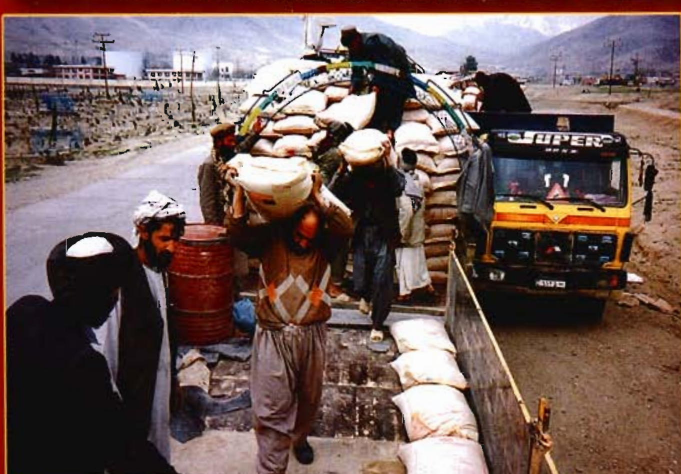
ICARDA Annual Report 2002



International Center for Agricultural Research in the Dry Areas

About ICARDA and the CGIAR

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

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

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

The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. Its mission is to promote sustainable agriculture to alleviate poverty and hunger, and achieve food security in developing countries. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South-North partnership to reduce poverty and hunger.

The Future Harvest centers of the CGIAR conduct strategic and applied research, with their products being international public goods, and focus their research agenda on problem solving through interdisciplinary programs implemented in collaboration with a range of partners. These programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and strengthening national agricultural research systems.

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 System with a Secretariat in Washington, DC. A Science Council, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

ICARDA

Annual Report

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AGROVOC descriptors: *Cicer arietinum*; *Lens culinaris*; *Vicia faba; Hordeum vulgare*; *Triticum aestivum; Triticum durum; Lathyrus sativus*; *Aegilops*; *Medicago sativa*; *Pisum sativum*; *Trifolium; Trigonella; Vicia narbonensis;* safflower; feed legumes; clover; shrubs; fruit trees; goats; ruminants; sheep; livestock; agricultural development; dry farming; farming systems; animal production; crop production; agronomic characters; biodiversity; biological control; disease control; pest control; pest-resistance; drought resistance; genetic maps; genetic markers; genetic-resistance; genetic resources; genetic variation; land races; germplasm conservation; plant collections; microsatellites; land use; pastures; grassland management; steppes; rangelands; reclamation; environmental degradation; irrigation; water harvesting; water management; harvesting; rural communities; rural development; social consciousness; training; human resources; development; malnutrition; nutritive quality; poverty; mechanical methods; remote sensing; research networks; research; resource conservation; resource management; seed production; stubble cleaning; sustainability; temperature resistance; cold; vegetation; geographical information system; diffusion of information; agroclimatic zones; arid zones; semiarid zones; international cooperation; Middle East; North Africa; Armenia; Azerbaijan; Eritrea; Ethiopia; Georgia; Kazakstan; Kyrgyzstan; Latin America; Pakistan; Sudan; Tajikistan; Turkmenistan; Uzbekistan.

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Foreword

The year 2002 marked ICARDA's 25th anniversary, and coincided with several honors and awards for the center's excellence in research. Research on developing high-yielding kabuli chickpea varieties that thrive in cool, wet winter conditions earned the 2002 King Baudouin Award of the Consultative Group on International Agricultural Research (CGIAR), jointly with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), which focuses on desi chickpea. Several ICARDA researchers won both national and regional awards for their contributions to improved crop production and protection of the natural resource base in dry areas.

The Center made a substantial contribution to the global efforts to rebuild agriculture in Afghanistan. In January, it convened a meeting in Tashkent, Uzbekistan, which was attended by representatives from 34 international organizations, including non-governmental organizations, and 10 of the 16 CGIAR centers. Based on the recommendations of the meeting, the Future Harvest Consortium to Rebuild Agriculture in Afghanistan was established. The United States Agency for International Development (USAID) and the International Development Research Center (IDRC) provided funds to implement the Consortium activities.

Led by ICARDA, the Consortium made rapid progress. With the overall objective of restoring and enhancing the food production capacity of farmers in Afghanistan, priority was given to multiply and deliver quality seed of adapted varieties to rebuild, with Afghan partners, an effective seed multiplication system that promotes the use of high-quality seed. As part of this effort, over 3500 tonnes of certified seed of wheat was provided for spring planting, and 5000 tonnes for the fall 2002 planting. The seed reached over 100,000 farm families. A "Code of Conduct" was developed to form the basis for a national seed policy and regulatory framework for Afghanistan.

The Consortium's research agenda went much beyond seed systems. It organized four needs assessments that obtained information from farm families throughout the country on (i) seed and crop improvement, (ii) soil and water management, (iii) livestock, forage and range, and (iv) horticulture. Information from these assessment missions was reviewed and discussed at a wrap-up meeting held at ICARDA in November 2002, and will form the basis of a wide range of crop, livestock, and infrastructure rehabilitation projects in 2003 and beyond. Several research laboratories were refurbished. Over 100 Afghan researchers were trained in key areas of research.

The Center continued its efforts with increased momentum to strengthen its partnerships. To set regional priorities for agricultural research in the CWANA region and integrate them with the CGIAR priorities, researchers and research administrators, and representatives from the non-governmental organizations, farmer associations and the private sector, from throughout Central and West Asia and North Africa (CWANA), met at ICARDA headquarters to review the recommendations of the five sub-regional priority-setting meetings organized by ICARDA, in cooperation with the Association of Agricultural Research Institutes in the Near East and North Africa (AARINENA) and the Regional Forum for Central Asia and the Caucasus (CAC) in 2001/2002. This effort should help increase the relevance, efficiency and impact of ICARDA's research.

The year saw increased participation of ICARDA in global conventions and in implementing their recommendations. The Center participated in the World Summit on Sustainable Development (WSSD), held in Johannesburg, South Africa. On behalf of the CGIAR, the Director General of the Center made a presentation in which he highlighted the role of agriculture in improving the quality of life of the poor, in protecting the natural resource base, and in promoting economic growth. He also made a statement on CWANA at the plenary devoted to regional implementation of the WSSD action plan.

ICARDA enters 2003 with increased focus on its mission to improve the welfare of the poor in the world's dry areas while preserving the natural resource base upon which we all rely. The Center's Board of Trustees, Management and Staff thank all of ICARDA's donors and cooperators for their continued support, and look forward to a productive and peaceful 2003.

Adel El-Beltagy
Director General

Robert Havener
Chairman, Board of Trustees

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Highlights of the Year

The year 2002 was marked both by the recognition of ICARDA's contributions to agricultural research in the dry areas and new challenges. Most noteworthy among the new challenges was ICARDA's key role in forming a consortium of 10 CGIAR centers to rebuild agriculture in the war-torn and drought-plagued Afghanistan. The Center continued its efforts with increased momentum to strengthen its partnership with national programs, sister centers, advanced research institutes and donors. The year saw increased participation of ICARDA in global conventions and in implementing their recommendations, and in the CGIAR Systemwide initiatives. Some of the highlights of the work on promoting science in the service of the poor are presented here. Progress made in specific research projects is reported in subsequent chapters.

H.E. Mr Hamid Karzai (right), President of Afghanistan, discusses the status of agriculture in his country and the work of the Future Harvest Consortium to rebuild Agriculture in Afghanistan with ICARDA Director General Prof. Dr Adel El-Beltagy in Kabul on 7 October.

Rebuilding Agriculture in Afghanistan

Topping ICARDA's research agenda in 2002 was its efforts to rebuild agriculture in Afghanistan. In January, ICARDA convened a meeting in Tashkent, Uzbekistan, attended by representatives from 34 international organizations and 10 CGIAR centers, to lay the foundation for action plans for rebuilding agriculture in Afghanistan.

The first task of the ICARDA-led Future Harvest Consortium to Rebuild Agriculture in Afghanistan entailed shipping 3500 tonnes of certified seed of improved wheat varieties to meet Afghan farmers' urgent needs. This 200-truck convoy was followed by a smaller, but no less important, shipment of seed from ICARDA headquarters, including Afghan landraces, stored in ICARDA's genebank, for testing, release, and further multiplication.

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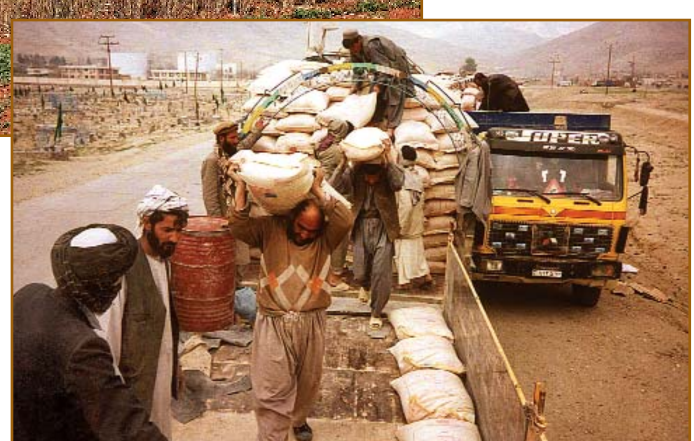
Foundation seed production at ICARDA's research farm for distribution in Afghanistan.



Improved wheat seed, provided by the Consortium for spring 2002 planting, being unloaded in Afghanistan.

Participants in the Future Harvest Consortium needs assessment workshop, held at ICARDA, Aleppo.

livestock, forage and range, and (iv) horticulture. Information from these assessment missions was reviewed and discussed at a wrap-up meeting held at ICARDA in November 2002, and will form the basis for a wide range of crop, livestock, and infrastructure rehabilitation projects in 2003 and beyond.

ICARDA has developed a strong relationship with the Afghan members of the Consortium, cemented by a meeting between Afghanistan's President, H.E. Mr Hamid Karzai, and Prof. Dr Adel El-Beltagy, Director General of ICARDA, in Kabul in October. A high-level Afghan delegation led by the Minister of Agriculture also visited ICARDA in the summer, following a visit by a delegation led by the Deputy Minister. On each occasion, plans were set for rehabilitation efforts, including laboratories, and for human resource development. The objective is food security, and improved nutrition and income for Afghan farm families, while protecting the environment.

H.E. Mr Sayed Hussain Anwari (center) visited ICARDA in 2002. Here, Dr Adel El-Beltagy (left), Director General, shows him the quality of wheat seed processed in the Center's Seed Laboratory.

25th Anniversary

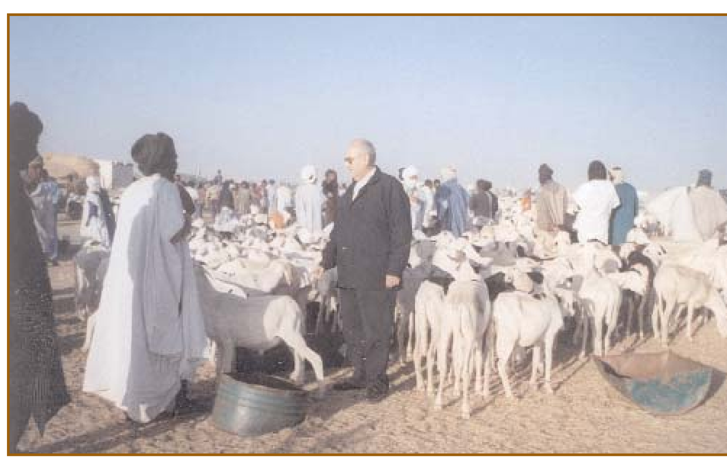
In May, ICARDA celebrated its 25th anniversary, with a program of seminars delivered by distinguished experts in policy and biotechnology research, attended by high-ranking international, regional and national scientists and administrators, and ICARDA staff. Prof. Dr El-Beltagy, made a comprehensive presentation in which he highlighted the achievements made and the work that remains to be done to improve the production systems in the dry areas. The 25th Anniversay program echoed the need for continued donor support to agricultural research and development in the world's dry areas.

Researchers and research administrators from throughout Central and West Asia and North Africa (CWANA) met at ICARDA headquarters on 8-10 May to integrate regional agricultural research priorities into the agenda of the Consultative Group on International Agricultural Research (CGIAR). The group worked with recommendations reached earlier at five sub-regional priority-setting meetings organized by ICARDA in 2001-2002.

The Anniversary was marked by the release of a commemorative volume entitled "ICARDA25: A Promise of Hope," written by Dr Mohamed A. Nour, former Director General of the Center.

Cooperation with NARS

- The Center hosted a meeting in May that renewed a two-year effort to integrate regional research priorities more closely into the CGIAR agenda. Researchers and research administrators from throughout Central and West Asia and North Africa (CWANA) met at ICARDA headquarters to work through recommendations reached earlier at five sub-regional priority-setting meetings organized by ICARDA in 2001/2002. Since ICARDA's research agenda is driven by NARS' needs, the research integration effort should go a long way in ensuring the continued efficiency and effectiveness of the Center's international cooperation.
- In March, the Director General met with Mauritania's Prime Minister, H.E. Cheikh El Avia Ould Mohamed Khouna, and the country's Minister of Rural Development and Environment, H.E. Moustapha Ould Maouloud. An eight-point aide mémoire was signed outlining future collaboration.
- The Iranian Minister of Agriculture, H.E. Mahmoud Hojjati, headed a mission to ICARDA in May. The Director General recalled the history of the establishment and development of ICARDA and the continuing role of Iran in enabling the Center to meet the agricultural research needs of the high-elevation areas in the region.



Most of Mauritania is rangeland and desert, so improving livestock production is an important part of ICARDA's cooperation with the country. The Director General talks with a herder in Mauritania.

- The Prime Minister of Tajikistan, H.E. Akil Akilov, and the Deputy Prime Minister, H.E. Kozidavlat Koimdodov, received the Director General in Dushanbe in September and signed a memorandum of agreement to expand cooperation between ICARDA and Tajikistan.
- Uzbekistan's Deputy Prime Minister and Minister of Agriculture and Water Management, H.E. Sobirjon Yusupov, received the Director General in Tashkent in June, on the occasion of the fifth annual program steering committee meeting of the CGIAR collaborative program for sustainable agricultural development in CAC.
- Pakistan's Minister for Food, Agriculture and Livestock, H.E. Khair Muhammad Junejo, received Prof. Dr El-Beltagy in October. H.E. the Minister supported increased collaboration with the Center and expressed support for a memorandum of understanding between ICARDA and Pakistan.

Planning for progress

ICARDA hosted and took part in numerous important meetings in 2002. Among these was the "World Summit on Sustainable Development," held in Johannesburg, South Africa in August and September. Prof. Dr Adel El-Beltagy represented ICARDA as a CGIAR delegate, and made a presentation in which he highlighted the role of agriculture in improving the quality of life of the poor, in protecting the natural resource base, and in promoting economic growth.

In March, donors, researchers, and development administrators met at ICARDA headquarters to consider a draft regional program for sustainable development of rainfed areas of West Asia and North Africa. It was a follow-up to a ministerial meeting held in Rabat, Morocco, in June.

Environmentalists, academicians, and agriculturalists met at ICARDA in May for an international workshop entitled "Desertification: Rehabilitation of Degraded Drylands and Biosphere Reserves."

Environmentalists and agriculturalists joined forces again at ICARDA in May for a workshop entitled "Agriculture, Environment and Human Welfare in West Asia and North Africa." The workshop was organized in cooperation with the International Geosphere Biosphere Program and the International Dryland Development Commission.

The fourth meeting of the Integrated Natural Resource Management (INRM) Task Force of the CGIAR was held at ICARDA headquarters in September. INRM is one of the three pillars of the CGIAR's agenda, along with integrated gene management and information technology.

In November, ICARDA was the featured CGIAR Center at the Tri-Society Meeting of the American Society of Agronomy (ASA), Crop Science Society of America (CSSA), and Soil Science Society of America (SSSA), held in Indianapolis, Indiana, USA. Several ICARDA scientists presented papers and posters. Prof. Dr El-Beltagy was the guest speaker at a special symposium on "Collaborative Strategy to Combat Drought."

ICARDA was privileged to have two opportunities to make statements at plenary sessions of the World Summit on Sustainable Development. Prof. Dr Adel El-Beltagy (fourth from left, front table), ICARDA DG, made a statement on behalf of the CGIAR at the plenary on 30 August, and another statement at the plenary on 29 August devoted to regional implementation of the WSSD action plan (above).

Awards for excellence in science

- Work to develop high-yielding kabuli chickpea varieties that thrive in cool, wet winter conditions earned for ICARDA the 2002 King Baudouin Award from the Consultative Group

on International Agricultural Research (CGIAR), jointly with its sister center, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), which focuses its research on desi chickpea. The award was presented to the two centers by the CGIAR Chairman, Dr Ian Johnson, at the Annual General Meeting of the CGIAR in Manila, Philippines, in October 2002.

- ICARDA's Director General, Prof. Dr Adel El-Beltagy, was elected Academician (Foreign Member) of the Tajik Academy of Agricultural Sciences in the field of crop science.
- Dr Rajendra S. Paroda, Regional Coordinator of ICARDA's Program for Central Asia and the Caucasus (CAC) and Head of the Program Facilitation Unit of the CGIAR Program for CAC, was elected Fellow of the Georgian Academy of Agricultural Sciences and Armenian Academy of Agricultural Sciences, and Academician of the Tajik Academy of Agricultural Sciences; and won the B.P. Pal Memorial Award for the Biennium 2001–2002 of the National Academy of Agricultural Sciences (NAAS), India. Dr Paroda was also honored by the ICRISAT Board of Trustees and Management. In December 2002, the Institute's prestigious germplasm repository was named the Rajendra S. Paroda Genebank, in recognition of his outstanding contributions to genetic resources conservation.
- In June 2002, His Majesty the King of Morocco, Mohamed VI, conferred the royal medal "Chevalier d'Honneur" on Dr Miloudi Nachit, CIMMYT/ ICARDA Durum Wheat Breeder, for his research on durum genome mapping and his success in improving wheat production in Morocco, Syria, and the Mediterranean region.
- Dr Miloudi Nachit, Dr Mustapha El-Bohssini, Entomologist, and Dr Ahmed Amri, Coordinator, Regional Agrobiodiversity Project, shared with Drs N. Nserallah and S. Lhaloui of the Institut National de la Recherche Agronomique, Morocco, the 2002 Prize for Research and Development in Morocco for their contributions to the development of the first durum wheat varieties resistant to Hessian fly.
- Dr Mustapha El-Bohssini also shared with Mr K. Mardini, Agricultural Research Center, Aleppo, and Dr Adnan Babi, University of Aleppo, the 2002 Basel Award for Scientific Agricultural Research in Syria for their contributions to the development of an integrated pest management package for chickpea leaf miner.
- At the International Soil Science Congress, held in Bangkok, Thailand, in August, Dr John Ryan, Soil Fertility Specialist, was elected Commission Chairman for Soil Fertility and Plant Nutrition, of the International Union of Soil Scientists.

Prof. Dr Adel El-Beltagy (right), ICARDA DG; Dr William Dar (left) ICRISAT DG; and Dr Jagdish Kumar, Principal Chickpea Breeder, ICRISAT, received the King Baudouin Award from the CGIAR Chair, Dr Ian Johnson (second from right).

Looking ahead

ICARDA enters 2003 with its focus on its mission to improve the welfare of the poor in the world's dry areas while preserving the natural resource base upon which we all rely. As lead Center in the international effort to rebuild agriculture in Afghanistan, ICARDA will continue to strengthen partnerships and apply the best of science to restore food security in that country.

The Center's Board of Trustees, Management and Staff thank all of ICARDA's donors and cooperators for their continued support, and look forward to a productive and peaceful 2003.

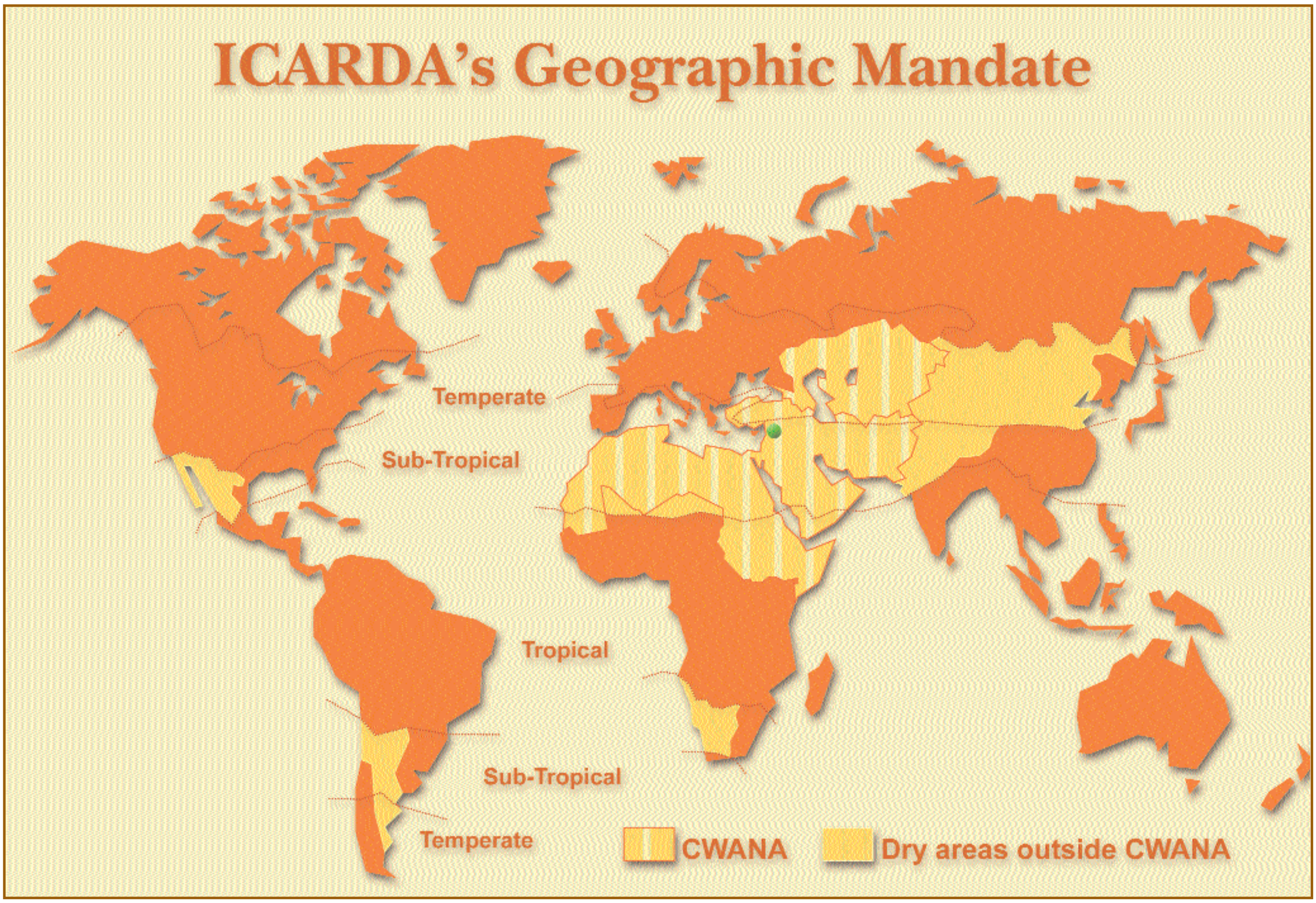
ICARDA's Research Portfolio

ICARDA developed a new strategy and initiated a project-based system in 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 web site (www.icarda.cgiar.org), the pages that follow present some key achievements made in each project during 2002.

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



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. These dry areas comprise five ecoregions, namely, the cool subtropics (with winter rainfall); the warm, seasonally dry subtropics (with summer rainfall); the highland subtropics; the seasonally dry tropics; and dry temperate areas. Algeria, Argentina, Bahrain, Chile, Cyprus, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Qatar, Saudi Arabia, South Africa, Syria, Tunisia and the United Arab Emirates are located in the cool subtropics; Botswana, Namibia, Nepal, northern Mexico, north-western India and Pakistan are located in the warm, seasonally dry subtropics; Afghanistan, Iran and Turkey are located in the highland subtropics; Eritrea, Ethiopia, Mauritania, Oman, Somalia, Sudan and Yemen are in the seasonally dry tropics; and Armenia, Azarbaijan, Georgia, Kazakstan, Kyrgyzstan, Mongolia, northwestern China, Tajikistan, Turkmenistan and Uzbekistan are located in the temperate dry areas.

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

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.

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." 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 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 the Agricultural Productive Capacity 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 will be investigated and institutional innovations that mitigate natural resource degradation and enhance collective action will be 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 more readily 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)	Total precipitation (mm) *	Long-term average (mm)
	Latitude	Longitude				
SYRIA						
Tel Hadya	36.01° N	36.56° E	284	948	404.7	343.7 (24 seasons)
Breda	35.56° N	37.10° E	300	95	340.0	269.1 (23 seasons)
LEBANON						
Terbol	33.49° N	35.59° E	890	23	516.6	529.1 (22 seasons)
Kfardane	34.01° N	36.03° E	1080	11	452.5	401.5 (8 seasons)

* For the 2001/2002 season

ICARDA's main research farm and headquarters (inset) at Tel Hadya, near Aleppo in Syria.

Theme 1. Crop Germplasm Enhancement

Project 1.1 Barley Germplasm Improvement for Increased Productivity and Stability

Farmers have grown barley for thousands of years, both for food and animal feed. Archaeological evidence suggests that barley was once more popular than wheat in North Africa. It had a reputation for being a 'strong' food, and was an important part of the diet of Roman gladiators—who were called '*hordearii*,' meaning 'barley-men.' Today, barley is widely grown for animal feed, and for making malt. It is still an important staple food, especially in regions of high altitude and low rainfall where many of the world's poorest people live. In 2002, participatory plant-breeding research provided valuable information about farmers' knowledge on genotype-by-environment interactions, in the risk-prone environments in which they farm. Using a novel pictorial technique, this research also helped farmers identify varieties suited to their localities. Progress was made in controlling the considerable yield losses caused by the Russian wheat aphid in Ethiopia, through the identification of promising, resistant lines. An efficient screening technique, using allele-specific PCR markers, was also developed, and could allow thousands of barley lines to be screened for BYDV resistance. ICARDA's nurseries have produced a number of lines suitable for use in Central Asia and Latin America. Collaborative breeding programs are currently testing and selecting the most suitable high-yielding, drought- and disease-resistant lines.

Farmers' conceptual knowledge

Participatory plant breeding (PPB) brings scientists and farmers together, and has the potential to effectively 'match' improved varieties with farmers' needs. However, the scientific basis of farmers' conceptual knowledge of plant breeding has received very little attention from researchers, even though this is the foundation of farmer-plant-breeder collaboration. This means PPB programs may often have to make assumptions that have not been empirically tested about farmer knowledge (FK) and its relationship to plant breeders' scientific knowledge (SK).

One common assumption is that FK and SK are fundamentally different; this defines the roles of farmers and scientists in PPB and limits the insights that scientists can gain through a greater understanding of farmers' conceptual knowledge—thus limiting the benefits that farmers can gain from PPB. Therefore, with funding from the US National Science Foundation, scientists from the University of California and ICARDA's farmer participatory barley breeding project successfully developed and tested a new technique for investigating both farmers' and plant breeders' conceptual knowledge, and the contribution such knowledge could make to collaborative crop improvement.

Efforts focused on the environmental scale for which crop varieties should be developed. Important to both parties, this decision relates directly to interactions between plant genotypes and their growing environments (GxE). It is commonly assumed that developed varieties should possess broad adaptation to a range of locations, thus increasing the impact of breeding efforts. But, such thinking also assumes the availability of inputs necessary to improve and equalize environmental conditions across locations. This may not be the case in the low-resource systems found in CWANA's variable, stress-prone environments. There, farmers often have to choose different varieties for different fields within a given planting season.

Farmers may observe qualitative GxE interactions (crossovers) in varietal performance between fields—i.e. that different varieties are performing differently in different locations. A farmer with two fields, for example, would then have to choose whether to grow one variety or two (one at each location). The decision will be reached by comparing the advantage obtained from growing two different varieties with the extra effort required.

Therefore, farmers were asked questions about the relationship between plant genotypes and environments. These were designed to probe the fundamental theoretical bases of plant selection and/or population choice from the perspective of farmers themselves. The results of these interviews were used to test the hypothesis that farmers have a conceptual knowledge of their crop populations and growing environments that, in part, forms the basis for their practices. The research aimed to discover whether farmers' knowledge can (a) provide insights into the fundamental design of breeding programs for their areas and (b) indicate issues requiring attention and empirical investigation.

Researchers interviewed 40 farmers in two villages (20 per village), which represented contrasting barley-growing environments in Syria: Barshaya in the north east (very arid and cold), and Mardabsi in the center (much less arid). Questions were based around scenarios derived from a basic biological model, which described the relationship between plant genotypes and growing environments. The scenarios considered three levels of spatial variation: (1) between locations/communities with contrasting growing conditions (including the farmer's own location); (2) among fields within the farmer's locality; and (3) within one, typical field at the farmer's location. Specifically, farmers were asked whether they thought the yields of two barley varieties—which originated in different and distant environments, but were exactly the same in all other ways—would be the same, or different, if they were grown in different environments. A rank change (in terms of yield) in response to the change in environments would indicate qualitative GxE interactions. Farmers were also asked about the potential for qualitative GxE interactions in response to annual variations in rainfall (temporal variation). The null hypothesis in each case was that farmers would not be aware of such interactions.

The results obtained showed that significant numbers of farmers believed that qualitative GxE interactions occur between locations. Between-location GxE interactions were anticipated by the largest proportion of respondents (63% overall), and within-field interactions by the lowest (16%). Moreover, results from Mardabsi showed that a significant proportion of farmers believed that temporal GxE interactions resulted from variation in rainfall (47% of respondents).

Which varieties farmers choose to grow in a given location depends both on average yield and on their perception of variation in yield (and income) over time for that location (temporal GxE). To clarify farmers' attitudes to the risks posed by qualitative temporal GxE, researchers asked which of two varieties would best suit them: a highly responsive variety (HRV), with high potential yields but high yield variance in variable-rainfall environments; or, a stable variety, with relatively low potential yields but higher yield stability. Simple visual aids were used to help both researchers and farmers when presenting and discussing the scenarios (Fig. 1a and b).

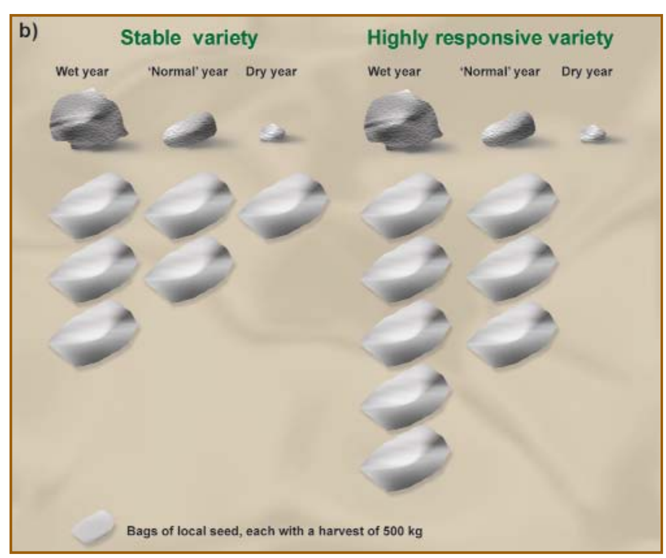


Fig. 1(a). Farmer Juri Aboud describing rainfall distribution and risk in her barley production, using stones of different sizes as visual aids. (b). Varietal yields in response to temporal environmental variation, i.e. year-to-year variation in rainfall.

Table 1. Farmers' estimations of rainfall distribution, experience of crop failure and choices between varieties that are highly responsive (HRV) or stable under temporal VE (annual variation in amounts of precipitation).

Community[a] (number of farmers interviewed)	Farmers' choice of variety (% of farmers)		Percentage of farmers choosing stable variety across communities	Farmers' estimations of rainfall distribution over time (% of years typically wet-'normal'-dry)	Percentage of farmers reporting having experienced crop failure
	HRV	Stable variety			
Syria (40)	48	52		30-40-30	51
Barshaya (D) (20)	25	75	71*	20-50-30	89
Mardabsi (F) (20)	70	30	29	30-40-30	15

a Barley-growing environment: D-'Difficult'; F-'Favorable'.
* Significantly higher than Mardabsi when tested with χ^2 test of null hypothesis that farmers would not perceive qualitative GxE interactions, $P \leq 0.05$.

Farmers' responses were nearly evenly divided between the HRV and the stable variety (Table 1). However, a significantly higher percentage in the 'difficult' environment (Barshaya) preferred the stable variety. More farmers in that environment had experienced crop failure (Table 1), although farmers' estimates of the proportion of wet and dry years were similar at both locations. The HRV represents a greater risk for those farmers who have few resources to rely on when insufficient rain leads to poor harvests. So, other potentially important factors not considered by this research also affect the decision to plant HRV or stable varieties. These require further investigation, and include the socioeconomic characteristics of households, social structure, community support networks, cultural values concerning risk, storage capability, and markets.

The findings of this research support the hypothesis that farmers have a conceptual knowledge of qualitative spatial and temporal GxE. The spatial scales considered important by farmers for varietal discrimination may indicate their receptivity to new material and the extent to which it may be used across a range of local growing environments. Overall, the methodology used appears to be a rapid, inexpensive way of eliciting, from farmers, knowledge which is both relevant to the basic assumptions of PPB projects and able to provide scientists with insights that can improve experimental design.

Specific adaptation: how specific?

Farmer participation has played a key role in the success of ICARDA's efforts to breed crops suitable for specific environments: the process of breeding for specific adaptation. While decentralized selection (selection in the target environment) is a powerful and effective methodology, it can still fail to achieve its objectives if farmers are not actively involved. Therefore, to maximize potential gains from its breeding efforts, ICARDA ensured that farmers participated in the process from the start, when the large base of genetic variability created by the breeders was, as yet, virtually untapped. Merging farmers' and breeders' knowledge of the crop proved to be extremely effective.

Results obtained in 2002 (from an ongoing project in four Syrian villages) demonstrate that, even within a limited geographical area, decentralized PPB can be very valuable when adapting a crop to a wide range of specific local environments (e.g. climate, agronomic management, soil type, depth and fertility). Data on the yields of barley varieties chosen by farmers and tested on farm in 2002 were analyzed, to assess genotype x farmer's field interactions. The resulting bi-plots (Fig. 2) were discussed with farmers in each village, in order to help them decide which lines they would like to test in further on-farm trials. Each village was characterized by both different levels of environmental stress and different management systems. The results of the study can best be illustrated by a comparison of the trial results from two of the villages (Mardabsi and Al Bab).

In Mardabsi village, four farmers each planted 20 different barley varieties for testing, plus a further two check varieties. Their barley yields were the highest of the four villages studied (4.4 t/ha on average)—a consequence of fertilizer use and the

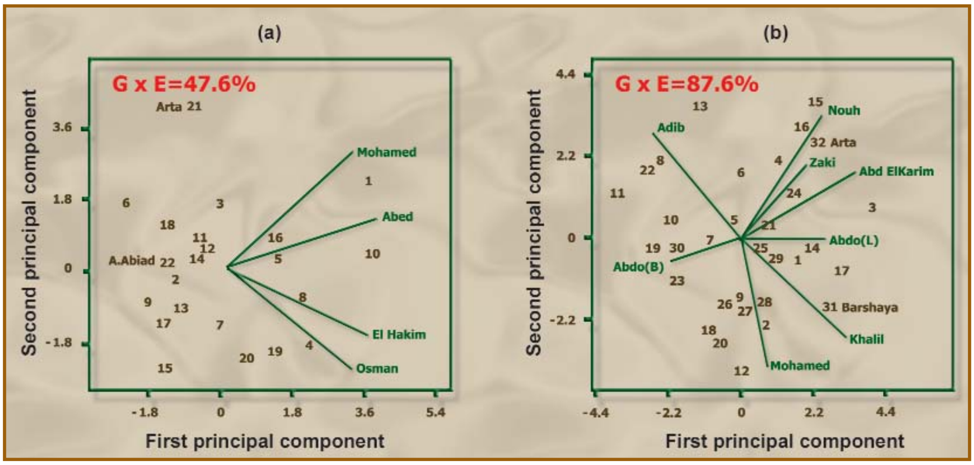


Fig. 2. Two contrasting bi-plots, based on barley grain yields, and representing genotype x farmer's field interactions in two Syrian villages: (a) Mardabsi and (b) Al Bab. Numbers represent breeding lines; 'Arabi Abiad', 'Barshaya' and 'Arta' are names of check varieties; vectors (solid lines) represent farmers' fields. At the origin (0,0), large angles between any two vectors, and between any two breeding lines, indicate large differences between farmers' fields and between genotypes, respectively. In (b) note the contrasting behavior of the breeding lines in the field of the farmer Abdo when grown after lentil (L) and after barley (B).

widespread use of barley in rotation with legumes (usually lentil) or cumin. Similarities in climatic conditions, soil type and management in Mardabsi were reflected in a genotype x farmer's field interaction which was slightly less important (47.6%) than the genotypic effects (52.4%). Under these conditions it was possible to identify lines which performed well in all farmers' fields (lines 1, 10, 8 and 4; Fig. 2a). Line 10 performed particularly well: it outyielded both the local landrace 'Arabi Abiad' and the improved cultivar 'Arta' in all the farmers' fields, with a yield advantage ranging from 19% to 42% over 'Arabi Abiad,' and from 1% to 37% over 'Arta.' In Mardabsi, because the genotype x farmer's field interaction was small, farmers chose the four lines that had performed well across all fields for further testing.

In Al Bab village, eight farmers each planted 30 different barley varieties for testing, plus a further two check varieties (Fig. 2b). In this village, farmers usually either crop barley continuously or in rotation with legumes. Interestingly, at the beginning of the PPB program, the farmers decided to test the breeding lines within these two different rotations, because they felt that each barley variety might perform differently under the two different rotations. In the trial, farmers' barley yields were low (1.2 t/ha, on average), a consequence of low temperatures occurring in the wet season. In contrast to the findings from Mardabsi village, the genotype x farmer's field interaction in Al Bab was found to be seven times more important (87.6%) than genotypic effects (12.4%). This was partly due to the effect of the different rotations used. Figure 2b clearly shows the difference between two adjacent fields cropped by one farmer, Abdo. Lines 19, 23, 10 and 30 were the highest yielding in the field previously cropped with barley (B); however, lines 3, 17 and 14 were the highest yielding in the field previously cropped with lentil (L). In this village, because the genotype x farmer's field interaction was so large, farmers chose the top-yielding lines from every field for further testing. These results demonstrate the value of quantifying GxE interactions and presenting them pictorially. They also demonstrate that participatory plant breeding can result in crops adapted to highly specific environmental conditions.

Progress in barley breeding for resistance to Russian wheat aphid in Ethiopia

Russian wheat aphid (*Diuraphis noxia*) is a major pest of barley in Ethiopia, where yield losses of 40-70% have been observed. Recognizing that host-plant resistance is the most economical and practical means of controlling the damage caused by this insect, scientists at ICARDA have focused on identifying, breeding and testing resistant lines of barley.

The sources of resistance available at ICARDA were tested for resistance to Russian wheat aphid (RWA) in aphid hot spots in Ethiopia. Six sources

Barley lines resistant (right and left) and susceptible (center) to Russian wheat aphid at ICARDA's main research station at Tel Hadya, near Aleppo, Syria.

of resistance (that conferred resistance to both the Syrian and the Ethiopian RWA biotypes) were crossed with nine Ethiopian landraces in 2000. The 20 F_2 populations obtained were planted at Tel Hadya in 2001, and artificially infested with RWA at the seedling stage. From these, 430 single F_2 plants were selected as being resistant. In 2002, F_3 seeds from each of the 430 selected F_2 plants were planted in progeny rows at Tel Hadya and artificially infested with RWA. In 2003, the F_4 seeds harvested from the 269 lines that were selected in 2002 will be evaluated in another cycle of selection for RWA resistance at ICARDA. The F_5 seeds harvested from the selected F_4 lines will be sent to Ethiopia for agronomic evaluation in different RWA-prone areas.

Advances in breeding for resistance to *Barley yellow dwarf virus* (BYDV)

ICARDA has developed a quick, effective method of screening for *Barley yellow dwarf virus* (BYDV), using allele-specific PCR markers. This could be used both to screen thousands of barley lines for BYDV resistance based on the *Yd2* gene and to identify resistance based on genes other than *Yd2.*

Resistant (symptomless) and susceptible (showing typical BYDV symptoms) plants in the F_2 populations, as well as selected resistant plants in the F_3 to F_5 families, were tested for the presence of the *Yd2* gene using the allele-specific PCR primers Ylp-MF (AAT ACA GGA ATC TGT TGA AAG AA) and Ylp-RAS (CTA GTA TCT CTG GCT CAG). In most cases, it was possible to amplify the *Yd2* gene in the resistant plants, but not in the susceptible plants (Fig. 3). Resistant, symptomless plants were strongly associated with the amplified *Yd2* fragment (88%). This association was stronger in the advanced (F_3 to F_5) lines (93%) than in the F_2 segregating population (83%).

These PCR markers are not only useful for identifying the presence of the *Yd2* gene in barley breeding materials, they can also confirm the absence of *Yd2* in BYDV-resistant barley germplasm.

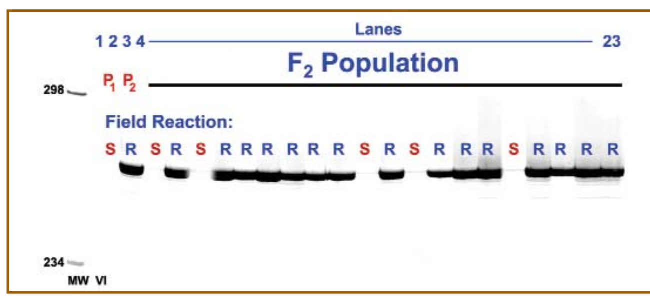


Fig. 3. PCR screening of F_2 populations segregating for BYDV resistance with allele-specific PCR markers. Top left: lane 1—size marker VI Roche; lane 2—P_1 Arbayan-01/CI07117-9/Deir-Alla, lane 3—P_2 Sutter//Sutter*2/Numar; lanes 4 to 23—20 individuals of the F_2 population of $P_1 \times P_2$.

Selection of BYDV-resistant barley plants continued in the F_2, F_3, F_4 and F_5 populations, and involved artificial inoculation with BYDV under field conditions.

Eighteen F_2 barley populations were inoculated and monitored on the basis of BYDV symptoms produced. The populations were derived from the crosses between three BYDV-resistant parents (Sutter//Sutter2*/Numar, Sutter*2/Numar//PI386540 and Lignee527/NK1272//JLB70-063) and 17 other parents adapted to different agroecological conditions in WANA. All plants exhibiting symptoms were eliminated. Seeds were only harvested from resistant, healthy plants. BYDV resistance in the F_3 progenies will be monitored during the coming growing season.

Five hundred F_3 single plant-progenies, selected from 40 crosses made in 1999, were planted during the 2001/02 growing season. Their reaction to BYDV, following artificial inoculation under field conditions, was then evaluated. All symptomless plants were selected and harvested. The seed of the resistans lines will be multiplied and distributed to NARS.

Five hundred and twenty-eight F_4 families, selected from 26 crosses made in 1998, were planted during the 2001/02 growing season. Their reaction to BYDV was then evaluated as above. Seeds from symptomless plants will be further evaluated during the coming growing season.

One hundred and thirty-six F_5 families, selected from 68 crosses made last year, were planted in 1-m rows and evaluated under field conditions. Most of the lines (such as 02F5-34-2, 02F5-45-1 and 02F5-65-2) exhibited a high level of resistance to BYDV infection, and gave higher yields than the resistant parent QB813-2.

In 2002, a large number of barley breeding lines also underwent preliminary screening for their reaction to BYDV. ICARDA evaluates the reaction of breeding lines to BYDV in three stages. Last year, breeding lines from a number of international nurseries underwent first-stage evaluation in short rows (30 cm), which permits the evaluation of a large number of entries. The preliminary evaluation of these 179 barley lines during the 2001/02 growing season identified some highly tolerant lines (Table 2) based on the severity of BYDV symptoms produced. These lines will be further evaluated in the second stage of evaluation, when they will be planted in 1-m rows and evaluated on the basis of disease score, biomass, grain weight and height.

During the 2001/02 season, small-plot (third stage) evaluations were also made of promising lines, such as 0F2-14-P1, 99F2-6-P2 and IBSCGP2000-18, found to be highly resistant to/tolerant of BYDV infection. As usual, these lines were the best performing lines identified during the previous two years (or stages) of evaluation. Planting in small plots (four 1-m rows) allows grain yield loss due to BYDV infection to be evaluated, by comparing infected plots with healthy ones—previous experience with cereal crops has shown that yield loss evaluation is the most reliable method of determining resistance to BYDV infection. The 2001/02 season trials found that, even though infected with BYDV, the grain yield of these lines was almost equal to that of the healthy control.

Table 2. Preliminary evaluation of barley genotypes in short rows (30 cm) for their reaction to BYDV infection after artificial inoculation with the virus during the 2001/02 growing season.

Nursery†	No. of lines tested	Lines with tolerance to infection‡
IBGP-02	110	1, 2, 8, 13, 34, 45, 51, 53, 74, 75, 79, 82, 90, 91, 94, 96, 97, 98, 103, 107
WBWSS-02	29	1, 3, 6, 12, 13, 16, 17, 18, 20, 21, 27
SBWSS-02	27	3, 10, 11, 25
BRWA-02	13	9, 10

† IBGP= International Barley Germplasm Pool for Disease
WBWSS= Winter Barley Nursery for Wheat Stem Sawfly
SBWSS= Spring Barley Nursery for Wheat Stem Sawfly
BRWA= Barley Nursery for Russian Wheat Aphid
‡ Evaluation was based on the severity of symptoms produced.

