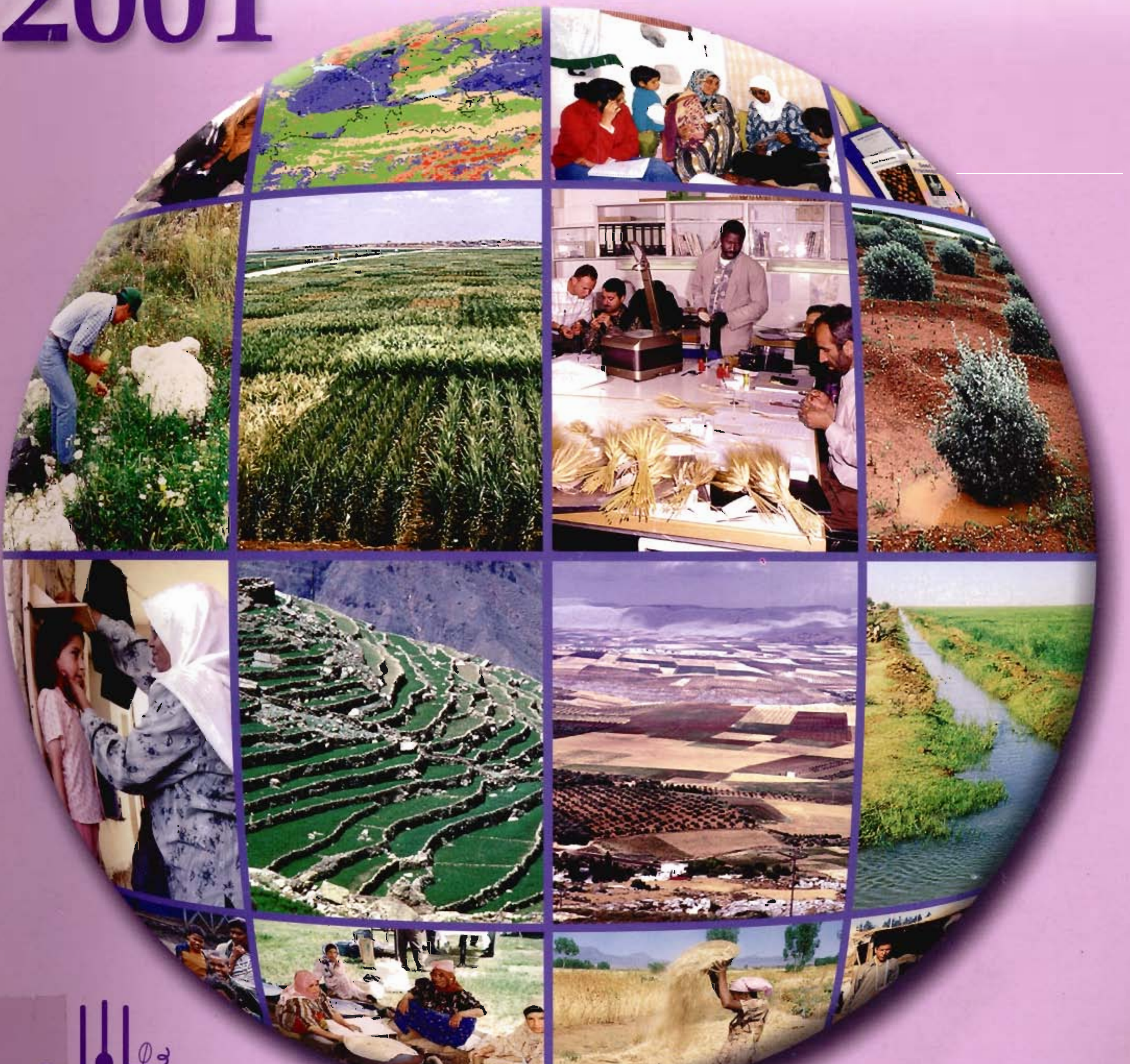
ICARDA Annual Report 2001



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

2001

International Center for Agricultual Research in the Dry Areas

Citation:

ICARDA. 2002. ICARDA Annual Report 2001. International Center for Agricultural Research in the Dry Areas, Aleppo, Syria. iv+112 pp.

