is part of the CGIAR's System-wide Harvest Plus Challenge Program.

New QTLs mapped for winter-hardiness in lentil

Lentil production in CWANA's cold areas could be greatly increased by planting in fall or winter rather than in spring, the traditional planting season, as crops would benefit from low evapotranspiration rates and a longer growing season. International and national improvement programs are, therefore, focusing on developing winter-hardy lentil varieties.

Past research indicates that sufficient winter-hardiness is available in ICARDA-conserved germplasm. However, identifying and transferring winter-hardiness genes is a difficult and slow process because field screening can be unpredictable. Improving winter-hardiness on the basis of lentil phenotype is also difficult, because the trait is complex and strongly affected by environmental factors, such as freeze-thaw cycles, waterlogging, ice encasement, diseases, and temperature. ICARDA is overcoming these problems using molecular markers and a marker-assisted selection program.

Genetic studies on winter-hardiness using recombinant inbred lines (RILs) have indicated that several genes control the trait. Therefore, as part of a USAID-funded program, researchers from ICARDA, Washington State University, USA, and the Central Research Institute for Field Crops, Ankara, Turkey, collaborated to identify and locate the quantitative trait loci (QTLs) which confer winter-hardiness, and the molecular markers that identify them. This involved an inheritance study which used a RIL population (WA8649090/Precoz) developed from a winter-hardy × non-hardy cross.

In total, 106 RILs were evaluated for winter hardiness in the field at Haymana and Sivas, Turkey, and

Pullman, Washington, USA, during the 1997/98, 1998/99, and 1999/00 growing seasons. Ninety-four F_6 to F_8 RILs were scored for 56 Random Amplified Polymorphic DNA (RAPD), 106 Inter Simple Sequence Repeat (ISSR), and 94 Amplified Fragment Length Polymorphism (AFLP) markers, and three morphological traits: plant height, fall growth habit, and leaflet size. Of these 256 markers, 84 were excluded from the QTL analysis because of lack of linkage, incomplete data, or distorted segregation.

Five independent QTLs were detected for winter survival at Haymana in 1997/98: one on linkage group 4 and two each on linkage groups 3 and 6. Together, these QTLs explained 33.4% of the total phenotypic variation in winter survival. Under harsh winter conditions at Pullman, where mortality was 95%, one QTL was detected on linkage group 4. In the mild winter conditions at Haymana in 1999/00, three putative QTLs were detected: two on linkage group 1 and one on linkage group 4. Together the QTLs explained 22.9% of phenotypic variation. The QTL located on linkage group 4 was common to all environments and years, but the effect and position differed across environments. The two QTLs on linkage groups 4 and 6 were detected when winter-survival data from all sites were combined and subjected to QTL analysis. (Fig. 9).

Of the four QTLs identified for winter survival, three were located on linkage group 1 and one on linkage group 4. These four QTLs accounted for 42.7% of the variation in winter injury. Three of the QTLs conditioning winter injury were located in the same genomic regions as QTLs for winter survival. The QTL on linkage group 1 at positions 39 cM and 129 cM were also detected at Haymana, and the QTL on linkage group 4 was probably the same QTL at all locations. Therefore, although five QTLs were detected for winter survival, only one (the QTL on linkage group 4 for winter survival) was expressed across all environments.

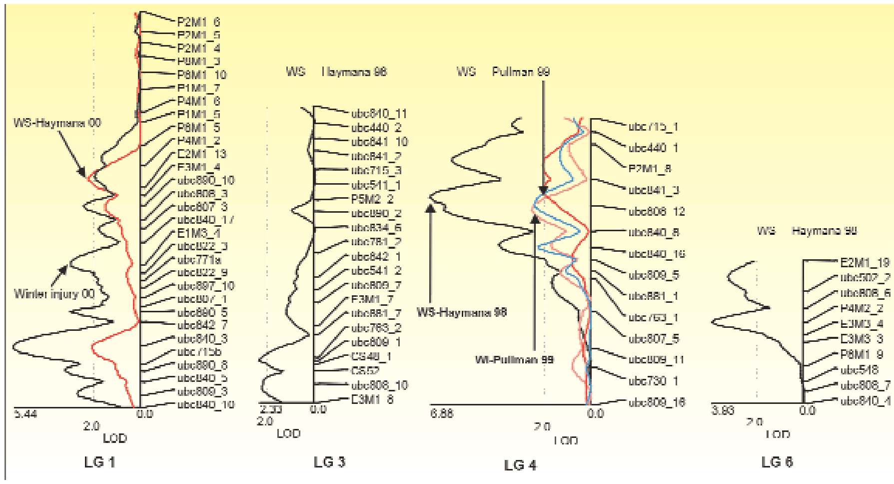


Fig. 9. Quantitative trait loci (QTLs) detected for winter survival (WS) and winter injury (WI) in lentil, at Haymana and Sivas in Turkey and at Pullman, USA; recombinant inbred lines from the WA8649090/Precoz population grown during four cropping seasons (1997/98 to 1999/00). LG = linkage group.

'Morton,' a lentil cultivar with QTLs for winter-hardiness, recently released by Dr Rick Short (right) of Washington State University, in USA.

On the basis of the QTL analyses, candidate molecular markers for winter survival were identified for use in marker-assisted selection programs. ISSR marker ubc808-12 (linkage group 4) was consistent across environments. Another ISSR marker (ubc840-3) was associated with winter injury at Pullman and Haymana. Marker-assisted selection will accelerate selection for winter-hardiness, particularly when mild or extremely unusual winter conditions occur.

Identifying dual-season chickpea cultivars for winter and spring planting

Farmers in WANA usually plant chickpea in the spring, making use of water retained in the soil following winter rainfall. However, ICARDA researchers have shown that winter planting can almost double yields, mainly because of increased water-use efficiency.

Researchers examined how Genotype × Environment interactions affect seed yield to identify chickpea lines that yield well during both the winter and spring growing seasons.

Genotypes developed for winter or spring sowing were assessed during both growing seasons between 1999 and 2003. These were planted in simple lattices at two contrasting sites: Tel Hadya, in northern Syria (284 m a.s.l., annual rainfall 360 mm) and Terbol in the Beqa'a valley in Lebanon (890 m a.s.l., annual rainfall 421 mm). Seed yields were analyzed using a mixed model to estimate variance components and predict mean yields for each genotype. Researchers found that the proportion of variation due to the Genotype × Season interaction was greater in lines developed for winter sowing than in those developed for spring sowing.

To assess the suitability of materials for both winter and spring planting, researchers investigated whether the predicted mean yields from winter plantings correlated with those from spring plantings. Low correlation values for a trial indicated that genotypes were more likely to be suitable for dual-season planting. In most trials, lower correlations were found for materials developed for winter sowing than for those developed for spring sowing. For example, at Terbol, a low correlation ($r = 0.059$) was found for the 2000 trial of winter-sowing material, but a high correlation ($r = 0.78$) was found for the 2002 trial of spring-sowing material.

Of the 49 winter-sowing genotypes evaluated in the 2000 trial, two were suitable for dual-season planting: FLIP 97-56C and FLIP 98-82C. The yields of these two lines were 2.5-2.6 t/ha when planted in winter, and 1.3-1.4 t/ha in spring. Of the spring-sowing genotypes evaluated in the 2002 trial, the five best lines yielded 2.4-2.9 t/ha in winter and 1.3-1.8 t/ha in spring.

Results showed that materials selected for winter sowing are more responsive to changes in the date of sowing than those selected for spring sowing. This is probably because winter-sowing materials are more tolerant to cold and *Ascochyta* blight, and better able to respond to the higher rainfall received in winter. Results from the other trials are being analyzed to identify more lines suitable for dual-season planting.

New chickpea cultivars for CAC

Chickpea improves soil quality through nitrogen fixation, provides protein-rich food and animal feed, and is an important component of subsistence farming in Central Asia and the Caucasus (CAC). ICARDA is, therefore, collaborating with NARS in the region to produce high-yielding, resistant lines.

In Uzbekistan, work with the Galla-Aral Research Center and the Andijan Research Institute of Grain and Legumes identified five lines suitable for rainfed conditions: FLIP 88-85C, FLIP 93-93C, FLIP 97-99C, FLIP 87-8C, and FLIP 95-55C. Over the last three years, the *Ascochyta* blight resistant line FLIP 88-85C, outyielded the local improved check 'Lazzat' by more than 10% and has been submitted for registration and release under the name 'Jahongir.' Five hundred kilograms of 'Jahongir' seed were tested in farmers' fields. In 2004, FLIP 97-95C was submitted to the State Varietal Testing Commission (SVTC) under the name 'Zumrad.' This has larger seeds and yields more than local varieties; it is also more cold-tolerant and resistant to *Ascochyta* blight. 'Zumrad' is suitable for winter planting in Uzbekistan's irrigated areas, and 70 kg of seed were available for multiplication.

Three promising lines were identified in Kyrgyzstan: FLIP 87-85C, FLIP 98-121C, and FLIP 98-142C. These outyielded the local check by 48%, 76%, and 94%, respectively. All produce large seeds, are *Ascochyta* blight resistant, and exhibit tall, erect growth, making mechanical harvesting easier. FLIP 98-121C and FLIP 98-142C were submitted to the SVTC for release in 2004.

Kazakhstan's Krasny-Vodopad

Over the past three years, 'ICARDA-1' chickpea has outperformed the local check 'Kamila' in Kazakhstan.

Institute submitted the high-yielding, *Ascochyta* blight resistant line FLIP 94-24C for registration in 2004 under the name 'Janalik.' This cultivar is suitable for general cultivation in southern Kazakhstan. In 2001 the Kazakh Research Institute of Crop Husbandry submitted FLIP 97-137C to the SVTC under the name 'ICARDA-1.' Over the last three years 'ICARDA-1' has yielded more seed and shown better disease resistance than the local check 'Kamila.'

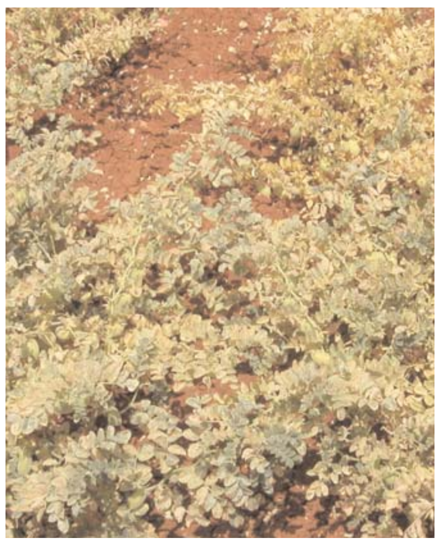
Several promising lines are being evaluated in Tajikistan by the Tajik Research Institute of Crop Husbandry. Of these, ILC 3279 outperformed the already-released variety 'Muktadir,' growing taller, yielding 20% more, and showing greater *Ascochyta* blight resistance. It was recently submitted for registration and release for general cultivation under the name 'C3-80.' In Turkmenistan, researchers identified several promising chickpea lines, including FLIP 98-131C, FLIP 82-150C, and FLIP 98-41C. All exhibit *Ascochyta* blight resistance, and heat and drought tolerance.

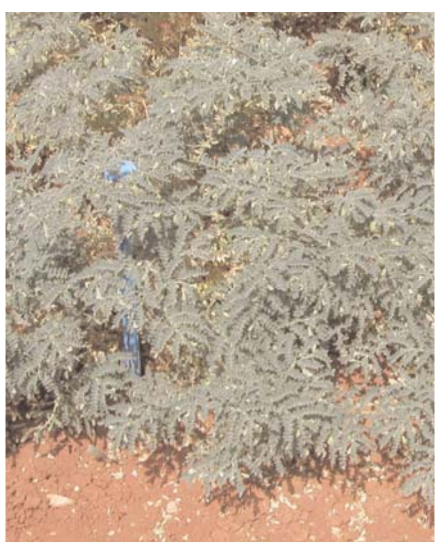
The new cultivars identified will increase chickpea production and help alleviate poverty and malnutrition in CAC countries. Growing chickpea in rotation with cereals will also help to overcome the soil-degradation problems caused by widespread continuous cereal cropping in the region.

Breeding chickpea for leaf miner resistance

The leaf miner insect pest causes serious crop losses in chickpea, which is traditionally grown in spring in Mediterranean environments in WANA. Chemical control methods are available, but are expensive and environmentally unfriendly. A better alternative is host-plant resistance, but resistance breeding programs require reliable germplasm screening techniques.

ICARDA recently developed an efficient screening technique for use in the field, which involves sowing chickpea in mid-April, one month later than usual. This ensures high humidity and moderate temperatures—conditions which promote leaf miner populations to develop faster. Limited irrigation is used to encourage germination, crop growth, and leaf miner development. Susceptible lines are planted after every nine test entries and around the perimeter of the experimental area to indicate infestation and ensure that high numbers of insects spread quickly through the field.





Breeding for leaf miner resistance. Above: susceptible line; Below: resistant line.

Plants are evaluated using a scale of 1 to 9, where 1 = no visible damage by leaf miner (leaf-miner free); 5 = less than 50% of leaflets damaged by leaf miner (tolerant); and 9 = almost all leaflets damaged by leaf miner (highly susceptible). When the susceptible check plants in a single row score 9, observations are recorded for all experimental materials.

Using this screening technique, researchers identified two leaf miner resistant lines: ILC 5901 and ILC 3805. However, these lines have narrow leaflets and small seeds. To understand how leaf miner resistance is inherited, and to develop large-seeded, resistant cultivars, researchers hybridized the resistant line ILC 5901 with the larger-seeded but leaf miner susceptible ILC 3397.

Parent lines and subsequent generations were grown in ICARDA's Leaf Miner Nursery using the new screening regime. Observation of the parents and the F_1, F_2, and F_3 generations showed that leaf miner resistance is dominant over susceptibility and is simply inherited.

Using the pedigree method of selection, researchers identified a large number of leaf miner resistant lines in the F_6 generation, which produced seeds of various sizes. Some seeds were larger (45 g/100 seeds) than those of the resistant parent ILC 5901 (20-24 g/100 seeds). Seed from visually homogenous F_6 lines showing the same level of leaf miner resistance will be multiplied at Tel Hadya, evaluated agronomically, and then shared with NARS.

Exploiting hybrid vigor in faba bean

On average, 35% of faba bean plants are cross-pollinated by the wind or insect pollinators such as bumble bees (*Bombus* spp.) and honey bees (*Apis* spp.). Many factors, such as location, season, plant density, plant genotype, and the number of insect pollinators, affect the amount of natural crossing that occurs in faba bean, which, in turn, affects seed production.

Crossbred faba bean cultivars generally perform better than inbred ones. Heterogeneity markedly increases yield and yield stability, so open-pollinated populations yield more than inbred lines. ICARDA is, therefore, working to vary the genetic backgrounds of cultivars while breeding for multiple disease resistance.

Hybrid vigor is a key factor in stress tolerance in faba bean, so researchers are using breeding methods that allow high levels of hybridization. In 1999, for example, the performance of 105 F_1 crosses was compared with those of their parents in screen houses. Average seed production by the hybrids was much greater than that of the parents (the 'mid-parent value'): 73% greater for seed number per plant and 76% greater for seed weight per plant. Some hybrids were also more resistant to chocolate spot and *Ascochyta* blight than their parents.

In the 2001/02 growing season, 10 crosses between seven different chocolate spot and *Ascochyta* blight resistant accessions were made in plastic houses at Tel Hadya. In the following season, the F_1 hybrids and their parents were evaluated under open pollination in the field using a randomized complete block design. The field was artificially inoculated with *Ascochyta* blight using infected debris and spore suspension sprays (500,000 spores/ml). Seed production was measured, and the plants scored for *Ascochyta* blight resistance using a scale of 1-9, where 1 = highly resistant, and 9 = highly susceptible.

The average disease rating of the F_1 crosses (4.8) was lower than the mid-parent value (5.5) and the rating for susceptible parents (6.2), but was close to the average for the resistant parents (4.5). With regard to *Ascochyta* blight resistance, over-dominance was revealed in three crosses (S2002-064; S2002-067; and S2002-074), complete dominance in one cross (S2002-066), and partial dominance in four crosses (S2002-063; S2002-078; S2002-095; and S2002-096). However, dominance was lacking in one cross, (S2002-065), while in another (S-2002-080) there was partial dominance for susceptibility to *Ascochyta* blight.

The F_1 hybrids produced significantly more seeds per plant than their parents, and all crosses exhibited over-dominance of this trait when compared with the mid-parent value. This indicated that hybrid faba bean plants are more fertile than their parental inbred lines. Overall, seed numbers in hybrids were greater than the mid-parent value by 40-181% (117% on average). Similar trends were seen for seed weight per plant (Table 2), as hybrid yields were 158% higher, on average, than parental yields. These results clearly show that exploiting hybrid vigor in faba bean breeding by developing synthetic or partially synthetic varieties with resistance to foliar diseases can increase yields and yield stability.

Table 2. Seed yield (g/plant) of faba bean F1 crosses compared with their parents at Tel Hadya, Syria, during the 2002/03 growing season.

Cross	Female parent (P1)		Male parent (P2)		Mid-parent	F_1 hybrid	Hybrid	Potence
no.	Entry name	Seed yield	Entry name	Seed yield	value†	seed yield	vigor (%)‡	ratio§
S2002-063	Iraq 697	12.7	Sel. 97 Lat. 98 108-2	20.1	16.4	31.4	91.5	4.1
S2002-064	Iraq 599	10.6	Sel. 97 Lat. 98 108-2	24.6	17.6	40.0	127.3	3.2
S2002-065	Iraq 610	23.5	Sel. 97 Lat. 98 133-3	17.0	20.3	42.9	111.3	7.0
S2002-066	Iraq 545	20.9	Sel. 97 Lat. 98 133-3	12.5	16.7	42.0	151.5	6.0
S2002-067	Iraq 194	12.9	Sel. 97 Lat. 98 123-5	11.5	12.2	40.4	231.1	37.6
S2002-074	Iraq 194	14.8	Sel. 97 Lat. 98 102-2	8.5	11.7	45.1	285.5	10.6
S2002-078	ILB 4362	15.1	Sel. 97 Lat. 98 102-6	21.3	18.2	32.1	76.4	4.5
S2002-080	987/ 255/ 95	5.0	Sel. 99 Lat. 10268-3	12.6	8.8	17.4	97.7	2.3
S2002-095	985/ 252/ 95	9.8	Ascot	10.7	10.3	28.6	177.7	40.7
S2002-096	ILB 4347	7.4	Ascot	8.9	8.2	27.0	229.3	25.1
Mean		13.3		14.8	14.0	34.7	157.9	

LSD 0.05 = 9.1; LSD 0.01 = 12.3; CV (%) = 21.3.

† Average seed yield of the two parents.

‡ Percentage increase in hybrid yield relative to mid-parent value: hybrid vigor.

§ Potence ratio = F_1 – Mid-parent value / 0.5(P1 – P2), where F_1 = F_1 mean, P1 = the better parent, and P2 = the other parent.

Project 1.6.

Forage Legume Germplasm Improvement for Increased Feed Production and Systems Productivity in Dry Areas

Forage legumes are valued for their ability to provide high-protein animal feed, while simultaneously maintaining or improving soil fertility. In 2004, ICARDA developed new, high-yielding lines of common vetch (*Vicia* spp.) whose pods do not shatter when mature. Non-shattering lines will reduce harvesting costs and seed prices—which will encourage farmers to plant more vetch. Advances were also made in reducing the toxicity of grass pea, a hardy, drought-resistant crop, which is an important source of food and feed.

Human and livestock populations are growing rapidly in CWANA. As a result, rangelands are being overgrazed, and farmers are cropping more marginal land and abandoning their traditional fallow–barley rotations in favor of continuous barley cropping. All these practices are placing increasing pressure on the agricultural resource base of the dry areas, and degrading farmers' soil resources.

Expanding the area cultivated with vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.) is a sustainable way of boosting food and feed production, and increasing the number of animals the land can support. Using these crops to interrupt barley monoculture, or to produce crops on land usually left fallow in fallow–barley rotations, improves the organic matter content and nitrogen status of the soil. It also helps to control the diseases and pests that affect continuous cereal rotations. Grown in this way, these drought-tolerant feed legumes can provide grazing during winter and early spring. They can also be harvested for hay in the spring or carried to maturity to provide both seed and straw.

New non-shattering lines of common vetch

Common vetch (*Vicia sativa*) is an important forage legume in the dry areas. However, its seed pods tend to shatter when mature, making them difficult to collect. Harvesting techniques have been developed to reduce the amount of seed lost as a result of shattering, but these are costly. As a result, common vetch seed is expensive—which places a financial burden on poor farmers, as the crop has to be resown each year.

To harvest as many seeds as possible, farmers have to collect them at exactly the right time and avoid pod-shattering. But, the optimum harvest time usually coincides with the harvest of important food legumes like lentil, which farmers need to harvest first. This, and the fact that the late harvest of common vetch can cause serious 'vetch weed' problems in any cereal crops grown after it, severely restricts its usefulness in prevailing farming systems.

These problems could be solved by producing a variety that retains its seed in pods at maturity. This would greatly benefit farmers, as common vetch could then be used to improve cropping systems (i) by being grown on land left fallow in traditional cereal–fallow rotations and (ii) by being used to interrupt the continuous cropping of barley in monoculture. In either case, it would replenish soil fertility and provide extra grazing.

ICARDA is now working to improve seed retention in common vetch through a breeding program that will incorporate non-shattering genes into promising existing lines lacking this character. As part of this program, researchers studied variation in seed retention and the nature of its genetic control.

Nine hundred accessions of common vetch were assembled at ICARDA from different areas and screened for pod-shattering. Initially plants were assessed visually under normal field conditions in July and August 2004, when intense summer heat encourages pod-shattering. Occurrences of pod-shattering were scored using a scale of 0 to 5 (0 = complete shattering; 5 = no shattering in 95% of plants). Genotypes with scores of 4 or 5 were then selected and re-tested in a glasshouse, to provide more heat and further encourage pod-shattering.

Under both field and glasshouse conditions, a high proportion of the genotypes had shattering pods (Table 3). However, highly desirable non-shattering behavior was identified in three wild mutant genotypes which each scored 5. Unfortunately, these also exhibited undesirable traits, such as late flowering, late maturity, dwarfing, low herbage yields, and small seeds.

These wild genotypes were crossed with two promising cultivated lines, developed by ICARDA (selections 715 and 2541). These cultivated lines were chosen because, although they exhibited a high level of pod-shattering at maturity, they matured early, gave a high dry-matter yield and exhibited a wide range of adaptation.

Crossing revealed that the non-shattering trait was independent of agronomic traits such as flowering time, seed size and growth habit. In all crosses, the shattering character showed complete dominance. F_2 populations segregated according to a 3:1 ratio (shattering:non-shattering) (Table 4). The results suggest that cultivated lines have a pair of dominant genes that condition pod-shattering, whereas non-shattering in the wild types is conditioned by a pair of recessive alleles.

Back-crossing was used to successfully incorporate the non-shattering genes from the wild lines into the cultivated lines. Researchers also selected for desirable traits from the cultivated lines, such as earliness, erect growth habit, leafiness, high number of pods per plant and large seed size. After five backcrosses, improved non-shattering, cultivated lines were selected and their seed multiplied. When the improved lines were assessed, the occurrence of non-shattering pods was found to be 98%.

No previous attempts have been made to find non-shattering strains of *Vicia sativa.* So, the development of varieties with a low shattering rate should encourage farmers to increase the area cropped with common vetch by increasing seed yield and reducing seed prices. The new lines will also facilitate mechanical harvesting, and allow farmers to defer their vetch harvest until after their lentil harvest.

The new non-shattering lines are now being made available to

Table 3. Evaluation of pod-shattering characteristics in common vetch (*Vicia sativa*), Tel Hadya.

	Shattering score*						
	0	1	2	3	4	5	Total
No. of accessions	500	150	110	100	37	3	900
(%)	55.6	16.7	12.2	11.1	4.1	0.3	100

* Scores: 0 = complete shattering; 5 = no shattering of pods.

Table 4. Mode of segregation of the shattering character in F_2 progenies of common vetch (*Vicia sativa*) crosses, Tel Hadya.

	No. of plants		Goodness of fit of 3:1 ratio		
Cross*	Shattering pods	Non-shattering pods	Chi-square	d.f.	Probability value
715×1416	190	57	0.48	1	0.5-0.3
715×1361	303	102	0.01	1	0.95-0.90
715×2014	117	40	0.02	1	0.90-0.80
2541×1416	790	270	0.13	1	0.80-0.70
2541×1316	266	105	2.16	1	0.20-0.10
2541×2014	376	80	13.52	1	<0.001
All crosses	2042	654	0.79	1	0.50-0.30
Sum of 6 chi-squares			16.13	6	0.01-0.001
Heterogeneity chi-square			15.86	5	0.01-0.001

* Selections 1416, 1361 and 2014 are wild types and non-shattering; selections 715 and 2541 are promising cultivated lines but with a high proportion of shattering.

Left: Seed multiplication of 'Baraka' - an improved non-shattering variety of common vetch used extensively in Iraq, Jordan, Lebanon, and Syria.

Mechanical harvesting of non-shattering common vetch.

NARS. Of these, line 715 has already been released in Lebanon, Jordan, and Iraq under the name 'Baraka,' and line 2541 has been recommended for release in Syria.

Grass pea research at ICARDA: current status and future strategies

The food and feed legume grass pea (*Lathyrus sativus*) requires low levels of inputs and is resistant to drought, flooding, and moderate levels of salinity. These traits have made it popular in certain Asian and African countries, including Bangladesh, China, Ethiopia, India, and Pakistan.

Because it is so hardy, grass pea is often the only food available to the poor when climatic conditions, such as drought and heat, cause other crops to fail. However, although its seeds are tasty and protein-rich, they also contain the neurotoxin 3-(N-oxalyl)-L-2,3-diaminopropionic acid (β-ODAP). As a result, eating too much grass pea can cause irreversible paralysis of the lower limbs, known as neurolathyrism.

ICARDA is working to make it safer for people and livestock in the dry areas to eat grass pea by reducing the amount of neurotoxin in the seeds while simultaneously improving yields. Through conventional breeding methods and the development of somaclonal variants, ICARDA researchers have now developed low-neurotoxin lines with β-ODAP contents of less than 0.07% (Table 5). Human consumption is considered to be safe at levels below 0.2%. Seeds from these lines have already been multiplied for distribution to national programs.

Seed multiplication of low-neurotoxin lines of grass pea at Tel Hadya, Syria for distribution to national programs.

Table 5. Performance of grass pea lines selected for low neurotoxin (β-ODAP) content at Breda, Syria, 2004 (average annual rainfall of 253 mm).

Line number	Yield (t/ha)	β-ODAP content (%)
190	1.4	0.07
288	1.6	0.07
289	1.4	0.06
290	1.6	0.07
299	1.5	0.03
387	1.6	0.06
390	1.4	0.07
499	1.3	0.06
111	1.1	0.02
222	1.4	0.02

Using both conventional techniques and new biotechnological methods, researchers will continue to develop high-yielding, adapted lines containing very little or no β-ODAP. One aspect of this will involve determining if the low-neurotoxin character of closely related species, such as underground chickling (*Lathyrus ciliolatus*), can feasibly be introgressed into grass pea.

Researchers will continue to analyze somoclonal variation in grass pea landraces from Afghanistan, Bangladesh, Eritrea, Ethiopia, India, Nepal, and Pakistan to identify new genotypes with zero or near-zero levels of the neurotoxin. The impact on meat and milk production of diets based on grass pea seed and fodder will also be evaluated.

Theme 2

Production Systems Management

Project 2.1.

Integrated Pest Management in Cereal and Legume-based Cropping Systems in Dry Areas

An integrated pest management (IPM) approach is one in which farmers use the most efficient combination of options to protect a crop from pests and diseases. Employing a range of options, such as host-plant resistance, biological control, suitable agronomic practices, and habitat management allows chemical control to be reduced and strictly targeted, benefiting human health and the environment. In 2004, ICARDA conducted surveys to identify the major diseases affecting legumes and cereals in Yemen and two provinces of China. To improve resistance breeding programs, researchers also investigated the genetic diversity of yellow rust on wheat in Eritrea, and used a novel mark–release–recapture field experiment to study the evolution of the pathogen that causes barley scald. Progress was made in the biological control of Sunn pest through field surveys in Syria which identified four species of Phasiine fly that parasitize the adult insect. Researchers also assessed how effectively a parasitoid wasp that attacks Sunn pest eggs was able to control the insect at different densities.

Integrated pest management in cereal and food legume crops

Parasitic weeds, insect pests, and fungal and viral diseases cause major cereal and food legume yield losses in CWANA. ICARDA is working with NARS to develop and fine-tune strategic measures to control pests and diseases of wheat, barley, and food legumes. Successful control measures are now being transferred to NARS and farmers through participatory Farmer Field Schools.

Traditional breeding for pest resistance is being used to produce cultivars that combine several desirable traits. However, using biotechnology, researchers are able to rapidly incorporate specific valuable genes for resistance to abiotic stresses, such as drought, and biotic stresses, such as pests. This allows researchers to keep up with the evolution of fungal pathogens and insect pests.

Insect pest and disease surveys are also an important part of ICARDA's IPM work, allowing researchers to monitor pests and target control measures such as host resistance, cultural practices, and biological control. The basic information required for the development and testing of IPM packages is now available, and can be modified for use in different farming systems.

Survey of legume and cereal viruses in Yemen

In 2004, ICARDA surveyed various locations in Yemen to identify viruses affecting food legume and cereal crops. The survey covered 16 randomly selected legume fields (7 faba bean, 6 pea, and 3 lentil) and 36 randomly selected cereal fields (23 bread wheat and 13 barley). Two hundred samples from each field were tested against the antisera of 11 legume and 4 cereal viruses to determine disease incidence.

In faba bean fields, *Bean yellow mosaic virus* (BYMV), followed by luteoviruses, were the most prevalent. Luteoviruses were most common in pea and lentil fields, followed by *Pea seed-borne mosaic virus* (PSbMV). Fourteen of the legume fields sampled had a viral disease incidence of 21% or higher. Of these, the highest infection rates occurred in a pea field in the El-Bon Valley (100% samples infected with PSbMV and luteoviruses) and in four faba bean fields in Jabal Sabir (100% infected with BYMV).

In cereal fields, *Barley yellow dwarf virus* (BYDV) was most common, followed by *Barley stripe mosaic virus* (BSMV). Two cereal fields had a viral disease incidence of 21% or higher; 29% of the samples taken from one barley field in the El-Bon Valley were infected with BSMV and BYDV.

Barley yellow striate mosaic virus (BYSMV) was only found in one bread wheat sample. However, this is the first report of BYSMV in cereals in Yemen. *Bean leaf roll virus* (BLRV) and *Beet western yellow virus* (BWYV) were also only found occasionally, although this is the first time BWYV has been found in legumes in Yemen.

Survey of faba bean and pea diseases and viruses in China

Yunnan Province

During 2004, Australian, Chinese, and ICARDA researchers surveyed the viruses affecting legume crops in China's Yunnan province. This was part of the ACIAR-funded project of ICARDA on 'Increased Productivity of Cool Season Pulses in Rainfed Agricultural Systems of China and Australia.' In all, 4494 plants were collected randomly (3551 faba bean and 943 pea). A further 896 plants with virus-like symptoms were collected (790 faba bean and 106 pea). All were tested for 14 different legume viruses using tissue-blot immunoassay (TBIA). Testing began on site by blotting the samples collected each day, and was completed at the Yunnan Academy of Agricultural Sciences, Kunming.

BYMV was found to be an important disease of faba bean, as 10 fields had a virus incidence of more than 10%. Six of these had a virus incidence greater than 75%, while one had an infection rate of almost 100%. Incidences of BWYV and FBNYV were low in almost all cases. The two exceptions were a field near Xiao Xinjian with an FBNYV incidence of 8% and a BYMV infection rate of 77%, and a commercial pea field with a high incidence of BWYV (41%) and a very low (1%) incidence of PSbMV.

Detailed analysis using a series of monoclonal antibodies revealed that the Yunnan strains of FBNYV are diverse, resembling *Milk vetch dwarf virus* in some locations—a closely related virus that has so far only been reported in Japan. FBNYV, BWYV, and *Cucumber mosaic virus* were all detected for the first time in legume crops in China.

One reason for the survey was the very high levels of resistance to BLRV found in Yunnan germplasm collected in 1996. The 2004 survey provided further evidence of resistance, as no BLRV-infected faba bean was found. There is also strong evidence that Yunnan pea has a good level of resistance to PSbMV, as the survey found few infected plants.

The project trained local partners in survey methods, symptom recognition, and the use of TBIA. Links were established with Chinese researchers during the survey, which will support future virology research in Yunnan and other Chinese provinces.

Qinghai Province

In 2004, ICARDA worked with the Qinghai Academy of Agricultural and Forestry Sciences (QAAFS), the Chinese Academy of Agricultural Sciences (CAAS), and the Australian

Chinese, Australian and ICARDA scientists conducting a survey of faba bean and pea viruses in Yunnan Province. Researchers spent the day in the field collecting samples (left) and the evening blotting the samples (right).


Chinese, Australian, and ICARDA scientists visiting a sick plot of pea at the Hebei Institute of Cool Season Crops, Zhangbie, China (left) where an unknown disorder was found in a number of faba bean fields. Samples (right) were collected, but so far no pathogenic organism has been isolated.

institutes to survey faba bean and pea diseases in northern China's Qinghai Province. The survey was conducted jointly by an ICARDA–ACIAR project and an Australia–China ACIAR project. Researchers targeted faba bean fields in the province's lowlands, and faba bean and pea fields in the uplands.

Cercospora leaf spot, *Alternaria* leaf spot, and chocolate spot were the most prevalent diseases of faba bean. The main diseases of pea were bacterial blight and a wilt/root rot complex. CAAS and ICARDA are processing speciments to identify components of the complex.

An unknown disorder was found in a number of faba bean fields. The symptoms include large necrotic lesions on the leaf, which progress from the older leaves up the stem, not unlike chocolate spot and *Ascochyta* blight. Stem lesions and subsequent collapse of the plant were observed in some cases. Researchers collected samples, but no pathogenic organism has yet been isolated.

Faba bean and pea aphids, which transmit some viruses, were found in significant numbers at different sites. However, very few of the symptoms typical of virus infection were present. One hundred samples from plants suspected of virus infection were blotted on nitro-cellulose membranes and tested at ICARDA's virology laboratory against virus-specific antibodies for FBNYV, luteoviruses, potyviruses, BYMV, and PSbMV. Most did not react. However, PSbMV was found in some pea samples and FBNYV was found in faba bean from the QAAFS research station at Xining. Further testing for other viruses is ongoing.

The survey's results did not support previous claims that root rots are an important problem in pulses in China's northern provinces, especially in pea in more marginal growing environments. However, more detailed studies are needed to determine the occurrence of different root rots in farmers' fields and the root rot resistance of local germplasm. The information on diseases provided by the survey will be used to refine the targeting of faba bean and pea improvement programs.

Genetic diversity of the yellow rust fungus in Eritrea

Yellow rust, caused by *Puccinia striiformis* f. sp. *tritici,* is a major disease of wheat in most wheat-growing regions. Keeping track of the development of the pathogen allows researchers to identify and deploy new sources of resistance. During general disease surveys in 2002 and 2003, more than 60 yellow rust isolates (pustules containing genetically identical spores) were collected from farmers' fields in the central highlands of Eritrea, the country's main cereal-producing area. At least two individual isolates were collected from each field sampled, and the exact locations of collection sites were recorded.

The isolates were multiplied singly in spore-proof containers at the Danish Institute of Agricultural Sciences (DIAS), then pathotyped on a set of varieties with known genes for resistance to yellow rust. DNA was extracted from a parallel sample of each isolate, using the CTAB extraction method, and stored for further Amplified Fragment Length Polymorphism (AFLP) analysis. DNA fingerprints were produced by up to 60 primer combinations, resulting in more than 100 polymorphic DNA fragments or markers. This allowed each isolate to be characterized with a high degree of confidence.

Only two pathotypes were found in 2002. These differed slightly in their ability to infect the range of host varieties used in the tests. Both pathotypes were also found in 2003, in addition to a third which occurred at a low frequency.

One of the pathotypes displayed a number of virulence traits commonly found in Mediterranean isolates; the other two shared a previously-undescribed virulence phenotype. There was no obvious aggregation of specific pathotypes on specific wheat varieties, suggesting that most wheat varieties in Eritrea lack yellow-rust resistance. However, the resistance of Eritrean wheat varieties has not yet been formally tested. The results indicate that resistance breeding programs could greatly improve the control of yellow rust in wheat in Eritrea.

Understanding the evolution of the barley scald pathogen

Scald, caused by the fungus *Rhynchosporium secalis,* is an economically important disease of barley. Cultivated barley is, genetically, extremely vulnerable to scald and breeding for scald resistance is difficult because the fungus evolves quickly. In addition, the climatic conditions and cultural practices found in many barley-growing areas encourage scald development.

Knowledge of *R. secalis*'s evolutionary potential is vital to the development of sustainable resistance breeding strategies. An understanding of its genetic structure has provided useful insights into the evolutionary processes that affect *R. secalis* population genetics. However, specific hypotheses about the pathogen's evolution have not been tested in controlled and repeatable field experiments.

In collaboration with the Phytopathology Group at ETH-Zurich, ICARDA is using an innovative, replicated, mark–release– recapture field experiment to quantify the relative impacts of sexual reproduction, asexual propagation, immigration, and selection on the genetic structure of an experimental random population of *R. secalis* in Syria.

More than 1500 scald isolates collected from field plots were assayed for eight individual microsatellite loci (Fig. 10). Researchers found eight isolates that differed markedly in their ability to infect, compete and reproduce on individual barley genotypes and barley mixtures. Significant differences were observed in the frequencies with which the inoculants were found, over time, on the different hosts tested. In addition, a considerable number of new *R. secalis* genotypes were found, based on their multilocus haplotype.

These results showed that use of the mark–release–recapture strate-

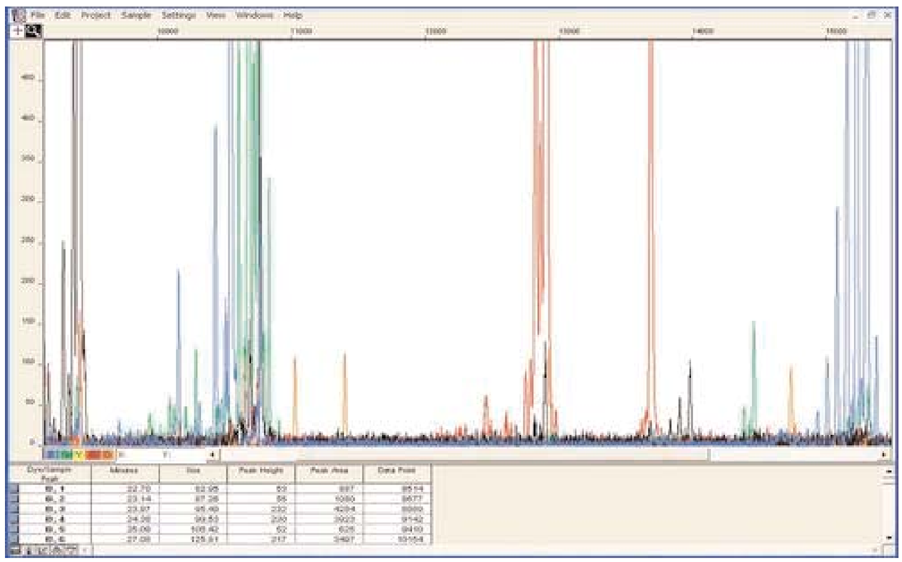
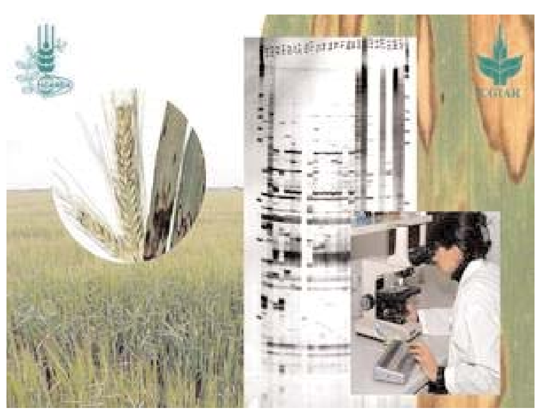


Fig. 10. Chromatogram of a representative Genescan gel illustrating microsatellite DNA fragment analysis of *R. secalis*.