Collaborative barley improvement in Central Asia and the Caucasus

Over the last four years, barley breeders in Central Asia and the Caucasus (CAC) have identified promising lines which have been distributed by ICARDA through the International Nursery System. Many of them have been widely used in breeding programs, as sources of valuable traits and qualities. An example is the spring barley variety 'Mamluk.' Identified as a result of collaboration between ICARDA and the Krasnodar Research Institute, Russia 'Mamluk' was officially released in Armenia in 2000. The Armenian Government has purchased 1000 tonnes of seed of this variety from Russia for fast dissemination to farmers.

Over the last two years, Armenian barley breeders have selected four promising lines from ICARDA nurseries. These lines were tested in demonstration nurseries and in on-farm trials. All available seed (5-7 kg) was planted for seed multiplication.

Azerbaijan breeders have identified the promising new variety 'Baharly' from ICARDA's nurseries. The variety has, over the last three years, outyielded the local check variety ('Siklon') by 35-40%. Based on the results of these three-year trials, 'Baharly' was submitted for release to the State Variety Testing Commission in 2001. This year, Azerbaijan breeders produced 1.5 tonnes of 'Baharly' seed, all of which was planted, in fall 2002, for on-farm testing and seed multiplication.

Kazakstan is the largest producer of barley in the CAC region. In fact, before the country gained independence, the crop covered almost 7 million hectares. Most of Kazakstan's barley crop is spring barley, and is grown, for use as feed, in the semi-arid climate of the steppes under rainfed conditions (250-350 mm per year).

In northern Kazakstan, the rains normally fall in the spring. However, this is followed by periods of drought, leading to severe soil dryness—to a depth of 7-8 cm. Rain begins to fall again in the area in July. To avoid planting in dry soil, and also to protect seeds from drought stress during the booting period, it is recommended that barley be sown at a depth of 8-10 cm, either in mid May or at the end of that month. Two selected lines of spring barley ('Batir-1' and 'Batir-2') have been found to be well adapted to conditions in North Kazakstan. During three years of testing, these lines yielded 20-30% more than the control ('Akmolinskaya-25'). Based on the results of these trials, the two varieties were submitted to the official State Variety Testing Commission in 2002. Another new spring barley variety ('Birlik-1'), also for use in northern Kazakstan, was selected from the ICARDA nurseries in 2002. This variety outyielded the control variety ('Akmolinskaya-25') by 90-95%, and yielded 5.6 t/ha during the last two years of testing. Four hundred kilograms of seed are available for on-farm testing and seed multiplication.

In South Kazakstan, winter barley is grown, and the Kraniy Vodopad Breeding station is responsible for the improvement of this crop. Three winter barley (Aziret-114, Sultan-118, and Ortai-111) were selected from the ICARDA nurseries for testing in this region. Of the selected lines, Ortai-111 (CWB117-77-9-7//Hml-02/ArabiAbiad*2) demonstrated a high level of resistance to diseases, pests and lodging, and was found to be cold tolerant. It also produces particularly large kernels, with a 1000-kernel weight of 52 g. From each line, 200 kg of available seed were planted in the fall of 2002, for the purposes of seed multiplication and on-farm testing.

Efforts made by a collaborative barley program undertaken by ICARDA and the national breeding project in Kyrgyzstan have also resulted in the identification of new, promising lines of spring and winter barley. 'Adel' (MV46/Mazurka/3/Roho//Alger/Ceres), the best line identified, outyielded the standard check line, 'Osnova', by 20-25% in advanced yield trials. The 400 kg of seed available from this line will be tested in a wide range of environments in order to assess its level of adaptation.

In 2000/01, in Turkmenistan, local breeders selected three promising barley lines (Sonata, Alpha/Durra, Lignee 131) from ICARDA nurseries that were suitable for local conditions. Selection was based on the results of trials conducted in previous years. Over the last two years, these lines have shown advantages in terms of disease resistance, heat and drought tolerance, and productivity. Available seed from these barley lines was then planted for seed multiplication and testing in on-farm trials (Sonata, 0.18 ha; Alpha/Durra, 0.29 ha; Lignee131, 0.14 ha).

Uzbekistan's main breeding center for the improvement of barley under rainfed conditions is the Galla-Aral Branch of the Andijan Research Institute of Grain. From ICARDA's nurseries, breeders from Galla-Aral identified three lines of barley for use under rainfed conditions: Arizona 5908/Aths//Avt, 7028/2759/3/69-82//Ds/Apro/4/OP/Zy//Alger/Union 385-2-2 and Arar/Lignee527//Arar/Rhn. The lines demonstrated some advantages, in terms of disease resistance and heat and drought tolerance. They also outyielded the local check variety ('Lalmikor') by 60-65%. Three other lines (GkOmega/3/Roho/Masurka//ICB-103020, 73TH/105//E10BulkCI7321/3/CWB117-5-9-5 and Wieselbuger/Ahor1303-61//Ste/Antares, from IWBON02) were also selected for use in irrigated areas. In irrigated areas, these lines outyielded the local check ('Mavlona') by 7-10%. Available seeds from promising lines (3-5 kg per line) have been planted for seed multiplication.

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

Over the years, the CIMMYT/ICARDA durum project has made steady progress in breeding durum wheat for increased productivity, yield stability and grain quality. In 2002, major advances were made in identifying and genetically mapping both the quantitative trait loci (QTLs) which control two traits influencing the milling quality of durum wheat, and the QTLs that control protein content. In total, 13 QTLs were identified, and strong QTL x environment interactions were detected for protein content in particular. These QTLs will be used in marker-assisted selection for these traits, a process that is more efficient than conventional selection.

New QTLs for milling-quality traits identified and mapped

The grain of durum wheat (*Triticum turgidum* L. var *durum*) is used to produce economically important foods (such as pasta, *couscous*, and *burghul*). Therefore, grain qualities which aid in milling and processing are being selected for. To increase the efficiency of conventional empirical breeding efforts, the CIMMYT/ICARDA durum project has produced a genetic linkage map of durum wheat. In 2002, scientists focused on identifying and mapping quantitative trait loci (QTLs) for the milling-quality traits of test weight (TW, hecto-liter weight) and 1000-kernel weight (TKW). A high TKW is desirable for easy processing and milling; and, high TKWs and TWs are both associated with the production of high quality semolina.

CIMMYT/ICARDA Durum Wheat Breeder, Dr Miloudi Nachit (pointing to the screen) and his colleague score molecular markers linked to durum grain quality for use in the marker-assisted breeding program.

A special mapping population (Omrabi5/ *Triticum dicoccoides*600545//Omrabi5, referred to as MDM), derived from an improved durum variety ('Omrabi5') and a wild relative of wheat (*Triticum dicoccoides*), was developed in order to study grain quality. The backcross made with the durum variety resulted in recombinant inbred lines (RILs) which were agronomically suitable for multilocational testing, i.e. the 18 environments in which the population was subsequently grown. The markers used in mapping were microsatellites, amplified fragment length polymorphisms (AFLPs), and seed storage proteins. The mapping analysis identified 14 chromosomal groups and an unassigned group referred to here as g15.

Researchers found that the mean TKW of the RILs was, over all environments, 29.9 g, while the means for the parents ('Omrabi5' and *T. dicoccoides*600545) were 32.1 and 28.6 g, respectively. The chromosomal regions that control kernel weight were found to be on chromosomes 3B, 4B, and 6B; these regions showed QTL x environment interactions (QTL x E; Fig. 4). The major contribution to the kernel weight was made by two areas on chromosome 6B, linked to the markers Xgwm518 on the short arm and Xgwm582a on the long arm. The locus identified on chromosome 4B corresponded with the marker XMcttEagg213. Using regression models on the interaction peaks in 3B, two markers were selected as being the best contributors (XMctcEaag350 on the short arm and XMctcEagg84 on the long arm).

The five kernel-weight QTLs detected explained 32% of the total variation in kernel weight, 25% of it was due to genetic variation. The major QTLs were located around the centromeric region of 6B (28% due to genetic variation), whereas the other QTLs (on 3BS, 3BL, and 4BL) showed additive minor effects (Table 3). These findings agree with earlier studies which reported an intermediate to

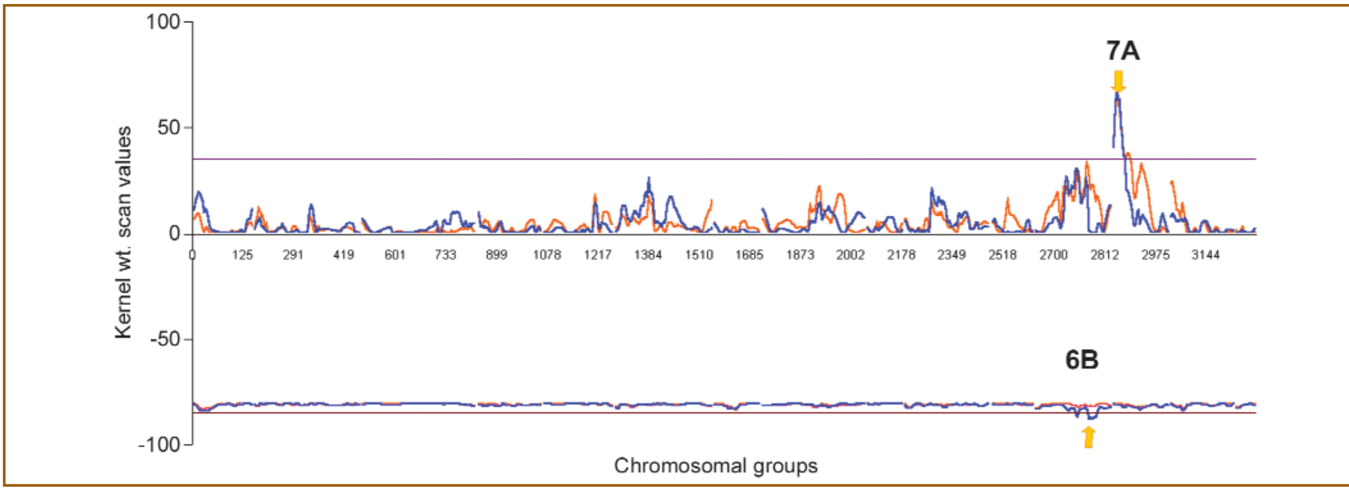


Fig. 4. Kernel weight scan for QTL main effect (top axis) and QTL x environment interaction (bottom axis). The 14 MDM chromosomes and g15 are shown from left to right (starting with short arm). Horizontal lines show thresholds with 5000 permutations. Arrows show positions of QTLs.

high heritability rate for TKW and indicated a high additive genetic effect.

'Omrabi5' alleles had a significant positive effect on the TKW trait (Fig. 4). In general, this positive effect was consistent across environments, especially through the QTLs on 6B. The QTL x E interaction effects of Xgwm582a and Xgwm518 were mainly due to changes in TKW values in different environments, whilst the QTL x E interactions of XMctcEaag350, XMctcEagg84, and XMcttEagg213 were due to crossover interactions.

The mean test weight for the recombinant inbred lines was 72.4 g (ranging from 66.6 g to 77.6 g), whereas the means for the parents ('Omrabi5' and *T. dicoccoides*600545) were 79.2g and 70.6 g, respectively. Test weights from all environments closely followed the normal distribution. The main chromosomal regions controlling the test weight in durum were found on chromosomes 7A and 6B. Across this 6B genomic region, Xgwm88a on 6BS was selected as the QTL for the test weight trait; this explained 9% of total variation in test weight. The other QTL identified for test weight—Xgwm60c on 7AS—explained 17% of the total variation observed. These findings are in agreement with earlier studies showing a high genotypic effect on test weight.

'Omrabi5' alleles had a consistent, significant and positive effect on the TW trait, with small magnitude changes occurring between different environments (Fig. 5). This positive effect was expected, as the wild relatives of wheat are known to have grains that are smaller and more shriveled than those of cultivated wheat.

Table 3. Detected QTLs for 1000-kernel weight (TKW) and test weight (TW).

Trait	Chromosomal Localization	QTL marker	cM	Vg/Vph	Vg + VQTLxE / Vph
TKW	3BS	XmctcEaag350	0	3	5
	3BL	XmctcEagg84	0	3	5
	4BL	XMcttEagg213	5	2	3
	6BS	Xgwm518	0	12	13
	6BL	Xgwm582a	5	20	22
Total* exp.				25 %	32 %
TW	6BS	Xgwm88a	0	9	9
	7AS	Xgwm60c	0	17	17
Total*				29 %	30 %

Vg = genetic variance; VQTLxE = QTLxE variance; Vph = phenotypic variance. *Total explained variation.

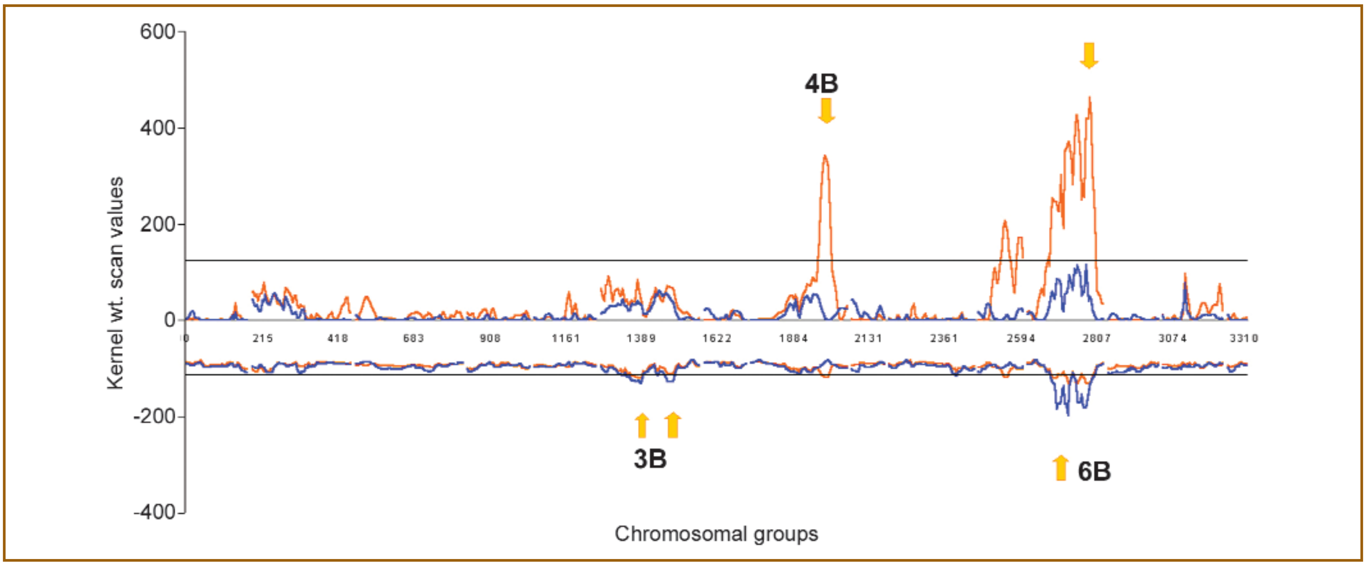


Fig. 5. Test weight scan for QTL main effect (top axis) and QTL × environment interaction (bottom axis). The 14 MDM chromosomes and g15 are shown from left to right (starting with short arm). Horizontal lines show thresholds with 5000 permutations. Arrows show positions of QTLs.

The fairly saturated genetic linkage map of durum, produced by the CIMMYT/ICARDA dryland durum breeding program, has confirmed both the usefulness of the two techniques used (SSRs and AFLPs) and their complementarities. Despite the backcross made to develop the population MDM, a high level of polymorphism was detected between the *T. dicoccoides* accession and the durum variety used ('Omrabi5'), suggesting a large genetic distance between them. The population Omrabi5/*Triticum dicoccoides*600545//Omrabi5, and the genetic map constructed by researchers, will be used as the basis for the future detection of QTLs linked to other grain-quality traits, as well as to other agronomic, physiological, and biotic traits. The mapping population may also be of help when assessing environmental impacts on trait expression, as it is already genetically fixed.

For TW and TKW, the QTLs determined here will be validated using populations with diverse genetic backgrounds and will be used in marker-assisted breeding. Consequently, researchers will be able to conduct selection at the genetic level, rather than having to rely on the phenotypic expression of these traits.

Protein-content QTLs and their interactions with different environments

Protein content is a major grain-quality trait controlled by a complex genetic system and strongly influenced by environmental factors. The major influences on grain crude protein concentration are environmental in nature (for example, rainfall and soil nitrogen levels). *Triticum dicoccoides*, a wild relative of wheat, is used as source of genes for high protein content, so this species was used to breed a specific mapping population (Omrabi5/*Triticum dicoccoides*600545//Omrabi5) for use in recent grain-quality studies. These studies—part of the CIMMYT/ICARDA Mediterranean durum program—aimed to determine the QTLs linked to protein content in durum, and to assess the QTL x environment (QTL x E) effect. A genetic linkage map for the mapping population was constructed using three types of markers: microsatellites, AFLPs, and seed storage protein components. The recombinant inbred lines (RILs) derived from the mapping population were planted in 18 different environments; their grain protein contents were measured at harvest.

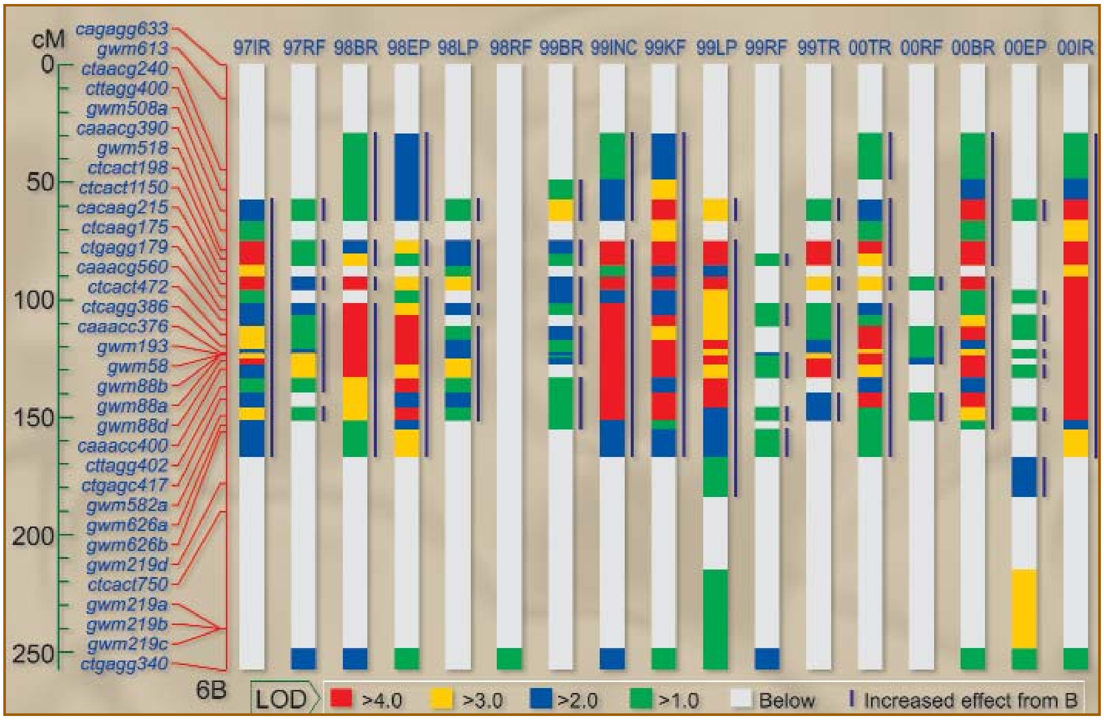


Fig. 6. QGene multiplot of protein content in the 18 environments studied, on chromosome 6B, based on a simple regression (LOD = Logarithm of Odds).

The mean protein content for the mapping population overall was 17.1%; individual values ranged from 10.6% to 23.5%. The RILs with the highest values exceeded the protein content of the improved durum variety 'Omrabi5,' which indicates the successful introgression of genes for high protein content into durum. With regard to QTLs, researchers identified two markers on 6BS: Xgwm518 and XMcaaEacg560 (close to the centromere). Two more protein-content QTLs were localized on 3BS (XMcttEaag140 and Xgwm154d) and one more on 4BL (Xgwm107). On chromosome 6A, b-gli69 (Gli-A2) was identified as having genetic and interaction effects. The six detected QTLs, in total, explained 27% of the total variation observed in protein content (Table 4). All the QTLs stemmed from *T. dicoccoides* and had a significant positive effect on protein content. The strong effects of the *T. dicoccoides* alleles and the different environments were large in magnitude (Fig. 6). The markers Xgwm518 and XMcaaEacg560 on 6BS each explained 14% of total variation, while Xgwm107 on 4BL explained 12%; XMcttEaag140 and Xgwm154d on 3BS explained 6% and 5%, respectively (Table 4). All QTLs showed QTL x E interaction effects.

Table 4. Detected QTLs for protein.

Chromosomal localization	QTL marker	cM	Vg/Vph	$V_g + V_{QTLxE}$ / V_{ph}
3BS	XMcttEaag140	0	5	6
3BL	Xgwm154d	5	4	5
4BL	Xgwm107	0	11	12
6AS	Gli-A2	0	4	5
6BS	Xgwm518	0	12	14
6BS	XMcaaEacg560	0	12	14
Total explanation (R2)			20 %	27 %

V_g = genetic variance; V_{QTLxE} = QTLxE variance; V_{ph} = phenotypic variance.

Because the most important genomic region controlling protein content was on 6BS, fine mapping is planned to saturate this region. In addition, because protein content is highly affected by environmental fluctuations, marker-assisted selection using protein-content QTLs will be more efficient than empirical selection.

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 person consumes more than 170 kg per year, the highest per capita consumption of wheat in the world. This dependence on wheat, combined with rapid population growth and increasing desertification, make this region the world's largest wheat importer. Poor farmers struggling to provide food for a growing population face formidable constraints, the foremost being the lack of water. Most of them depend on meager rainfall to grow their crops. Yields are low and the crop is attacked by a number of diseases and insect pests. Improved wheat varieties resistant to pests and diseases and tolerant to drought, along with techniques for efficient water management, are needed to boost wheat production.

West Asia is the birthplace of wheat and it remains a treasure trove of wheat wild relatives, which can provide resistance genes. Rapid breeding of these genes into high-yielding, high-quality wheat varieties will improve wheat production around the world.

In a concerted effort to address the wheat production problems in CWANA, Dr Masa Iwanaga, the new Director General of CIMMYT, based in Mexico, and Prof. Dr Adel El-Beltagy, Director General of ICARDA, organized a joint meeting of scientists from both centers in Cairo, 8-9 September 2002.

Mr Robert Havener and Dr Alex McCalla, ICARDA and CIMMYT Board Chairmen, respectively, were present. They both stressed the importance of the meeting in planning for future joint CIMMYT/ICARDA wheat improvement activities in CWANA. Senior scientists from both centers participated in the meeting. Dr Ronnie Coffman, from Cornell University and a former ICARDA Board Member, served as moderator.

The two centers committed themselves to a single CIMMYT/ICARDA joint program with renewed enthusiasm to increase wheat production in the different agroecologies of CWANA, with the goal of delivering sustainable wheat production technologies designed to improve rural livelihoods in the region.

A new screening technique for resistance to Sunn pest under artificial infestation

Sunn pest is a major insect pest of bread wheat in the cooler areas of Central and West Asia. Pest resistance has been elusive to date. A novel screening technique has been developed over the last three years, in collaboration with NARS partners in Syria, and is being used in artificial infestation trials. The test uses mesh screen cages (6 m x 9 m x 3 m), and is carried out in two stages (preliminary and advanced evaluation). In the preliminary screening, wheat entries are planted in hill plots at the usual fall planting time. Sunn pest

Wild relatives of wheat: susceptible (in the middle) versus resistant to Sunn pest.

adults are then introduced (at a rate of $6/m^2$) during the period when the insects naturally migrate to wheat fields. The parameters used in evaluating resistance are shoot, leaf and spike damage. In the advanced screening, wheat lines selected in the first stage are planted in rows 1 m long. A cage of uninfested plants is used as a control. Test plants are then infested (at a rate of 2 adults/m^2), again during the period when the insects normally migrate to wheat fields; later, the number of nymphs is adjusted to 8-10/m^2. In the advanced screening, the parameters used to evaluate resistance are the same as those used in the preliminary screening; in addition, the weight of 1000 kernels was recorded, and grain-quality tests were conducted. Several promising lines of wheat and its wild relatives have been identified. Germplasm with a confirmed resistance to Sunn pest will be used to develop resistant wheat varieties for use in Central and West Asia.

Industry Awareness

The joint bread wheat improvement program is placing a major emphasis on grain quality. In December 2002, CIMMYT and ICARDA co-hosted the first Lebanon/Syria Grain Quality Symposium bringing together millers, bakers, brewers and breeders for a one-day meeting at Tel Amara, Lebanon. The meeting was attended by more than 50 participants representing both private and public milling, baking and brewing enterprises. Not surprisingly, the focus of the user community was quality. The structure of crop subsidies in the Levant countries favors yield per hectare, with no premiums being offered by government purchasers for either protein content or milling or brewing quality. Nonetheless, discussions demonstrated that the private sector was willing and able to work around this problem, and would be willing to purchase high quality wheat at a premium from specific wheat producing communities. This brings a new dimension to participatory crop improvement research— not only encouraging producers to identify varieties based on production characteristics, but encouraging the user community to work with producer communities to identify varieties that fit both local ecological niches and end-user needs.

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

Yields of spring bread wheat have improved dramatically over the past 20 years, but production of winter and facultative wheat, grown predominantly in developing countries, has lagged behind. To redress the balance, the International Winter Wheat Improvement Project (IWWIP), a partnership between ICARDA, CIMMYT and Turkey's national agricultural research system, continues to develop improved varieties for use in CWANA. In 2002, disease-resistant winter and facultative wheat varieties were provided for use throughout the CAC region. Various new trials and demonstration plots were also initiated, to speed the transfer of this technology to farmers.

New yellow-rust resistant varieties

Cool, damp weather during the 2001/02 growing season, coupled with the large-scale cultivation of genetically susceptible cultivars, underlay the yellow rust (YR) epidemic which struck CAC in 2002. A positive outcome of the epidemic was that it made the NARS in CAC countries realize the urgent need to replace old and susceptible wheat varieties with new, high-yielding varieties resistant to YR. The development of disease-resistant wheat cultivars leads to higher grain yields and reduces chemical use, thus benefiting human health and the environment. A total of 7,500 winter and facultative wheat accessions were provided, through IWWIP nurseries, to all eight CAC countries during the 2001/02 season.

Wheat breeders from CAC countries and researchers from ICARDA and CIMMYT also collaborated both in the development and identification of promising lines and in ensuring fast seed multiplication and adoption at the farm level. This resulted in the development of several winter wheat varieties for use in CAC countries. In Uzbekistan, 'Dostlik' was released in 2002, principally for cultivation in five provinces, where it is expected to help improve the incomes of farmers, who previously had to rely on poorly adapted varieties. 'Dostlik' is early-maturing, drought and salt tolerant, and has good resistance to pests and diseases, especially yellow rust. It also requires less water and fertilizer.

Scientists from the Galla-Aral Branch of the Andijan Research Institute of Grain, Uzbekistan, have also identified two promising drought-tolerant winter wheat lines (8023.16.1/Kauz and Ok82282//BOW/NKT). Selected from the Project's nurseries, the lines exceeded the grain yield of the standard variety ('Sanzar-8') by 21% and 14%, respectively. Based on three years of research, the Scientific Council of the Galla-Aral Branch decided to submit these varieties to the State Variety Testing Commission in 2002.

Several wheat cultivars selected from the Project have been released or submitted for state variety testing by different CAC countries. 'Ruzi' was released in Azerbaijan; 'Nelly' and 'Agemen' in Kazakstan; 'Jamin' and 'Nilek' in Kyrgyzstan; 'Bitarap', 'Guncha' and 'Garagum' in Turkmenistan; 'Mtshetskaya-1' in Georgia; 'ATGF-2 (shark-6)' and 'ATGF-5' in Armenia; and 'Tacica', 'Norman', 'TAST/SPRW//ZAR', and 'Ormon' in Tajikistan. In Turkey, two promising lines—k82282//BOW/NKT/3/F4105 (irrigated), and Vee/TSI//Grk79/3/NS55.05/4/Suzen (rainfed)—were submitted for release. These lines have demonstrated both yield advantages and resistance to major diseases, especially yellow rust. Both show great promise, and will soon replace the yellow-rust susceptible varieties used in the region.

New on-farm trials and demonstrations

Swift introduction of a new variety requires seed multiplication, on-farm evaluation and the transfer to farmers of both the new variety and its production technology. On-farm trials and demonstrations are considered to be the most effective tools for testing new varieties under farmers' conditions. Thus, on-farm activities are to be continued and further supported by ICARDA. The Participatory Variety Selection (PVS) model has been found to be most applicable in CAC countries. Thus, farmers, or representatives of large farms, will be encouraged to play an active role in the evaluation and multiplication of selected lines and varieties that are candidates for release. Examples of previously tested lines are shown in Table 5.

Table 5. Grain yield (t/ha) of promising wheat varieties compared with local checks in on-farm trials in CAC countries.

Variety	Yield, t/ha	% of yield of local variety
Uzbekistan		
1- 'Dostlik'	5.7	124
2- 'Intensivnaya'[1]	4.6	100
Kyrgyzstan		
1- 'Jamin'	4.6	112
2- 'Lutescence'[1]	4.1	100
Turkmenistan		
1- 'Bitarap'	5.9	120
2- 'Guncha'	5.3	109
3- 'Garagum'	5.6	114
4- 'Skifynka'[1]	5.0	100
Azerbaijan		
1- 'Azametli-95'	7.1	132
2- 'Gobustan'	7.0	129
3- 'Ekinchi-84'[1]	5.4	100
Georgia		
1- 'Mtshetskaya-1'	5.0	141
2- 'Bezostaya-1'[1]	3.5	100
Armenia		
1- 'Ani-326'	4.9	116
2- 'Armyanka-60'	4.4	105
3- 'Bezostaya-1'[1]	4.2	100

1 Local checks

A winter wheat line selected from the International Winter Wheat Improvement Project nurseries and submitted for release in Uzbekistan.

During the 2001/02 growing season, on-farm trials and demonstration plots were set up in 24 locations, representing all the grain-producing zones of Uzbekistan. Variety testing, on-farm trials and field demonstrations of the identified lines and varieties will continue and will be supported by ICARDA and various NARS. Such on-farm trials will take into consideration the specific requirements of different CAC countries (such as the need for disease-resistant, early-maturing, and drought and cold-tolerant wheat varieties), in order to ensure increased wheat production.

Project 1.5. Food legume (lentil, kabuli chickpea, and faba bean) germplasm improvement for increased systems productivity

Chickpea, lentil, and faba bean are important food crops in CWANA. In addition to providing a major source of dietary protein (particularly for the poor), they play an important role in maintaining and improving soil fertility. In 2002, high-yielding, cold-tolerant varieties of chickpea were developed. Resistant to ascochyta blight, these varieties are suitable for winter planting. Researchers also identified ways to improve the efficiency of statistical analyses of variety trials, and conducted the first study of pathotype-specific resistance to ascochyta blight. Lentil research concentrated on producing winter-hardy varieties for use in the highlands. Lentil cultivars suitable for introduction into the CAC region and new lentil lines with combined resistance to a number of viruses were identified. Progress was made in improving the nutritional value of faba bean, by breeding new lines which contain low levels of an anti-nutritional factor and are resistant to ascochyta blight and chocolate spot disease. Finally, work on developing faba bean resistance to the parasitic weed Orobanche is in progress.

Two new chickpea varieties released in Syria

Chickpea is one of the most important cool-season food legumes grown in Syria, occupying about 90,000 hectares annually. It is traditionally grown in the spring (from mid February to mid March) using conserved soil moisture, which gives an average productivity of 670 kg/ha. However, the local, spring-grown landraces are susceptible to ascochyta blight—a devastating fungal disease which can cause serious damage if conditions favor the disease's development. Terminal drought can also cause serious yield losses and, sometimes, even near-total crop failure, as the crop is mainly rainfed. In Syria, late rains in the last three years (1999/2000 to 2002/2003) have favored disease development. This has caused serious losses in Syria's spring-sown crop, further highlighting the need for ascochyta-blight-resistant lines which would ensure successful chickpea crops.

In a cooperative effort, the Ministry of Agriculture in Syria (MOA) and ICARDA's researchers have clearly demonstrated that chickpea can make most efficient use of available water if grown earlier in the winter, producing almost double that of the spring-sown crop. However, for winter-sown chickpea to be successful, the cultivars must be ascochyta-blight resistant and cold tolerant, traits lacked by the traditional spring-sown chickpeas grown by farmers. To address this, a large number of cultivars were developed at ICARDA, and evaluated at various locations in Syria in collaboration with the MOA. Improved materials were identified as being both ascochyta-blight resistant and cold tolerant. Three winter-sown varieties ('Ghab 1', 'Ghab 2', and 'Ghab 3') were released (prior to 2002) by the MOA for cultivation in different areas in Syria.

One of the varieties ('Ghab 3') is both high yielding and more resistant to ascochyta blight than are local landraces. However, the seeds it produces are smaller. In the absence of an alternative, this variety is currently being grown by farmers. However, efforts are being made to address farmers' demand for larger seeds. Some new materials, which produce larger seeds than the three previously released varieties, have been developed at ICARDA. These were also jointly evaluated in Syria, using multilocation trials. Two improved cultivars (FLIP 93-93C and FLIP 88-85C) were identified and tested against 'Ghab 3' in two different on-farm evaluations in Syria. FLIP 88-85C pro-

H.E. Dr Noureddin Mona (center), Syrian Minister of Agriculture, visits a farmer's field near Aleppo in the company of ICARDA researchers and Syrian farmers and researchers, where a susceptible local chickpea variety was devastated by ascochyta blight.

duced a mean seed yield of 1603 kg/ha (Table 6)—3.8% more, overall, than the yield of 'Ghab 3' (the check variety). Although FLIP 88-85C exhibited little superiority over 'Ghab 3' in terms of seed yield and tolerance to ascochyta blight, it produced much larger seeds (35 g/100 seeds, compared with 29 g/100 seeds). This new cultivar (developed at ICARDA from a cross between ILC 629 and FLIP 82-144C) has recently been released for general cultivation in Zones 1* and 2* (except Malkieh) in Syria under the name 'Ghab 5'.

In another trial, FLIP 93-93C gave an average seed yield of 1792 kg/ha, 13.4% more than 'Ghab 3.' FLIP 93-93C also produced larger seeds (35.5g/100 seeds) and taller plants than 'Ghab 3,' and was more resistant to ascochyta blight. As a result, FLIP 93-93C was released by the MOA in Syria under the name 'Ghab 4' for general cultivation in Zone 1 and Zone 2 (except Malkieh). 'Ghab 4' was developed at ICARDA from the cross (FLIP 85-122C × FLIP 82-150C) × FLIP 86-77C.

The General Organization of Seed Multiplication (GOSM) is multiplying the seed of the two new varieties ('Ghab 4' and 'Ghab 5') for distribution to farmers. It is expected that 'Ghab 4' and 'Ghab 5' will be used by farmers in Syria very soon, as they produce larger seeds than those previously released, and are suitable for mechanical harvesting. Moreover, when these varieties are sown in winter, the crop can be harvested at least 2-3 weeks earlier than the traditional spring-sown crop. This will help farmers avoid the losses caused by terminal drought, which is becoming a common phenomenon due to global warming.

Table 6. Performance of two new cultivars, FLIP 88-85C and FLIP 93-93C against the improved variety 'Ghab 3' in Syria.

	Seed yield (kg/ha)							
Cultivars	**1994/95**	**1995/96**	**1996/97**	**1998/99**	**1999/00**	**2000/01**	**2001/02**	**Mean**
FLIP 88-85C	2693	1701	2137	898	1296	1065	1432	1603
'Ghab 3'	2420	1682	1964	837	1402	991	1514	1544
No. of locations	14	12	13	5	6	6	6	
		1997/98	**1998/99**	**1999/00**	**2000/01 Set I**	**2000/01 Set II**	**2001/02**	**Mean**
FLIP 93-93C		2166	2202	1941	1364	1429	1647	1792
'Ghab 3'		2121	1883	1823	1145	991	1514	1580
No. of locations		15	10	14	4	6	6	

* Zone 1: Rainfall between 350-600 mm and not less than 300 in 2 years out of 3
Zone 2: Rainfall between 250-350 mm and not less than 250 in 2 years out of 2

A new high-yielding and ascochyta blight tolerant kabuli chickpea variety, jointly developed by ICARDA and Syrian researchers, being demonstrated at El Ghab Research Station, Aleppo, by the Station Director to Syrian farmers on a Field Day.

Genetic dissection of pathotype-specific resistance to ascochyta blight disease in chickpea

Ascochyta blight is an economically important disease of chickpea, caused by the fungus *Ascochyta rabiei*. Although the fungus shows considerable variation in terms of its pathogenicity, the genetics of pathotype-specific resistance has not previously been studied in this plant-pathosystem. The chickpea landrace ILC 3279 is resistant to pathotypes I and II of the pathogen. In order to understand the inheritance of pathotype-specific resistance in chickpea, both Mendelian and quantitative trait loci analyses were performed using microsatellite markers and a set of intraspecific, recombinant inbred lines derived from a cross between the susceptible accession ILC 1272 and the resistant accession ILC 3279. Researchers identified and mapped a major locus on linkage group 2, which confers resistance to pathotype I. Two independent recessive major loci were also mapped on linkage groups 2 and 4, with complementary gene action conferring resistance to pathotype II. Of two pathotype II specific resistance loci, one was linked very closely with the pathotype I specific resistance locus, indicating clustering of resistance genes in that region of the chickpea genome.

Modeling spatial variability in chickpea trials

Chickpea yield trials are normally conducted using complete or incomplete block designs. Although carefully constructed block designs do control experimental error resulting from soil variability in field trials, considerable variability may still remain and can lead to biased estimates of the performances of the cultivars being evaluated. Spatial models have been found to be useful in terms of accounting for such variability in field trials of some crop plants. But analyses using various aspects of spatial variability have yet to be implemented in chickpea field-evaluation trials. Therefore, researchers examined the nature of spatial variability in chickpea field trials conducted at ICARDA's main research site at Tel Hadya, Syria.

Yield data from 39 chickpea trials, 34 of which used lattice designs, and 5 of which used randomized complete block designs (RCBs), were analyzed statistically, using 18 models. These models incorporated a range of spatial features described in terms of block structure, linear trends, and spatial errors. Researchers fitted all these models, selected the model most consistent with the spatial pattern in a given field and compared the efficiency of each selected model with the classical (RCB and lattice) models. The model which best described the data in a trial was used to compare the performance of the different genotypes.

Of the 34 lattice-design trials, 22 exhibited variable spatial patterns not accounted for by the lattice blocks. Interestingly, no single model was found suitable for all the trials. On average, classical lattice analyses exhibited an efficiency of 128% over RCB analyses (Fig. 7), while the spatial method gave an efficiency of 144%. The study thus indicated that the gain in efficiency based on spatial models increases with the heterogeneity of the experimental field. As examples, the efficiencies of the spatial models and lattices, and the ranking of the genotypes based on the block and the spatial models in two different chickpea trials (conducted during the 1998/99 growing season) are given in Table 7. It is evident that the ranking of the genotypes can change in cases where the spatial model shows a higher level of efficiency than the classical method. Therefore, we recommend that incomplete block layouts should continue to be used when planting chickpea trials, but in analyses, spatial models should be used to detect the presence of spatial variability, if any. The best model that accounts for spatial variability should be identified, and used in the analysis, in order to select the best-performing cultivars. This analysis adds value to the data ordinarily collected by making selection for yield more precise.

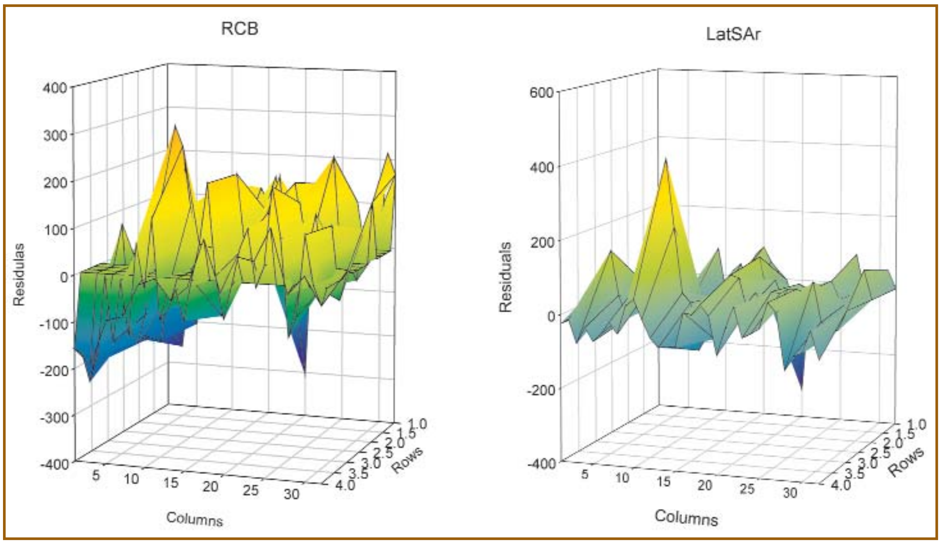


Fig. 7. Spatial variability patterns as exhibited by 3-dimensional graphs of the residuals from yield data from Trial 2 evaluated using randomized complete block design (left) and the 'best' model -- the lattice design with linear trend, random cubic smoothing spline and first order autoregressive errors in column direction (right). It may be seen that the best model accounts for the features of spatial variation in the field as reflected by the residuals indicating no pattern (right).

Winter Lentils: hope for highland farmers

In West Asia, lentil is traditionally grown in winter in the lowlands (<850 m a.s.l., with temperatures of about -10°C or below) and in spring in the

Table 7. The top 10 of 64 genotypes (G1 to G64) and their mean seed yields (kg/ha) selected using best spatial model in two trials conducted in 1998/99, and their respective ranks using lattice and RCB models.

a) Trial 1										
Genotype	G2	G13	G1	G20	G22	G44	G11	G41	G55	G50
Yield (in kg/ha, using spatial model)	1596	1540	1519	1516	1454	1445	1443	1437	1428	1425
Rank (Spatial model: 197% efficiency)	1	2	3	4	5	6	7	8	9	10
Rank (Lattice model: 103% efficiency)	1	2	3	6	4	14	13	18	7	8
Rank (RCB model)	2	1	4	9	6	13	14	16	5	7
b) Trial 2										
Genotype	G64	G15	G13	G63	G14	G29	G56	G17	G47	G1
Yield (in kg/ha, using spatial model)	1106	1083	996	914	880	841	770	748	699	680
Rank (Spatial model: 297% efficiency)	1	2	3	4	5	6	7	8	9	10
Rank (Lattice model: 267% efficiency)	1	2	3	4	5	6	7	8	11	13
Rank (RCB model)	2	1	3	7	4	5	8	6	17	10

Spatial: Randomized complete blocks with linear trend, random cubic spline and first-order autoregressive errors across the 'columns' in the layout of the trials in the field.

highlands, where winter conditions approaching -25°C are too severe for lentils. In the highlands of Afghanistan, Iran, Pakistan and Turkey, lentil is also normally grown as a spring crop, because of the severe winter cold. In these areas, ICARDA's major aim is to shift lentil production from spring to winter planting, to boost production and increase profits for farmers.

Research, in collaboration with national programs, has shown that lentil production can be increased significantly by shifting planting from spring (March-April) to early spring (February) or fall (October-November). The crop then benefits from winter rainfall and the fact that any moisture received during that period is less subject to evaporation, because temperatures are lower as the crop approaches maturity. This allows optimum vegetative growth and higher water-use efficiency. It has been estimated that about 400,000 ha of the spring crop could be replaced by winter lentil in the highlands of West Asia.

One might ask, "If the winter crop is so profitable, why haven't farmers tried growing lentil in winter before?" The answer is that farmers avoid winter sowing, because of heavy or total crop losses due to cold stress, weeds, and blight. ICARDA and the national program researchers have identified three elements essential for a successful winter crop: (1) cultivars which are sufficiently hardy, (2) weed control, and (3) resistance to ascochyta blight.

The first step in developing cultivars appropriate for winter planting is finding plants that can survive the harsh winter cold. ICARDA has a rich collection of cultigens and wild relatives (around 10,500). These include a number of collections from cold-prone areas. These accessions are the raw material from which ICARDA is breeding elite lines for winter cultivation.

In the highlands of central Anatolia, where lentil is grown as a spring crop on about 200,000 ha, mid-winter temperatures vary from -12°C to 30°C. Working with ICARDA, the Central Research Institute for Field Crops (CRIFC) in Ankara, Turkey released a number of winter-hardy varieties for use in the region. Three high-yielding winter-hardy varieties (providing a 30-44% increase over a check variety; Table 8) have recently been added

ICARDA and Turkish scientists evaluate the performance of 'Kafkas,' a high-yielding and winter-hardy lentil variety in Turkey.

to this number. All appear resistant to ascochyta blight. In addition, CRIFC researchers have identified many winter-hardy lines from ICARDA-supplied nurseries. These are now at various stages of evaluation, and some of them are undergoing advanced testing.

Table 8. Yield and cold-tolerance score of recently released winter-hardy lentil cultivars in Turkey.

Variety	Yield (kg/ha)	Cold-tolerance score*	% increase over local check
'Kafkas'	1705	1	42
'Ciftci'	1558	1	30
'Ozbek'	1730	2	44
Local	1199	7	-

* Scale from 1 to 9, where 1 = most hardy and 9 = highly susceptible.

Lentil is also an important crop in Iran, where it is grown on about 200,000 ha. However, productivity is poor (464 kg/ha). The major lentil-producing regions in Iran are East Azerbaijan, Ardebil, Khorasan, Zanjan, Ghazvin and Lorestan. In winter, temperatures can drop to -22°C. To date, the only variety released in Iran for early-spring sowing is 'Gachsaran' (ILL 6212), which originated from ICARDA material and has a moderate level of winter-hardiness. Some other winter-hardy lines (such as ILL 590, ILL 662, ILL 857 and ILL 975) are in on-farm trials. These lines have a high level of resistance to cold and fusarium wilt, and are free from ascochyta blight.