ISSN: 0254-8313

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; Kazakastan; Kyrgyzstan; Latin America; Pakistan; Sudan; Tajikistan; Turkmenistan; Uzbekistan.

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

Foreword

The world is witnessing a period in its history when the increasing socio-political upheavals are taking the lives of thousands, and destroying the natural wealth of our planet. Poverty and food insecurity are two key forces driving this destruction. These ongoing problems compound those already being posed by an increasing shortage of water, scarcity of productive land, an expanding population, and the threat of global warming. ICARDA strongly believes that solutions to these problems can only be found through innovative partnerships. Working with its partners the Center can widen the scope of its research geared to reduce poverty, increase food production, and protect the natural resource base throughout the dry areas of the world. The year saw a major breakthrough in forging new partnerships.

For example, the war-torn and drought-hit Afghanistan urgently needs support to rebuild its agriculture. In 2001, ICARDA initiated a major international effort—The Future Harvest Consortium to Rebuild Agriculture in Afghanistan—to help the country achieve sustainable development of its agriculture and reduce poverty and hunger. The Consortium is drawing together partners and expertise from many organizations, including the CGIAR, UN agencies, U.S. universities, local and international NGOs, and USAID and other donors. The most immediate problem facing Afghan farmers is the lack of good quality seed, so the Consortium has developed a detailed plan to multiply and deliver quality seed of adapted varieties, and to establish an efficient seed production system in the country. Needs assessments for medium- and long-term interventions have been started with full participation of the Ministry of Agriculture, Afghanistan.

Reversal of the trends in land degradation requires a holistic approach that focuses on three key components. First are technological interventions that address land, water and food security problems. Second is the active involvement of local communities employing a strategy that increases their knowledge and organizational capacity. With increased capacity to solve problems and to manage risk, communities can reverse land degradation, generate employment opportunities, improve their livelihoods, and become responsible stewards of the natural resources. Thirdly, appropriate incentives at the policy and institutional level are required to stimulate land users to adopt new technologies to improve their income and quality of life. Progress in these and other areas of ICARDA's research agenda is reported in the pages that follow.

At the dawn of the 21st century, ICARDA, with renewed vigor, remains firmly committed to the advancement of science in agricultural research; free exchange of germplasm and information; protection of intellectual property rights, including indigenous knowledge of farmers; human resource development; and the sustainable use of natural resources with the overall goal of reducing poverty, particularly among women and children.

In presenting this Annual Report to our readers, we would like to take this opportunity to extend ICARDA's grateful thanks to donors for their continuing support to the Center's research and training activities. We also thank ICARDA's partners throughout the world, without whose active participation the work reported here would not have been possible.

Adel El-Beltagy
Director General

Robert Havener
Chairman, Board of Trustees

Contents

Highlights of the Year

In 2001, ICARDA responded to numerous challenges. Several areas in the Central and West Asia and North Africa (CWANA) region were hit by drought. Turning this to their advantage, the Center's researchers, in collaboration with their national partners, were able to test their new drought-tolerant lines of food and feed crops in the field. Progress made in plant breeding and natural resource management, using new tools of science such as biotechnology, remote sensing and geographic information system, was significant in the face of global warming, which is predicted to make the world's dry areas drier and warmer. As in past years, ICARDA greatly relied in 2001 on the power of partnerships in addressing the complex problems of dry area agriculture. The Center both expanded and strengthened its partnerships with national research systems and advanced research institutes during the year.