Culturing scald in order to understand pathotypic and genotypic relationships.

gy was appropriate to the barley–*R. secalis* pathosystem. They also showed the possible effects of selection due to specific host–pathogen interactions.

The genetic recombinants detected in the study constitute a significant source of inoculum for scald pathotypic variations and epidemic development. Breeding for resistance should, therefore, focus on quantitative resistance traits, as well as increasing genetic diversity in commercial barley cultivation.

These findings will help breeders incorporate scald resistance into barley genotypes suited to different agroclimatic conditions and farming systems, thereby contributing to a sustainable increase in barley yields.

Controlling Sunn pest using egg parasitoids

Sunn pest (*Eurygaster integriceps*) is the most important insect pest of wheat in Central and West Asia. It causes yield losses of 50-90% and severely reduces the quality of any flour produced by degrading gluten proteins in the grain as it feeds. Chemical control is costly and unsustainable, and Sunn pest is now resistant to many insecticides. ICARDA is, therefore, investigating the use of parasitoids that attack Sunn pest eggs as a promising alternative control option.

In 2003 and 2004, researchers assessed the effect of various densities of Sunn pest egg parasitoid density at three levels of Sunn pest infestation. The aim was to determine how these factors influence the percentage of eggs parasitized and the quality of the grain produced. The study was conducted in the field at Tel Hadya using the parasitoid wasp, *Trissolcus grandis*, and the bread wheat variety 'Cham 6,' which was grown in screen cages.

At low adult Sunn pest densities ($2/m^2$ and $4/m^2$), 65-90% of eggs were parasitized four weeks after exposure; parasitoid wasp density did not affect the percentage of eggs parasitized (Fig. 11). However, at a high Sunn pest density ($6/m^2$), significantly fewer eggs were parasitized when only one wasp was present per square meter than when two or three wasps were introduced (Fig. 11). The results show that, per square meter, at least two adult parasitoid wasps are needed to significantly reduce the damage caused by up to six adult Sunn pest.

The results obtained for grain quality were similar to those found for egg parasitism. At low Sunn pest densities ($2/m^2$ and $4/m^2$), and regardless of the density of wasps, gluten quality (represented by the grain's SDS sedimentation value) was comparable to that of wheat that was not infested with Sunn pest. However, gluten quality was significantly lower than that of non-infested wheat when only one wasp was present per square meter in the high Sunn pest density treatment ($6/m^2$). The results show that egg parasitoids could play a very important role in reducing Sunn pest populations, if heavy pesticide use is controlled and applications are carefully timed so that as few of the parasitoids as possible are killed.

Natural enemies of adult Sunn pest found in Syria

In 2004, more than 277,000 ha of wheat and barley in Syria were sprayed with insecticides to control Sunn pest. To develop alternative biological control options, ICARDA researchers are surveying the parasitoids that attack Sunn pest in the field. Potentially useful species include some Phasiine flies of the Tachinidae family, as the larvae of these parasitoids kill the adult pest. Until recently, however, very little was known about these natural enemies of Sunn pest.

In 2003 and 2004, ICARDA researchers surveyed the parasitoids of adult Sunn pest in Syria, by collecting infected adults from

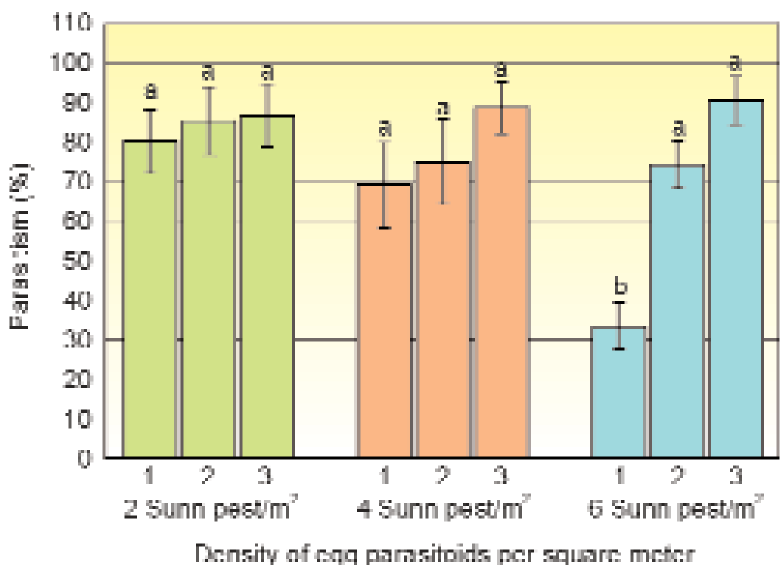


Fig. 11. Percentages of Sunn pest eggs parasitized when the densities of Sunn pest and an egg parasitoid (the wasp *Trissolcus grandis*) were varied experimentally. Means labeled with the same letter are not significantly different from each other at the 5% significance level (Fisher's LSD test within each Sunn pest density group).

over-wintering sites in Azaz, Ariha, Ksabia, and Tel Hadya, and from wheat fields in Kamishly, Malkeia, Hama, Ariha, Idlib, Sweida, and Azaz. Researchers found four species of Phasiine fly that attack Sunn pest: *Phasia subcoleoptrata*, *Heliozeta helluo*, *Ectophasia oblonga,* and *Elomyia lateralis*. This is the first time that these four species have been reported to affect Sunn pest in Syria.

In 2003, parasitism rates in all the over-wintering sites sampled were negligible. In early spring, very low rates of parasitism were found in wheat fields in Hama (1.3%) and Sweida (2.7%); there were no occurrences at the other sites surveyed. Towards the end of the spring, however, parasitism rates in wheat fields increased dramatically to 6.5%, 4.0%, 5.9%, and 13.3% in Azaz, Idlib, Kamishly, and Sweida, respectively. In 2004, parasitism levels were negligible in all over-wintering sites except Azaz (1%). Parasitism was not detected in wheat fields in early spring, except in Malkeia where levels reached 1.9%. However, in late spring, rates reached 5.9% in Kamishly and 12.5% in Malkeia.

Larva of a parasitoid (*Phasia* sp.) emerging from an adult Sunn pest.

Results showed that the parasitoids are active in the spring about two weeks after Sunn pest adults migrate to cereal fields from their over-wintering sites and start laying eggs. However, the level of parasitism varies from year to year. These parasitoids could help reduce Sunn pest populations if they are not affected by the aerial spraying of broad-spectrum insecticides.

Project 2.2.

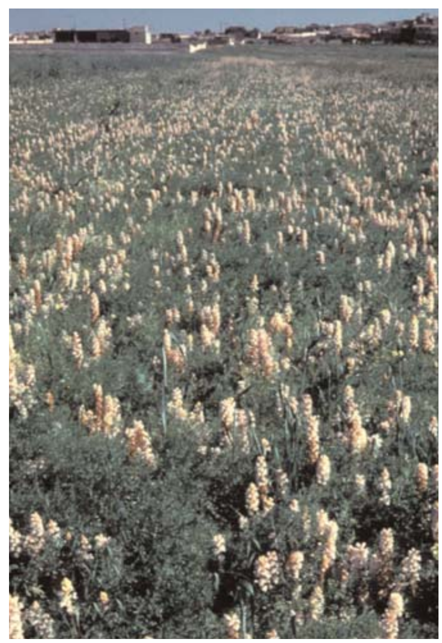
Agronomic Management of Cropping Systems for Sustainable Production in Dry Areas

To identify best practices for weed control, ICARDA researchers have developed appropriate chemical methods of controlling *Orobanche*, a damaging parasitic weed that attacks legume crops. The most effective chemicals, doses, and application times were identified for *Orobanche* control in lentil, *Vicia* spp., *Lathyrus* spp., and faba bean.

Successful chemical control of *Orobanche* in legumes

Orobanche spp. (broomrape) are parasitic weeds which attack many cultivated and wild plants. They mainly parasitize legumes such as faba bean (*Vicia faba*) and lentil (*Lens culinaris*) and solanaceous crops such as tobacco and tomato by attaching themselves to the roots of their hosts and absorbing the food they gather. *Orobanche* produces large numbers of small, easily-disseminated seeds that remain viable for long periods, making this weed difficult to control. It also spreads through the planting of contaminated crop seed.

Two types of *Orobanche* are present in CWANA: *O. crenata* and *O. aegyptiaca-ramosa*. Both attack faba bean, vetch, winter chickpea, lentil, safflower, and rapeseed, although *O. aegyptiaca-ramosa* mainly invades lentil and rapeseed fields. Studies at ICARDA have shown that lentil, narbon vetch (*Vicia narbonensis*) and faba bean are most susceptible to *Orobanche*. The number of *Orobanche* shoots per square meter in these three crops reached 191, 226, and 226, respectively. However, the pres-



Severe *Orobanche* infestation in a lentil field.

ence of *Orobanche* in other legumes also needs to be carefully monitored, so that it can be controlled before its seeds are dispersed.

Over the years, researchers have tested many different *Orobanche* control methods, with varying levels of success. These include the use of trap crops, such as flax, hemp, and fennel (which was not successful), hand pulling, breeding *Orobanche*-resistant varieties, and biological control. Farmers growing legumes delay planting as a control measure. However, this reduces yields by around 30-50%.

Since 1997, ICARDA has been studying the chemical control of *Orobanche* in lentil, forages, and faba bean at its Tel Hadya research station. Three chemicals were tested in conjunction with different varieties and sowing dates: imazaquin (‘Scepter’) imazathapyr (‘Persuit’), and imazapic (‘Oroban-Cadre’). In some treatments, chemicals were applied once—either soon after emergence (‘early’) or in the middle of the crop’s development (‘middle’). In other treatments, combinations of application times were used: (i) ‘early’ and ‘middle’; (ii) ‘early’, ‘middle’ and ‘late’ (i.e. late in the crop’s development); and (iii) ‘middle’ and ‘late’. Imazapic was found to give a good level of *Orobanche* control in lentil and forages (Tables 6 and 7).

The results of the Tel Hadya studies, coupled with further on-farm testing, showed that two applications of imazapic at a rate of 3 g of active ingredient/hectare (ai/ha) controlled severe *Orobanche* infestations in lentil, vetch, and *Lathyrus* spp. The first application should be made when the crop is 10-15 cm tall and the second 15-20 days later.

In later trials, ICARDA researchers tested imazapic on larger areas of lentil (82 ha in 2000/01, 134 ha in 2001/02, and 90 ha in 2002/03). No, or very little phytotoxicity was observed and yields were not reduced when crops were treated twice with imazapic at a dose of 3 g ai/ha on each application. However, when crops are sprayed twice, care should be taken to ensure that the applications do not overlap, as this can cause some stunting or result in the lentil maturing slightly later. Because imazapic is effective, almost all the

Table 6. Effect of different doses of imazapic, applied at various stages of the crop's development, on *Orobanche* control in lentil. Data from four years of trials (1997-2000) at Tel Hadya, Syria.

Control method: imazapic dose (grams of active ingredient, ai/ha) and time of application†			Lentil yield (t/ha)		Percent *Orobanche* killed	Lentil crop phytotoxicity‡
'Early'	'Middle'	'Late'	Biomass	Seed		
0	0	0	2.56	0.43	0	1
5.0	0	0	2.86	0.58	98	3
5.0	2.5	0	2.76	0.43	100	3
2.5	2.5	2.5	2.66	0.48	98	3
0	5.0	0	2.61	0.42	75	2
0	5.0	2.5	2.54	0.36	90	4

† 'Early' = when 5-7 true leaves had developed; 'Middle' = before flowering; 'Late' = when in full flower.

‡ Based on the European Weed Research Society scoring system, using a scale of 1-9, where 1 = crop unharmed and 9 = crop dead.

Table 7. Effect of different doses of imazapic, applied at various stages of the crop's development on *Orobanche* control in forage species. Data from four years of trials (1997-2000) at Tel Hadya, Syria.

	Vicia spp.			*Lathyrus* spp.		
Control method: imazapic dose, (g ai/ha) and time of application†	Biomass yield (t/ha)	Seed yield (t/ha)	Crop phyto-toxicity‡	Biomass yield (t/ha)	Seed yield (t/ha)	Crop phyto-toxicity‡
5 ('Middle')	3.80	0.77	3	4.13	0.75	3
5 ('Middle') + 5 ('Late')	3.44	0.56	5	4.63	1.18	3
5 ('Middle') + 2.5 ('Late')	3.55	0.61	4	4.38	0.75	3

† 'Early' = early in growing season; 'Middle' = middle of growing season; 'Late' = late in growing season.

‡ Based on the European Weed Research Society scoring system, using a scale of 1-9, where 1 = crop unharmed and 9 = crop dead.

A comparison of *Orobanche* growth in lentil roots shows greater infestation in the check plot (left) vs. plants sprayed with imazapic (right).

The check plot (left) succumbed to *Orobanche* infestation while early application of imazapic (right) resulted in *Orobanche* control.

lentils and forage legumes grown at Tel Hadya (160 ha) are now sprayed with this chemical.

Imazapic was also tested on 34 ha of winter chickpea during the 2002/03 growing season. Two applications of imazapic at a rate of 1.5 g ai/ha controlled *Orobanche* successfully. Only slight phytotoxic effects were observed and yields were not reduced.

Assessing phytotoxicity is important in herbicide trials. Farmers fear that phytotoxic side effects will reduce yields, and will not use chemicals that damage their crops at the early stages of development, even if they later recover. While imazapic is a feasible option for *Orobanche* control in lentil and forage legumes, researchers found that it could not be used in faba bean because its phytotoxic effects were too severe. Glyphosate ('Round-up') is a better alternative, as it controlled *Orobanche* without affecting faba bean. Two to three applications of glyphosate at a dose of 60 g ai/ha per application are recommended. The glyphosate should first be applied soon after flowering; later applications should be separated by an interval of 15-20 days. Another alternative is the use of 'Giza 4,' an *Orobanche*-tolerant faba bean variety developed by ICARDA. This option would require the use of no, or little, glyphosate. Extension efforts are needed to disseminate this information to farmers growing faba bean.

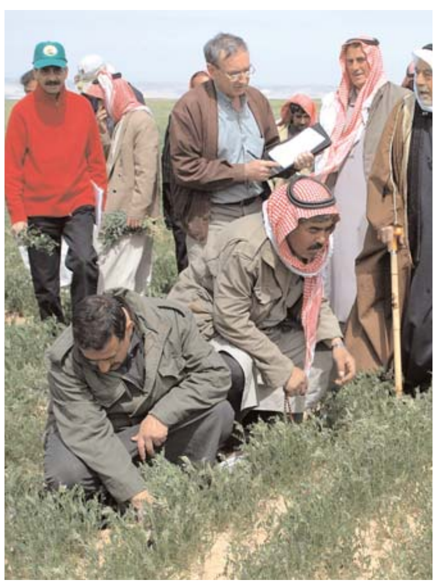
Project 2.3.

Improvement of sown pasture and forage production for livestock feed in dry areas

Large feed deficits are predicted for more than 80% of the countries in the dry areas of CWANA. This will prevent resource-poor livestock producers from taking advantage of the growing market for livestock products. Introducing forage legumes into crop–livestock systems can help increase meat, milk, and wool production, and also make these systems more sustainable. In 2004, participatory approaches were used to promote the adoption of forage technologies and determine which forage legumes farmers preferred. Trial results also showed that grazing forage legumes such as bitter vetch could help to overcome feed shortages in the spring.

Selecting forages with farmers to promote adoption

At least 250 million poor farmers in CWANA's dry areas rely on livestock for their livelihoods. This number is expected to increase rapidly over the next five decades. When coupled with the effects of climate change, it means that mixed crop–livestock and peri-urban meat and milk production systems will become the region's dominant farming systems. Economic reforms and urbanization have already started boosting market demand for livestock products.



Syrian farmers discuss the performance of common and narbon vetch, and grass pea lines with ICARDA scientists.

However, resource-poor producers will not be able to benefit from this growing market, because large feed deficits are projected for more than 80% of the countries in the region. ICARDA and its national partners are using participatory approaches to test new forage-legume technologies designed to improve crop and animal production, as well as soil fertility, in small-scale crop–livestock systems.

Researchers evaluated the performance of common vetch (*Vicia sativa*), narbon vetch (*V. narbonensis*) and grass pea (*Lathyrus sativus*) under on-farm conditions in the El-Bab and Khanasser areas of northern Syria. Farmers in these areas were recently introduced to grass pea and narbon vetch, and asked to compare these with common vetch, which they have been growing for several years.

Earliness, tolerance to water stress and frost, vigorous growth, leaf size and color, and pod size and number, were the traits farmers valued most. They preferred narbon vetch to common vetch because of its larger pods and broad, dark-green leaves. They also preferred grass pea to common vetch, because it can tolerate water stress. Grass pea and narbon vetch yielded around 30% more than common vetch, on average (Fig. 12). For these reasons, many of the farmers stated that they were interested in growing grass pea and narbon vetch. This suggests that working with farmers to evaluate forage legumes could improve technology adoption.

Researchers also assessed whether elite lines of bitter vetch (*V. ervilia*) and common vetch could be used to fill the early spring 'feed gap'. Average daily weight gains in weaned Awassi lambs grazing bitter vetch did not differ significantly from those of lambs grazing a released cultivar of common vetch 'Baraka' (Table 8). Daily gains ranged from 160 to 181 g/head (381 to 420 kg/ha), which means that either bitter vetch or 'Baraka' could be used to fatten lambs in small-scale semi-intensive systems. This would help farmers benefit from the growing market for livestock products.

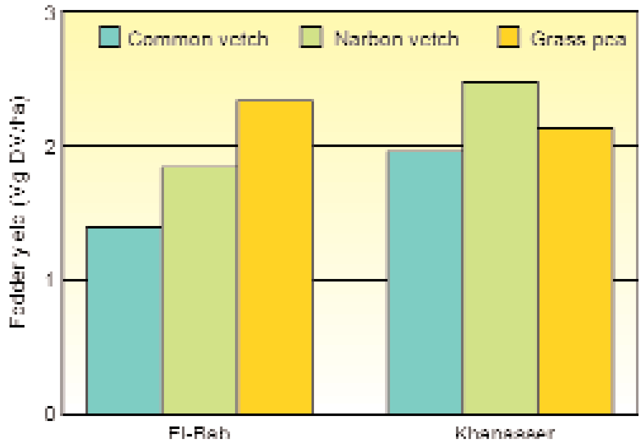


Fig. 12. Dry fodder yield of common vetch (*Vicia sativa*), narbon vetch (*V. narbonensis*) and grass pea (*Lathyrus sativus*) on seven farms in the El-Bab area, and 11 farms in the Khanasser area, in northern Syria in 2004.

Table 8. Mean dry matter forage yield and average daily gain (ADG) of weaned Awassi lambs grazing pure stands of *Vicia* species for 42 days during the spring, in Tel Hadya, Syria, in 2004.

Vicia cultivar/line	Yield (Mg/ha)	ADG (g/head)
Vicia sativa cv 'Baraka'	1.23	181
Vicia sativa 2556	1.13	160
Vicia ervilia 3330	1.99	173
SE	0.23	2.4

Project 2.4.

Rehabilitation and Improved Management of Rangeland in Dry Areas

In many dry areas of CWANA, increasing population pressures are degrading the region's natural resource base and undermining the long-term well-being of the area's people. ICARDA and its partners are addressing the problems of agricultural encroachment and overgrazing in several countries. In 2004, livestock and rangeland resources, rangeland use patterns, and local institutions were assessed in 11 communities in Syria to help develop management plans for the region's rangelands. This helped researchers understand the social and ecological conditions under which one management option—community-based rotational grazing—could be successful.

ICARDA researchers interviewing community leaders in Aleppo Province, Syria.

Developing community-focused management plans for rangelands in Syria

More than half of CWANA consists of rangeland used to graze small ruminants. However, much of this area is overgrazed and severely degraded. ICARDA is using participatory approaches to improve rangeland management, increase supplies of fuel and animal feed, and boost livestock productivity.

In areas where use rights are communal, the only management options likely to halt rangeland degradation are rotational grazing and controlled stocking rates.

Developing these kinds of community-based practices requires a good understanding of local institutions, rangeland use, land degradation, and the interactions among these factors. Researchers also need to gauge local people's knowledge and views. In 2004, ICARDA and Syrian national program researchers conducted a rapid socioecological survey of the resources of 11 Syrian steppe communities by interviewing their leaders. In total, these communities comprised 615 households. The findings are being used to explore socially appropriate options for cooperative rotational grazing.

Researchers quantified the numbers of livestock and households in each community, and the amount of rangeland each village controlled (Table 9). On average, between 1999 and 2003, 58% of households used the range to graze livestock, and animals spent eight months per year on the range. However, rangeland-grazing times varied considerably during this period, from 2 to 12 months, depending on rainfall and the community surveyed. Most time was spent on the range in 2003, when grazing was relatively good.

The project also assessed communities' perceptions of the effects of grazing. Most felt that poor plant growth (short and weak plants) was due to continuous grazing. However, all felt that native plants would recover from overgrazing during a good rainy season. According to the communities, most of their rangelands had degraded over the past 20 years as a result of heavy grazing.

All households in each community were represented in a livestock-breeding and rangeland-improvement cooperative. All communities were aware of the boundaries of their land and there were no inter-community boundary disputes. When researchers suggested rotational grazing as a means to control degradation, one community indicated that it did not have enough rangeland to implement rotational grazing. The other 10 said that they could subdivide their rangeland and graze it in rotation, but only if they were provided with either supplementary feed or guards.

Researchers worked with community leaders and shepherds to assess rangeland conditions at 17 sites. Previously cultivated areas were not evaluated, as they were severely degraded and will not be suitable for rotational grazing until forage plants have been restored. According to the communities, 14 of the sites were best grazed in spring, because they were dominated by annual plants that disappear in summer, and three could be grazed in summer. Communities named two sites that were best used in winter and autumn because these were dominated by the perennial shrub *Artemisia* spp.

The value of the forage available per site in the 2003/04 growing season was assessed based on total plant biomass and the number of palatable plant species. Sixty percent of the sites had a low forage value, 35% a medium value, and only 6% (a shrub plantation) a high value. Shepherds estimated that 30-50% of the vegetation available could be used as forage in a typical year. Of the 34 major plant species identified, 50% provided good forage, while 32% were poor forage. Fourteen percent had no value, 6% had medicinal value, 6% could be used as human food, and 6% as fuel. Most of the species used for

Table 9. Rangeland area, household and livestock numbers, time spent grazing on the range, and degradation index, in 11 communities in the Syrian steppe: results of a survey conducted in 2003/04 to assess the feasibility of cooperative rotational grazing.

Community	No. of households	Rangeland area (ha): Not improved	Rested	Replanted	Previously cropped	Total	Previously cropped area (% of total)	No. of livestock	No. of months grazed on range (2003/04)	Stocking rate (2003/04)‡	Degradation index†
Bir Zedan	100	23000	5000	100	7000	35100	19.9	40000	12	13.7	2.8
Al Khashabieh	70	3000	3250	0	15400	24000	64.2	16000	12	8.0	2.8
Al Tahamiz	50	10000	0	0	2000	12000	16.7	5000	12	5.0	2.3
Shikh Hilal	100	3000	0	0	7000	10000	70.0	450	7	0.3	1.9
Kherbet Hachem	40	7000	100	100	150	7350	2.0	3400	8	3.7	2.9
Al Haddaj	50	4000	300	0	2700	7000	38.6	10000	12	17.1	2.4
Abou AlAllaj	60	3500	0	0	3000	6500	46.2	7000	5	5.4	2.4
Abou Mial	25	2000	500	1500	2000	6000	33.3	1600	3	0.8	3.6
Al Ksair	10	2150	150	1700	300	4300	7.0	2500	12	7.0	2.3
Hwayet Aldibeh	90	100	250	850	1200	2400	50.0	9000	12	45.0	1.8
Al Alia	20	1100	100	0	500	1700	29.4	2500	12	17.6	2.2
TOTAL	615	58850	9650	4250	41250	116350		97450			
AVERAGE	56	5350	877	386	3750	10577	34.3	8859	10	11.2	2.5

‡ Stocking rate, expressed per hectare, i.e., the total number of sheep x number of months grazed, divided by land area.

† Assessed using a scale of 1-5, where 1 = lowest level of degradation and 5 = highest.

medicine, fuel, and food were also grazed. On average, only 43% of the 400 kg/ha of annual biomass was considered good forage. However, in reality, only 80 kg/ha of residual vegetation remained after grazing. This indicates that livestock will graze most plants when no other forage is available, even during a 'high' rainfall year such as 2003/04.

On average, 27% of the ground's surface was protected by perennial vegetation, which provides forage throughout the year, unlike annual plants which are only available in spring. Ground cover was also provided by moss and lichen (7%) and rock and gravel (12%). However, almost half of the ground's surface was bare soil or was only covered by annual plants, and was, therefore, exposed to erosion. Although vegetative ground cover was relatively sparse, researchers concluded that plants which protect the ground from erosion would recover at most previously uncultivated sites if rotational grazing was implemented. Replanting efforts would, therefore, only be needed on abandoned cropland.

An index of degradation was calculated by evaluating nine erosion and degradation indicators, scoring each on a scale of 1-5 (1 = least degradation and 5 = most), and then averaging the scores. The indicators included root exposure, soil compaction, and the presence of gullies and invasive plants. Some communities' rangeland was more severely degraded than that of others, as values of the index ranged from 1.8 to 3.6; the overall average was 2.5 (Table 9).

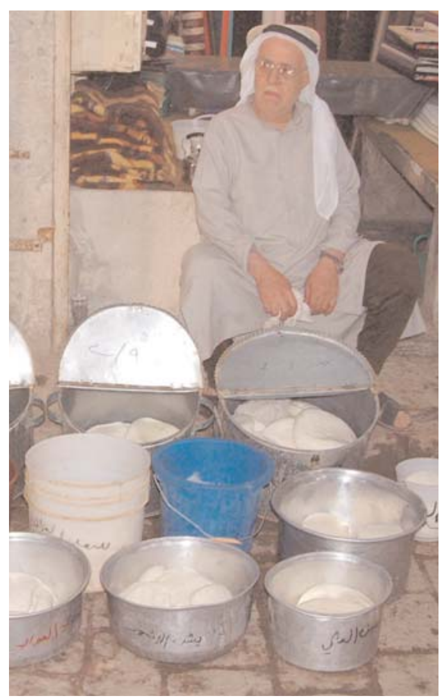
Researchers found no clear relationship between the degradation index and the livestock stocking rate (number of sheep x number of months grazed/land area; Table 9). This may be because the amount of forage produced by different types of rangeland varied, ranging from 200 to 500 kg/ha at most sites (Table 9), but reaching 1100 kg/ha at one site. In addition, the degradation index represents the current amount of degradation, which is the result of historical stocking rates rather than the current stocking rates.

Communities with the least amount of forage available per animal are most likely to degrade their rangeland in the future. Overall, researchers concluded that, despite high levels of degradation, changes in grazing management would significantly improve the area's native rangeland and ensure the long-term sustainability of such systems.

Project 2.5.

Improvement of Small-Ruminant Production in Dry Areas

ICARDA is helping small-scale farmers in CWANA cope with the challenges facing their traditional production systems. In 2004, ICARDA worked with communities in northern Syria to boost sheep milk production and farmers' incomes by introducing low-cost feeding systems and improved management practices. Participatory approaches were used to test new milking equipment that reduces women's workloads. Farmers and extension workers were trained in simple new techniques to improve processing and hygiene—including pasteurization—which minimized spoilage and increased the value of farmers' products.



A high market demand exists for a variety of milk products (especially cheese and yogurt) in CWANA countries.

Market-oriented improvement of dairy sheep production in Syria

Sheep milk products are widely consumed in Jordan, Lebanon, Syria, Turkey and elsewhere in CWANA. Milk, cheese, and yogurt from indigenous breeds such as the Awassi sheep are in great demand and command favorable prices in expanding local markets. As a result, farmers are attempting to intensify production. However, productivity remains low, partly because of water and feed scarcity, which often forces farmers to buy feed to maintain their flocks. In addition, flocks are inefficiently managed and sheep milk is often processed wastefully and unhygienically.

ICARDA, therefore, began a multidisciplinary research program in 2000 to improve productivity in El-Bab, an area in northern Syria where sheep milk products are traditionally produced. The project originally used an on-farm adaptive research approach. However, a community-based, participatory approach is now being used to develop appropriate technologies, evaluate new production and income scenarios, and encourage farmers to work together.

Participatory workshops and rapid rural appraisals were used to characterize production processes and analyze production constraints. Market opportunities and local knowledge of milk processing were also considered. It was found that, on average, sheep milk production contributed almost half (48%) to a family's income and served as an important source of employment for family members. On average, each farm kept 49 Awassi ewes, that represents 68% of each flock. These were used to produce milk, which was mainly processed into yogurt and cheese and then marketed through intermediaries.

Several production constraints were identified, including the cost of feed, inadequate management, and lack of access to improved breeding ewes and rams. In addition, no infrastructure existed for milk processing. For example, electricity was not available for refrigeration, so products spoiled easily.

The constraints identified were addressed by (i) introducing efficient feeding systems and improved flock management; (ii) improving the collection and processing of milk; and (iii) promoting community action.

Participatory workshops and rapid rural appraisals were used in El-Bab, Syria, to integrate research efforts to improve productivity and market targeting of dairy products.

To improve milk production, farmers tested strategic feeding methods using treated straw and cheap agricultural by-products (i.e. olive cake, tomato pulp, and citrus pulp). This simple technology improved milk production by 12.5 kg per ewe. For an average flock of 50 ewes, this translates into an additional US$ 217 per season.

Use of a better feeding regime also motivated farmers to consider using Awassi varieties that produce more under less harsh conditions. Because farmers listed this as an important intervention, ICARDA introduced a genotype that produces up to 17% more milk than the local genotype under a similar feeding regime on-station. The performance of these animals is currently being evaluated. The project is also working to increase the adoption of technologies such as lamb fattening using low-cost diets, as the use of more intensive systems will add value to farmers' produce.

To improve the collection and processing of milk products, a series of training workshops was held to make farmers aware of consumer preferences and persuade them to focus on improving the quality of their products. Consumers strongly prefer yogurt and cheese made from sheep milk. They want high-quality produce, and because they can determine what region a product comes from by its flavor, it is impossible to sell products adulterated with goat or cow milk. Consumers rated cleanliness and flavor very highly in both cheese and yogurt, and also required yogurt to be firm.

Traditional milking methods can often contaminate an entire day's batch of milk. In fact, bacterial contamination is the main problem in traditional processing systems. According to recent estimates at least 30-40% of milking ewes suffer from mastitis. Furthermore, 2.7% of the sheep in the region carry brucellosis.

Training farmers in improved techniques of processing of milk derivatives is helping to produce healthy and better quality dairy products.

However, though contamination is a problem, very few farmers pasteurize the milk. This causes problems, as 'fresh' cheese, for example, usually has to be boiled before it is eaten—which destroys its smell and taste. Therefore, improved processing methods, including simple pasteurization techniques, were introduced. This has led some farmers to pasteurize their milk and sell their cheese for higher prices.

Better hygiene and superior starters produced a firmer, more stable yogurt that could better withstand transport. This resulted in producers earning up to 20% more per kilogram of yogurt. However, many of the improved hygienic processing techniques formulated could not be adopted by individual farmers because of the costs involved. So, widespread use of this technology will require cooperative organization. This is being promoted by the second phase of the project.

Women usually do the milking and process the milk, and suffer from back pain as a result of a heavy workload. The project tested a new style of milking parlor, which successfully reduced both these problems. The parlor is easy to build using local materials and workshops. However, adoption of the new system will require cooperation, which the project is now encouraging in El-Bab.

Intermediaries who buy and sell milk products often obtain greater profits than the producers. These working relationships could, therefore, be improved. Farmers could also earn more by marketing their own produce through farmer associations, and by selling it out of season when prices are higher. The project also identified a market for *jameed*, a by-product of milk processing which has a high market value in Jordan. As a result, one farmer diversified into the production and export of *jameed*. ICARDA is now exploring the potential of this market.

Both farmers and extension workers received intensive training. This was a key aspect of the project, as farmer participation was found to be most effective when the farmers thoroughly understood the technologies and the conditions required for them to work. ICARDA researchers developed easy-to-read, foldable posters to facilitate training, and established farmer 'schools.' Older teenagers were also targeted specifically, as they are the next generation of farmers.

Exchanges of information between women farmers from different areas also proved useful. Meetings between female producers from El-Bab and women from Jordan's Cooperative Corporation, for example, had a major impact on the introduction of improved milk-processing technologies.

Although the process of working with communities is lengthy, successful and suitable technologies have been identified that could be disseminated and used on a wider scale.

Theme 3

Natural Resource Management

Project 3.1.

Water Resource Conservation and Management for Agricultural Production in Dry Areas

Efficient management of water resources is especially important in the dry areas of CWANA where water scarcity is severe. ICARDA has tested new water-use-efficient irrigation technologies to increase and stabilize the yields of strategic cereal and legume crops. Results from four years of lentil, chickpea, and faba bean trials showed that appropriate combinations of planting date and deficit supplemental irrigation can substantially increase yields and maximize the water-use efficiency of these crops. In order to identify parameters to improve crop tolerance to salinity, researchers assessed the relationship between tolerance to drought and tolerance to salinity and identified different mechanisms for each.

Legumes benefit from supplemental irrigation

Lentil, chickpea, and faba bean are the major cool-season food legumes grown in CWANA. They provide food and animal feed and restore soil fertility. However, productivity needs to be increased, as yields are currently quite low: 0.8, 1.0, and 1.7 t/ha, on average, for lentil, chickpea, and faba bean, respectively.

Because rainfall in the region is low and variable, legume crops usually suffer water stress during the reproductive stage of development. This leads to low yields and low productivity per unit rainfall. Options for improving and stabilizing rainfed yields and water productivity were, therefore, tested at ICARDA's Tel Hadya research station over four years (1997/1998 to 2000/2001).

The trials involved various planting dates (to help the crops avoid terminal drought stress) and different levels of supplemental irrigation (SI). These levels were 'full SI', which completely satisfies a crop's water requirements, and one-third and two-thirds of this amount (deficit supplemental irrigation). Researchers measured grain and biomass yields and calculated water-use efficiency (water productivity): the yield per unit of water used. This was expressed per cubic meter of water (kg/m^3) or per millimeter of water applied per hectare 1kg/m^3 = 10 kg/ha-mm).

A supplemental irrigation trial of lentil at Tel Hadya, Syria, 2003/04.

In the lentil trials, supplemental irrigation increased biomass and grain yields significantly. In response to increases in the total amount of water supplied (including rain), grain yields increased linearly, rising from 1.04 t/ha under rainfed conditions to 1.81 t/ha under full SI (Fig. 13). The same was true for biomass yield, which rose from 4.27 t/ha under rainfed conditions to 6.2 t/ha under full SI.

Supplemental irrigation also increased water productivity relative to rainfed conditions. Optimum water productivity—for both grain (0.6 kg grain/m^3 water) and biomass—occurred when only two-thirds of the water required for full SI was applied.

However, the study showed that varying the sowing date did not significantly affect lentil grain yield (Fig. 13). In fact, sowing at the traditional time (late December to mid-January) gave the greatest overall grain yield (1.6 t/ha). Biomass yield, on the other hand, was higher when lentil was sown earlier, as was biomass water productivity. In the case of grain, however, water productivity under sup-

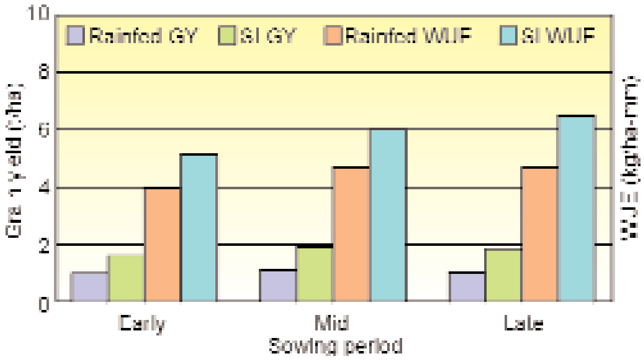


Fig. 13. Grain yield (GY) and water-use efficiency (WUE) of lentil under rainfed conditions and full supplemental irrigation (SI), at different sowing dates in northern Syria.

plemental irrigation decreased steadily with earlier sowing—dropping from 0.59 kg/m³ when lentil was sown late (late January to mid-February) to 0.47 kg/m³ when it was sown early (mid-November).

Chickpea is traditionally sown as a rainfed crop in spring (March–April), in WANA and is largely raised on residual moisture. But, the resulting low and variable yields discourage farmers from investing in inputs for this crop. To increase production, ICARDA bred cold-tolerant, winter-sown varieties in the 1990s. These yield more than spring-sown chickpea and use water more efficiently. A winter-sown variety was used in the chickpea trials reported here.

The study found that increasing the amount of water used for irrigation boosted both chickpea grain and biomass yields. Mean grain yields under full SI (1.9 t/ha) were 65% higher than under rainfed conditions (Fig. 14). A similar percentage increase was found for biomass yield. As with lentil, water productivity for chickpea grain (0.55 kg grain/m³ water) and biomass was greatest at the two-thirds SI level.

Sowing chickpea early also steadily increased biomass yields, from 3.75 t/ha (late sowing in late February) to 4.44 t/ha (early sowing in late November). However, sowing in mid-January gave the highest grain yield (1.71 t/ha).

When chickpea is planted early, evapotranspiration rates are high. So planting later should increase water-use efficiency (WUE), allowing more grain and biomass to be produced using less water. The trial confirmed that planting late rather than early increased WUE by 17-20%. Under rainfed conditions, WUE was highest when chickpea was sown around mid-January. However, under irrigation, WUE was highest when the crop was sown in late February and irrigated at the two-thirds SI level.

Increased irrigation also boosted the grain and biomass yields of faba bean. Overall, grain yield increased by 67%, from 1.13 t/ha under rainfed conditions to 1.89 t/ha under full SI (Fig. 15). Biomass yield rose from 3.26 t/ha under rainfed conditions to 4.87 t/ha under full SI.

As with chickpea and lentil, water productivity for both grain (0.61 kg grain/m³ water) and biomass was optimal at the two-thirds SI level. Therefore, as with the other crops, deficit irrigation provides a water-efficient option for increasing faba bean yields.

Early sowing of faba bean also steadily increased both grain and biomass yields. Average grain and biomass yields were 25% and 47% higher, respectively, at early sowing (in early November) than at late sowing (in late January/early February). Biomass water productivity under SI also increased steadily in response to earlier sowing. For grain, however, average water productivity was highest (0.61 kg/m³) when the crop was sown at the traditional time (mid-December).

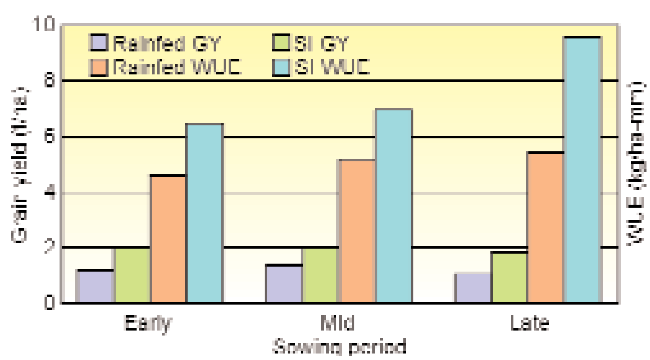


Fig. 14. Grain yield (GY) and water-use efficiency (WUE) of chickpea under rainfed conditions and full supplemental irrigation (SI), at different sowing dates in northern Syria.

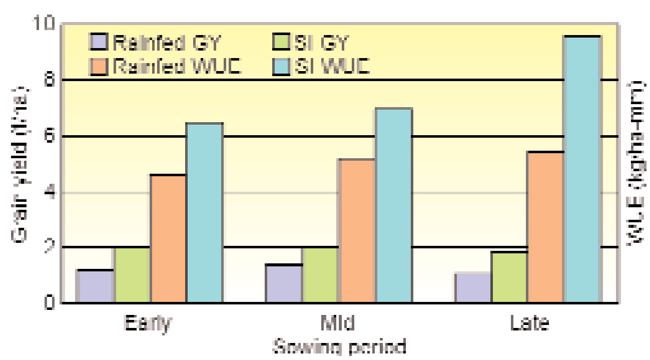


Fig. 15. Grain yield (GY) and water-use efficiency (WUE) of faba bean under rainfed conditions and full supplemental irrigation (SI), at different sowing dates in northern Syria.