In the highlands of the Baluchistan province of Pakistan, lentil is planted in the spring and gives a low yield. To address this, scientists at the Arid Zone Research Center released 'ShirAZ-96,' a line for winter cultivation developed by ICARDA.

In Afghanistan, two moderately winter-hardy varieties ('ILL 5582' and 'ILL 7180') have been released, for early-spring planting, in the Herat, Balkh, and Takhar provinces. On average, 'ILL 5582' gives a yield which is 53% higher than that of local cultivars, whilst the average yield of 'ILL 7180' is 37% higher. Seeds of these varieties were supplied to Afghanistan.

In the Atlas Mountain of North Africa, where a moderate level of winter-hardiness is required in winter crops, newly released varieties are spreading fast. For example, farmers in Morocco have started growing 'Hamria' and 'Bichette' varieties, which are derived from ICARDA-supplied materials.

Obviously screening plants for winter-hardiness plays a major role in winter-cultivation development; the fast-growing field of biotechnology has a vital part to play in this. Research has shown that, although sufficient winter-hardiness is available in cultivated lentil germplasm, the genes conferring winter-hardiness must be bred into good lines (those bearing a host of desirable traits). Past progress was slow, due to the difficulties inherent in identifying and transferring winter-hardiness genes using traditional field screening methods. To remedy the problem, ICARDA is working (in collaboration with Washington State University, USA, and CRIFC) to identify and tag, using molecular markers, genes that confer winter-hardiness.

The inheritance study indicated that winter-hardiness is a quantitative trait controlled by many genes of small effect, with heritability estimates among the populations ranging from 15.9% to 90.7%. A recombinant inbred population was genotyped using AFLP, RAPD and isozyme markers and a genetic linkage map has been developed. The linkage map and phenotypic data used for a quantitative trait locus (QTL) analysis indicated that three QTLs were present, accounting for 33.4% of the phenotypic variation for winter survival. Markers flanking the QTLs are available for use in marker-assisted selection for winter-hardiness in lentil breeding.

Revival of a forgotten crop in CAC: Lentils

Old Soviet texts note that people used to use lentil as a food (mostly in soup), which indicates that it was once cultivated in that region. However, as a result of the monoculture of cotton, wheat, barley, and grapes, etc. dictated by government-controlled collective farming of the Soviet era, lentil became a 'neglected' crop. Later, it was entirely forgotten in the CAC region.

When Armenia, Azerbaijan, Georgia, Kazakstan, Kyrgyztan, Tajikistan, Turkmenistan and Uzbekistan gained their independence, they realized the importance of various other crops in food, feed and cropping systems. National programs in the region therefore launched, in 1998, food-legume research activities in collaboration with ICARDA. The need to include food legumes, including lentil, in the diets of people in the CAC region is made more pressing by an increasing lack of animal protein in their diet. Scarcity of animal feed also drives the need for higher straw production. The research

Azerbaijan scientists select elite lentil lines from international nurseries.

administrators, state policy makers, and scientists in CAC region have therefore included lentil in their "Crop Diversification Program."

With regard to identifying and releasing promising, elite lentil genotypes, some national programs have made commendable progress in a very short period. All activities related to food legume improvement are coordinated by the CAC-Legume Network, through ICARDA's Tashkent Regional office in Uzbekistan. Shipping of relevant genetic materials, the training of scientists, and the participation of ICARDA legume breeders in the planning/coordination meetings, joint field evaluations of test materials, and exchanges have formed strong bonds between the research communities involved.

Azerbaijan, Georgia, Kazakstan and Uzbekistan are at the forefront of the eight countries in the CAC region in terms of selecting promising lines of lentil, releasing varieties and making those varieties available to farmers.

In Azerbaijan, rigorous testing and evaluation of ICARDA-supplied germplasm in three contrasting environments (Absoyron, Jallabad and Gobustan) has identified the promising lentil line ILL 6037. This has now been submitted for release. Developed through hybridization at ICARDA, this breeding line is characterized by good seed quality (large, cream-colored seed), a better standing ability and a high biomass yield. It produced an average yield of 1.3 t/ha (compared with the 1.05 t/ha produced by local varieties). A number of elite lines have also been identified for further testing. One of them (ILL 8119) is 'in the pipeline' for release.

The Mtskheta Breeding Station of the Georgian Academy of Agricultural Sciences, Georgia, recently released a lentil variety 'Pablo' (ILL 759), which gives an average yield of 2.5-3.0 t/ha. Farmers appreciate the variety's higher yield, resistance to lodging and larger seed size, and it is now being cultivated in the Marneuli, Gurdjaani and Signaghi regions of Georgia. The Station is multiplying the seed of this and other varieties for large-scale on-farm demonstrations and for future distribution to farmers. The Station has also identified a number of promising lines for further evaluation. Among others, the lines ILL 8070 and ILL 7940 are candidates for future release.

In Uzbekistan, the Galla-Aral branch of the Andijan Research Institute and the Andijan Research Institutes of Grain Farming are involved in grain legume research. Galla-Aral has identified two promising lentil lines from ICARDA (ILL 7172 and ILL 7513) with an average yield of 1.1 and 1.2 t/ha. The higher yielding ILL 7513 has been proposed for release. Other bold-seeded lentil lines, (ILL 7943, ILL 7985, ILL 8066, ILL 4400, ILL 7946 and ILL 7940) have been selected from ICARDA nurseries in Andijan, and simultaneous seed multiplication of these elite lines is underway.

The Kazak Scientific Research Institute of Land Management has forwarded for release 'ILL 6434,' a large-seeded lentil line developed by ICARDA, for use in southern Kazakstan.

In Azerbaijan, Georgia and Uzbekistan, lentil lines haves been selected for autumn planting in areas with mild winters. The selected lines are moderately winter-hardy, surviving temperatures as low as -6 to -7°C on some research stations. Lentil is being selected for early-spring planting in southern Kazakstan. The success of these lines lies in the fact that the phenology of the materials developed at

'Pablo,' a high-yielding (3 t/ha) lentil variety released in Georgia.

ILL 7513 has been recommended for release in Uzbekistan.

ICARDA, Syria, matched the prevailing climatic conditions of the test sites. No disease or insect pests have been observed in these lentil fields so far.

Turkmenistan, Armenia, Tajikistan and Kyrgyzstan have begun to select promising lines from ICARDA-supplied nurseries for their own use. To date, about 1350 lines have been shipped to the region for evaluation and selection for local agroecological conditions.

Lentils with combined resistance to viruses

Lentil is affected by a number of viruses, the most important being those transmitted by aphids. Over the last decade, progress has been made in virus diagnostics at ICARDA and elsewhere, which has permitted precise identification and understanding of the distribution of such viruses in lentil-growing areas in the world. Although nine viruses have been reported to infect lentil in Syria, *Bean leaf roll virus* (BLRV), *necrotic yellows virus* (FBNYV) and *Soybean dwarf virus* (SbDV) are most commonly encountered and cause substantial yield reduction. In Syria, virus-related yield losses of up to 80% (BLRV), 70% (FBNYV) and 100% (SbDV) have been recorded. In a comprehensive screening effort, 191 lentil lines (originating from 14 countries and ICARDA breeding lines) were evaluated for their reaction to BLRV, SbDV and FBNYV.

Based on a symptoms score (SS), on a scale of 0 to 3, and yield loss (YL) in response to infection, the evaluated genotypes were grouped into: Highly resistant (SS = 0 and YL ≤ 1%), Resistant (SS = 1 and YL ≤ 10%), Moderately resistant (SS = 2 and YL ≤ 25%), and Susceptible (SS = 3 and YL > 25%) lines. The reactions of genotypes with combined resistance to viruses are presented in Table 9.

Of the lines tested, ILL 75 is resistant to BLRV, FBNYV and SbDV; ILL 74, ILL 85, ILL 213, ILL 214 and ILL 6816 are resistant to FBNYV and BLRV. ILL 74 and ILL 75 are landraces from Chile. ILL 85 was introduced from Tajikistan, while ILL 213 and ILL 214 were collected from Afghanistan. ILL 6816 is a breeding line developed at ICARDA from a cross between Indian (ILL 3527) and Ethiopian (ILL 5071) parents. The lines have been described in the journal Crop Science (vol. 41: 931-932, 2001) and will be useful in developing lentil cultivars resistant to a range of viruses. ICARDA's Germplasm Program is maintaining seed from these lines, small quantities of which can be made available to national programs on request.

Table 9. Reactions of lentil genotypes to artificial inoculation with three different viruses.

		Bean leaf roll virus			*Soybean dwarf virus*		*Faba bean necrotic yellows virus*			
Genotype	**Source**	**1997**	**1998**	**1999**	**1995**	**1997**	**1995**	**1997**	**1998**	**1999**
ILL 74	Chile	HR	R	R	MR	MR	R	R	R	R
ILL 75	Chile	HR	R	R	R	R	HR	HR	HR	R
ILL 85	Tajikistan	HR	R	R	S	MR	R	R	R	R
ILL 213	Afghanistan	HR	R	R	S	MR	R	HR	R	R
ILL 214	Afghanistan	HR	R	-	MR	MR	MR	R	R	-
ILL 6816	ICARDA	MR	R	R	S	S	R	R	R	R

HR = Highly Resistant; R = Resistant; MR = Moderately Resistant; S = Susceptible.
- = Not tested

Improvement of faba bean nutritive value

Faba bean is an important pulse crop, having the potential to contribute to world food supplies in a sustainable way. It is a major source of human nutrition in developing countries in WANA, China and Latin America, where it is part of the daily diet. In developed countries, by contrast, it is used as animal feed. Faba bean is also one of the cheapest ways to increase soil nitrogen levels (through biological nitrogen fixation) without causing pollution. Therefore, it is being used as a break crop in cereal rotation systems to sustain soil fertility.

Faba bean is widely grown throughout the world (covering 2.3 million hectares), though it is concentrated in temperate and subtropical climates. With regard to its production, 43%, 35%, 7%, 6%, 5% and 2% occurs in Asia, Africa, South America, Europe, Australia, and North and Central America, respectively.

Many studies have shown that faba beans have a low nutritional value due to the presence of anti-nutritional factors, particularly tannins. Experiments conducted on small laboratory animals (such as rats and chicken) have clearly demonstrated that the digestibility of crude protein decreases with increasing concentrations of the tannins contained in faba bean.

Tannins are present in the colored seed of faba beans, and form complexes with proteins, carbohydrates and other polymers in feed and food. Complexes are formed with proteins more easily than with carbohydrates, and thus reduce protein digestibility. Moreover, ingested tannins may form complexes with digestive enzymes, thus leading to decreased enzyme activity that may result in a decrease in the ability to digest nutrients. Tannins also damage the intestinal mucosa and interfere with mineral absorption, resulting in reduced growth and poorer feed conversion efficiency.

It is likely that removal of the hull or the use of a low tannin (white flower) variety of faba bean (such as 'Triple White') would significantly reduce anti-nutritive effects. This is indicated by studies which have confirmed that, while all the haemagglutinin activity of the bean is associated with the cotyledon, 60% of trypsin inhibitor activity is associated with the hull.

In order to address the above issues, lines with low tannin contents are being developed. In the 1996/97 cropping season, two groups of single crosses were made at ICARDA's Tel Hadya site. The first group comprised parents resistant to chocolate spot disease. The second comprised early-maturing parents from Egypt, Sudan, and Bangladesh, as well as from other sources available from ICARDA.

In the 1997/98 season, the F_1 of the first group was crossed with the F_1 of the second group. And the hybrid seeds of 22 double crosses ($F_1 \times F_1$) were raised in bulk in 1998/99 and 1999/2000, in the screen houses at Tel Hadya. In 2000/2001, the F_2 population was artificially infected with chocolate spot disease, in the screen houses at Lattakia (Syria) and individual plants with white flowers and an improved level of resistance to chocolate spot were selected. In 2001/02, the F_3 families were artificially infected with ascochyta blight under open-field conditions at Tel Hadya and in the screen houses at Lattakia (where natural and artificial infection with chocolate spot disease was implemented). Field evaluations were conducted, between and within the F_3 families, of disease resistance (along with different agronomic characters). The best tannin-free (white flower) families were selected (Tables 10 and 11) for further evaluation and seed multiplication, so that they could be shared with NARS. These faba bean lines will be useful in upgrading the quality of protein in the diets of people in the developing world.

F_3 lines of improved faba bean (right) with low tannin content (white flower and white or beige seed), compared to the local lines (flower with black spot and brown seed).

Table 10. Frequency distribution of selected F_3 families within different classes of chocolate spot disease infection, at Lattakia, 2001/02.

	Chocolate spot infection[1]					Mean infection score
	3	4	5	6	7	
No. of F3 families	1	8	21	7	2	5.0
(% of families)	(2.6)	(20.5)	(53.8)	(17.9)	(5.1)	
'ICARUS' (resistant check)		2	4			4.7
'Giza 40' (susceptible check)				2	4	6.8

1 Disease scale (1-9) where 1 = highly resistant and 9 = highly susceptible..

Table 11. Frequency distribution of F_3 families within different classes of ascochyta blight disease infection, at Tel Hadya, 2001/02.

	Ascochta blight infection[1]					Mean infection score
	3	4	5	6	7	
No. of F3 families		6	9	15	9	5.7
(% of families)		(15.4)	(23.1)	(38.5)	(23.1)	
'Ascot' (resistant check)	5	1				3.2
'Giza 4' (susceptible check)				1	5	6.8

[1] Disease scale (1-9) where 1 = highly resistant and 9 = highly susceptible.

Breeding faba bean for resistance to Orobanche

Orobanche (or broomrape), a parasitic weed, is one of the major biotic constraints to faba bean and lentil production. In the Mediterranean region, two species (*Orobanche crenata* and *Orobanche aegyptiaca*) cause high yield losses in both faba bean and lentil.

Around 65% of the area cultivated with faba bean in the Behera Governorate of Egypt's North Delta is estimated to be infested, causing yield losses of about 19,000 tonnes. Infestations extend to Middle and Upper Egypt, covering 18-86% of the total cultivated area and causing yield losses of 7-80%. In Morocco, the infested area is estimated to be 113,000 ha, causing yield losses ranging from 12% to 60%. Recent estimates indicate that 32.6% of the cropped area is infested, causing yield losses equal to US$8.6 million. In Spain, Syria, and Portugal, Orobanche is reported to affect about 50,000, 5600, and 13,500 ha, respectively. Moreover, the distribution of *Orobanche foetida* is expanding fast in Tunisia, badly affecting faba bean crops there. The parasite is also spreading to previously uninfected countries, such as Ethiopia and Sudan.

Orobanche attaches to the host plant and produces large quantities of extremely small seeds,

Orobanche-resistant faba bean lines (left), compared with a local susceptible check (ILB1814, right, killed) at Tel Hadya.

which only germinate under the influence of a germination stimulant. ICARDA has found that control of the parasite by agronomic and chemical means is difficult and uneconomical. Therefore, scientists are focusing on developing new faba bean lines resistant and/or tolerant to orobanche. During the last five years, many crosses have been made between locally adapted lines (from NARS) and resistant germplasm accessions (from ICARDA), to incorporate genes for orobanche resistance into high yielding gene pools adapted to WANA, Latin America and China. To develop lines that were resistant to a number of diseases as well as to orobanche, some crosses also included parents that were resistant to rust, chocolate spot and ascochyta blight.

The F_3 and F_4 families, along with other breeding lines, were compared with the local check cultivar (ILB 1814, repeated every 10 rows) and screened and evaluated (according to the pedigree procedure of plant breeding) under heavy, natural orobanche field infestation at Tel Hadya. The results showed a wide range of variability between and within tested populations. Over the last five years, 27 F_4 families have been developed (Table 12) from the different populations. All 27 possess resistance (an infestation rate of 1, as compared with the infestation rate of 5 exhibited by the local check, ILB 1814). The seeds of these lines are being grown as F_5 families, so that they can be further evaluated and shared with NARS next season (2002/03).

Project 1.6. Forage Legume Germplasm Improvement for Increased Feed Production and Systems Productivity in Dry Areas

Forage legumes (valued for their ability to provide high-protein animal feed, whilst simultaneously maintaining or improving soil fertility) are receiving increasing attention from scientists and farmers. Nutritious, high yielding vetch (*Vicia* spp.) and chickling (*Lathyrus* spp.) lines have been developed for use in different agroecological zones. Suitable vetch lines have been identified for use in low-rainfall areas of CWANA, whilst cold-tolerant vetches (with the potential to increase forage production at high altitudes) have been identified and distributed to farmers. Results from four years of testing have identified vetch and chickling lines well adapted to use on the alpine grasslands of China. ICARDA has also made advances in reducing the toxicity of grass pea, a drought-resistant crop which is an important source of food for the poor and feed for livestock.

Promising new vetch and chickling lines for CWANA

Livestock and human populations in the CWANA region are growing rapidly, increasing the pressure on the agricultural resource base. Severe feed deficits have triggered the replacement of the fallow-barley rotation system with continuous barley cropping in

Table 12. Number of Orobanche-resistant F_4 families (and orobanche infestation rates), selected at Tel Hadya (in the 2001/02 growing season).

Population	No. of F_4 families	Orobanche infestation score[1]	Pedigree
HBP/ DS0/ 2000	10	1	Improved population
HBP/ ES0/ 2000	2	1	Improved population
S 98012	3	1	Double cross
S 98013	3	1	Double cross
S 98019	3	1	Backcross
S 98020	5	1	Backcross
Sel/ Gz 4 / 2002	1	1	'Giza 4'
ILB 1814		5	Local check

[1] 1 = low infestation (i.e. highly resistant), 5 = high infestation (i.e. highly susceptible).

dry areas, and with increased cropping of marginal land. The agroecosystems of such marginal, low-rainfall areas are very fragile, and this unsustainable increase in the annual cropping of barley threatens to degrade and erode these delicate systems.

Forage legumes such as vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.), which also improve the soil, are essential if sustainable cropping systems are to be achieved in the dry areas. Recognizing the urgent need for feed legume crops adapted to such dry conditions, ICARDA is focusing on developing these crops in areas where the annual rainfall is 200-350 mm. As a result, during the past five years, ICARDA has made considerable progress both in identifying high-yielding, improved germplasm adapted to different agroecological zones and in breeding vetch and chickling lines with a high yield potential and a high nutritive value for use in grazing, hay-making, and grain and straw production.

Collaborative research between ICARDA and NARS has identified promising vetch lines for use in CWANA (Table 13). Each has a high yield potential, as well as more end uses and a greater nutritive value than local landraces. The new variety of common vetch 'Baraka' is non-shattering and so it does not appear as a weed in subsequent cereal crops. It gives both a high yield of biomass during winter and spring and a high grain yield at harvest (outyielding local landraces by 40%). The new variety of narbon vetch 'Velox' produced an average of 2.1 t/ha grain, and 1.4 t/ha of baled straw, in farmers' fields in Jordan and Syria.

In 1998, realizing the need for crop diversification, researchers, administrators and state policy makers in CAC initiated research into feed legume crops in collaboration with ICARDA. Since then, some of the national programs have made commendable progress in identifying and releasing promising, elite lines of vetch and chickling (Table

'Ali-Bar,' a grass pea variety released in Kazakstan.

Evaluating forage legumes in Georgia.

Table 13. Promising feed legume varieties and elite lines for CWANA rainfed agricultural systems.

Crop/line	Location	Used for
Vicia sativa ('Baraka')	Lebanon, Syria, Iraq	Grazing, grain and straw production
Vicia sativa #709	Morocco	Grazing, hay making
Vicia narbonensis #2380 ('Velox')	Jordan, Syria, Georgia	Grain and straw production
Vicia narbonensis #2383('Cyprum')	Cyprus, Syria, Jordan, Iraq, Iran	Grain and straw production
Vicia ervilia # 2520 (Amara)	Lebanon, Iran	Grain production and hay making

14). Efforts are now being made to transfer the technologies to farmers, in order to achieve an impact at farm level, and seeds from these lines are being multiplied for distribution to farmers.

Cold-tolerant vetches have the potential to benefit farmers in the highlands of Balochistan (Pakistan), and Afghanistan. In comparison with other forage legumes, woolly-pod vetch (*Vicia villosa* subsp. *dasycarpa*) is well adapted to high elevation, cold areas (because of its rapid winter growth, which is associated with cold tolerance). It produces a high biomass yield and is suitable for winter sowing. To rehabilitate the seed production sector in Afghanistan, seeds of the variety 'Kouhak-96' were multiplied at ICARDA's main research station at Tel Hadya. Three tonnes of this seed were dispatched to Afghanistan for winter sowing.

On-farm trials of narbon vetch in Syria.

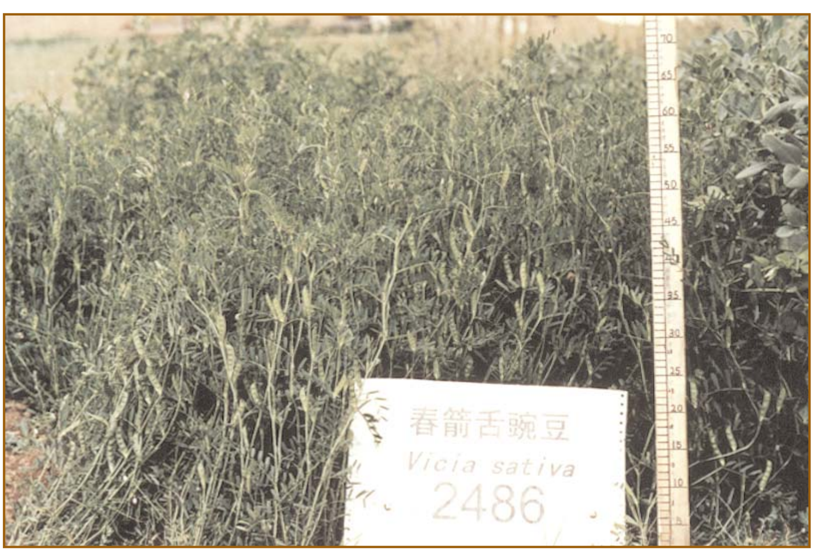
Table 14. Released variety and promising elite lines selected in CAC in collaboration with ICARDA.

Country	Released variety and promising (#) lines
Kazakstan	*Lathyrus sativus* 'Ali-Bar'
Azerbaijan	*Lathyrus sativus* # 481
Georgia	*Vicia sativa* #2556 *Vicia narbonensis* #2380 *Lathyrus sativus* # 377
Uzbekistan	*Vicia sativa* # 2628 *Lathyrus sativus* #562

Identifying vetch and chickling lines for China's alpine grasslands

Promising lines of vetch and chickling have been tested for a fourth growing season under alpine grassland conditions (which constitute approximately one-third of the total grassland area of China). A shortage of forage legumes (which would improve grassland and provide supplementary feed necessary in this harsh environment) is the main factor limiting grassland livestock production in China. In 1998, with the support of the Gansu provincial government, ICARDA began to evaluate and select promising vetch and chickling species.

Improved lines of *Vicia villosa* subsp. *dasycarpa, Lathyrus cicera, V. sativa, L. sativus* and *V. narbonensis* were tested at 3000 m a.s.l. in Xiahe county, Gansu province. This typical alpine grassland is



Vicia sativa Sel No. 2486, a promising line, being field-tested at Xiahe County, Gansu Province, in China.

250 km southeast of Lanzhou city, and has an annual rainfall of around 350 mm.

Twenty elite lines of each of the above species were tested. The mean herbage (DM) yields were 9.0, 7.4, 6.4, 5.6, and 3.6 t/ha, respectively, with *V. villosa* subsp. *dasycarpa* producing the highest herbage yield, followed by *L. cicera*. *Vicia narbonensis* had the lowest herbage yield. *Vicia sativa* and *V. narbonensis* also showed high levels of adaptation, with average grain yields of 1.04 and 1.07 t/ha, while the average seed yield of *L. cicera* was 0.8 t/ha.

The elite lines *V. sativa, V. narbonensis*, and *L. cicera* demonstrated high levels of adaptation and high yield potentials under alpine grassland conditions in China, and have been selected for further, large-scale tests in farmers' fields.

Reducing the toxicity of grass pea to safeguard the health of the poor

Lathyrus sativus, or grass pea (also known as *khesari* in India and Bangladesh, *guaya* in Ethiopia, *san li dow* in China, and *pois carré* in France) is a drought-tolerant crop popular in drought-prone areas of Africa and Asia. Grass pea is not simply an animal feed. When other crops fail due to adverse conditions grass pea can be used as a food source, especially by the poor, thus acting as a 'survival food' in times of drought-induced famine (as happened in Ethiopia in 2002).

Despite the obvious advantages grass pea has, relatively little effort has been made, until recently, to improve this very hardy crop. This is mainly because its seeds contain the neurotoxin 'β-ODAP'. This causes irreversible paralysis of the legs when grass pea is consumed as a major portion of the diet over a three-to-four month period. Despite this, grass pea is still produced in significant quantities in many countries (such as Ethiopia and Bangladesh).

Realizing the importance of this crop, ICARDA and the Ethiopian Agricultural Research Organization (EARO), developed a joint project financed by DFID to develop lines containing lower levels of β-ODAP and to improve on-farm management (helping to produce grass pea seeds safe for human consumption). As a result, promising low-neurotoxin, crossbred and soma clone lines have been developed. These have higher protein contents than local landraces, and much lower neurotoxin contents (only 10%-16% of that of the variety used locally).

In Ethiopia, test results indicated that delayed sowing increases the β-ODAP content of grass pea seed (Table 15). It was found that as soil moisture decreases the concentration of β-ODAP increases in the seeds. This suggests that combining low-neurotoxin lines with early-sowing regimes will reduce β-ODAP content to a level safe for both human and animal consumption. Currently, the effects of zinc applications and sowing dates on the neurotoxin content of improved lines are being studied at different locations in Ethiopia.

Testing a low-neurotoxin grass pea line on a farmer's field in Ethiopia in 2002, when the country was hit by a severe drought.

Table 15. Grass pea seed yield (t/ha) and β-ODAP neurotoxin content (%) of the seed, as influenced by sowing date at Debre-Zeit, Ethiopia, 2002.

Variety/attribute	Sowing date				
	Aug 10	Aug 25	Sept 10	Sept 25	Mean (Standard error)
Line B-520					
Grain yield (t/ha)	2.59	3.1	2.5	1.8	2.5 (0.53)
β-ODAP (%)	0.086	0.095	0.096	0.16	0.096 (0.015)
Ethiopian landrace					
Grain yield (t/ha)	1.7	1.70	1.5	1.5	1.62 (0.06)
β-ODAP (%)	0.41	0.45	0.45	0.58	0.473 (0.02)

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 insects 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 2002, ICARDA identified and released new sources of resistance to lentil vascular wilt, and continued to refine the use of promising, insect-killing fungi isolates as a means of controlling Sunn pest (an insect which attacks barley and wheat crops). A new screening technique was also developed to identify wheat varieties resistant to Sunn pest damage: several promising lines have already been identified. Yellow rust populations in the CAC region were characterized, identifying resistance genes with the potential to be effective throughout the region. Finally, research continued into the integrated management of chickpea chlorotic dwarf virus, barley leaf blotch diseases, Hessian fly in wheat, and ascochyta blight in chickpea

Integrated pest management in cereal and food legume crops

In CWANA, cereal and food legume production is severely affected by a number of diseases and insect pests. The most important of these are rusts; leaf blotch diseases (septoria, tan spot, scald, ascochyta blight, chocolate spot); viral diseases (BYDV, BNV); seed-borne diseases (smuts, barley stripe); root rot diseases (fusarium wilts, fusarium head scab); and insect pests (aphids, Hessian fly, Sunn pest, leaf miner, wheat stem sawfly). Research has focused on host-plant resistance, and several sources of resistance have been identified and utilized in the wheat, barley, lentil, faba bean, and chickpea breeding programs at ICARDA and in the collaborative NARS programs. The search for new sources of resistance is an important activity undertaken by the IPM project. Resistant sources, from the ICARDA breeding nurseries and gene bank, are provided to breeding projects annually, by the plant health group. Monitoring of pest biotypes/pathotypes and changes in virulence are a major concern, and ICARDA conducts annual surveys in collaboration with its NARS partners to address this.

The most effective way to maintain a low threshold of major pests and reduce crop losses is to implement an IPM approach. Therefore, biological control agents are being developed, and have shown promise in the control of Sunn pest (*Eurygaster integriceps*). IPM options (including selected cultural practices, host resistance, provision of high-quality seed, and limited use of pesticides) have also been successfully used by farmers to control Hessian fly (in Morocco) and chickpea ascochyta blight (in Syria). The following summaries highlight some examples of pest management, and show that pre-emptive control and avoidance of epidemics and subsequent crop losses could be achieved through well-planned and coordinated research, in close collaboration with NARS scientists and farmers.

New sources of resistance to lentil vascular wilt

Vascular wilt (caused by *Fusarium oxysporum* f. sp. *lentis*) is the most widespread and destructive soil-borne disease of lentil. Complete crop failure can occur in heavily infested fields when dry, warm weather prevails late in the cropping season. Efforts to identify new sources of resistance to this disease are a major aspect of ICARDA's lentil breeding and pathology program. During the 2002 cropping season, 1500 accessions from the lentil core collection, and a large number of breeding lines and wild relatives, were screened against the prevailing Syrian isolate of *F. oxysporum* in a sick plot at Tel Hadya, Syria. A total of 34 confirmed and stable


A lentil line highly resistant to fusarium wilt (left), developed at ICARDA, compared with a susceptible line (right).

sources of resistance, originating from 14 countries, were identified. Germplasm originating from the Mediterranean region had a higher incidence of resistant sources, as compared with accessions originating in countries at lower latitudes.

Resistant lines confirmed in four generations of the breeding cycle have been included in the Lentil International Fusarium Wilt Nursery, and will be distributed to different NARS as additional sources of resistance. Two lines (ILL 6994 and ILL 7201) were released under the names 'IDLIB 3' and 'IDLIB 4' by the Syrian Ministry of Agriculture in 2002, in view of their resistance to wilt and their agronomic performance.

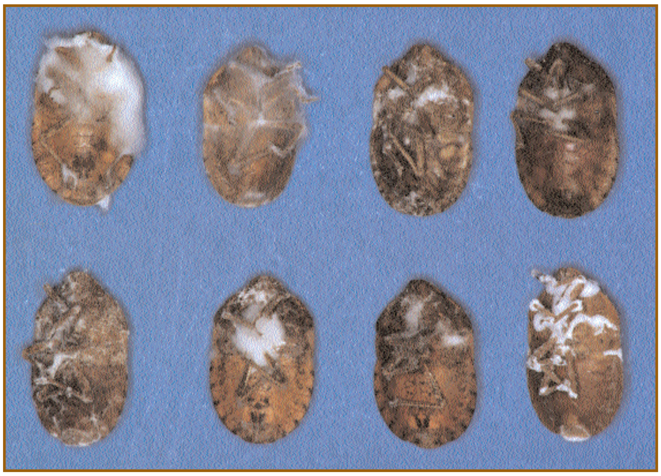
Innovations in Sunn pest control

Sunn pest (*Eurygaster integriceps*) is a serious pest of wheat and barley in the CWANA region, and contributes to both yield losses and processing problems. ICARDA and its partners are working on new control methods, and in 2002 conducted a number of relevant laboratory and field-based studies.

Field testing of promising insect-killing fungi

Scientists are now testing a promising new biological control method, involving natural enemies of Sunn pest—insect-killing fungi. Laboratory bioassays of fungi collected from Sunn pest populations across CWANA led to certain isolates being selected for testing in the field. Trials were then conducted to determine the effectiveness of introducing fungi to Sunn pest overwintering sites. Scientists found that significantly greater mortality resulted in plots treated with *Beauveria bassiana* and a *Metarhizium anisopliae* than in the controls. A high percentage of the dead insects in the treated plots were infected by the fungus with which it had been treated, strongly suggesting a significant role of fungi as biological insecticides.

Researchers also assessed the persistence of the fungal treatments applied to the overwintering sites. At all sampling periods (the day of treatment, and three, six and nine days after treatment) the fungi were observed to have had a significant effect on Sunn pest. Even after nine days, some of the treatments still showed an effect, indicating that the fungi can persist under dry, hot conditions in the field. Future plans include testing fungi formulated as nutrient-based and non-nutrient-based granulars, and making applications in both the fall and the spring.


Sunn pest adults killed by naturally occuring fungi.

Field trials were also conducted on wheat to assess the fungi's efficacy against Sunn pest when applied directly to wheat plants—the first trials ever of this kind. Based on mortality alone, no significant effect was observed as a result of the fungal treatments. However, based on an evaluation of the dead insects, researchers demonstrated that infection had occurred, under wheat-field conditions, in the treatment plots. For example, up to 49% of the Sunn pests from the *B. bassiana* treatments were infected with that fungus. Therefore, a slightly different experimental design is envisioned for next year, so that fungi can be applied more effectively, using an ultra-low-volume sprayer, to tall wheat plants.

Bioassays using fungal isolates from Iran

Using standardized bioassay methods for Sunn pest, both in litter and on plants, researchers tested several fungal strains isolated in 2001 at Iranian overwintering sites. In most cases, Sunn pest mortality was greater when the fungal isolates were applied to litter than when applied directly to plants (Fig. 8). Although the *Paecilomyces farinosus* isolates were not particularly effective, three of the Iranian *B. bassiana* isolates tested showed great potential for Sunn pest control. Additional isolates are available for testing in the coming year. This work was carried out in collaboration with the University of Vermont, and was funded by DFID and USAID.

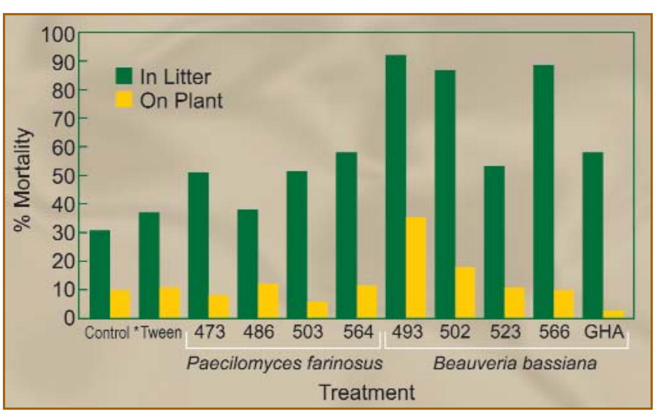


Fig. 8. Mortality of Sunn pest caused by isolates of two species of insect-killing fungus from Iran, when applied to leaf litter and to wheat plants (10 days after application of fungal isolates). *Tween 80 (monooleic acid).

Molecular characterization of promising fungal isolates

Detailed molecular characterization studies were conducted on promising isolates of *Beauveria bassiana* to investigate their genetic diversity. These were carried out as part of a DFID-funded IPM project on Sunn pest in West Asia, in collaboration with CABI Bioscience and the University of Vermont. DNA was extracted from a total of 112 isolates (106 of *Beauveria bassiana*, 5 of other *Beauveria* species and 1 of *Beauveria brongniartii*) obtained from surveys of Sunn pest and related insects. Four techniques were used: ISSR-PCR (Inter-Simple Sequence Repeat PCR), AFLP, restriction analysis of the ITS (Internal Transcribed Spacer) region, and ITS sequencing. The latter two methods did not detect genetic variation among the *B. bassiana* isolates. However, results from both the ISSR-PCR and the AFLP analyses clearly indicated genetic diversity among the isolates, and revealed some intraspecific groupings in the various geographical origins (Fig. 9).

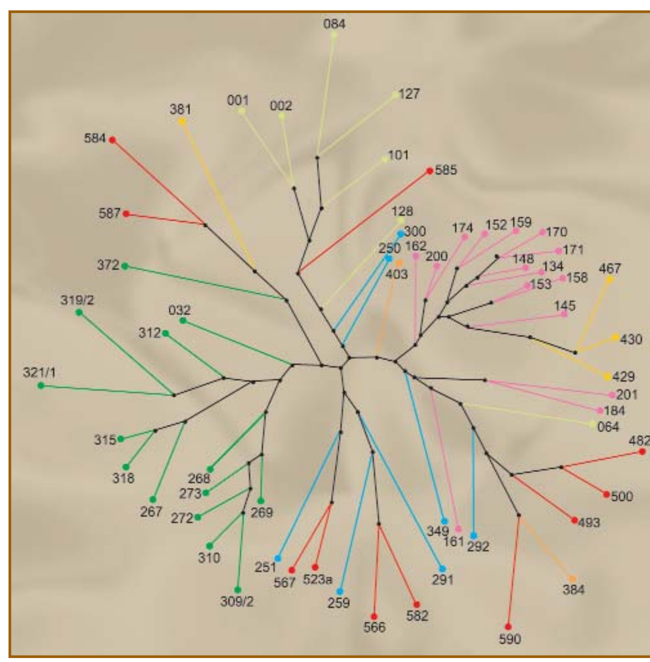


Fig. 9. Cluster analysis of AFLP banding patterns obtained from 112 isolates of an insect-killing fungus. Each country of origin was assigned a color: Iran (red), Uzbekistan (blue), Syria (dark green), Turkey (light green), Kazakstan (yellow), Kyrgyzstan (orange), Russia (light pink).

Status of yellow rust in Central Asia and the Caucasus region

Yellow rust (caused by *Puccinia striiformis* f. sp. *tritici*) is an important disease of wheat in most wheat-growing regions, including the Caucasus, West Asia, Central Asia, the Nile Valley and the Horn of Africa. In East Africa, the Middle East, China, the Caucasus, and Central and West Asia, yellow rust epidemics have caused severe wheat crop losses over the past decade. During the last growing season, at least 30-40% yield losses were recorded in major wheat-producing areas of Azerbaijan, Kyrgyzstan, and South Kazakstan. In Uzbekistan, however, over 60% of the country's wheat-producing area has been protected with fungicides.

Enhanced development and spread of yellow rust in Central Asia and the Caucasus can be attributed to three major factors: (1) environmental effects, (2) the nature of the cultivars employed, and (3) pathogenic evolution.

An example of the first factor is the yellow rust epidemic observed in Central Asia in 2002, which was exacerbated by extended periods of cool wet spring weather in regions that normally experience a rapid temperature increase during this period. Under such conditions of severe inoculum pressure, cultivar response to *Puccinia striiformis* f. sp. *tritici* (or *Pst*) was unexpectedly variable. Other environmental effects, which may also have an impact, include the development of irrigation facilities, and the expansion of wheat cultivation into fertile regions (such as the Fergana Valley in Tajikistan).

A limited number of cultivars (such as 'Yuna,' 'Steklovidnaya,' 'Spartanka,' 'Sanzar4,' 'Sanzar8,' 'Skifyanka,' and 'Mirbachir') are grown over large areas of the CAC region. These cultivars are highly susceptible to yellow rust, and therefore contribute to the rapid increase of the inoculum. The resultant high disease pressure also causes moderately resistant varieties ('Zhetysu,' and 'Polovchanka') to succumb.

The final factor underlying change in cultivar disease response is pathogenic evolution. It is possible that, in the CAC region, the evolution of *Pst* has followed a series of step-wise mutation events, including occasional reversions to virulence (this appears to have occurred in Tajikistan). It is also possible that genetic recombination has occurred in the *Pst* pathogen, in areas where the rust spores of different pathotypes (races) have been blown in by the wind from different regions (this seems to have occurred in Kyrgyzstan and Azerbaijan).

The yellow rust population in the CAC region consists of a number of pathotypes that differ in their pathogenicity toward the host plant. Some (such as 2E0 and 6E0) attack only two resistance genes in the host plant, others (such as 198E150, 230E150) can attack 11 identified genes in the host plants. In collaborative research conducted by ICARDA and NARS in the CAC region, yellow rust populations were characterized using two methods: (1) the Central Western Asia Yellow Rust Trap Nursery (CWAYRTN), planted at yellow rust hot spots in Azerbaijan, Uzbekistan, Kyrgyzstan, Tajikistan and Kazakstan, and (2) artificial inoculation at experimental stations in Syria, Lebanon and Turkey. By 2003 and 2004, respectively, the Absheron station in Azerbaijan and the selection station in Bishkek, Kyrgyzstan, will have the capacity to conduct artificial inoculation (allowing proper selection to be made under conditions of disease pressure).

Analysis of this collaborative research showed that most single resistance genes were defeated in at least one testing site in the Central Asia region, and that gene combinations offered better resistance. Of the 30 resistance genes available, only the following seven remained effective across the whole CAC region:

- YrSP and YrCV—available in facultative and spring bread wheat;
- Yr10, Yr3V and Yr3N—available in winter wheat;
- Yr5 and Yr15—available in wild relatives of wheat (*Triticum* spp.).

The level of resistance that Yr18 alone provides in adult plants may not be sufficient in environments highly conducive to yellow rust development. Even so, it may provide useful protection in terms of yield. Leaf tip necrosis, possibly a linked characteristic, may assist in the selection of plants possessing this gene. Combining Yr18 with other genes (such as Yr29 and the components of resistance found in a wheat variety such as 'Cappelle Deprez') could produce adequate and perhaps durable resistance in most environments.

The germplasm provided by the CIMMYT/ICARDA wheat program contains a high degree of genetic diversity in terms of race-specific genes that are currently effective in most CWANA countries. Though the diversity of yellow rust's population creates problems, more information is slowly emerging concerning both examples of durable resistance to yellow rust in wheat and the genetic control of such resistance. Evidence suggests that adequate levels of resistance could be obtained using a few additive genes, each having a small to moderate effect. However, improvement is still needed in the application of programs intended to achieve durable resistance to yellow rust in wheat. In the CAC region, surveys of pathogen populations and the genetic characterization of resistance continue to provide information valuable in the design of breeding strategies.

Integrated management of chickpea stunt in northern Sudan

Chickpea stunt, caused by chickpea chlorotic dwarf virus (CpCDV), is an important disease of chickpea in central and northern Sudan. In collaboration with the Agriculture Research Corporation, ICARDA conducted experiments at the Hudeiba Research Station in northern Sudan during the 1999/2000, 2000/01 and 2001/02 growing seasons. This research evaluated the influence of cultivar type ('Shendi' and 'ICCV-2'), sowing date (late October, early November and late November) and irrigation interval on the natural spread of CpCDV in chickpea fields.

Virus incidence was lower in cultivar 'Shendi' than in 'ICCV-2', regardless of the planting date used during the 1999/2000 and 2001/02 growing seasons. Delayed sowing reduced CpCDV incidence in both cultivars during all three growing seasons (Table 16). In fact, in one season, virus incidence was 93% in a crop of 'ICCV-2' sown in late October, but only 29% in a crop sown just 28 days later. Short irrigation intervals also reduced virus incidence during the 1999/2000 and 2001/02 growing seasons (Table 17). Therefore, the combined effect of partial resistance, delayed planting and irrigation at short intervals proved useful in CpCDV management in chickpea fields in northern Sudan.

Table 16. Effect of sowing date and cultivar on chickpea chlorotic dwarf virus (CpCDV) incidence and chickpea yield, Hudeiba, Sudan, during three growing seasons (1999-2002).

Growing season/ Sowing date	Chickpea cultivar 'ICCV-2' Virus incidence (%)	'ICCV-2' Yield (kg/ha)	'Shendi' Virus incidence (%)	'Shendi' Yield (kg/ha)
1999/2000				
25 October	93.1	177	17	770
22 November	29.2	721	5	1096
2000/01				
23 October	8.0	950	na*	na
6 November	5.6	1276	na	na
20 November	0.0	2050	na	na
2001/02				
29 October	28.5	875	6.1	1190
5 November	18.9	1005	6.2	1275
26 November	3.4	1116	0.0	2360

* na = data not available.

Table 17. Effect of irrigation intervals on Chickpea chlorotic dwarf virus (CpCDV) incidence at Hudeiba, Sudan, during the 1999/2000 and 2001/02 growing seasons.

Growing season/ Irrigation interval	Total no. of irrigations	CpCDV incidence (%) Chickpea cultivar 'ICCV-2'	'Shendi'
1999/2000			
10-day interval	9	8.5	0.02
20-day interval	5	39.4	0.90
2001/02			
7-day interval	11	10.2	1.7
14-day interval	5	27.6	2.8
21-day interval	4	26.8	5.1
28-day interval	3	46.9	9.2

Impacts of farmers' practices on barley disease control in Tunisia

Barley is cultivated mainly in the semi-arid regions of Tunisia. In these regions production is relatively low, and barley leaf blotch diseases cause significant yield losses. Therefore, ICARDA, in collaboration with Tunisian researchers, conducted a large-scale investigation, covering 1576 farmers' fields, to determine the association between disease severity, grain yield and cultural practices (which included the use of fungicides, fertilizer, and local and certified seed).

Scientists found that the main barley varieties grown in the region were 'Rihane' (76%), 'Manel' (14%) and 'Tej' (5%): local landraces made up 5% of the total. The predominant blotch diseases were scald (*Rhyncosporium secalis*) and net blotch (*Pyrenopora teres* f. *teres*), covering 87% of the area. Powdery mildew and leaf rust occurred at a lower frequency (28%). Farmers mainly used the fungicides Opus (Epoxyconazole), Tilt (Propiconazole), and Sportak (Prochloraz), and applied nitrogen (ammonium nitrate, 33.5%) and phosphate (Super 45-P_2O_5, 45%) fertilizers at rates that ranged from 15 kg to 200 kg/ha and 80 kg to 150 kg/ha respectively.

Fungicide treatments were applied more on small farms than on larger farms: 58% of farms less than 30 ha in size were treated, yet this figure was less than 15% for farms between 30 ha and 120 ha in size. The existence of a government assistance program, aiming to enhance cereal production by small farmers, explains this use of fungicides on small farms.

Over all farms surveyed, disease incidence (% of farms infected) was lower for fungicide-treated farms (33%) than for untreated farms (85%). Correspondingly, the mean barley yield for treated farms was higher (270 kg/ha) than the mean for treated farms (180 kg/ha). Fungicide use also effectively reduced disease severity (measured on a scale of 0-9) in barley fields in the surveyed area (Fig. 10). A leaf-blotch severity of 9 (the maximum possible) was recorded in 25% of untreated fields, while a further 38% of untreated fields showed a disease severity that ranged from 6 to 9. This range was observed in only 2% of the treated fields.