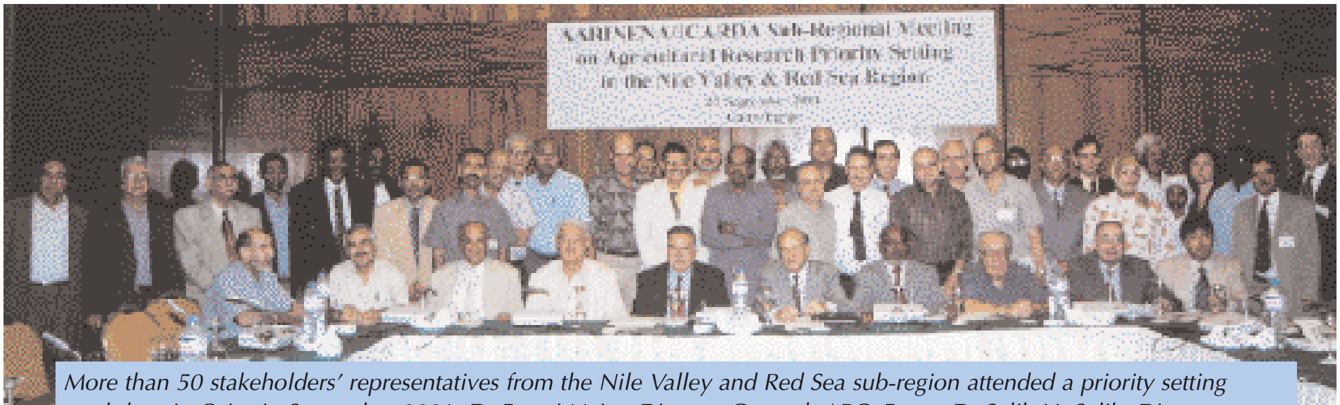
Some of the highlights of the work on promoting science through partnerships during the year under report are presented here. Progress made in specific research projects is reported in subsequent chapters.

Agricultural Research Priority Setting for CWANA

During the mid-term meeting of the CGIAR in Dresden, Germany, in 2000, the CGIAR Technical Advisory Committee's proposal for a regional approach to agricultural research priority setting and for greater integration of the CGIAR Center activities into regional priorities was approved. The Center Directors Committee (CDC) assigned ICARDA to facilitate the process of integrating regional priorities with the CGIAR research in CWANA.

The goal is to enhance the effectiveness of the CGIAR in helping NARS address key problems at the sub-regional and regional levels. The process in CWANA was initiated in close collaboration

Participants in the "Brainstorming Workshop on Agricultural Priority Setting for CAC," held in September 2001 in Tashkent. Dr U. Kazaryan from Armenia, Dr A. Musaev from Azerbaijan, Acad. G. Agladze from Georgia, Prof. A. Satybaldin from Kazakstan, Acad. J. Akimaliev from Kyrgyzstan, Dr B. Sanginov from Tajikistan, Dr Shamurad Kheremov from Turkmenistan, and Dr Sh. Nurmatov from Uzbekistan made presentations on behalf of their respective countries and highlighted their priorities. These were then discussed in detail by the participants.



More than 50 stakeholders' representatives from the Nile Valley and Red Sea sub-region attended a priority setting workshop in Cairo in September 2001. Dr Fawzi Naim, Director General, ARC, Egypt; Dr Salih H. Salih, Director General, ARC, Sudan; Dr Ismail Muharram, Chairman of AREA, Yemen; Dr Geletu Bejiga, Director, Field Crops Research Division, EARO, Ethiopia; Dr Nawfal Rasheed, Advisor to the President of the Arab Authority for Agricultural Investment and Development in Sudan; and Dr Christo Hilan, representing AARINENA, participated in the workshop.

with the Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA) and the NARS Forum for Central Asia and the Caucasus (CAC). ICARDA is following a bottom-up approach that encourages broad participation from a wide range of stakeholders. The process began with the development of an inventory of CGIAR activities in CWANA, and was supplemented with a questionnaire and consultation meetings.