In summary, the results showed that supplemental irrigation is a viable way of increasing and stabilizing food legume yields. It can also boost water productivity (water-use efficiency), allowing farmers to irrigate more land and produce more crops. Sowing cool-season legumes early increases yields and, when combined with supplemental irrigation, can help crops escape terminal drought stress.

Irrigation in rainfed areas, however, comes at a cost. Economic and feasibility studies are needed to assess how farmers can best allocate their limited water supplies among different legume and cereal crops. In this study, food legumes produced around 0.5 kg grain per cubic meter of water added through SI. This response to SI is only half of that obtained for cereal crops in the same location. The gross economic return per unit of water consumed under SI is also one-third higher in wheat than in legumes.

However, the economic return per kilogram of legumes is greater than that of cereals, and legumes also increase the nitrogen and organic matter content of the soil. So, when legumes are used in rotation with cereals, they improve soil structure, and increase both the sustainability of the system and the fertilizer-use efficiency of the cereal crops. All these factors, plus environmental conditions, production costs and crop prices, need to be taken into account, when weighing up the costs and benefits of irrigating different crops.

Response of ICARDA's drought-tolerant varieties of food legumes to salinity

Salinity affects about 10 to 30% of the cultivated lands in WANA countries. Farmers in these salt-affected areas have fewer choices of crops to grow since many species, especially food legumes, are sensitive to salinity. Most breeding efforts have focused on finding tolerance to drought and little has been done to characterize or improve tolerance to salinity.

In 1998, international researchers from INRA,France; University of Wageningen, the Netherlands; ISA,Italy; CIHEAM/IAMB; and ICARDA developed a research program to study the tolerance of cereals and legumes to salinity. The goal was to verify whether there is a relationship between tolerance to drought and tolerance to salinity, and identify parameters to improve crop tolerance to salinity. The studies were conducted on varieties developed by ICARDA for drought tolerance, using greenhouses and lysimeters at CIHEAM-IAMB, Italy. So far, results have been obtained for legumes and the work on cereals is continuing.

The chickpea and faba bean results are particularly impressive. Researchers found that varieties that were sensitive to drought were more tolerant of saline conditions, rather than drought-tolerant varieties. The drought-tolerant varieties had adopted a classical response to salinity - the plant shortened its growing period by reducing its use of water while maintaining a high water potential. This strategy has a cost of lower water-use efficiency under saline conditions. However, the legume varieties that are sensitive to drought were able to slow down foliar senescence. By producing new leaves and new reproductive organs, as well as accumulating vegetated biomass during the last phase of vegetative growth, these drought-senstive plants had a net improvement in water-use efficiency compared to tolerant varieties.

The studies indicate that, for rainfed legumes, the mechanisms governing tolerance to drought and salinity are different, as is the case with many field crops such as maize and wheat. Therefore, the elimination of winter legumes from the rotation is not advised. The choice of the appropriate variety, depending on salinity level and species, permits a substantial increase of grain yield which approaches yields obtained in soils that are not affected by salinity.

Lysimeters installed at CIHEAM-Bari, Italy to study lentil crop response to various levels of salinity.

Project 3.2.

Land Management and Soil Conservation to Sustain Rural Livelihoods

ICARDA's soil conservation and land management project focuses on areas where rural poverty is widespread, agricultural production constrained, and land is being degraded. In 2004, a new tool was developed to help researchers assess land degradation and its dynamics at the community level. This livelihood-centered assessment framework links the major social and environmental drivers of land degradation with livelihood strategies, degradation processes, and people's responses. ICARDA evaluated the framework in three different agro-ecosystems in northwest Syria, and identified soil-conservation strategies appropriate for particular environmental and socioeconomic conditions.

Analyzing land degradation: a new holistic assessment tool

Around 1000 million hectares of land in the dry areas is degraded, resulting in the deterioration and loss of unique ecosystems and biodiversity. Degradation also causes traditional livelihood systems to break down, forcing people to migrate in order to support themselves. To secure food supplies, conserve the environment, and alleviate poverty, ICARDA is working with stakeholders to overcome land degradation and ensure sustainable resource use.

Land degradation is influenced by many biophysical and socioeconomic factors which interact in complex ways. These interactions have not been well analyzed or understood. To combat land degradation at the community and catchment levels, researchers need a simple, holistic tool to analyze the causes and consequences of land degradation and identify entry points for action research and development efforts.

Inspired by the 'driving forces–pressures–state–impact–responses (DPSIR) framework,' ICARDA developed the 'livelihood-centered land degradation assessment framework' (LILAF, Fig. 16). This tool links the major social and environmental drivers of land degradation with livelihood strategies, degradation processes, and people's responses.

LILAF differs from the DPSIR framework in several ways:

- Rather than using a single cycle of cause and effect, LILAF uses two interconnected cycles: a socioeconomic and a land-management cycle.
- Besides 'pressures' on livelihoods and land, LILAF also considers potential 'opportunities', such as new income-generating activities and sustainable land–management options.
- LILAF makes the interactions between scales (such as farm, community, and policy-making levels) more explicit.
- LILAF draws a clear distinction between the rate of degradation and the actual state of degradation.

LILAF can be used as a rapid rural appraisal tool to increase understanding of land-degradation dynamics at the community level. It is especially useful for identifying critical points at which livelihoods interact with land degradation. For example, it can help researchers understand why farmers use unsustainable land-management methods, why their responses to degradation are inadequate, and identify appropriate entry points for action. The visual flow charts used in LILAF case studies can be used to make stakeholders, such as farmers and decision makers, more aware of the risks of ongoing degradation,

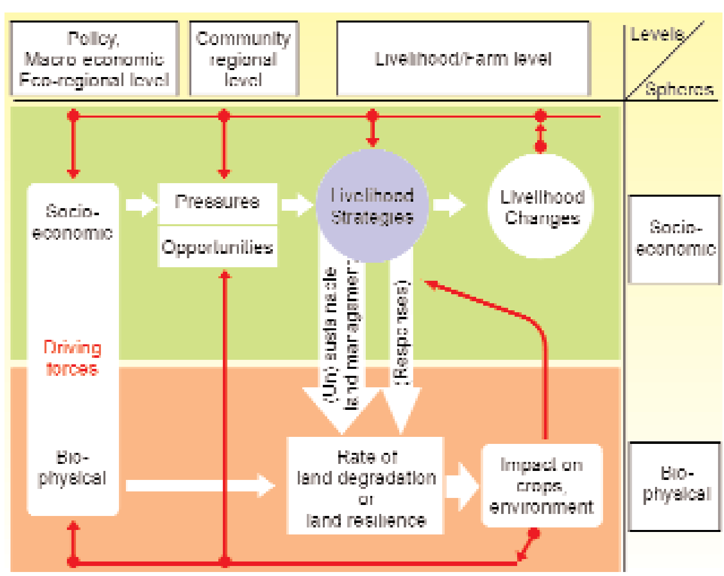


Fig 16. LILAF provides researchers with a holistic tool to analyze the causes and consequences of land degradation and identify entry points for research and development efforts.

prompting them to take action or ask for technical support.

ICARDA evaluated LILAF by studying three villages in different degraded agro-ecosystems in northwest Syria:

1. Yakhour (horticultural farming system; annual rainfall of 600 mm)—located in a mountainous area; olive orchards dominate the steep mountain sides.
2. Harbakiyeh (agro-pastoral system; annual rainfall of 220 mm)—located in the transition zone between Syria's agricultural areas and its steppe land; the farming system is based on barley cultivation, sheep rearing and a few cash crops.
3. Hammam (pastoral system; annual rainfall of 150 mm)—located in the steppe; the farming system is based on extensive sheep rearing.

The information used in the study was collected using semi-structured interviews, soil sample analyses, and research reports related to the three areas. At all sites, researchers found that land degradation was driven by (i) rapidly growing populations; (ii) irregular droughts; and (iii) the policies applied in each zone (e.g. a cultivation ban in the steppe and an irrigation ban in the 200-250 mm/year rainfall zone).

Population pressure, the breakdown of social networks, and lack of cash for investment in agriculture were placing pressure on villagers' livelihoods in all three areas. The new livelihood opportunities identified included marketing certain cash crops and animal products, and off-farm wage-labor opportunities in more productive agricultural areas, or nearby cities.

Strikingly, the villagers in all areas were either not addressing land degradation or were only responding in a very limited way. This was explained using the livelihood perspective built into the framework. Livelihood strategies are based on household objectives, which are strongly influenced by pressures (e.g. lack of cash for investment) and opportunities (e.g. wage-earning opportunities in other areas). Whether or not people address degradation depends on how strongly they feel it affects their livelihoods. The case studies identified two different scenarios that explain people's failure to address degradation:

1. Land in a degraded state

In Harbakiyeh (agro-pastoral system) and Hammam (pastoral system), land is obviously degraded. But, this is the result of centuries of degradation and villagers are used to their degraded environment. In addition, the current rate of degradation is quite low, so it tends to go unnoticed. People feel that the issue is simply not as important as the other livelihood pressures they face, especially since reversing degradation would require major investment. Local farmers, therefore, use little mineral fertilizer and sell their manure to farmers in nearby irrigated areas, rather than using it on their own fields.

2. High rate of land degradation

At Yakhour (horticultural system) the situation is different. The area's soils are less degraded and more fertile than those of the other two sites. However, soil erosion has accelerated in recent decades and the current rate of erosion is very high. As a result, most households are very aware that their land is degrading and reducing olive productivity. They also know that soil-conservation efforts are needed and are aware of possible conservation measures. However, they are not investing in these, because they are often very costly and most households are too busy with short-term survival. In addition, many male farmers are absent for long periods as they work off-farm as wage laborers.

The results obtained using the framework show that the land-management strategies required for villages in areas where the land has already degraded are very different from those required in areas where it is currently degrading.

The agro-pastoral farming system in Harbakiyeh (left). The land here has been degraded for centuries. A view of olive orchards in Afrin (right). The land is still in a reasonably good condition, but is degrading due to severe tillage and water erosion.

- In degraded areas, efforts should concentrate on showing that improving land quality pays off by increasing agricultural productivity in an economically viable way. This will require awareness campaigns and suitable technologies (e.g. low-cost measures to improve soil fertility).
- In degrading areas, cheap soil-conservation measures, which are adapted to the farming system and require little labor, need to be identified to halt land degradation efficiently.

Recognizing this, ICARDA is currently developing appropriate technologies in a participatory way for these two systems.

Project 3.3.

Agrobiodiversity Collection and Conservation for Sustainable Use

ICARDA continued to collect, document, and conserve plant genetic resources in 2004, and the Center's germplasm collection grew by 1723 accessions. Researchers assessed genetic variation in durum and bread wheat accessions from Afghanistan using microsatellite markers, and were able to clearly distinguish between hexaploid and tetraploid wheat. The health of 29,000 incoming and outgoing seed samples and 140 hectares of on-station crops was tested. The community-based agrobiodiversity conservation project in Jordan, Lebanon, Palestine, and Syria, promoted *in situ* conservation and reforestation. The project also demonstrated new technologies, characterized livelihood strategies, and launched community-development and habitat-management plans. ICARDA updated the global database on wheat wild relatives, and developed new database and GIS technologies to find 'best-bet' sets of germplasm containing desirable traits. Chickpea and barley accessions representing the genetic diversity in ICARDA's collection were selected for use in an international genetic-characterization program. Researchers also studied the photothermal responses of 277 barley accessions to identify germplasm containing the traits needed to cope with climate change.

Germplasm collection and distribution

In 2004, ICARDA's germplasm collection grew by 1723 new additions and reached a total of 132,831 accessions. A unique set of 781 accessions resulted from collection missions in Afghanistan, Armenia, Azerbaijan, Syria, and Tajikistan.

In 2003 and 2004, work continued to restore Afghanistan's national germplasm collections through IDRC-funded collection missions in the northern provinces of Badakhshan, Baghlan, Kunduz, and Takhan. Four ICARDA-trained germplasm collection teams collected 581 new accessions, including 383 of bread wheat, 62 of chickpea and 55 of barley. These will be used to assess genetic erosion in Afghanistan.

Researchers from ICARDA, the Russian Vavilov Institute (VIR), and national programs undertook collecting missions in Tajikistan and Armenia for cereals and food legumes and their wild relatives, as well as forage and pasture species. In Azerbaijan, researchers from ICARDA, Australia, and the country's national program focused on the collection of pasture and forage species. In total, these missions covered more than 5000 km, and collected 1543 accessions from 221 sites (Table 10). A full set of germplasm was left with the national programs; the rest was divided between the other partners according to their interests. ICARDA focused mainly on its mandate crops and their wild relatives, as well as on a limited range of pasture and forage legumes.

The mission in Tajikistan yielded some important endemic landraces previously thought to be extinct. The missions to Armenia and Azerbaijan mainly yielded pasture and forage materials, including a potentially new sub-species of *Lens ervoides* that produces seeds above and below ground. This is a useful trait, because the underground seed is protected from predation and a new crop can regenerate without sowing.

In 2004, ICARDA distributed more than 21,000 seed samples on request. Of these, 8300 were sent to users in developing countries, 3800 to users in the industrialized world, 6200 to scientists in ICARDA's Germplasm Program, and 2700 to those in ICARDA's Genetic Resources Unit.

Table 10. Accessions collected in Armenia, Azerbaijan, and Tajikistan in 2004.

Crop	Armenia	Azerbaijan	Tajikistan
Wheat	14	13	107
Barley	4	7	37
Other cereals	20	63	61
Food legumes	30	23	115
Pasture and forage	374	568	85
Other	6	0	16
Total	448	674	421

Assessing genetic variation in durum and bread wheat accessions collected in Afghanistan

Simple sequence repeat (SSR) microsatellite markers are relatively easy and cheap to generate because genetic sequence data for expressed sequence tags (ESTs) is available through online databases. EST-derived SSRs can be used to assess diversity in natural populations and germplasm collections, and are often used in comparative mapping and evolutionary studies. They have been developed and mapped in several crop species and could prove useful for marker-assisted selection. Characterization of genetic variation within and among natural populations is essential for effective conservation and exploitation of genetic resources for crop improvement.

ICARDA used 18 EST-derived microsatellite markers from a database to describe genetic diversity in 82 Afghanistan wheat landrace accessions. The objectives were to (i) discriminate between hexaploid wheat (bread wheat and *Triticum compactum*) and tetraploid durum wheat accessions; (ii) compare the level of variability between the two types of wheat studied, and (iii) assess the potential of these molecular markers for use in studies to evaluate and conserve wheat genetic resources.

A total of 122 alleles were detected; the number of alleles per locus ranged from 2 to 29 (mean 7.75). The percentage of polymorphic loci was 89%. To measure the informativeness of the EST-SSR markers, the polymorphism information content was calculated for each. The highest value (0.921) was observed with the EST-SSR marker DuPw 221.

Using the database-derived EST-SSR microsatellites, researchers were able to clearly discriminate between hexaploid wheat (genomes A, B, and D) and tetraploid durum wheat (genomes A and B). The study also identified a single species-specific marker for wheat species discrimination. Hierarchical cluster analysis showed high levels of genetic diversity in Afghanistan wheat landraces, particularly in hexaploid wheat (Fig. 17).

Seed health testing

The use of healthy seed increases crop productivity and prevents the spread of pathogens. In 2004, ICARDA's Seed Health Laboratory (SHL) tested and distributed more than 10,000 outgoing samples of cereal, and food and feed legume seed to 61 countries in 258 shipments. ICARDA also tested more

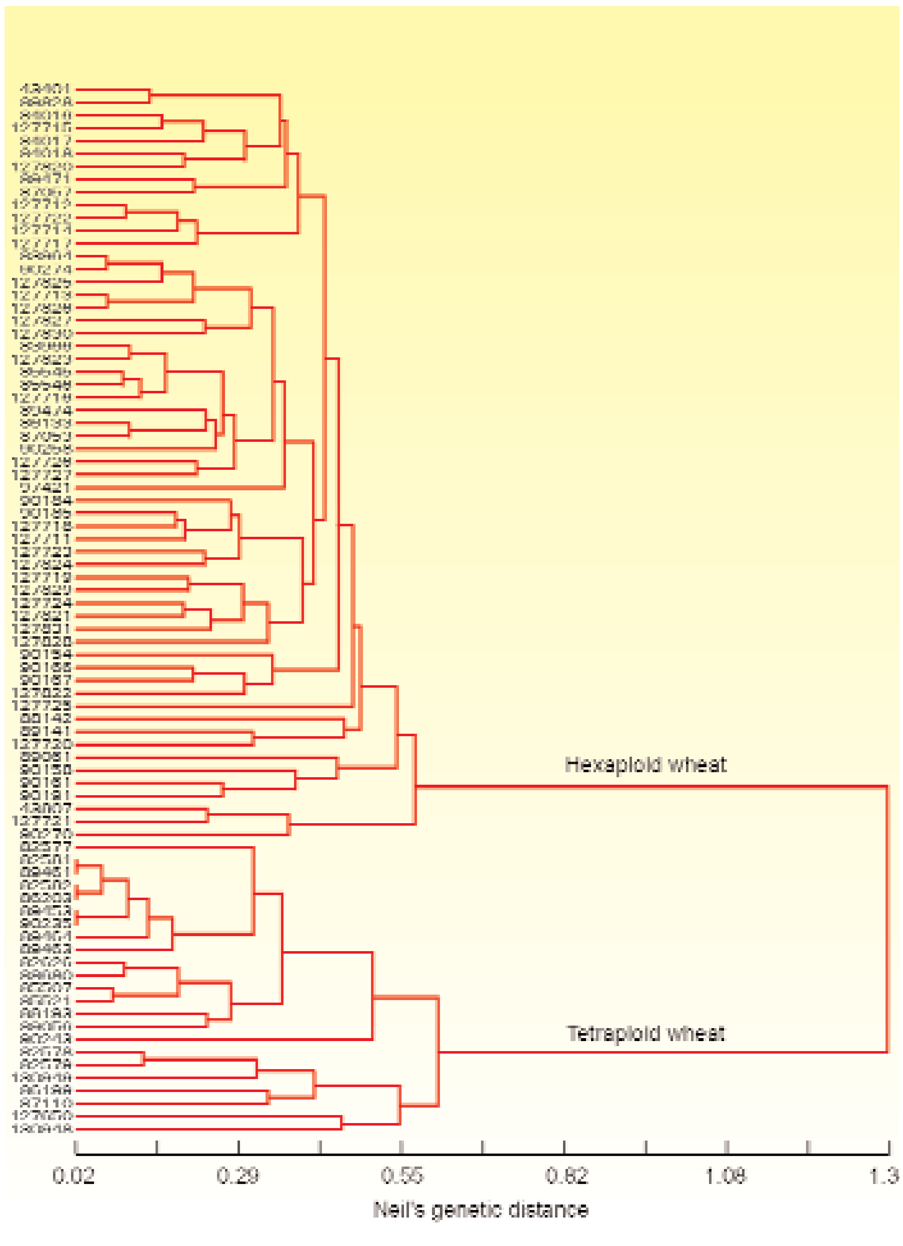


Fig. 17. Dendrogram based on EST-SSR markers generated data for Afghanistan wheat landrace accessions in ICARDA genebank.

than 10,000 accessions in 35 incoming shipments from 24 countries. Various *Tilletia* pathogens were found in wheat seed from Afghanistan, Armenia, Azerbaijan, Russia, Tajikistan, and Turkey. More than 2% of the wheat accessions from Afghanistan were infected with Seed Gall Nematode.

Researchers inspected 140 hectares to remove plants infected with seed-borne disease from germplasm intended for international distribution. The most frequent diseases recorded in cereal fields were common bunt, barley stripe, and loose smut. Flag smut, net blotch, and barley stripe mosaic virus were also found. *Ascochyta* blight, *Botrytis* spp., *Sclerotium* root rot, and viruses were found in legume crops. Twelve hectares of post-quarantine fields were also inspected, but no quarantine pathogens were found.

National staff in Afghanistan were trained in seed health, production, and enterprise management. An on-farm seed production and post-harvest technology workshop was held in Jordan. Seed health staff from Iraq were trained at ICARDA's headquarters in Syria and capacity-building activities were undertaken at plant health and quarantine laboratories in UAE. Training in various aspects of seed health was also given to one Masters student from Iraq and three individuals from Syria and Afghanistan.

Community-based agrobiodiversity conservation in West Asia

In 2004, the GEF/UNDP-funded West Asia Dryland Agrobiodiversity Project continued its work in Jordan, Lebanon, Syria, and the Palestinian Authority.

The Dryland Agrobiodiversity Project reintroduces landraces of crops through a program of seed multiplication and distribution.

Activities focused on the large-scale demonstration of new technologies, empowering local communities, and strengthening their involvement. Project exit strategies such as launching community development plans, characterizing livelihood strategies, and developing natural habitat management plans were also developed.

To date, the project has distributed 35 tonnes of cereal and legume seed in Palestine and planted more than 41,000 fruit trees in Jordan, Lebanon, and Syria. Outscaling has also resulted in large areas being planted with native fruit trees: 1.8 million ha in Syria, 180,000 ha in Jordan, and 20,000 ha in both Lebanon and Palestine. In 2004, 60 hectares were reforested with native species and rangeland management was implemented on a further 191 hectares.

The project has also brought about institutional change. Jordan, Lebanon, and Syria have now signed the International Treaty on Plant Genetic Resources and Lebanon has agreed to use wild fruit trees in afforestation efforts. Agrobiodiversity conservation is being taught to tenth-grade schoolchildren in Syria and Masters degrees in natural habitat management and biodiversity conservation have been developed at the Faculty of Science Technology at Al-Qods University, Jordan. The project's Regional Coordinator provided lectures on conservation as part of the University of Jordan's genetic resources course and project staff are being hired by local agrobiodiversity units in Syria and Palestine.

In 2004, the project conducted eco-geographical and botanical surveys to assess agrobiodiversity and identify causes of degradation. In Palestine, soil maps of project sites were developed using GIS and remote sensing. Socioeconomic surveys were also devised to study households, livelihood strategies, and community-development plans. Management plans for selected natural habitats are being drafted by each component.

Regular meetings were held by each project component to evaluate the project and monitor its impact. A team from DFID also reviewed the activities of ICARDA's Genetic Resources Unit, visited project sites in Jordan, Lebanon, and Syria, and attended the fifth Regional Technical and Planning Meeting held in Lebanon. GEF/UNDP also reviewed the project, conducting a desk-based evaluation and meeting with the regional, Jordanian, and Lebanese project staff. A thematic meeting and training course were also held on impact assessment.

To build capacity, the regional components of the project organized training courses for 189 participants. Fifty-six training courses were also conducted by the project's national components for 1263 people, including 531 women. The courses considered habitat and rangeland management, alternative sources of income, value-adding technologies, and the use of feed blocks. As a result, para-veterinary services were initiated in Jordan and *shinglish* cheese production began in Jordan and Palestine for the first time. The courses also led to the start-up of small businesses based on nursery development, dairy and mushroom production, and the cultivation of medicinal and herbal plants. Through the project, seven students gained higher degrees.

Mushroom production has been initiated by local communities in Ajloun, Jordan for the diversification of their income.

Large-scale demonstrations were used to transfer new technologies such as cereal-legume rotations, integrated pest management, seed cleaning and treatment, water harvesting, and rangeland improvement and management. The project encouraged local NGOs to participate by providing them with seed-cleaning and feed-block units.

The project distributed large numbers of medicinal plants to women.

Public awareness was enhanced through posters, leaflets, newsletters, websites, television documentaries, and plays performed at schools and rural theatres. National and international workshops and conferences were also used to promote the project.

The project developed curricula and scientific guides for all the countries involved to promote biodiversity conservation in schools. The Syrian and Palestinian components also worked with teachers to draft teaching guides. Gardens were created in schools and field visits organized for students and teachers. Environmental clubs were also set up in Palestine. In Jordan, students documented their parents' knowledge of agrobiodiversity and teachers in Lebanon, Palestine, and Syria were trained in conservation. In addition, more than 4000 students and 273 teachers attended presentations about the project during the International Convention on Education in Lebanon. The project also organized site visits for senior ministers and donors in Jordan, Lebanon, and Syria.

Technologies for value-added products and alternative income-generating activities were also promoted. This focused on training women, providing technical support for new businesses, and creating links with markets. Two newly-created NGOs in Lebanon were helped with processing and packaging local products. In Syria, an agrobiodiversity shop was set up by a private business with links to the Al-Haffeh Women's Union. Two thousand medicinal plant seedlings were distributed in Lebanon and Jordan, while 230,000 medicinal plants and 115 kg of seed were also distributed in Palestine. The project also promoted eco-tourism at Ham in Lebanon by organizing two visits for a tour operator.

Three theme-specific meetings were held on socioeconomics, fruit tree conservation, and biodiversity in education to strengthen regional integration and networking. The impacts of the project were acknowledged by national partners and donors at the sixth Regional Steering Committee Meeting. Plans were also made for the first international conference to promote community-based conservation and the sustainable use of dryland agrobiodiversity, to be held at ICARDA headquarters in April 2005.

Global database on wheat wild relatives updated

The Wild Wheat Global Database, developed by ICARDA and IPGRI and maintained by ICARDA, records the accessions of *Aegilops, Amblyopyrum,* and wild *Triticum* species held in major genebanks worldwide. This database helps researchers plan collecting missions, conduct research into species distributions, and locate samples of germplasm.

In 2004, the database was updated by adding records of the samples collected worldwide since 1990. ICARDA's collecting missions alone yielded around 2000 accessions and additional data was obtained from published catalogs and the internet sites of major genebanks. The update also georeferenced collection sites to allow researchers to use GIS and link climatic data to the sites. The database was made completely compatible with ICARDA's main germplasm database, allowing it to be continuously updated; it now cross-references accessions that are duplicated in different genebanks.

Researchers also developed a new database that registers only 'unique' accessions. This records almost 18,000 accessions: 4800 accessions of wild *Triticum* (four species), 13,000 of *Aegilops* (22 species) and 100 of *Amblyopyrum* (one species). These were collected from 6300 sites between 1948 and 2004, and represent 88% of the world collection. The latitude and longitude of collection sites are available for nearly 15,000 (83%) of these accessions. Figure 18 shows the distribution of samples registered in the database.

Technologies to improve the use of *ex-situ* germplasm collections

To allow *ex situ* collections to be used more efficiently, ICARDA is developing a 'focused identification of germplasm strategy' (FIGS). Using databases and GIS, FIGS links environmental data to the geographical coordinates at which individual accessions were collected. Researchers can then filter the data and extract subsets of accessions most likely to contain the traits breeders require to enhance productivity. For example, accessions collected from very dry areas that have evolved under those conditions are highly likely to contain useful drought-tolerance traits and can be identified using FIGS.

The FIGS concept is being developed further as part of a project funded by Grains Research and Development, Australia. This aims to identify and utilize useful traits in the bread wheat germplasm held within VIR, ICARDA, and the Australian Winter Cereals Collection. These three institutions hold more than 17,000 bread wheat landrace accessions, many of which were collected early in the 20th century from a diverse range of environments to which they were adapted.

The project has now captured the geographical coordinates of more than 6000 collection sites by reviewing written accounts of past collecting missions. The coordinates were checked using GIS software that incorporated road maps and a digital elevation model. Each accession was then linked to a range of agroclimatic and edaphic data generated by ICARDA's GIS Unit, which extended its continuous surface coverage from CWANA to the whole of Eurasia to do this.

In 2004, the project identified a subset of accessions likely to contain drought-tolerance traits by filtering the records in the combined collection using a number of criteria. Only accessions from sites that received 180-300 mm of precipitation per year in agroclimatic zones where moisture limits the growing period were included. Accessions from irrigated sites or sites with dubious geo-coordinates were excluded. A hierarchical cluster analysis of the site data was then used to produce 750 clusters of accessions. One accession was then chosen at random from each cluster to make up the final 'Drought' subset (Fig. 19).

ICARDA researchers also selected a subset of 422 bread wheat landrace accessions to be used for salinity tolerance screening. A 1-km

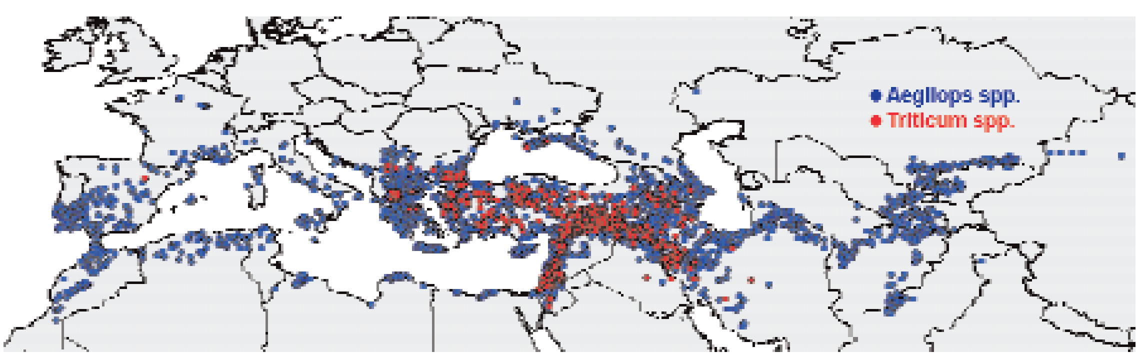


Fig. 18. Collection sites of the *Aegilops* and wild *Triticum* species held in the Wild Wheat Global Database developed by ICARDA and IPGRI and maintained by ICARDA.

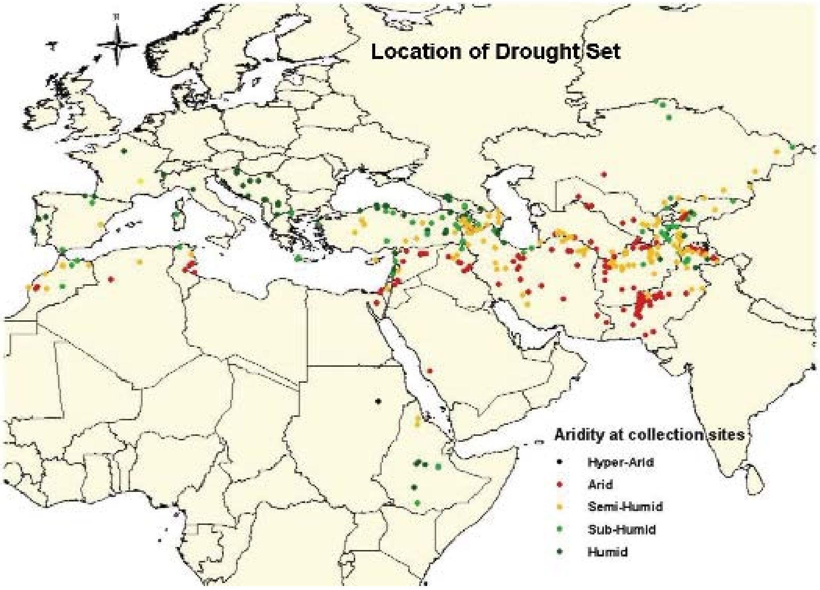


Fig. 19. Collection sites of a subset of bread wheat accessions likely to contain valuable drought-tolerance traits; the subset was identified using a new tool ('FIGS') based on GIS and database technologies.

resolution map was extracted from the FAO-UNESCO digital Soil Map of the World which showed the probability of saline soils recurrence. This map was then overlaid with collection-site coordinates. Only accessions from sites with a 40% or higher probability of encountering saline soils were chosen for laboratory screening. Most of these were in Central (47%) and East Asia, mainly the Indian subcontinent (31%); 16% and 5% came from North Africa and West Asia, respectively. Both the 'Drought' and 'Saline' subsets are currently being evaluated for tolerance to drought and salinity at Tel Hadya.

At the request of the University of Zurich, the project also produced a 'best bet' subset of material which will be screened for resistance to powdery mildew. Researchers compiled collection-site information for a set of 400 accessions known to be resistant to powdery mildew in addition to those landrace accessions already included in the database. Multivariate analyses identified 1350 accessions from collection sites that closely matched those of the resistant set. This 'Mildew' subset will be screened for powdery mildew resistance in Zurich during the 2004/05 growing season.

This method of identifying sets of material likely to contain valuable traits is expected to make the process of choosing germplasm for screening far more efficient.

Creating global 'composite sets' of chickpea and barley germplasm

In 2004, ICARDA participated in a System-wide program that aims to explore the genetic diversity of the CGIAR research centers' global germplasm collections. This project, Subprogram 1 of the CGIAR's Generation Challenge Program, will identify a composite set of germplasm for individual crops. These sets represent the range of diversity of a crop and will be characterizes using anonymous molecular markers. This will allow researchers to study diversity across a given genus and identify genes for resistance to biotic and abiotic stresses that can be used in crop-improvement programs. ICARDA was responsible for creating the composite set for barley, and helped to create the composite set for chickpea.

In 2004, a global composite collection of 3000 chickpea accessions was compiled from core collections, trait-donor parental lines, landraces, wild *Cicer* species, and elite germplasm and cultivars. ICARDA contributed 752 chickpea cultivars to the set from its collection of 12,153 accessions.

The ICARDA accessions were chosen by identifying material that (i) had sufficient seed for distribution; (ii) was unique to ICARDA; and (iii) was FAO–designated, and, therefore, owned by the global community. The catalog and evaluation data for these 5042 accessions were then separated into five main data sets which were further divided into 29 data sets based on geographic location and subjected to hierarchical cluster analysis based on 16 phenological, yield, and crop-size characteristics. Approximately 10% of the accessions in each cluster within a set were selected randomly and included in ICARDA's contribution to the composite set.

To ensure that chickpea's full agroclimatological range was represented, the entire set of 5042 accessions was subjected to a two-step cluster analysis using agroclimatological data linked to the geographical coordinates of the accessions' collection sites. Two hundred clusters were produced, and one accession was selected randomly from each.

Researchers also included an additional 16 accessions known to have resistance to certain diseases and insects. Seeds from the 752 accessions (Fig. 20) were sent to ICRISAT for DNA extraction and molecular analysis as per agreement in the Challenge Program.

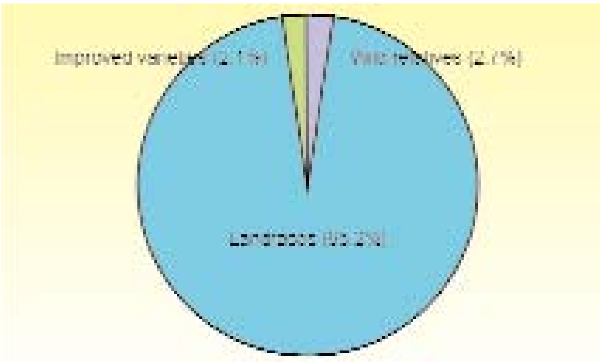


Fig. 20. Types of accessions from ICARDA's chickpea collection chosen for inclusion in a global composite germplasm set that will be used to find valuable genes for crop breeding.

ICARDA's collection of nearly 26,000 barley accessions is the second largest in the world. It includes 15,500 accessions of locally-adapted landraces, a quarter of the global total, and 8700 accessions from CWANA, the largest collection of landraces from that region. The Center's 1800 accessions of *H. vulgare* ssp. *spontaneum* represent its full geographical range.

Using GIS, researchers generated detailed agroclimatological information, based on 67 variables, for accessions with collection-site coordinates: 72% of the landrace accessions and 52% of the wild progenitor accessions. Landrace and wild barley accessions were selected for the composite set by analyzing this information using a two-step cluster analysis. This produced 260 clusters, from which researchers selected accessions from different geographical areas. Improved germplasm was selected for the barley composite set using passport information, including pedigrees, to ensure that the most common parental varieties and lines were represented. ICARDA barley breeders also chose improved drought-tolerant germplasm for inclusion.

The final barley composite set (Fig. 21) consisted of 445 accessions of *H. vulgare* ssp. *spontaneum* (15% of the total), 1935 landrace accessions (65%), and improved germplasm (20%). The improved germplasm category includes cultivars, unfinished breeders' materials, and genetic stocks, representing 13%, 6%, and 1% of the composite barley set, respectively.

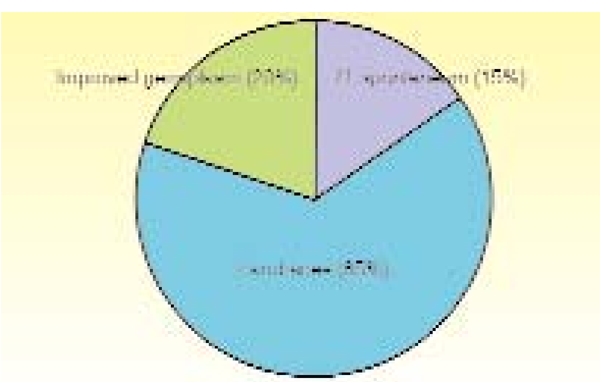


Fig. 21. Types of accessions chosen by ICARDA from its barley collection for inclusion in a global composite germplasm set that will be used to find valuable genes for crop breeding.

Of the barley wild progenitor accessions, 65% are original accessions collected during GRU missions. Hyper-arid, arid and semi-arid collection sites represent 1%, 20%, and 63% of the total, respectively. These accessions originate from 20 countries and their collection sites belong to 58 ecological clusters.

Of the landraces, 20% are original materials collected by ICARDA. Hyper-arid, arid and semi-arid collection sites represent 3%, 33%, and 43% of the total, respectively. The landrace set originates from 85 countries, and 78% are from CWANA. Collection sites belong to 255 ecological clusters.

Exploring variation in barley's photothermal response to meet the challenges of climate change

Global warming is expected to reduce grain yields in rainfed farming systems in CWANA's arid and semi-arid regions. To develop crop varieties able to cope with climate change, breeders are working to optimize the timing of the crop's growing season in relation to temperatures and the amount of rainfall expected. This requires the use of traits associated with a crop's photothermal response. To identify these traits, researchers from ICARDA and Germany's Institute of Genetics and Plant Breeding are evaluating ICARDA's germplasm collection as part of a project funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and GTZ.

The speed with which cereals reach the heading stage is controlled by three separate genetic mechanisms which determine (i) response to temperature over a period of time (earliness *per se*); (ii) response to day length (photoperiod sensitivity); and (iii) response to low temperatures at the initial stages of plant development (vernalization sensitivity). Researchers studied these responses in 77 improved barley lines and cultivars from ICARDA breeders' collections, and in 115 landraces and 35 wild barley (*Hordeum vulgare* ssp.

spontaneum) accessions selected from ICARDA's genebank using agroclimatological information generated by GIS.

Accessions were grown in a plastic house under three replicated day-length and temperature treatments. The earliness response was assessed in a long-day treatment using vernalized germinated seeds. Photoperiod sensitivity was estimated in a short-day treatment with vernalized seeds, while vernalization sensitivity was studied in a long-day treatment using unvernalized seeds. The number of days to heading in each treatment was recorded and subjected to multivariate statistical analyses.

Hierarchical cluster analysis produced thirty photothermal response groups, which were then used in a discriminant analysis. The first and second canonical discriminant functions obtained (Fig. 22) accounted for 55.2% and 33.6% of the total variation in the experiment, respectively. The first function was strongly linked to the vernalization response and, to a lesser extent, to the earliness response; the second function was closely associated with the photoperiod response.

Most accessions exhibited a weak vernalization and photoperiod response (lower left quadrant of Fig. 22). A few accessions exhibited weak vernalization and strong photoperiod reactions (upper left quadrant). The remaining accessions required strong vernalization (right-hand side of Fig. 22) and, in some cases, were photoperiod-insensitive (lower right quadrant).

The 10 accessions with the weakest earliness response were landraces from Egypt, Iran, Lebanon, Libya, and Oman, and the improved germplasm Mari/Aths and 'Harmal.' The 10 accessions with the weakest vernalization response included a landrace from Afghanistan and nine improved varieties and lines, six of which were bred by ICARDA. Most sensitive to vernalization were ICARDA's 'Pamir 9' and 'Batal-1,' a landrace from Tunisia, and landrace and wild barley accessions from Azerbaijan and Turkmenistan.

Among the 10 least photoperiod-sensitive accessions were landraces from Ethiopia, Morocco, Pakistan, and Yemen, two wild barley accessions from Jordan, ICARDA's *H. spontaneum* 41-1 line, and ICARDA's improved barley SLB05-96/*H. spont.*41-5. The 10 most photoperiod-sensitive were landraces from Azerbaijan, Iran, Jordan, Syria, Tunisia, Uzbekistan, and the 'Tokak' cultivar from Turkey.