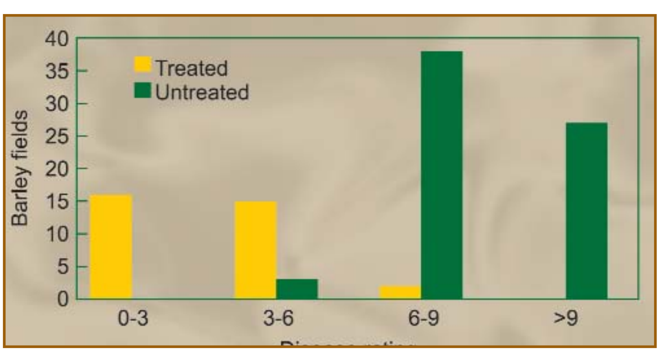


Fig. 10. Frequency of disease-severity scores in Tunisian barley fields, with and without fungicide treatments (0 = resistant; 9 = susceptible).

Table 18. Correlation coefficients for relationships among grain yield, disease incidence and fertilizer use for fungicide-treated and untreated barley fields in Tunisia (data from untreated fields in parentheses).

	Nitrogen	Phosphorous	Disease incidence	Grain yield
Nitrogen		NA	0.73**	0.26
Phosphorous	NA		0.79**	-0.66**
Disease incidence	(0.87**)	(0.82**)		-0.89**
Grain yield	(0.94**)	(0.90**)	(-0.87**)	

** = statistically significant at the 1% level.

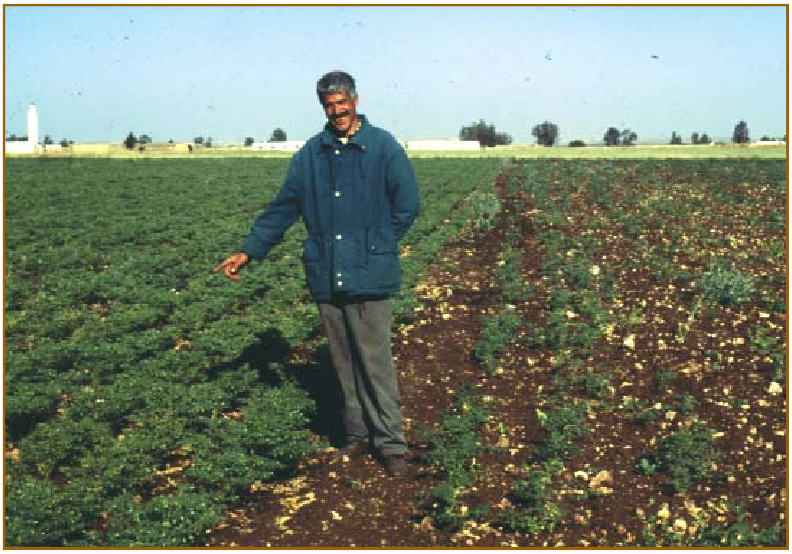
Also, significant positive associations were found to exist between disease incidence and fertilizer use (both nitrogen and phosphorus), with or without the use of fungicides; however, the associations were stronger in untreated fields (Table 18).

IPM in Morocco: testing bread wheat resistant to Hessian fly, and winter vs. spring sowing of chickpea

Funded by the CGIAR's Systemwide Initiative on IPM, the second year of the IPM Farmer Participatory Training and Research program was completed during the 2001/02 growing season. Each of the program's six sites (located in the Sidi El Aidi, Ain N'Zagh and Jemaa Shaim regions) tested the following IPM options:

- Two bread wheat varieties ('Aguilal' and 'Arrihane') resistant to Hessian fly, against a susceptible bread wheat ('Marchouch') using an early planting date.
- One resistant bread wheat variety (either 'Aguilal' or 'Arrihane'), against a susceptible one ('Marchouch') using a late planting date.
- Winter chickpea (early planting) vs. spring chickpea (late planting)—'Rizki' vs. a local landrace.

Through lead farmers, a number of farmers expressed their willingness to try some of the options offered last year. These farmers chose a number of good practices to implement (early seeding, weed control, and the use of adequate fertilization), as well as the bread wheat varieties resistant to Hessian fly and the winter chickpea varieties they wanted to grow. A considerable



Winter (left) vs. spring-sown chickpea in Morocco.

amount of help was given to them to seed their fields with the chosen varieties and learn from the experience. To aid in the latter, several small group meetings (timed to coincide with the seeding of the early-planting-date cereals and winter chickpea) were held in the field. Considerable interest was shown in the project, and the planting operations were themselves attended by a large number of farmers, and not only by the participating farmers. Many farmers were also present during the seeding of the late-planting-date cereals.

Figure 11 shows the decline in final yield in percent when comparing the different bread wheat treatments (pair by pair). The treatments combined cultivars susceptible or resistant to Hessian fly with early and late sowing dates. At an early sowing date, the susceptible cultivar yielded 14.5% and 30% less than the two resistant cultivars (Fig. 11, treatment comparisons T3/T1 and T3/T2). Late planting of the susceptible cultivar resulted in even greater yield loss (more than 70%), relative to the yields of the early-planted resistant cultivars (comparisons T5/T1 and T5/T2). In both susceptible and resistant cultivars, late sowing dates resulted in lower yields than early sowing dates, although the relative yield loss was smaller in the resistant cultivar than in the susceptible cultivar (comparisons T4/T1 and T5/T3). These results show that the use of cultivars resistant to Hessian fly in conjunction with an early sowing date would, under conditions similar to those of the experiment, increase final grain yield by more than 70%.

Chickpea yield could be significantly improved in the region by the adoption of winter chickpea technology, in preference to traditional spring planting. Recent trial results support previous findings, and illustrate the gains that can be achieved by using winter chickpea technology (i.e. improved varieties with resistance to ascochyta blight and cold, in conjunction with appropriate cultural practices). Early weed control, using either pre-emergence herbicides or early hoeing and hand weeding, is one of the main components of winter chickpea technology, as it reduces competition for limited water and nutrient supplies. Also, because winter planting of chickpea predisposes the plants to a higher level of infestation by weeds, unless there is adequate weed control, yields can be drastically reduced. The application of a pre-emergence herbicide resulted in an increase of up to 210% in the yield of winter chickpea (in one site). However, using pre-emergence herbicide raises some difficulties in terms of cost, timely application, and farmers' habits.

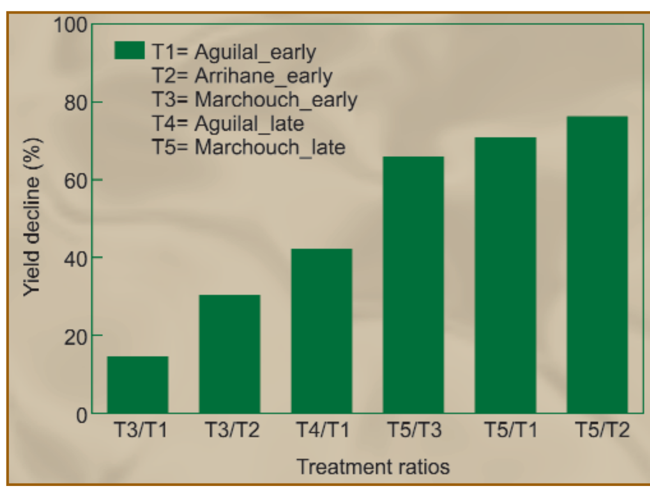


Fig. 11. Wheat grain yield decline among 'treatment ratios,' i.e. pairwise comparisons of yields in different treatments (T1-T5). Each treatment combines a cultivar that is either susceptible ('Marchouch') or resistant ('Aguilal' and 'Arrihane') to Hessian fly, with an early or a late sowing date. Results obtained from the IPM Farmer Participatory Training and Research Program in Morocco.

Project 2.2. Agronomic Management of Cropping Systems for Sustainable Production in Dry Areas

ICARDA has continued to address the key issues of fertilizer use, soil fertility, and soil degradation. The Center's partnership with the private sector representative IMPHOS has both considerably increased the knowledge base related to on-farm P use in WANA and provided a wide range of outputs, such as publications and conferences. Research into appropriate tillage systems has also continued, identifying and testing conservation tillage methods that conserve soil fertility, limit degradation, and benefit the environment by reducing erosion and encouraging carbon sequestration.

ICARDA's partnership with the private sector: the phosphate fertilizer industry

Soil fertility constraints and fertilizer use in the WANA region have been a major focus of ICARDA's research since its inception. In the mid-1980s, such activities were organized, in collaboration with the region's national programs, under the umbrella of the Soil Test Calibration Network. Though the project was mainly supported by the United Nations Development Program (UNDP), financial assistance to some countries (Morocco, Turkey, Tunisia, Lebanon and Syria) was provided by the World Phosphate Institute (IMPHOS), based in Casablanca, Morocco. This initial support (US$40,000) proved to be invaluable for the national programs, especially in conducting on-farm trials.

IMPHOS is a non-profitmaking organization that represents a group of the world's leading producers of phosphate rock (Morocco, Tunisia, Jordan, Senegal, Algeria, Togo and South Africa). Its primary mandate is to collect and disseminate scientific information regarding the rationale for, and sustainable use of P rock and fertilizers. IMPHOS has both Agronomic and Technical divisions. Its scientific activities are monitored by a scientific advisory committee composed of scientists eminent in the areas of agronomy, soil science, and the environment. A major part of its mandate is to financially support various fertilizer-related technical projects in developing countries, as well as conferences and publications.

Within a collaborative phosphate fertilizer project involving ICARDA (1997-2002), IMPHOS provided financial assistance (US$75,000 in total) to several of ICARDA's national partners (in Morocco, Jordan, Sudan, Yemen, Pakistan and Turkey) for applied P research. Examples of such programs include the following: the assessment of P-fertilizer use in relation to indigenous and introduced forage legumes, assessments of the interactions between P use and soil mycorrhizae, surveys of the spatial distribution of P forms in soils, field evaluation of N and P fertilizers, plant analyses for P, and nutrient budgeting. Assistance was also provided to support an M.S. graduate student. The project has already produced scientific publications and presentations, including two poster presentations at the American Society of Agronomy's meetings in 2001 and 2002, and journal articles.

Proceedings of two technical conferences funded by IMPHOS and ICARDA ('Accomplishments and Future Challenges in Dryland Soil Fertility Research in the Mediterranean Area,' held in 1995 and published in 1997, and, 'Plant Nutrient Management under Pressurized Irrigation Systems in the Mediterranean Region', held in 1999 and published in 2000) have been published jointly. A joint ICARDA–IMPHOS fertilizer guide for extension agents is now being prepared, and will be published in English, Arabic and French.

The ICARDA–IMPHOS project is an example of successful collaboration between an international research organization and a private sector organization which share a common objective—the promotion of agricultural output and food security in developing countries, in conjunction with the environmentally safe use of fertilizer.

Conservation tillage as an alternative to conventional deep tillage in the cropping systems of CWANA

Over the past few decades, CWANA's dryland farming systems have become more intensive. However, in many areas, arable lands are experiencing alarming rates of degradation, due either to inappropriate soil and crop management or to the impact of drought and/or erosion. Tractor use has spread to much of the region in the last 40 years,

Conservation tillage practice in Central Asia, Kazakstan.

and it is now common practice to plow to a depth of 20-30 cm every year, using a disc or moldboard plow—plows designed for use in more humid and temperate areas. Harrows or tyned implements are also used to prepare the seedbed. Regional scientists and farmers give various reasons for such deep plowing, including: the need to break up the cultivated layer, increased water and soil conservation (by preventing runoff), and weed control (through the deep burial of weed seeds).

Unfortunately, deep tillage is not sustainable in the CWANA region. ICARDA's research has shown that it causes the breakdown and loss of soil organic matter (SOM), and so increases loss of soil C in the form of CO_2—a greenhouse gas. These losses contribute to the reduction in yields that farmers are experiencing, to a reduction in soil fertility, and to soil erosion, water pollution and the greenhouse effect.

Therefore, ICARDA has been investigating the potential for alternative 'conservation tillage' practices (i.e. 'minimum tillage' and 'no-till' systems) to increase the sustainability of arable farming in CWANA. No-till systems involve drilling seeds directly into the ground; minimum tillage involves shallow cultivation, using tyned implements which disrupt the soil to a depth of only 10 cm (once or twice before planting), or direct planting using a tyned implement combined with a drill box. Both practices minimize soil disturbance and ensure the presence of a residue cover—an important consideration in WANA. Conservation tillage, particularly no-till direct drilling, considerably reduces C losses (relative to conventional tillage) by reducing C mineralization rates, because the soil is less disturbed and experiences little or no exposure to radiation. By contrast, in conventional deep tillage, moldboard plows turn over the deeper soil layers, bring them to the surface, and so expose a larger surface area to radiation. Indeed, five times more C is lost to the atmosphere under conventional tillage than under no-till practices. With careful management of the soil, as reported in the literature, the potential sequestration of C per year may reach 0.1-0.2 Mg/ha for irrigated cropland and 0.05-0.10 Mg/ha for both rainfed cropland and rangeland. This has the potential to mitigate the greenhouse effect. Thus, ICARDA, in collaboration with NARS, has conducted trials in six countries, to compare conservation tillage with conventional tillage systems, within the crop-rotation systems commonly used by farmers.

No-till direct drill equipment for sustainable management of soil.

Results of trials in southern Kazakstan showed that, at a depth of 0-30 cm, the SOM content of moderately washed-out soils fell from 1.37% to 1.30% in 10 years under conventional deep plowing. However, at the same depth in soil undergoing conservation tillage, SOM content remained the same, while conservation tillage, combined with NP fertilization and straw residue or manure application, increased SOM content to 1.5% during the same period. In Jordan, Morocco, Syria and Turkey, similar results have been obtained from trials in continuous cropping systems. In Syria in particular,

the no-till system increased SOM content by about 0.5% in the top 10 cm of the soil.

This has important implications, as high SOM levels lead to improved soil structure, increased water infiltration, and also increased soil water-holding capacity and water-use efficiency in crop production—valuable in the drought-prone areas of CWANA. Soils with higher SOM contents are also more fertile, having greater nutrient cycling and storage capacities, as well as greater biological activity and diversity. Thus, conservation tillage can both reduce the need for fertilizer inputs and increase farmers' yields sustainably; it can also reduce soil erosion.

Conservation tillage is also more energy-efficient than conventional deep plowing systems, offering savings of up to 12-18 liters of gasoline/ha. This also reduces farmers' input costs and improves their productivity, and can result in lower consumer food costs if appropriate policies are implemented.

From a practical point of view, the tools needed for the minimum tillage system are readily available to farmers in CWANA. However, for the no-till system, suitable drills would have to be manufactured locally. Further collaboration with NARS is planned with regard to no-till drill design and agronomic practices that can be used in conjunction with conservation tillage.

To realize the potential of conservation tillage, further socioeconomic studies are planned to document how land users are adapting their production systems to changing conditions where access to, and availability of, inputs are restricted. These studies will include analysis of short and long-term profitability, as well as of constraints to adoption and the effects of various sociological factors. ICARDA also plans to analyze current and future policy scenarios, in order to provide policy makers with the information necessary for policy development and implementation.

In 2002, CIMMYT and ICARDA conducted a symposium on 'Conservation Agriculture' at the Annual Meeting of the Agronomy Society of America. ICARDA scientists presented their findings on conservation tillage and direct sowing, illustrating the potential of these systems to improve crop production while safeguarding the local and global environment. To further its aim of promoting conservation tillage in the CWANA region, in 2002 ICARDA also contributed to a funding proposal, initiated by CIRAD-France, for worldwide comprehensive conservation agriculture.

Project 2.3. Improvement of Sown Pasture and Forage Production for Livestock Feed in Dry Areas

Introducing forage legumes into cereal crop rotations can have a number of benefits. In addition to providing nutritious fodder, soil fertility improves and cereal yields are maintained, resulting in a more sustainable production system. ICARDA recently completed a long-term collaborative study of the use of legumes in barley rotations in WANA. As a result, researchers have identified barley/legume rotations that increase crop yields and reduce weed problems. These were found to be agronomically efficient alternatives to unsustainable continuous barley cropping, in which yields declined. The higher yields of both grain and feed in the new rotations will greatly improve the net incomes of farmers in the region.

Barley/legume rotations for semi-arid areas of Lebanon

In the arid and semi-arid areas of WANA, continuous barley cultivation is increasing. In such environments, barley is the dominant winter crop, as it tolerates dryness, poor soils and salinity better than wheat, and usually gives a higher grain yield. Sheep husbandry and barley cropping are the most important agricultural activities in the region, and barley grain is the traditional, and most used, sheep feed. After the grain harvest, barley straw and stubble are also important feed sources in the summer. In years when barley production is poor, farmers often do not harvest their mature barley, but simply let their sheep graze the crop in the field instead.

Inadequate feed supplies and high feed prices are some of the main problems reported by farmers in the region, where the number of sheep and goats being kept has increased rapidly. The increased demand for feed has led farmers to grow barley continuously, rather than using their traditional barley/fallow rotations. Though this practice can provide short-term economic benefits, there are concerns regarding its long-term sustainability, as cereal monocultures can deplete soil nutrients and increase pest and weed populations, leading to reductions in yields and farmers' returns. A sustainable and productive option to replace barley monoculture is urgently needed.

Crop rotations have been widely used to increase the sustainability of farming systems, and the planting of legumes in rotation with cereals has been beneficial in many semi-arid areas. However, feed legumes have not been widely adopted by farmers in WANA. Therefore, in order to identify sustainable, more profitable, and more environmentally friendly alternatives to cereal monoculture, researchers from ICARDA and the American University of Beirut designed a long-term rotation trial in Lebanon. The objectives of the study were (1) to determine whether continuous barley monoculture is unsustainable, (2) to ascertain whether barley and total dry matter yields can be increased and sustained by including a legume crop in the rotation, and (3) to determine which barley/legume rotations are most productive. The trial was initiated, under rainfed conditions, in the 1994/95 growing season, at the Agricultural Research and Educational Center in Lebanon, in collaboration with the Lebanese Agricultural Research Institute (LARI).

Eight two-phase barley-based rotations were compared. These comprised barley in rotation with crops grown for their seed (lentil, common vetch, bitter vetch); crops grown specifically to be grazed *in situ* (common vetch, medics) and crops grown for hay (common vetch and common vetch mixed with barley). The eighth rotation, barley/barley, represented the continuous barley monoculture currently used by many farmers to produce seed (and straw).

In the barley monoculture, seed and straw yields began to decline after three years, because of infestation by wild barley, which could not be effectively controlled using herbicide. By contrast, wild barley did not infest barley grown after legumes, because it could be controlled by using herbicide during the legume phase. On average, over the entire period of the study (1994-2002), barley/legume rotations yielded between 41% and 80% more barley grain, and between 27% and 53% more barley straw, than barley grown in monoculture (Table 19).

Furthermore, in the legume phase, common and bitter vetch gave higher seed yields than barley grown in monoculture. Thus, all barley/legume rotations (except barley/medics) yielded more total dry matter than barley monoculture per rotation. Among the barley/legume rotations, the rotation of barley with common vetch (for seed) gave the highest and most stable dry-matter yield.

Because barley yield (including dry-matter yield) in barley monoculture declines due to a build-up of weeds, and because of the lower N content of the soil and the higher yield instability associated with continuous barley cropping, farmers in the northern

Table 19. Mean yields of barley grain and straw in different rotations during the 1995/96 to 2001/02 cropping seasons in the Beka'a Valley, Lebanon.

Rotation	Grain yield (kg/ha)	Straw yield (kg/ha)
Barley/barley	590	2010
Barley/lentil	1010	2620
Barley/vetch (s)[a]	1050	2800
Barley/bitter vetch	1060	3070
Barley/vetch (g)[a]	830	2800
Barley/vetch (h)[a]	1060	2850
Barley/[V+B]h[a]	970	2580
Barley/medics	850	2560
Mean	930	2660
LSD (p=0.05)	244	449

a (s): for seed, (g): for grazing, (h): for hay, [V+B]h: vetch/barley mixture for hay.

Left: A poor barley in continuous barley cropping. Right: A good barley crop after vetch.

Beka'a Valley, Lebanon, should discontinue barley monoculture and adopt a barley/legume rotation. Barley monoculture has been found to be unsustainable, but barley yields could be increased and sustained by including legumes in the rotation. Because of the higher yields they provide, the net incomes from barley/legume rotations would be much higher than those obtained from barley monoculture.

Project 2.4 Rehabilitation and Improved Management of Native Pastures and Rangelands in Dry Areas

In many dry areas of CWANA, increasing population pressure is causing changes in land use that are degrading the region's natural resource base and undermining the long-term well-being of the region's people. Agricultural encroachment and overgrazing are issues that ICARDA and its partners are addressing in several countries. Researchers working in Syria have now developed an innovative system in which barley is intercropped with saltbush—a hardy, drought-tolerant shrub which produces high-quality fodder. The system compared favorably with barley monoculture, traditionally used as grazing. Not only did the daily weight gain of sheep increase, but higher barley yields were also obtained. Progress has also been made in rehabilitating degraded rangeland and abandoned farmland in Syria, where water-harvesting pits have been successfully used to establish a number of native rangeland shrubs. Similar techniques are also being used to exploit the high production potential of Syria's wadis. Once revegetated, low-lying wadis could provide a key resource for agropastoralists in the region.

On-farm intercropping of barley and saltbush in Khanasser Valley, Syria

Barley is the dominant crop in the low-rainfall areas of WANA, where soils are very poor. However, because of low productivity and unreliable rainfall, it is usually used for grazing sheep rather than for harvesting grain. Rainfall in the area is sufficient to produce a grain crop in less than one year out of five: only when underground water is available for supplemental irrigation can a crop be harvested more frequently. Stubble is available for grazing only in those years in which grain is harvested.

However, crop residues are gaining ground as the main source of livestock feed in the dry areas of WANA. The most important of these is barley straw, which is usually grazed as stubble in the summer months. Over a period of 90 to 120 days, stubble grazing provides about 25% of the annual feed requirements of sheep and goats in Syria and Jordan. But, stubble has a low nutritive value, and is generally considered to provide an inadequate diet. In order to address this problem, ICARDA researchers working in the Khanasser Valley, near Aleppo, Syria have developed a new alley-cropping system, designed to produce high-quality fodder without decreasing grain production.

Alley cropping is a well-known technique in the subtropics where, for example, maize is grown in alleys between hedgerows of the leguminous tree *Leucaena leucocephala*. By cropping barley between rows of the drought-tolerant saltbush *(Atriplex halimus)*, researchers have adapted the system for use in the marginal zone of the Mediterranean Basin. Because saltbush (native to West Asia and North Africa) is both rich in protein and available in the dry season, the system will provide a high-quality diet for small ruminants while simultaneously protecting the soil and sheltering the associated barley crop. Therefore, the same piece of land satisfies both farmers' profit and subsistence needs.

Alley cropping in Khanasser Valley; barley is grown between rows of saltbush.

Khanasser Valley has an average annual rainfall of 200-250 mm. The system being studied there aims to improve both the quantity and the quality of the grazing that barley stubble provides for small ruminants in northwestern Syria. Nine farmers in the study area have participated in the study over the past four years. Their fields (ranging from 1 to 4 ha in size) were planted with saltbush in rows 10-m apart, at a density of 500 shrubs/ha. By the time they were ready for grazing (in the second year after planting) the shrubs occupied about 10% of the field.

It was found that barley yield (both grain and straw) was enhanced in the alleys between the saltbush rows (Table 20), which more than compensates for the 10% reduction in cropped area caused by planting saltbush. The average yield of barley (grain plus straw), expressed on an equal-area basis, was calculated to be 1313 kg/ha in the control fields, and 1614 kg/ha in fields with shrub hedgerows. What is more, in alley-cropped fields, saltbush foliage increased total forage yields by another 23.6%.

In interviews, farmers said the most valuable aspect of the intercropping technology was its alleviation of the negative effects of drought on sheep (because the shrubs provide forage during drought periods).

Farmers are, therefore, most interested in the protein-rich foliage of this shrub, which is available to sheep grazing barley stubble in the summer. In the alley-cropping system, daily intake of shrub foliage (calculated using pre- and post-grazing measurements of shrub biomass/ha) ranged from 46 g to over 500 g dry matter/sheep. The daily weight gain of sheep in shrub fields was almost 22% higher than in fields of barley stubble alone (Table 20). However, some of that extra weight gain may be associated with water retention—a response to the higher salt content of the sheep's shrub-supplemented diet. *Atriplex halimus* is a halophytic species that contains high levels of salt: shrub leaves sampled from three trial sites in the Khanasser Valley in 1999, for example, showed average sodium and potassium contents of 11.6% and 3.3%, respectively. Fuel is another benefit associated with the intercropped shrubs: three-year-old lightly grazed plantations yielded one tonne of woody material per hectare.

Barley–saltbush intercropping shows great promise in the marginal lands of West Asia. Perhaps one of the best indications of this is that farmers no longer participating in the research study have retained their saltbush hedgerows and continue to use the shrubs. One farmer decided to conserve his intercropped field for autumn feed—instead of grazing it in summer, as was done during the research trial. Another farmer rented out his intercropped field—after harvest—to a livestock producer for a higher price than his neighbor could obtain for a field of barley stubble alone. Presumably the presence of the shrubs among the barley stubble meant that the field was valued more highly in terms of grazing, the shrub being viewed as an *in situ* protein supplement.

Table 20. Production of barley and saltbush (*Atriplex halimus*) foliage (kg/ha), and daily live weight gain (g/head) in sheep, in barley fields with and without saltbush hedgerows, in the 2001/02 growing season in the Khanasser Valley, Syria (means of 2 trials).

	Barley monocrop (no hedgerows)	Barley with saltbush hedgerows		
		Yield (per ha of barley-growing area)	Results per field (area: 10% shrub, 90% barley)	% increase over barley monocrop on a per-field basis
Barley grain	626	698	628	0.3
Barley straw	687	916	824	20.1
Total barley yield[1]	1313	1614	1452	10.6
Saltbush foliage	0	na	171	na
Saltbush plus barley	1313	na	1623	23.6
Live weight gain	89	na	108	21.9

1Grain plus straw. 2 na: not applicable.

Reseeding severely denuded native rangeland

Extreme overgrazing and shrub collection (for fuel) have stripped many rangeland areas in Syria's steppe zone of nearly all their perennial and woody shrubs. The soil seed stock is depleted and, because the soil surface layer is usually crusted and resistant to water infiltration, seeds often fail to germinate. To address these problems, ICARDA conducted experiments on range reseeding and restoration in collaboration with the Aleppo Steppe Directorate.

Left: Pitting-Seeder for range reseeding, (a modified Camel Pitter from Kimberly Seed Co.)

The seeds of native shrubs were harvested and used immediately in a reseeding operation. Each species was seeded with a pitter-seeder, adapted by ICARDA for use in this system. This machine dug and placed seeds into water-harvesting pits in a single operation; a total area of 87 ha was planted with various species. Of the species studied, *Salsola vermiculata* exhibited the best level of emergence in the first year, in terms of number of seedlings, followed by *Artemisia herba-alba* and *Atriplex halimus* (Table 21). Plant numbers stabilized after two years.

Table 21. Survival, over five years, of seedlings of three range species seeded by the pitter-seeder (expressed as the mean number of seedlings that had emerged and survived in 100 x 20-cm quadrats) at Obissan range station, Aleppo steppe.

	Survival		
	Salsola vermiculata	*Artemisia herba-alba*	*Atriplex halimus*
April 1998	30.4	18.4	0.6
July 1998	24.0	15.2	0.3
July 1999	2.8	5.7	0.1
July 2000	2.3	5.1	0.1
July 2001	2.8	4.8	0.1
July 2002	3.0	4.7	0.1

Re-establishing rangeland vegetation on abandoned farmland

Government policy in the Syrian steppe prohibits the cultivation of land, including wadis, below the 200 mm rainfall isohyet. Since the implementation of this law in 1995, former barley-farming areas have become infested with weeds. Moreover, in parts of Jordan and southern Syria, rainwater has sealed the surface soil of broad wadis, causing shallow lakes to form. This leads to water being lost by evaporation and reduces the chances of a successful harvest. The communities in these areas are also threatened by restricted access to other natural resources and instability of household incomes; many households now perceive emigration to the cropping zone to be their only long-term option.

ICARDA's Range and Forage team with a truckload of seedlings for planting on the Syrian steppe.

However, the broad wadi basins remain the sites with the highest potential, in terms of crop and forage production. They have deeper, more fertile soils than the upland rangelands, while the rainwater they receive is actually double or triple that provided by actual rainfall in the area, a result of run-on water from the surrounding catchment. Historically, these key resource areas have sustained the steppe communities. However, forage productivity remains very low because native vegetation has not returned to these abandoned fields, even after seven years. Reseeding of these areas is a measure often necessary to make them productive again.

Overall, the study aims to improve the forage productivity of the high-potential, low-lying (HPLL) wadi basins in the semi-arid zone of Syria, making them available for use by pastoralists and agro-pastoralists on a sustainable basis. Largely ignored by development programs since barley farming was banned, these high-potential sites have fallen into various states of degradation. The specific purposes of ICARDA's project are to test the value and acceptability of multipurpose perennial vegetation as (1) an alternative to barley cultivation or land abandonment and (2) a method of restoring the productivity of HPLL areas, whilst simultaneously mitigating soil erosion and ecological deterioration.

The first step taken in achieving the study's goals was the collection of 75 perennial forage species, which were then assessed in terms of their suitability for use in re-establishing vegetation on the abandoned farmland. From this array of species and ecotypes, a subset was chosen for establishment trials at field sites. In collaboration with the Aleppo Steppe Directorate, and with the British Embassy funding, three field sites were established on 15 ha in the dry zone in which barley cultivation has been banned. Eight thousand perennial shrub and grass seedlings (grown in the ICARDA nursery) were transplanted into rows perpendicular to the direction of the prevailing wind. Direct-seeding of perennial forage species will take place next fall, by broadcast-seeding between the rows and into water-harvesting pits created by a pitter-seeder.

Project 2.5. Improvement of Small-Ruminant Production in Dry Areas

ICARDA is helping small-scale farmers in CWANA to cope with the challenges of their traditional production systems. These include a significant decline in rangeland productivity in Central Asia, which has been exacerbated by droughts, and reduced market opportunities for traditional products. At the same time, opportunities are offered by the development of potential new markets for non-traditional products. To improve productivity, research has focused upon both plausible marketing options and the use of alternative fodder sources to cope with feed shortages in the rangelands. In 2002, studies in Uzbekistan and Turkmenistan demonstrated the potential for milk production in sheep breeds traditionally used for wool and pelts. Farmers found that cheese production was a valuable source of additional income. In addition, to address dry-season feed constraints in Turkmenistan, highly saline irrigation drainage water, otherwise dumped in the desert, was used innovatively to irrigate cultivated salt-tolerant plants. Even in a drought year, resulting forage yields were up to 60 times greater than those from natural rangelands.

Diversifying into sheep milk production in the steppes of Uzbekistan and Turkmenistan

The dissolution of the large Soviet market, after the breakdown of the Soviet Union, plunged Central Asian sheep production into crisis. Previously, production was centered on wool and pelts, meat was a by-product and milk production was not even considered an option. Now there is little local and regional demand for wool and pelts, prices are low, and the scale of production has shifted; huge landholdings and flocks have been replaced by thousands of small privatized units, each having a handful of animals. Returns per head and per flock are low. Thus, there is a need for increased diversification and the re-orientation of production systems, to match current production to demand and to the scale of operations.

ICARDA and Central Asian scientists, with financial support from the International Fund for

Agricultural Development (through the Integrated Feed and Livestock Production Project) investigated production opportunities and market niches that could be exploited by small-scale producers. Some systems, such as those based on indigenous sheep (e.g. the Karakul sheep of Turkmenistan and Uzbekistan), require diversification, in view of the difficulties involved in marketing pelts and wool. Simultaneous studies on consumption of, and demand for, milk products suggested that production of milk derivatives could be an alternative. Therefore, to obtain much-needed baseline data, scientists studied milk production in native sheep breeds.

The first study considered Karakul sheep in Uzbekistan, a breed native to the steppes of Central Asia. New-born Karakul lambs are slaughtered for their high-quality pelts. After they lamb, the so-called 'Mary' ewes are not milked until the next lambing season, as milk production is not usually the aim of the system.

During spring, in 2000 and 2001, the milk production of 50 Karakul Mary ewes of two color genotypes (gray and black) was investigated in collaboration with the Karakul Sheep Breeding and Desert Ecology Research Institute in Nurata, Uzbekistan. Milk yields were monitored every 10 days for 70 days during the period March to May. This is the characteristic suckling period, before the start of the summer. Total milk yield was 54.5 kg per ewe (Table 22); production peaked in the third 10-day period and then decreased. By the fifth 10-day period, some 15% of the total milk produced overall was still to be collected; in the final 10-day period, at the end of lactation, only 5.5% of the total milk yield was produced. As in other breeds, milk was richest in the first 10 days (Table 22). Fat and total solid contents then decreased (being lowest at the point of maximum milk production in the third period), and then increased as milk production dropped.

Table 22. Milk production of Karakul Mary ewes[1] (20 March-29 May 2001).

Consecutive periods of 10 days	Milk production in the period (kg/ewe)	Distribution of production (% of total)	Content in milk per period (%)	
			Fat	Total solids
10	9	16.5	9.7	28.5
20	10.5	19.3	8.1	22.2
30	11	20.2	7.8	21.7
40	9	16.5	7.9	22.1
50	7	12.8	8.0	22.5
60	5	9.2	8.1	22.8
70	3	5.5	8.5	23.1
Total	54.5	100.0		

[1] Mary ewes: ewes whose lambs were slaughtered at birth.

Both age and genotype affected milk production. Total milk production, and its fat and solid contents, decreased with age: 3- to 4-year-old ewes produced the largest yield (65 kg) while older animals produced 20-30% less. The gray and the black Karakul sheep demonstrate many genetic differences. Gray lambs are usually heavier than black, and their pelage (fur) is usually overdeveloped; but, they are less healthy. Black ewes trailed gray ewes in total milk yield (50.65 vs. 57.67 kg). However, the milk of the black ewes was richer in fat and total solids. Gray ewes were depleted more rapidly during lactation than black ewes (whose milk contained high levels of fat and solids until the end of lactation).

Milking Karakul ewes, not practicd before in Central Asia, is proving to be an important source of additional income for farmers in Uzbekistan.

Though low compared with specialized milk-sheep breeds, the production of 54.5 kg in 70 days, under rangeland conditions—that are sometimes marginal—is encouraging. Thus, there exist possibilities for increasing income from the present pelt-production system and, most promisingly, for increasing income-generating activities available to women.

A second study considered lactating Karakul ewes in Turkmenistan. During 2000 and 2001, the productivity of ewes raising their lambs was assessed in collaboration with the Turkmen Agricultural University. During four months of lactation, ewes raising a single lamb produced 62.4 kg of milk; ewes raising twins produced 1.9 times that amount (120 kg). Maximum production (41-44% of total yield) was observed in the first month of lactation. By the end of the second month, almost 70% of the milk had been produced. Results obtained by farmers, though from another breed (Sarajin), suggest that a progressive milking strategy—as early as 60 days after lambing—in addition to some level of feeding with hay and concentrates (250-300 g per head), could stimulate milk production to the extent that some milk could be recovered. Under these conditions, a total of over 20 kg of milk per ewe would be possible. This could provide income in addition to the production of lambs.

Central Asian farmers and scientists visiting the Sheep Unit at ICARDA's headquarters in Aleppo, Syria.

Finally, the stories of two innovative Sarajin sheep farmers in Turkmenistan illustrate just how strong the desire of farmers to diversify production can be. The two farmers (Sapargulyev and Imamgulyev) collaborate with ICARDA and Turkmen scientists in an on-farm research network in Turkmenistan. Sarajin is a breed native to Turkmenistan, its meat is in high demand and its wool is used in the renowned Turkmen carpets. The breed has not previously been used for milk production.

In mid-2000, the farmers attended a traveling workshop in West Asia that exposed them to production strategies, including milk production and processing, which are already being practiced by their counterparts in Syria and Turkey. The farmers did not wait to formally assess their flocks' milk production, but, using the knowledge they had gained, immediately milked their animals and turned that milk into cheese. In 2001, farmer Sapargulyev milked 40 of his lactating ewes from January to March, obtaining 1,148 kg of milk (28.7 kg per ewe). With techniques he had learned, he processed the milk into 230 kg of cheese that he sold for around US$380. In 2002 he milked more ewes, for a longer period (January to April), and produced 386 kg of cheese that sold for US$675. Also in 2002, farmer Imamgulyev decided to milk 30 of his ewes from January to April. This yielded 654 kg of milk (21.8 kg per ewe); the resulting cheese sold for US$150.

Although Karakul and Sarajin are not specialized dairy breeds, the milk obtained under targeted management strategies offers possibilities for diversification and income generation in times when frustrated farmers face difficulties in marketing their pelts and wool. In 2002, ICARDA conducted a successful workshop on milk processing technologies designed for women farmers in Uzbekistan. It is expected that these efforts will help farmers to sustain their livelihoods during the critical period of their transition to a market-oriented economy.

New opportunities to enhance the feed base: using waste drainage water in the deserts of Turkmenistan

The breakdown of the former Soviet Union has had a major impact on both the feed production chain in Central Asia and the provision of fodder during critical periods of feed shortage. Previously large land-

holdings were broken up, and now the vast majority of producers farm on a small scale, with small numbers of animals, while others are landless. They have neither the resources nor sufficiently large flocks to justify seasonal grazing, nor can they produce fodder for the months of scarcity in drought and winter periods. This results in low productivity levels and serious degradation around villages. The crisis is severe in countries with harsh winters, where animals have to remain housed for several months due to extreme cold and snow. But the situation is also critical in countries (such as Turkmenistan and Uzbekistan) with less severe winters and extended periods of drought and hot weather.

Ephemeral vegetation on rangelands is heavily grazed by sheep—the main livestock species. It starts growing in spring and early summer, but then declines in abundance from July until the rains start at the end of the year. Unfortunately, this decline occurs during two important periods in sheep production: mating, and the onset of the critical last 50 days of pregnancy. Rangeland feed availability can also decrease dramatically in drought years, as scientists from ICARDA and Turkmenistan's Research Institute of Desert Flora and Fauna found when measuring the biomass on two types of range on Yzgant Farm in the Central Karakoum desert (Fig. 12). Less than 25 kg/ha of standing biomass occurred in the fall of 2001, as rainfall that year (the end of a three-year drought) was only 80-90 mm.

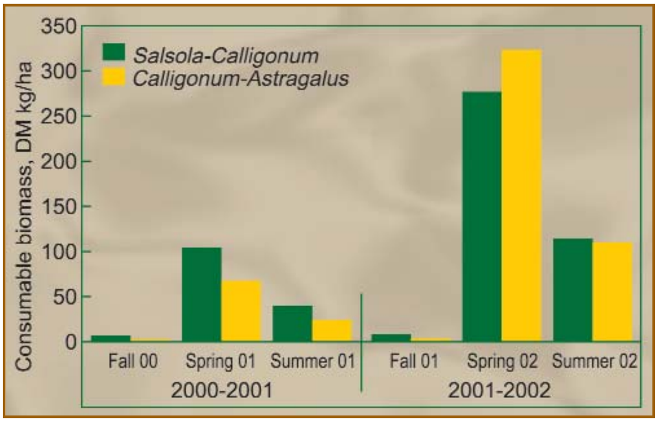


Fig. 12. Consumable biomass (kg/ha of dry matter), in two types of ranges (*Salsola-Calligonum* and *Calligonum-Astragalus*), over periods of drought (2000-2001) and of average rainfall (2002), on Yzgant Farm, Central Karakoum, Turkmenistan.

To address production constraints such as these, ICARDA, in collaboration with Central Asian NARS, and with funding from the International Fund for Agricultural Development, launched the Integrated Feed and Livestock Production Project in 1999. Through this, a way to produce low-cost fodder in the deserts of Turkmenistan was identified. Large irrigation systems in the country are used for the production of key crops, involving three major rivers being directed through the Karakoum Channel. Each year, an estimated 6-7 km^3 of drainage water, passing through about 35,140 km of drainage channels, is dumped into the deserts after being used to irrigate crops. This water could be used to produce forage biomass to overcome feed shortages after the summer, particularly in degraded areas with high levels of salinity.

An experiment was begun in 2001, on the farm where natural range vegetation had been measured (Fig. 12). Drainage water gathered in a collector (with a capacity of about 0.5-1.0 m^3) installed in a drainage water channel, was used to irrigate 2.5 ha of degraded land with salinity problems. The land was sown with salt-tolerant plants (halophytes), both annual and perennial. Salinity levels of this water were higher (3-7 g/l, depending on the season) than those of the water in the major Karakoum Channel (0.6-0.7 g/l). On these saline soils, halophytes were sown between January and February and received two irrigations, each of 1,000 m^3. The first was applied at the end of April, because the spring was unusually dry; the second was applied in August. By September, plant growth satisfied expectations, with annual *Atriplex* species (*Atriplex heterosperma, A. dimorphostegia*, and *A. ornata*) and *Suaeda altissima* attaining the greatest heights: 104 and 89 cm, respectively (Table 23). Perennial *Atriplex* species (*A. canescens* and *A. turcomanica*) exhibited the slowest growth.

By September, the most productive species (*Climacoptera lanata* and annual *Atriplex*) were able to produce 7.8 and 8.8 tonnes of dry matter (DM)/ha, respectively. When compared with the small amount of biomass that is naturally available on the range at this time (less than 0.15 t/ha, Fig. 12), it is not surprising that local farmers are very interested in the results.

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's research has recently demonstrated that supplemental irrigation at sowing can considerably increase wheat grain yield. Even greater gains can be made if deficit supplemental irrigation is applied as the crop grows. This gives a maximum grain yield only slightly lower than that obtained by full supplemental irrigation, while simultaneously allowing a larger area of land to be irrigated with the same volume of water.

Improving wheat production through supplemental irrigation in Central Anatolia, Turkey

Since 1998, ICARDA has been conducting joint trials at the Ankara Research Institute for Rural Services. These four-year trials follow-up earlier joint modeling work, which indicated that supplemental irrigation has the potential to greatly benefit central Anatolia's highland agro-ecology. The results of the more recent trials show that limited supplemental irrigation may double rainfed wheat's grain yield.

The trial results show that applying only 50 mm of supplemental irrigation to rainfed wheat at sowing can increase grain yield by over 60%, adding more than 2.0 tonnes/hectare to the average rainfed yield of 3.2 t/ha (Fig. 13). Water-use efficiency reached 5.25 kg/m^3, with an average of 4.4 kg/m^3. These are the highest water-use efficiency values ever reported with regard to the irrigation of wheat.

Supplemental irrigation given at sowing substantially increases wheat yield because plants which emerge earlier in the autumn grow more vigorously and yield much more in the following spring than plants which germinate later. In most years, the first rainfalls sufficient to germinate the seeds occur later than October, the optimal emergence date. Because of this, unirrigated wheat plant stands are small when the first frost stops their growth in early December. In the trials, supplemental irrigation at sowing allowed wheat plants to emerge early and stand for the optimal time before they were subjected to the frosts of early winter. This allowed the maximum yield to be achieved.

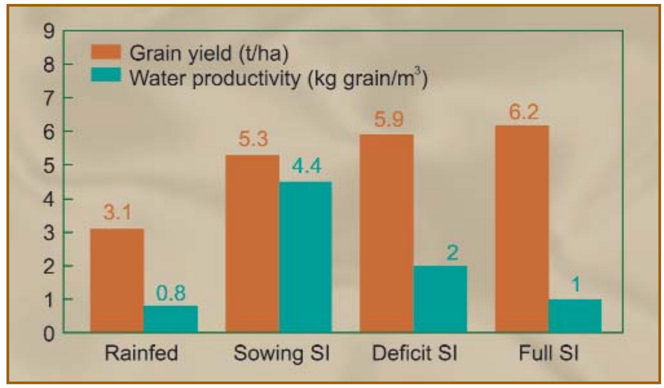


Fig. 13. Water productivity and yield of wheat under supplemental irrigation (SI) in Central Anatolia, Turkey.

The trials also revealed that supplemental irrigation given later in the spring and early summer further increased grain yield, but involved a lower rate of water-use efficiency. Applying enough water to fully satisfy the crop's requirements further increased the yield by 1 t/ha, to over 6.2 t/ha.

However, applying deficit irrigation at the rate of one-third of the amount used in full irrigation (a water saving of 67%) reduced yield by less than 10%. This confirms the result of earlier research, conducted in Syria and already published by ICARDA, which showed that deficit supplemental irrigation is much more efficient in terms of water-use than full supplemental irrigation.

Moreover, in areas where water resources are scarce and more limiting than land, the water saved as a result of deficit irrigation can be used to irrigate new lands (so increasing water productivity). Using this strategy, total farm production can be increased by over 30%, as was shown in farmers' fields in northern Syria. Adopting such a strategy can help farmers cope with increased water scarcity in the dry areas.

Project 3.2. Land Management and Soil Conservation to Sustain the Agricultural Productive Capacity of Dry Areas

ICARDA's innovative integrated natural resource management research project in the Khanasser Valley, Syria, was further developed in 2002. Emphasis was placed on improving the participatory component of the on-going, on-farm research at the site, and on developing an integrative conceptual framework, which is now being used to efficiently coordinate this large multidisciplinary project.

Khanasser Valley Integrated Research Site (KVIRS)

The Khanasser Valley lies approximately 80 km southeast of Aleppo city, and represents an area where the agricultural zone meets the natural rangelands of the steppe. The Valley's diverse ecosystem exhibits several NRM-related problems. Therefore, ICARDA selected Khanasser as an important integrated research site (453 km^2), in order to address problems characteristic of marginal, dryland environments. The diversity and dynamics of the natural resources and livelihoods, the prevailing poverty, and the relatively easy access to the Valley, were the main factors influencing the selection of this site.

Major progress has been made by ICARDA and its partners (the Atomic Energy Commission of Syria and the University of Bonn, Germany) in integrating different sectoral research activities and in involving different stakeholders in the research. The framework found to be invaluable in guiding this process was the Integrated Natural Resource Management (INRM) approach, which 'aims to improve livelihoods, agro-ecosystem resilience, agricultural productivity and environmental services' (http://www.inrm.cgiar.org). In the KVIRS, the concept was translated into 16 tools, grouped as 'diagnostic,' 'process' and 'problem-solving' tools (Table 24), which, when used at an appropriate time and place, are designed to improve NRM and livelihoods. Most of these tools are already used in the project: those instrumental to the progress made during 2002 are reported here.