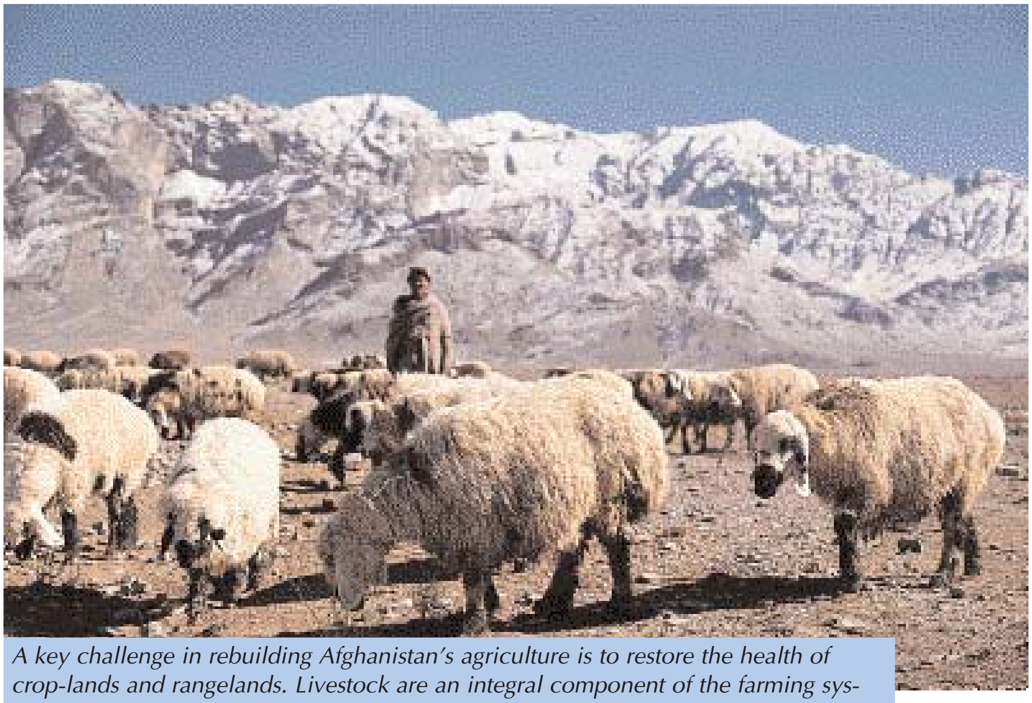
Senior researchers, research managers, farmers, and NGO representatives from eight countries in West Asia, along with their ICARDA colleagues, participated in the "Brainstorming Meeting on Agricultural Research Priority Setting in West Asia," held at ICARDA, in November 2001.

Three sub-regional priority setting meetings were held in 2001: for CAC in September in Tashkent; for the Nile Valley and Red Sea countries in September in Cairo, and for West Asia in November at ICARDA headquarters. Meetings are planned for North Africa, in Tunis, Tunisia, and for the Arabian Peninsula, in Kuwait, in January 2002. Outputs from these meetings will be discussed and recommendations developed at a regional meeting for the CWANA region, scheduled for May 2002 at ICARDA. The priority setting efforts are supported in part by the Global Forum for Agricultural Research.

Future Harvest Consortium to Rebuild Agriculture in Afghanistan

In October 2001, ICARDA proposed an initiative at the Annual General Meeting (AGM) of the CGIAR to help Afghanistan, particularly to meet the need for emergency seed supplies and to rehabilitate the local crop variety development and testing system and the seed supply sector. Following discussions with USAID, ICARDA received a US$2.5 million grant from the Office for Foreign Disaster Assistance to implement a project. The objectives are to:

Multiply and deliver quality seed of adapted varieties through effective delivery systems to reach



A key challenge in rebuilding Afghanistan's agriculture is to restore the health of crop-lands and rangelands. Livestock are an integral component of the farming systems, but rangelands are severely degraded and exposed to desertification.

affected farmers in time, and to build, with Afghan partners, an effective regulatory system that enforces standards and promotes the use of high quality seed and varieties. Establish a framework and strategy for CGIAR technical assistance, in cooperation with partners, for the development of seed systems and sustainable agricultural production systems in Afghanistan.

A meeting of stakeholders is planned for January 2002 in Tashkent. The meeting, supported by the United States Agency for International Development (USAID), and organized by ICARDA's Regional Office for Central Asia and the Caucasus, is expected to bring together representatives from 10 of the 16 Future Harvest Centers of the CGIAR, non-governmental organizations (NGOs), United Nations agencies, United States institutions, various international agencies, and donors including the Department for International Development (DFID), U.K.; the International Development Research Centre (IDRC), Canada; USAID, and others.