Different genetic mechanisms control earliness *per se*, vernalization, and photoperiod response. Therefore, the large amount of variation identified for these parameters in the accessions tested will be useful in programs designed to breed material suited to different temperature scenarios. Earliness *per se* and vernalization are related to temperature, and so will respond directly to warmer climates. Although photoperiod response will not be affected by climate change, the genetic variation in this trait could usefully be exploited in efforts to adjust plant phenology to new climatic conditions.

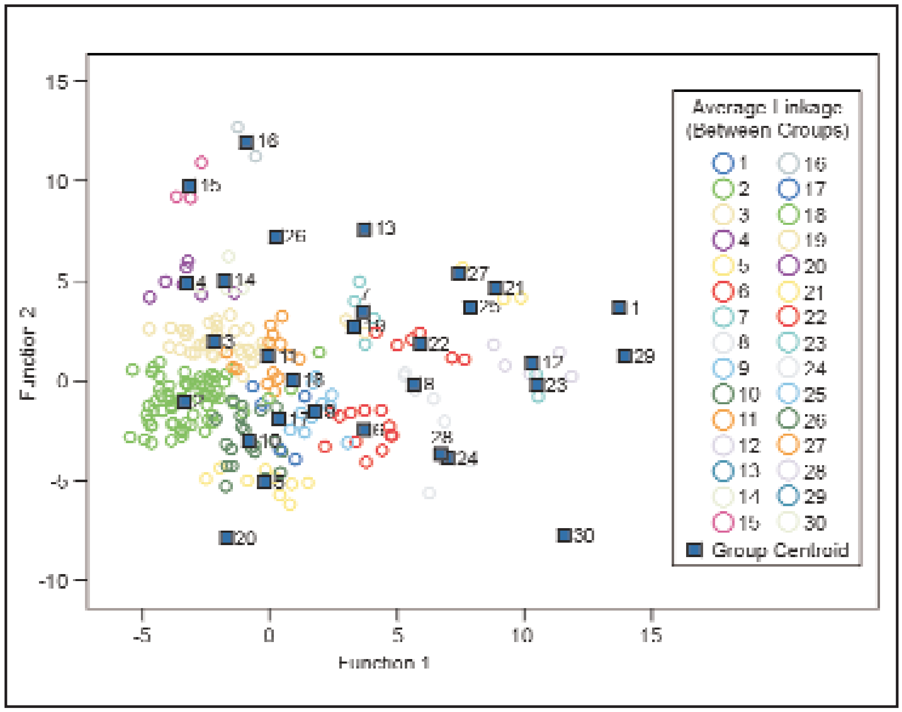


Fig. 22. Results of a canonical discriminant multivariate statistical analysis conducted using data on number of days to heading in 227 barley accessions (circles). Thirty photothermal response groups are indicated by different colors and group centroids are represented by solid squares. 'Discriminant Function 1' was strongly linked to vernalization sensitivity and, less strongly, to earliness *per se*. 'Function 2' was linked to the response to photoperiod regimes.

Project 3.4.

Agroecological Characterization for Agricultural Research, Crop Management, and Development Planning

Remote sensing and geographical information systems (GIS) are powerful and flexible tools that ICARDA is using to integrate multi-thematic data into new applications to support its research. In 2004, ICARDA scientists developed an index-based method to map 'agricultural resource poverty' and the 'agricultural resource endowment' of different areas. They also developed two new mapping approaches: a national approach to address the needs of agricultural planners and decision-makers, and a participatory approach to capture the local agroecological knowledge of farmers and land users.

Mapping agricultural resource poverty and resource endowments in CWANA

CWANA probably has the highest proportion of marginal agricultural land in the world, and thus the highest level of 'agricultural resource poverty.' This is mainly due to an unfavorable agricultural climate, complex topography, and a lack of water and soil resources.

Climatic factors such as temperature, which determines when crops can be grown, most limit agriculture in the region. Water availability is also a major constraint, though in some cases this can be alleviated using irrigation. The topography of CWANA's many mountainous areas is also a constraint, as rivers, valleys, steep slopes, and poor accessibility all greatly reduce the available area of good-quality farmland. Finally, the region's soils suffer from such problems as salinity, sodicity, shallowness, high levels of stoniness, and a very coarse texture, all of which are either impossible or too expensive to correct.

Constraints such as these probably play a key role in human poverty. However, the links between these factors and poverty have not been studied in enough depth, particularly in CWANA. Agricultural resource poverty, therefore, needs to be quantified. However, this is difficult, because the biophysical factors involved are complex and interact with each other.

ICARDA researchers developed an index-based method of quantifying resource poverty that can be used to produce an agricultural-resource-poverty index (ARPI). This simple method considers all relevant biophysical factors, and allows different locations to be compared consistently. It incorporates an 'audit trail,' to assess the contributions that individual environmental factors make to agricultural resource poverty, and is scale-independent and can be applied using currently available datasets. The model has a broad scope, but does not take into account land and water resource degradation caused by poor management.

Researchers determine an ARPI value by considering three separate indices, each of which represents one component of resource poverty (Fig. 23):

- Climatic and water resource poverty (CWRPI), derived from data such as temperature, rainfall, and plant productivity
- Soil resource poverty (SRPI), derived from the FAO Soil Map of the World
- Topographic resource poverty (TRPI), derived from the U.S. Geological Survey's GTOPO30 Global Digital Elevation Model

Each index has a value within the range 0-100; the highest of these three values is taken to be the value of the ARPI. So, the ARPI also ranges between 0 and 100.

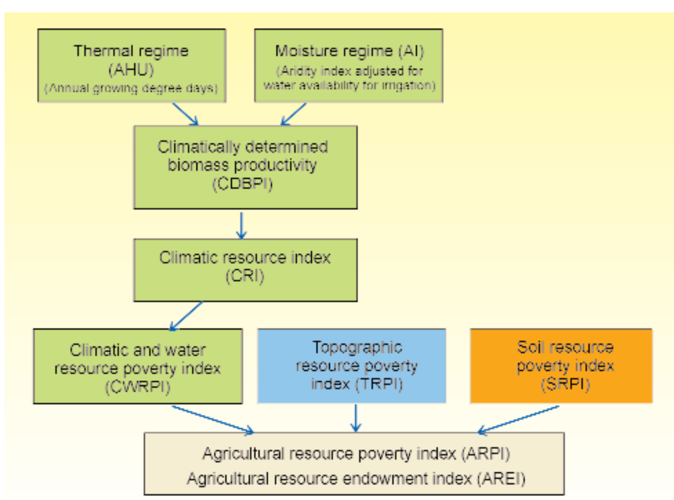


Fig. 23. Main steps involved in developing the Agricultural Resource Endowment Index.

If users want to represent the results obtained as resource endowments, rather than resource poverty, an agricultural-resource-endowment index (AREI) can easily be calculated as 100-ARPI. This method was used to develop an AREI map of CWANA (Fig. 24), which was validated using various case studies. These were undertaken at different scales, ranging from the regional to the local, and showed that relationships exist between the AREI and various indicators of poverty—such as a country's agricultural GDP, malnutrition, village income, and population density. They also showed that the method is scalable and can be used outside CWANA.

This simple tool for integrating complex natural-resource data into a single indicator of resource poverty or endowment has already been used to map the distribution of agricultural income in Syria.

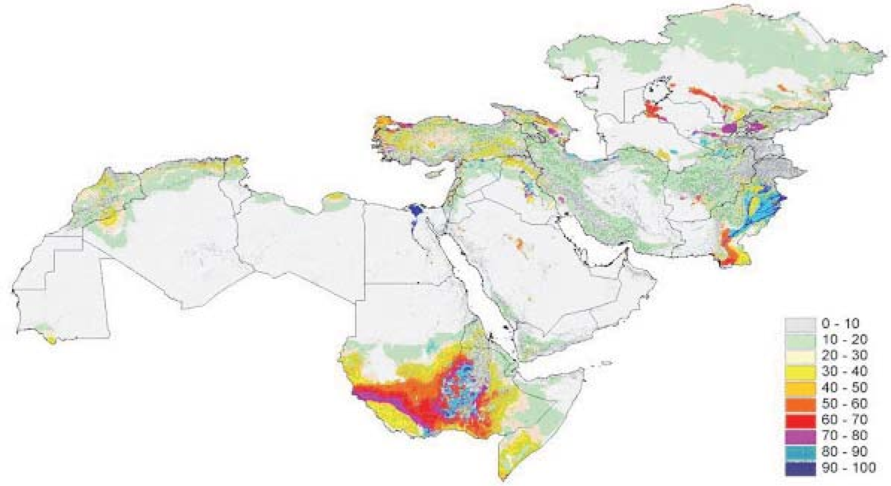


Fig. 24. Distribution of the Agricultural Resource Endowment Index (AREI) in CWANA.

Mapping the agricultural regions of Syria

'Agricultural regions' are integrated spatial units in which water resources, climate, terrain, and soil conditions combine to create unique environments associated with distinct farming systems and land-use and settlement patterns. ICARDA researchers have developed a technique to map these regions in order to produce a single synthesis map that represents several issues in agriculture such as land degradation and identification of areas with agricultural potential or constraints, planning rural land use, developing input and subsidy policies, and targeting efforts to alleviate rural poverty.

Mapping agricultural regions requires a good multi-thematic database, expert knowledge, and validation of the map produced through fieldwork and remote sensing. When mapping the agricultural regions of Syria, researchers delineated the boundaries between mapping units using recent satellite imagery and secondary information, including geological, soil, landform and climate maps. The boundaries were drawn in vector format, based on a visual interpretation of Landsat imagery for the spring of 2003 and the summer of 2002, using the 15-m Landsat panchromatic band merged with three multi-spectral bands 541 in RGB. This produced a provisional map based on 27 mapping units (Fig. 25). The map's legend consists of 'labels' to which large attribute tables can be attached; the map can easily be modified by regrouping some of the units. The limited number of spatial units used means that this type of map can easily be understood by decision-makers and used to target different policies and interventions.

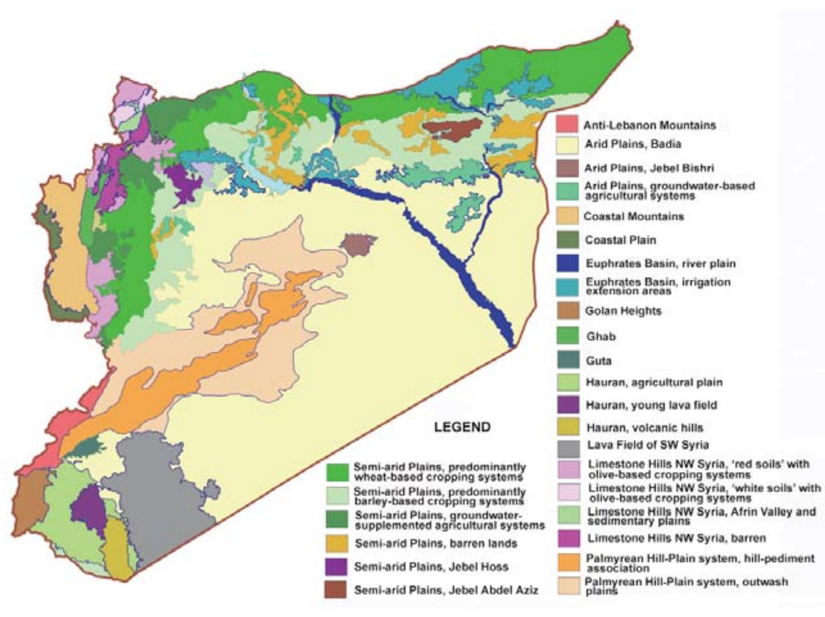


Fig. 25. Provisional agricultural regions of Syria.

Agricultural planning authorities in CWANA have recently shown interest in the 'agricultural regions' concept. Morocco identified 31 'régions agricoles' during a similar mapping exercise, and Syria and ICARDA are working to identify new agroecological zones to improve rural land-use planning and replace the six 'agricultural stability zones' currently used. In addition, Turkey has asked ICARDA for help in mapping agroecological zones. These will be used to decide which crops to promote or subsidize in particular regions.

Integrating conventional land-evaluation methods and farmers' soil-suitability assessments

Farmers often possess valuable agroecological knowledge, which they translate into informal soil-classification and land-evaluation systems. These are complex and surprisingly accurate when used to predict the productive capacity of their land. However, farmers are unable to exploit this knowledge when adopting new technologies or management practices drawn from outside their farming system and environment.

By contrast, researchers and planners, often cannot fine-tune their recommendations to local conditions because they do not fully understand the micro-scale variations that occur within farmers' environments. However, they do have access to standardized methods of characterization and extrapolation. This allows them to assess technologies developed in one area and decide if they are likely to perform well in other locations with similar ecological and socioeconomic conditions.

To exploit the comparative strengths of these two groups, ICARDA assessed the benefits of participatory agroecological characterization and the feasibility of capturing local knowledge and integrating it with scientific knowledge. This involved a two-part land-suitability assessment in the pilot village of Karababa in northwestern Syria.

The first part of the assessment, a farmer-led land-suitability assessment (FLSA), used participatory mapping and characterization tools such as transect walks, field visits, individual interviews, and ranking exercises (Fig. 26). The other part of the assessment, an expert-led land-suitability assessment (ELSA), involved standard scientific methods such as land-resource mapping and evaluation techniques (Fig. 26). Integrated transect analysis was used in both parts of the study. This combined biophysical survey techniques with participatory research methods and involved scientists and farmers working together to assess a range of land-use and soil types. The results of both assessments were integrated into GIS and analyzed.

Many discrepancies were found between the results of the two assessments. These were mainly due to the detailed local information provided by farmers during the FLSA. The FLSA also helped researchers understand the impact of microclimatic variations on crop productivity. This is an important benefit of the approach, since good climatic records are not available for most rural communities.

In an area with no major biophysical constraints, the study showed that land use was mainly determined by socioeconomic conditions. It also confirmed that farmers have an excellent understanding of their biophysical environment. However, the study also showed that useful and interesting indigenous knowledge is now scarce, and may be declining as a result of urbanization. Special techniques are, therefore, urgently needed to record this valuable knowledge before it is lost.

This new method could be used to develop land-use plans and identify the opportunities and constraints associated with different farming systems. It could complement such methods as rapid and participatory rural appraisal, which often emphasize the socioeconomic dimensions of farming systems while underestimating the importance of the natural resource base and its variation in space and time. The participatory approach developed by the study is now being tested in Morocco.

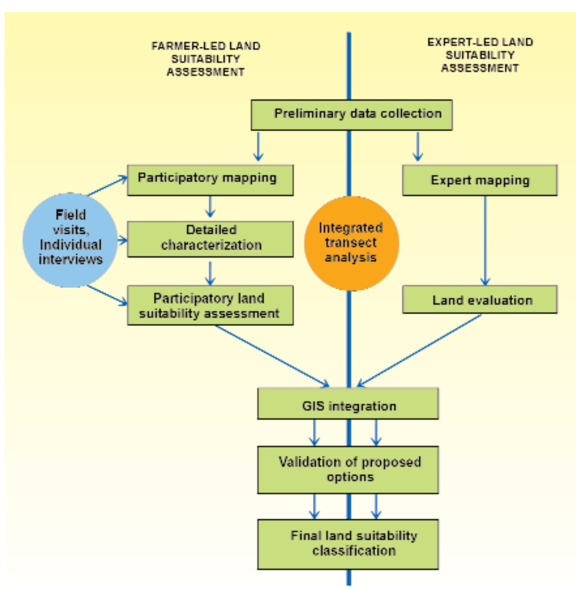


Fig. 26. Steps in farmer-led (FLSA) and expert-led (ELSA) land-suitability assessment at the local level.

Theme 4

Socioeconomics and Policy

Project 4.1.

Socioeconomics of Natural Resource Management in Dry Areas

In order to maintain and improve the livelihoods and welfare of CWANA's rural poor, the fragile natural resource base that supports the region's agriculture must be preserved. In 2004, ICARDA focused on improving water-use efficiency at the farm level. Researchers used models to identify the economic and technical factors that determine how farmers allocate water among different crops. They also developed methods for measuring irrigation-water-use efficiency—an indicator of over- or under-irrigation. In six locations in Egypt, Iraq, Jordan, and Syria, it was found that farmers consistently applied more irrigation water than necessary, implying that water savings of up to 66% could be made.

Assessing on-farm water-use efficiency

In the dry areas of West Asia and North Africa (WANA), scarce water resources are often poorly managed and inefficiently used, especially in agriculture. Because irrigation accounts for 80–90% of all water consumed in WANA, ICARDA and the United Nations Economic and Social Commission for West Asia (ESCWA) are working to measure and improve on-farm water-use efficiency.

Simple, 'technical' measures of water-use efficiency, such as crop yield per unit of water applied, do not reflect the economic efficiency of water use, as this also depends on crop and water prices, and the prices of other inputs. They also do not reflect the complex decisions farmers make when allocating a fixed amount of water among their different crops. To take account of all these factors, researchers assessed farm-level water-use efficiency (FWUE) – the ratio of the required amount of water for a target production level to the actual amount of water used.

Farm surveys were conducted at six locations in Egypt, Iraq, Jordan, and Syria between 1999 and 2002. Data, such as the area planted to each crop, the irrigation technology used, the amount of water available per farm, and the prices of water and other inputs (e.g. labor, fertilizer, and pesticides), were then used to model on-farm water use. Researchers developed and validated three types of model: a fixed-allocatable input model, a variable input model, and a behavioral model. These were used to (i) identify the most important factors influencing farmers' decisions to allocate irrigation water to different crops, and (ii) calculate the estimated water requirement to allow researchers to calculate the FWUE for each farm.

Researchers found that farmers over-irrigated their crops in all the areas studied. Wheat, for example, was given 20-70% more water than necessary (Fig. 27), as FWUE values ranged from 0.3 to 0.8 kg/m^3. Correcting this would save an enormous amount of water, which could be used to irrigate more land. Alternatively, farmers could greatly increase their wheat yields per hectare simply by using the same amount of water in conjunction with improved water- and crop-management practices. Either option would contribute greatly to food security in WANA.

The study also showed that some crops had a higher FWUE than wheat, so water could be saved by changing the mix of crops grown. In Beni Sweif in Egypt, and Radwania in Syria, for example, the FWUE of cotton (0.75 kg/m^3) was higher than that of the other crops grown in those areas. However, cotton farmers still exceeded crop water require-

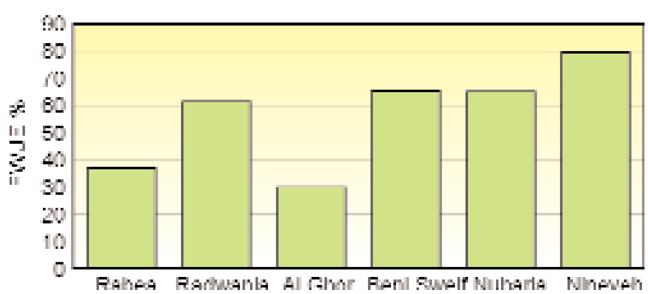


Fig. 27. On-farm water-use efficiency (FWUE) for wheat in Rabea, Iraq; Radwania, Syria; Al Ghor, Jordan; Beni Sweif and Nubaria, Egypt; and Nineveh, Iraq.

ments by nearly 25%, so extension efforts are needed to promote efficient water use. The FWUE of two irrigated forage crops, berseem and corn, was also high in Egypt (0.72–0.76 kg/m^3; Fig. 28), and greater than that of faba bean (0.55 kg/m^3) and sunflower (0.64 kg/m^3).

The FWUEs of vegetable crops varied among locations and crops. For example, tomato's FWUE ranged from 0.53 to 0.69 kg/m^3 across four different sites (Fig. 29). The FWUE of watermelon and pepper also varied between locations, being much higher in Nubaria, Egypt (0.76 kg/m^3 and 0.74 kg/m^3, respectively) than in Al Ghor, Jordan (0.44 kg/m^3 and 0.53 kg/m^3, respectively). Differences between crops were also found within a location: the FWUE of eggplant (0.66 kg/m^3) was considerably higher than that of cucumber (0.56 kg/m^3) in Al Ghor, illustrating that water is not used efficiently in cucumber grown there.

The FWUE estimates obtained for cereal, vegetable, and industrial crops indicate a wide gap between the amount of water actually needed and the amount applied. Improving water-use efficiency in the production of these crops would save a considerable amount of water in the areas studied.

The models showed that when farmers had a limited supply of water, they would allocate any extra water available to crops with higher water requirements, such as cotton, tomato, potato, sugar beet, and berseem, rather than to crops requiring less water, such as wheat and barley. Water allocation among different crops was mainly determined by output prices, the crops chosen for planting, the area of each crop, and the type of irrigation technology used. Water prices had little effect on water allocation once crops were planted, probably because water prices were highly subsidized in the study areas. Large increases in water

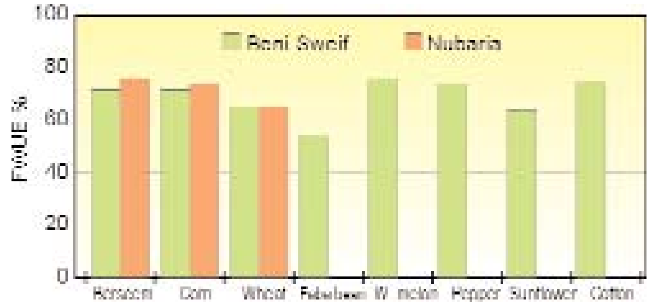


Fig. 28. On-farm water-use efficiency (FWUE) for different crops in Beni Sweif and Nubaria, Egypt.

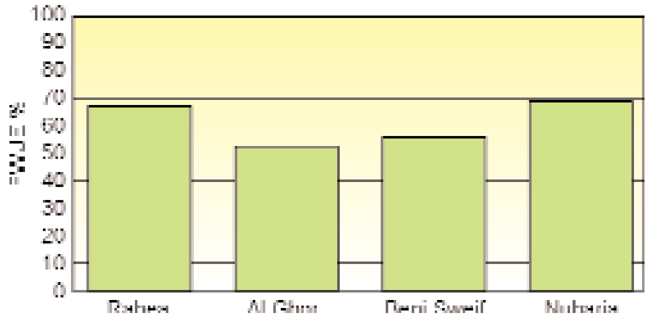


Fig. 29. Tomato FWUE in different areas in WANA: Rabea, Iraq; Al Ghor, Jordan; and Beni Sweif and Nubaria, Egypt.

charges would reduce the amount of water used for irrigation, but also adversely affect farmers' incomes.

Using the same models, researchers also analyzed farm-survey data collected from 284 wheat farmers participating in a supplemental irrigation project in Nineveh province, Iraq. In this project, reducing the amount of irrigation water used boosted wheat yields by 58-100% and raised water productivity (yield per unit water used) by 31% on average. Even in this project, however, the average FWUE for all farms was 0.8 kg/m^3, indicating that farmers over-irrigated their wheat by 20% on average.

However, this average value masked differences between different groups of farmers. So, while 56% of the Nineveh farmers over-irrigated their wheat by 13%, 20% of those studied over-irrigated their crops by 36%, and a further 4% applied 66% too much water. In addition, another group, the remaining 20% of farmers actually under-irrigated their wheat. These differences highlight the need to develop targeted recommendations for different irrigation practices of each farmer group.

Researchers also found that water-use efficiency in Nineveh was greater on small farms (less than 10 hectares) and medium-sized farms (10-20 hectares), than on large farms (more than 20 hectares). This should be considered when introducing supplemental irrigation on large farms, as farmers with large holdings over-irrigated their wheat by 28%, whereas those with small and medium-sized holdings over-irrigated by only 23% and 19%, respectively.

Policies are needed to encourage the design of appropriate incentives and technical packages for improving water-use efficiency. Introducing more water-efficient irrigation technologies is one option. Center-pivot sprinklers, for example, used 7.2% less water than solid-set sprinklers in wheat production in Nineveh. Sound extension strategies are needed to optimize water use at the farm level and reduce the adverse effects of over-irrigation, such as salinization and waterlogging. This would increase crop productivity while ensuring the sustainable use of water and land.

Project 4.2.

Socioeconomics of Agricultural Production Systems in Dry Areas

Knowledge gained through socioeconomic studies can be applied when researchers work with farmers to develop improved, more sustainable production systems and household livelihood strategies. In 2004, ICARDA continued to assess the impacts of new and traditional institutions on the welfare of the rural poor. In northwest Syria, researchers evaluated how a newly-introduced micro-finance scheme affected the assets, debts, and incomes of 180 poor households. Informal local institutions involved in cheese-making in dairy sheep systems in dry marginal areas were also studied in detail using a sustainable livelihoods approach.

Impacts of village credit and savings associations on poverty in Syria

Formal financial institutions often do not reach the poorest in CWANA, forcing them to borrow from local lenders and traders, who charge high interest rates. The high cost of borrowing means that the poor cannot build up assets, which limits their ability to cope with the risks inherent in these harsh environments.

Micro-finance institutions can boost rural development by increasing the rural poor's access to capital. These institutions are a relatively recent innovation in CWANA, and their effectiveness within the social and cultural context of the region has not been fully studied.

In 2000, the UNDP and the Syrian Ministry of Agriculture and Agrarian Reform inititiated the Rural Community Development Project (RCDP). The project set up village credit and saving programs in northern Syria's Jabal al Hoss region – an area of about 157,000 hectares of which 85% of the land is cultivable. ICARDA examined the impact of these credit institutions on household poverty by assessing three types of household:

1. Households from the first nine villages where micro-credit schemes were established, which had borrowed money in either 2000 or 2001,
2. Households from the same nine villages which had not joined the micro-credit scheme,
3. A control group of households from seven randomly selected villages in the project area.

ICARDA researchers surveyed 60 households in each category using 12 indicators to define household poverty. These indicators reflected different dimensions of poverty, and covered human resources, dwellings, assets, food security, and vulnerability. Most of the micro-credit scheme members (61.7%) were categorized as 'less poor,' while 21.7% and 16.7% belonged to the 'poor' and the 'poorest' categories, respectively (Fig. 30). This spread reflects the fact that micro-finance schemes were only established in villages with at least 300 inhabitants and a road that was accessible all year round. The RDCP's selection criteria excluded smaller, less developed villages, and most of the area's 'poor' and 'poorest' households.

However, although a large proportion of the 'poorest' category was not reached by the RCDP, the micro-credit scheme members, including those categorized as 'less poor', are actually some of the poorest people in Syria.

In 2000, households in villages with micro-credit schemes had significantly more assets overall than households in control villages, regardless of whether they were members of a micro-credit scheme. By 2003, households in credit-scheme villages had increased their total assets to a greater extent than the control households, although this increase was not statistically significant.

Between 2003 and 2004, the livestock holdings of credit-scheme members increased more than those of non-members from the same village. By contrast, the livestock assets of households in the control group decreased. Micro-credit availability has, therefore,

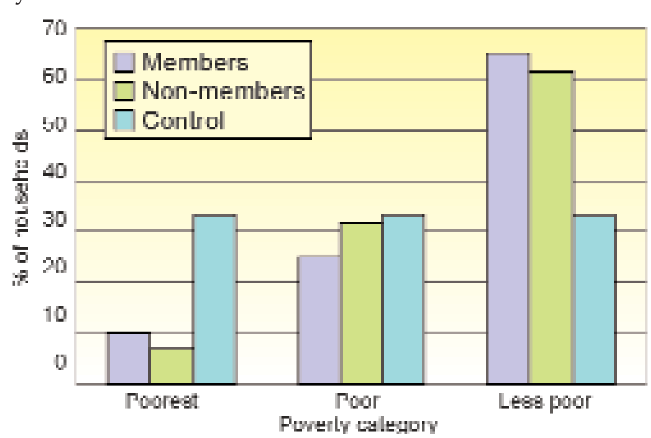


Fig. 30. Poverty categories in 2000, according to type of household: credit-scheme members and non-members in villages in which a micro-credit scheme had been set up, and 'control' households (randomly selected from villages within the region).

had a significant effect on people's livelihoods, because livestock are one of the main sources of income in these dry marginal areas.

Researchers also found that the households which borrowed money from micro-credit schemes in 2000 or 2001 were those already most in debt. This suggests either that these households were less suspicious of the new micro-finance institutions, because they had already borrowed from informal sources, or that they were under pressure to accept money from any source without considering the risks.

Even after micro-credit schemes were introduced, villagers continued to borrow from informal sources (Fig. 31). Although friends and relatives sometimes provided interest-free loans, shopkeepers, traders, and moneylenders charged interest rates of 77% per year on average. What is more, the 'poorest' had no access to formal lending institutions (Fig. 31). This demonstrates the importance of micro-credit facilities, because without them the poorest households are forced to rely on very expensive informal credit sources.

The study also examined the effect of micro-credit on household incomes by asking people whether they felt that their income had decreased, increased, or stayed the same since 2000. Answers were scored using a five-point scale, where 1=substantially decreased, 3=no change, and 5=substantially increased. Scores were averaged across the different household types and poverty categories.

In general, across all three household types, the 'poorest' felt that their incomes had decreased, while the 'less poor' felt that their incomes were the same as, or higher than, in 2000. The benefits of micro-finance schemes were seen in the 'less poor' category, as 'less poor' credit-scheme households perceived a

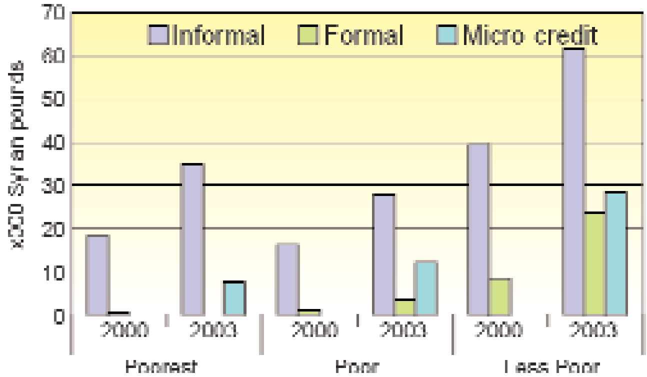


Fig. 31. Average amount of money that households in different poverty categories borrowed in 2000 and 2003, classified according to lending institution.

greater increase in their incomes than 'less poor' control-village households. Overall, the 'less poor' credit-scheme members benefited more from the initiative than the 'poorest' credit-scheme members.

The study showed that micro-finance schemes can alleviate poverty in the dry areas. However, efforts must be made to include smaller, poorer villages with less infrastructure, so that the poorest are not excluded from such schemes.

Local institutions in dairy sheep systems in dry marginal areas

Informal local institutions give the poor access to markets and inputs, and act as safety nets when crops fail and livestock are lost. However, they are not necessarily fair because the poor lack bargaining power. Traders often take advantage of them, paying low prices for their products and charging them more for their inputs. Better understanding of these informal local institutions is essential for designing policy interventions that will improve their efficiency and postively impact the poor.

In 2003 and 2004, ICARDA studied informal local institutions governing the processing and marketing of dairy sheep products in dry marginal environments. The study covered 44 villages in northwest Syria's Khanasser Valley (annual rainfall 200-250 mm), one of ICARDA's integrated research sites.

The sustainable livelihoods framework was used to conduct qualitative and quantitative studies. To measure social capital and analyze the linkages between institutions and rural livelihoods, participatory tools were used to collect and analyze information. Historical calendars were constructed to show trends in weather, population, land tenure, migration, irrigation, health, education, and electricity supply. Cheese-makers (*Jabbans*) and their families were interviewed individually and in groups, and observations were made in the field. A sample of cheese-makers also completed a questionnaire.

The main livelihood strategies in the valley were identified as (i) off-farm work; (ii) cropping—mainly barley, cumin, and some wheat for home consumption; and (iii) sheep-related activities—lamb fattening, and milk production and processing. Sheep milk production and processing are mainly managed and funded by local producers, and are still important even though the percentage of villages with milk producers and cheese-makers has declined steeply over the last 30 years—from 77% to only 23% in 2003. This is mainly due to increased cumin cropping and a fall in sheep numbers (Table 11). Although cumin was strongly emphasized by farmers, the

Table 11. Reasons for the decline in the number of cheese-makers in Khanasser, Syria.

Reason given	Percentage of respondents
Sheep numbers and milk production are decreasing and grazing is being lost as fallow land is being planted to cumin.	57.2
Yogurt production is replacing cheese-making, because it is more profitable and because improved roads mean that yogurt can be transported to cities without spoiling.	23.8
Milk producers and cheese-makers cannot agree on milk prices and producers wish to supply sheep's milk adulterated with goat's milk.	9.5
Investors/traders from Aleppo are encouraging milk producers to abandon dairy production and switch to sheep-fattening.	9.5

investigation showed that the increase of sheep fattening and the improvements in infrastructure, especially roads which allowed easy access to markets to sell dairy products, have played an important role in the decrease of *Jabbans* in the area, and farmers have started producing more yogurt which is more profitable than cheese.

The study clarified the steps and financial arrangements involved in cheese production in the valley. This begins in October and November or in early February, when cheese-makers, most of whom are from outside the region, meet local community representatives. These meetings lead to verbal agreements which assign certain responsibilities to each party.

Cheese-makers are responsible for providing interest-free loans to milk producers. These are usually used to buy winter feed, and the amount owed is later deducted from the value of the milk delivered. During poor years, repayments are carried over to the next year's milking season. Cheese-makers may also provide cash advances. These arrangements provide poor producers with a regular source of cash. Cheese-makers control the prices paid for milk, and vary these throughout the season in line with fluctuations in cheese prices. The best milk prices are obtained mid-season. Milk producers have to deliver a minimum amount of milk as a community: about 400-800 liters per day for communities with 500-950 milking ewes. They deliver this twice daily to the cheese-maker.

There is a high demand for the 'white cheese' traditionally produced by cheese-makers. They transport this to traders in neighboring cities, who then sell it to consumers or retailers. White cheese does not keep for long and must be boiled before it is eaten or stored. Therefore, any cheese unsold at the end of the day is processed into *mushallaleh,* which can be stored longer and commands a higher price. However, milk producers do not benefit from the value added by this process.

The study also found that women are mainly responsible for dairy production and processing, while men handle marketing and loan transactions. Women, therefore, have an important role to play in any efforts made to improve dairy sheep production.

Results showed that although local institutions are not perfect, they provide essential services to the poor, particularly in the absence of adequate infrastructure and markets. Pooling village production makes it profitable for cheese-makers to come to villages, and allows small producers to access markets. Cheese-makers are well-organized and are trusted by the communities they work with. Local customary rules and arrangements define the roles and responsibilities of each party and the system appears to be sustainable and mutually beneficial.

Women making cheese for home consumption; additional cheese may be sold in the market.

However, the study raised some questions. For example, would it be more profitable for poor milk producers to process milk and cheese in a community-owned facility? And, would the potential benefits of community-based milk processing outweigh the current benefits provided by cheese-makers? If so, would communities be able to play a greater role in marketing?

ICARDA researchers will address these questions by quantitatively analyzing the data gathered and develop and test a capacity-building model. This model will focus on milk and cheese processing, and will include technological options relevant to the dairy sheep sector in Khanasser, as well as marketing information, such as prices and hygiene and quality requirements.

Project 4.3.

Property Rights and Resource Management in the Low-Rainfall Areas of North Africa and West Asia

In 2004, ICARDA researchers developed a new framework to analyze the legislation and policies that govern the use of land, water, and forests in six countries. The framework also helped researchers analyze the interactions and conflicts that occurred between institutional factors, resource users, and the resources themselves. A separate, in-depth study investigated the process of 'mainstreaming' innovations. A number of livestock-focused development projects were reviewed, and a framework was developed to guide future mainstreaming efforts.

Land tenure, institutions, and conflict management

Conflicts between stakeholders can reveal institutional and market failures, and highlight property-right regimes that encourage inefficient, inequitable, and unsustainable resource use. However, conflicts can also arise from attempts to reform customary property-right systems, correct inequalities, or improve the efficiency of resource access, control, and use. In either case, it is necessary to set up effective conflict-resolution mechanisms and identify policies that will enhance the performance of existing or newly-introduced institutions.

With funding from the World Bank's Rural Development, Water, and Environment Group, researchers from ICARDA, IFPRI, the World Bank and national programs of Jordan, Mali, Morocco, Senegal, and Tunisia developed a theoretical framework that will increase the understanding of property-right policies and systems and their relationships to conflicts over natural resources (Fig. 32). The framework considers three important components around which the management of natural resources revolves:

Component 1—the type and nature of the resources

Component 2—the resource users/stakeholders

Component 3—the legal and institutional frameworks that regulate ownership, management, access to and use of a given resource.

The framework shows that these three components intersect at four points.

1. *The tenure regime(s)* used to govern natural resources and allocate different resource-management responsibilities to State and local institutions (Interface 1, Fig. 32).
2. *The types of rights granted to different resource users and stakeholders*, which determine the opportunities, incentives, and constraints faced by users when managing and using a resource (Interface 2, Fig. 32).
3. *The different production strategies used by rural producers and communities* (Interface 3, Fig. 32), which may place competing demands on the same resource.
4. *The critical triangle*, in which resources, users, and legal and institutional frameworks all interact (Interface 4, Fig. 32), resulting in equity, efficiency, and sustainability.

These interactions determine how the different aspects of natural resource management affect each other and the likelihood of conflicts occurring as a result (Fig. 33). Identifying what types of conflicts fall within the boundaries of each interface helps researchers understand the effects that tenure regimes and allocated and perceived property rights have on the management of natural resources. The framework was used to analyze the legislation and policies that govern the use of land, water, and forests in Jordan, Mali, Morocco, Niger, Senegal, and Tunisia.

In all six countries, the legal and institutional frameworks used to manage land resources have developed in a chaotic way. Three differ-

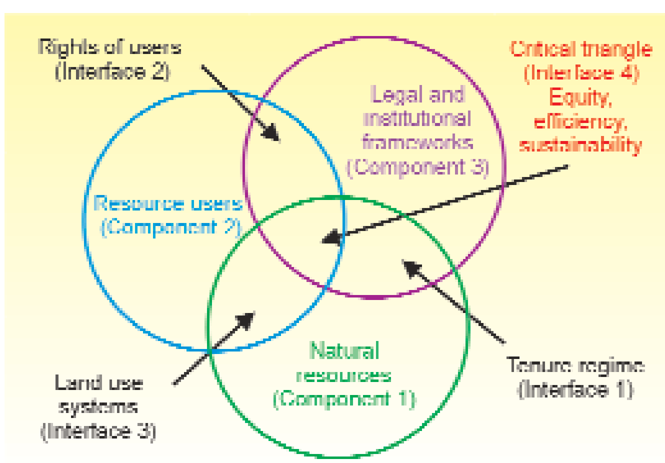


Fig. 32. Resources, users, and tenure.

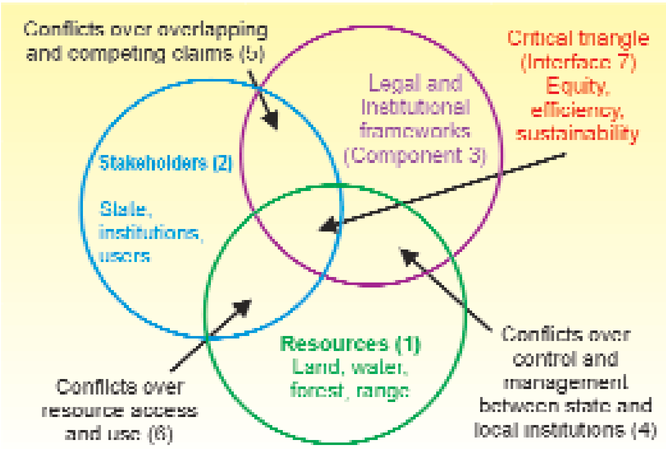


Fig. 33. Conflicts over resources.

ent approaches have been used:

1. Recognition and strengthening of customary land-tenure systems (Morocco, Mali, and Niger)
2. Individualization of collective land resources and promotion of privatization (Tunisia)
3. State appropriation of land resources (Jordan and Senegal).

In general, land-related policy reforms have aimed to strengthen the land-tenure security of individuals. Only Morocco and Mali have encouraged communities to register their collective use rights in order to preserve land resources. However, to fully address the trends emerging in rural areas, use rights need to evolve to full private property rights.

The study found that the legal and institutional frameworks governing water rights were similar in all six countries. Legislation recognized the rights of landowners to harvest water or dig wells on their land to irrigate their crops and water their animals. Most governments granted use rights to other water users. However, Senegal gave users added security by granting them compensation if government actions prevented them from exercising their water rights.