Table 24. Adapted INRM toolbox for the Khanasser Valley Integrated Research Site.

Process tools	Diagnostic tools	Tools for problem-solving and capitalizing on opportunities
1. Cross-disciplinary approach 2. Envisioning 3. Farmer participatory research 4. Strengthening local organizational capacity 5. Monitoring, evaluation and impact assessment 6. Stakeholder cooperation (NARS and policy makers) 7. Effective communication and facilitation strategy 8. Capacity building 9. Scaling-out and scaling-up	10. Multi-level framework 11. Livelihood and community analysis 12. Analysis of policy and institutional environment 13. Natural resources analysis and agroecological characterization 14. Holistic analysis	15. 'Plausible options' or 'best bets' (i.e. testing of alternative technologies or modifications of existing practices) 16. Decision and negotiation support tools

Cross-disciplinary grouping and coordination

Interdisciplinary research is one of the cornerstones of the KVIRS project. Achieving the necessary level of cooperation was initially a major challenge, as the project involved both the study of a large number of issues and bringing together more than 50 scientists and extension agents. The challenge was met by organizing the research according to the most relevant farming enterprises in the Valley—the form of classification which would be understood best by farmers.

These enterprises included an extensive livestock-barley system, which is the traditional farming practice in Khanasser, and three alternative activities which are fast gaining popularity:

1. Intensive livestock production system (sheep fattening)
2. Annual cash crops (cumin and wheat, as well as annual plants collected from the wild)
3. Fruit trees (mainly olive)

In addition, secondary coordination linkages were set up to study the interactions that occur when natural resources are used by two or more enterprises—e.g. the stony hillsides in the area, which are used for extensive grazing, olive groves and collection of valuable wild plants.

Clustering of research topics, using an interdisciplinary matrix, was a major tool used to clarify the roles of research partners both from within and outside ICARDA. As a result, collaboration with Syrian NARS has intensified, and four memorandums of understanding have been prepared.

Farmer participatory research (FPR)

In 2002, a training workshop on FPR methods was organized to strengthen the capacities of the research and extension staff involved in the KVIRS. The underlying intention was to initiate a shift from supply-driven to demand-driven technology development, and to increase the participation of farmers in the research process. The workshop resulted in the initiation of three different farmer interest groups, separately concerned with olive, cumin and barley growing. This improved researcher-farmer interaction, so increasing the influence farmers exerted on the research agenda. It also led farmers to evaluate proposed technologies, and helped in the identification of local innovators and local technical knowledge. For example, researchers suggested to farmers a new sys-

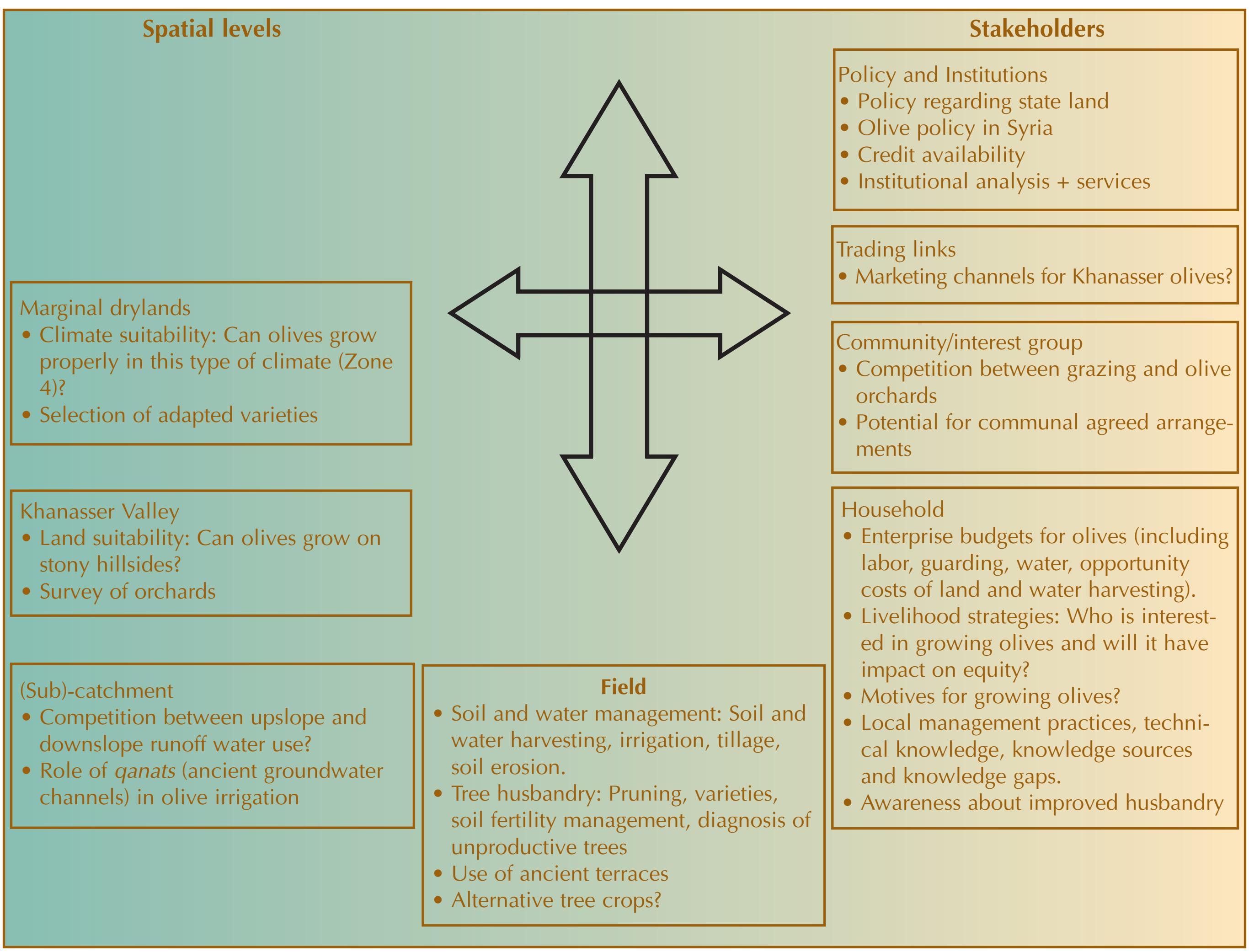


Fig. 14. Application of the multi-level framework for olive orchard technology on degraded hillsides.

tem, which involved (1) not plowing their olive orchards and (2) constructing V-shaped stony-earth bunds around each of their olive trees (to harvest water and to control soil erosion). In practice, however, farmers adapted this technology to their needs. They continued to plow, in order to minimize the growth of weeds (which they felt attract grazing sheep, fuel fires and compete for water with the olive trees). But, they did build V-shaped and/or fishbone shaped earthen bunds around their trees, to collect the water from the furrows. This simple, locally adapted system for soil and water harvesting is now being monitored by researchers to assess its physical and economic efficiency. In such ways, improved farmer-researcher interaction helped researchers to learn more about potential improvements to the technology, while FPR work now complements on-going, controlled, on-farm research.

Diagnostic tools: the multi-level framework

The multi-level framework tool (Fig. 14) was the diagnostic backbone of the project (all the other diagnostic tools are linked and integrated with it). The tool does not list all possible influencing factors but, instead, prioritizes issues which (actually or potentially) constrain the optimum use of technologies or resources, and lists potential solutions. The issues identified are grouped into a 'spatial pillar,' a 'stakeholder pillar' and a 'field-level box,' all linked vertically and horizontally to different degrees. This framework was instrumental in:

- enabling a comprehensive analysis of technologies or resources,
- focusing research time and resources upon strategically important issues,
- addressing all major issues at the right scales and with the right stakeholders, and
- obtaining interdisciplinary cooperation.

Significant progress has been made in terms of both the 'spatial' and 'stakeholder' pillars. A striking factor is the diversity of livelihood strategies and their responsiveness to new land-use restrictions and resource decline. Our understanding of the status and use of the Valley's natural resources has also progressed significantly, especially with regard to groundwater, hillside vegetation and soil loss through water and wind erosion. In general, there is unsustainable over-use and degradation of natural resources.

Technology development and evaluation

Since the beginning of the project, most emphasis has been placed on finding options for the traditional extensive livestock-barley farming system. In 2002, research was widened to include technologies for alternative farming enterprises (particularly olive and cumin production and sheep fattening). The first results on phosphogypsum and atriplex use in barley fields, and on soil and water harvesting for olive trees, are promising, and will soon be published.

Project 3.3 Agrobiodiversity Collection and Conservation for Sustainable Utilization

Further progress in collecting, documenting, and conserving plant genetic resources was made by ICARDA in 2002, and the Center's germplasm collection continued to grow. Studies of ICARDA's wild barley core collection, the genus *Aegilops* and the six closely related taxa of the *Vicia sativa* aggregate, yielded new insights into the genetic diversity of these groups. Germplasm was characterized and multiplied, and more than 16,000 samples dispatched to users in 28 countries. In West Asia, the promotion of *in situ* conservation and sustainable use of dryland agrobiodiversity continued in Jordan, Lebanon, Palestine and Syria. In CAC, a regional genetic resource network instituted in 1999 was further strengthened, to promote the conservation of the region's genetic resources. Allied to this was the updating of related facilities, and the provision of capacity-building training. Progress was also made in providing an internet-based inventory of barley genetic resources throughout the world. Seed health testing continued, and a number of ICARDA's gene bank accessions were cleaned of seed-borne viruses.

Germplasm Collection

In 2002, ICARDA's germplasm collections grew by 1331 new accessions, to reach a total of 128,462. A unique set of 692 accessions resulted from plant collection missions to Jordan, Romania, Syria and Turkmenistan (Table 25). Most valuable were 585 unique accessions of barley and bread wheat, originating from the germplasm collections of Vavilov and his colleagues in 1920s and 1930s and donated by the Vavilov Institute (VIR), St Petersburg, Russia.

The GEF/UNDP Dryland Agrobiodiversity Project conducted a one-week collection mission in Jordan by researchers from ICARDA and the National Center for Agricultural Research and Technology Transfer (NCARTT), Jordan. The mission, to collect wild relatives and landraces of cereals, forage legumes and pasture species, targeted the central and northern provinces of Jordan. A total of 374 accessions were collected (102 cereals, 40 forage legumes and 232 pasture species).

ICARDA organized a collection mission in Romania, in collaboration with the Suceava Gene Bank, Romania, and VIR. The mission was conducted with support from Australian donor projects (the Australian Center for International Agricultural Research-ACIAR, and the Grain Research and Development Corporation-GRDC). Its main objectives were to survey, collect and conserve the genetic diversity of crops in isolated areas of the west Transylvanian Plateau. In the areas where collection was undertaken, farming occurs on a small scale due to the topography of the plateau, which is characterized by high mountains covered by dense forest. Therefore, landraces of wheat, barley, and other crops have persisted in the region. Fifty-two sites were visited and more than 2500 km were covered by the collecting team. Collection focused on isolated areas on the

Collecting forage legumes in mountainous areas in Romania.

Table 25. Number of accessions collected in missions to Jordan, Romania, Syria and Turkmenistan.

Crop/Genus	Country	Number of accessions
Wild *Hordeum*	Jordan	24
	Syria	5
	Turkmenistan	24
Sub-total		53
Barley	Jordan	20
	Romania	9
	Turkmenistan	6
Sub-total		35
Aegilops	Jordan	43
	Syria	32
	Turkmenistan	49
Sub-total		124
Wild *Triticum*	Syria	3
Primitive wheat	Turkmenistan	1
Bread wheat	Jordan	1
	Romania	17
Sub-total		18
Durum wheat	Jordan	4
Wild *Lens*	Syria	12
	Turkmenistan	2
Sub-total		14
Wild *Cicer*	Jordan	1
	Syria	2
Sub-total		3
***Medicago* annual**	Jordan	65
Lathyrus	Jordan	13
	Syria	17
	Turkmenistan	12
Sub-total		37
Trifolium	Jordan	98
	Romania	2
Sub-total		100
Vicia	Jordan	29
	Romania	4
	Syria	41
	Turkmenistan	44
Sub-total		118
Pisum	Jordan	2
	Syria	5
	Turkmenistan	1
Sub-total		8
Other forage and range species	Jordan	69
	Romania	17
	Turkmenistan	13
Sub-total		99
Total		692

plateau and priority was given to cereals and legumes; but, other crops were also collected. Altogether, 300 population samples were collected from different crops of interest to the three mission parties.

Cereal landraces and their wild relatives were also collected in northeastern Syria in June 2002, while another mission collected food and forage legumes in northeastern and southern Syria. ICARDA and ARC Douma, Syria, participated in these missions, which collected a total of 88 accessions.

From 25 May to 15 June 2002, a collaborative plant collection mission was undertaken in Turkmenistan, involving the Turkmenistan Garry Gala Research Institute for Plant Genetic Resources, VIR, ICARDA, USDA and Agriculture Western Australia. The mission was supported by Australian donor projects (ACIAR and GRDC), and covered the territory from the Caspian Sea to the west of Ashgabat, as well as to the east along the Afghan border. A total of 413 accessions, belonging to 106 species, were collected from 48 sites.

Collecting forage and rangeland species in Turkmenistan.

Molecular analysis of ICARDA's wild barley core collection

Out of the total of 1679 accessions of barley's wild progenitor (*Hordeum vulgare* subsp. *spontaneum*), held at ICARDA, a core collection was established, consisting of 150 accessions originating from 17 countries. The genetic diversity of the core collection was studied using AFLP (amplified fragment length polymorphism) molecular markers. Accessions were grouped by origin into 22 geographic sub-regions, and the total genetic variation of the samples was partitioned by analysis of molecular variance (AMOVA). Twenty-three percent of the total variance was among the geographic groups, whilst most of the variance (77%) occurred within the groups. Discriminant analysis showed a well-defined geographic pattern of genetic diversity in wild barley, as 94% of the original grouped cases were correctly classified and, in the 17 sub-regions, all the accessions were properly allocated. The genetic distance matrix (Euclidean squared distances) was computed from canonical discriminant functions evaluated at group means; hierarchical cluster analysis (UPGMA) was performed using the SPSS software package (Fig. 15).

Accessions from southern Jordan and Palestine were found to be genetically distant from the wild barley collected in Syria and northern Jordan,

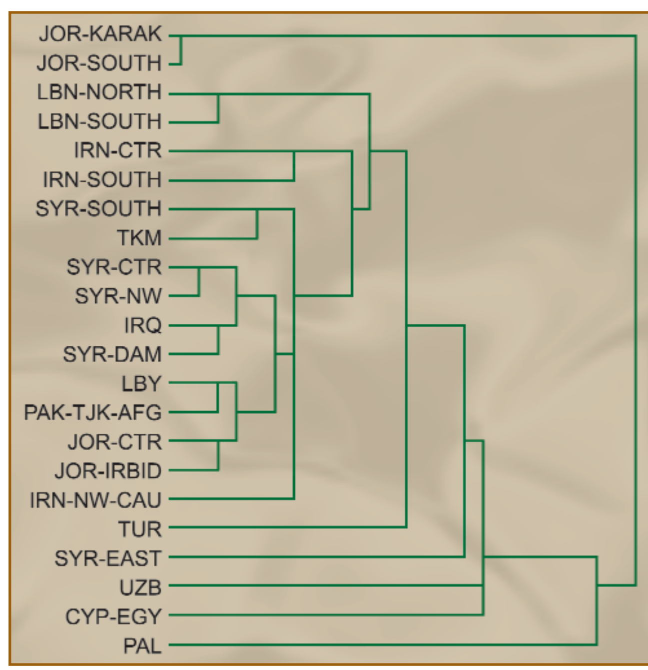


Fig. 15. Dendrogram for sub-regions of wild barley origin based on UPGMA hierarchical cluster analysis of AFLP marker data.

while geographically remote germplasm accessions from the Central Asia sub-region (Pakistan, Afghanistan and Tajikistan) and from Libya were found to be relatively closely related to accessions from western Syria, northern and central Jordan, Iraq and southern Iran. This indicates that wild barley spread outwards from the nuclear Near East area with cultivated cereals, moving eastward along the 'Silk Road' and westward to Libya by sea. Accessions from Jordan and Syria were found to be more diverse than those from Iran, Central Asia and Turkey. The results of this study suggest that the genetic variation found in the ICARDA *H. spontaneum* core collection is geographically structured, with a major part of that diversity being found within the geographical sub-regions.

Genetic diversity and phylogenetic relationship of diploid *Aegilops* species

Wild relatives of wheat, including *Aegilops* species, are a valuable source of genes for stress tolerance and adaptation to harsh environments. To better understand relationships among the species, the genetic diversity of the genus *Aegilops* was evaluated and its phylogeny studied. To this end, the genetic variation of diploid *Aegilops* species was investigated using the AFLP technique. Four primer combinations were used to analyze intraspecific genetic diversity, while 15 primer combinations were used to analyze interspecific phylogenetic relationships. Genetic diversity within the *Aegilops* species was categorized into three classes based on the level of diversity found: i.e. the highly variable species (*Ae. speltoides* and *Ae. mutica*, syn. *Amblyopyrum muticum*), species with a medium level of variation (*Ae. umbellulata*, *Ae. caudata*, *Ae. bicornis* and *Ae. searsii*) and species with a low level of variation (*Ae. tauschii*). In general, geographical relationships among populations were detected for each species. With respect to the interspecific phylogenetic relationships, three Sitopsis species (*Ae. bicornis*, *Ae. searsii* and *Ae. speltoides*) were found to form a cluster. The C and U genome species (*Ae. caudata* and *Ae. umbellulata*) formed another cluster in the phylogenetic trees (Fig. 16). These results are more consistent with results obtained from cytological genome analysis than they are with those obtained by molecular plasmon analysis, suggesting that the nuclear genomes have evolved differently from the cytoplasmic genomes in the genus *Aegilops*.

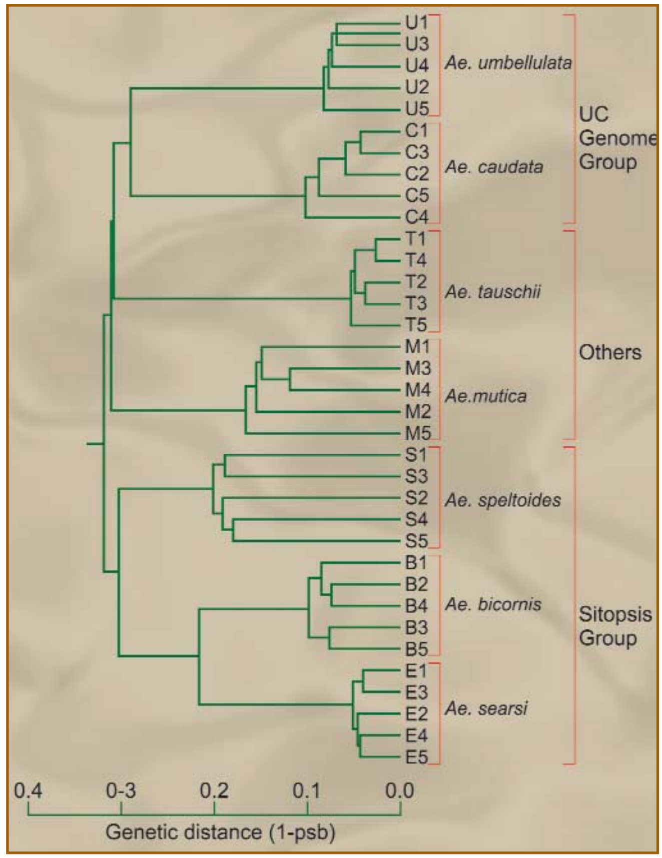


Fig. 16. Phylogenetic tree of diploid *Aegilops* species based on AFLP marker analysis.

Patterns of genetic and taxon diversity in the *Vicia sativa* aggregate

Common vetch (*Vicia sativa*) is an important forage legume, not only in the CWANA region, but also in other parts of world. Therefore, ICARDA researchers used AFLPs to study the geographic distribution of genetic diversity in the *Vicia sativa* aggregate, a complex of six closely related taxa. The study demonstrated that the center of diversity for the aggregate is located in the Mediterranean (Fig. 17). The highest level of diversity and a relatively high concentration of rare alleles were found in the South Mediterranean floristic

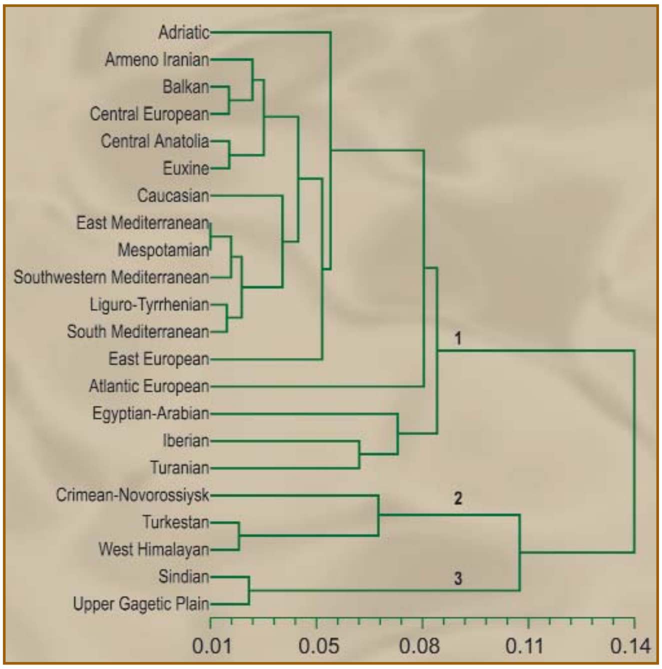


Fig. 17. Geographical diversity in *Vicia* aggregate.

province, in the north of Tunisia in particular. The East Mediterranean floristic province was also found to have a high level of diversity. A genetic bottleneck was observed in South Asia, with low diversity and no rare alleles being found east of Iraq. A significant correlation was found between the number of subspecies present in an area and the average diversity within the subspecies. This indicates that, for the *Vicia sativa* aggregate, the number of subspecies in a region can be used as a predictor for genetic diversity levels.

Germplasm multiplication, characterization and utilization

In the 2001/2002 growing season, a total of 2500 accessions were characterized using 15 to 30 descriptors. A representative set of barley, wheat, lentil, chickpea, pea and faba bean landrace accessions from Afghanistan (271 in total) was selected from ICARDA's gene bank. These were multiplied in large plots in the field, and characterized for a number of agro-morphological characters. Priority was given to seed multiplication to replenish seed stocks, since demand for germplasm from ICARDA's gene bank has further increased in 2002. A total of 16,300 seed samples were dispatched, on request, to external users in 28 countries. This included the repatriation of indigenous germplasm to Afghanistan, Jordan and Palestine, a total of 271, 1350 and 1000 accessions, respectively. An additional 4700 seed samples were distributed to breeders and scientists within ICARDA.

Community-based agrobiodiversity conservation in West Asia

ICARDA's project for the conservation and sustainable use of dryland agrobiodiversity is funded by the Global Environment Facility (GEF), through the United Nations Development Program (UNDP). It aims to promote community-driven *in situ* conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestine and Syria. ICARDA is responsible for regional coordination and networking among the national components and provides, in cooperation with the International Plant Genetic Resources Institute (IPGRI) and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), necessary technical backstopping and training.

During the 2002 season, the project had a significant impact at community, national and regional levels. Summaries of its achievements are given below.

The project has increased the use of wild fruit trees in reforestation efforts. More than 17,000 seedlings were planted during public-awareness campaigns run in Syria, while Forestry Departments in Jordan, Palestine and Syria increased the use of targeted species in their afforestation and reforestation programs. In Jordan, the project has helped to create a biodiversity unit within the Forestry Department. Similarly, biodiversity and genetic resources units were created within the General Council for Scientific Agricultural Research in Syria and the Ministry of Agriculture in Palestine. The project has also assisted local NGOs and individual farmers in Jordan, Lebanon and Syria in the creation of 11 agrobiodiversity nurseries, focusing on multiplying the seedlings of landraces and of wild relatives of targeted fruit trees. Seven field gene banks and 11 *in situ* conservation sites have been developed by the project in the four countries, in addition to the enrichment of existing gene banks with more than 500 accessions of target species.

An inexpensive water harvesting technique using stones.

Through eco-geographic surveys and the use of GIS/RS technologies, the project demonstrated that the main factor affecting the diversity and abundance of wild relatives of fruit trees is natural habitat destruction resulting from the reclamation of agricultural land in mountains and rangeland. The respective acreages of crop and fruit tree landraces are mainly being reduced by the spread of, and replacement with, apple, cherry and olive plantations using introduced new varieties. The project documented the failure of these plantations in some project sites, and recommended that extension services consider any long-term economic benefits before switching to new, introduced species.

The project has demonstrated the value of water-harvesting techniques for rangeland rehabilitation, and the value of seed treatment and cleaning in increasing the grain yields of cereals and legumes. In collaboration with local communities of herders, the best options for improved management of rangelands have been developed and will be tested on a large scale.

In its efforts to advise male and female collaborating farmers on alternative sources of income, the project has provided a total of 23 training courses and 21 farmer workshops on food processing, the development of apiculture and honey production and the cultivation of medicinal plants. A successful eco-tourism experience was also organized, in collaboration with the private sector in Lebanon and the local community of Ham. Additionally, a permanent agrobiodiversity store was created at Al-Haffa (Syria) and a weekly market organized at Ajloun (Jordan), both of which will allow local communities to sell products derived from their local agrobiodiversity.

The project has also been very active with regard to increasing public awareness of the importance of conserving dryland agrobiodiversity. This has been achieved through

- the organization of agrobiodiversity fairs in Jordan, Lebanon and Syria;
- participation in agricultural fairs organized in Syria and Jordan;

Processing local products, especially on how to produce malban from grapes.

- the introduction of biodiversity conservation into education systems (school curricula development is in progress, biodiversity clubs are being created in Palestine, and school gardens have been created, painting contests have been organized. Six MSc and two BSc studentships have also been created in areas related to the conservation of target species);
- distribution of T-shirts, hats and calendars;
- collaboration with a rural theater, in order to prepare a play entitled "Life Box." This considered the agrobiodiversity of the project sites at which it was performed;
- participation in more than 25 radio and TV interviews, and the development, in collaboration with UN Geneva TV, of a regional documentary film on the importance of preserving West Asian agrobiodiversity. This will be broadcast by 77 international channels; and

- contributions to more than 10 regional and international conferences.

The project is currently contributing to the development of different national policies and pieces of legislation. With the help of an FAO expert, the Syrian Component of the project has drafted legislation regarding access to and exchange of genetic resources. The Jordanian and Lebanese Components have contacted the FAO, in order to achieve the goal in their respective countries. The Regional Component organized the first Arab workshop on "The Implications of International Agreements on the Development of National Policies and Legislations Related to Biodiversity Conservation." This was conducted in collaboration with ACSAD, ICARDA, IPGRI, UNEP's Regional Office for West Asia, FAO, and the Arab Organization for Agricultural Development. The workshop was held at the Arab League headquarters in Cairo in May 2002. It was attended by guest speakers, and more than 55 participants representing the governments of Egypt, Saudi Arabia, Oman, Sudan, Lebanon, Syria, Palestine and Iraq, and the GEF-UNDP projects in Morocco, Tunisia and Algeria. Important recommendations were made to the Arab League by participants whose aim is the better coordination of efforts to conserve biodiversity in the Arab world.

Project Managers have been very active with regard to empowering local communities. They helped to create local cooperatives (in Lebanon, for example), organized donor visits to project sites, and developed proposals intended to obtain small GEF grants to support both local communities and collaboration with other projects.

The project continued its efforts to develop the scientific basis of the *in situ* conservation of agrobiodiversity, and has contributed to the development of new proposals focusing on the conservation and sustainable use of dryland agrobiodiversity.

Plant Genetic Resources in Central Asia and the Caucasus

The CAC region is rich in plant diversity. Many of the world's economically important domesticated crop species originated in the area. Thus, besides the landrace material native to the area, it also contains many of the progenitors and wild relatives of these domesticated species, which contain unique combinations of potentially useful genes.

ICARDA's long-standing relationships with national programs ensure that the countries concerned benefit from the results of collection missions. This is most readily achieved through the ICARDA gene bank, which now houses one of the world's largest germplasm collections. Between 1998 and 2001, ICARDA, in collaboration with NARS and VIR, organized collection missions to all eight countries, during which 1442 accessions of ICARDA's mandate crops were collected.

Conserving plant genetic resources: a new regional network

Due to financial constraints, the region's national genetic resource institutes' links with other research institutes have become weak. The national institutes' abilities to collect, conserve, and document local and exotic genetic resources needed to be enhanced, to allow them to secure germplasm for national breeding programs. Therefore, in 1999, the Central Asia and Transcaucasia Network on Plant Genetic Resources (CATCN PGR) was established, involving all eight CAC countries. Within this network, eight PGR units were established to focus on field crops in the region. ICARDA supported the training of PGR documentation specialists, and provided the eight units with computers, so that they could produce inventories and documentation concerned with the PGR in their countries. In addition, to highlight the aims and achievements of the ACIAR-funded PGR-CAC project, raise awareness of the importance of PGR work in the region and act as a networking and information sharing device, an Internet website was developed in 2002.

A regional meeting of the CATCN-PGR network was organized jointly by ICARDA and IPGRI in Tashkent in June 2002. The meeting was attended by the scientists involved in two working groups: one on cereals and the other on medicinal plants. A total of 23 specialists from the eight CAC countries participated, along with scientists from ICARDA and IPGRI. During the working sessions, they reviewed PGR activities for the period 1999-2002 and developed a work plan for 2002-2004. This meeting was followed by the CATCN-PGR Steering Committee Meeting of National Coordinators (NCs), which was

attended by all eight NCs as well as by representatives from IPGRI and ICARDA. Participants discussed issues related to the strengthening of PGR activities in the region and approved the proposed work plan for 2002-2004.

New facilities, new opportunities

Great improvements in PGR facilities have recently been made in CAC: in 2002, an upgraded gene bank, and three genetic resource centers were inaugurated. At the request of Uzbek PGR scientists, and in collaboration with the Ministry of Agriculture and Water Management of Uzbekistan, ICARDA, IPGRI and USDA jointly upgraded the Uzbek gene bank facility at the Uzbek Research Institute of Plant Industry (UzRIPI) in Uzbekistan. This medium-term storage facility could serve as a gene bank for the whole region, and will allow seed quality to be conserved for 10-15 years. Thus, replanting of stored accessions can now be undertaken every 10-15 years, rather than every 2-3 years.

At the request of PGR scientists from Azerbaijan, Kyrgyzstan and Tajikistan, ICARDA provided financial support for the initial stages in the development of seed storage facilities, including the purchase of new equipment. This type of ICARDA-supported PGR activity in the area has led to the inauguration of Plant Genetic Resource Centers in each of the above countries.

Based on requests made by the Director General of the Agrarian Science Center in Azerbaijan, the Ministry of Agriculture in Armenia, and the Agrarian Academy in Georgia, in 2002 ICARDA organized a visit by the Gene Bank expert from ICARDA's Genetic Resources Unit (GRU) to Azerbaijan, Armenia and Georgia. Ways of strengthening the Caucasian Plant Genetic Resources conservation program were assessed, and the potential for seed storage facilities in the three countries were appraised. National and international funding proposals are now being developed to support their development.

Prof. Dr Adel El-Beltagy (second from left), ICARDA Director General, inaugurated a new genetic resources center in Tajikistan. Present on the occasion were, from left, Dr C. Buhariev, Director of the Crop Husbandry institute; Acad. Bobo Sanginov, President of the Tajik Academy of Agricultural Sciences; Dr Raj Paroda, ICARDA-CAC Regional Coordinator; Dr Mohan Saxena, ICARDA Assistant Director General; and Dr Jan Konopka, ICARDA Germplasm Documentation Officer.

Training and human capacity building

A regional training and coordination workshop for Plant Genetic Resource Units was held in Tashkent in April 2002. Organized by the CGIAR Program Facilitation Unit and GRU-ICARDA, the meeting was attended by 24 scientists from the eight CAC countries. The meeting assessed the progress made by the units over the last 12 months, discussed solutions to operational problems, and gave training on updating the database system to document *ex situ* collections, and in using e-mail.

Capacity building through training continued. In February and April, documentation specialists from Georgia and Armenia visited Australia for two months, for documentation training and to attend courses on working with modern gene banks and on the Australian PGR network. In September, a documentation specialist from Azerbaijan visited the Vavilov Institute for two weeks, in order to receive PGR, gene bank, and documentation training. Two scientists from the Uzbek PGR Unit attended a three-and-a-half-month English language course in Tashkent. Another twelve scientists from PGR Units in Georgia (1), Kazakstan (1), Kyrgyzstan (2), Tajikistan (3), Turkmenistan (2) and Uzbekistan (3) will attend the same course in 2002/03. Finally in October and November three documentation officers from the Caucasus attended an on-the-job training program at ICARDA, in which they learnt to design and construct a web-page. The product of this initiative will soon be published, and will act as a valuable networking and information service tool.

Global inventory of barley genetic resources

The FAO estimates that more than 300,000 accessions of barley are conserved in numerous *ex situ* collections. There is no doubt that there is a significant overlap between these collections, but the extent of this overlap is unknown. What is more, although some collections can be accessed via the Internet, differences in separate systems, both in the format of the data and in the interfaces offered, prevent users from efficiently accessing information on conserved material. During 2002, ICARDA began a collaborative project (involving organizations with large collections of barley) which aims to compile a Global Inventory of Barley Genetic Resources.

The project is supported by the CGIAR Systemwide Genetic Resources Program (SGRP) and the Inventory will be published on the Internet using the Systemwide Information Network for Genetic Resources (SINGER) platform. Currently the database holds passport data on over 165,000 accessions conserved in 40 institutes (Table 26), and the challenge is to cross-reference the accessions across collections.

Table 26. Major holders of barley germplasm collections included in the inventory.

Collection/Institute	Number of accessions
USDA, USA	27,010
ICARDA, Syria	25,202
VIR, Russia	19,437
IPK, Germany	13,124
John Innes Centre, UK	10,828
AWCC, Australia	9,947
34 Other smaller collections	59,660

Probably the most important part of any 'global collection' is the material collected in the field: approximately 40% of conserved material can be attributed to efforts of collectors. Based on available data, the project identified over 280 collecting missions conducted during the period 1921-2001 in 57 countries. Unfortunately, there still exist many accessions for which the information concerning collectors and/or collection dates is untraceable. The project places great emphasis on the geo-referencing of collection sites, and the database can map out over 9,000 sites. However, the majority of conserved material is the result of breeding efforts, and the project aims to standardize the names of accessions by correcting misspellings, ensuring consistent transliteration into Latin, consolidating synonyms, etc. The standardization of names will allow the collections to be cross-referenced and will facilitate searching of the database.

Currently the system registers approximately 49,900 names, associated with over 83,200 accessions. For cultivars and breeding lines, the database compiles information on pedigree, developer and date of release. The inventory will be published on the Internet in 2003.

Seed health testing

During 2002, approximately 12,000 incoming, and 18,000 outgoing seed samples were tested at the Seed Health Lab (SHL). This volume of seed constituted 15 shipments imported from 13 countries and 270 shipments exported to 94 different countries worldwide. *Tilletia controversa* was the most frequently found quarantine pathogen, contaminating incoming bread wheat seeds. The percentage contamination in shipments varied, reaching up to 38% (in seed from Turkey) and 100% (in seed from Russia).

During the period April-June 2002, SHL personnel carried out field inspections and roguing of infected plants with seed-borne diseases at Tel Hadya Station. The planted area was rather large (more than 200 ha) during this season, due to additional plots being used to produce seed for Afghanistan. In spite of a prolonged period of humidity during the season, the occurrence of seed-borne diseases was limited in most crops. However, black chaff (a bacterial disease

of wheat) was found in some bread wheat plots. In station fields, scientists look for the following: spot blotch, barley stripe, scald, loose and covered smuts, net blotch, barley stripe virus (on barley), black chaff, common bunt, loose smut (on bread wheat), ascochyta blight, chocolate spot, wilt/root rot, downy mildews, and *Orobanche* spp., and *Cuscuta* spp. (on legume crops).

During 2002, the SHL also gave individual training courses on seed health testing and field inspection to six trainees from Iraq, Syria and Jordan (two per country). The SHL also gave training on aspects of seed health through (1) a two-week seed quality course held at the Seed and Plant Improvement Institute (SPII), Karaj, Iran; (2) a one-week seed science and technology course held in Kabul, Afghanistan, and (3) a four-day course on the production and processing of indigenous forages, held at Sharjah, UAE.

Cleaning seed-borne viruses from ICARDA gene bank accessions

Fifty-eight lentil accessions, planted in the field for multiplication (1000 plants per accession), were tested in ICARDA's Virology Laboratory for the presence of seed-borne virus infection. This effort was intended to eliminate all infected plants during the late flowering stage (April-May), and only seeds from healthy plants were harvested and stored. A total of 2180 accessions of barley seed were tested for the presence of Barley Stripe Mosaic Virus (BSMV): 233 accessions were found to be infected. The virus-free accessions will be stored in the gene bank, and accessions with virus-infected seeds will be cleaned.

Seed-borne virus testing for international nurseries

About 183 faba bean accessions (100 seeds per accession) were tested in ICARDA's Virology Lab for the presence of Broad Bean Stain Virus (BBSV), Bean Yellow Mosaic Virus (BYMV) and Pea Seed-borne Mosaic Virus (PSbMV). Fifty accessions were found to be infected with a seed-borne virus. A total of 383 lentil accessions were evaluated in the field by testing fresh leaf samples (400 plants per accession) for the presence of seed-borne virus infection: 217 accessions were found to be virus-free. In addition, seed samples from 286 lentil accessions (400 seeds per accession) were tested, during August, for the presence of seed-borne viruses. Of these, 132 accessions were found to contain one or more seed-borne infections and were disqualified from being dispatched.

Project 3.4. Agroecological Characterization for Agricultural Research, Crop Management and Development Planning

'Hot spot' assessment of land cover change and land degradation in CWANA using AVHRR satellite imagery

Land degradation is one of the most serious threats to the prosperity of rural populations in dryland areas. A major problem, in terms of combating land degradation in ICARDA's mandate region, is a shortage of reliable basic data on its extent and severity. In a dryland region as huge and diverse as CWANA, with limited reliable ground-based resource inventories and monitoring systems, remote sensing is a valuable tool for getting to grips with the highly complex issue of land degradation.

Since 1982, the Advanced Very High Resolution Radiometer (AVHRR) satellite system has acted as a platform for the continuous space-based monitoring of the world's vegetation cover. Although covering a relatively short period of time and having a rather coarse resolution (8 km), it is the only consistent dataset to permit the detection of trends in land use/land cover change at global and regional scales. At the level of CWANA, a time series of AVHRR imagery could thus be used to identify 'hot spots' of land use/land cover change. This would overcome both the problems of the system's short time series and low spatial resolution, and the difficulties involved in distinguishing genuine trends in the land cover from short-term fluctuations in biomass (a result of year-to-year weather variations). ICARDA has now developed a specific methodology to achieve this.

Six-hundred and twelve 10-daily composites of 8 km-AVHRR reflectance data, covering the period from January 1982 to December 2000, were downloaded from the relevant NASA website for band 1 (0.58-0.68 mm) and band 2 (0.725-1.1 mm). The data, consisting of separate subsets for Africa and Asia, were imported and merged to give complete coverage of the CWANA region. The Normalized Difference Vegetation Index (NDVI) was calculated and aggregated into monthly NDVI composites in order to reduce the effects of cloud cover. Additional corrections were made for 'noise' and sensor drift.

In order to convert this temporal NDVI dataset into a land use/land cover classification, ICARDA developed two procedures. The first (described in the ICARDA Annual Report 2000, pp. 49-52) consisted of a hierarchical decision-tree, based on the average values of the mean and maximum NDVI, to take into account average weather conditions. The second procedure adjusted the NDVI thresholds of the hierarchical decision-tree for different agroclimatic zones, to take into account the fact that, in any particular year, the actual weather can differ substantially from the average.

Using these procedures, 17 annual land-cover maps were produced for each year of the period 1982-1999. This dataset was further condensed into four maps, showing the majority land-cover classes for the key periods 1982-1984, 1987-1989, 1992-1994, and 1997-1999 (Fig. 18 gives an example). Depending on the value and sequence of the majority land-cover types, the following kinds of change were allocated to each pixel: 'noise', 'stable land use/land cover', 'stable land use/land cover mosaic' and 'change pattern'. Seventeen stable classes were recognized, as well as 66 change patterns. The latter were regrouped into 22 change classes, and four change trends:

1. 'intensification of agriculture' (e.g. a change from rainfed to irrigated agriculture)
2. 'intensification of natural vegetation' (an increase in vegetation biomass/density, e.g. a change from bare soil to grassland, or from grassland to forest);
3. 'retrenchment of agriculture' (a change from a more-intensive to a less-intensive form of agriculture);
4. 'retrenchment of natural vegetation' (a decrease in vegetation biomass/density).

On the basis of this hierarchical classification 'change maps' were prepared for the CWANA region (Fig. 19), and areas belonging to individual change combinations, change classes and change trends were calculated.

On the basis of this exploratory assessment, it was concluded that, in terms of area, the most dramatic changes in land cover in CWANA have occurred in the Sahel, followed by North Central

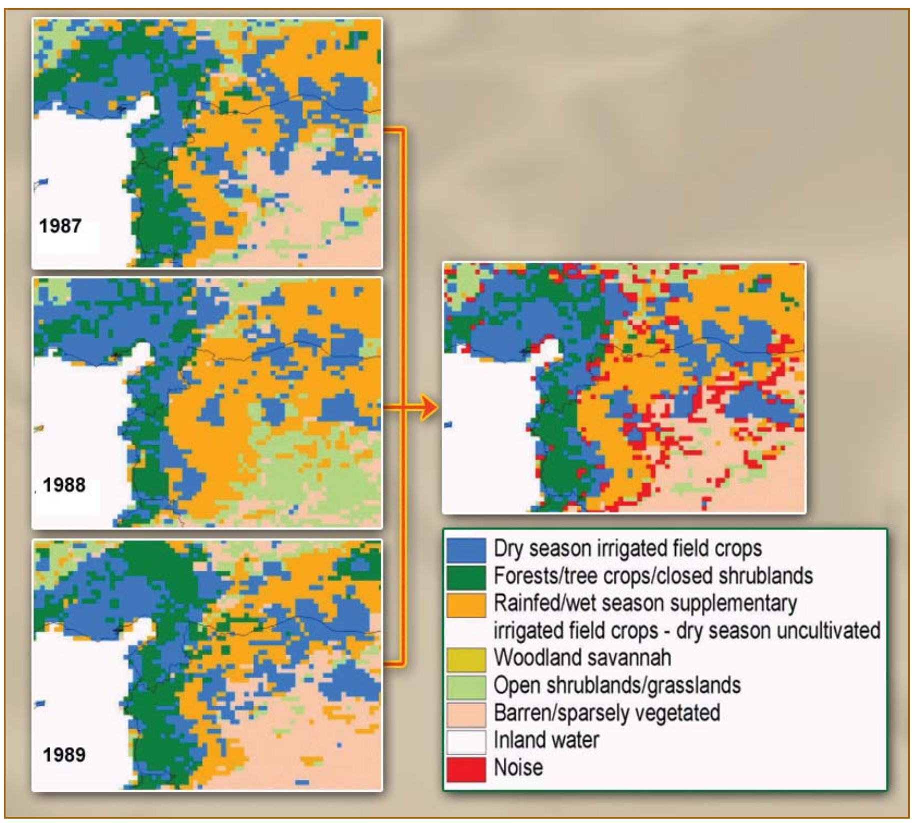


Fig. 18. Majority land-cover classes for different years: northwest Syria (on the left, the land-cover classes for 1987, 1988, 1989; on the right, the majority land-cover class for the period 1987-89, obtained by superimposing the 1987, 1988 and 1989 images upon each other).

Theme 4. Socioeconomics and Policy

Project 4.1. Socioeconomics of Natural Resource Management in Dry Areas

ICARDA's provision of technical support to resource management and rural development projects has effectively contributed to sustaining fragile resource bases, and improving the livelihoods and welfare of the rural poor in CWANA. Assessments in 2002 showed that research and development (R&D) programs, conducted in collaboration with ICARDA and with the participation of farming communities, have improved the design and implementation of development projects in Egypt and Pakistan. These successes highlighted opportunities for international agricultural research centers (IARCs) to play a more direct role in rural development, and also the need to develop new concepts and methodologies for use in this context.

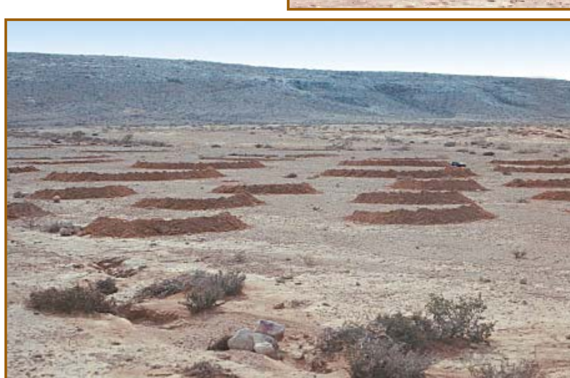
Research and development projects: sustaining the resource base, and improving the livelihoods of the rural poor

In Egypt, between 1996 and 2001, ICARDA provided around 4000 person-days of on-site technical assistance, and over 1500 person-days of overseas training, to support the Matrouh Resource Management Project. It also contributed to project management, financial management, and monitoring and evaluation of the US$29.6 million research-based rural development project.

The project aimed at breaking the degradation cycle and improving the livelihoods of the rural poor in Egypt's Northwest Coast region—a very poor, semi-desert environment with a fragile natural resource base. Acknowledging the impressive achievements of the project, the Government of Egypt and international funding agencies (World Bank, IFAD, and GEF) have provided tentative funding of about US$50 million for a second 5-year phase.