TAC Sees Research in Action at ICARDA

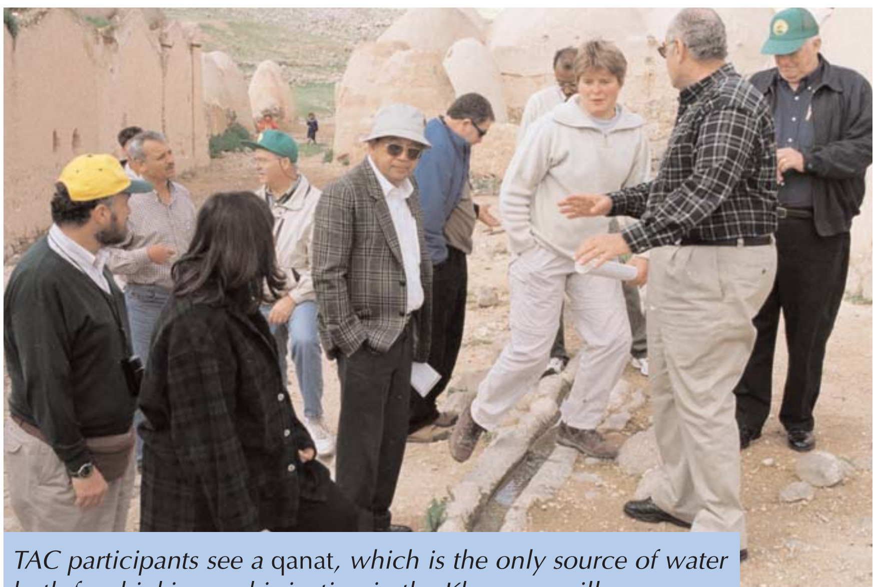
The 80th meeting of the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) was held at ICARDA in March 2001. TAC advises the CGIAR on emerging trends in science and their importance to the overall goals of the CGIAR System. It oversees the research agendas of the CGIAR Centers, ensuring quality and consistency with the vision and strategic priorities of the CGIAR. It also assesses the impact of research conducted by the Centers.

TAC Chair Dr Emil Javier characterized this year's meeting as "most intense and exciting" because of the challenges the CGIAR System is facing. More than 30 participants attended the meeting. These included the TAC members; donor representatives from France, Germany, Italy, and USA; CGIAR Center Directors General from the International Livestock Research Institute (ILRI) and the International Water Management Institute (IWMI); Mr Robert Havener, Chair of ICARDA's Board and Vice-Chair of Center Board Chairs Committee; Prof. Dr Adel El-Beltagy, Director General of ICARDA; and Dr Francisco J.B. Reifschneider, Director, and other colleagues from the CGIAR Secretariat.

"Given our commitment to alleviate poverty, we have elevated our aim in trying to help the poor through strategic research partnerships," Dr Javier said.

Opening session of the TAC80 meeting. Dr Emil Q. Javier (second from right), TAC Chair, welcomed the participants to the meeting. Prof. Dr Adel El-Beltagy (second from left) said ICARDA was pleased to host the meeting. Dr Francisco J.B. Reifschneider (left), Director of the CGIAR Secretariat, summed up the recent major developments in the System. Seated on right is Dr Shellemiah O. Keya, Executive Secretary, TAC.

Prior to their meeting, the TAC participants visited Khanasser Valley, southeast of Aleppo, which is one of ICARDA's integrated research sites, to learn about the Center's work. Their first stop was Jabul Salt Lake, at the northern end of the Valley, where



TAC participants see a qanat, which is the only source of water both for drinking and irrigation in the Khanasser village. Among others, seen in the picture, are Dr Emil Q. Javier, Mr Robert Harvener, and Prof. Dr Adel El-Beltagy.

they saw ICARDA's integrated approach to sustainable natural resource management in dry areas. Researchers explained the groundwater system of the Valley and how over-pumping for irrigation was causing intrusion of salt water from the lake into the Valley. The group then continued to Shallaleh Sakhireh, a small village in the shadow of the Jebel Al Hoss, where they saw action research with the villagers that led to community renovation of a *qanat*, an ancient water system that is the only source of drinking and irrigation water for the village.

In the village of Rasm Hamid, ICARDA's livestock specialists showed the work on sheep fattening and the production of milk products and how these were contributing to improve the income of people in the Valley. The group continued to Al Hobs, a small side-valley, where it saw olive groves planted on stony slopes, fed by simple water-harvesting techniques. Within just three years, several farmers in the Valley have adopted water-harvesting techniques, returning land to productivity. The group also visited other ICARDA research projects in the Valley.