With the exception of Jordan, the governments of the countries studied have introduced various legal reforms to encourage communities to manage their forest resources. Legal distinctions are drawn between protected forests, forests managed by local communities, and forest-service-managed State forests, where neighboring communities only have use-rights.

In the case of community-managed forest, the managerial capacities of local people need to be improved. Development programs need to recognize that urban demands for charcoal and wood encourage local user groups to harvest and sell their forest resources. The expansion of cropped areas into forests, and conflicts of interest between user groups and the forest services also need to be addressed. However, community forest management can be successful. In Tunisia, it has reduced the illegal harvest of forest products. By contrast, in Jordan, where forest management is state-controlled, encroachment and the illegal harvest of forest products has not been reduced.

Differences between statutory and customary tenure systems cause land-use conflicts between the State and local institutions in all six countries. Decentralization policies are also causing conflict, as local communities are attempting to assert their right to manage their own natural resources. However, in both Mali and Senegal decentralization has allowed local communities to oppose government institutions and win more control over their resources.

Conflicts also arise because many different stakeholders lay claim to the same resources making it difficult for governments to determine what rights to grant to various users. In addition, conflicts over land, water, and forest resources are often closely linked, further complicating the situation. Within the case studies, there were a number of examples of parties trying to use the law to resolve their conflicts. However, outcomes showed that legal frameworks were not necessarily the best conflict-resolution tool.

Conflicts also arise over resource access and use, because the rights allocated to users do not always match their perceived rights. Lack of convergence between customary and statutory tenure regimes creates loopholes, allowing users to illegally encroach on or harvest natural resources. In addition, governments fail to address all the constraints faced by users when allocating rights, forcing them to use their resources in illegal and unsustainable ways.

The dissimilarity of statutory and customary property rights systems was one of the major sources of conflict over resource use. The framework helped to disentangle the different types of conflicts that resulted from interactions among the resources, the legal and institutional regimes governing those resources, and the rights allocated to the different resource users.

Scaling up innovative livestock-management practices: a new framework

Innovative technologies and policies are not enough to alleviate poverty and improve people's livelihoods. Research organizations and financial development institutions also have to ensure that new options are taken up by policy makers and applied as widely as possible. However, although this process of 'mainstreaming' is extremely important, it has received little research attention.

ICARDA, IFPRI, and the livestock group of the International Fund for Agricultural Development (IFAD) have studied the process in depth and developed a framework (Fig. 34) to guide efforts to mainstream innovations. The study was funded by IFAD.

The framework represents all the different aspects of 'mainstreaming' and clearly shows the many activities and processes involved within the research– development continuum. This allows decision makers to evaluate the impact of innovations in a structured way, considering all the processes involved and ensuring that nothing is forgotten.

The framework consists of three key areas or 'domains' of the research–development process: (i) the 'research and action-research' domain; (ii) the 'implementation and development' domain; and (iii) the 'planning, monitoring, and evaluation' domain (Fig. 34).

The research and action-research domain includes the research conducted by international and national research centers, universities, NGOs, and the private sector. In this domain, institutions develop, adapt, and test new technical, institutional, and policy options (TIPOs). At this stage, the interventions are relatively small-scale, so the number of beneficiaries is limited. The way options perform in practice, and their effect on other development options, helps decision makers choose which of them should be included in future pilot programs. The activities of ICARDA's Mashreq/Maghreb project teams are good examples of the work undertaken in this domain. The outputs of these teams have contributed directly to the design and implementation of a range of development projects in Algeria, Jordan, Morocco, Syria, and Tunisia.

The planning, monitoring, and evaluation domain acts as an interface between the other two domains. Information fed into this domain from the research domain helps decision makers choose the best TIPOs for a development project. Information from the implementation and development domain allows decision makers to monitor and evaluate the performance of these TIPOs after they have been implemented. The information gathered in the planning, monitoring, and evaluation domain also creates the demand for more reforms, research, and innovations. This is then fed back into the research and action-research domain, allowing better options to be developed.

The implementation and development domain includes all government, donor, and development agency interventions. It is the point in the research–development continuum at which most development projects operate. It can be divided into three key areas: pilot projects, innovation mainstreaming, and project replication (Fig. 34).

The new framework was used to review three innovative livestock-management models introduced through IFAD-funded pilot projects. These are the Smallholder Poultry Production model in Bangladesh and Senegal; the Community-Based Animal Health Workers model in Cambodia and Sudan; and the Community-Based Rangeland Management model in Morocco and Syria.

The framework helped researchers pinpoint areas that are key to the success of mainstreaming efforts. Monitoring and evaluation, for example, was found to play a crucial role—providing feedback that can be used to fine-tune and re-target implementation and research efforts. Monitoring and evaluation systems should, therefore, be integrated into projects from the start. They should also assess the wider changes associated with the introduction of innovations such as the creation of village enterprises or community groups.

Identifying why different options succeed or fail, and pinpointing how they improve the welfare of the rural poor, are important aspects of innovation up-scaling and out-scaling. Improving mainstreaming efforts will have major implications for developing countries and financial development institutions, as it will cut the transaction costs involved in replicating projects.

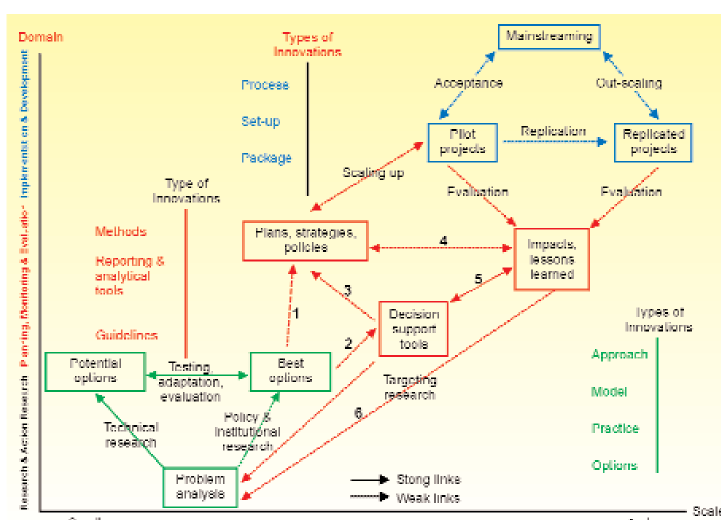


Fig. 34. A new framework designed to guide the scaling-up of innovations.

Theme 5

Institutional Strengthening

Project 5.1.

Strengthening National Seed Systems in CWANA

Development of a new, superior variety marks the end of a breeding effort, but the beginning of a long and difficult process of producing sufficient quantities of high-quality seed and distributing it to thousands of small-scale farmers. ICARDA's Seed Unit collaborates with national programs in CWANA to address seed-supply constraints and provide human-resource development for effective seed systems. In 2004, the Center set up 15 decentralized village-based seed enterprises in Afghanistan to provide farmers with easy access to improved seed. The Seed Unit also continued to assist Iran in developing a national seed policy, acts and bylaws covering seed certification, enforcement, and import and export. A mobile seed-processing machine was also developed in Syria to give farmers involved in the informal seed sector access to high-quality seed.

Setting up village-based seed enterprises in Afghanistan

Afghanistan's rural economy is still in urgent need of improvement. Market-oriented farm activities and crop diversification could significantly increase agricultural productivity and improve rural livelihoods. However, a lack of improved varieties and poor access to quality seed and other agricultural inputs are major constraints. Modern technologies are needed to improve household food security and produce a surplus for the market.

A village-based seed production field in Afghanistan.

Afghanistan has almost no formal seed sector, and what does exist cannot meet national seed requirements. The private sector is not interested in meeting this need because the seed business is risky and much less profitable than other investment opportunities since farmers either plant their own seed or exchange seed with each other.

However, the needs of resource-poor farmers can be effectively met by farmer-led production and marketing systems. ICARDA is, therefore, setting up village-based seed-production units able to produce high-quality, affordable seed of improved crop varieties adapted to local conditions.

The Future Harvest Consortium to Rebuild Agriculture in Afghanistan (FHCRAA) is working closely with the Ministry of Agriculture and Animal Husbandry (MAAH), CIP, ICRISAT, IRRI, CIMMYT, and other NGOs, to set up 20 village-based seed enterprises (VBSEs). Five provinces have been targeted (Ghazni, Helmand, Kunduz, Parwan, and Nangarhar), with funding from by USAID. These VBSEs will be responsible for seed quality assurance and all seed production, processing, and storage. They will also market the seed produced to farmers within and outside the community, either directly or through village traders and NGOs. When the project ends in June 2006, each VBSE should be producing 100 tonnes of quality seed of a wide range of crop varieties each year.

ICARDA is providing technical support and helping VBSEs to prepare business plans. It is also supplying the initial batches of high-quality stock seed, which the VBSEs will multiply. This seed originates from varieties adapted to the specific agro-ecologies found in the country. ICARDA is also helping to source fertilizer, equipment, and credit for the farmer groups.

Such capacity building is important because small-scale seed enterprises are vulnerable, especially during the early years. This is not just because the farmers involved have to learn the difference between informal and commercial seed production. Agricultural businesses also face risks associated with unreliable climatic conditions and market demand, both of which are major constraints.

Experience has shown that the success of a seed business depends on: (i) the marketing of a range of products (seed of different crops, agro-inputs, custom seed cleaning, etc.); (ii) proximity to markets; (iii) close linkage with formal seed-sector institutions (for research, extension, and quality control); and (iv) educational support to entrepreneurs. The survival and expansion of such businesses, therefore, requires detailed planning, which must include sensitivity analyses.

By the end of 2004, the first year of the project, 15 VBSEs were operational (Table 12). These marketed or exchanged more than 800 tonnes of seed—more than half of the target amount (1500 ton per year) set by the project. A total of 113 VBSE member farmers, along with 187 staff from partner organizations (extension services, MAAH, and NGOs), were trained in technical seed-production operations, enterprise management and financial accounting.

Developing a national seed policy and seed regulations in the Islamic Republic of Iran

Since the mid-1980s the private sector has been encouraged to participate in Iran's seed industry to stimulate national economic development. But this requires many changes—including policy and regulatory reforms—to promote a competitive seed industry with multiple players.

In 2002, ICARDA organized a National Seed Workshop in collaboration with Iran's Seed and Plant Improvement Institute. This brought together international experts and national stakeholders from the Iranian seed industry to discuss options for improving and developing the sector. Participants discussed the policy and regulatory reforms needed. They also presented key recommendations for possible actions by policy makers.

The government of Iran has now established the Seed and Plant Certification and Registration Institute (SPCRI). This is an independent government agency. Its overall mandate is to implement (i) a seed certification scheme for seed and planting material; (ii) plant variety protection efforts; and (iii) adaptive research in seed technology. SPCRI has become a focal point for the formulation of policies and regulations. It is now responsible for preparing a national seed policy and a comprehensive set of acts and bylaws for the national seed sector.

Table 12. Numbers of staff trained, and amount of seed produced, sold or exchanged by new village-based seed enterprises (VBSEs) in different provinces of Afghanistan.

Province	VBSE districts	Crops	Seed sold/ exchanged (tonnes)	No. of VBSE members trained	No. of partners trained
Ghazni	Khoja Omari	Wheat	90	27	21
	Qara Bagh	n.a.†			
Helmand	Nad Ali	n.a.†		3	22
	Boolan				
Kunduz	Ali Abad	Wheat, paddy rice, mung bean, and chickpea	400	45	60
	Chardarah				
	Khanabad				
	Center				
Parwan	Bagram	n.a.†		15	30
	Jabulsaraj				
	Tutum Dara				
Nangarhar	Behsood	Wheat	323	23	54
	Kama				
	Khewa				
	Surkhrood				
Total	15		813	113	187

† Group established only recently.

ICARDA researchers were invited to help develop and review drafts of these documents. As a result, two separate policies have been revised and amalgamated to produce a comprehensive national seed policy addressing both seed and vegetative planting materials. The bylaws to be issued under the Seed Act have also been revised, and now address issues such as seed certification, enforcement, and seed import and export. They have also been made compatible with national seed policy and the Seed Act. In addition, in 2004, ICARDA helped to develop a model plant variety protection act based on the 1991 International Union for the Protection of New Varieties of Plants (UPOV) Convention. This will undergo further discussion and consideration.

A mobile seed-processing machine developed in Syria for farmers in Afghanistan and other countries.

Appropriate technology developed for seed cleaning and treatment

Processing seed to improve its quality is a key feature of the formal seed sector. However, setting up seed-processing plants requires considerable capital investment. This is beyond farmers growing low-value crops in marginal areas.

Traditional seed-cleaning methods can be used to clean seed to an acceptable quality at the farm level. However, seed treatment, to control seed-transmitted diseases, cannot be done by hand. This is because it is virtually impossible to apply, by hand, the exact quantities (1 ml) of chemicals required per kilogram of seed.

To overcome this problem, ICARDA has collaborated with Darbas Company, a manufacturer of grain cleaners in Syria, and developed a purpose-built mobile seed-processing machine. Development began in 2000, and since then several modifications have been made based on intensive testing at ICARDA's headquarters and feedback from users. These machines, which can clean and treat approximately 300-400 kg of seed per hour, provide seed of a very good quality. They are currently being used in Afghanistan, Jordan, Lebanon, Palestine, Syria, and Vietnam.

International Cooperation

ICARDA cooperates internationally with NARS, and advanced research institutions to pursue its research and training agenda. Activities that promote partnerships with NARS within ICARDA's mandated region, including networks (see Appendix 6) and capacity building are outlined below. Collaborative projects with advanced research institutes and regional and international organizations are listed in Appendix 5, and the results of joint research with them, as well as between ICARDA and its NARS partners, are presented in the research section of this Annual Report.

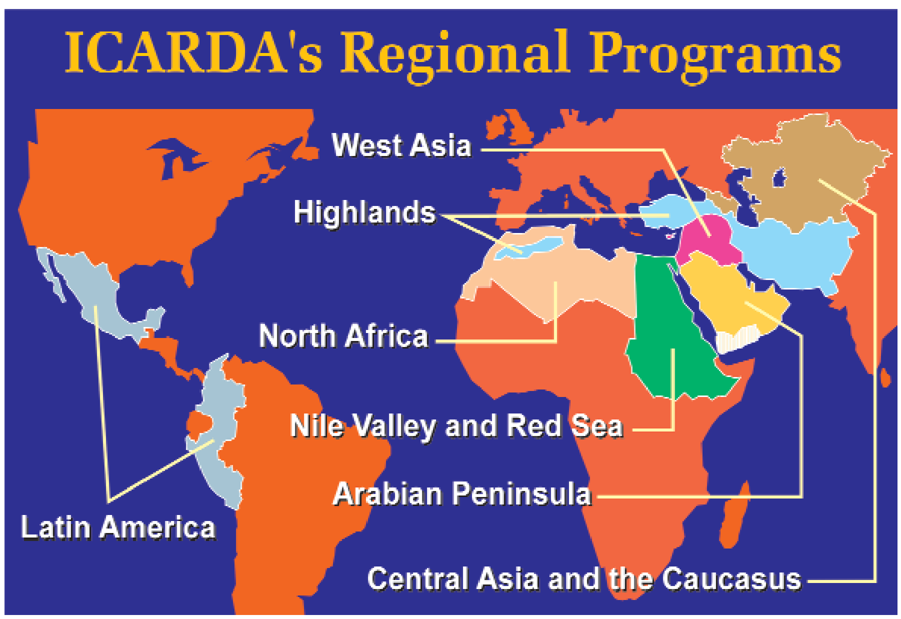
ICARDA's research activities at its headquarters and collaborative projects with the NARS of CWANA cover the entire research spectrum, from basic and strategic research to applied and adaptive research and, finally, to technology transfer. ICARDA promotes its partnership with NARS through seven Regional Programs across the geographic subregions in CWANA that share similar agroecologies: North Africa, Nile Valley and Red Sea, West Asia, Arabian Peninsula, Highlands, Central Asia and the Caucasus, and Latin America.

North Africa Regional Program

The North Africa Regional Program (NARP) coordinates activities in Algeria, Libya, Mauritania, Morocco and Tunisia, and is administered through ICARDA's Regional Office in Tunisia. It aims at implementing ICARDA's strategy in the region through collaborative activities with NARS. The objective of the program is to contribute to poverty alleviation, natural resources conservation, enhancing productivity of crops and livestock, human resources capacity building, and networking in the region.

A number of regional collaborative projects continued to be implemented in 2004, including "Sustainable Management of the Agro-Pastoral Resource Base in the Maghreb" phase II (SDC Maghreb), funded by SDC and implemented in Algeria, Libya, Mauritania, Morocco and Tunisia; "*Les obstacles aux transferts technologiques dans les petites et moyennes exploitations agricoles des zones arides et semi arides du Maghreb*" (FEMISE II) implemented in Algeria, Morocco and Tunisia; "Functional Genomics of Drought Tolerance in Chickpea in Tunisia," funded by BMZ; the "Regional Program to Foster Wider Adoption of Low-Cost Durum Technologies" (IRDEN), funded by IFAD and implemented in Algeria, Morocco, Syria, Tunisia and Turkey; "SDC Mountains, Maghreb" project; "Community-based Optimization of the Management of Scarce Water Resources in Agriculture in WANA;" "Assessing Potential of Water Harvesting and Supplemental Irrigation in WANA;" "Systemwide Program on Impact Assessment of Natural Resources;" and "Livestock Health and Market Opportunities."

Five bilateral projects funded by USDA in Tunisia continued to be



The IRDEN seed component workshop participants at a seed production and demonstration site in Tunisia on 10-12 May 2004.

implemented, with ICARDA providing backstopping. These are "Medicinal Plants in Tunisia," implemented by IRA Medenine; "Small Ruminants," with IRESA (INAT-INRAT) and ILRI; GIS for Watershed Management in the Arid Regions of Tunisia;" "Oats and Vetch;" and "Biotechnology in Algeria, Morocco and Tunisia." Another project "Biological Control of Weeds" is managed by ICARDA. Through these projects ICARDA enhanced its partnership with Tunisian research and teaching institutions (IRESA, INRAT, INAT, IRA Medenine) and USDA and US universities (University of Minnesota, Purdue State University, Fort Valley State University of Georgia, and University of Mississippi).

In Mauritania, the "Rapid Impact Program on Research and Extension," funded by CIDA, entered its second year. Activities during the year included implementation of a rural rapid appraisal in Brakna Province; introduction of spineless cactus at two research stations; and training of technicians from research institutions and development projects on cactus plantation, management and use in animal feeding. In addition, a new project on livestock and rangeland—"*Project Gestion des Parcours et Developpement d l'Elevage (PADEL),*" funded by the African Development Bank, started in December. ICARDA is associated as a partner in this project to provide backstopping in participatory and community approaches, water harvesting, animal feed resources and alternatives, and rangeland management and improvement.

In Morocco, INRA and ICARDA started a competitive grant initiative called the "Morocco Collaborative Grants Program (MCGP)." During the year, 14 project proposals were developed and submitted for funding under the program. As a result, five new projects in the areas of barley improvement, durum wheat improvement, genetic resources, integrated pest management (IPM) in cereals-legumes cropping systems, integrated natural resource management, and conservation agriculture were approved for funding. These projects will run for four years starting in the 2004/05 cropping season. In addition, five bilateral projects, which started in 2003 and were jointly implemented by INRA and ICARDA, yielded encouraging results. The projects are in biotechnology, crop improvement, genetic resources, IPM, and agroecological characterization and GIS.

Technical assistance

Within the framework of the IFAD-funded "Accelerated Project Performance in North Africa," ICARDA provided technical support to the following projects: (i) "Integrated Agricultural Development in Siliana" and "Integrated Agricultural Development in Zaghouane" in Tunisia—on monitoring, evaluation and impact assessment, and alternative feed resources and enhancing local institutions; and (ii) mountains and rural development projects in Morocco—on sociology, local institutions and rangeland management. ICARDA also provided technical backstopping to the IFAD-funded "Agro-Pastoral Development and Local Initiatives Promotion Program in the South-East" to institutionalize the community participatory approach within the project. Major achievements include: delimitation of the project area into 27 socio-territorial units, communities where an ethnic group is managing an area; production of two participatory community development plans of Ouled Chehida and Germessa communities; the production of a book of guidelines for working with communities; and providing training to the personnel of the project on the approaches and methodologies for working with communities.

Workshops and coordination meetings

Workshops organized by NARP in collaboration with other partners in 2004 included: (i) a workshop on "Assessing the Needs for Biotechnology in Algeria, Morocco and Tunisia," in collaboration with

Participants of the regional workshop on community approaches held at ICARDA's office in Amman, Jordan on 25-29 July 2004.

Moroccan farmers exchange knowledge and experience about durum wheat cropping with Syrian farmers during their visit to Syria on 24-27 May 2004.

USDA in Algiers in April, (ii) a regional workshop on "Promoting Medicinal and Aromatic Plants in the Mediterranean Region," in collaboration with IRA Medenine, in Djerba, Tunisia in June, (iii) a start-up workshop for the project "Improving the Livelihoods of Rural Communities and Natural Resource Management in the Mountains of the Maghreb Countries of Algeria, Morocco and Tunisia," funded by SDC, in Morocco, and (iv) a workshop on "Exploring On-Farm Research for Wheat-Based Farming Systems in North Africa," organized jointly with FAO in Tunisia in July.

National coordination meetings were held in Algeria, Libya, Morocco, and Tunisia to review results of collaborative research and develop plans of work for the future. There was a notable increase in participation of scientists from different NARS of each country. More than 300 scientists, research mangers, and extension agents attended these meetings in addition to officials from FAO, OSS, UNDP, IRD, AOAD and NGOs.

The third Technical Coordination and Planning meeting, and the Steering Committee meeting, of the "Program to Foster Wide Adoption of Low-Cost Technologies in Durum Wheat" (IRDEN), funded by IFAD, were held in Diyarbakir, Turkey, in September. Results of the 2003/04 cropping season were reviewed and a plan of work for 2004/05 was developed and approved. Participants included directors of research from Algeria, Morocco, Syria, Tunisia, and Turkey.

Nile Valley and Red Sea Regional Program

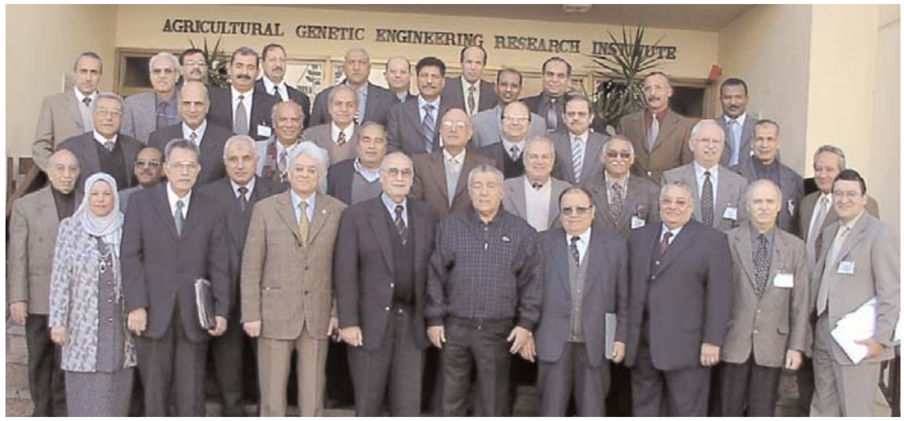
The Nile Valley and Red Sea Regional Program (NVRSRP) aims to increase the incomes of smallholder farmers in the region through the improvement of the productivity and sustainability of production systems, while conserving natural resources and enhancing the research capacity of national scientists in Egypt, Eritrea, Ethiopia, Sudan, and Yemen. Operating through ICARDA's Regional Office in Cairo, Egypt, NVRSRP coordinates the Center's activities and special projects in the member countries.

Collaborative projects

The crop commodity improvement and natural resources projects within NVRSRP include: "Improvement of Food Legume and Cereal Crops in Egypt," "Natural Resource Management in Egypt," "Control of Wild Oats in Cereals and other Winter Crops in Egypt," "Strengthening Client-Oriented Research and Technology Dissemination for Sustainable Production of Cool-Season Food and Forage Legumes in Ethiopia," "Transfer of Improved Production Packages for Wheat and Legumes in Sudan and Ethiopia," the ICARDA/AGERI project on "Identifying Resistance Genes in Cereals to Abiotic Stresses in Food Legumes Transformation," the ICARDA/CLAES project on "Upgrading of Faba Bean and Wheat Expert Systems," "Technology Generation and Dissemination for Sustainable Production of Cereals and Cool-Season Legumes in the Nile Valley Countries," funded by IFAD, "Integrated Cereal Disease Management in Eritrea," and "Barley Participatory Breeding in Marsa Matrouh."

During the year, four new projects in partnership with NVRS countries were launched. The project on "Community-based Optimization of the Management of Scarce Water Resources in Agriculture in West Asia and North Africa," funded by AFSED and IFAD, aims at improving the use of scarce water resources in agriculture. Three benchmark sites and six satellite sites will be established in the WANA region. One of the benchmark sites is on "irrigated agriculture" and will be established in Egypt, and two satellite sites will be established in Sudan and Iraq. A second new project on "Small Ruminant, Improved Livelihood and Market Opportunities for Poor Farmers in the Near East and North Africa Region" is funded by IFAD. Sudan is a partner in this project. The third project on "Improving Water Productivity of Cereals and Food Legumes in the Atbara River Basin of Eritrea" was started under the CGIAR Challenge Program on Water and Food. A regional FAO-TCP project on "Training on *Orobanche* Management in Legume Crops" was the fourth project started during the last quarter of 2004 in partnership with Egypt, Ethiopia, and Sudan.

In addition, the NVRSRP is involved in the ICARDA/UNCCD/GM which is coordinated within the framework of a regional program for sustainable dryland development in WANA. The focal institutions in the concerned NVRSRP countries are the Desert Research Center, Egypt; the national drought and desertification control unit, Ministry of Agriculture, Sudan; and the Ministry of Agriculture and Irrigation,Yemen.



Participants of the workshop held in Cairo, 6-8 January 2004, to launch an irrigation benchmark site in Egypt and satellite sites in Sudan and Iraq.

Workshops and coordination meetings

Within the framework of the project on "Community-based Optimization of the Management of Scarce Water Resources in Agriculture in West Asia and North Africa," a planning workshop, in collaboration with the Agricultural Research Center (ARC), Egypt, was organized in Cairo to develop workplans for the benchmark site in Egypt and the satellite sites in Sudan and Iraq. More than 40 participants from Egypt, Sudan, Iraq, and Jordan attended the workshop.

ICARDA co-sponsored the fifth international workshop on "Artificial Intelligence in Agriculture," held in Cairo. Other co-sponsors were the International Federation of Automatic Control, the International Commission of Agricultural Engineering, and the Central Laboratory for Agricultural Expert System (CLAES) in Egypt. More than 30 participants from Belgium, China, Denmark, Egypt, France, Hungary, India, Japan, Malaysia, Pakistan, Sudan, Turkey, Ukraine, United Arab Emirates, and the USA attended the workshop.

In addition, ICARDA co-sponsored the first international conference on "Strategy of the Egyptian Herbaria," held at the Agricultural Museum in Cairo in March. The conference was organized by the Horticulture Research Institute of the Agricultural Research Center (ARC) and the Egyptian Botanical Society. Participants came from Kuwait, Lebanon, Jordan, Saudi Arabia, FAO, and from several research centers and universities in Egypt.

The fourteenth NVRSRP Regional Technical Coordination meeting, and the Steering Committee meeting, were held in Sana'a, Yemen, in October. More than 50 scientists from the five countries and ICARDA participated. The meeting was inaugurated by the Minister of Agriculture and Irrigation of Yemen, H.E. Mr Hassan Omar Sowaid, and attended by the Deputy Minister of Agriculture and Irrigation, H.E. Mr Abdelmalek El-Arishi. The participants discussed and finalized the workplans for the 2004/05 growing season. The workshop particularly focused on the activities of the IFAD-funded project on "Technology Generation and Dissemination for Sustainable Production of Cereals and Cool-Season Legumes."

Annual coordination meetings were held in Egypt, Ethiopia, Sudan, and Yemen. A large number of scientists and research managers from the respective national programs, collaborating universities, and from ICARDA, participated in the meetings. They reviewed results of last season's activities and discussed future plans.

Human resource development

Within the framework of the NVRSRP/IFAD-funded project on

"Technology Generation and Dissemination for Sustainable Production of Cereals and Cool-Season Legumes," the following events were organized:

- A regional specialized training course on "Integrated Pest Management" in Aleppo, Syria, in May. Twelve scientists, researchers and extensionists from Egypt, Eritrea, Ethiopia, Sudan, and Yemen participated in the course
- A regional wheat and food legumes traveling workshop in Egypt in March. More than 100 scientists from ARC, 40 extensionists from the Ministry of Agriculture and more than 200 farmers participated.
- A regional traveling workshop in Ethiopia in September. Participants came from Egypt, Ethiopia, Sudan, and Yemen and included farmers, extensionists and researchers.
- A national traveling workshop on food legumes and wheat in Sudan in January, organized by ARC-Sudan, and ICARDA. Participants included more than 60 scientists from ARC, professors and students from faculties of agriculture from Nahr El-Nile and northern states, extensionists from the Ministry of Agriculture as well as more than 100 farmers from different locations.

Also, the NVRSRP and the ICARDA Seed Unit organized a regional training workshop on "Informal Quality Seed Production" at Wad Medani, Sudan, in December. The activity was implemented within the framework of the "Canada for Africa Grant," targeting sub-Saharan African countries. Participants came from Eritrea, Ethiopia, Sudan, and Yemen. Specialists from ICARDA and Sudanese institutions acted as facilitators.

Interregional cooperation

H.E. Dr Mohamed Emadi, Deputy Minister of Agriculture, Extension and Farming Systems, Iran, visited Egypt in March to discuss bilateral collaboration between the two countries in agricultural research and development. He visited ARC and CLAES. He also participated in a regional traveling workshop organized in Egypt by the ICARDA/IFAD-funded project on "Technology Generation and Dissemination for Sustainable Production of Cereals and Cool-Season Food Legumes." During a farmer field school session, Dr Emadi had extensive discussions with farmers, researchers, and extensionists on improved technologies and IPM.

H.E. Dr Mohamed Emadi (second from right), Deputy Minister of Agriculture, Extension and Farming Systems, Iran, participated in a traveling workshop in Fayoum, Egypt on 21-23 March.

More than 100 Sudanese farmers participated in the traveling workshop on food legumes and wheat conducted in Sudan on 14-20 January 2004.

In March, a delegation from the Barani Project in Pakistan, comprising the Director of Barani Agricultural Research Institute and a senior pathologist from the Fodder Research Institute in Pakistan, visited ARC, Egypt, to get acquainted with seed production systems of forage crops, particularly Egyptian clover. They also visited Sakha and Seru Research Stations, the modern private farms in the newly reclaimed lands, the Matrouh Resource Management Project (MRMP), and Ain Shams University.

A delegation from Kyrgyzstan consisting of H.E. Mr Aleksander Kostyuk, Minister of Agriculture, Mr Samagan Mamatov, Chairman of Agrarian Committee of Kyrgyz Parliament, and Mr Kambaralt Kasymov, Member of Kyrgyz Parliament, visited Egypt in June. The delegation visited the Agricultural Genetic Engineering Research Institute (AGERI) and a modern farm in the newly reclaimed areas of Nubaria region to see modern agricultural production systems.

H.E. Mr M. K. Anwar, Minister of Agriculture, Bangladesh, visited Egypt in October. He visited CLAES, AGERI, the Library of Alexandria, and a modern farm in the newly reclaimed areas of Nubaria region where he was shown modern production systems of cash crops.

West Asia Regional Program

The West Asia Regional Program (WARP), based in Amman, Jordan, works in partnership with the NARS of Cyprus, Iraq, Jordan, Lebanon, Palestine, Syria, and the southern parts of Turkey. Collaborative activities with Cyprus are mainly related to exchange of germplasm and expertise. For Syria and Lebanon, there are several collaborative activities aimed at enhancing productivity of crops and rangelands in the dry areas. In spite of the prevailing difficult situation in Palestine and Iraq, ICARDA has continued its collaborative activities mainly in training, exchange of visits, and provision of genetic material.

Collaborative research

The Dryland Agrobiodiversity Project, now in its fifth year, continued its activities in Jordan, Lebanon, the Palestinian Authority and Syria, of promoting the conservation and sustainable use of landraces and wild species of global importance originating from the Fertile Crescent. During the year, implementation of the project focused on community participation and empowerment, the demonstration of technological options on a large scale, and the development of project exit strategies through formulation of community development plans, characterization of livelihood strategies, and development of natural habitats management plans (for more information, see Project 3.3).

H.E. Dr Ibrahim Abu El-Naja (second from left), Minister of Agriculture, Palestine, speaking at the opening session of the Palestine/ICARDA Biennial Coordination Meeting held at ICARDA headquarters on 7-8 October 2004. Seated with him are: Prof. Dr Adel El-Beltagy (second from right), ICARDA Director General; H.E. Dr Azzam Tubeileh (right), Deputy Minister of Agriculture, Palestine; and Dr Mohan Saxena (left), ICARDA ADG (At-Large).

During the year, three new ICARDA projects on management of water scarcity and one on livestock health and marketing were started in the region. Site selections were conducted for the project on "Communal Management and Optimization of Mechanized Microcatchment Water Harvesting for Combating Desertification in East Mediterranean," also known as the Vallerani Project, and for the "Badia Benchmark Sites." These projects have boosted research activities and enhanced networking among national institutions and local communities. WARP also supported NARS of Algeria, Morocco, and Tunisia to develop a project on agrobiodiversity conservation using the experience gained from implementing a similar project in West Asia.

Workshops and coordination meetings

The Palestine/ICARDA biennial coordination meeting was held at ICARDA headquarters in October. The Palestinian delegation was led by H.E. Mr Ibrahim Abu Al-Naja, Minister of Agriculture. He thanked ICARDA for the support to Palestine amidst the difficult political environment. Highlights of collaborative activities presented at the meeting included the training of more than 233 researchers from Palestine, provision of valuable germplasm, exchange of visits, and development of joint projects.

Results of the dryland agrobiodiversity and the dryland initiative projects were presented and the future priority areas of research, including dryland farming, management of scarce water resources, rangeland rehabilitation, agrobiodiversity conservation, and seed production discussed. In addition, a memorandum of understanding between ICARDA and the Palestinian Ministry of Agriculture was signed and a meeting was held between Mr Abdallan Al-Lahham from UNDP and Prof. Dr Adel El-Beltagy, Director General of ICARDA, to discuss the best ways for the two institutions to join efforts in serving agricultural development in Palestine.

More than 80 representatives from NARS, farmers' cooperatives, and international and regional organizations participated in the twelfth Jordan/ICARDA Biennial Coordination Meeting, held at NCARTT headquarters in September. Progress of the four new projects on water management and animal health, and the achievements of the collaborative activities

Participants of the "12th Jordan/ICARDA Biennial Coordination Meeting," Jordan, 12-13 September 2004.

in genetic resources, agrobiodiversity and germplasm enhancement was discussed. The meeting also discussed future collaborative work, especially within the context of ICARDA's new research thrusts.

Within the framework of the dryland agrobiodiversity and IRDEN projects, a regional workshop on "Community Participatory Approaches" was held in July in Amman, Jordan,. The workshop attracted 23 participants from the agrobiodiversity project components of Jordan, Lebanon, Palestine, and Syria; the Turkish and Syrian components of the IRDEN project; and the Jordanian teams of the Badia Benchmark and "Vallerani" water harvesting projects.

The participants shared experience in applying community participation approaches within the respective projects. A logical framework for effective community participation and empowerment approaches was also developed. The Dryland Agrobiodiversity Project organized a workshop on "Seed Production and Health" in Amman, Jordan, in October. Facilitated by ICARDA scientists, the workshop attracted 17 participants from Jordan, Lebanon, Palestine, and Syria.

The sixth Regional Steering Committee Meeting of the Dryland Agrobiodiversity Project was held at the headquarters of the General Commission for Scientific Agricultural Research in Damascus, Syria, in November 2004. The achievements of the project were noted, and a recommendation was made to document lessons learnt for the benefit of similar future projects.

A delegation of high-ranking officials from northern Iraq visited ICARDA on 6-8 April 2004 to identify areas for collaboration in rebuilding agricultural research and human resources. Led by Mr Anwar Ahmed, Program Officer, Office of Project Coordination (OPC), the delegation consisted of Mr Ali Mohamed Ameen, Director General, Agricultural Research, Extension and Training in Erbil; Dr Nariman Haweiz, Director General, Veterinary and Animal Production; and Mr Bahjat Mohamed, Director, Dohuk Research Station.

The delegation held meetings with the members of ICARDA senior management and the scientists in the Germplasm Program, Natural Resources Management Program, Human Resources Development Unit, Genetic Resources Unit, Computer and Biometrics Services Unit, Seed Unit, and Station Operations.

The following areas were identified for collaboration: (i) human resource development and capacity building, including degree-oriented training, and short-term training at ICARDA headquarters as well as in northern Iraq, (ii) organization of study tours in areas of mutual interest, (iii) participation in some of the regional and international scientific conferences, workshops and meetings coordinated by ICARDA, (iv) exchange of adapted germplasm and improved varieties for testing in the northern Iraq environment, (v) establishment of on-farm and on-station verification and demonstration trials, (vi) assistance in organizing farmer field days and schools to strengthen the extension sector, (vii) exchange of visits by Iraqi and ICARDA scientists, and (viii) exchange of publications and other information material.

The delegation members pointed out that irrigation, particularly supplemental irrigation, is one of their top priorities, and will receive a major share of financial allocation for research for development. Animal feeding, rangeland, and fodder crops are some of the other priority areas.

The delegation members and ICARDA scientists jointly developed a draft proposal for the implementation of collaborative research and training activities in northern Iraq.

A memorandum of partnership between the Agricultural Education and Development Project (AHEAD), College of Tropical Agriculture and Human Resources, University of Hawaii, Manoa, and ICARDA was signed on 9 May 2004. The AHEAD Project is funded by a grant from USAID and activities include: four workshops/seminars in early 2005, and support to four Iraqi visiting scientists and four PhD students.

Prof. Dr Adel El-Beltagy (left), Director General of ICARDA, in a discussion with a delegation to ICARDA from northern Iraq. Seated next to the DG from left to right: Mr Anwar Ahmed, Program Officer, Office of Project Coordination (OPC); Mr Bahjat Mohamed, Director, Dohuk Region Research Station; Mr Ali Mohamed Ameen, Director General, Agricultural Research, Extension and Training in Erbil; and Dr Nariman Haweiz, Director General, Veterinary and Animal Production in Sulaimanyah. The discussions focused on rebuilding agriculture in the country.

JICA, in collaboration with ICARDA and the national program of Syria, approved a training program for Iraqi researchers within the framework of its Third Country Training Program (TCTP). The training course in this program will commence in 2005 and will include the following areas: Water-Use Efficiency; Drought Monitoring; Crop Improvement; Livestock Integration; and Biotechnology Application in Crop Improvement.

ICARDA, in collaboration with ESCWA, developed a website for registering professionals interested in contributing to reconstructing Iraq. The website lists hundreds of professionals willing to work in Iraq.
http://www.escwa.org.lb/information/iraq/IPR/main.html

Human resource development

The Agrobiodiversity Project organized 29 national training activities in which more than 700 farmers, researchers, and extensionists participated. More than 40 officials including the UNDP representative, the President of the University of Jordan, deans of agriculture in many universities and more than 50 farmers and herders and their leaders attended a field day at the project site in Muwaqqar, Jordan in May. It was an opportunity to show the impact of the project on range rehabilitation and the use of community participation approach.

Six Iraqi researchers each participated in three training courses at ICARDA: "Production and Management of Electronic Documents and Bibliographic Database Management," on 19-30 September; "Experimental Station Operation Management" on 3-14 October; and "Utilization of Expert Systems in Agricultural Research and Production" on 4-14 October. A one-month training program for four technicians and four pilot farmers was held on 19 September at ICARDA.

Arabian Peninsula Regional Program

The Arabian Peninsula Regional Program (APRP), based in Dubai, coordinates ICARDA's activities in Bahrain, the Emirates, Kuwait, Oman, Qatar, Saudi Arabia, and Yemen. Collaborative activities include research, capacity building, and human resource development in water resource management; forage and rangeland management; and protected agriculture. Major emphasis is placed on strengthening national institutions, enhancing human resource capacity, technology development and transfer, information technology and networking. APRP is funded by AFESD, IFAD, and the OPEC Fund.