ICARDA has provided assistance to all programs within the project. In the Soil and Water Management Program, technical support was given to many R&D activities. These included determining runoff coefficients, improving the design and positioning of water-harvesting structures (then testing and disseminating them), and adopting an integrated watershed planning approach. Project interventions increased the area's water supply by more than 50%; 1.2 million m^3 of rainwater was harvested in 8000 cisterns and conserved for human, livestock and crop use. Small dikes were established, providing water to 2000 ha of orchards, and soil was conserved on thousands of hectares, through engineering and cultural measures. Some 58% of the 17,500 project households benefited from these efforts.

In the Rangeland Rehabilitation Program, strategies and location-specific technologies were developed and used to rehabilitate highly degraded rangelands with low productivity (48% of the pro-



Project staff inspect a site installed with water measurement devices (above). Micro water harvesting techniques being tested at Hajji Hmeida's on-farm research site (left), in Egypt.

ject area). Over 10 million fodder shrubs were planted and/or inter-planted on 10,000 ha, and 1500 ha were reseeded with annual and perennial fodder species or planted with barley–vetch mixtures. Over 13.5 million Feed Units (each equivalent to 1 kg of barley) were produced, and the feed deficit was reduced by about 20%. Farmers were supported both in collecting and multiplying the seeds of rangeland plants, so conserving many threatened species, and in establishing private nurseries and adopting improved nursery techniques. Impact studies showed that 67% of rangeland holders benefited from this program, while 45% increased their income by 25% to 50%.

Crop Improvement R&D programs increased the productivity of cropping systems. For barley, ICARDA introduced its participatory breeding approach, as well as a new agronomic package, and the use of rotations or mixtures of feed legumes and fodder shrubs. ICARDA also introduced improved germplasm and cultural practices for fruit production. About 53% of barley producers (farming 27,300 ha) increased their yields, by between 20% and 100%. About 62% of fruit producers (on 14,700 ha) also increased their yields—by 25-200%. Fig and olive yields rose by 60%, and the average farm income rose by 52%.

In the Livestock Improvement component, 49% of animal breeders adopted new technologies. Of these, 65% increased livestock productivity by 25%, while 8% realized increases of 50% or more. Improvements included rotating rams, fattening early-weaned lambs, crossbreeding with *Shami* goats, introducing new poultry breeds, feeding with urea-treated straw and olive-pulp cakes, and improving veterinary services.

In the area of human resource development, on-the-job training upgraded staff and farmers' skills and capacities, and speeded-up the implementation of project activities. Overseas training, particularly joint 'researcher–extensionist–farmer' study tours, enhanced the adoption of new technologies.

In Pakistan, in an area with better agroclimatic and socioeconomic conditions than the Matrouh project, ICARDA has been contracted to provide technical assistance to the research component of the Barani Village Development Project. This six-year project (1999-2005) aims to sustain the resource base and alleviate the high poverty levels in Barani (in the Punjab region). With virtually all arable land and water resources being used, the pressure on the limited natural resources has reached critical levels.

The Barani project has R&D programs for community development, including those aimed at women, water management and soil conservation, crop and livestock improvement, and enterprise development. The programs are implemented in collaboration with research institutes, extension agencies, NGOs, and farmer organizations. Most work is conducted on farm at three integrated research sites (IRS), representing a range of agroclimatic and socioeconomic conditions. Technical backstopping, by ICARDA, has focused on integrated production systems and on improving water and land management. Furthermore, ICARDA is both introducing proven technologies developed in similar agroecologies, and supporting the program's research component through training and capacity building.

Assessment of adoption and impact is ongoing, and has shown that the project achieved promising results in its first three years. New germplasm, agronomic practices, and location-specific packages have increased crop production by 60-100%. Stone-outlets on earth dikes have been redesigned, and have regulated water flow and improved water distribution on a large scale. Soil conservation technologies (growing fruit trees on eroded gullies with micro-water harvesting or supplemental irrigation techniques, and the reseeding of indigenous fodder species) were well-received by farmers, as was feed-block technology. R&D plans have been made to test, and provide to farmers, several types of water-harvesting techniques that will improve water-use efficiency, conserve soil, and increase farm incomes. Also planned are interventions to encourage the establishment of family or community-based seed enterprises, as is an investigation into efficient mechanisms for handling the feed-block technology.

ICARDA's technical assistance has also highlighted the need to:

- develop more effective collaboration between project stakeholders—to improve community-based approaches to R&D;
- inform farmers, at the IRS, of the R&D programs—through extension pamphlets and mass media;
- develop a monitoring-and-evaluation system and indicators—to investigate the sustainability of the project's impact on the natural resource base and poverty;
- support in-country, formal and on-the-job training for project personnel and farmers; and
- organize regular consultation meetings with farmers' organizations—to develop mechanisms for community management of water resources and rangeland.

Useful lessons relevant to IARCs can be learned from ICARDA's new partnership experiences. Indeed, the World Bank considered the Matrouh project to be one of its most successful pioneer resource management and rural development projects, and one which could be adopted elsewhere in marginal dryland areas. It specifically acknowledged the role of ICARDA's technical support.

Besides the required budgets and the motivation of all stakeholders to develop the area, the main factors contributing to the project's success were the use of an innovative management model and participatory approaches, the establishment of an efficient monitoring and evaluation system, and the building of staff and farmers' skills and capacities.

Conversely, development projects could themselves provide opportunities for IARCs, as they provide an ideal setting in which to conduct strategic research programs. The projects are long term and multi-institutional, and integrate research, extension and development efforts. They can thus facilitate integrated research on biophysical and socioeconomic issues over large areas, as well as upon technology transfer (including the assessment of real adoption and impact).

ICARDA is seeking new ways to integrate its research activities into rural development projects and build up the technical and managerial capacities necessary for this. Careful thought is needed, to ensure that research is both applicable to, and beneficial in, a development-project context.

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 2002, ICARDA scientists completed a comprehensive study of small-ruminant production in WANA. Examining socioeconomic and market trends, this study promises to provide a platform for policy decisions which could greatly benefit the rural poor involved in this sector. ICARDA's Mashreq/Maghreb Project has already improved household food security in the region, by developing and introducing improved crop and livestock technologies. Recent surveys show an impressive rate of adoption, indicating a significant contribution to the welfare of farmers in the dry areas of WANA.

Livestock production and its influence on livelihoods in the dry areas

ICARDA recently completed a comprehensive desk-based study of livestock production and livelihoods in the dry areas. Soon to be published, this study synthesizes current information about small-ruminant production and trade in the WANA region and raises critical questions concerning the improvement of this important sector. Such questions relate to factors that affect regional trade in small ruminants, influencing the income of millions who depend on them. The detailed picture given will be valuable both to ICARDA, in planning research for this sector, as well as to other international and national organizations interested in the sector's performance and the role it plays in the livelihoods of millions of rural people.

Livestock production accounts for about one-third of the agricultural revenue of the WANA countries. In terms of the national incomes of these countries, the livestock sector was valued at US$107 billion in 1999, with small ruminants contributing $US25 billion (about 3%) to the total GDP. Some countries in the region depend more

on livestock than others. For example, in 1999, livestock accounted for between 17% and 52% of the GDPs of Ethiopia, Mauritania, Pakistan, Somalia, and Sudan, but only between 3% and 8% of the GDPs of Algeria, Egypt, Iran, Morocco, Syria and Tunisia. Small-ruminant production is the main agricultural output in less favored areas (those receiving less than 300 mm of annual rainfall), and is the basis for the livelihoods of most of the poor people in such areas.

Trends in small-ruminant populations

In 2000, the WANA region contained 480 million head of small ruminants, 70% more than in 1960 (Fig. 22).

Large producers (Group I), such as Ethiopia, Iran, Pakistan and Sudan, hold 56% of the total WANA small-ruminant stocks. Medium-sized producers (Group II), including Afghanistan, Algeria, Morocco and Somalia, hold about 19% of the total stocks. Small producers (Group III), including Egypt, Iraq, Saudi Arabia, Syria and Tunisia, hold 10% of the total. The remaining 15% of small ruminants are distributed amongst the other Gulf countries, and Lebanon, Jordan, Libya and Yemen.

Supply and demand factors influence the region's small-ruminant population. On the supply side, the improvement of veterinary services (such as free vaccination) is a major factor contributing to the growth of the small-ruminant population.

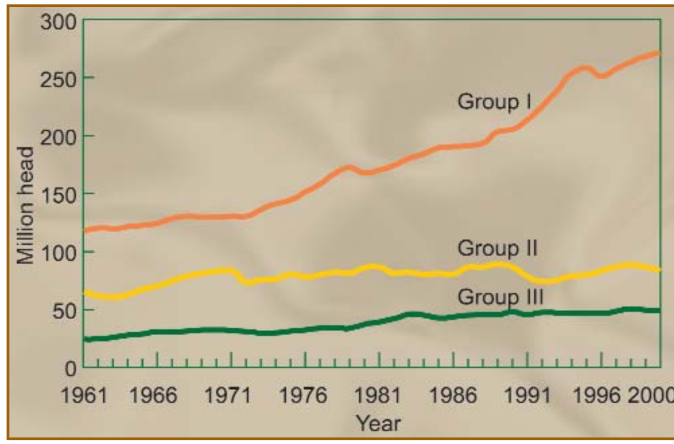


Fig. 22. Small-ruminant population trends in the WANA region between 1961 and 2000 (Groups I, II and III denote groups of countries with high, medium and low production).

The provision of feed subsidies, organized feed deliveries, feed stores in dry rangelands, and credit (for sheep-fattening cooperatives) are also important factors, reducing production costs and risks, and increasing profitability. However, feed subsidies, though often intended to achieve social and equity goals by supporting livestock producers during drought years, are not available in the poorest WANA countries (such as, Ethiopia, Mauritania, Somalia and Sudan). On the demand side, the market has driven the increase in the small-ruminant population of the WANA region, providing powerful signals to producers. Two major demand factors affecting meat consumption are income and population growth.

First, per capita meat consumption in WANA countries is strongly associated with per capita income. The Gulf countries with a GNP of over US$8000 per capita, recorded the highest per capita meat consumption (over 50 kg). The poorest countries, with per capita incomes of less than US$500, showed the lowest per capita meat consumption (below 20 kg). Second, rapid population growth (from 400 million people in 1981 to over 640 million in 2000) also increased demand. These demand factors led to the emergence of profitable sheep-

Consumption of meat of small ruminants in WANA increased from 1.2 million tonnes in 1963 to 3.0 million tonnes in 2000.

fattening systems, targeted at major urban centers and export markets.

Consumption of the meat of small ruminants in WANA increased from 1.2 million tonnes in 1961 to 3.0 million tonnes in 2000—an average annual growth rate of 2.2%. Small-ruminant meat production increased from 1.2 million tonnes in 1961 to 2.7 million tonnes in 2000—a slightly lower annual growth rate of 2.1%. The gap between production and consumption was filled by imports.

Market shares and implications for the poor

Traditionally, small ruminants were traded between WANA countries—a result of competitiveness, proximity, consumer preferences, established trade networks and religious and cultural familiarity. However, because many WANA countries could not meet the newly increased demand, new, non-WANA small-ruminant traders (including Australia, Bulgaria, Hungary, New Zealand and Romania) recently captured a substantial portion of the WANA small-ruminant market. Though originally small in the 1960s (about 20%), their market share expanded to over 80% in the late 1970s (Fig. 23). WANA countries regained some of that lost market share in the 1990s, but even so, controlled only about 38% of the regional market by 2000.

Probably it was the occurrence of a sharp rise in domestic demand in the traditional exporting countries of WANA which gave non-WANA exporters the opportunity to fill the gap between demand and supply. But, the following factors probably also contributed to the WANA producers' loss of traditional markets.

Many WANA producers use nomadic, semi-nomadic or transhumance production systems, and rely on the use of common rangelands for feed resources and living space. Because such lands are usually state-owned, producers have no incentive to invest and improve their production capacities. Therefore, extensive production systems with low productivity dominate. These systems are relatively less competitive (in terms of price) than the high output:input ratio systems of the non-WANA exporters, leading to further potential loss of export markets.

A lack of region-wide institutions governing animal health regulations and a lack of common rules may also have led to unilateral decisions to ban trade on the grounds of health, with or without evidence of significant health risks to consumers. Moreover, recent outbreaks of livestock diseases (such as Rift Valley Fever in East Africa, and Foot and Mouth and Mad Cow Disease in Europe) raise serious concerns which, if not addressed, could have a negative impact on the livelihoods of livestock producers in WANA.

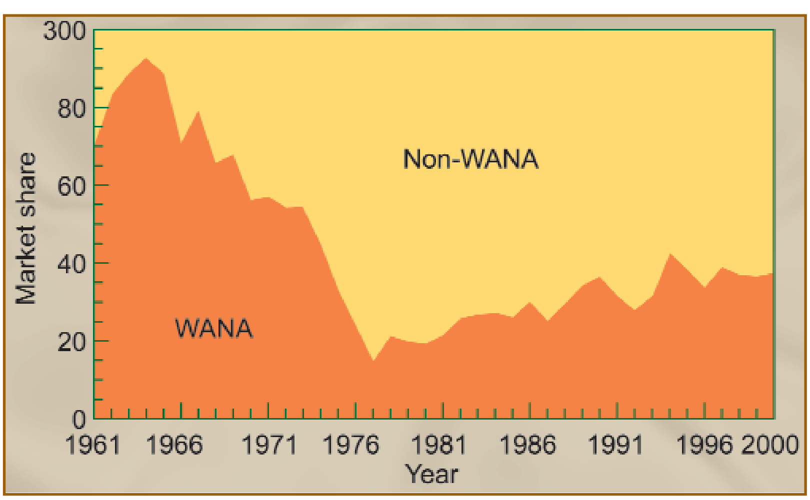


Fig. 23. Market share of WANA and non-WANA countries in the WANA small-ruminant market (1961-2000).

Policy action needed

At the national level, policy changes are needed to stimulate the adoption of productivity-enhancing practices, to increase investment in the vast rangelands (upon which many livestock producers rely) and to reduce the risk of environmental degradation. Productivity-enhancing technologies are the key to competitiveness in the market place. Without productivity improvements, producers may not only lose traditional export markets, they may also lose their domestic markets to more competitive producers.

ICARDA is collaborating with national agricultural research programs to develop and adapt livestock productivity-enhancing technologies in the dry areas. Market efficiency and access to investment capi-

tal (to modernize production systems) also affect the profitability of livestock enterprises. Research is needed on livestock marketing and the role credit plays in livestock improvement. Such research could provide guidelines for policy action. Certainly, in exporting countries, policy action is needed on measures which will reassure importing countries that livestock production meets required standards, minimizing human health risks.

At the regional level, common policies and coordinated efforts on health-related regulations on livestock trade are essential. Without such polices, small-ruminant producers in WANA may fail to compete in the regional and global markets. This would have negative impacts on the livelihoods of poor, rural communities, particularly in livestock-exporting countries.

Adoption and economic impact of improved technologies in Mashreq and Maghreb countries

ICARDA's Mashreq/Maghreb (M&M) Project has developed and introduced several improved crop and livestock technologies into the farming systems of Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria and Tunisia. The project is being implemented by NARS in the eight countries, and by ICARDA and IFPRI, and is funded by the International Fund for Agricultural Development (IFAD), the Arab Fund for Economic and Social Development (AFESD), and the International Development Research Centre (IDRC). In order to assess the adoption rates of the introduced technologies (in terms of the percentage of sample farmers and percentage of land areas of sample farmers), surveys were recently conducted with 1148 farmers throughout the project. The economic benefits of the technologies were also calculated—i.e. productivity increases, cost–benefit ratios, and internal rates of return (IRRs).

New barley technology is being adopted at high rates in the Project's target areas (Table 27)—a result of the improved varieties' higher yields, improved resistance to disease and lodging and, in some areas, distinctively higher returns.

In Iraq, the improved barley variety 'Rihan 03' yielded 43% more grain than the local variety ('Aswad') when grown with fertilizer. This gave a net productivity increase of 19% over the local variety under the same input levels. In Syria, the net productivity increase was 20%; household food security (annual production of barley/household) also improved, by 14%, in comparison with local varieties. Amongst those who adopted the improved variety in Syria, the Gini coefficient was calculated to be 0.69, as compared with 0.82 for non-adopters. This means that the adoption of improved varieties has reduced the dispersion of the distribution of net returns among barley farmers there.

In Morocco, improved varieties ('ACSAD 60', 'Annoucer' and 'Tamelalet') also increased barley grain yield (by 35%), although straw yield decreased by 12%, in comparison with the local variety. However, this trade-off does not affect the economic feasibility of using improved varieties. Moreover, the improved varieties contribute greatly to feed security, by increasing feed availability by 0.175 tonnes/head annually. Improved barley varieties had a neutral impact on the equality of income distribution among farmers in Morocco, with Gini coefficients estimated to be 0.14 for the local variety and 0.13 for the improved variety.

Developed, tested, and disseminated by the M&M team as part of a collaborative effort, feed-blocks are another success story arising from this project. Feed-blocks (dietary supplements) are used to improve sheep production. Therefore, the project's experts trained private firms and extension staff in the setting-up of manufacturing plants. Feed-block production (from agro-industrial by-

Table 27. Adoption of improved barley cultivars and their impacts on productivity.

Country	Adoption (%)		Change in productivity (%)
	Farmers	Land area	
Iraq	60	54	17
Jordan	55	67	25
Libya	17	12	na
Morocco	46	40	35 (grain), -12 (straw)
Syria	32	21	20

na= data not available.

products) and use is now well established in Iraq (Fig. 24), where many sheep owners, regardless of flock size, now use them. A survey of 81 Iraqi sheep owners also indicated a high purchase rate, with blocks bought twice, on average, during the 1999/2000 season. Through the M&M Project, feed-block technology has also spread to other countries, with adoption rates of 21% and 32% for farmers in Jordan and Morocco, respectively. Tunisia's adoption rate was only 17%; but, it was found that, in one dry season, around 25% of small ruminants in one community were fed feed-blocks.

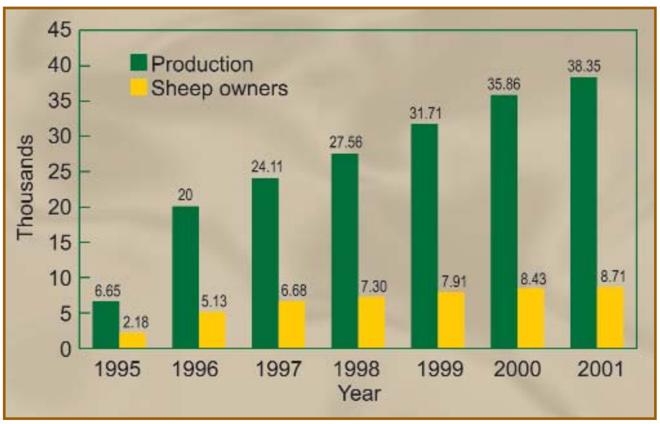


Fig. 24. Development of feed-block technology in Iraq: production and use.

In Iraq, the use of feed-blocks increased sheep production by 32%, by increasing the number of lambs born. They also increased annual meat and milk production (by 4.09 kg and 8.28 kg/ewe respectively), when 116 kg of feed-blocks/ewe were used with conventional feed resources (barley grain, straw and green fodder). The benefit–cost ratio for feed-block use was 1.56, while the IRR was 87%. Comparing this IRR with the effective rate of interest (10%) indicates that investment in feed-blocks is paying farmers high dividends.


Feed-blocks ready for distribution in Iraq.

In Tunisia feed-blocks are being used as a substitute for expensive feed resources (such as barley grain and wheat bran), giving an estimated IRR of 57% while maintaining weight levels in small ruminants. In Jordan, where early weaning is used to increase milk production, the use of feed-blocks adds an additional 0.78 JD/head (US$1.01) to the net revenue gained.

Because they are a welcome supplement during drought seasons, in Iraq, the project also made available 11.4 kg of feed-blocks per head during the dry 1999/2000 season, when up to 85 kg per head were bought and used by some sheep owners to bridge the feed gap they faced.

The planting of cactus, and its use as an animal feed, is expanding in the Maghreb region with government support. In Algeria and Tunisia the practice is well established, with adoption rates of 40% and 17%, respectively, among farmers in the target communities. Furthermore, 37% and 24% of the target communities' lands in Algeria and Tunisia are planted with cactus. Estimates of the IRR obtained in Tunisia when cactus is planted in natural rangeland vary from 73% (without government subsidies) to 80% (with government subsidies). When planted in marginal cereal-growing land, IRRs for monocropped cactus range from 61% to 66%, and from 81% to 89% for cactus alley-cropped with barley. Comparable IRRs were obtained for cactus alley-cropped with barley in Algeria (71%-99%). Similarly, in Morocco, alley cropping saltbush (*Atriplex* spp., another drought-tolerant forage) with barley gave an IRR of 79% (compared with 59% for monocropped barley), indicating the efficiency of research investment in this technology.

Using rainfall data (1974-1998), estimated production functions were used to predict yield levels of barley in rotation with forage legumes. The barley/vetch, barley/vetch-barley mixture and barley/fallow rotations were most profitable, and thus are recommended for the low-rainfall area in

Simple structures, such as this stone dyke, help farmers retain precious rainwater to maintain their plantations of fruit trees and fodder plants, such as the spineless cactus, foreground.

Iraq. The barley/fallow rotation was one of the most efficient, even though the net return it gave was not the highest, probably because of its low coefficient of variation. However, before recommendations are given to individual farmers, more information on their personal preferences and objectives is needed. For farmers with mixed crop-livestock enterprises, the rotations of barley/vetch and barley/vetch-barley mixture are recommended, as they allow better crop/livestock integration.

Several other technologies have increased the welfare of the rural poor in the selected areas. In Syria, the use of vetch in barley rotations, and early weaning, had adoption rates of 28.5% and 28.8%, respectively, influencing sheep raising and related economic returns. Sheep-raising in the Maghreb region also benefited from the use of improved rams. In Algeria, for example, 6% of sheep owners bought improved rams, and 16% of the ewes in the study communities were mated by them.

In conclusion, the technologies introduced are economically feasible regardless of government subsidies, though government incentives are important initially, in securing widespread dissemination of the technology. However, the relatively high IRRs noted were only achieved because the technologies introduced were designed specifically for the areas the project targeted in the low-rainfall Mashreq and Maghreb countries.

Project 4.3. Policy and Public Management Research in West Asia and North Africa

A community-focused phase of the Mashreq/Maghreb project, which involved eight countries, was successfully completed in 2002. Target communities chose a number of appropriate technological, institutional and policy options, and evaluated them at the community level. Researchers in multi-disciplinary teams facilitated the process, and analyzed the project's results from many different perspectives. Innovative community models, which can be used by policy makers as a decision-making tool, were also developed. The communities themselves chose the 'best-bet' options for their development, and used these to develop their own Community Development Plans.

The Mashreq/Maghreb project: empowering agro-pastoral communities

The Mashreq/Maghreb (M&M) project (coordinated by ICARDA and IFPRI, and funded by IFAD, AFESD, and IDRC) has recently used an innovative community-development approach in Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Tunisia and Syria. Its overall aim was to foster the integration of improved and sustainable crop and livestock production systems in low-rainfall areas. The project addressed problems from a technical, socioeconomic, cultural, institutional and policy perspective, with the full participation of the intended beneficiaries and other stakeholders. It supported the development strategy of selected communities—by addressing needs identified by the communities themselves.

In Phase I of the project (1995-1998), appropriate technology components were tested and demonstrated at the farm level, and the results evaluated within a whole-farm context. Phase II of the project, which has just been completed, was instead aimed at the community level—two target communities were selected in each country. The communities were chosen to represent areas where production systems were either based on barley or rangelands, or were 'in transition' (e.g. evolving towards an irrigated system—an agro-industrial system—as a result of changes in government policies). The project's foundations were laid by multi-disciplinary national teams, who characterized the communities' environments and investigated the policy and property rights issues that existed in each area.

The project has made a significant contribution in terms of changing the paradigm of research and development in the dry areas. Valuable lessons have been learned, not only in making the transfer of new technologies more effective, and in developing new decision-making tools for policymakers, but also in participatory processes that led to the communities developing their own 'Community Development Action Plan'—the project's ultimate goal. The process began with researchers conducting RRA and PRA exercises in the selected communities, along with comprehensive surveys of selected households. These data, and the results from Phase I of the project, were then presented at a community workshop. This led to the communities deciding that some of the technologies developed during Phase I should be dropped, while others should be selected for community-level testing. The communities identified the technological, institutional and policy options that would, potentially, be most beneficial to them, and that would also benefit from further research (Table 28). These options formed the foundations of a 'Negotiated Plan of Action' (Fig. 25), developed by each community.

The selected combinations or 'packages' of associated technologies were then tested by farm households, with the involvement of the local private and cooperative sector, as well as other institutions and stakeholders (such as local extension services, agricultural authorities and NGOs). Because each community assumed ownership of,

Table 28. Production systems used by the participating communities, and options chosen by them for community-level testing within the Mashreq/Maghreb project.

Production systems	Selected communities†	Options		
		Technological	Policy‡	Institutional
Barley-based system	Ain-Talawi (IRQ) Al-Harsh (JOR) Deir El-Ahmar (LEB) Wadi Hai (LIB) Sidi-Boumehdi (MOR) Zoghmar (TUN)	Improved cultivars Fertilizer use Dual-purpose barley varieties Feed blocks Forage crops Animal husbandry	Price policy Seed production Credit Drought-relief program	Identification and creation of institutional mechanisms that would best help in implementing the Community Development Action Plan
Rangeland-based system	Mtoussa (ALG) Mahalabia (IRQ) Mkaifteh (JOR) Ghadama (LIB) Aït-Ammar (MOR) El Mahmoudli (SYR)	Cactus plantations Fodder shrubs Feed blocks Alley cropping Water harvesting Animal husbandry	Price policy Fodder-plant production Support for alternative feed use Credit Drought-relief program	
System 'in transition'	Sidi Fredj (ALG) Nweyel (TUN) Um El Amad (SYR) Aarsal (LEB)	Improvement of current cropping systems Introduction of new crops Feed blocks	Price policy Support for development of the new system (if sustainable) Credit	

† ALG = Algeria; IRQ = Iraq; JOR = Jordan; LEB = Lebanon; LIB = Libya; MOR = Morocco; TUN = Tunisia; SYR = Syria.
‡ Examples: price policy-liberalization of prices, subsidies etc.; seed production-policy to make seeds of improved crop varieties more accessible to resource-poor farmers; drought-relief-importing barley for feed, subsidizing food prices, and digging wells.

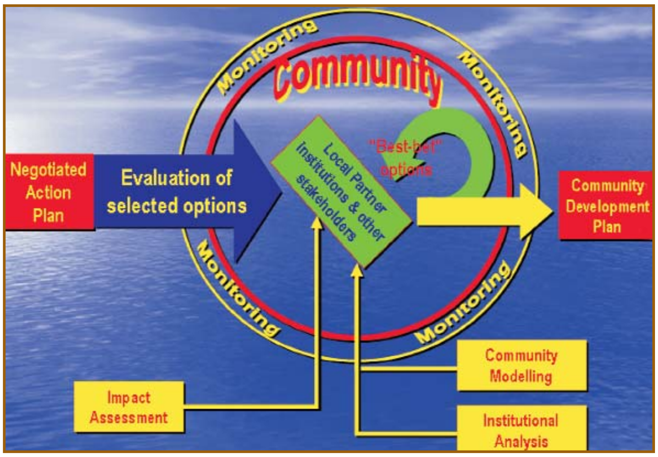


Fig. 25. Community-level phase of the Mashreq/Maghreb project, which aims to develop improved and sustainable integrated crop-livestock production systems in low-rainfall areas.

and responsibility for, its own Plan of Action, the role of the M&M project's national teams was capacity building and the facilitation of this evaluation process. To help the community, by sharing experiences across all eight countries, a project facilitator was installed in each village whose role was to channel important information into the community and to channel feedback to the project. The M&M teams monitored the evaluation process, in order to devise corrective measures and/or make adaptations if necessary.

As well as assisting in the adaptive testing of the technologies, researchers prepared community land suitability maps, after completing detailed agroecological characterization studies, and conducted policy, institutional and monitoring surveys. As part of the institutional analyses, researchers identified existing community and higher-level institutions whose involvement could be beneficial to the project communities (Table 29). Representatives of these institutions were, in

Table 29. Existing local and partner institutions involved in the Mashreq/Maghreb project, and institutions created by the project in the selected communities.

Local institutions	Selected communities	M&M Partner institutions	M&M-created institutions
Elected bodies (Municipalities, rural communes, etc.)	Aarsal (LEB) Deir El-Ahmar (LEB) Sidi-Boumehdi (MOR) Aït-Ammar (MOR) Al-Harsh (JOR)	Municipality	Sheepherders' Associations
Appointed bodies (community heads, state project, etc.)	El Mahmoudli (SYR) Um El Amad (SYR) Ain-Talawi (IRQ) Mahalabia (IRQ)	Mokhtar (community-level representative of the authorities)	Community Steering Committees
	Wadi Hai (LIB) Ghadama (LIB)	State Settlement Project	
Farmers/herders organizations (cooperatives, associations, etc.)	Sidi Fredj (ALG)	Opuntia Growers Association	
	Nweyel (TUN)	Collective Interests Association (AIC)	
Traditional organizations (tribal, religious, etc.)	Mkaifteh (JOR)	The local Sheikh Municipality (elected)	
No institution	Mtoussa (ALG) Zoghmar (TUN)		Farmers' Association Collective Interests Association (AIC)

ALG = Algeria; IRQ = Iraq; JOR = Jordan; LEB = Lebanon; LIB = Libya; MOR = Morocco; TUN = Tunisia; SYR = Syria.

some cases, elected to sit on the Community Steering Committees set up by the communities (with help from the M&M project). The project also assisted target communities in establishing new informal and formal organizations to facilitate and support the uptake of new technologies or management strategies. For instance, in Lebanon, specialized cooperatives for livestock producers were set up.

Researchers assessed the adoption and impact of the various technologies (see Project 4.2, this report), and carried out econometric analyses. Innovative bio-economic community models were developed to evaluate the technologies and to assess the potential impacts of policy reforms on both the community's welfare and on different farm types.

All these analyses helped the project's researchers identify packages of tested and adapted 'best-bet' technological, institutional and policy options. These options, and the project's results, were presented to the communities in further community workshops. The communities chose the options they thought were most appropriate, and used them as the foundation of a 'Community Development Action Plan' (Fig. 25). Each Plan will also include non-agricultural priorities (such as education, health and infrastructure), and will have a lifetime longer than the M&M project itself. Each community's Plan can be used both to steer its own development and communicate its needs to development and government agencies in the future. Indeed, communities in Morocco, Jordan and in Tunisia, have already attracted outside funding for priorities they had identified.

Farmers discussing criteria for selection of barley genotypes with project scientists.

Theme 5. Institutional Strengthening

Project 5.1. Strengthening National Seed Systems in Central and West Asia and North Africa

When seed reaches farmers, it is the end product of a long process. ICARDA's role does not end with the development of an improved variety. The difficult task of distributing the seed to farmers throughout the CWANA region remains, with a special need to reach the region's numerous small-scale farmers. The Center's Seed Unit collaborates with national seed programs to address seed supply constraints, providing the backstopping and human resource development for cost-efficient and effective seed systems. In 2002, Afghanistan's immediate and long-term agricultural needs for seed were addressed, by the ICARDA-led Future Harvest Consortium to Rebuild Agriculture in Afghanistan. Also, ICARDA helped promote free trade in quality seed in the region by organizing a workshop which addressed national seed policy laws and regulations.

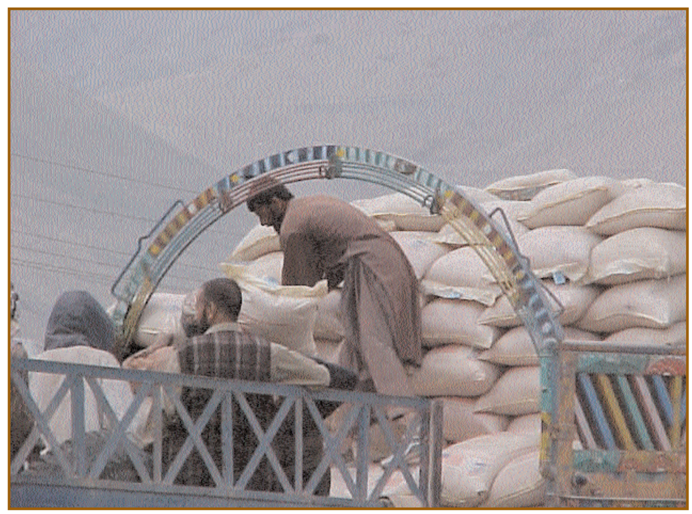
Future Harvest Consortium: helping to restore agriculture in Afghanistan

With funding from the United States Agency for International Development (USAID), the ICARDA-led Future Harvest Consortium to Rebuild Agriculture in Afghanistan (FHCRAA) was formed in January 2002 in Tashkent, Uzbekistan. A program to restore Afghanistan's agricultural production systems was immediately implemented.

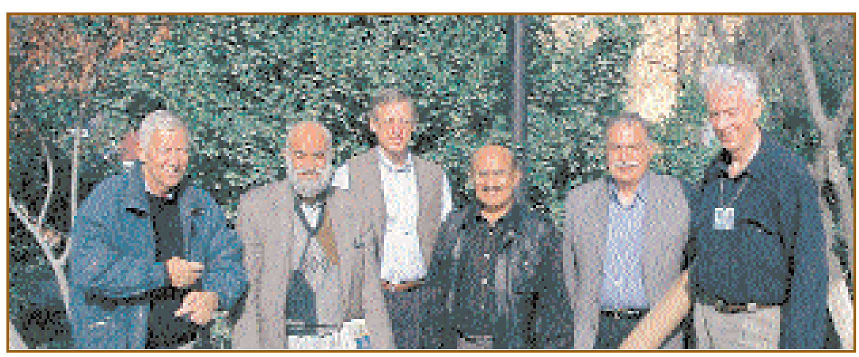
The Consortium is a joint effort of the International Agricultural Research Centers of the CGIAR, other international research and development organizations, the Food and Agriculture Organization of the United Nations, United States universities, several international and local non-governmental organizations (NGOs) working in Afghanistan, and the Afghan Ministry of Agriculture and Livestock (MOAL).

Addressing short-term needs

An immediate, short-term need was the provision of seed, to enable Afghan farmers to sow their spring crop. Therefore, the Consortium made available a total of 3,500 tonnes of seeds of two adapted wheat varieties. Procured in Pakistan and transported to Kabul by the UN World Food Programme (WFP), and then, via local transporters, to NGOs in the interior of the country, the seed reached around 70,000 farming families in eight provinces. The



High-quality wheat seed, provided by the Consortium, being unloaded in Afghanistan.



The first ICARDA–led Future Harvest Consortium mission to Kabul, Afghanistan, in March. From left, Dr Tony van Gastel, Head, ICARDA Seed Unit; Mr Abdul Rahman Manan, Chief Advisor, Future Harvest Consortium; Dr Larry Paulson, Agricultural Development Officer, United States Agency for International Development (USAID); Dr Nasrat Wassimi, Executive Manager, Future Harvest Consortium; Dr Mahmoud Solh, Assistant Director General, International Cooperation, ICARDA; and Dr Ray Morton, Senior Policy Advisor, USAID.

Cleaning seed near Kabul, a source of cash income for farm families, particularly war widows.

International Fertilizer Development Center (IFDC) later provided fertilizer.

During the fall planting season, the Consortium arranged for the delivery of almost 5,000 tonnes of wheat seed. This seed was produced, under contract, by selected farmers in Afghanistan, and a rigorous quality-control program was established. Approximately 100,000 farming families received the seed. The seed production, cleaning and post-harvest operations provided cash incomes for a large number of families. Seeds of a variety of other crops (such as rice, barley, alfalfa, clover, chickpea and flax) were also procured for fall planting in 2002 and spring planting in 2003.

Rebuilding Research Stations

In the early 1970s there were 22 agricultural research stations in Afghanistan. Most of them have been abandoned, bombed, looted or confiscated by warlords. ICARDA has been successful in refurbishing six stations in five provinces (Kabul, Baghlan, Kunduz, Takhar, and Nangahar). The refurbished agricultural stations serve as launching points for hundreds of village seed enterprises (VSEs) throughout Afghanistan. VSEs provide the means for small business development, new markets, crop improvement, technology transfer, training and educational opportunities for Afghan farmers. The stations are also essential components in the development of crop diversification.

Seed health and testing laboratories are being re-installed along with meteorological equipment to provide accurate weather data. Training courses for Afghan men and women are ensuring that the stations have skilled and qualified staff now and for the future.

The war and conflict left most of the research stations in Afghanistan destroyed or abandoned (left). As part of research infrastructure rebuilding, the ICARDA-led Consortium, with financial support from USAID, was successful in 2002 in refurbishing six research stations in five provinces (Kabul, Baghlan, Kunduz, Takhar and Nangahar) in Afghanistan (above, refurbished research station at Darul Aman, Kabul).

Long-term interventions

To provide the basis for long-term strategies of sustainable agricultural development, ICARDA fielded needs assessment teams in four areas: seed systems and crop improvement; livestock, forage and rangelands; soil and water; and horticulture. Probably the first scientific teams to enter Afghanistan, the general approach of these experts was first to assess the situation on the ground, through discussions with officials, donors, and international organizations. Field surveys in provinces and wrap-up meetings with all stakeholders then followed. Summaries of need assessments are available on ICARDA's website (www.icarda.cgiar.org), but the general conclusion drawn was that all the sectors of Afghanistan's agricultural system are in urgent need of rehabilitation.

The ICARDA Seed Unit provided technical support to the Seed Systems and Crop Improvement Needs Assessment team, including the selection of experts, design of survey questionnaires, training of enumerators and data analysis. The survey was conducted by the Afghan Survey Unit (ASU), whose enumerators have long-standing experience in carrying out agricultural surveys for many development agencies. In six provinces within the country's six agricultural regions, a total of 390 households were randomly selected and interviewed. As food security was its primary focus, the survey covered seven major food crops (irrigated wheat, rainfed wheat, barley, potato, maize, rice and chickpea).

The survey showed that, given appropriate support, Afghan farmers could produce much of the country's food requirements. Moreover, there seems to be increasing scope for Afghan farmers to adopt new varieties: those they currently have are mostly of local origin. Given the large areas cultivated with rainfed wheat, the continuing drought and the shortage of irrigation water, it is important to intensify efforts to develop more efficient varieties of this crop. Also, seed production should focus on quality enhancement and not on quantity, since households have the capacity to meet a high proportion of their seed needs from village sources. Alternative seed systems should, therefore, be developed within communities to produce and make available high-quality seed. Since most farmers posses their own land, or can practice sharecropping, access to water resources is more important than access to land itself.

As the foundation for broadening farmers' future production options, 53 tonnes of source seed from a large number of wheat, barley, lentil, chickpea and vetch varieties were provided to Afghanistan for evaluation and testing in cooperation with researchers and farmers. This included landraces and germplasm stored in ICARDA's gene bank.

To improve production of potato—an important cash crop for farmers in Afghanistan—the International Potato Center is running a Jalalabad-based potato multiplication program. This aims to make healthy potato planting material of improved and adapted varieties available to Afghan farmers. In addition, planting material from a number of tree crops (almond, pistachio, apricot, walnut and peach) has also been procured, and nurseries have been established in Darul Aman (near Kabul) and at the Taloqan Research station. These activities

Discussing survey questionnaires with enumerators from the Afghan Survey Unit in Peshawar.

are being carried out in close cooperation with the International Plant Genetic Resources Institute (IPGRI).

In order to rebuild a normal seed industry, variety maintenance of important varieties of wheat and barley and an international nursery testing program have been initiated. This program involved the planting of international nurseries, composed of 400 kg of seed—wheat (bread and durum), barley, chickpea, lentil, faba bean and forage legumes—planted in replicated yield trials. Several initiatives have been undertaken to support a decentralized seed production system. These include the multiplication of 200 Mt of seed by farmers, and arrangements with NGOs involved in the fall distribution to supervise 10-15 progressive farmers as seed producers.

A Code of Conduct has been drawn up to guide all parties involved in the provision of seed to rebuild Afghanistan's agricultural sector. As the first step, a workshop held in May brought together around 80 participants from international and Afghan institutions. As the country moves from dependence on emergency assistance to sustainable agricultural development, the Code of Conduct developed will form the basis for a much-needed national seed policy and regulatory framework for Afghanistan.

The Consortium is also assisting the MOAL in undertaking regulatory functions related to the seed industry. Equipment has been provided for seed testing and seed-health testing, to ensure seed quality and to help enforce quarantine measures at ports of entry (Herat, Jalalabad and Kabul).

Rehabilitated farm building near Taloqan in Takhar province

The long conflict in Afghanistan resulted in the breakdown of educational systems, and an entire generation of young people is deprived of formal education. The Future Harvest Consortium has initiated training programs, which began with a field-based course on seed production practices for field crops, held in Kabul. More than 70 trainees were exposed to modern seed-production practices. The course supported ongoing activities to upgrade grain fields, and began the training of a new generation of farmers and researchers. The rebuilding of Afghanistan's agricultural sector has only just begun; it requires a long-term commitment.

Cooperation could lead to a common market for seed

CWANA faces the serious challenge of achieving national food security while reducing environmental degradation and depletion of its natural resource base. Seed plays a critical role in the transfer of all science-based, new agricultural technologies to farmers, and effective seed industries form the basis of any strategy to improve food production. Each country is attempting to build its own national seed program in isolation. More importantly, each national seed industry faces different regulations, standards and procedures, which often act as barriers to regional integration.

Since the mid-1980s, there has been a strong movement towards economic liberalization; and, policy shifts related to economic development have caused many changes in the seed industry. Such changes include (1) policy and regulatory reforms, to reduce government involvement in seed production and allow the participation of the private sector and other actors; (2) globalization of the seed industry in cases where seeds are considered to be a strategic commodity for international trade; and (3) harmonization initiatives to create regional markets to attract investment in the seed sector.

There is now a strong trend towards political and socioeconomic integration at the sub- and/or supra-regional levels, to promote freer movement of goods and services. Within this context, harmonization of policy laws and regulations for the freer movement of crop varieties and seed throughout Central and West Asia could lead to

Participants of the workshop entitled "Review of National Seed Systems and Regulations in Central and West Asia," Karaj, Iran, 2–3 November 2002.

the establishment of a common regional market. This might, in turn, attract foreign and domestic private investment and help to create a competitive, efficient, and sustainable seed industry, allowing returns on investments in agricultural research and development to be realized.

Dryland agricultural systems predominate in CWANA, leading to the use of similar crops, varieties and seeds. This forms a strong basis for the required regional collaboration. To help promote free trade in quality seed, ICARDA and its NARS partners organized a regional workshop entitled "Review of National Seed Systems and Regulations in Central and West Asia," held at Karaj, Iran, on 2–3 November 2002.

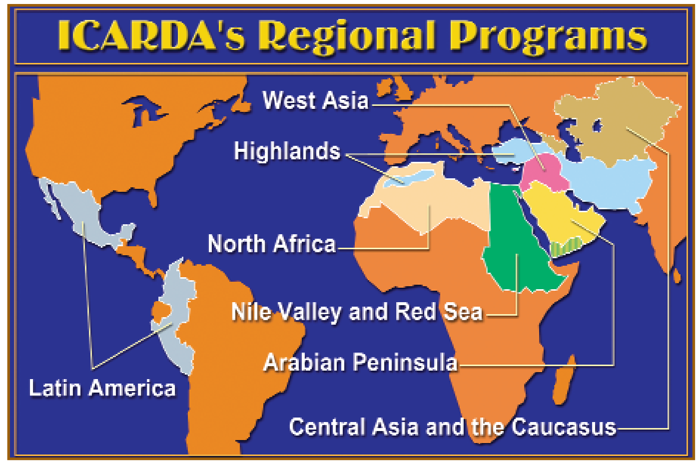
The Karaj workshop explored opportunities for harmonizing seed policy laws and regulations, and was attended by senior managers and policy makers from Afghanistan, Azerbaijan, Iran, Iraq, Kazakstan, Kyrgyzstan, Pakistan, Tajikistan, Turkmenistan, Turkey and Uzbekistan. Participants endorsed the harmonization initiative, and agreed to take the first step in the process by organizing an in-depth review of policies, laws, and regulations pertaining to the seed sector in each country. The review will be undertaken by each country and will include: (1) variety regulations (variety release and registration procedures); (2) seed regulations (certification procedures and standards); (3) seed trade regulations (seed import/export procedures); (4) phytosanitary regulations; (5) plant variety protection; and (6) regional seed policy initiatives. The reviews will be further discussed through consultative meetings among the stakeholders at national and regional levels, in order to reach a final agreement at the regional level.

In laying foundations for the integration of agriculture in the region, which will both allow the development of a regional common market for seeds and give farmers better access to science-based crop varieties and seeds across the region, the meeting had both historical and political significance.

International Cooperation

The success of ICARDA's research and training activities largely depends on its active partnerships with national programs. Besides a large number of joint activities with other CGIAR centers and advanced research institutes throughout the world, the Center has consolidated its outreach activities into seven regional programs, five in WANA, one in Central Asia and the Caucasus and one in Latin America. These programs act as a mechanism for resource-use effectiveness, eliminating duplication of effort, balancing activities according to the identified needs of each country, exploiting spillover of research from one region to another, and, more importantly, for providing a research continuum and a long-term vision of the impact of ICARDA's work.

These seven regional programs link scientists both within countries and within the region, promote leadership at the national and regional levels, foster cooperation in solving problems common to a group of countries, capitalize on complementarity between countries, promote transfer of technology, and encourage self-reliance in research and development. They also help in identifying particular expertise in NARS to decentralize ICARDA's research and training activities. Where appropriate, they play a catalytic role in attracting donor funding for national programs and establishing linkages with advanced research institutes.



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.

Collaborative projects

Several collaborative projects were implemented in 2002, including a trans-regional project on "Development of Integrated Crop/Livestock Production Systems in the Low Rainfall Areas of West Asia and North Africa" (The Mashreq/Maghreb Project), funded by IFAD, AFESD, and IDRC; "Development of Biotechnological Research in the Arab States," funded by AFESD; "Optimizing Soil Water Use," within the framework of the CGIAR Systemwide Program on "Soil Water and Nutrient Management (SWNM);" and the "Pilot IPM Site in Morocco," within the framework of the CGIAR Systemwide Program on "Integrated Pest Management (IPM). Two USDA-Tunisia bilateral projects continued for the second year: "Economic and Cultural Value of Herbal, Aromatic and Medicinal Plants" and "GIS for Watershed Management in South Tunisia," both with IRA Medenine.