Collaborative research

Soilless growing techniques, introduced in several Arabian Peninsula countries to maximize quality and quantity of production per unit of water by APRP, have continued to be accepted by farmers. The techniques are considered the best option in situations where the greenhouse soil has deteriorated due to salt accumulation and infestation with soil-borne pathogens. Simple growing systems were constructed and tested in Kuwait, Oman, Qatar, the UAE, and Yemen

Production of high-quality tomato in soilless culture at Rumais research station, Oman. "More crop per drop."

with locally available materials for the production of tomato, cucumber, pepper, and lettuce crops. Vertical soilless growing techniques have been studied in Oman and Kuwait during the past four years at research stations, and are now being transferred to farmers' fields by APRP in collaboration with NARS. The success of the vertical soilless growing systems in Kuwait and Oman encouraged NARS in Bahrain and Saudi Arabia to adapt it. Two such systems have so far been developed in Riyadh and Manama.

Buffel grass or Lebid (*Cenchrus ciliaris*) has been identified in the UAE as a source of high-quality feed with high water-use efficiency. The forage can be harvested 10 times per season, with an average dry matter yield of up to 20 t/ha. Irrigated Rhodes grass is widely used as forage by farmers in Emirates and other Arabian Peninsula countries. To demonstrate the new forage to farming communities, APRP, in collaboration with the Ministry of Agriculture in the UAE, started a program of field verification in the central agricultural region and in Al Ain area, where five farmers and three government and private farms have been identified to grow the new forage on relatively large areas. The farmers were provided with seeds and a field guide for producing the forage. Seed technology units have also been established in Oman and Saudi Arabia to address the constraint of seed availability of the newly identified forage and range species in the Arabian Peninsula.

A five-year study aimed at developing a proper grazing management system on rangelands in the arid environment of the Arabian Peninsula was started in 2004. It is a joint effort between ICARDA and the Ministry of Agriculture in Saudi Arabia.

Participants of the "Regional Workshop on Agricultural Research Systems and Strategies in GCC Countries," held at ICARDA on 23-25 February 2004.

New project proposals

Three new project proposals were developed: (i) "Supporting Rural Development and Food Security in the Terraces of Yemen: Adoption of Sustainable Protected Agriculture Technology for the Production of Cash Crops in Taez Region;" (ii) "Development of Sustainable Date Palm Production Systems in the Gulf Cooperation Council (GCC) Countries of the Arabian Peninsula;" and (iii) "Evaluation and Restructuring of Agricultural Research Systems in the GCC Countries."

New partnership agreements

ICARDA signed a Memorandum of Understanding with the United Arab Emirates University (UAEU). This agreement will open new avenues of cooperation in research, human resources development, and exchange of information between the two institutions. A new agreement between ICARDA and the Government of the UAE was also signed in December, to supersede the one signed in 1991. A Memorandum of Understanding was also signed between ICARDA and the Sultanate of Oman for the establishment of a seed technology unit.

Workshops and coordination meetings

A regional workshop on "Agricultural Research Systems and Strategies in the GCC Countries" was organized by APRP in Aleppo in February. Twenty-seven scientists from the GCC and ICARDA participated. The workshop participants discussed the status of research systems in the NARS of the six countries of the GCC, developed a project proposal for collaborative research, and generated a common understanding on managing inter-country collaborative research.

The Regional Steering Committee Meeting of APRP was held in February at ICARDA headquarters in Aleppo, Syria. The meeting was attended by 17 participants representing ICARDA, AFESD, the OPEC Fund, and AP countries. APRP activities, achievements, and future plans were discussed.

A workshop on "Date Palm Development in the GCC countries of the Arabian Peninsula" was held in Abu Dhabi in May. It was organized by ICARDA in collaboration with the Ministry of Agriculture and Fisheries of the UAE, the UAE University, and the General Secretariat of the GCC. More than 70 researchers from the six GCC countries and international date palm experts from ICARDA, Egypt, Iran, Morocco, Sudan, Tunis, USA, and Yemen participated.

Human resource development

A training course on protected agriculture was organized in October by APRP in collaboration with Rumais Agricultural Research Center in Oman. Five researchers from Bahrain and Saudi Arabia were trained on vertical growing systems. In addition, four Yemeni researchers were trained in two-month courses on protected agriculture in Qatar and Oman. Also, a two-day training course on maintenance and operation of seed technology units was held by APRP in collaboration with the Ministry of Agriculture and Fisheries for one Omani researcher at Dhaid in the UAE, in September.

Highland Regional Program

Highlands (> 800 masl) cover over 40% of the agricultural land in Central and West Asia and North Africa (CWANA), and are home to the most disadvantaged sector of the population in the region. The harsh environment and poor accessibility, to a great extent, explain the neglect of these areas by national and international research and development organizations. Harsh conditions promote outmigration and land abandonment. Subsistence is secured from drought-tolerant, low-productivity crops such as barley, as well as fruit trees and vegetables, and from transhumant flocks of small ruminants that move to mountain pastures in the summer. Much of the agriculture is conducted on sloping land and soil erosion is a major problem, especially in areas that have become degraded as a result of overgrazing and other inappropriate farming practices.

From its inception, ICARDA has devoted an important proportion of its resources to improving agricultural productivity and maintaining natural resources in the highlands, initially in West Asia (Afghanistan, Iran, Pakistan and Turkey) and North Africa (Morocco, Algeria and Tunisia), and subsequently in Central Asia as well.

Highland Research Regional Network

From its early days and until mid 2004, ICARDA managed its regional highland activities through the Highland Regional Program, that included countries of North Africa, West Asia, and CAC. Because those countries fall within the geographic mandate of other ICARDA Regional Programs, it was decided to address the problems of highland agriculture within the framework of a Highland Research Regional Network (HRN). The goal of HRN is to contribute to improving the welfare of rural populations in the highlands of CWANA through the identification and adoption of strategies and technologies that ensure a sustainable improvement of agricultural productivity in those areas. ICARDA project staff are located in Iran and Afghanistan, while work in Turkey is handled from the headquarters.

Afghanistan

ICARDA's highland collaborative research activities in Afghanistan are managed by its Kabul-based office, which coordinates the work in six target provinces (Ghazni, Helmand, Kabul, Kunduz, Nangarhar and Parwan). Additionally, the Kabul office coordinates the activities of the Future Harvest Consortium to Rebuild Agriculture in Afghanistan, which is a conglomerate of 18 organizations from the world over. Besides, it also provides technical and logistic support to ICARDA's program on Research on Alternative Livelihoods Fund (RALF), supported by DFID, and the IDRC project on Seed System Analysis.

A smile of satisfaction after years of suffering: A farmer in Parwan, Afghanistan who participated in wheat demonstrations.

Collaborative research

ICARDA scientists, along with their counterparts in the Ministry of Agriculture, Animal Husbandry and Food (MAAHF) and NARS in Afghanistan have worked to rebuild the destroyed agriculture, through funding from USAID (Rebuilding Agricultural Market Program-RAMP), International Development Research Centre (IDRC), Organization of Oil Producing and Exporting Countries (OPEC), and ICARDA's own funds. Collaborative projects within ICARDA-Afghanistan program

A rich harvest of high quality wheat seed: Village-Based Seed Enterprise members in Kunduz, Afghanistan sharing their happiness over the success of their efforts.

Participants after building the first greenhouse in Kabul, Afghanistan.

include: "Demonstrating New Technology in Farmers' Fields to Facilitate Rapid Adoption and Diffusion", "Village-Based Seed Enterprise Development in Afghanistan", "Introducing Protected Agriculture for Cash Crop Production in Marginal and Water-Deficit Areas of Afghanistan", "Community Based Research on Agricultural Development and Sustainable Resource Management in Afghanistan", the ICARDA/CIP project on "Clean Seed Production, Multiplication and Marketing for Increased Potato Production in Afghanistan", and ICARDA/IDRC Project on "Strengthening Seed Systems for Food Security in Afghanistan".

To increase agricultural productivity and rural incomes by demonstrating and catalyzing adoption of improved varieties and new technologies, ICARDA established 362 demonstrations of wheat, potato, onion, tomato, rice and mung beans in six target provinces of Ghazni, Helmand, Kabul, Kunduz, Nangarhar, and Parwan. A total of 11 improved varieties of wheat, potato, tomato, onion, rice, and mung beans were successfully introduced. ICARDA in close association with the Ministry of Agriculture, Animal Husbandry and Food has established 15 village-based seed enterprises in five provinces of Afghanistan to provide rapid access to quality seed of most profitable crop varieties. The enterprises produced 1092 tons of quality seed of wheat, rice, chickpea, and mung beans.

Protected agriculture has the potential to contribute significantly to both the development of rural communities and to the Afghan economy. ICARDA has helped to establish a protected agriculture center, comprising four greenhouses and a manufacturing workshop in Kabul which serves as a production center and training facility for the trainers and growers. Farmers, extension workers, NGO personnel, and MAAHF staff have been trained in installation and maintenance of greenhouses for growing cucumber, tomato, lettuce, and onions. ICARDA aims to install 19 more greenhouses in five provinces.

With support from the OPEC Fund, ICARDA scientists working with their national counterparts have revived a program of screening and identifying new varieties and production of early-generation seed of wheat, barley, potato, chickpea, and mung beans. A total of 48 trials were conducted and pure seed produced from 13,620 progeny rows. More than 130 tons of high quality seed of 15 different wheat varieties was produced and will be multiplied by farmers in eastern and north-eastern Afghanistan. It is expected that

Mung bean varietal trial at Sheesham Bagh research station in Nangarhar, Afghanistan under OPEC-Fund Supported Project.

2675 tons of seed will be produced in 2005. In addition, ICARDA scientists collected 677 germplasm accessions of *Aegilops* spp., barley, chickpea, lentil, melon, rice, and wheat from Afghanistan.

New projects

Two new research projects were funded through the RALF program. Through one of these projects, ICARDA will introduce improved mint varieties and its use for medicinal purposes, while through the other project, suitable cereal-legume forage crops will be introduced with the objective to increase milk production in East and North-East Afghanistan as alternative livelihood approaches.

Workshops and coordination meetings

A workshop on Sunn pest Integrated Pest Management was held in Kabul in March. More than 20 scientists from different departments of MAAH, Kabul University, and from FAO participated. Ways and means to control Sunn pest using mechanical and chemical approaches were discussed.

A Regional Potato Workshop was held in Tashkent, Uzbekistan in April in which Afghan researchers participated. ICARDA-Afghanistan sponsored two national experts to participate in the Second International Conference on Sunn pest, held at ICARDA headquarters in Aleppo. A meeting of stake holders on Strengthening Seed System for Food Security in Afghanistan was organized in Kabul in September. Participants from ICARDA, ICRISAT, MAAH and various national and international NGOs discussed seed related issues in Afghanistan. H.E. Mr M. Sharif, Deputy Minister of Agriculture, inaugurated the meeting.

Afghan farmers in a training session on seed production and seed enterprise management.

Human resource development

ICARDA-Afghanistan sponsored and arranged training for four MAAH scientists on "Bread Wheat Improvement and Agronomy," "Winter and Facultative Bread Wheat Improvement," "Plant Protection in Cereals and Food Legumes," and "Quality Assurance in Seed Testing" at ICARDA headquarters in Aleppo.

A Baseline Survey Course was held in March in Kabul, where 12 participants were trained in survey methodology to determine the current status of crop production, and assess the project impacts. CIP/ICARDA scientists conducted training on Integrated Crop Management of potato in Ghazni and Parwan provinces during April, where 111 farmers and staff of MAAH and other NGOs were trained. ICARDA scientists conducted a course "Train- the-Trainer on Seed Production Technology and Enterprise Management" in February in Kabul. Forty-two researchers of MAAH, extension workers, and staff of various NGOs were trained. Seed Production Technology and Seed Enterprise Management Trainings were held in Jalalabad and Kunduz provinces in May. A total of 131 farmers, members of Village-Based Seed Enterprise (VBSE), staff of MAAH and NGOs, and extension workers were trained.

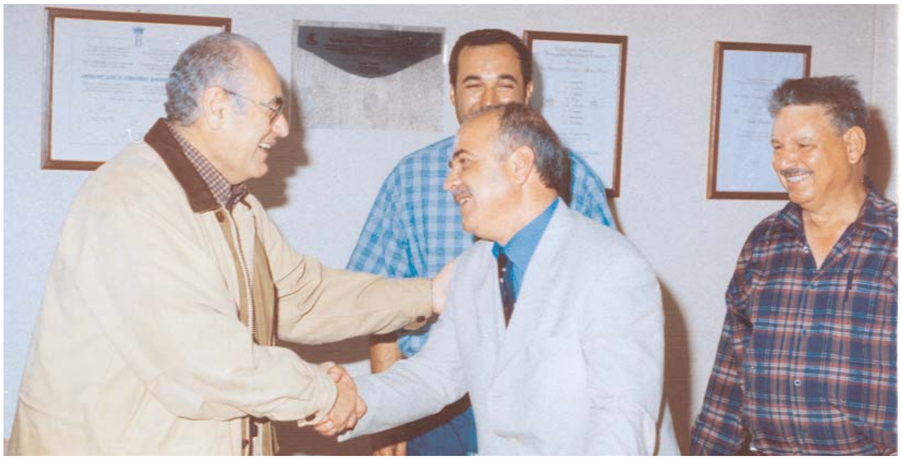
Two training courses on Greenhouse Installation and Preparation for the Production of Cash Crops were organized in Kabul during July and August. A course on Greenhouse Manufacturing was organized in Kabul in December where seven technicians were trained in using various machines for manufacturing greenhouses. Other courses, all in December, included a Business Management and Financial Analysis Training Course in Nangarhar and Parwan provinces; a course on Post-Harvest and Demand Survey in Kabul; a Tissue Culture Training Course in Badam Bagh; and an Integrated Production and Protection Management Training Course for Trainers, Growers, and Extension Workers in Kabul.

Through 15 field and farmer days, 1500 farmers were trained in modern agricultural techniques for growing food, vegetables, and cash crops.

Turkey

Collaborative projects

ICARDA has developed strong partnership with the Turkish NARS, based mainly on the decentralization of activities. During 2004, three projects were jointly conducted, namely, the winter and facultative



Mr Refet Yilmazoglu (center), GAP Regional Director, being received by Prof. Dr Adel El-Beltagy (left), ICARDA Director General, during his visit to ICARDA along with 11 agro-pioneer farmers from Tukey. Standing behind is Mr Mehmet Emin Akil, farmer representative, and on the right, Dr Moussa Mosaad, ICARDA/GAP Coordinator.

wheat improvement; a program to foster adoption of low-cost durum technologies (IRDEN Project); and a third project on the use of naturally occurring fungi to control Sunn pest.

The joint Turkey/CIMMYT/ ICARDA International Winter Wheat Improvement Program (IWWIP) continued to collaborate with NARS in the region. Germplasm is developed and tested in Turkey and Syria before it is dispatched to a large number of sites in CWANA. A total of 100 sets of international nurseries for different ICARDA crops were provided to Turkish partners for testing at research institutes and universities.

ICARDA also has strong collaboration with the Southeastern Anatolia Project (GAP). GAP is mainly a development project operating under Turkey's Prime Minister's Office to promote agriculture and improve the livelihood of farmers in the Southeastern Anatolia region. The collaboration covers two projects: "On-farm Demonstrations and Seed Multiplication" and "Improvement of Natural Pastures and Forage Crops and Small Ruminant Production." Improved and adapted varieties of wheat, barley, lentil, and chickpea have been introduced, along with improved production practices. These are being transferred through on-farm trials in cooperation with progressive farmers. The improved cultivars of different crops yielded much higher in demonstration fields than the local cultivars grown elsewhere in the region. ICARDA provided the GAP project with one ton of quality seed of 'Idlib-3' lentil, as this variety is expected to be released in Turkey soon. Also, ICARDA provided 800 fodder-shrub seedlings, seeds of eight *Atriplex* species, and new forage legumes for testing. The introduced material is monitored and evaluated by GAP staff, local extension personnel, and cooperating ICARDA scientists.

The Technical and Steering Committee Meeting of the GAP-RDA/ICARDA Project was held at ICARDA headquarters in February. Achievements of the previous season were reviewed, and workplans for the next season were developed. A new agreement was signed to cover the revised, expanded workplans.

Human resource development

Fifteen Turkish scientists from the Ministry of Agriculture and GAP visited ICARDA for 1 to 2 weeks to participate in training courses on seed production, water management, data management and analysis, lentil hybridization and breeding techniques, and scientific writing and data presentation. Four Turkish wheat breeders visited the IWWIP to get acquainted with the program activities at ICARDA. A group of 11 agro-pioneer farmers and six senior officials from GAP areas visited ICARDA. The group viewed crops, seed, and livestock production activities at ICARDA and in some areas in Syria.

One training course was conducted in Turkey on "Strategic Feeding of Small Ruminants and Improvement of Milk Yield," in which farmers, agricultural researchers and extensionists participated. Thirteen ICARDA scientists visited Turkey to provide technical backstopping and monitoring of collaborative activities.

To transfer the experience to neighboring countries, ICARDA in collaboration with GAP, organized a traveling workshop on livestock and milk production and the development of dairy sector in Jordan for GAP president and six staff.

Iran

Collaborative activities in Iran, under the ICARDA/Iran project, are coordinated through the ICARDA Office in Tehran, which was established in 1996 at the premises of the Agricultural Research and Education Organization (AREO), and is headed by an ICARDA scientist.

Collaborative research

A combination of factors including the development of improved varieties and better agricultural practices led to the production of more than 14 million tons of wheat in Iran during the year, giving the distinction to the country of becoming self-sufficient in wheat for the first time in more than 40 years. Growing conditions during the 2003/04 season were generally favorable, despite the late start of rains. In areas where farmers adopted the improved technology recommended by the Dryland Agriculture Research Institute (DARI) and ICARDA scientists, wheat yields reached 3 t/ha, compared with 1.5 to 2 t/ha in other areas. DARI released a new chickpea variety 'Arman' selected from ICARDA-supplied germplasm. The variety showed resistance to *Ascochyta* blight in 10-year evaluations under both field and artificial epidemic conditions. In 2003/04, 'Arman' yielded 1 t/ha in farmers' fields in five provinces and was gaining popularity.

Results of forage legume experiments conducted on various DARI research stations showed that genotypes of *Vicia panonica, V. ervilia* and *V. dasycarpa* could be planted as winter crops in cold-winter areas. Some of the most promising genotypes of *V. sativa* were: IFVS 715 Sel 2556 (5.45 t/ha biological yield) and Sel 2717 (5.88 t/ha).

Iran spends nearly US$0.8 billion annually to import oilseed crops. The country has developed a national 10-year "oilseed crops project" aimed at reducing dependence on imports. The most important oilseed crop in Iran is rapeseed, followed by safflower and sunflower. Most of rapeseed is grown in high rainfall or irrigated areas, generally located in warm or mild-winter regions where yield may reach 4 to 5 t/ha. ICARDA and DARI have been working on improving production in the rainfed areas mainly through development of varieties resistant to cold.

During the past five years, DARI researchers have identified cultivars with adaptation to certain rainfed niches, where rapeseed can fit within the traditional cereal-fallow system, in such rotation as "cereal-rapeseed-cereal." Promising safflower breeding lines for rainfed conditions include PI 537536-S (yield 2.67 t/ha), PI537598 (0.9 t/ha in on-farm testing—this entry will be submitted for release), PI592391/Sunset, PI250537, and S-541.

A formal agreement for the new AREO-ICARDA International Spring Wheat Improvement Program (AIISWIP) was signed in September by AREO and ICARDA. The major aim of AIISWIP is to develop and distribute to requesting NARS improved wheat germplasm suitable for the warm winter, high-rainfall or irrigated areas of low latitudes in CWANA. Implementation of the program started in 2004.

Collaboration in Sunn pest research continued with joint visits by ICARDA and Iranian scientists to research sites for the implementation and observation of entomopathogenic fungi experiments.

Workshops and coordination meetings

ICARDA and Iranian scientists participated in the workshop to launch the "Karkheh River Basin Project" funded under the CGIAR Challenge Program on Water and Food. Scientists from CIAT, IWMI, and UC-Davis also participated in the workshop. During the first three days, participants held meetings in Karaj and discussed the themes, sub-themes, composition of teams, and the planning of different activities for the two approved projects "livelihood resilience" and "water productivity." They also visited Karkheh River Basin—both at the upper and lower catchments—for site selection.

The twelfth IRAN/ICARDA Annual Planning and Coordination Meeting took place at Sararood Research Station, Kermanshah, Iran, on 9-13 September with the participation of more than 40 Iranian and 5 ICARDA scientists. Participants reviewed results and discussed the plan of collaborative work with DARI. This included research experiments on breeding wheat, barley, chickpea, lentil, and forage crops; on soil and water resource management; and on diseases control.

The "First National Seed Seminar" was held in November in Iran. Participants included scientists from ICARDA, FAO, CIHEAM, and local NARS. They reviewed ways to build capacity for seed certification in Iran. Two international consultants were hired through ICARDA to provide advice on seed policy and related by-laws and seed health. Meetings were also held in Iran at the new SPCRI (Seed and Plant Certification Research Institute) through which scientists from SPCRI and ICARDA identified areas of technical cooperation.

Human resource development

Five researchers from different Iranian research institutions received specialized training at ICARDA headquarters on barley quality analysis, water-use efficiency, management of electronic databases, expert systems, and experimental station operation management. Iranian researchers also participated in the Second International Conference on Sunn pest, held at ICARDA in July.

An in-country training course on "Breeding for Stress Tolerance in Food Legumes and Analysis of G-by-E Interaction Using Specialized Techniques and Software" was organized in March at the Seed and Plant Improvement Institute (SPII), Karaj. Fourteen Iranian researchers and four ICARDA scientists participated in the training.

Training workshops were conducted in Iran to introduce the concepts and practices of farmer-participatory research to the staff of two projects of the Challenge Program on Water and Food.

Two training workshops were organized in Iran during the year within the framework of the Karkheh River Basin (KRB) projects funded by the Challenge Program on Water and Food. The first workshop focused on participatory research approach and participatory diagnosis. It was held in Karaj and Kermanshah in September. More than 35 national research staff and extension officers participated in the training. The second workshop focused on farmer innovation and innovators. It was held in Kermanshah in November with the participation of 23 staff members involved in the two projects. The participants were introduced to concepts of indigenous knowledge and farmer innovation, and discussed ways of integrating the available knowledge with new innovations.

Central Asia and the Caucasus Regional Program

Established in 1998, the Central Asia and the Caucasus (CAC) Regional Program promotes regional cooperation in research, capacity building, and human resource development in countries of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan in Central Asia; and Armenia, Azerbaijan and Georgia in the Caucasus. In a short span, strong partnerships with the CAC NARS have been built in germplasm improvement, plant genetic resources, soil and water management, integrated feed and livestock production, and human resource development.

Collaborative research

Collaborative research made considerable progress in 2004. Six varieties of wheat developed from the germplasm supplied by ICARDA were released: 'Azametly 95' and 'Nurlu 99' in Azerbaijan, 'Jamin,' 'Zubkov' and 'Azirbosh' in Kyrgyzstan and 'Bitarap' in Turkmenistan. Also, one variety each of barley, chickpea and lentil were released. In addition, more than 54 promising varieties are being tested for final release by the different countries in the region. A major thrust has been on the seed production of improved varieties and their testing on farmers' fields.

An IPM strategy for the control of yellow rust was developed by studying the race spectrum and identification of resistant genes to be deployed in the breeding programs to replace the susceptible varieties. Also, a Cereal Leaf Beetle Nursery (CLBN) was established for the first time in Kyrgyzstan for evaluation of resistance of bread wheat lines to this insect pest.

ICARDA and IPGRI provided technical support for the renovation of the Uzbek Genebank and germplasm storage facilities at the Uzbek Cotton Breeding Research Institute, the Research Institute of Genetics and Experimental Biology of Plants and the Andijan Research Institute of Grain and Legume Crops. In Kyrgyzstan, Tajikistan, and Georgia, considerable progress was made to establish national genetic resources centers with medium-term storage facilities, for which the CGIAR program is providing the necessary backstopping support. In Azerbaijan, efforts are underway to establish a separate Genetic Research Institute.

In collaboration with NARS, the Vavilov Institute (VIR-Russia) and the ACIAR, collection missions were organized in all the eight countries of CAC. A total of 2484 accessions of different crops have been collected, of which 364 accessions were collected in Armenia and 318 in Tajikistan during the year.

Within the framework of the Central Asia and the Trans Caucasian Plant Genetic Resources (CATPGRN) Network, eight working groups on plant genetic resources (PGR) on ICARDA's mandate crops were established in countries of CAC. Each group comprises three specialists on grain crops, legume crops, and documentation. ICARDA provided all the eight groups with computers to establish a documentation system for the plant genetic resources in their countries and supported training of national documentation specialists.

To improve soil and water management, efforts continued to devel-

Participants of the seventh Program Steering Committee meeting of the CGIAR Collaborative Program for Sustainable Agricultural Development in Central Asia and the Caucasus (CAC), held in Baku, Azerbaijan, on 6-8 June, 2004.

op technologies for conservation tillage, crop diversification, on-farm water-use efficiency, and salinity management. Promising results were obtained with direct seeding of wheat in standing cotton, raised-bed planting of wheat, minimal tillage for crop diversification after winter wheat, alternative furrow irrigation, and terracing and mulching on sloping lands. Under the crop diversification activities, new alternative crops found promising are: chickpea, safflower, soybean, common bean, mungbean, buckwheat, and groundnut. These crops are now being adopted on large areas. The alternate furrow system provided a saving of water by 30%, and a reduction on the pressure on the drainage system by 40%. Based on these results, obtained in southern Kazakhstan, alternate furrow irrigation technology is now practiced in Uzbekistan and Kyrgyzstan.

Work on feed and livestock management has offered new opportunities for income generation through early lambing and weaning, sheep milking, use of alternative feed resources, and rangeland rehabilitation. In view of low nutritional value of rangeland fodder, feed-block technology for sheep feeding has been found promising and was successfully adopted by the farmers in Uzbekistan and is being tested by a number of farmers in other countries. Also, fortification of poor quality straw using ammonia has proved to be useful.

Workshops and coordination meetings

An inception workshop for the ADB-funded project on "Improving Rural Livelihoods through Efficient On-farm Water and Soil Fertility Management in Central Asia" was held in Tashkent in February. More than 60 participants attended the workshop, including heads of NARS and leading scientists from all Central Asian countries and Azerbaijan, representatives of ADB, SDC, USAID, GTZ, NGOs, and ICARDA. Later, the first steering committee meeting of the project was held.

A regional workshop on "Strengthening Partnerships for More Effective Planning, Research and Development in Agriculture in Central Asia" was jointly organized in Tashkent by ADB and ICARDA

Participants of the regional workshop on "Strengthening Partnerships for More Effective Planning, Research, and Development in Agriculture in Central Asia," held in Tashkent on 23-25 August 2004. H.E. Mr Abduvohid Juraev, First Deputy Minister of Agriculture and Water Management of Uzbekistan, and Dr Pratima Dayal, Senior Agriculture Specialist of the Asian Development Bank, are seen here.

Meeting of the CGIAR Program for CAC on Centers' and Members' Day at AGM04 on 25 October. From left to right: Dr Ali Ahoonmanesh, Deputy Minister of Agriculture and Head of AERO, Iran; Dr Franklyn Moore from USAID; Dr Philippe Vialatte from the European Union; Prof. Dr Adel El-Beltagy, ICARDA DG; Dr Kevin Cleaver from the World Bank; and Dr Tumurdavaa Bayarsaihan from ADB.

in August. About 35 participants from Central Asian countries and Azerbaijan, including policy makers, representatives of NARS, NGOs, farmer organizations and donor agencies attended.

The Second Meeting of the Inter-Regional Cotton Network for Central Asia and North Africa (INCANA) was held in Tashkent, Uzbekistan, in September. The meeting was organized by ICARDA-CAC Regional Office under the umbrella of the Central Asian and Caucasian Association of Agricultural Research Institutions (CACAARI). About 35 scientists from 10 countries participated in the meeting, including representatives from Kazakhstan, Tajikistan, Uzbekistan, and Azerbaijan.

An ADB Mission headed by Dr Katsuji Matsunami, Director, Agriculture, Environment and Natural Resources Division, ADB, visited ICARDA-CAC Regional Office in Tashkent in February. Also, the ICARDA Director General, Prof. Dr Adel El-Beltagy, and the ICARDA-CAC Program Coordinator, Dr Raj Paroda, visited ADB Headquarters in May and had meetings with senior officials of the Bank. They discussed issues related to strengthening cooperation between ICARDA and ADB.

A special donor support meeting for the CGIAR Program for CAC was organized in Mexico in October during the annual general meeting of the CGIAR. The meeting was chaired by Prof. Dr Adel El-Beltagy, ICARDA Director General, and attended by representatives of the World Bank, ADB, European Union, USAID, IFAD and other stakeholders.

Human resource development

A total of 306 CAC scientists and farmers participated in different international conferences, workshops, seminars, field visits and training courses. In addition, 23 scientists from all CAC countries were trained through an intensive training course in English, held in Tashkent.

A training course on ”Biosaline Agriculture: Principles and Applications, with Reference to the Central Asia and Caucasus Region,” organized jointly by the International Center for Biosaline Agriculture (ICBA) and ICARDA, in collaboration with the Government of Uzbekistan, was held in September in Tashkent. A total of 35 participants from five Central Asian countries and Azerbaijan attended the course. Also, 12 scientists and agronomists from Kazakhstan and Uzbekistan participated in a traveling workshop to north Kazakhstan and western Siberia on “Conservation Tillage and Crop Diversification” in July. The group was introduced to on-going research activities on tillage and crop diversification.

A training course on “Participatory Approaches in Natural Resource Management Research” was organized within the framework of the ADB project in Tashkent in September. A total of 18 participants from Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan attended. Also, 11 scientists from Central Asia, Azerbaijan and ICARDA participated in a traveling workshop to India in September, organized by ICARDA in collaboration with the Indian Council for Agricultural Research (ICAR) within the framework of the ADB-funded project. The group visited several agricultural research centers located in the north-west of India where they were acquainted with on-going research on crop diversification, zero-tillage, and improved irrigation.

Latin America Regional Program

The Latin America Regional Program (LARP) operates through ICARDA’s office based at CIMMYT headquarters in Mexico, and headed by an ICARDA/CIMMYT barley breeder. Its overall objective is to collaborate with NARS in the region in germplasm enhancement and facilitate networking with the researchers based at ICARDA’s headquarters in Aleppo.

Collaborative Projects

The barley enhancement program focuses on the development of germplasm with multiple disease resistance and adaptation to the environments in Latin America.

Since 2000, LARP has been actively working with the US Wheat and Barley Scab Initiative with the common objective to fight an extremely destructive disease, *Fusarium* Head Blight (FHB). Networking with more than 16 institutions in the US and worldwide has made it possible to make available promising germplasm to national partners. The Oregon State University, USA, and the Field Crops Development Center, based in Alberta, Canada, are the best examples of long-term collaboration in the development of superior germplasm.

Working in alliance with the private sector, the program has a research agreement with Busch Agricultural Resources Inc. (BARI), the agricultural research branch of Anheuser-Busch, the largest brewery in the world. The objective of the research includes the development of barley that combines malting quality characteristics and resistance to several diseases, including FHB. The germplasm developed through this effort is available to any collaborator in the region and worldwide. The main objective is to improve the barley crop and meet the increasing demand for malting barley.

Busch Agricultural Research Inc. (BARI) scientists collaborating in the barley enhancement project to develop germplasm with good malting quality and resistance to Fusarium Head Blight visit research experiments at Toluca, Mexico, with Dr Flavio Capettini (second from right), ICARDA Barley Breeder in the Center's Latin America Regional Program, and Dr Maarten van Ginkel (right), CIMMYT Head of FHB Research.

Since LARP is based in Mexico, special attention has been given to support local institutions in the development of new barley types with high adaptation to the region and new production alternatives to local farmers. The alternatives include the development of forage barley lines, as well as feed barley lines with higher yield than the local malting types.

The long-term collaboration in legume research has been yielding encouraging results. One of the examples was the release of a new faba bean variety, 'San Isidro' in Mexico in 2004, developed from the germplasm supplied by ICARDA. 'San Isidro' has tolerance to chocolate spot and was released by the Institute of Agricultural, Water, and Forestry Research and Training of the State of Mexico (ICAMEX).

Technical Assistance

A research program with the Brazilian Agricultural Research Corporation, EMBRAPA, started in 2001 to develop barley adapted to the environments in Central Brazil. A local barley breeder has visited Mexico twice since, with the objective of receiving training in barley breeding and carrying out *in situ* selection of germplasm delivered to Brazil. The ICARDA/CIMMYT barley breeder also provides support through visits and selection of materials at experiment stations and farmers' fields in Latin America.

Research Support Services

Communication, Documentation and Information Services

During 2004, the Communication, Documentation and Information Services (CODIS) Unit completed a ground-breaking publication entitled "Healing Wounds." The book is a synthesis of the work of the CGIAR centers in rebuilding agriculture over the past three decades in the wake of conflicts and natural disasters across CWANA, Asia, Sub-Saharan Africa, Latin America, and the Pacific. An initiative of the Marketing Group of the CGIAR, "Healing Wounds" was produced at ICARDA and published by the CGIAR.

A journalist and author based in London visited ICARDA and developed a feature article based on Healing Wounds, which appeared in New Scientist. An Australian journalist from the rural press, who visited ICARDA early in the year and interviewed several scientists, published a number of articles in the Australian media on agriculture in the CWANA region. Articles that featured ICARDA's work included "Benefits for Australian Barley," "Syrian Research to Help Farmers" and "Why Middle East Research Helps Australian Farmers." The strong linkages between ICARDA and Australia were highlighted in all stories. In addition, the December 2004 edition of ISSUES Magazine in Australia published a feature article by an ICARDA scientist on "Racing Against Time to Save our Green Gold." It focused on the importance of conserving crop varieties and landraces before they are eroded from various parts of the world, pointing out what ICARDA has been doing in this regard. A Swiss journalist from *WOZ Die Wochenzeitung* also visited ICARDA and interviewed several scientists and visited ICARDA's integrated research site in Khanasser Valley, Syria. Leading national and regional media organizations in CWANA also frequently covered the activities of the Center during the year.

CODIS continued to offer capacity building support to NARS in the CWANA region. A two-week training course on "Management of Electronic Documents and Web Databases" was conducted, which attracted 16 participants from Armenia, Egypt, Iraq, Iran, Lebanon, Sudan, Syria, and Turkey. Also, CODIS worked with the NARS of Egypt and Sudan to develop a Twinning Agreement in information management and exchange.

Many books and information materials were developed during the year including an issue of Caravan which introduced ICARDA's new strategic focus on alleviating poverty and the Center's role in helping countries in the dry areas to achieve the Millennium Development Goals. ICARDA publications were displayed at major meetings and events including the Annual General Meeting of the CGIAR in Mexico. In addition, the ICARDA website was regularly updated and improved to provide more information to users in English and Arabic. A number of sub-sites were developed, including web pages on the CWANA Wheat Networks. Visits to the site during the year were significantly higher than in 2003.

Computer and Biometric Services Unit

A key activity undertaken during 2004 was the start of a project on the implementation of the web-based version of the Oracle Applications 11i to meet new reporting requirements and overcome current deficiencies in the system. An external consultant was engaged and detailed business requirements were captured from the functional units of ICARDA as well as the scientists, outreach offices and management. The new system is to be implemented in 2005.

Within the framework of the CGIAR ICT-KM projects, the Unit developed a Virtual Resources Center questionnaire as a web application, prepared mailing lists, and analyzed collected data.

The Unit continued to work on the Meteorological Database to migrate legacy data to the new Oracle database, introduced a dynamic reporting system with predefined templates and a charting module. System requirements were developed for a Soil Database and a Laboratory Information Management System. Software for bar code reader for the genebank accessions was also developed.

In addition, a website with a database was developed for UNCCD TPN4 and data from Syria, Uzbekistan, and Kyrgyzstan was uploaded. Training was conducted for those who will administer the website. Also, a website on "Water Benchmark Database" was developed for one of ICARDA's projects.

A joint project proposal on "Utilization of Intelligent Information Systems for Crop

Protection" was revised and approved for the initial implementation phase.

A Meta Database was created to cover all undocumented datasets in ICARDA.

It was decided to adopt the CIAT Project Manager system. The database has been installed and the data preparation and loading has been initiated. The system is expected to be fully operational with an interface to Oracle Financials during 2005. For the current Oracle Financial/ Administrative Applications, several reports were modified and upgraded. An updated requirements study was conducted for the Payroll system. For the new Payroll system, about 32 reports and 20 forms were developed or modified.

Biometric consultancies were rendered to researchers on more than 100 occasions. Support on statistical software and data management and online bio-computing facility was provided.

Statistical designs were developed for various experiments including evaluation of the core collection and drought-tolerant set of wheat lines and legume germplasm lines; agronomic experiment on safflower response to variety, planting date, spacing and seed rate; seed-priming in barley at Khanasser Valley farmers' fields; water-harvesting catchment areas, shrub species and seeding methods at two diverse sites in Syria; and land development methods, seeding methods and shrub species.

Five new modules on stability analyses from multi-environment variety trials were added to the online biocomputing facility. Also, a Perl program was developed to identify haplotypes to be used for diversity analysis. GenStat programs were developed for various situations including measurement of repeatability of genotype x location interaction and transforming micro-satellite (SSR) molecular weight data into zero-one matrix for further analysis in other software.

The Unit conducted a course on "Data Management and Basic Statistical Tools in Animal Production Research" and contributed to various ICARDA training courses including "Management of Water Resources and Improvement of Water-Use Efficiency in the Dry Areas" and "Breeding for Stress Tolerance in Food Legumes and Analysis of Genotype x Environment Interaction Using Specialized Techniques and Software," in Iran. Also, training sessions for ICARDA scientists were conducted on various software packages including GenStat.

Human Resource Development Unit

Two 5-year training projects were finalised within the framework of the Third Country Training Programs of the Japan International Cooperation Agency (JICA), with the Syrian Planning Commission as a partner, for Afghanistan and Iraq. Implementaton of the training programs will start in 2005.

A Center-Commissioned External Review (CCER) of human resources development and capacity building at ICARDA was launched in November, and is expected to be completed in the first half of 2005.

During the year, ICARDA offered training opportunities to 691 national scientists from 37 countries including CWANA, Africa, Asia and the Pacific, and Europe. Forty-four national scientists from the developing and developed countries conducted graduate research training for MSc and PhD degrees jointly between ICARDA and agricultural universities around the world. About 14% of all the ICARDA training participants in 2004 were women. ICARDA continued its strategy to gradually decentralize its training activities by offering more non-headquarter training courses.

The Unit facilitated and coordinated implementation of different training courses for several externally-funded projects. Examples include:

- Twelve training courses conducted at ICARDA headquarters on "Design and Analysis of Field Experiments," "Variety Management and Seed Quality Assurance," "Management of Water Resources and Improvement of Water-Use Efficiency in the Dry Areas," "Integrated Pest Management of Cereals and Legumes Crops," "Integrated Pest Management of Sunn Pest" "Data Management and Analysis" "Electronic Production of Agricultural Documents and Web Databases" "Experimental Station Operation Management" "Utilization of Expert Systems in Agricultural Research and Production" "Capacity Building for Wheat Quality Seed Production," and "Capacity Building for Wheat Quality Seed Production."

- Eight in-country training courses conducted in Afghanistan within the framework of the ICARDA-led Future Harvest Consortium for the Rebuilding of Agriculture in Afghanistan on "Seed Production Technology and Enterprise Management," "Integrated Pest Management of Sunn Pest," "Seed Production Technology and Enterprise Management," "Green House Installation and

Preparation for Cash Crop Production," "Quality Seed Supply in the Informal Seed Sector," "Integrated Production and Protection Management (IPPM) for Cash Crop Production under Protected Agriculture," and "Greenhouse Manufacturing."

- Regional training course on "Participatory Approach to Rangeland Management" held in Tataouine, Tunisia, jointly organized and sponsored by SDC, INRAT, and ICARDA.

- In-country training course on "Breeding for Stress Tolerance in Food Legumes and Analysis of Genotype x Environment Interaction Using Specialized Techniques and Software" held in Karaj, Iran, jointly organized and sponsored by the Agricultural Research and Education Organization (AREO) of the Ministry of Jihad and Agriculture, Iran.