The Mashreq/Maghreb Project was in its final year in 2002, and its activities concentrated on (i) adoption studies and assessment of the impact of the technologies promoted by the project, (ii) community development plans, and (iii) finalization of a proposal for a new project building on the achievements of the Mashreq/Maghreb project in its two phases. Two sub-regional workshops were held, one in Syria (Mashreq) and the other in Tunisia (Maghreb), to standardize approaches for adoption and impact assessment studies.

Five new collaborative projects were launched during 2002. Three of them were funded by USDA as bilateral projects with Tunisia, with ICARDA associated as a partner to provide backstopping: "Partnership to Improve Rural Livelihoods in North Africa and West Asia through Strengthened

Teaching and Research on Sheep and Goat Production;" "Biological Control of Weeds with Plant Pathogens;"and "Research on Improving Productivity of Oats as Priority Forage Species." One regional project "Integrated Research and Durum Economics Network" that covers Algeria, Morocco and Tunisia in addition to Turkey and Syria, was implemented with funding from IFAD. A sub-regional project funded by the Swiss Development Cooperation (SDC) was started on "Sustainable Management of the Agropastoral Resource Base in the Maghreb, Phase II."

Participants in the workshop on "Sustainable Management of the Agropastoral Resource Base in the Oujda Region of Morocco."

Research priority setting

Representatives from the development and NGO organizations and NARS of the five countries, and from ICARDA, CIMMYT and IPGRI, met in January in Hammamet, Tunisia to hold a consultation meeting to set research priorities for the region. Consultation followed a bottom-up participatory approach, and participants outlined research priorities and strategies with emphasis on the strong linkages between research, extension and development for achieving sustainable agricultural development and food security in the region.

Workshops and coordination meetings

NARP organized three workshops in collaboration with FAO: (i) "Barley for Food," (ii) "Policy Aspects to Foster the Adoption of Appropriate Technologies by Small and Medium Farms in the Arid Zones of the Maghreb Countries," and (iii) "Expert Consultation on the Rehabilitation of Food Legumes in the Production Systems of the Maghreb Countries." The first two were organized in Hammamet, Tunisia, and the third in Settat, Morocco.

National coordination meetings were held in Algeria, Libya, Morocco, and Tunisia to review the results of collaborative research and develop work plans for the future. The Ninth Regional Coordination Meeting, which is held every two years, took place in Libya. NARS managers and scientists from Algeria, Libya, Mauritania, Morocco and Tunisia, in addition to managers and scientists from ICARDA, attended the meeting. Collaborative activities of the two years as well as new projects were reviewed and discussed. The meeting recommended for NARS of the region to join the CGIAR and strengthen the AARINENA regional forum.

Nile Valley and Red Sea Regional Program

The Nile Valley and Red Sea Regional Program (NVRSRP) operates through ICARDA's Regional Office in Cairo, Egypt. Its overall objective is to increase the incomes of smallholder farmers in Egypt, Eritrea, Ethiopia, Sudan, and Yemen through the improvement of productivity and sustainability of the production systems, while conserving natural resources and enhancing the research capacity of national scientists.

Collaborative projects

The crop commodity improvement projects within NVRSRP include: "Food Legumes and Cereals Improvement 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," and "On-Farm

Demonstration of Improved Production Packages for Wheat in Sudan." Several activities address sustainable natural resource management, such as the "Natural Resource Management Project" in Egypt and the "Mountain Terrace Conservation Project" in Yemen. In addition, the "Problem-Solving Regional Networks Project," started earlier in all four countries, continued to operate with funding from the national programs.

Other projects, undertaken in the NVRSRP countries and managed from ICARDA headquarters, cover such areas as integrated pest management in faba bean (Egypt), integrated cereal disease management (Eritrea), genetically engineered stress resistance in lentil and chickpea (Egypt), on-farm water husbandry (Yemen and Egypt), grass pea improvement (Ethiopia), village-based participatory breeding (Yemen and Egypt), and the development of biotechnological research in the Arab States (Sudan and Egypt).

The following new collaborative projects were approved for funding and started activities in the last quarter of 2002:

- "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," which involves Egypt, Ethiopia, Sudan, and Yemen. The project is funded by IFAD, and builds on the previous regional activities under the Problem-Solving Networks.
- "Developing Faba Bean Expert System in WANA Region," with Egypt, Ethiopia, and Sudan from the NVRSP region, and three other countries from WANA.
- "Leveraging NEPER Wheat Expert System for WANA Region." Seven countries are involved, among which two (Egypt and Sudan) are members of NVRSRP.
- An interim phase of NVRSRP on the "Development of Sustainable Agricultural Production Systems in Egypt through Resource Management" has been funded through the EU Food Aid Counterpart Program for a period of two years.

New partnership Agreements

ICARDA signed a Twinning Agreement with the Central Laboratory for Agricultural Expert Systems (CLAES) of the Agricultural Research Center (ARC) and a Cooperation Agreement with the Desert Research Center (DRC) in Egypt. The agreement with CLAES aims to strengthen the existing research and training collaboration. The focus will be on the development of Expert Systems on crop and livestock production in dry areas, with emphasis on environmental stresses (drought, heat and salinity) and biotic stresses caused by pests and diseases. The agreement with DRC will focus on research and training on the optimal use of natural resources, improvement of rangeland and livestock production, and arresting soil degradation in dry and desert areas.

Workshops and coordination meetings

ICARDA cosponsored an international symposium on "Optimum Resource Utilization in Salt-Affected Ecosystems in Arid and Semi-Arid Regions," in Cairo, Egypt, in April. The Symposium was organized by the Desert Research Center, Egypt. Participants from 21 countries and representatives from the International Center for Biosaline Agriculture (ICBA), Arab Authority for Agricultural Investment and Development (AAAID), Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), Egyptian Environmental Affairs Agency (EEAA), German Technical Cooperation Agency (GTZ), and UNESCO attended the symposium. ICARDA also cosponsored a regional "Biosafety Development Workshop," organized by the Agricultural Genetic Engineering Research Institute (AGERI) in Egypt in April. The other cosponsors were the United States Department of Agriculture (USDA) and the Islamic Educational, Scientific and Cultural Organization (ISESCO). More than 50 representatives from 11 countries attended the workshop and reported on the current situation of biotechnology and biosafety regulations and systems in their countries. ICARDA made a major presentation "The Potential Benefits of Biotechnology Research for Farmers Worldwide." An international conference on "Biotechnology and Sustainable Development: Voices of the South and North" was held in Bibliotheca Alexandria, Alexandria, Egypt, in March. It was cosponsored by the Government of Egypt, Biovision, FAO, World Bank, OECD,

CGIAR, ICARDA, AGERI, AAST, KISR, NAS and TWAS. The multi-faceted biotechnology debate covered scientific, ethnical and safety issues, and regulations, intellectual property rights, trade and economic issues. An ICARDA/UNU/UNESCO international workshop on "Sustainable Management of Marginal Drylands: Application of Indigenous Knowledge for Coastal Drylands," was organized in Egypt in September.

H.E. Prof. Dr Youssef Wally (second from right), Deputy Prime Minister and Minister of Agriculture and Land Reclamation, Egypt, discusses issues and approaches identified at the annual Regional Coordination Meeting of the Nile Valley and Red Sea Regional Program with (from right) Prof. Dr Adel El-Beltagy, Director General, ICARDA; Prof. Dr Salih Hussein Salih, Director General, Agricultural Research Corporation, Sudan; Dr William Erskine, Assistant Director General for Research, ICARDA; and Dr Ismail Muharram, Chairman of the Board, Agricultural Research and Extension Authority, Yemen.

ICARDA and CIMMYT's joint CWANA wheat program Annual Meeting, held in Cairo in September, was attended by the two Centers' Board Chairmen, Directors General, Directors of Research and several scientists associated with wheat production improvement. Dr Ronnie Coffman, former Board Member of ICARDA, moderated the meeting. The objective was to further harmonize the activities in wheat improvement in the CWANA region.

The Twelfth NVRSRP Regional Coordination Meeting was held in Cairo, Egypt in October. Directors of NARS of Egypt, Ethiopia, Sudan and Yemen, in addition to more than 100 scientists from the four countries, senior scientists from ICARDA, and representatives from the Arab Authority for Agricultural Investment and Development (AAAID), FAO, the African Development Bank (AfDB), and the German Technical Cooperation Agency (GTZ) attended the meeting. Participants discussed the work plans of the newly approved project entitled "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," besides reviewing the work of the past season. This was followed by the Steering Committee Meeting of NVRSRP, which was attended by the Directors General of the NARS of Egypt, Ethiopia, Sudan and Yemen, and ICARDA representatives.

National coordination meetings were held in Sudan, Egypt, and Yemen. A large number of scientists and research managers from the respective national programs and collaborating universities, and from ICARDA participated in the meetings. Presentations covered key aspects of collaborative research. Plans for the following season were developed. The meetings emphasized the need for appropriate government policies for achieving rapid adoption of improved technologies developed through joint research.

Human resource development

A course on forage and pasture seed production and quality assurance in seed testing was conducted in Khartoum jointly by the Seed Administration in Sudan and ICARDA's Seed Unit, in January. Twenty-two seed production and quality control specialists from several agricultural organizations in Sudan participated. In response to a request from the Agricultural Production and Identification Project (APIP) in Egypt, a training course on "Production of Cereal and Legume Crops" was organized in Aleppo by ICARDA, in April. Eleven participants from different Egyptian institutes attended.

A follow-up regional training workshop on "Utilization of Expert Systems in Agricultural Research and Production" was jointly organized with the Central Laboratory for Agricultural Expert Systems (CLAES) in Egypt, in October, within the Twinning Agreement signed between ICARDA and CLAES. Thirteen senior scientists from Egypt, Ethiopia, Jordan, Lebanon, Morocco, Qatar, Syria, Sudan, and Yemen participated in the workshop, which aimed at assessing the impact of the course that CLAES and ICARDA had been jointly conducting for the last five years.

First follow-up workshop in Egypt to evaluate the impact of expert systems in agricultural research and production. Former trainees in the ICARDA/CLAES courses in expert systems participated in the workshop.

At the request of the Ministry of Agriculture in Ethiopia, ICARDA conducted an in-country training course on water harvesting techniques. Eighteen participants from various agricultural development research services attended. Traveling workshops on wheat, barley, wild oats, and resource management were organized in Egypt in March-April, with the participation of scientists from ARC and other institutions. The participants visited research activities in ARC research stations and demonstration plots in farmers' fields. Two traveling workshops were organized in Ethiopia, one on the improvement of lathyrus production, and the other on highland cool-season legumes. More than 30 participants from 12 research stations, as well as representatives from the extension department of the Ministry of Agriculture, participated in the workshops. A Regional Food Legumes Traveling Workshop was held in Egypt in March. Forty-five researchers from the region, along with researchers from ICARDA, Tunisia and Australia, visited various research activities and on-farm trials and demonstrations at research stations and in farmers' fields.

Technical Assistance/Outsourcing

ICARDA outsourced the coordination of a regional training course on "Water Management and Optimum Use of Water Resources in the Arid Region," organized by the Center in collaboration with JICA in Aleppo, April–June, to a water/irrigation scientist from the Soil, Water and Environment Research Institute of ARC, Egypt. Seven participants from Egypt, Ethiopia, Sudan, and Yemen participated in the course along with their counterparts from other CWANA countries.

A team of three senior scientists from ARC, Egypt, visited Aleppo to work with their counterparts at ICARDA on the analysis of the data collected during the last five years from the Long-Term Trials (LTT) and Long-Term Monitoring (LTM) activities. It is expected that this analysis of data would lead to recommendations for the farmers in both the "old" and "new lands" in Egypt.

A nematologist from CNR, Institute di Protezione delle Piante, Italy, visited Ethiopia to assist nematologists at the Ethiopian Agricultural Research Organization (EARO) in surveying nematode infestation of cool-season. This activity was conducted within the Ethiopian Legume Project funded by the Government of the Netherlands and implemented by EARO.

Within the framework of the Twinning Agreement with AGERI, a systematic survey was jointly organized in the rainfed areas in North Coast of Egypt in June by AGERI, ICARDA and the Matrouh Resource Management Project (MRMP) to assess factors leading to the deterioration of fig trees there.

Interregional Cooperation

Four officials from the Ministry of Agriculture and L'Office de L'Elevage et des Pâturages (Livestock and Pasture Authority) of Tunisia visited Egypt in February to learn about the institutional aspects of livestock production in Egypt.

ICARDA organized a 10-day study to Syria in May for a team of two farmers and one scientist from MRMP, Egypt, to expose them to the activities of barley participatory breeding, and to interact with Syrian farmers involved in this activity.

The Arabian Peninsula Regional Program (APRP) and NVRSRP, in collaboration with the Central Laboratory for Agricultural Climate (CLAC) and for Agricultural Expert Systems (CLAES) of ARC, Egypt, organized a training course on "Information Technology Systems for Agriculture and Natural Resource Management in the Arabian Peninsula (ITAP)—Weather Station Network and Expert Systems." The course was held at CLAES and CLAC in Cairo, in June, and was attended by 14 participants from Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, and Yemen. Scientists and researchers from CLAES and CLAC conducted the course.

West Asia Regional Program

The West Asia Regional Program (WARP) continued its efforts to strengthen its partnership with the NARS of Iraq, Jordan, Lebanon, Palestine, and Syria to enhance productivity of crops and rangelands in the dry areas. This is mainly done through regional and bilateral projects conducted by multidisciplinary teams from national research institutes and universities, and with the involvement of NGOs and local communities. More than 15 projects are executed in the countries with technical backstopping from ICARDA. Most of the activities are conducted within four main projects: "Dryland Agrobiodiversity," "Mashreq and Maghreb," "Participatory Barley Breeding", and "Water and Soil Management." ICARDA's research station in Terbol, Lebanon is an integral component of these activities. Collaboration with Cyprus is focused on exchange of germplasm and expertise and contributions to priority setting.

The Dryland Agrobiodiversity Project

This project, supported by GEF/UNDP, aims at promoting community-driven *in situ* conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestine Authority and Syria through a holistic approach involving integrated natural resource management. ICARDA is responsible for the regional coordination and networking among the national components and provides, in cooperation with IPGRI and ACSAD, technical backstopping and training.

Planting wild species of fruit trees in the garden of a school in Ajloun, Jordan

During 2002, the project made a significant impact at the community, national, and regional levels. More than 17,000 seedlings of wild fruit trees were planted during public awareness campaigns in Syria. In Jordan, Palestine and Syria, biodiversity and genetic resources units were created to promote the use of targeted species in afforestation and reforestation programs. Local NGOs and individual farmers in Jordan, Lebanon and Syria received support in the creation of 11 agrobiodiversity nurseries for raising seedlings of landraces and wild relatives of targeted fruit tress. Seven field genebanks and 11 *in situ* conservation sites were developed by the Project in the four countries, in addition to enrichment of their genebanks with more than 500 accessions of target species.

Through ecogeographic surveys and the use of GIS/RS technologies, it was demonstrated that nat-

Participants in the Fourth Regional Technical and Planning Meeting of the project entitled "Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Syria and Palestinian Authority," held in Amman, in September.

ural habitat destruction is the main factor causing the loss of diversity and depletion of wild relatives. The landraces of crops and fruit trees are being reduced by the introduction of new varieties of apple, cherry and olive. The Project has documented the adverse effect of the new introductions in some sites and recommended to extension services to take into consideration the long-term economic benefits before switching to new varieties. The project has demonstrated the relevance of water harvesting techniques in rangeland rehabilitation, and of seed treatment and cleaning in increasing grain yields of cereals and legumes.

Twenty-three training courses and 21 farmer workshops were organized to advise collaborating male and female farmers on food processing, apiculture and honey production and cultivation of medicinal plants to improve their income. Eco-tourism was successfully initiated with a private sector organization in Lebanon in collaboration with the local community of Ham. An agrobiodiversity product store and a weekly market were established, respectively, at Al-Haffa in Syria and at Ajloun in Jordan, to allow communities to sell their local agrobiodiversity products.

The development of national policies and legislation for the protection as well as use of agrobiodiversity is in progress. With the help of FAO, the Syrian Component drafted a legislation on access and exchange of genetic resources. The Jordanian and Lebanese Components initiated similar efforts. The project continued to increase public awareness through different mechanisms on the importance of conservation of dryland agrobiodiversity. In collaboration with UN Geneva TV, a regional documentary film was produced. Three issues of the "Dryland Agrobio" newsletter were published and the project website was updated.

The mid-term evaluation of the Dryland Agrobiodiversity Project took place on 14 July to 4 August, and the report was endorsed by GEF-UNDP, and all members of Regional Steering Committee. The ministers of agriculture of the four countries participating in the Project appreciated the progress. They recommended that the project activities be extended to other areas in their countries.

The Mashreq and Maghreb Project

The final evaluation of the Project took place in April. The policy and property rights component of the project, which is implemented jointly with IFPRI, was evaluated in June. The evaluation teams met with the ministers of agriculture to share assessment and obtain their impressions about the project achievements and impact. The feedback

was positive.

Workshops and coordination meetings

A regional workshop on "Integrated On-farm Water Husbandry" was held in Amman in March jointly with NCARTT and the University of Jordan. Participants from nine countries attended the workshop. This was followed by the Regional Steering Committee Meeting of the Project to discuss new proposals.

In collaboration with ACSAD, IPGRI, UNEP-ROWA, FAO and AOAD, ICARDA organized the first Arab workshop on the "Implications of International Agreements on the Development of National Policies and Legislations Related to Biodiversity Conservation," in May at the Arab League headquarters in Cairo. More than 55 participants representing Egypt, Saudi Arabia, Oman, Sudan, Lebanon, Syria, Palestine and Iraq, the GEF-UNDP projects in Morocco, Tunisia and Algeria, and several guest speakers participated. Recommendations were made to the Arab League on better coordination of the efforts on conservation of biodiversity in the Arab world.

A participatory barley breeding workshop was organized in Jordan in May in which 15 farmers and 7 technicians participated in selecting promising lines from the trials conducted jointly in fields of six farmers.

WARP participated in the AARINENA General Conference, held in Amman in May. WARP also assisted IDRC in the organization of the " Third International Forum on Partnership between the Public and Private Sectors on Water Demand Management," held in Amman in October.

The Fourth Regional Technical and Planning Coordination Meeting of Dryland Agrobiodiversity Project was held in Amman in September, and was attended by representatives of GEF and UNDP offices, DGs of national research institutes, national project managers and scientists from the four countries and from ICARDA, ACSAD and IPGRI-CWANA. The Regional Steering Committee Meeting followed on 15 September.

The ICARDA/Lebanon Biennial Coordination Meeting was held at Tal Amara in October. A number of NGOs participated in the meeting and requested the assistance of LARI and ICARDA.

The "Eleventh ICARDA/Jordan Biennial Coordination Meeting" held at NCARTT, Amman, in September, was attended by 120 national and 8 ICARDA researchers. A lead farmer shared his experience of achieving record yields using the newly developed barley, wheat, chickpea and vetch varieties.

Mashreq and Maghreb farmers visit a farmer's field in Lebanon in a traveling workshop organized for them by the Project. These workshops, also attended by Project scientists and extensionists, have helped in the adoption of many technologies developed by the Project.

Human resource development

The Regional Component of the Agrobiodiversity Project organized three training courses and participated in the conduct of 23 courses organized jointly with the National Components. A regional training course on "Participatory Plant Breeding and Conservation of Agrobiodiversity" was organized in Amman in March for 14 participants. The participants visited the barley trials conducted with farmers in Ramtha region. A traveling workshop for 13 farmers and Project staff from Jordan and Syria was organized to the project sites in Jordan, Lebanon and Syria. Another traveling workshop was organized for 20 women farmers from the four countries. They visited the food processing units and the project sites in Jordan, Lebanon and Syria.

A traveling workshop was held in Jordan for seven Tunisians representing NGOs and project teams working on medicinal plants in Jordan and Lebanon.

Arabian Peninsula Regional Program

The Arabian Peninsula Regional Program (APRP) promotes regional cooperation in research, capacity building and human resource development in countries of the Arabian Peninsula: Bahrain, Kuwait, Oman, Qatar, United Arab Emirates (UAE), Saudi Arabia, and Yemen. Three main research themes, namely, water resource management; forage production and rangeland management, and protected agriculture represent the framework of the program research activities. Major emphasis is laid on strengthening national institutional and human resource capacity, technology transfer and information technology, and networking. APRP is financially supported by AFESD, IFAD, and OPEC.

Collaborative projects

To enhance farmers' income in the mountain terraces of Yemen, cultivation of cash crops in greenhouses was introduced in collaboration with national research partners. Three plastic houses were constructed in farmers' fields in Al-Mahweet, Yareem, and Al-Turba, using a participatory approach. The cost/benefit analysis of plastic house cultivation revealed that the total cost of these constructions could be recovered in three seasons. Several farmers in each location expressed an interest in the investment in plastic houses.

The extensive use of chemicals to control diseases and pests in greenhouses results in complex problems of resistance build-up in the causal organisms, and health and environmental hazards. An Integrated Production and Protection Management (IPPM) program was developed and implemented by APRP in all the Arabian Peninsula countries to provide greenhouse growers with simple techniques for crop protection, thereby reducing the use of hazardous chemicals. Application of IPPM techniques in Sa'ada area in Yemen, helped to cut down pesticide application per growing season (4-5 months) of cucumber crop from an average of 20 to 2-3 sprays. Similar results were obtained in other countries in the region. Soil solarization is part of the IPPM, which could provide growers with safe and effective methods for soil sterilization instead of using chemicals. The technique was developed and simplified for growers and a technical handbook was published.

Priority indigenous grass species have been identified in most countries of the Arabian Peninsula. Shrub species have also been identified in the northern part of the Kingdom of Saudi Arabia. Seed multiplication fields for indigenous grasses are now established in the UAE, Sultanate of Oman, Yemen and Qatar, whereas shrub seeds are being produced in large quantities (5 tonnes per season) in Saudi Arabia. Following the establishment of a successful seed technology unit in the UAE in 2002, another one is under establishment in Oman to promote the seed production of indigenous forages.

A newly developed Soil-less Vertical Growing System for the production of strawberry was adopted in Kuwait. The technology was transferred successfully to three growers in Wafra and Abdaly

Protected agriculture is being introduced in the mountain terraces of Yemen to diversity crop production, particularly vegetables and fruits, and increase farmers' incomes.

areas. An agroeconomic appraisal was conducted to compare the new and the traditional systems. The study revealed a major reduction in production cost of the new system by 50-65%. In addition, production per m^2 was doubled, production season was longer, and major savings were achieved in water, fertilizers, and labor with the new system.

Four new project proposals have been developed: (1) Development of Information Technology Systems for Agriculture and Natural Resource Management in the Arabian Peninsula; (2) Elevating Income of the Yemeni's Rural Family through Transfer of Technology and Training of Rural Women on the Production of Cash Crops Using Protected Agriculture Techniques, (3) Enhancing Seed Multiplication of Indigenous Forage and Range Plants in the Arabian Peninsula, and (4) Adoption of Protected Agriculture Techniques in Afghanistan for Rural Development Utilizing Marginal Lands and Less Water to Produce Cash Crops.

The APRP website (www.icarda.org/aprp) was further developed and restructured. Most of the APRP publications have been up-loaded to the site. A "Weather Station Network" for the Arabian Peninsula has been established. Eleven automatic weather stations were supplied to all the AP countries for installation at pre-specified locations. Most of these stations have been connected through telephone lines. The Expert Systems in Arabic for crop protection in cucumber and the irrigation and fertigation management program for greenhouse crops are active on the Internet.

Workshops and coordination meetings

The Second APRP Regional Technical Coordination Meeting was held in Kuwait in January , and brought together over 38 scientists from all the Arabian Peninsula countries. This was followed by the Second Regional Steering Committee Meeting, which was hosted by AFESD and attended by 20 participants from the Arabian Peninsula countries, and donor and ICARDA representatives.

The Third APRP Regional Technical Coordination Meeting was held in Sana'a, Yemen. Over 60 participants from AP countries, universities (Sana'a and UAE), FAO, and ICARDA attended the meeting. Participants discussed their research activities and future plans. A brainstorming meeting followed on 2 October to discuss the prospects of the continuation of the APRP activities. The use of biotechnology and molecular fingerprinting was stressed for conserving and protecting national agrobiodiversity in the Arabian Peninsula. Following the above meetings, the Third APRP Regional Steering Committee Meeting was held in October in Sana'a, Yemen.

APRP scientists participated in several international and regional workshops. These included the (i) "Regional Conservation Forum of the World Conservation Union (IUCN)", held in Kuwait; (ii) "International Conference on Waste Water Management and its Effects on the Environment in Hot and Arid Countries," held in Muscat, Oman; (iii) "Halophytes Workshop," held in Riyadh, Saudi Arabia; (iv) "Combating Desertification," held in Dhofar, Oman; (v) "Sustainable Management of Water Resources in Arid Environments," held in Dubai, UAE; and (vi) "Abu Dhabi Declaration on Perspectives of Arab Environments," jointly organized by UNEP, ESCWA and CAMRE and hosted by the Federal Environmental Agency of the UAE in Abu Dhabi.

Human resource development

A training course was organized in July in collaboration with the Central Laboratory for Agricultural Expert Systems (CLAES) and the Central Laboratory for Agricultural Climate (CLAC) in Cairo, Egypt on the "Information Technology Systems for Agriculture and Natural Resource Management in the Arabian Peninsula (ITAP)." Fourteen participants from the Arabian Peninsula countries attended. Another training course was organized on seed production and processing of indigenous forage species, in collaboration with the Ministry of Agriculture and Fisheries in UAE. Fifteen participants from the Arabian Peninsula countries attended. The course emphasized the field techniques of seed production of four indigenous grasses (*Cenchrus ciliaris, Panicum turgidum, Coelachyrum piercei* and *Lasiurus scindicus*).

Highland Regional Program

The Highland Regional Program (HRP) addresses the constraints to agricultural production in the highland areas of Afghanistan, Iran, Pakistan and Turkey, the Atlas mountain range in Algeria, Morocco and Tunisia, and the highland areas in Central Asia and the Caucasus. ICARDA has a major collaborative project with Iran, supported by the Islamic Republic of Iran.

Iran

Collaborative research

In 2002, collaboration between Iran and ICARDA witnessed a significant increase in joint research and training activities and in on-farm demonstration and adoption of research results.

Demonstration activities covered over 4,000 hectares in four provinces, as opposed to less than 100 hectares in 2001. In wheat, yield superiority in different areas was generally over 50% (0.6-1.5 t/ha in traditional farming and 1-2.5 t/ha in farms with improved technology). Similar results were observed for other crops, including chickpea and barley.

'Azar2' wheat continued to yield well under rainfed dry conditions of the cold-winter areas. 'Sahand' barley continued to perform well in cold-winter areas and 'Sararood-1' in moderately cold areas. Candidates for release in 2002 included: (i) wheat lines Sbn/1-64-199; Fenkang/Sefid; and 87Zhong291; (ii) barley lines Yesevi and ICB111838; and (iii) chickpea lines: FLIP 90-96C, FLIP 93-93C; FLIP 84-42C; and FLIP 86-108C. However, the yellow rust epidemic damaged both wheat (cv. "Sabalan" has become susceptible) and barley in Khorasan Province.

The area under newly introduced oilseed crop, rapeseed, expanded to 48,000 ha, with an average yield of 1.43 t/ha, which compares well with the world average for this crop. However, it is being grown mainly in irrigated or high-rainfall warm areas. Some progressive farmers there have obtained as high yield as 5 t/ha. Results indicate that rapeseed cannot be cultivated successfully in cold- or moderately- cold winter areas under rainfed conditions without a high risk of crop failure. Safflower is found more suited to dry areas than rapeseed, but is a longer-season crop and tends to deplete soil moisture, with an obviously negative effect on the following crop.

Workshops and Meetings

An Interregional Cotton Workshop was held in October at AREO (Agricultural Research and Education Organization), Tehran, Iran, with participants from Azerbaijan, India, Iran, Pakistan, Tajikistan, Turkmenistan, Uzbekistan, and from the workshop sponsors: AREO, AARINENA, GFAR, CAC-Forum, APAARI, and ICARDA. A representative from EU also participated. The participants stressed the importance of cotton as a fiber crop, being also a source of edible oil, feed, and fuel, and as a key component of rotation systems (e.g. cotton-wheat) in many areas of the region. They agreed to establish an "Interregional Network for Research Collaboration on Sustainable Cotton Production in Asia and North Africa."

Two major meetings related to seed were organized: (1) "Iran/ICARDA National Seed Workshop," held at SPII premises in Karaj, Iran, in October. Participants were seed specialists from different Iranian institutions, as well as experts or consultants from ICARDA, ISTA, UPOV, OECD, CIHEAM, and from Egypt, Lebanon, Morocco, Syria, Turkey, and UK. (2) "Workshop on Review of National Seed Systems and Seed Regulations in Central and West Asian Countries," also held at SPII, in November. Participants came from Afghanistan, Azerbaijan, Iran, Iraq, Kazakstan, Pakistan, Tajikistan, Turkmenistan, Turkey and Uzbekistan as well as from FAO, ICARDA, ISTA, and UPOV.

The Tenth Iran/ICARDA Annual Coordination/Planning Meeting took place at Maragheh on 31 August to 3 September, with participation of over 70 Iranian and 10 ICARDA scientists. Results of 2002 and plan of work for DARI/ICARDA projects in 2003 were discussed, and finalized. A plan for collaboration in management of marginal rangelands was also discussed among ICARDA, RIFR, DARI, and Provincial Range and Forestry Department in Kermashah.

Within the framework of the Water Challenge Program, a team of IWMI, ICARDA and Iranian scientists met twice (in June and September) in Iran to discuss a plan for joint research and application of improved management of water resources for increased water-use efficiency in the Karkheh River Basin, in western Iran. ICARDA's input in the tripar-

tite collaboration will be in the areas of water-use efficiency at the farm level, including supplementary irrigation, water harvesting, use of marginal water, and development and use of water-efficient crop cultivars and techniques.

The second annual meeting of the "Sunn Pest IPM Project" was held in Tehran, in October. Scientists from the three countries involved in the Project (Iran, Syria, and Turkey), and from ICARDA, University of Vermont, CABI, and NRI, reviewed research results obtained by the different parties during the second year of the Project, developed a work plan for 2002/03, prepared a concept note for a second phase of the Project, and discussed and agreed upon an overall agenda for an International Conference on Sunn Pest to be held at ICARDA in 2004.

Human resource development

Twenty-five Iranian participants from different research and extension organizations visited ICARDA for 1 to 9 weeks to participate in courses on integrated diseases or insect pest management, cereal or legume crop breeding, seed production, water management, technology adoption, electronic documentation, and scientific writing. In addition, two junior researchers from DARI received 1-month on-the-job training in oilseed crop (rapeseed and safflower) improvement at the Institute of Agronomy and Plant Breeding of Georg-August University, Gottingen, Germany.

Twenty Iranian students pursued their PhD degree studies at universities in Australia, Canada, Europe, India, or Japan.

Five training courses were conducted during 2002 in Iran: (i) "DNA Markers for Crop Improvement," jointly conducted by Agricultural Biotechnology Research Institute (ABRII), Iran and ICARDA, at Karaj, in May, with participation of 16 trainees, and 5 scientists from ICARDA, and 2 consultants, one each from Germany and Denmark; (ii) "Farmer Participatory Training and Research," jointly conducted with Plant Pests and Diseases Research Institute (PPDRI), Tehran, in June, with two instructors, one each from PPDRI and CABI-UK, and 20 trainees, including farmers, extension and research staff, all involved in Sunn pest control activities; (iii) "Monitoring and Evaluation of On-Farm Trials and Technology Adoption," jointly conducted with AREO at Maragheh, with field visits to other sites, in June, with 18 research and extension staff and 25 farmers; (iv) "Seed Science and Technology" conducted with SPII-Karaj, in June, with 20 Iranian participants; (v) "Wheat Transformation," held in October at ABRII, Karaj, with 15 participants from different Iranian institutions, and instructors from CIMMYT, ICARDA and Iran.

Four staff members of the Ministry of Agriculture and Livestock of Afghanistan received training in Sunn pest control at the PPDRI, Tehran, in June.

Turkey

The joint Turkey/CIMMYT/ICARDA Winter Wheat Improvement Program 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. Five international nurseries were sent to 30 cooperators in CWANA for testing and selection by NARS.

Sets of international nurseries (35 for winter facultative wheat, 7 for durum wheat, 6 for spring bread wheat, 11 for barley, 9 for lentil, 31 for chickpea, and 11 for forage legumes) were provided to Turkish partners for testing at research institutes and universities in various regions.

ICARDA scientists are collaborating with colleagues in the United States and Turkey to use naturally occurring fungi to control Sunn pest, which severely reduces yield and quality of wheat. About US$15 million is spent annually on chemical sprays to combat the pest in Turkey. The team is looking at the use of appropriate fungi as soft insecticides. Efforts are being made to have communities of farmers and extension agents work together to address the problem.

ICARDA, in partnership with Southeast Anatolian Research and Development Administration (GAP-RDA), is helping to improve the production, productivity, and nutritional quality of food, while preserving the natural resource base. GAP-RDA/ICARDA partnership activities in research and development included two projects:

1. On-farm demonstrations and seed multiplication
2. Improvement of natural pastures and forage crops and small-ruminant production

ICARDA is providing technical backstopping to establish a Seed Technology Center at Dicle University, including a seed processing plant, with financial support from the GAP project, to clean and treat the seed produced by the University.

ICARDA provided seeds of vetch (*Vicia* spp.), which will benefit the farmers in the GAP region. Improved vetch varieties in the cropping system would offer an environmentally sound and productive alternative to monoculture. Also, ICARDA is helping GAP to introduce *Mucuna* spp. (velvet beans) as a solution to the feed shortage in the region, in cooperation with the International Institute for Tropical Agriculture (IITA).

To transfer the experience to neighboring countries, ICARDA, in collaboration with Turkey, organized a traveling workshop on crop diversification and conservation tillage in Turkey for researchers and farmers from Central Asia and the Caucasus on "On-Farm Soil and Water Management for Sustainable Agricultural System in Central Asia," in May. A training course on animal epidemiology for four scientists from Central Asian countries was also organized on 15 January to 14 February at Konya University.

Central Asia and the Caucasus Regional Program

The Central Asia and the Caucasus Regional Program (CACRP) works in partnership with NARS of Kazakstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan in Central Asia, and Armenia, Azerbaijan and Georgia in the Caucasus. The Program includes activities relating to germplasm improvement, plant genetic resources, soil and water management, integrated feed and livestock production, and strengthening capacity building of NARS.

Collaborative projects

Collaborative research made substantial progress in 2002. Three varieties were released of different crops based on germplasm provided by ICARDA breeders. A large number of wheat, barley, chickpea and lentil lines are being tested by the State Seed Testing Commissions for future release. The cereal, legume and yellow rust networks were further strengthened. In all, 4565 new accessions/ breeding lines of different crops were supplied to the national programs during the year.

A collection mission was launched in Turkmenistan in June in collaboration with the Ministry of Agriculture, the Australian Center for

National program leaders and scientists from Central Asia and the Caucasus (CAC) who participated in the Sixth Regional Coordination Meeting at Dushanbe, Tajikistan.

International Agricultural Research (ACIAR) and Vavilov Institute (VIR) scientists. This helped increase the number of accessions so far collected from the CAC region to around 1500. The collected germplasm is being kept by the host country and conserved "in-trust" in ICARDA's gene bank, providing safety duplication. Support in the form of technical backstopping and equipment was provided for the renovation of the genebank in Uzbekistan jointly by ICARDA, IPGRI and USDA, and for the establishment of genetic resources centers in Tajikistan, Kyrgyzstan and Azerbaijan.

To improve milk productivity of local sheep breed in Uzbekistan, 600 ewes were artificially inseminated with frozen semen provided by the University of Wisconsin, USA. A specialist in artificial insemination from Indonesia assisted the farmers and Uzbek scientists. Several livestock production practices, such as early weaning, early lambing, market oriented lamb fattening and milking, have been tested and some of them have already shown considerable economic promise in Central Asian countries.

An agreement for research collaboration was signed between ICARDA and the Republic of Tajikistan.

Workshops and coordination meetings

In January, CACRP hosted a meeting for the Consortium on Afghanistan, initiated with support from the United States Agency for International Development (USAID). Seventy-four representatives from international and non-governmental organizations, United Nations agencies and donor agencies came together to form the "Future Harvest Consortium to Rebuild Agriculture in Afghanistan." Ten of the sixteen Future Harvest Centers of the CGIAR are now members of the Consortium. The immediate aim was to develop a work plan for a 12-month project on seed systems, and lay a framework for longer-term activities in seeds and crop improvement; soil and water management; livestock, feed, and rangeland improvement; and horticulture.

A special Symposium on Central Asia was organized during the Annual Meeting of American Society of Agronomy, Crop Science Society of America and Soil Science Society of America in Indianapolis on 10–14 November in order to provide special focus on agricultural development in the region. ICARDA and the German Center for Development Research (ZEF) jointly cosponsored the session and supported participation of scientists from the region.

The heads of NARS from Uzbekistan, Tajikistan and Turkmenistan participated in the "Interregional Workshop for the Development of Partnership on Cotton Research in Central Asia, South Asia and WANA Regions," organized jointly by AARINENA, APAARI, CAC-Forum and ICARDA Office in Tehran. An Interregional Network for research collaboration on sustainable cotton production systems was established. The organizers as well as AERO, Iran agreed to support this network.

Senior seed program managers and policy makers from six countries of the region (Azerbaijan, Kazakstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) participated in the "Regional Workshop on Harmonization of Seed Regulations for Central Asia and West Asia," organized by the Seed Unit of ICARDA in cooperation with the SPII, Iran. Harmonization initiative was endorsed to be undertaken in the participating countries.

CACRP co-sponsored the "International Workshop on Conservation Agriculture for Sustainable Wheat Production in Rotation with Cotton in Limited Water Resource Areas," jointly with the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME) of the Ministry of Agriculture and Water Resources (MAWR), Uzbekistan and FAO. The purpose of the meeting was to bring together farmers, policy-makers, scientists, private sector and decision makers to share information and experiences, and to encourage further interactions and development. Over 155 participants from 15 countries participated in this important event.

A genetic resources documentation workshop was organized for representatives from the Central Asian PGR Units, whereas a regional workshop for plant genetic resources units was organized jointly with USDA in Tashkent to assess the progress made by the various groups. In addition, another meeting of Central Asian and Trans-Caucasian Network (CATCN) on Plant Genetic Resources (PGR) was organized jointly with IPGRI. The participants discussed issues related to strengthening of PGR activities in the region and approved the proposed work plan for 2002-2004.

Human resource development

Considerable emphasis was placed on strengthening the NARS in the region. A total of 520 CAC scientists and farmers participated in different international conferences, workshops, seminars, field visits and training courses. In addition, more than a hundred scientists were trained in English language skills, and 132 scientists, officials and farmers participated in various traveling workshops organized in Uzbekistan, Kazakstan, Kyrgyzstan and Tajikistan.

A traveling workshop to Turkey on crop diversification and soil tillage practices was organized for scientists and farmers from the Central Asian countries under an ADB-funded project as already reported under the section on "Highland Regional Program." Conservation practices, such as zero tillage, minimum tillage, and raised-bed planting proved very successful for large-scale adoption in the region. Also, on-farm demonstrations to promote these practices have been taken up.

Advanced models of soil moisture meters were also made available to the scientists in Central Asia under the ADB project and a training course on its use was organized. An automatic weather station was installed in Kyrgyzstan, and portable soil moisture meters produced by the scientists of SANIIRI, Uzbekistan were provided under the ADB-funded project to all the eight countries of the region. The laboratory of the Karakul Sheep breeding research institute, Samarkand was renovated and equipped for feed quality analysis under a project funded by IFAD. A young scientist involved in this project was trained on feed quality

Research Support Services

Communication, Documentation and Information Services

The Communication, Documentation and Information Services (CODIS) Unit was actively involved in 2002 in developing information material for display and distribution at three key events: the World Food Summit, the World Summit on Sustainable Development, and the 25th anniversary of the founding of ICARDA. To commemorate the anniversary, ICARDA also commissioned and published *ICARDA25: A Promise of Hope*, a history of the Center written by its second Director General, Dr Mohamed A. Nour.

The Unit launched a section on ICARDA's website to report the progress of activities, and promote interaction among the stakeholders of the Future Harvest Consortium to Rebuild Agriculture in Afghanistan. In addition, special public awareness materials were produced, and a large number of press releases were issued. A project was launched aimed at producing and broadcasting agricultural messages to farmers throughout the country, which included training of agricultural broadcast journalists in Afghanistan.

The Unit also provided on-site communication support for projects in Ethiopia, Sudan, Tunisia, and Turkmenistan. Video and still images were taken in Ethiopia; Sudanese cooperators were assisted in setting up a computerized document collection and retrieval system; in Tunisia material was collected that was used to produce a website dedicated to the Mashreq–Maghreb project; and in Turkmenistan, information on the Center's germplasm collection and conservation efforts was collected and sent to media outlets in Australia, in cooperation with the Crawford Fund, where it generated national press and broadcast attention.

ICARDA's website continued to be enhanced and updated. In addition to a section devoted to the Future Harvest Consortium, improvements in the section on the Center's Arabian Peninsula Regional Program were made, and a new section on participatory plant breeding was added. The section on ICARDA's work in Central Asia and the Caucasus was updated.

Also added to the website was a section on media coverage, which contains scans of press articles on ICARDA's work. The Center gained good attention from media outlets in 2002. Two staff members of WRENmedia, UK, visited headquarters and prepared stories that appeared on the *New Agriculturist* website and were distributed to radio stations in Africa and elsewhere. A comprehensive article entitled *A Quiet Revolution: Vetch Helps Transform Agriculture in Syria* appeared in the April 2002 issue of *The World&I* magazine, a publication of the Washington Times Corporation, and another article, entitled *ICARDA's Research Saves Family Farms on the Prairies and Around the World: A Tale of Two Farmers*, appeared in *Food & Future* newsletter, published in Canada.

Capacity building remained a central component of ICARDA's work in 2002. A specialized training course on scientific writing and data presentation attracted participants from several countries. Researchers who cannot come to headquarters for training and direct interaction are nonetheless well served through CODIS' publishing and distribution programs, and the Center's 'virtual library,' which averages 150 inquiries, or hits, per month.

A large number of publications were produced, including a special issue of *Caravan* to mark the Year of Mountains.

Computer and Biometric Services Unit

During 2002, considerable effort was made in protecting the institutional memory and explicit knowledge. The Unit actively led a knowledge management project aimed at developing a knowledge management strategy and gathering and protecting ICARDA knowledge base. Within the context of making the ICARDA Intranet the main source of knowledge in the center, the site design was revamped in cooperation with CODIS and a new server running the Intranet was installed. Critical data were moved from users' PCs to the network File Server.

An Information Technology Strategy and Plan was developed in cooperation with all stakeholders in the center. ICARDA led a CGIAR-wide project on implementing Windows 2000 Active Directory in the CG centers, and organized and coordinated the CGIAR Active Directory workshop at IMWI, Sri Lanka. The workshop agreed unanimously to adopt Active Directory design presented at the workshop.

Travel Access Service, new users and dialup points were established to support the scientists on the move. A new local area Fast-Ethernet computer network was commissioned with minimal disruption to the service, and as a result network performance significantly improved. New networking services were implemented using Windows 2000 platform.

Support to ICARDA outreach offices continued. A local area network and a file computer server were installed in ICARDA Kabul office and Internet access was made available to all workstations connected to the network. The ICARDA School was supported with the installation of a local area network, shared Internet access and hardware maintenance.

The Unit developed and implemented a Water Inventory Database in West Asia on the web, in cooperation with NRMP, for the United Nations Convention for Combating Desertification. A Seed Management System was made operational and a number of customizations carried out for data entry and reporting. The upgrade of the Meteorological Database was initiated. The new Training Database is now being used by HRDU, and a Travel Schedule Database is also operational. A discussion group for the Afghanistan project participants was set up on the web.

For the existing Oracle Financial/Administrative Applications, 32 new custom reports and 5 new forms were developed, and 34 custom reports and 3 forms and several procedures were modified. Financial reports for all projects and personal statements for employees were made directly accessible on the Intranet with appropriate security. A new sub-system for vehicle maintenance information and charge back was developed. The Medical sub-system was debugged and reviewed, and Finance assisted in clearing the Accounts Payables balances.

Preparations for the implementation of Oracle Applications 11i were made, which included a scoping study carried out by an external consultant, training on the new version, and review of the Payroll system. The Unit participated in testing of the CIAT Project Manager software, and initiated the requirements specification for the system.

Biometric consultancies were provided to researchers on more than 75 occasions. Designs were provided for experiments including those for evaluating response to: fungicide application in chickpea; drought stress on lentil and chickpea; faba bean entries; mixtures of wheat varieties; growth conditions and regeneration media in barley lines. Statistical analyses were carried out on data from experiments including evaluation of phosphogypsum and cropping system at Khanasser Valley; packaging treatments on seed germination; zinc concentration in Ethiopian trials; production system and gender on child-growth; bread wheat genotypes and barley genotypes; production models under supplemental irrigation. Minimum plants to estimate gene diversity in wild wheat populations using AFLP markers were evaluated using bootstrap re-sampling procedure.

Statistical analysis of data from NARS scientists included three-course rotation trial at Sids, Egypt; the line x tester experiments on corn and sorghum in Syria and the gamma irradiated chickpea genotypes in Jordan.

Bioinformatics support was initiated and a number of software can now be downloaded from the Intranet for estimation of QTL, detection of Single Nucleotide Polymorphisms, and querying nucleotide databases and presentation in various formats.

An online biocomputing facility using GENSTAT was developed for analysis of similar trials in RCBDs, and a set of six modules for spatial variability analysis of data from unreplicated trials, RCBD trials and incomplete block design trials were made available.

Ten NARS staff attended a training course in various aspects of statistical design, data management and analysis and 5 other staff received individual training. A student completed his Ph D thesis with the Unit's staff supervision. Over 90 ICARDA staff were trained on various IT applications, software and services in a total of 17 courses.

Human Resource Development

During 2002, ICARDA offered training opportunities to 561 national scientists from 38 countries including Central and West Asia and North Africa (CWANA), Africa (excluding North Africa), Asia and the Pacific region (excluding West Asia), and European countries. In addition, 54 national scientists from the developing and developed countries have been conducting their graduate research training for M Sc and Ph D degrees jointly between ICARDA and the agricultural universities in their countries or overseas. About 19 % of all the ICARDA training participants in 2002 were women.

ICARDA continued its strategy to gradually decentralize its training activities by offering more non-headquarters training courses. In 2002, ICARDA offered 9 headquarters training courses and 16 in-country, regional and sub-regional courses. Of the total number of trainees, about 44% were trained at ICARDA headquarters, while the remaining were trained in CWANA countries.

In responding to the evolving demands for training from NARS, the Unit also facilitated and coordinated implementation of different training courses for several external-funded projects. Examples:

1. Two regional training courses on "Production and Management of Electronic Documents and Bibliographic Database Management," funded by FAO and conducted at ICARDA.
2. One regional training course on "Management of Water Resources and Improvement of Water Use Efficiency in the Dry Areas," partially funded by the Japan International Cooperation Agency (JICA), and conducted at ICARDA.
3. One international training course/study tour on "Conservation and Utilization of Plant Genetic Resources," jointly conducted with the University of Birmingham, U.K. at ICARDA.
4. Four regional training courses funded by the Asian Development Bank (ADB) for participants from Central Asia and the Caucasus: "Drainwater Reuse Strategies with Management Considerations of Soil Physiochemical Properties," held in Ashgabad, Turkmenistan; "Improved Methods of Analysis of Soil, Plant and Water," held in Dushanbe, Tajikistan; "Water Saving Technologies and their Socioeconomic Implications Under Drought Conditions,"held in Taraz, Kazakstan; and "Advanced Soil Monitoring Techniques," held in Tashkent, Uzbekistan.
5. One in-country training course on "Control of Industrial Wastewater Pollution," funded by UNDP and the Syrian Ministry of Irrigation and conducted at ICARDA.
6. The first regional training workshop on "Utilization of Expert Systems in Agricultural Research and Production,"organized jointly with the Central Laboratory for Agricultural Expert Systems (CLAES) in Cairo, Egypt. The technical report of this workshop was presented at the parallel session on "Human Resources Development and Capacity Building" at the Annual General Meeting of the CGIAR, held in Manila, the Philippines.

Inter-Center collaboration was also strengthened through participation in the IARCs Inter-Center Training Group (ICTG) and the exchange of the ICARDA training database with other sister centers. The ICARDA training database was further refined for posting on the Intranet.

Appendices

Appendix 1

The following list covers, as of the time of going to press, journal articles published by ICARDA researchers, many of them in collaboration with colleagues from national programs. A complete list of publications, including book chapters and papers published in conference proceedings, is available on ICARDA's web site: www.icarda.cgiar.org.

Journal Articles

Abraham, A. and K.M. Makkouk. 2002. The incidence and distribution of seed-transmitted viruses in pea and lentil seed lots in Ethiopia. Seed Science and Technology 30: 567-574.

Ahmed, S., C. Akem, B. Bayaa, and W. Erskine. 2002. Integrating host resistance with planting date and fungicide seed treatment to manage *Fusarium* wilt and so increase lentil yields. International Journal of Pest Management 48(2): 121-125.

Al-Khalaf, M., K.M. Makkouk, and Kasem A. Haj. 2002. Seed transmission of broad bean stain virus in lentil with respect to genotype variability and seed size. Arab Journal of Plant Protection 20(2): 106-110. (In Arabic, English summary).

El-Hussein, N., B. Bayaa, and W. Erskine. 2002. Integrated management of lentil broomrape. 1. Sowing date and chemical treatments. Arab Journal of Plant Protection 20(2): 84-92. (In Arabic, English summary).

El-Khalifeh, M., A. El-Ahmed, and N. Bek. 2002. Field survey of the black point disease on wheat crop and its development under storage conditions at Raqqa province, Syria. Arab Journal of Plant Protection 20(2): 137-144. (In Arabic, English summary).

El-Naeb, R., A. Yahyaoui, A. El-Ahmed, and M. Nachit. 2002. Survey on common root rot disease of wheat and barley in Aleppo and Idleb governorates (northern Syria). Arab Journal of Plant Protection 20(2): 131-135. (In Arabic, English summary).

Hamed, A.A. and K.M. Makkouk. 2002. Occurrence and management of chickpea chlorotic dwarf virus in chickpea fields in northern Sudan. Phytopathologia Mediterranea 41: 193-198.

Hegde, S.G., J. Valkoun, and J.G. Waines. 2002. Genetic diversity in wild and weedy *Aegilops*, *Amblyopyrum*, and *Secale* species - A preliminary survey. Crop Science 42(2): 608-614.

Hoque, M.E., S.K. Mishra, and A. Sarker. 2002. Inheritance and linkage relationship between morphological and RAPD markers in lentil (*Lens culinaris* Medik.). Indian Journal of Genetics 62(1): 5-10.

Kugbei, S. and Z. Bishaw. 2002. Policy measures for stimulating indigenous seed enterprises. Journal of New Seeds 4(1-2): 47-63.

Makkouk, K.M., S.G. Kumari, and J.A.G van Leur. 2002. Screening and selection of faba bean (*Vicia faba* L.) germplasm for resistance to bean leafroll virus. Australian Journal of Agricultural Research 53: 1077-1082.

Makkouk, K.M., Y. Fazlali, S.G. Kumari, and S. Farzadfar. 2002. First record of beet western yellows virus, chickpea chlorotic dwarf virus, faba bean necrotic yellows virus and soybean dwarf virus affecting chickpea and lentil crops in Iran. Plant Pathology 51(3): 387.

Makkouk, K.M. and S.G. Kumari. 2002. Low-cost paper can be used in tissue-blot immunoassay for detection of cereal and legume viruses. Phytopathologia Mediterranea 41: 275-278.

Malhotra, R.S., K.B. Singh, M. Di Vito, N. Greco, and M.C. Saxena. 2002. Registration of ILL 10765 and ILC 10766 chickpea germplasm lines resistant to cyst nematode. Crop Science 42(5): 1756.

Parker, B.L., S. D. Costa, M. Skinner, and M. El-Bouhssini. 2002. Sampling sunn pest (*Eurygaster integriceps* Puton) in overwintering sites in northern Syria. Turkish Journal of Agriculture and Forestry 26: 109-117.

Pereira, L.S., T. Oweis, and A. Zairi. 2002. Irrigation management under water scarcity. Agricultural Water Management 57: 175-206.

Petersen, E.H., D.J. Pannell, T.L. Nordblom, and F. Shomo. 2002. Potential benefits from alternative areas of agricultural research for dryland farming in northern Syria. Agricultural Systems 72(2): 93-108.

Sasanuma, T., K. Chabane, T.R. Endo, and J. Valkoun. 2002. Genetic diversity of wheat wild relatives in the Near East detected by AFLP. Euphytica 127(1): 81-93.

Sayed, H., H. Kayyal, L. Ramsey, S. Ceccarelli, and M. Baum. 2002. Segregation distortion in doubled haploid lines of barley (*Hordeum vulgare* L.) detected by simple sequence repeat (SSR) markers. Euphytica 125: 265-272.

Shahadi, F., M. El-Bouhssini, and A. Babi. 2002. First record of parasitoids on the predator seven spotted Coccinellid, *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) in Syria. Arab Journal of Plant Protection 20(1): 49-51. (In Arabic, English summary).

Singh, M. and M.J. Jones. 2002. Modeling yield sustainability for different rotations in long-term barley trials. Agricultural, Biological, and Environmental Statistics 7(4): 525-535.

Udupa, S.M. and M. Baum. 2002. Genetic dissection of pathotype-specific resistance to ascochyta blight disease in chickpea (*Cicer arietinum* L.) using microsatellite markers. Theoretical and Applied Genetics http:/link.springer-ny.com/link/service/journals/00122/co…/s00122-002-1168-xch002.htm, Abstract 10.1007/s00122-002-1168x

Yahyaoui, A.H., M.S. Hakim, M. El-Naimi, and N. Rbeiz. 2002. Evolution of physiologic races and virulence of *Puccinia striiformis* on wheat in Syria and Lebanon. Plant Disease 86: 499-504.

Yau, S.K. 2002. Comparison of European with West Asian and North African winter barleys in tolerance to boron toxicity. Euphytica 123(3): 307-314.

Yau, S.K. 2002. Interactions of boron-toxicity, drought, and genotypes on barley root growth, yield, and other agronomic characters. Australian Journal of Agricultural Research 53: 347-354.

Appendix 2

Graduate Theses Produced with ICARDA's Assistance

Master of Science

2002

Jordan, University of Jordan

Ayalew, Melkamu. 2002. The effect of *Glomus mosseae* and *Trichoderma harzianum* on *Fusarium* wilt (*Fusarium oxysporum* f. sp. *ciceri*) of chickpea. 89 pp. (Arabic summary).

Biftu, K.N. 2002. Some physiological aspects of the competitive ability of cowpea (*Vigna sinensis* L.) and redroot pigweed (*Amaranthus retroflexus* L.) with special reference to moisture and phosphorus fertilizer. 100 pp. (Arabic summary).

Nure, Tadele Amde 2002. Induction of variability in chickpea (*Cicer arietinum* L.) using gamma radiation. 137 pp.

Syria, Damascus University

Kharouf, Shoula. 2002. Virulence of wheat stripe (yellow) rust (*Puccinia striiformis* West. f. sp. *tritci*) in Syria, host preference on bread and durum varieties, comparative resistance of seedling and adult stage. 99 p. (In Arabic, English summary).

Syria, University of Aleppo

Alkhalaf, Mohammad 2002. A study of the most important seed-borne viruses on lentil and faba beans and their detection in Syria. 112 pp. (In Arabic, English summary).

Obaedo, Housam. 2002. A study of the factors causing vigour variability of barley seeds and seedlings and their effects on grain yield. 88 pp. (In Arabic, English summary).

Shahadi, Fatima 2002. Bio-ecological study of two Coccinellids, efficiency of its utilisation in biological control of aphids. 116 pp. (In Arabic, English summary).

Doctor of Philosophy

Syria, Damascus University

Sayed, Mahmoud Haitham 2002. Identification of DNA markers for selection of disease resistance genes in barley. 177 pp. (In Arabic, English summary).

Syria, University of Aleppo

Kumari, Safaa M. Ghassan. 2002. A study on luteoviruses affecting cool season food legumes. 230 pp. (In Arabic, English summary).

Appendix 3

Agreements Signed in 2002

Agreements of cooperation with international organizations

Food and Agriculture Organization of the United Nations (FAO)

8 August 2002. Memorandum of Understanding between the Food and Agriculture Organization of the United Nations (FAO) and the International Center for Agricultural Research in the Dry Areas (ICARDA) for Cooperation in Rebuilding Agriculture in Afghanistan within the Future Harvest Consortium to Rebuild Agriculture in Afghanistan (FHCRAA).

Agreements of cooperation with national governments and institutions

Afghanistan

1 August 2002. Agreement between the Government of Afghanistan and the International Center for Agricultural Research in the Dry Areas (ICARDA).

Egypt

9 January 2002. Cooperation Agreement between the Desert Research Center (DRC) in Egypt and the International Center for Agricultural Research in the Dry Areas (ICARDA).

9 January 2002. Twinning Agreement between the Central Laboratory for Agricultural Expert Systems (CLAES) of the Agricultural Research Center and the International Center for Agricultural Research in the Dry Areas (ICARDA).

Tajikistan

28 September 2002. Agreement between the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Government of the Republic of Tajikistan on Cooperation in the Field of Agricultural Science.

Appendix 4

Restricted Projects

ICARDA's research program is implemented through 19 research projects, as detailed in the Center's Medium-Term Plan. Restricted projects are those activities that are supported by restricted funding 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.

During 2002, the following Restricted Projects were operational.

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).
- Development of integrated crop/livestock production systems in low-rainfall areas of the Mashreq and Maghreb regions.
- Sustainable management of natural resources and improvement of major production systems of the Arabian Peninsula.

Asian Development Bank

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

Australia

ACIAR (Australian Centre for International Agricultural Research)

- Near isogenic lines for the assessment of pathogenic variation in the wheat stripe (yellow) rust pathogen.
- 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.
- Host resistance, epidemiology and integrated management of faba bean, chickpea and lentil diseases.
- Impact of ICARDA Research on Australian Agriculture.

GRDC (Grains Research and Development Corporation)

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

Belgium

VVOB (Flemish Association for Development Cooperation and Technical Assistance)

- Associate Expert in the utilization of remote sensing techniques for monitoring changes in land cover and land use in ICARDA's mandate region.
- Associate Expert in land resources assessment.

Canada

CGIAR-Canada Linkage Funds

- The increasing role of women in resource management and household livelihood strategies.

Crop Development Centre, University of Saskatchewan

- Off-season evaluation of ascochyta blight reaction in chickpea.

CGIAR Systemwide Programs

CGIAR Impact Assessment and Evaluation Group (IAEG)

- CGIAR's impact on germplasm improvement.

CGIAR Collaborative Program for Central Asia and the Caucasus

- Program Facilitation Unit.

- Germplasm conservation, adaptation and enhancement for diversification and intensification of agricultural production in Central Asia and the Caucasus.
- On-farm soil and water management for sustainable agricultural systems in Central Asia and the Caucasus.

Systemwide Genetic Resources Program (SGRP)

- Management and characterization of small ruminants.
- Global inventory of barley genetic resources.

Systemwide Program on Integrated Pest Management

- Inter-Center IPM Adoption Initiative: Pilot sites in Egypt and Morocco.
- SP-IPM Soil Biota Global Workshop.

Systemwide Programme for Participatory Research and Gender Analysis (SP-PRGA)

- Village-based participatory breeding in the terraced mountain slopes of Yemen.
- Impact assessment of participatory breeding.
- Analysis of PRGA approaches in ICARDA.

Systemwide Program on Soil Water and Nutrient Management (SWNM)

- Optimizing soil water use.

CIHEAM (International Centre for Advanced Mediterranean Agronomic Studies)

- Collaborative Molecular Biotechnology Integrating Network COMBINE: Integrating regional expertise in biotechnology for sustainable exploitation of plant genetic resources in the Mediterranean region.
- Mediterranean Rainfed Agriculture Technologies Evaluation (MEDRATE): Evaluation of agricultural practices to improve efficiency and environment conservation in Mediterranean arid and semi-arid production systems.
- Screening legumes and forage nursery for salinity tolerance.

Denmark

- Collaborative research in Eritrean National Seed Development Programme (ENSDP).
- 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) Attributed Funding

- 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.

FAO (Food and Agriculture Organization of the United Nations)

- Electronic production of agricultural documents and bibliographic database management.
- Translation of AGROVOC terms into Arabic.
- International workshop on food barley.
- Publication on quality declared seed.
- Expert Consultation Meeting on rehabilitation of food legume crops in North Africa.
- Expert Consultation on IPM for Orobanche control in food legume systems in the Near East and North Africa.
- Expert Consultation Meeting on greenhouse ventilation and cooling in the Arabian Peninsula.

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

- Action research for sustainable groundwater use in Syria.
- An integrated approach to sustainable land management in dry areas.
- Functional genomics of drought and cold tolerance in chickpea and lentil.
- International workshop on barley leaf blight.
- Facilitator for international workshop on integrated natural resources management.

IDRC (International Development Research Centre)

- From formal to participatory plant breeding: improving barley production in the rainfed areas of Jordan.
- Improving natural resources management and food security for rural households in the mountains of Yemen.
- International workshop on integrated natural resources management.
- Strengthening seed systems for food security in Afghanistan.

IFAD (International Fund for Agricultural Development)

- Development of integrated crop/livestock production systems in low-rainfall areas of the Mashreq and Maghreb regions.
- Sustainable management of natural resources and improvement of major production systems of the Arabian Peninsula.
- Integrated feed and livestock production in the steppes of Central Asia.
- Projet du developpement agropastoral du Gouvernorat de Tataouine, Tunisie.
- 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.
- Workshop for the development of the CGIAR Challenge Program on Desertification, Poverty and Agriculture.

International Nutrition Foundation

- Impact of lysine fortified wheat flour on the nutritional status of rural families in northwest Syria.

Iran

- Scientific and technical cooperation and training.

Italy

- Associate Professional Officer in barley improvement.

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.

Japan

- Improving income of small-scale producers in marginal agricultural environments: small ruminant milk production and milk derivatives, market opportunities and improving value added returns.
- Training program in management of water resources.

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.

OPEC Fund for Internationl Development

- Devolution of barley breeding to farmers in North Africa.
- Sustainable management of natural resources and improvement of major production systems of the Arabian Peninsula.

Pakistan

- Cooperation in the applied research component of the Barani Village Development Project (BVDP).

Switzerland

- Renovation of traditional water supply system: sustainable management of ground water resources.
- Sustainable management of the agropastoral resource base in the Maghreb.

Turkey

- Technical assistance to Southeast Anatolia Project Regional Development Administration.

United Kingdom

DFID (Department for International Development) Competitive Research Facility

- Improving the yield potential and quality of grasspea (*Lathyrus sativus* L.): a dependable source of dietary protein for subsistence farmers in Ethiopia.

- Integrated pest management of Sunn Pest in West Asia.

British Embassy, Damascus

- Restoring production and ecological integrity to high-potential low-lying areas in the Syrian steppe.

U.K. Attributed Funding

- Food legume germplasm improvement for increased systems productivity.
- Land management and soil conservation to sustain the agricultural productive capacity of dry areas.
- Socioeconomics of agricultural production systems in dry areas.

UNCCD (United Nations Convention to Combat Desertification) Global Mechanism

- Workshop on development of a regional program for rainfed areas in WANA.
- Regional Environmental Management Officer, Tashkent.

UNCCD Sub-Regional Action Program (SRAP) for West Asia

- Inventory study and regional database on sustainable water management in West Asia.
- Preparing project proposals on integrated natural resources management for combating desertification in West Asia.

UNDP (United Nations Development Programme)

- Yemen: Sustainable environment management.

UNEP (United Nations Environment Programme)

- Preparation of a feasibility study on the establishment of a bank for plant genetic resources in the Arab world.

United States of America

USAID (United States Agency for International Development)

- Adaptation of barley to drought and temperature stress using molecular markers.
- Inheritance and mapping of winter hardiness genes in lentil for use in marker assisted selection.
- Use of entomopathogenic fungi for the control of Sunn pest in West Asia.
- Feasibility study of use of remote sensing and image analysis for land use mapping and evaluation.
- Poverty, agricultural household food systems and nutritional well-being of the child.
- Assisting Afghan farmers to restore food security.

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

- Collection of plant genetic resources in the Central Asia and the Caucasus region.
- Climatological analysis as a tool for agricultural decision making in dry areas.

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.
- 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.
- Tunisia-U.S. collaboration on biological control of weeds with plant pathogens.

Wold Bank

- Workshop on Rural Development in WANA February 2003.

Republic of Yemen

- Agriculture Sector Management Support Project (ASMSP), Yemen.

Appendix 5

Collaboration in Advanced Research

Regional and 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 formulation and implementation of Thematic Networks (TN1 and TN2) of the UN Convention to Combat Desertification (UNCCD): Sub-Regional Action Program for Western Asia.
- Cooperation in providing technical backstopping and training requested by the National Components of the GEF/UNDP project on Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Palestinian Authority and Syria.

CIAT (Centro Internacional de Agricultura Tropical)

- ICARDA is participating in the Systemwide Program on Soil Water and Nutrient Management and in the Systemwide Program on Participatory Research and Gender Analysis for Technology Development, both coordinated by CIAT.
- CIAT and ICARDA are members of the Ecoregional Alliance.
- ICARDA is participating in the Challenge Program on Biofortified Crops for Improved Human Nutrition, led by CIAT and IFPRI.

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 a Network on Drought Management for the Near East, Mediterranean and Central Asia (NEMEDCA Drought Network).

CIMMYT (International Center for the Improvement of Maize and Wheat)

- CIMMYT/ICARDA Joint Dryland Wheat Program. Two CIMMYT wheat breeders were seconded to ICARDA in 2002.
- 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.
- ICARDA and CIMMYT jointly coordinate a durum wheat research network encompassing WANA and southern Europe.
- 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 to Rebuild Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.

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.

FAO (Food and Agriculture Organization of the United Nations)

- ICARDA and FAO are co-sponsors of AARINENA.
- In 2002 ICARDA and FAO concluded a Memorandum of Understanding for cooperation in Afghanistan within the Future Harvest Consortium to Rebuild Agriculture in Afghanistan (FHCRAA), which is coordinated by ICARDA.

- 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).
- FAO-RNE and ICARDA co-sponsored an Expert Consultation Meeting on Rehabilitation of Food Legume Crops in North Africa in December 2002.
- Joint training courses, workshops, publications and exchange of information.

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)

- ICARDA and ICRISAT cooperate in a joint kabuli chickpea improvement program.
- 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 to Rebuild 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 Program on Soil Water and Nutrient Management.
- ICARDA is collaborating with ICRISAT on insect pests of grain legumes within the Systemwide Program on Integrated Pest Management.
- ICARDA and ICRISAT are co-conveners of the Challenge Program on Desertification, Drought, Poverty, and Agriculture (DDPA).
- ICARDA and ICRISAT are members of the Ecoregional Alliance.
- ICARDA and ICRISAT collaborate in the Cereal and Legumes Asia Network (CLAN).

IFPRI (International Food Policy Research Institute)

- ICARDA participates in the Systemwide 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 to Rebuild Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- Collaboration in policy and property rights research 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 the 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 Program on Integrated Pest Management.
- IITA and ICARDA are members of the Ecoregional Alliance.

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 to Rebuild Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- ILRI is a partner in studies of breed characterization of small ruminants in the Caucasus and on-station characterization of small ruminants in WANA.
- ILRI and ICARDA cooperate in increasing feed resources in the Caucasus.

- ILRI and ICARDA cooperate in strengthening teaching and research on sheep and goat production in Tunisia.

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 Program, 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 to Rebuild 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.
- ICARDA is developing a global inventory of barley genetic resources within the framework of linking SINGER to crop networks.
- IPGRI-CWANA is a partner with ICARDA in providing technical backstopping and training requested by the National Components of 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 to Rebuild Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- ICARDA is a member of the working group on improving agricultural water productivity, led by IRRI, within the Challenge Program on Water and Food.

ISNAR (International Service for National Agricultural Research)

- ICARDA and ISNAR are co-sponsors of AARINENA.
- ISNAR participates in the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, coordinated by ICARDA.
- ICARDA is participating in the Agricultural Science and Technology Indicators (ASTI) Initiative led by ISNAR and IFPRI.

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 to Rebuild Agriculture in Afghanistan (FHCRAA), coordinated by ICARDA.
- ICARDA serves on the Steering Committee of the Systemwide Initiative on the Comprehensive Assessment of Water, coordinated by IWMI.
- Collaboration in research on supplemental irrigation, issues of salinity and sustainable use of shallow groundwater aquifers, and the use of marginal water in agriculture.

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.

University of Adelaide, CRC for Molecular Plant Breeding, Waite Campus

- International collaboration in barley research. Joint training of a PhD student.
- Host resistance, epidemiology and integrated management of faba bean, chickpea and lentil diseases.

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.
- Host resistance, epidemiology and integrated management of faba bean, chickpea and lentil diseases.

Department of Agriculture, Western Australia

- Host resistance, epidemiology and integrated management of faba bean, chickpea and lentil diseases.

NSW Agriculture, Tamworth Centre for Crop Improvement

- Durum wheat improvement.
- Chickpea improvement.
- Identification of legume viruses and selection of legume germplasm for virus disease resistance.
- Host resistance, epidemiology and integrated management of faba bean, chickpea and lentil diseases.

Plant Breeding Institute, University of Sydney

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

Victorian Institute for Dryland Agriculture

- Improvement of lentil and grass pea in Bangladesh.
- Improvement of narbon vetch for low rainfall cropping zones in Australia.
- 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.
- Coordinated improvement project on Australian lentils.
- Host resistance, epidemiology and integrated management of faba bean, chickpea and lentil diseases.

AUSTRIA

Federal Institute for Agrobiology, Linz

- Safety duplication of ICARDA's legume germplasm collection.

BELGIUM

University of Gent

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

University of Leuven

- Participatory agroecological characterization.

CANADA

University of Guelph, School of Rural Development and Planning, Ontario

- Role of women in resource management and household livelihood strategies.

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 chickpea germplasm and their wild relatives.

Simon Fraser University, British Colombia

- Collaboration in Sunn pest pheromones.

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.

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 food legumes.
- Evaluating the performance of crop model STICS developed by INRA.

Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM)

- 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.

University of Frankfurt am Main

- Development and use of DNA molecular markers for indirect selection in chickpea.

University of Hamburg

- Establishment of barley transformation system.

University of Hannover

- Development of transformation protocols for chickpea and lentil.

University of Hohenheim

- Increasing the heterozygosity level of barley to exploit heterosis under drought stress.

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.

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.

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.

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.

Kyoto University

- Collaboration in molecular characterization of wheat wild relatives.

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.

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.

University of Cordoba

- Durum grain quality.

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 College of Agriculture (SCA), Department for International Agriculture

- Training of SCA students within short research programs in animal production at ICARDA.

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 fat-tail sheep as a trait to be used in strategic feeding systems.
- Research on feeding systems for small ruminant production in the dry areas.

- Upgrading of skills in methodologies of feed evaluation in Central Asia.

Natural Resources Institute, University of Greenwich

- Sunn pest pheromones.

University of Reading

- Gender analysis in the agricultural systems of WANA.
- Testing woolly-pod vetch in hillside project in Uganda.

Scottish Crop Research Institute

- Use of microsatellite markers to characterize barley genetic resources of WANA.

UNITED STATES OF AMERICA

University of California, Riverside

- Biodiversity of wheat wild relatives.

University of California, Davis

- GL-CRSP (Global Livestock Collaborative Research Support Program): rangeland production and utilization in Central Asia.
- Developing chickpea cultivars with resistance to Ascochyta blight.
- Study of genetic diversity in natural populations of *Aegilops tauschii*.

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.

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 Massachusetts

- Child nutrition in rural areas of Syria.

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.

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.

Texas Tech University, Plant Molecular Genetics Laboratory

- 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 through the GL-CRSP (Global Livestock Collaborative Research Support Program).

Washington State University

- The use of CropSyst simulation model in the WANA region for generalization of the site-specific research results for wider ecoregions.

Yale University, Center for Earth Observations

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

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 National Soil Erosion Research Laboratory, West Lafayette, Indiana

- Technical advice on soil conservation technologies and erosion research.

USDA/ARS Forage and Range Research Laboratory, Logan, Utah

- Central Asian rangeland and sheep evaluation.

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 winter-hardiness genes in lentil for use in marker-assisted selection.

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.

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 worldwide; CIMMYT; ICRISAT	ICARDA Core funds
SEWANA (Southern Europe and WANA) Durum Wheat Research Network	Cooperation between durum breeders and crop improvement scientists from southern Europe, West Asia and North Africa (SEWANA) in developing techniques and breeding material adapted to the Mediterranean environment and with high grain quality.	ICARDA Germplasm Program	Algeria, Jordan, Lebanon, Morocco, Tunisia, Turkey, Syria, France, Greece, Italy, Spain, Canada, USA	ICARDA Core funds; France; Italy
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 provides a Secretariat	Countries of the Near East, Mediterranean and Central Asia; FAO; EC; CIHEAM	ICARDA; FAO; CIHEAM

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support

Sub-Regional Networks

Networks operating under the Nile Valley and Red Sea Regional Program (NVRSRP):

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
Control of Wheat Rusts: Sources of Primary Inoculums and Resistance to Yellow, Stem and Leaf Rusts of Wheat	Monitoring the physiologic races of rusts (stem, leaf and yellow rusts), their composition, frequency and virulence. Identifying the effective genes that condition resistance against the prevailing and newly developed rust races. yielding genotypes. Studying through forecasting studies the factors responsible for rust epiphytotics in each country. Demonstration on farmers' fields of improved wheat cultivars with resistance to different rust races.	ARC, Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA	IFAD
Management of Wilt and Root Rot Diseases of Cool Season Food Legumes	Identification of races of Fusarium wilt pathogens at national levels and their geographical contribution at the regional level. Development of integrated disease management measures, Demonstration of available control measures for wilt and root-rot diseases in legumes crops. Identification of sources of resistance to wilt and root-rots at national and regional levels.	EARO, Ethiopia	Egypt, Ethiopia, Sudan, ICARDA, ICRISAT	IFAD
Integrated Control of Aphids and Major Virus Diseases in Cool Season Food Legumes and Cereals	Creation of data bases on the temporal and spatial population dynamics of viruliferous virus vectoring aphids. Identification of germplasm resistant to specific viruses. Development of integrated management practices that will decrease a phid populations and the incidence of the viral infections that they transmit to wheat, barley and faba bean.	ARC, Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA	IFAD
Integrated Management of Chocolate Spot Disease of Faba Bean	Studies of integrated management of chocolate spot, using resistant cultivars and cultural practices. Evaluation on farmers' fields in Egypt and Ethiopia, of available IPM practices identified in on-station research and verification of their performance. Collection and characterization of isolates of *Botrytis* spp. at national and regional levels.	ARC, Egypt	Egypt, Ethiopia, ICARDA	IFAD
Thermotolerance in Wheat and Maintenance of Yield Stability in Hot Environments	Identification of physiological and morphological traits for improving wheat adaptation to heat. Development of heat tolerant high yielding cultivars and selection of the best for commercial production after demonstration of their yield potential on farmers' fields with the participation of farmers and extension workers.	ARC, Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA	IFAD

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
Drought And Water Use Efficiency in Cereals and Food Legumes	Development and identification of high yielding wheat, barley, lentil and chickpea cultivars that require less water, tolerate moisture stress in irrigated areas and drought in rainfed areas. Development of improved production packages comprising moisture stress tolerant cultivars, effective irrigation regimes/moisture conservation systems and appropriate cultural practices to utilize water more efficiently.	ARC, Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA	IFAD
Socio-Economic Studies	Identification of production constraints for target crops in target environments in a participatory approach. Quantification of the impact and distribution of benefits from the use of improved technology at the farm level. Incorporation of socioeconomic research results in the technology generation process to improve the efficiency and effectiveness of agricultural research and the technology transfer process.	ARC, Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA	IFAD

Appendix 7

Financial Information

(Audited Financial Statements) (US$ ×1000)

	2002	2001
REVENUES		
Grants (Core and Restricted)	23,134	21,712
Other revenues and supports	1,091	259
Total revenues	24,225	21,971
EXPENSES		
Research	20,745	17,303
Training	970	1,460
Information services	730	691
General administration	1,051	2,324
General operation	1,731	895
Total expenses	25,227	22,673
Recovery of indirect costs	(998)	(635)
Net expenses	24,229	22,038
EXCESS REVENUES OVER EXPENSES	(4)	(67)
ALLOCATED AS FOLLOWS:		
Unrestricted unappropriated assets	(4)	(67)
Surplus/(Deficit)	(4)	(67)

Statement of Financial Position (US$ x000)

	2002	2001
ASSETS		
Current assets	25,291	20,613
Property & equipment	3,287	3,322
Total assets	28,578	23,935
LIABILITIES AND ASSETS		
Current liabilities	13,706	9,585
Long-term liabilities	3,316	2,790
Total liabilities	17,022	12,375
Net assets	11,556	11,560
Total liabilities & net assets	28,578	23,935

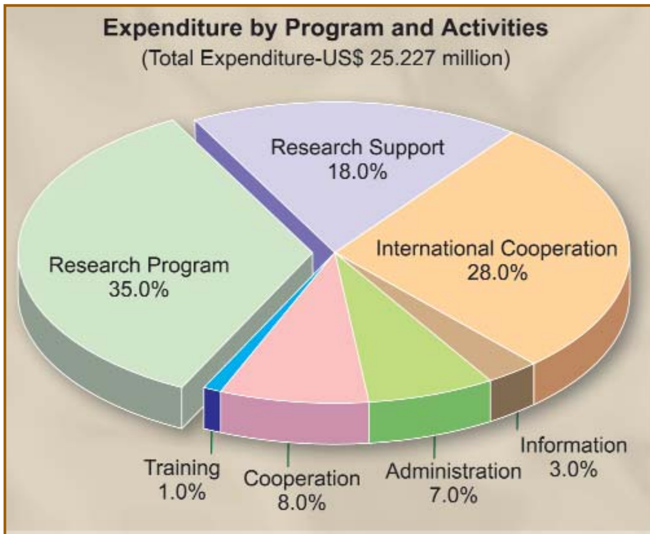
Statement of Grant Revenues, 2002 (US$x000)

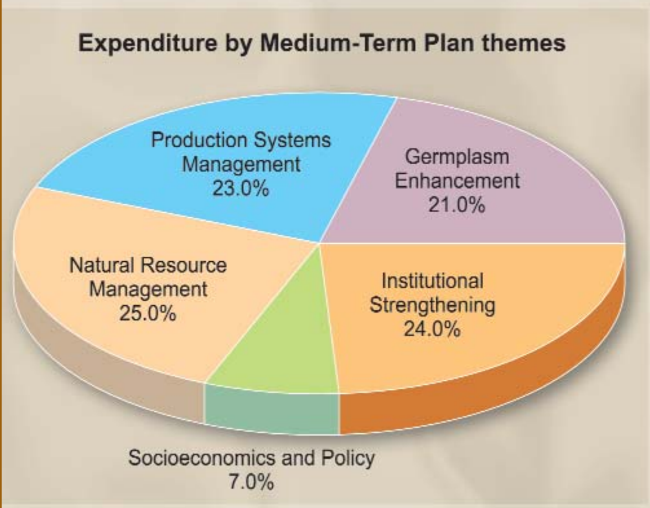
Donor	Amount
Arab Fund	1,000
Asian Dev. Bank	445
Australia*	322
Belgium*	86
Canada*	413
Denmark*	498
Egypt*	506
Ethiopia	44
European Commission	1,458
FAO	50
France*	160
Germany*	680
IDRC	232
IFAD	788
India*	38
Iran*	236
Italy*	788
Japan*	545
Norway*	600
OPEC	49
South Africa	10
Sweden*	447
Switzerland	18
Syria*	505
The Netherlands*	744
Turkey	28
UNDP	237
UNEP	78
United Kingdom	1,045
USAID*	7,179
USDA	231
World Bank*	3,464
Miscellaneous	210
Total	23,134

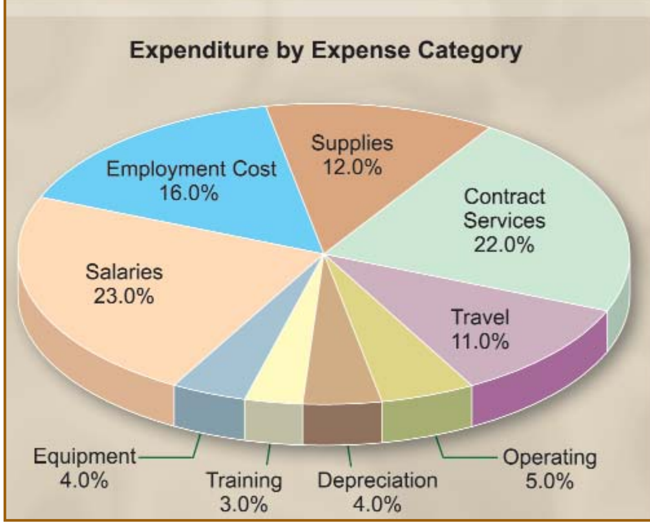
*Donors that provided core funds

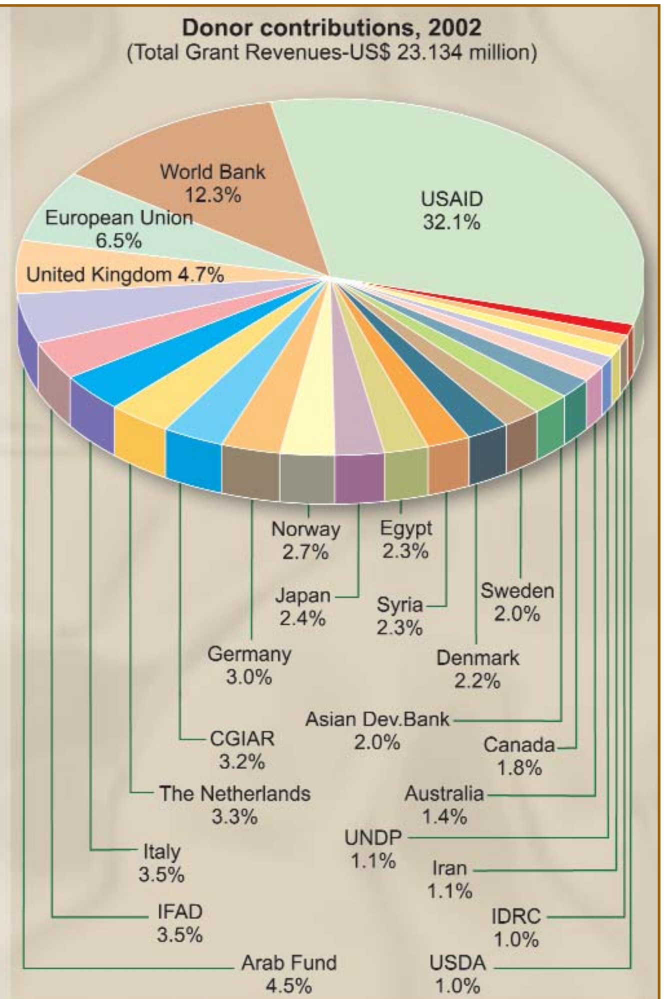
Appendix 7 (Cont.)

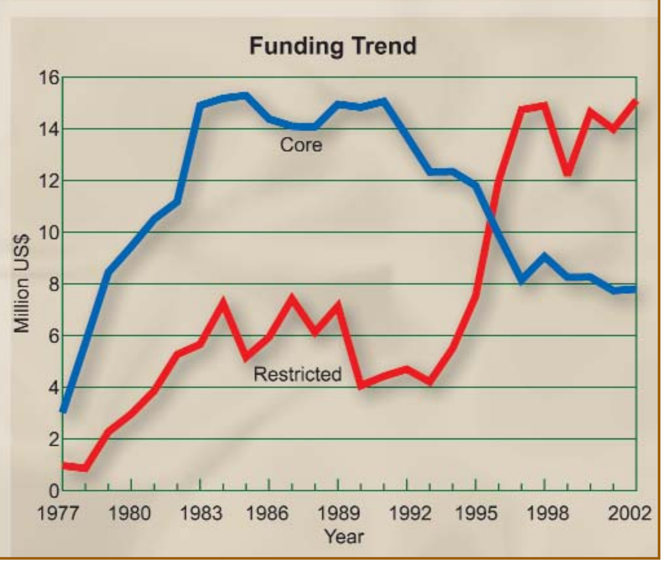
Financial Information











Appendix 8

Board of Trustees

Four new members joined the Board in 2002: Dr Michel Antoine Afram, Dr Guido Gryseels, Dr Shinobu Inanaga, and Dr Mohamed S. Zehni. Prof. Iwao Kobori, Vice-Chair of ICARDA Board, completed his second 3-year term of office as a member. In bidding farewell to him, the Board paid tribute to his outstanding contributions to the growth and development of ICARDA.

Dr Michel Antoine Afram

A specialist in agricultural education and policy, Dr Michel Antoine Afram is President of the Board of Directors and Director General of the Lebanese Agricultural Research Institute. He holds many other positions, including Deputy Director of the Global Association of Francophonie Agricultural and Food Processing Universities. He is a member of the Lebanese Higher Agricultural Council, Professor at the School of Agriculture, Saint Joseph University, and is a member of several Lebanese national committees pursuing improved agriculture and food production. From 1993 to 2002, he was Dean of the School of Agriculture, Saint Joseph University, Lebanon.

Dr Guido Gryseels

An economist, Dr Guido Gryseels is presently Director of the Royal Museum for Central Africa, Tervuren, Belgium, and Principal Agricultural Research Officer, Food and Agriculture Organization of the United Nations. He also holds important positions in the Consultative Group on International Agricultural Research (CGIAR), including Deputy Executive Secretary, Interim Science Council (formerly the Technical Advisory Committee), with responsibility for committees looking into priorities and strategies and impact assessment. He is immediate past Executive Secretary of the CGIAR's Impact Assessment and Evaluation Group. From 1987 to 1993 he held various senior positions with the International Livestock Center for Africa.

Dr Shinobu Inanaga

Dr Shinobu Inanaga is Professor of Crop Ecology and Physiology and Director of the Arid Land Research Center, Tottori University, Japan. From 1996 to 1997, he was a Professor in the Faculty of Agriculture, University of Tokyo. He has worked on dryland agriculture in many countries in West Asia and North Africa, and his various professional activities include membership on the Japan International Cooperation Agency Advisory Committee for the Middle East, the Board of the Japanese Association for Arid Land Studies, and several other bodies related to agriculture and combating desertification.

Dr Mohamed S. Zehni

A plant physiologist from Libya, Dr Mohamed S. Zehni is an independent consultant. Presently he is Advisor for International Agriculture Studies, Institute of Agriculture, University of Malta. He is former Director, Plant Production and Protection Division, and Director, Research and Technology Development Division, Food and Agriculture Organization of the United Nations. From 1978 to 1984 he was Ambassador, Permanent Representative of Libya to the United Nations Organizations (FAO, IFAD, World Food Council) in Rome. He is also past Chairman and Director General of Libya's Agricultural Research Center, and past Director General, Plant Production Department. His association with the CGIAR dates back to 1980, and he has served as a member of the Review Panel of IPGRI, member of the 2nd Review of the CGIAR and of the Technical Advisory Committee (TAC).

Full Board 2002

On 31 December 2002, the membership of ICARDA's Board of Trustees was as follows:

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Appendix 9

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(As of 31 December 2002)

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Dr John Dodds, Special Advisor
Dr Elizabeth Bailey, Project Officer
Ms Houda Nourallah, Administrative Officer to the Director General and Board of Trustees

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Government Liaison

Dr Faisal Maya, Director, Office of Government Liaison

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Natural Resource Management Program

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Dr Hiroaki Nishikawa, Honorary Consultant (Animal Parasitology)
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Dr Mustafa Pala, Wheat-Based Systems Agronomist
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Dr Francis Turkelboom, Soil Conservation/Land Management Specialist
Mr Akhtar Ali, Water and Soil Engineer
Ms Azusa Fukuki, Research Associate, Anthropology
Mr Adekunle Gabriel Ibiyemi, Senior GIS Analyst
Dr Roberto La Rovere, Researcher in Economics
Dr Malika Abdelali Martini, Research Associate, Socioeconomics and Gender Analysis
Dr Ahmed Mazid, Agricultural Economist
Ms Monika Zaklouta, Research Associate, Animal Nutrition
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Mr Alois Klewinghaus, Research Fellow, Land Management
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Germplasm Program

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Dr Osman Abdalla El Nour, Breeder/Pathologist (CIMMYT/ICARDA wheat program)
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Dr Michael Baum, Biotechnologist
Dr Mustapha El-Bouhssini, Entomologist
Dr Salvatore Ceccarelli, Barley Breeder
Dr Stefania Grando, Barley Breeder
Dr Rajinder Malhotra, Chickpea Breeder
Dr Miloudi Nachit, Durum Wheat Breeder (CIMMYT/ICARDA wheat program)
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Mr Tarif Kayali, Legal Advisor (Aleppo)

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
ARC Agricultural Research Center
ASU Afghan Survey Unit
CABI Commonwealth Agricultural Bureau International, England
CAC Central Asia and the Caucasus
CACRP Central Asia and the Caucasus Regional Program
CAPRi CGIAR Systemwide Program on Collective Action and Property Rights
CATCN Central Asian and Trans-Caucasian Network
CGIAR Consultative Group on International Agricultural Research
CIHEAM Centre International de Hautes Etudes Agronomiques Mediterraneennes, France-International Centre for Advanced Mediterranean Agronomic Studies.
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
GTZ German Agency for Technical Cooperation
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
IAEA International Atomic Energy Agency, Austria
ICRISAT International Crops Research Institute for the Semi-Arid Tropics, India
IDRC International Development Research Centre, Canada
IFAD International Fund for Agricultural Development, Italy
IFDC International Fertilizer Development Center, USA
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
ISESCO Islamic Educational, Scientific and Cultural Organization, Iran
ISNAR International Service for National Agricultural Research, Holland
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
ORSTOM Institut Français de Recherche Scientifique pour le Développement en Coopération (France)
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
WANANET West Asia and North Africa Network
WARP West Asia Regional Program, Jordan
ZEF Center for Development Research, Germany

Appendix 11

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Listed in descending order of contribution.
For more information, please refer to page 125.

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Front Cover:

ICARDA, as the lead Center of the Future Harvest Consortium to Rebuild Agriculture in Afghanistan, provided seed from its own farm as well as from other sources to Afghan farmers for both spring and fall planting. The Center also played a major role in refurbishing research laboratories and training local researchers as part of its efforts to develop an efficient research infrastructure and build human resource capacity in the country.

Back cover:

Water-scarcity is the most serious constraint in dry areas where farmers depend on crop/livestock production systems. ICARDA has developed new water harvesting and supplemental irrigation tehnologies to cope with the shortage of water, and improved nutrition and management of small ruminants, to contribute to improving the livelihoods of the poor farming communities in these areas.

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ICARDA-/5000/June 2003

About ICARDA and the CGIAR

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

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

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

CGIAR

The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. Its mission is to promote sustainable agriculture to alleviate poverty and hunger, and achieve food security in developing countries. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South-North partnership to reduce poverty and hunger.

The Future Harvest centers of the CGIAR conduct strategic and applied research, with their products being international public goods, and focus their research agenda on problem solving through interdisciplinary programs implemented in collaboration with a range of partners. These programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and strengthening national agricultural research systems.

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 System with a Secretariat 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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