- In-country training course on "DNA Molecular Marker Techniques for Crop Improvement" held at the headquarters of the Syrian General Commission for Scientific Agricultural Research (GCSAR) in Douma, Damascus, jointly sponsored and organized by ICARDA and the Syrian component of the GEF/UNDP Project on Conservation and Sustainable Use of Dryland Agrobiodiversity in West Asia.

- In-country training course on "DNA Molecular Marker Techniques for Crop Improvement" held at INA, El Harrach, Alger, Algérie, co-organized and sponsored by ICARDA and the Algerian national program.

- Regional training course on "Drought Preparedness and Mitigation Strategies in the Mediterranean Region" held in Zaragoza, Spain, and co-organized by CIHEAM and ICARDA.

- In-country training course on "Integrated Pest Management of Cereal and Legume Crops," organized by ICARDA in Tashkent, Uzbekistan, and jointly sponsored by CIMMYT and GTZ.

- Regional training course on "Livestock Market Assessment" held in Khartoum, Sudan, sponsored by IFAD, jointly organized by the Federal Ministry of Animal Resources and Fisheries, Sudan, ILRI, and ICARDA.

- Regional training workshop on "Biosaline Agriculture: Principles and Applications, with Reference to Central Asia and the Caucasus Region" jointly organized and sponsored ICBA and ICARDA, held in Tashkent, Uzbekistan. The course was offered in Russian language and involved 37 senior researchers from the Central Asia and the Caucasus region.

Appendices

Appendix 1

Journal Articles

The following list covers journal articles published in 2004 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 available on ICARDA's web site: www.icarda.org.

Abdul Hai, M., M. El-Bouhssini, and A. Babi. 2004. Some biological characteristics of two egg parasitoids (*Trissolcus grandis* Thomson) and (*Trissolcus simoni* Mayr) the on Sunn pest eggs (*Eurygaster integriceps* Put.) under laboratory conditions in Syria. Arab Journal of Plant Protection 22(1): 82-84. (In Arabic, English summary).

Ajouri, A., H. Asgedom, and M. Becker. 2004. Seed priming enhances germination and seedling growth of barley under conditions of P and Zn deficiency. Journal of Plant Nutrition and Soil Science 167: 630-636.

Akem, C., S. Kabbabeh, and S. Ahmed. 2004. Integrating cultivar resistance with single spray to manage *Ascochyta* blight for increased chickpea yields. Plant Pathology Journal 3(2) 105-110.

Akem, C., S. Kabbabeh, and S. Ahmed. 2004. Integrating cultivar resistance and seed treatment with planting dates to manage chickpea *Ascochyta* blight. Plant Pathology Journal 3(2) 111-117.

Al-Housari, F., M. El-Bouhssini, J. Ibrahim, and M.N. Al-Salti. 2004. Effect of methanol extract from fruits of *Melia azedarach* L. on *Coccinella septempunctata* L. (Coleoptera: coccinellidae). Arab Journal of Plant Protection 22(1): 85-87. (In Arabic, English summary).

Ali, M.A., S.G. Kumari, K.M. Makkouk, and M.M. Hassan. 2004. Chickpea chlorotic dwarf virus (CpCDV) naturally infects *Phaseolus* bean and other wild species in the Gezira region of Sudan. Arab Journal of Plant Protection 22(1): 96. (In Arabic, English summary).

Amaraya, S., S. Kabbabeh, and B. Bayaa. 2004. Evaluation of some seed dressing fungicides to control soil-borne fungi affecting chickpea and lentil. Arab Journal of Plant Protection 22(2): 136-141. (In Arabic, English summary).

Belabid, L, M. Baum, Z. Fortas, Z.. Bouznad, and I. Eujayl. 2004. Pathogenic and genetic characterization of Algerian isolates of *Fusarium oxysporum* f.sp. *lentis* by RAPD and AFLP analysis. African Journal of Biotechnology 25-31.

Chabane, K. and J. Valkoun. 2004. Characterization of genetic diversity in ICARDA core collection of cultivated barley (*Hordeum vulgare* L.). Czech Journal of Genetics and Plant Breeding 40 (4): 134:136.

Choumane, W., P. Winter, M. Baum, and G. Kahl. 2004. Conservation of microsatellite flanking sequences in different taxa of Leguminosae. Euphytica 138: 239-245.

Choumane, W., P. van Breugel, T. O. M. Bazuin, M. Baum, G. W. Ayad, and W. Amaral. 2004. Genetic diversity of *Pinus brutia* in Syria as revealed by DNA markers. Forest Genetics Vol. 11, No. 2: 87-102

Derkaoui, M., J. Ryan, and M. Abdel Monem. 2004. Significance of phosphorus fertilizer for annual medics (*Medicago* spp.) in semi-arid Morocco. Al-Awamia 109-110 (New Series Vol. 1, No. 1-2): 176-186.

El-Ashkar, F., A. Sarker, W. Erskine, B. Bayaa, H. El-Hassan, N. Kadah, and B.A. Karim. 2004. Registration of 'Idlib-3' lentil. Crop Science 44: 2261.

El-Ashkar, F., A. Sarker, W. Erskine, B. Bayaa, H. El-Hassan, N. Kadah, and B.A. Karim.. 2004. Registration of 'Idlib-4' lentil. Crop Science 44: 2261-2262.

El-Bouhssini, M., A. Abdulhai, and A. Babi. 2004. Sunn pest (Hemiptera: Scutelleridae) oviposition and egg parasitism in Syria. Pakistan Journal of Biological Sciences 7(6): 934-936.

El-Damir, M., M. El-Bouhssini, and M. N. Al-Salty. 2004. Embryo development and egg hatching of *Sitona crinitus* Herbst (Coleoptera: Curculionidae) under constant temperature regimes. Pakistan Journal of Biological Sciences 7(7): 1191-1193.

Elouafi, I. and M. Nachit. 2004. A genetic linkage map of durum x *Triticum dicoccoides* backcross population based on SSRs and AFLP markers, and QTL analysis for milling traits. Theoretical and Applied Genetics 108: 401-413.

Fisher, M.J. and R.J. Thomas. 2004. Implications of land use change

to introduced pastures on carbon stocks in the central lowlands of tropical South America. Environment, Development and Sustainability 6: 111-131.

Ghafoor, A., M. Qadir, M. Sadiq, G. Murtaza, and M.S. Brar. 2004. Lead, copper, zinc and iron concentrations in soils and vegetables irrigated with city effluent on urban agricultural lands. Journal of the Indian Society of Soil Science 52:114-117

Ghannoum, M.I., M.N. Al-Salti,and J. Ibrahim. 2004. Wheat stem sawfly (Hymenoptera : Cephidae) screening for durum wheat, bread wheat, and barley in northern Syria. Arab Journal of Plant Protection 22(2): 128-131. (In Arabic, English summary).

Ghannoum, M.I., M.N. Al-Salti, and J. Ibrahim. 2004. Mortality rates of the wheat stem sawfly (Hymenoptera: Cephidae) during the hibernation and effect of burning wheat yield residuals on its population in northern Syria. Arab Journal of Plant Protection 22(2): 156-158. (In Arabic, English summary).

Ghosh, S., A. Aw-Hassan, and P.L. Pellett. 2004. Growth status of children in north-west Syria: A comparison of three rural livelihood groups. Ecology of Food and Nutrition 43(1-2): 107-148.

Harmsen, K., and F.J. El Mahmoud. 2004. Yield response of lentil to directly applied and residual phosphorus in a Mediterranean environment. Nutrient Cycling in Agroecosystems 69(3): 233-245.

Hermiz, H.N, M. Singh, A.A. Al-Rawi, and J.E. Alkass. 2004. Genetic and non-genetic parameters for milk traits in Iraqi local goat and their crosses. Dirasat, Agricultural Sciences 31(2): 223-228.

Ibrikci, H., J. Ryan, U. Yildiran, N. Guzel, A.C. Ulger, G. Buyuk, and K. Korkmaz. 2004. Phosphorus fertilizer efficiency and mycorrhizal infection in corn genotypes. Renewable Agriculture and Food Systems 19(2): 92-99.

Iniguez, L. 2004. Goats in resource-poor systems in the dry environments of West Asia, Central Asia and the Inter-Andean valleys. Small Ruminant Research 51:137-144.

Kahraman, A., I. Kusmenoglu, N. Aydin, A. Aydogan, W. Erskine, and F.J. Muehlbauer. 2004. Genetics of winter hardiness in 10 lentil recombinant inbred line populations. Crop Science 44: 5-12.

Kahraman, A., I. Kusmenoglu, N. Aydin, A. Aydogan, W. Erskine, and F.J. Muehlbauer. 2004. QTL mapping of winter hardiness genes in lentil. Crop Science 44: 13-22.

Kayali, M., A. El-Ahmed, B. Debs, K. Makkouk, S. Asaad, S.G. Kumari, and A.N. Attar. 2004. Production of specific antiserum to *Xanthomonas translucens* pv. *undulosa* the causal organism of bacterial stripe on wheat in Syria. Arab Journal of Plant Protection 22(1): 72-76. (In Arabic, English summary).

Kumari, S.G., K.M. Makkouk, N. Attar, W. Ghulam, and D.E. Lesemann. 2004. First report of chickpea chlorotic dwarf virus infecting spring chickpea in Syria. Plant Disease 88(4): 424.

Makkouk, K.M., S.G. Kumari, W. Ghulam, and N. Attar. 2004. First record of barley yellow striate mosaic virus affecting wheat summer-nurseries in Syria. Plant Disease 88: 83.

Malhotra, R.S., M. Singh, and W. Erskine. 2004. Application of spatial variability models in enhancing precision and efficiency of selection in chickpea trials. Journal of the Indian Society of Agricultural Statistics 57 (Special Volume): 71-83.

Mando, J.S., H.Z. Kawas, K.M. Makkouk, and S.G. Kumari. 2004. Forage legume viruses in Syria: Economic importance and seed transmission. Arab Journal of Plant Protection 22(2): 122-127. (In Arabic, English summary).

Oweis, T., A. Hachum, and M. Pala. 2004. Lentil production under supplemental irrigation in a Mediterranean environment. Agricultural Water Management 68: 251-265.

Oweis, T., A. Hachum, and M. Pala. 2004. Water use efficiency of winter sown chickpea under supplemental irrigation in a Mediterranean environment. Agricultural Water Management 66: 163-179.

Pala, M., J. Ryan, A. Mazid, O. Abdallah, and M. Nachit. 2004. Wheat farming in Syria: An approach to economic transformation and sustainability. Renewable Agriculture and Food Systems 19(1): 30-34.

Qadir, M. and J.D. Oster. 2004. Crop and irrigation management strategies for saline-sodic soils and waters aimed at environmentally sustainable agriculture. Science of the Total Environment 323: 1-19.

Rashid, A. and J. Ryan. 2004. Micronutrient constraints to crop production in soils with Mediterranean-type characteristics: A review. Journal of Plant Nutrition 27(6): 959 - 975.

Rischkowsky, B. E.F. Thomson, R. Shnayien, and J.M. King. 2004. Mixed farming systems in transition: The case of five villages along a rainfall gradient in north-west Syria. Experimental Agriculture 40: 109-126.

Sakr, B., A. Sarker, H. El Hassan, N. Kadah, B.A. Karim, and W. Erskine. 2004. Registration of Bichette lentil. Crop Science 44: 686.

Sakr, B., A. Sarker, H. El Hassan, N.

Kadah, B.A. Karim, and W. Erskine. 2004. Registration of Hamria lentil. Crop Science 44: 686.

Sasanuma, T., K. Chabane, T.R. Endo, and J. Valkoun. 2004. Characterization of genetic variation in and phylogenetic relationships among diploid *Aegilops* species by AFLP: Incongruity of chloroplast and nuclear data. Theoretical and Applied Genetics 108: 612-618.

Sayed, H., G. Backes, H. Kayyal, A. Yahyaoui, S. Ceccarelli, S. Grando, A. Jahoor, and M. Baum. 2004. New molecular markers linked to qualitative and quantitative powdery mildew and scald resistance genes in barley for dry areas. Euphytica 135: 225-228.

Schiere, J.B, A.L. Joshi, A. Seetharam, S.J. Oosting, A.V. Goodchild, B. Deinum, and H. Van Keulen. 2004. Grain and straw for whole plant value: Implications for crop management and genetic improvement strategies. Experimental Agriculture 40: 277-294.

Schweers, W., A. Bruggeman, A. Rieser, and T. Oweis. 2004. Farmers' response to water scarcity and salinity in marginal area of northern Syria. Journal of Applied Irrigation Science 39(2): 241-252.

Singh, M. and M. Pala. 2004. Use of covariance structures for temporal errors in the analysis of a three-course wheat rotation and tillage trial. Journal of Agricultural Science, Cambridge 142: 193-201.

Tavakkoli, R. and T. Oweis. 2004. The role of supplemental irrigation and nitrogen in producing bread wheat in the highlands of Iran. Agricultural Water Management 65: 225-236.

Udupa, S.M., R.S. Malhotra, and M. Baum. 2004. Tightly linked di- and tri-nucleotide microsatellites do not evolve in complete independence: evidence from linked (TA)n and (TAA)n microsatellites of chickpea (*Cicer arietinum* L.). Theoretical and Applied Genetics 108(3): 550-557.

Von Korff, M. S.M. Udupa, A. Yahyaoui, and M. Baum. 2004. Genetic variation among *Rhynchosporium secalis* populations of West Asia and North Africa as revealed by RAPD and AFLP analysis. Journal of Phytopathology 152: 106-113.

Yahyaoui, A., M. Hovmoller, B. Ezzahiri, A. Jahoor, M.H. Maatougui, and A. Wolday. 2004. Survey of barley and wheat diseases in the central highlands of Eritrea. Phytopathologia Mediterranea 43: 39-43.

Appendix 2

Graduate Theses Produced with ICARDA's Joint Supervision

Doctor of Philosophy

Jordan, University of Jordan

Ayimut, Kiros Meles. 2004. Pathogenic and genetic variability in *Rhynchosporium secalis* (OUD.) Davis on barley. 116 p.

Tiruneh, Adamu Molla. 2004. Effect of barley/wheat mixed intercropping and irrigation water levels on water use and yield. 180 p.

The Netherlands, Wageningen University

Bishaw, Zewdie. 2004. Wheat and barley seed systems in Ethiopia and Syria. 383 p.

Ghannoum, M.I. 2004. Ecology and biology of wheat stem sawfly and its natural enemies in northern Syria. 133 p. (In Arabic, English summary).

Turkey, Cukurova University

Shomo, Farouk 2004. Economic efficiency of sheep production systems in Syria. 84 p.

USA, University of Massachusetts

Ghosh, Shibani A. 2004. Poverty, household food availability and nutritional well-being of children in north west Syria. 308 p.

Master of Science

Al-Tarsha, R. 2004. Impact of rangeland regimes on plant biodiversity in the marginal sloping lands of northwestern Syria. 150 p. (In Arabic, English summary).

Shamsi, Roula Housein. 2004. Use of radiometric spectral reflectance in chickpea *Ascochyta* blight management. 104 p. (In Arabic, English summary).

Kadah, B.A. Karim, and W. Erskine. 2004. Registration of Hamria lentil. Crop Science 44: 686.

Sasanuma, T., K. Chabane, T.R. Endo, and J. Valkoun. 2004. Characterization of genetic variation in and phylogenetic relationships among diploid *Aegilops* species by AFLP: Incongruity of chloroplast and nuclear data. Theoretical and Applied Genetics 108: 612-618.

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Yahyaoui, A., M. Hovmoller, B. Ezzahiri, A. Jahoor, M.H. Maatougui, and A. Wolday. 2004. Survey of barley and wheat diseases in the central highlands of Eritrea. Phytopathologia Mediterranea 43: 39-43.

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Jordan, University of Jordan

Ayimut, Kiros Meles. 2004. Pathogenic and genetic variability in *Rhynchosporium secalis* (OUD.) Davis on barley. 116 p.

Tiruneh, Adamu Molla. 2004. Effect of barley/wheat mixed intercropping and irrigation water levels on water use and yield. 180 p.

The Netherlands, Wageningen University

Bishaw, Zewdie. 2004. Wheat and barley seed systems in Ethiopia and Syria. 383 p.

Ghannoum, M.I. 2004. Ecology and biology of wheat stem sawfly and its natural enemies in northern Syria. 133 p. (In Arabic, English summary).

Turkey, Cukurova University

Shomo, Farouk 2004. Economic efficiency of sheep production systems in Syria. 84 p.

USA, University of Massachusetts

Ghosh, Shibani A. 2004. Poverty, household food availability and nutritional well-being of children in north west Syria. 308 p.

Master of Science

Al-Tarsha, R. 2004. Impact of rangeland regimes on plant biodiversity in the marginal sloping lands of northwestern Syria. 150 p. (In Arabic, English summary).

Shamsi, Roula Housein. 2004. Use of radiometric spectral reflectance in chickpea *Ascochyta* blight management. 104 p. (In Arabic, English summary).

Appendix 3

Agreements signed in 2004

Agreements of cooperation with international and regional organizations in 2004

Generation Challenge Program

10 August 2004. Agreement to Establish a Consortium for the Generation Challenge Program: Cultivating Plant Diversity for the Resource Poor.

The World Vegetable Center (AVRDC)

25 October 2004. Memorandum of Understanding between the World Vegetable Center (AVRDC) and the Program Facilitation Unit of the CGIAR Program for Central Asia and the Caucasus, hosted by ICARDA.

Agreements of cooperation with national governments and institutions in 2004

Australia

1 June 2004. Memorandum of Understanding between the Center for Legumes in Mediterranean Agriculture (CLIMA), University of Western Australia, and ICARDA.

Austria

29 February 2004. Academic Cooperation Agreement between the University of Natural Resources and Applied Life Sciences (BOKU), Vienna, and ICARDA.

Iran

21 September 2004. Supplementary Agreement between the Agricultural Research and Education Organization and ICARDA for the joint program on Spring Wheat Improvement for Low Latitudes of CWANA.

Nepal

29 March 2004. Memorandum of Understanding concerning Scientific Collaboration between the Nepal Agricultural Research Council (NARC) and ICARDA.

Sultanate of Oman

22 September 2004. Memorandum of Understanding between ICARDA and the Ministry of Agriculture and Fisheries in the Sultanate of Oman.

Pakistan

8 November 2004. Agreement held between the Government of Pakistan through the Ministry of Food, Agriculture and Livestock and ICARDA.

Palestinian National Authority

7 October 2004. Memorandum of Understanding held between ICARDA and the Ministry of Agriculture of the Palestinian National Authority.

Turkey

24 February 2004. Agreement between the Southeastern Anatolia Project Regional Development Administration (GAP-RDA) and ICARDA concerning Technical Backstopping for the Southeastern Anatolia Project, Republic of Turkey.

United Arab Emirates

22 February 2004. Agreement between the Government of the United Arab Emirates and ICARDA.

29 May 2004. Memorandum of Understanding between the United Arab Emirates University (UAEU) and ICARDA.

Appendix 4

Restricted-Fund Projects

ICARDA's research program is implemented through 19 research projects, as detailed in the Center's Medium-term Plan. Restricted-Fund projects are those activities that are supported by restricted funding, provided separately from the Center's unrestricted core funding. Restricted funding includes donor attributed funding (core funds allocated by the donor to specific activities) and project-specific grants. The financial contributions by the respective donors are reported in Appendix 7. Reports on the activities listed are encompassed in the appropriate sections of the body of this Annual Report.

The Restricted Projects operational during 2004 are listed below.

AFESD (Arab Fund for Economic and Social Development)

- Technical assistance to ICARDA's activities in Arab countries (Training Arab nationals and support to Arab national programs).
- Sustainable management of natural resources and improvement of major production systems of the Arabian Peninsula.
- Options for coping with increased water scarcity in agriculture in West Asia and North Africa.

Asian Development Bank

- On-farm soil and water management for sustainable agricultural systems in Central Asia.
- Implementation of a regional workshop on strengthening partnerships for more effective planning, research and development in agriculture for Central Asia.

Australia

ACIAR (Australian Centre for International Agricultural Research)

- Lentil and Lathyrus in the cropping systems of Nepal: improving crop establishment and yield of relay and post-rice-sown pulses in the terai and mid hills.
- Conservation, evaluation and utilization of plant genetic resources from Central Asia and the Caucasus (completed June 2004)
- Genetic resource conservation, documentation and utilization in Central Asia and the Caucasus (commenced July 2004)
- Host resistance, epidemiology and integrated management of faba bean, chickpea and lentil diseases (completed June 2004).
- Plant health management for faba bean, chickpea and lentils (commenced July 2004)
- Project planning meeting for crop improvement in Iraq.

Cooperative Research Center for Molecular Plant Breeding

- Post-doctoral Fellow in barley improvement

GRDC (Grains Research and Development Corporation)

- Technologies for the targeted exploitation of the N.I. Vavilov Institute of Plant Industry (VIR), ICARDA and Australian bread wheat landrace germplasm.
- CIPAL (Coordinated Improvement Program for Australian Lentils).
- Coordinated improvement of chickpeas in Australia – Northern Region module.
- Faba bean improvement - Northern Region.
- Associate Expert in legume pathology
- International durum wheat improvement cooperation
- Collaborative barley breeding for low rainfall environments
- Durum industry development - Collaboration with ICARDA to accelerate cultivar improvement for adaptation across all production regions

Grain Foods Cooperative Research Centre Ltd

- Genetic manipulation of pulses for improved flavour and colour.
- Novel germplasm for food and malt (barley products).

Austria

- Production diversification and income generating options for small-scale resource poor livestock farmers of the dry areas: The case of lamb fattening in WANA

Canada

CGIAR-Canada Linkage Funds

- Characterization and Molecular Mapping of Drought Tolerance in Chickpea

Canada Fund for Africa

- Support to research and capacity building activities in Eritrea, Ethiopia, Mauritania and Sudan.

Crop Development Centre, University of Saskatchewan

- Off-season evaluation of Ascochyta blight reaction in chickpea

CGIAR Standing Panel on Impact Assessment (SPIA)

- Ex post impact assessment of natural resources management technologies in crop-livestock systems in arid and semi arid areas

CGIAR Challenge Programs

Generation Challenge Program

- Commissioned research
- Allele mining based on non-coding regulatory SNPs in barley germplasm

HarvestPlus

- Identification of barley germplasm accessions with high concentration of B-carotene, iron and zinc
- Identification of lentil germplasm accessions with high concentration of B-carotene, iron and zinc

Challenge Program on Water and Food

- Improving water productivity of cereals and food legumes in the Atbara RIVER BASIN of Eritrea.
- Strengthening livelihood resilience in upper catchments of dry areas by integrated natural resources management.
- Improving on-farm agricultural water productivity in the Karkheh river basin.

CGIAR ICT-KM Programme

- CSI (CGIAR Consortium for Spatial Development) project research activities

CGIAR Marketing Group

- ICARDA Marketing Group activities in 2004

CGIAR Systemwide Programmes

CGIAR Collaborative Programme for Central Asia and the Caucasus

- Program Facilitation Unit

Systemwide Genetic Resources Programme (SGRP)

- Global inventory of barley genetic resources.

Systemwide Livestock Programme (SLP)

- Low-toxin grasspea for improved human and livestock nutrition and ecosystems health in drought-prone areas in Asia and Africa.
- Public Awareness Grant: Fodder shrubs and trees for improved livelihoods in the dry areas of West Asia, North Africa and the Sahel.
- Public Awareness Grant: Feed resources for smallholder livestock farmers in the Caucasus.

Systemwide Programme for Participatory Research and Gender Analysis (SP-PRGA)

- Analysis of participatory research and gender analysis approaches in ICARDA.

IWMI Comprehensive Assessment Program

- Assessment of water harvesting and supplemental irrigation potential in arid and semi-arid areas of West Asia and North Africa

Denmark

- Integrated disease management to enhance barley and wheat production in Eritrea.
- Junior Professional Officer in milk transformation.
- Junior Professional Officer in characterization of small ruminant production and associated local knowledge systems.

EC (European Commission)

EC Attributed Funding

- Barley germplasm improvement for increased productivity and yield stability.
- Durum wheat germplasm improvement for increased productivity, yield stability and grain quality.
- Food legume germplasm improvement (lentil, kabuli chickpea, faba bean and pea) for increased systems productivity.
- Agrobiodiversity collection and conservation for sustainable production.

EC 6th Framework International Cooperation (INCO)

- Mapping adaptation of barley to drought environments (MABDE).

- Improving durum wheat for water use efficiency and yield stability through physiological and molecular approaches (IDuWUE).
- Consultative Workshop on Participatory Plant Breeding (CONPAB).
- Exploiting the wheat genome to optimize water use in Mediterranean ecosystems (TRITIMED).

ERF (Economic Research Forum) FEMISE Program

- Les obstacles aux transferts technologiques dans les petites et moyennes exploitations agricoles des zones arides et semi arides du Maghreb. Discussion sur les conditions d'amélioration de la productivité en Algérie, Maroc et Tunisie.

ESCWA (UN Economic and Social Commission for West Asia)

- Analysis of water use efficiency.
- Database design concerning the establishment of a Professionals Registry for Iraq Reconstruction

FAO (Food and Agriculture Organization of the United Nations)

- Applied research to improve and maintain seed quality for fodder shrubs and grass species used for rangeland rehabilitation.
- Preparation of the Proceedings of the International Sunn Pest Conference, July 19-22, 2004, and follow-up activities for the development of IPM strategies for Sunn Pest.
- Applied research component of project GCP/PAK/095/USA "Food Security/Poverty Alleviation in Arid Agriculture Balochistan - Pilot Project Phase"
- Technical Cooperation Programme (TCP): Training on Orobanche weed management in leguminous crops.
- Technical Cooperation Programme (TCP): Sustainable agriculture practices in the drought affected region of Karakalpakstan

France

- Associate Expert in socioeconomics of rangeland management.

GEF (Global Environment Facility)/UNDP (United Nations Development Programme)

- Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Syria and the Palestinian Authority.

Germany

- An integrated approach to sustainable land management in dry areas.
- Functional genomics of drought and cold tolerance in chickpea and lentil.
- Exploration of genetic resources collections at ICARDA for adaptation to climate change

GCC (Gulf Cooperation Council)

- International conference on launching collaborative research on date palm improvement

IDRC (International Development Research Centre)

- Regional Consultation on biotechnology.
- Scaling up decentralized participatory plant breeding in Syria.
- Strengthening seed systems for food security in Afghanistan.
- Institutionalizing participatory plant breeding within national plant breeding systems: costs and benefits.

IFAD (International Fund for Agricultural Development)

- Sustainable management of natural resources and improvement of major production systems of the Arabian Peninsula.
- Assistance in developing policies and strategies to improve livestock production systems in Central Asia and the Caucasus
- Programme for strengthening research and development to improve marketing of small ruminant products and income generation in dry areas of Latin America
- Agro-pastoral development and local initiatives promotion programme in the South-East (PRODESUD)
- Programme to foster wider adoption of low-cost durum technologies.
- Programme for enhancing food security in the Nile Valley and Red Sea region: Technology generation and dissemination for sustainable production of cereals and cool-season food legumes.
- Technical assistance for accelerated project performance in North Africa.
- Small ruminant health-improved livelihood and market opportunities for poor farmers in the Near East and North Africa region.
- Community-based optimization of the management of scarce water resources in agriculture in West Asia and North Africa.

International Nutrition Foundation

- Impact of lysine fortified wheat flour on the nutritional status of rural families in north west Syria.

Iran

- Scientific and technical cooperation and training.

Italy

Italy Attributed 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

Islamic Development Bank

- Joint ICBA-ICARDA training of Afghan nationals in irrigated Agricultural Production from Groundwater and Saline Water

Japan

Japan Attributed Funding

- Rehabilitation and improved management of native pastures and rangelands in dry areas.
- Improvement of small ruminant production in dry areas.
- Germplasm enhancement for diversification and intensification of agricultural production in Central Asia and the Caucasus.
- Improving income of small-scale producers in marginal agricultural environments: small ruminant milk production and milk derivatives, market opportunities and improving value added returns.

JICA (Japan International Cooperation Agency)

- Training program in management of water resources and improvement of water use efficiency in dry areas.
- Third Country Training Program in crop improvement and seed technology.

JIRCAS (Japan International Research Center for Agricultural Sciences)

- Collaboration in durum research: Growth response of some recombinant inbred lines of durum wheat under different moisture stressed conditions.

KOREA: Rural Development Administration (RDA), Republic of Korea

- Collaboration in barley research.

Mauritania

- Technical assistance within the project Projet Gestion des Parcours et Developpement de l'Elevage (PADEL)

Morocco

- Collaborative activities in crop improvement, biotechnology, GIS and agroecological information system services, genetic resources and biodiversity, and integrated management of cereal and legume pests

OPEC Fund for International Development

- Decentralization of barley breeding with farmers' participation.
- Sustainable management of natural resources and improvement of major production systems of the Arabian Peninsula.
- Community-based research for agricultural development and sustainable resource management in Afghanistan

Pakistan

- Cooperation in the applied research component of the Barani Village Development Project (BVDP).

Switzerland

Swiss Agency for Development and Cooperation (SDC)

- Associate Expert in poverty analysis.
- Sustainable management of the agropastoral resource base in the Maghreb.
- Communal management and optimization of mechanized micro-catchment water harvesting for combating desertification in the East Mediterranean region.
- Improving the livelihoods of rural communities and natural resource management in the mountains of the Maghreb countries of Algeria, Morocco and Tunisia.

Swiss Centre for International Agriculture (ZIL), Federal Institute of Technology Zurich (ETHZ)

- Research Fellowship project on improving resistance to barley scald.

Turkey

- Technical assistance to Southeast Anatolia Project Regional Development Administration.

United Kingdom

DFID (Department for International Development) Competitive Research Facility

- Integrated pest management of Sunn Pest in West Asia.

- Management of Research in Alternative Livelihoods Fund (RALF), Afghanistan.
- Cultivation of mint as a viable alternative livelihood in East and North East of Afghanistan.
- Improved rural incomes in Afghanistan from better production and sales of milk products.

UNCCD (United Nations Convention to Combat Desertification)

- Establishment of a website for TPN4

Global Mechanism of the UNCCD

- Regional Environmental Management Officer, Tashkent.
- Development of a facilitation unit for the establishment of a Regional Programme for Sustainable Development of the Drylands of West Asia and North Africa
- Regional Programme for Sustainable Development of the Drylands of West Asia and North Africa: Inventory of activities and gap analysis
- Regional Environmental Management Officer, Tashkent (BC 543)

UNCCD Sub-Regional Action Program (SRAP) for West Asia

- Integrated natural resources management programme to combat desertification in Lebanon and Jordan (Pilot Projects)

Unesco

- Sustainable Management of Marginal Drylands (SUMAMAD) - Khanasser Valley Integrated Research Site, Syria.
- Sustainable Management of Marginal Drylands (SUMAMAD) - Zeuss Koutine site, Tunisia.
- Third International SUMAMAD Workshop.

United States of America

USAID (United States Agency for International Development) Linkage Funds

- Cooperation with University of Vermont: Use of entomopathogenic fungi for the control of Sunn pest in West Asia.
- Cooperation with University of Massachusetts: Poverty, agricultural household food systems and nutritional well-being of the child.
- Cooperation with University of Delaware: Improving water use efficiency
- Cooperation with University of California, Davis: Evaluation of pulse genetic resources.
- Cooperation with Washington State University: Lentil research.

USAID Rebuilding Agricultural Markets Program (RAMP), Afghanistan

- Village-based seed enterprise development in Afghanistan.
- Demonstrating new technologies in farmers' fields to facilitate rapid adoption and diffusion.
- Introducing protected agriculture for cash crop production in marginal and water deficit areas of Afghanistan
- Nangarhar emergency seed wheat and fertilizer distribution.

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

- Collection of plant genetic resources in the Central Asian and Caucasus region.
- Climatological analysis as a tool for agricultural decision making in dry areas
- Identifying wheat and barley germplasm resistant to Syrian and United States populations of the Russian Wheat Aphid

USAID Cereal Comparative Genomics Initiative

- Mining wild barley in the Fertile Crescent: A genomics approach for exploiting allelic diversity for disease resistance in barley

USDA/FAS (United States Department of Agriculture/ Foreign Agricultural Service)

- Biological diversity, cultural and economic value of medicinal, herbal and aromatic plants in southern Tunisia.
- Biological diversity, cultural and economic value of medicinal, herbal and aromatic plants in Morocco
- Partnership to improve rural livelihoods in West Asia and North Africa through strengthened teaching and research on sheep and goat production.
- GIS for watershed management in the arid regions of Tunisia.
- Research on improving productivity of oats as a priority forage species in Tunisia.
- Biological control of weeds with plant pathogens.

World Bank

- Regional initiative for dry land management.

Appendix 5

Collaboration with Advanced Research Institutes and Regional and International Organizations

CGIAR Centers and Regional/International Organizations

ACSAD (The Arab Center for the Studies of Arid Zones and Dry Lands)

- Joint workshops, conferences and training.
- Exchange of germplasm.
- Cooperation in implementing pilot projects on integrated natural resource management for combating desertification in Syria, Jordan, Yemen and Lebanon within the Thematic Networks (TN1 and TN4) of the UN Convention to Combat Desertification (UNCCD) Sub-Regional Action Program for Western Asia
- Cooperation in GEF/UNDP project on "Conservation and sustainable use of dryland agro-biodiversity in Jordan, Lebanon, Palestinian Authority and Syria".

AOAD (Arab Organization for Agricultural Development)

- Sub-regional training course on electronic document management and tools for database management and development.
- ICARDA participated in the "Workshop on Activating the International Agreements and Arab Coordination on Biodiversity", organized by AOAD.
- Individual training on IPM and legume pathology related subjects

CIAT (Centro Internacional de Agricultura Tropical)

- ICARDA participates in the Systemwide Programme on Soil Water and Nutrient Management (SWNM) and in the Systemwide Programme on Participatory Research and Gender Analysis (PRGA), both coordinated by CIAT.
- ICARDA is participating in HarvestPlus (Challenge Program on Biofortified Crops for Improved Human Nutrition), led by CIAT and IFPRI.
- CIAT is the managing center for Theme 2 of the Challenge Program on Water and Food and collaborates in the project led by ICARDA on strengthening livelihood resilience in the Karkeh River Basin in Iran.

CIHEAM (International Center for Advanced Mediterranean Agronomic Studies)

- Joint training courses and information exchange.
- Study of the tolerance of ICARDA mandate crops to salinity at CIHEAM Mediterranean Agronomic Institute of Bari.
- ICARDA participates in the FAO-CIHEAM subprogram for nutrition and feeding strategies and the subprogram for breeding strategies for sheep and goats.
- Collaboration with CIHEAM Mediterranean Agronomic Institute of Zaragoza in the evaluation of Mediterranean rainfed agriculture technologies.
- ICARDA participates in the Collaborative Molecular Biotechnology Integrating Network (COMBINE) coordinated by CIHEAM Mediterranean Agronomic Institute of Chania.
- ICARDA participates in the FAO/CIHEAM Cooperative Research Network on Sheep and Goats, Genetic Resources Sub-Network.
- ICARDA is participating in a project on mapping adaptation of barley to drought environments coordinated by CIHEAM.
- CIHEAM, ICARDA and FAO-RNE are co-conveners of the Network on Drought Management for the Near East, Mediterranean and Central Asia (NEMEDCA Drought Network).
- Collaboration in Consultative Workshop on Participatory Plant Breeding.
- Joint supervision of graduate students on improved water management

CIMMYT (International Center for the Improvement of Maize and Wheat)

- CIMMYT and ICARDA cooperate through the Joint Dryland Wheat Program.
- An ICARDA barley breeder is seconded to CIMMYT.
- CIMMYT's outreach program in Turkey and ICARDA's Highland Regional Program share facilities in Ankara, Turkey and collaborate with Turkey in a joint Winter and Facultative Wheat Improvement Program.

- CIMMYT participates in the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, coordinated by ICARDA.
- CIMMYT participates in the Future Harvest Consortium for Rebuilding Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- ICARDA is participating in the Generation Challenge Program (Unlocking Genetic Resources in Crops for the Resource Poor) led by CIMMYT and IRRI.

CIP (International Potato Center)
- CIP participates in the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, coordinated by ICARDA.
- CIP participates in the Future Harvest Consortium for Rebuilding Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.

ESCWA (UN Economic and Social Commission for West Asia)
- Development of a website for " Professionals for Iraq Reconstruction".
- Collaboration in a study of on-farm water use efficiency.
- Joint publication on enhancing agricultural productivity through on-farm water use efficiency: an empirical case study of wheat production in Iraq.

FAO (Food and Agriculture Organization of the United Nations)
- ICARDA and FAO are co-sponsors of AARINENA.
- ICARDA participates in FAO's AGLINET cooperative library network, AGRIS and CARIS.
- ICARDA cooperates with FAO in the production of the Arabic version of the agricultural multilingual thesaurus AGROVOC.
- ICARDA participates in FAO's Global Animal Genetic Resources program.
- Joint planning in areas of feeding resources and strategies with FAO's Animal Production and Health Division.
- ICARDA participates in the FAO/CIHEAM Cooperative Research Network on Sheep and Goats, Genetic Resources Sub-Network.
- ICARDA cooperates with the FAO Commission on Plant Genetic Resources.
- ICARDA participates in the Inter-agency Task Forces convened by the FAO-RNE (FAO Regional Office for the Near East).
- FAO-RNE, ICARDA and CIHEAM are co-conveners of a Network on Drought Management for the Near East, Mediterranean and Central Asia (NEMEDCA Drought Network).
- Joint training courses, workshops, publications and exchange of information.
- ICARDA cooperates with FAO in translating FAO plant and animal terminology to Arabic.
- Expert Consultation Meeting on Orobanche management in food legumes.
- FAO-RNE and ICARDA coordinate the Oat-Vetch Regional Network (REMAV).
- FAO-RNE and ICARDA collaborate in applied research to improve and maintain seed quality for fodder shrubs and grass species used for rangeland rehabilitation.
- Collaboration in a project on food security and poverty alleviation in Balochistan, Pakistan.
- Collaboration in a Technical Cooperation Programme on Orobanche control in food legumes.
- FAO participates in the Future Harvest Consortium for Rebuilding Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.

FAO/IAEA (International Atomic Energy Agency) Joint Division
- Management of nutrients and water in rainfed arid and semi-arid areas for increasing crop production.
- Research in feeding systems for small ruminants in the dry areas.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)
- ICRISAT participates in the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, coordinated by ICARDA.
- ICRISAT participates in the Future Harvest Consortium for Rebuilding Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- ICARDA and ICRISAT are co-conveners of the sub-program on Optimizing Soil Water Use within the Systemwide Programme on Soil Water and Nutrient Management.
- ICARDA is collaborating with ICRISAT on insect pests of grain legumes within the Systemwide Programme on Integrated Pest Management.
- ICARDA and ICRISAT are co-conveners of the Consortium on Desertification, Drought, Poverty, and Agriculture (DDPA).
- ICARDA and ICRISAT collaborate in the Cereal and Legumes Asia Network (CLAN).
- ICARDA and ICRISAT are part-

ners in a study of yield gaps within the Comprehensive Assessment of Water Management of the Systemwide Program on Water.
- ICRISAT participates with ICARDA in research on strengthening seed systems for food security in Afghanistan"

IFPRI (International Food Policy Research Institute)
- ICARDA participates in the System Wide Program on Collective Action and Property Rights (CAPRi) coordinated by IFPRI.
- IFPRI participates in the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, coordinated by ICARDA.
- IFPRI participates in the Future Harvest Consortium for Rebuilding Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- Collaboration in research on property rights and collective action in CWANA through a joint staff appointment.
- ICARDA is participating in the Agricultural Science and Technology Indicators (ASTI) Initiative led by IFPRI and ISNAR.
- ICARDA is participating in HarvestPlus (Challenge Program on Biofortified Crops for Improved Human Nutrition), led by IFPRI and CIAT

IITA (International Institute of Tropical Agriculture)
- ICARDA is collaborating with IITA on parasitic weeds within the Systemwide Programme on Integrated Pest Management.

ILRI (International Livestock Research Institute)
- ILRI participates in the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, coordinated by ICARDA.
- ILRI participates in the Future Harvest Consortium for Rebuilding Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- ILRI and ICARDA share a joint position on animal epidemiology.
- ILRI and ICARDA cooperate in a joint project on small ruminant health, improved livelihoods and market opportunities in the Near East and North Africa.
- ILRI and ICARDA cooperate in strengthening teaching and research on sheep and goat production in Tunisia.

International Center for Biosaline Agriculture (ICBA)
- ICBA and ICARDA jointly delivered two training courses on salinity management in Central Asia

IPGRI (International Plant Genetic Resources Institute)
- ICARDA hosts and services the IPGRI Regional Office for Central and West Asia and North Africa (IPGRI-CWANA).
- ICARDA participates with other CG Centers in the Systemwide Genetic Resources Programme, coordinated by IPGRI, in both plant and animal genetic resources.
- IPGRI participates in the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, coordinated by ICARDA.
- IPGRI participates in the Future Harvest Consortium for Rebuilding Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- ICARDA collaborates with IPGRI in two sub-regional networks on genetic resources (WANANET and CATN/PGR).
- ICARDA participates in developments of the SINGER project coordinated by IPGRI and contributes data to the core SINGER database.
- IPGRI-CWANA is a partner with ICARDA in the GEF/UNDP project on "Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestinian Authority and Syria".

IRRI (International Rice Research Institute)
- IRRI participates in the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, coordinated by ICARDA.
- IRRI participates in the Future Harvest Consortium for Rebuilding Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- ICARDA is participating in the Generation Challenge Program (Unlocking Genetic Resources in Crops for the Resource Poor), led by IRRI and CIMMYT.
- IRRI is the Managing Center of ICARDA's projects in Iran and Eritrea within Theme 1 on water productivity of the Challenge Programme on Water and Food.

IWMI (International Water Management Institute)
- IWMI participates in the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, coordinated by ICARDA.
- IWMI participates in the Future Harvest Consortium for Rebuilding Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.

- ICARDA is participating in the Challenge Program on Water and Food, coordinated by IWMI.
- ICARDA serves on the Steering Committee of the Systemwide Initiative on the Comprehensive Assessment of Water, coordinated by IWMI.
- IWMI and ICARDA share a joint position on marginal water use.
- IWMI and ICARDA are partners in a joint research project on salinity in Central Asia.
- ICARDA is participating in the CGIAR Consortium for Spatial Information - Knowledge Management Project, coordinated by IWMI

UNESCO-MAB (United Nations Education Scientific and Cultural Organization- Man and the Biosphere Program)
- Collaboration in sustainable land management of marginal drylands

United Nations University
- Collaboration in sustainable land management of marginal drylands

World Vegetable Center - formerly the Asian Vegetable Research and Development Center (AVRDC)
- AVRDC participates in the CGIAR Consortium for Central Asia and the Caucasus.

AUSTRALIA

Australian Winter Cereals Collection, Tamworth.
- Development and conservation of plant genetic resources in the Central Asian Republics.
- Bread wheat landrace eco-geographic diversity studies.

Australian Temperate Field Crops Collection, Horsham.
- Development and conservation of plant genetic resources in the Central Asian Republics.
- Plant health management for faba bean, chickpea and lentils.
- Survey of faba bean diseases in Quinghai Province, China.

University of Adelaide, CRC for Molecular Plant Breeding
- Joint training of a PhD student (enrolled in the Southern Cross University).
- Collaborative barley breeding for low rainfall environments.
- Developing elite barley germplasm for salt stressed environments.

University of Adelaide, Waite Campus
- Plant health management for faba bean, chickpea and lentils.

Centre for Management of Arid Environments, Kalgoorlie, WA
- International collaboration in grazing management.

Centre for Plant Conservation Genetics, Southern Cross University
- Development of ESTs using wild barley from ICARDA.

CLIMA (Centre for Legumes in Mediterranean Agriculture)
- Development and conservation of plant genetic resources in the Central Asian Republics.
- Preservation of the pulse and cereal genetic resources of the Vavilov Institute.
- Improving crop establishment and yield of relay and post-rice-sown pulses (lentil and *Lathyrus*) in the cropping systems of the terai and mid-hills in Nepal.
- Development of interspecific hybrids between chickpea and its wild relatives.
- Plant health management for faba bean, chickpea and lentils.

Department of Agriculture, Western Australia
- Plant health management for faba bean, chickpea and lentils.

Department of Primary Industry, Tamworth Centre for Crop Improvement
- Durum wheat improvement.
- Chickpea improvement.
- Identification of legume viruses and selection of legume germplasm for virus disease resistance.
- Plant health management for faba bean, chickpea and lentils.
- Survey of faba bean diseases in Quinghai Province, China.

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

Department of Primary Industry, Horsham, Victoria
- Improvement of narbon vetch for low rainfall cropping zones in Australia.
- Coordinated improvement project on Australian lentils.
- Plant health management for faba bean, chickpea and lentils.
- Survey of faba bean diseases in Quinghai Province, China.

AUSTRIA

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

University of Natural Resources and Applied Life Sciences, Vienna
- Production diversification in small ruminant production in some countries of WANA

BELGIUM

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

University of Leuven
- Joint supervision of MSc graduate research on integrated assessment of land degradation.
- Cooperation with in research on strengthening livelihood resilience in the Karkeh River Basin in Iran.

CANADA

Agriculture Canada, Field Crop Development Centre, Alberta
- Development of barley germplasm with multiple disease resistance.

University of Guelph, School of Rural Development and Planning, Ontario
- Role of women in resource management and household livelihood strategies.

University of Guelph, Ontario Agriculture College, Department of Plant Agriculture
- Modeling Sustainability of Cropping Systems based on Long-term Trials

University of Manitoba, Winnipeg
- Collaboration in tan spot disease

University of Saskatchewan, Saskatoon
- Genetic improvement of resistance to Ascochyta blight and Anthracnose in Lentil.
- Evaluation of chickpea for Ascochyta blight resistance.
- Evaluation of resistance of chickpea germplasm and their wild relatives to vascular wilt.

DENMARK

Risø National Laboratory, Plant Biology and Biogeochemistry Department
- Genetic mapping in barley
- Barley pathology
- Integrated cereal disease management in Eritrea.

Danish Institute of Agriculture Sciences (DIAS)
- Yellow rust of wheat
- Integrated cereal disease management in Eritrea.

Danish International Development Agency (Danida)
- Cooperation in the development of appropriate seed processing technology in Vietnam.

EGYPT

AGERI (Agricultural Genetic Engineering Research Institute), Cairo
- Development of transformation systems for wheat and barley: gene discovery for tolerance to abiotic stresses.
- Transformation systems for lentil, chickpea and faba bean.
- Assessment of factors leading to deterioration of fig trees in the dry areas of Egypt and development of virus free fig seedlings.

CLAES (Central Laboratory for Agricultural Expert Systems), Cairo, Egypt
- Collaboration in delivering a regional training course on utilization of expert systems in agricultural research and production.
- Collaboration in development and utilization of intelligent systems in plant protection
- Collaboration in upgrading and regionalizing expert systems for faba bean and wheat.

FINLAND

Agricultural Research Center of Finland (MTT)
- Nutritional aspects of grain legumes

FRANCE

CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement)
- Bioeconomic and agro-pastoral community modeling studies in WANA.
- Socioeconomic studies of rangeland management in WANA.
- Global program for direct sowing, mulch-based systems and conservation tillage.

Institut National de la Recherche Agronomique (INRA)
- Morphophysiological traits associated with constraints of Mediterranean dryland conditions in durum wheat.
- Water balance studies in cereal-legume rotations in semi-arid mediterranean zone.
- Collaboration on cereal cyst nematodes.
- Genotyping of crop wild relatives.
- Biological control and botanical pesticides against insect pests.
- Studies on salt tolerance in cereals and food legumes.
- Evaluating the performance of crop model STICS developed by INRA.

L'Institut de Recherche pour le Développement (IRD)
- Cooperation in the establishment of a network on water information.

Université de Paris-Sud, Labo Morphogenese Vegetale Experimentale
- Production of doubled haploids in bread wheat and barley

GERMANY

University of Bonn
- QTL analysis in barley

- Integrated approaches to sustainable land management in dry areas
- Joint supervision of Ph.D. graduate research on the use of remote sensing and GIS techniques for land degradation assessment in Syria.

University of Frankfurt am Main
- Genomics of cold and drought tolerance in chickpea and lentil.

University of Hamburg
- Establishment of a barley transformation system.

University of Hannover
- Development of transformation protocols for chickpea and lentil.
- Collaboration in research on impact assessment.

University of Hohenheim
- Increasing the heterozygosity level of barley to exploit heterosis under drought stress.
- Joint supervision of Ph.D. graduate research on sustainable management of a wheat-chickpea rotation using a cropping systems simulator

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

University of Kiel
- Assessment of information needs for development of water management models.
- Institutions of supplemental irrigation.
- Development of SSER markers in lentils.

ITALY

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

Institute of Nematology, Bari
- Studies of parasitic nematodes in food legumes.

Istituto Sperimentale per la Cerealicoltura, Sezione di Fiorenzuola d'Arda
- Collaboration in mapping adaptation of barley to drought environments"

University of Tuscia, Viterbo.
- Diversity of storage proteins in durum wheat

University of Tuscia, Viterbo; Germplasm Institute, Bari; ENEA (Italian Research Agency for New Technologies, Energy and the Environment), Rome.
- Evaluation and documentation of durum wheat genetic resources.

Plant Pathology Research Institute, Rome
- Collaboration on vascular wilt in lentil

JAPAN

Japan International Cooperation Agency (JICA)
- JICA's volunteers program supports research on small ruminant health and nutrition.
- Joint training program in management of water resources and improvement of water use efficiency in dry areas.

Japan International Research Center for Agricultural Sciences (JIRCAS)
- Comparative genomics and cDNA microarray technology for the identification of drought and cold inducible genes in model plants.
- Evaluation of genetic resources and biotechnological approaches for the improvement of wheat germplasm tolerant to environmental stresses.

Kyoto University
- Collaboration in molecular characterization of wheat wild relatives

Tottori University
- Collaboration on human resource development programs for arid land sciences.

NETHERLANDS

Vrije Universiteit Amsterdam (Faculteit der Aard en Levenswetenschappen)
- Collaboration on groundwater research in Syria

Wageningen University
- Collaboration on land and water management research in Syria
- Collaboration on internship on technology transfer mechanisms and participatory approaches in dry areas.
- Collaboration in international training course on agrobiodiversity and support to local seed supply systems.

Department of Plant Science, Laboratory of Plant Breeding, Wageningen
- Collaboration in mapping adaptation of barley to drought environments

NORWAY

Noragric (Agricultural University of Norway)
- Collaboration on soil and water management research in Syria

PORTUGAL

Estacao National de Melhoramento de Plantas, Elvas
- Developing lentil, faba bean, chickpea, and forage legumes adapted to Portugal's conditions.
- Evaluation of IZARIG irrigation management model for supplemental irrigation.

RUSSIA

All Russian Institute of Agricultural Biotechnology, Moscow

- Establishment of barley transformation system

The N.I. Vavilov All-Russian Scientific Research Institute of Plant Genetic Resources (VIR)

- Genetic resources exchange, joint collection missions and collaboration in genetic resources evaluation and documentation.
- Bread wheat eco-geographic diversity studies

SPAIN

University of Barcelona

- Durum and bread wheat stress physiology
- Barley stress physiology
- Mapping adaptation of barley to drought environments

University of Cordoba

- Durum grain quality

UdL-IRTA (University of Lleida and Institut de Recerca i Technologia Agroalimentaria - IRTA)

- Mapping adaptation of barley to drought environments

SWITZERLAND

Institut Universitaire d'Études du Développement (IUED), Geneva

- Sustainable dryland resource management in the arid margins of Syria.

Station Fédérale de Recherches Agronomiques de Changins (RAC), Nyon

- Duplication of *Lathyrus* genetic resources and data

Swiss Centre for International Agriculture

- Improving resistance to barley scald through understanding the processes that govern the evolution of *Rhynchosporium secalis* populations

Swiss Federal Institute of Technology (ETH), Animal Nutrition Department

- Feeding systems and quality of sheep milk products

University of Bern

- World Overview of Conservation Approaches and Technologies (WOCAT)

Swiss College of Agriculture

- Joint supervision of student research in livestock production.
- Joint supervision of graduate student on water harvesting

THAILAND

Khon Kaen University

- Technical assistance to ICARDA on livestock management in Pakistan.

UNITED KINGDOM

Birmingham University

- Collaboration in advising students on *in situ* conservation.

Bristol University

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

CABI Bioscience

- Entomopathogenic fungi for Sunn pest control

Macaulay Land Use Research Institute

- Research planning on feeding systems for small ruminant production in the dry areas.
- Joint Ph.D. study on analysis of long-term rotational trials in sheep and fodder production in Syria together with Reading University, U.K.

Natural Resources Institute, University of Greenwich

- Sunn pest pheromones

University of Reading

- Gender analysis in the agricultural systems of WANA.
- Testing wooly-pod vetch in hillside project in Uganda.

Scottish Crop Research Institute

- Mapping adaptation of barley to drought environments

UNITED STATES OF AMERICA

Busch Agricultural Resources Inc.

- Development of barley germplasm with multiple disease resistance and enhanced malting quality.

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.
- Study of genetic diversity in natural populations of *Aegilops* spp
- Study of genetic diversity and evolution in cultivated and wild lentil, peas and chickpea

Colorado State University

- Testing for stripe rust in barley

Cornell University

- Use of molecular markers for genome mapping and marker-assisted selection for stress resistance in durum wheat.
- Spatial variability in lentil trials.

University of Delaware

- Use of information technology for improving water use efficiency

DuPont Agric. Biotechnology

- Development of EST markers in wheat and lentils

Fort Valley State University, Georgia

- Strengthening teaching and research on sheep and goat production in Tunisia

University of Hawaii:

- Collaborative training program for visiting scientists and graduate research fellows from Iraq.

University of Massachusetts

- Child nutrition in rural areas of Syria.

University of Minnesota:

- Research on improving productivity of oats as priority forage crops

North Carolina State University, Department of Statistical Genetics

- QTL estimation for disease data

Oklahoma State University

- Collaboration in feasibility study for sustainable renovation of *qanats* in Syria

Ohio State University

- Collaboration in research on carbon sequestration.

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.

Purdue University

- GIS for watershed management in the arid regions of Tunisia

University of Missouri, Columbia

- Adaptation to drought and temperature stress in barley using molecular markers

TIGR (The Institute for Genomic Research)

- Development of functional genomics and single nucleotide polymorphism platforms for cereals and legumes

University of Vermont

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

University of Wisconsin

- Small ruminant production with emphasis in dairy sheep evaluation and crossbreeding.
- Sheep production in Central Asia

Washington State University

- The use of CropSyst simulation model in the WANA region for generalization of the site-specific research results for wider ecoregions.

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

- Biological diversity, cultural and economic value of medicinal, herbal and aromatic plants in southern Tunisia

USDA/ARS Beltsville Agricultural Research Center, Beltsville, Maryland

- Development of bread wheat cultivars facilitated by microsatellite DNA markers

USDA/ARS, Manhattan, Kansas

- Molecular genetics of Hessian fly

USDA/ARS Plant Stress and Water Conservation Laboratory, Lubbock, Texas

- Climatological analysis as a tool for agricultural decision-taking in dry areas.

USDA/ARS Stillwater, Oklahoma

- Russian wheat aphid resistance and biotypes

USDA/ARS Grain Legume Genetics and Physiology Research, Pullman, Washington

- Gene mapping of economic traits to allow marker assisted selection in chickpea.
- Exploitation of existing genetic resources of food legumes
- Inheritance and mapping of rust and Stemphylium resistance genes in lentil

USDA/ARS Plant Science Research Unit

- Research on improving productivity of oats as priority forage crops

USDA/ARS Western Regional Plant Introduction Station, Pullman, Washington

- Conservation of temperate food, pasture and forage legume biodiversity.
- Conservation and collection of plant genetic resources in Central Asia and the Caucasus

United States Wheat and Barley Scab Initiative

- Research network for the development of effective control measures that minimize the threat of Fusarium head blight (scab)

Yale University

- Collaboration in research on poverty, rural livelihoods and impact analysis.

Appendix 6

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
International & Regional Networks				
International Germplasm Testing Network	Disseminates advanced lines, parental lines and segregating populations of barley, durum wheat, bread wheat, lentil, kabuli chickpea, faba bean, vetches and chicklings developed by ICARDA, CIMMYT, ICRISAT and national programs. Feedback from NARS assists in developing adapted germplasm and provides a better understanding of GxE interaction and of the agroecological characteristics of major production areas.	ICARDA Germplasm Program	52 countries world-wide; CIMMYT; ICRISAT	ICARDA Core funds
WANA Plant Genetic Resources Network (WANANET)	Working groups specify priorities in plant genetic resources; identify and implement collaborative projects; implement regional activities.	IPGRI Regional Office for CWANA; ICARDA Genetic Resources Unit	WANA countries; IPGRI; FAO; ACSAD	IPGRI, ICARDA, FAO
WANA Seed Network	Encourages stronger regional seed sector cooperation, exchange of information, regional consultations, and inter-country seed trade.	ICARDA Seed Unit	Algeria, Morocco, Iraq, Cyprus, Turkey, Jordan, Syria, Egypt, Sudan, Libya, Yemen	ICARDA
Agricultural Information Network for WANA (AINWANA)	Improve national and regional capacities in information management, preservation and dissemination.	ICARDA Communication, Documentation and Information Services	WANA countries; CIHEAM; ISNAR	ICARDA
The Network on Drought Management for the Near East, Mediterranean and Central Asia (NEMEDCA Drought Network)	Enhanced technical co-operation among concerned national, regional and international organizations in the Region, particularly the exchange of information and experience among the member countries, on issues concerning drought mitigation.	ICARDA serves as a Secretariat	Countries of the Near East, Mediterranean and Central Asia; FAO; EC; CIHEAM.	ICARDA; FAO; CIHEAM

Appendix 7

Financial Information

Audited Statement of Activity (US$ ×000)

	2004	2003
REVENUES		
Grants (Core and Restricted)	26,032	24,356
Other revenues and supports	474	806
Total revenues	26,506	25,162
EXPENSES		
Program related expenses	23,517	22,674
Management and general expenses	3,076	3,246
Other losses and expenses	44	-
Total expenses and losses	26,637	25,920
Indirect costs recovery	(801)	(760)
Net Expenses and losses	25,836	25,160
EXCESS REVENUES OVER EXPENSES	670	2

Statement of Financial Position (US$ x000)

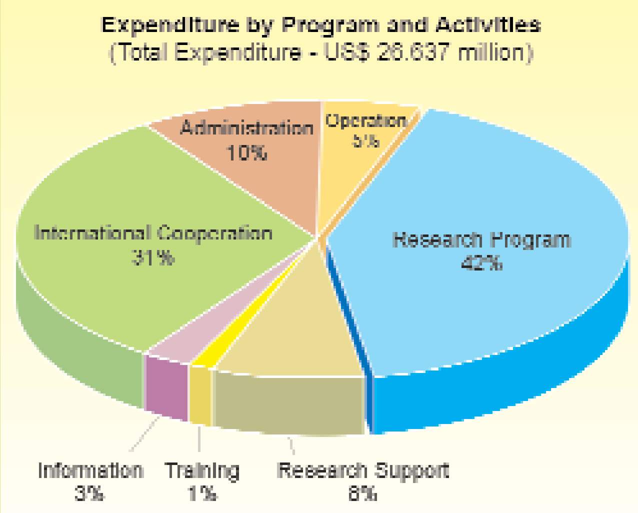
	2004	2003
ASSETS		
Current assets	26,984	25,988
Property & equipment	2,808	2,738
Total assets	29,792	28,726
LIABILITIES AND ASSETS		
Current liabilities	13,473	13,456
Long term liabilities	4,091	3,712
Total liabilities	17,564	17,168
Net assets	12,228	11,558
Total liabilities & net assets	29,792	28,726

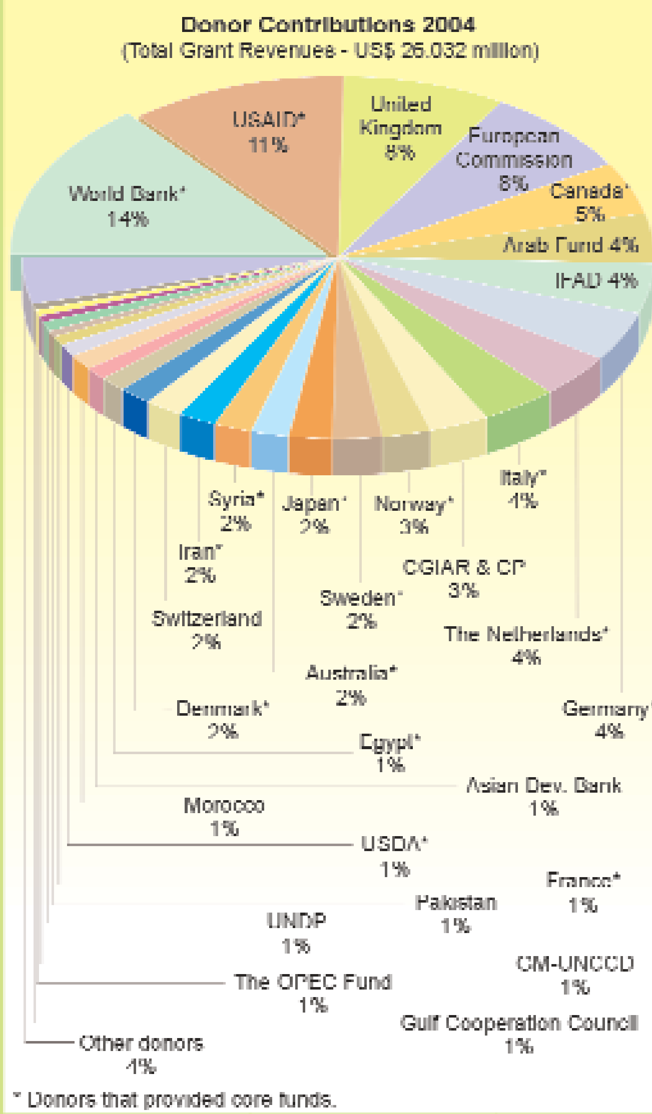
Statement of Grant Revenues, 2004 (US$ x000)

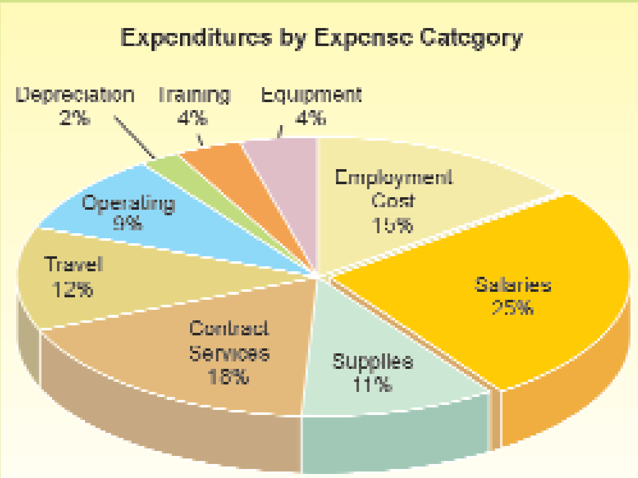
Donor	Amount
Arab Fund	1,163
Asian Dev.Bank	345
Australia*	536
Austria	91
Belgium*	98
Canada*	1,236
CGIAR & CP	792
China*	30
Denmark*	443
Egypt*	350
ERF-FEMISE	104
European Commission	2,039
FAO	66
France*	218
Germany*	1,113
GM-UNCCD	155
Gulf Cooperation Council	131
IDRC	68
IFAD	1,156
India*	38
Iran*	492
Italy*	1,014
Japan*	554
Morocco	308
Norway*	662
The OPEC Fund	140
Pakistan	194
South Africa	31
Sweden*	626
Switzerland	491
Syria*	500
The Netherlands*	1,049
Turkey	42
UNCCD	15
UNDP	177
UNEP	55
UNESCO	23
United Kingdom	2,161
USAID*	2,932
USDA	282
World Bank*	3,664
Miscellaneous	448
TOTAL	26,032

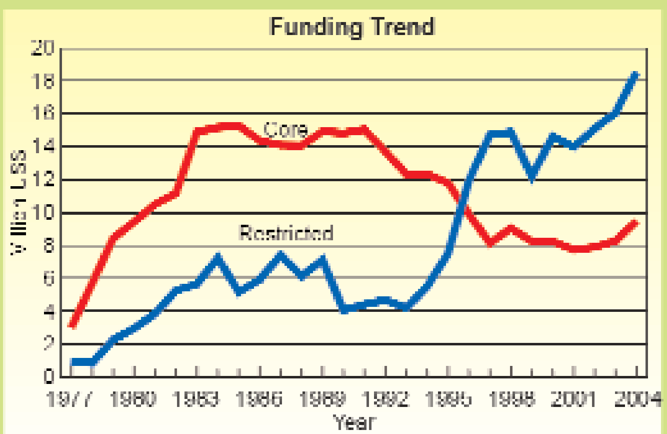
*Donors that provided core funds

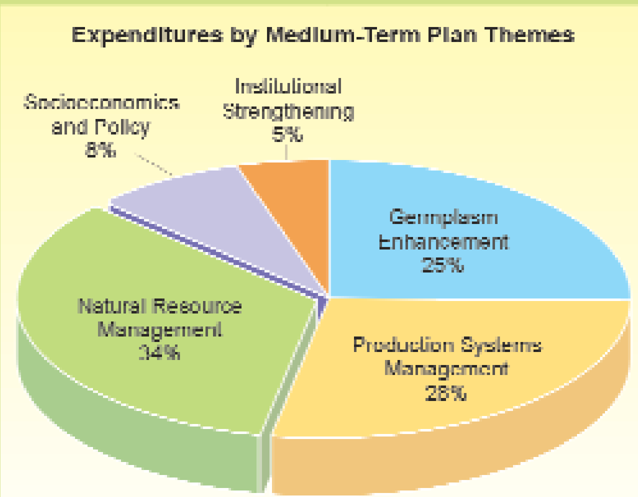
Financial Information











Appendix 8

Board of Trustees

At its annual meeting held on 22-23 April 2004, the Board of Trustees appointed two new Board Members for a term of 3 years starting from 24 April 2004: (1) Dr Majd Jamal as the host country representative replacing Dr Reiad Kassem who retired from his post as Director, International Cooperation at the Ministry of Agriculture and Agrarian Reform, Syria; and (2) Dr Abdelmajid Slama as a regular Member.

Dr Abdelmajid Slama

An agronomist and an agricultural economist, Dr Abdelmajid Slama was the Director of the Near East and North Africa Division of the International Fund for Agricultural Development (IFAD). Dr Slama was responsible for agricultural research training, capacity building, and managing IFAD operations such as grants and loans in 22 countries. He also manage several regional technical grants on agricultural research and technology transfer. Dr Slama's areas of expertise include agriculture and food policy; project analysis; financial, economic, social and institutional analysis of agricultural projects; marketing and price analysis; and the management of agricultural research.

Dr Majd Jamal

Dr Majd Jamal is the Director General of the General Commission for Scientific Agricultural Research (GCSAR), Syria, as well as an Associate Professor at the College of Agriculture, University of Damascus. He has worked as Director of Syrian Directorate for Scientific Agricultural Research (DSAR), and as a Cooperating Expert at the Arab Center for the Studies of Arid zones and Dry lands (ACSAD). Dr Jamal's research interests include pest control, economic entomology, and pesticide toxicology. He is a member of the editorial board of the University of Damascus Journal for Agricultural Sciences and is the National Coordinator of the GEF/UNDP-funded Dryland Agrobiodiversity Project.

Full Board

At the 38th annual meeting of ICARDA Board of Trustees, held on 22-23 April 2004, the membership of the Board was as follows:

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* Resigned in October 2004.

Appendix 9

Senior Staff

(as of 31 December 2004)

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Dr Mohan Saxena, *Assistant Director General (At-Large)*
Dr William Erskine, *Assistant Director General (Research)*
Prof. Dr Magdy Madkour, *Director (International Cooperation)*
Dr Adel Aboul Naga, *Senior Advisor*
Dr Elizabeth Bailey, *Project Officer*
Mr Hembapura Tharanga De Silva, *Internal Auditor*
Ms Houda Nourallah, *Administrative Officer to the Director General and Board of Trustees*

Corporate Services

Mr Michel Valat, *Director*
Mr Essam Abd Alla Saleh Abd El-Fattah, *Assistant Director*

Government Liaison

Dr Ahmed El-Ahmed, *Director*

Finance Department

Mr Vijay Sridharan, *Director*
Mr Ahmed El-Shennawy, *Associate Director*
Mr Mohamed Samman, *Treasury Supervisor*
Mrs Imelda Silang, *Finance Officer, Budget, Donor Reporting and Outreach*

Natural Resource Management Program

Dr Richard Thomas, *Director*
Dr Aden Aw-Hassan, *Agricultural Economist*
Dr Adriana Bruggeman, *Agricultural Hydrology Specialist*
Dr Eddy De Pauw, *Agroclimatologist*
Dr Luis Iniguez, *Senior Small-Ruminant Scientist*
Dr Asamoah Larbi, *Pasture and Forage Production Specialist*
Dr Aggrey Ayuen Majok, *Project Coordinator/Epidemiologist*
Dr Theib Oweis, *Water Management/Supplemental Irrigation Specialist*
Dr Mustafa Pala, *Wheat-Based Systems Agronomist*
Dr Manzoor Qadir, *Marginal-Water Management Specialist*
Dr Abdul Bari Salkini, *Agricultural Economist/Liaison Scientist*
Dr Kamel Shideed, *Natural Resource Economist*
Dr James A. Tiedeman, *Range Management Scientist*
Dr Francis Turkelboom, *Soil Conservation/Land Management Specialist*
Dr Ahmed Mazid, *Agricultural Economist*
Mr Markus Buerli, *Junior Professional Officer*
Dr Celine Dutilly-Diane, *Junior Professional Officer*
Dr Bogachan Benli, *Post-Doctoral Fellow (Irrigation and Water Management)*
Dr Hanadi Ibrahim El-Dessougi, *Post-Doctoral Fellow (Nutrient and Water Flows)*
Dr Ashraf Tubeileh, *Post-Doctoral Fellow (Nutrient and Water Flows in CWANA)*
Mr Akhtar Ali, *Water & Soil Engineer*
Ms Azusa Fukuki, *Research Associate*
Mr Adekunle Gabriel Ibiyemi, *Senior GIS Analyst*
Dr Roberto La Rovere, *Researcher in Economics*
Dr Malika Martini Abdelali, *Socioeconomist, Community and Gender Analysis Specialist*
Dr Safouh Rihawi, *Research Associate, Animal Nutrition*
Mrs Monika Zaklouta, *Research Associate*
Mr Haben Asgedom Tedla, *Research Fellow, Land Management (BMZ/GTZ project)*
Dr Birgitte Larsen Hartwell, *Research Fellow*

Germplasm Program

Dr Ali Mohamed Abdel Moneim, *Acting Director, Forage/Legume Breeder*
Dr Osman Abdalla El Nour, *Bread Wheat Breeder*
Dr Michael Baum, *Biotechnologist*
Dr Mustapha El-Bouhssini, Entomologist
Dr Salvatore Ceccarelli, *Barley Breeder*
Dr Stefania Grando, *Barley Breeder*
Dr Rajinder Malhotra, *Senior Chickpea Breeder*
Dr Miloudi Nachit, *Durum Wheat Breeder*
Dr Sanjaya Rajaram, *Senior Scientific Advisor*
Dr Ashutosh Sarker, *Lentil Breeder*
Dr Amor Yahyaoui, *Senior Cereal Pathologist*
Dr Masanori Inagaki, *Visiting Scientist*
Dr Moussa Guirgis Mosaad, *Visiting Scientist, Winter and Facultative Wheat Breeder, and Coordinator, ICARDA/Turkey Activities*
Dr Sripada M. Udupa, *Biotechnologist*
Dr Bassam Bayaa, *Senior Consultant Legume Pathologist*
Dr Shaaban Khalil, *Consultant Faba Bean Breeder*
Dr Khaled Makkouk, *Consultant Virologist*
Dr Mathew Musumbale Abang,

Junior Professional Officer (Plant Pathology)
Dr Bitore Djumahanov, *Post-Doctoral Fellow (Cereal Breeder/ Geneticist)*
Dr Fekadu Fufa Dinssa, *Post-Doctoral Fellow (Barley Breeder)*
Dr Peiguo Guo, *Visiting Scientist (Biotechnology)*
Mr Fadel Al-Afandi, *Research Associate*
Mr Akinnola Nathaniel Akintunde, *International Crop Information System and International Nursery Scientist*
Mr Berhane Lakew Awoke, *Visiting Research Fellow*
Dr Kiros Meles, *Visiting Research Fellow*

Genetic Resources Unit

Dr Jan Valkoun, *Head*
Dr Bonnie Jean Furman, *Legume Germplasm Curator*
Dr Kenneth Street, *Coordinator, CAC Projects*
Mr Jan Konopka, *Germplasm Documentation Officer*
Dr Kamel Chabane, *Biotechnologist*
Dr Siham Asaad, *Research Associate*
Mr Bilal Humeid, *Research Associate*

Seed Unit

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Human Resource Development Unit

Dr Samir El-Sebae Ahmed, *Head*
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Computer and Biometrics Services

Dr Zaid Abdul-Hadi, *Head*
Dr Murari Singh, *Senior Biometrician*
Mr Awad Awad, *Data Base Administrator and MIS Team Leader*
Dr Fadil Rida, *Applications Specialist (Oracle Applications)*
Mr Michael Sarkisian, *Senior Maintenance Engineer*
Mr Colin Webster, *Senior Network Administrator*
Mr Hashem Abed, *Scientific Databases Specialist*

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Appendix 10

Acronyms

AAAID	Arab Authority for Agricultural Investment and Development, Sudan
APAARI	Asia-Pacific Association of Agricultural Research Institutions
AARINENA	Association of Agricultural Research Institutions in the Near East and North Africa
ABRII	Agricultural Biotechnology Research Institute of Iran
ACIAR	Australian Centre for International Agricultural Research, Australia
ACSAD	Arab Center for Studies of the Arid Zones and Dry Lands, Syria
ADB	Asian Development Bank, Philippines
AFESD	Arab Fund for Economic and Social Development, Kuwait
AREO	Agricultural Research and Education Organization, Iran
AGERI	Agricultural Genetic Engineering Research Institute, Egypt
AOAD	Arab Organization for Agricultural Development, Sudan
APRP	Arabian Peninsula Regional Program
ASU	Afghan Survey Unit
CAC	Central Asia and the Caucasus
CACRP	Central Asia and the Caucasus Regional Program
CATCN	Central Asian and Trans-Caucasian Network
CGIAR	Consultative Group on International Agricultural Research
CIHEAM	Centre International de Hautes Etudes Agronomiques Mediterraneennes, France
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico
CIAT	Centro Internacional de Agricultura Tropical, Colombia
CIP	International Potato Center, Peru
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement, France
CLAC	Central Laboratory for Agricultural Climate, Egypt
CLAES	Central Laboratory for Agricultural Expert Systems, Egypt
CLIMA	Centre for Legumes in Mediterranean Agriculture, Australia
CWANA	Central and West Asia and North Africa
DARI	Dryland Agricultural Research Institute, Iran
DFID	Department for International Development, UK
ERF-FEMISE	Economic Research Forum—Euro-Mediterranean Forum of Economic Institutes
ESCWA	Economic and Social Commission for Western Asia
EARO	Ethiopian Agricultural Research Organization
FAO	Food and Agriculture Organization of the United Nations, Italy
FHCRAA	Future Harvest Consortium to Rebuild Agriculture in Afghanistan
GAP	Southeastern Anatolia Project, Turkey
GEF	Global Environment Facility
GEF/UNDP	Global Environment Facility/United Nations Development Programme
GFAR	Global Forum on Agricultural Research
GIS	Geographic Information Systems
GOSM	General Organization for Seed Multiplication, Syria
GRU	Genetic Resources Unit
GTZ	German Technical Cooperation Agency
HRP	Highland Regional Program
CRISAT	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

IITA	International Institute for Tropical Agriculture, Nigeria
ILRI	International Livestock Research Institute, Kenya
IMPHOS	World Phosphate Institute, Morocco
INRA	Institut National de la Recherche Agronomique, France
IPGRI	International Plant Genetic Resources Institute, Italy
IPM	Integrated Pest Management
IRRI	International Rice Research Institute, Philippines
IWMI	International Water Management Institute, Sri Lanka
IWWIP	International Winter Wheat Improvement Project
JICA	Japan International Cooperative Agency, Japan
JIRCAS	Japan International Research Center for Agricultural Sciences
LARI	Lebanese Agricultural Research Institute, Lebanon
MAWR	Ministry of Agriculture and Water Resources, Uzbekistan
M&M	Mashreq and Maghreb
MRMP	Matrouh Research Management Project, Egypt
NAAS	National Academy of Agricultural Sciences, India
NARP	North Africa Regional Program
NARS	National Agricultural Research Systems
NASA	National Aeronautics and Space Administration, USA
NCARTT	National Center for Agricultural Research and Technology Transfer, Jordan
NGO	Non-Governmental Organizations
NVRSRP	Nile Valley and Red Sea Regional Program
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of Petroleum Exporting Countries, Austria
PPDRI	Plant Pests and Diseases Research Institute, Iran
SDC	Swiss Agency for Development and Cooperation, Switzerland
SPII	Seed and Plant Improvement Institute, Iran
TIIAME	Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent
TWAS	Third World Academy of Sciences, Italy
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UNU	United Nations University, Japan
UN/WFP	United Nations/World Food Programme
UPOV	International Union for the Protection of New Varieties of Plants, Switzerland
USAID	United States Agency for International Development, USA
USDA	United States Department of Agriculture, USA
WANA	West Asia and North Africa
WARP	West Asia Regional Program, Jordan
ZEF	Center for Development Research, Germany

Appendix 11

ICARDA Addresses

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Investors in ICARDA, 2004

Listed in descending order of investment.
For more information, please refer to page 111.

1. World Bank	14. Australia	27. The OPEC Fund
2. USAID	15. Syria	28. Gulf Coop. Coun.
3. United Kingdom	16. Iran	29. Belgium
4. European Comm.	17. Switzerland	30. Austria
5. Canada	18. Denmark	31. IDRC
6. Arab Fund	19. Egypt	32. FAO
7. IFAD	20. Asian Dev.Bank	33. UNEP
8. Germany	21. Morocco	34. Turkey
9. Netherlands	22. US Dept. of Agric.	35. India
10. Italy	23. France	36. South Africa
11. Norway	24. Pakistan	37. China
12. Sweden	25. UNDP	38. UNESCO
13. Japan	26. GM-UNCCD	

Front Cover:

Above (left to right): An improved variety of lentil, derived from ICARDA germplasm, planted by a farmer in his field in Nepal; bed-planted wheat in Iran; biotechnology laboratory at ICARDA.

Below (left to right): Harvested rainfall water being drawn from a Roman-time cistern in Egypt; sheep grazing improved vetch at ICARDA farm, at Tel Hadya, in Syria; an improved, drought-tolerant barley line growing in a low-rainfall area in Syria.

Back cover:

Above (left to right): Distribution of nurseries of medicinal plants by ICARDA's Dryland Agrobiodiversity Project to women in West Asia; a field training course in progress in Kabul, Afghanistan; an olive orchard established in a village near Aleppo, Syria to prevent land degradation and diversify farmers' income.

Below (left to right): Woman milking sheep in Syria; cheese made from sheep milk on sale in a village market in Syria; a new winter and facultative wheat variety 'Bitarap,' derived from ICARDA-supplied germplasm, growing in a field in Turkmenistan; Sudanese farmers in a traveling workshop on food legumes held in Sudan.

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Investors in ICARDA, 2004

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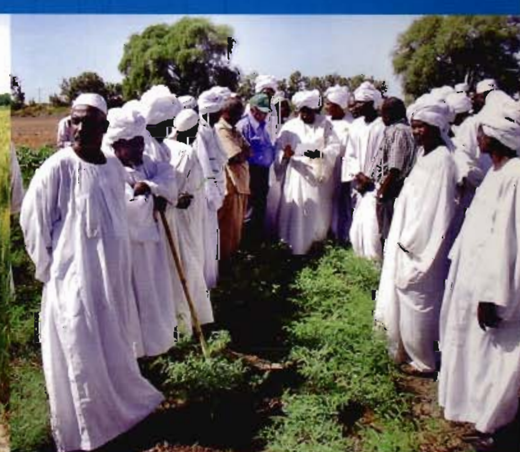

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