In partnership with community members and the national agricultural research systems (NARS), ICARDA is working to create sustainable and improved livelihoods for the people of Khanasser Valley. The resource management approaches developed or improved in Khanasser will be applied in dry areas elsewhere in Syria and other countries, based on the detailed agroecological and socioeconomic characterization of this integrated site.

ICARDA Participates in UNCCD COP5

ICARDA participated in the United Nations Convention to Combat Desertification (UNCCD) COP5, in October 2001, in Geneva, Switzerland. The Center is involved in the preparations for, and implementation of, the UNCCD National Action Plans; Sub-Regional Action Programs (SRAP); and the Thematic Program Networks (TN). ICARDA is the facilitator of the SRAP Thematic Network on Water Resources (TN1) and a partner in TN2 on Vegetative Cover in West Asia and TN4 on Water Resources in Asia.

ICARDA representatives also participated in a meeting called by the United Nations Environment Programme (UNEP) Regional Office for West Asia (ROWA) to discuss the implementation of SRAP projects in West Asia—particularly the pilot projects on mountain agriculture, rangelands, and salinity-affected areas. The projects will be developed jointly by ICARDA and the Arab Center for Studies of the Arid Zones and Dry Lands (ACSAD). The meeting also discussed the next steps for finalizing a Regional Program for Dryland Management in West Asia and North Africa (WANA) as a follow-up to the Rabat Declaration, made at the WANA Ministerial Meeting held in June 2001 in Rabat, Morocco. ICARDA is the coordinator of the regional program in which 13 WANA countries, and regional and international organizations are involved.

'Gokçe' Chickpea Gaining Popularity in Turkey

Demand from chickpea consumers and exporters in Turkey is rising for 'Gokçe,' a chickpea variety developed from ICARDA line FLIP 86-87C and released in the country in 1997. Seed is being produced in Central Anatolia. Farmers and consumers like the variety's large seeds.

The large-seeded chickpea variety 'Gokçe' was identified from ICARDA-supplied germplasm and released in Turkey in 1997. It occupied over 2000 hectares in Turkey in the year 2001 to meet the increasing demand from farmers and consumers.

To meet the demand, the Mediterranean Exporters' Union has contracted farmers to produce 'Gokçe' on 2000 hectares. The variety has also shown good potential in Kyrgyzstan and Kazakstan.

Turkey Releases New Lentil Varieties

With over 700,000 ha under lentil, Turkey ranks next only to India, the world's largest lentil producer. Five lentil varieties were registered in Turkey—three of them for winter cultivation selected from local landraces, and two spring varieties developed through selection from ICARDA-supplied international nurseries. Two were spring varieties selected from the ICARDA germplasm. 'Meyveci-2000' (FLIP 90-3L) was developed from a cross ILL 28 × ILL 851. The variety is a yellow lentil with a seed-weight of 6.9 g/100 seeds. It matures in 93 days and produces an average yield of 1.2 t/ha. The second variety, 'Ali Dayi' (FLIP 84-51L) has been selected from an ICARDA cross between ILL 883 × ILL 470. It is a red lentil variety, matures in 92 days, has a seed-weight of 5 g/100 seeds, and a seed yield of 1.5 t/ha.

New Food Legume Cultivars Released in Iraq

A lentil line ILL5883 (IPA 98) and a chickpea line FLIP 86-5C (IPA 510), selected from ICARDA-supplied germplasm, were released in Iraq. Seed of these lines is being produced in large quantities for distribution to farmers.

New Legume Varieties for CAC

The Kazakh Research Institute of Agriculture, Almalybak, has identified a new ICARDA Lathyrus line, IFLS 225 Sel. 554, for Official State Trials based on its good yield performance during the past three years. The pedigree of this line is:

ICARDA Lathyrus line IFLS 225 Sel. 554, being grown at Almalybak, Kazakstan. It has been selected for Official State Trials before release as 'Ali-Bar' in the country.

IFLLS197/450 (male parent from Afghanistan) crossed with IFLLS 416/514 (female parent from Ethiopia). The new variety, when released, is proposed to be named 'Ali-Bar.'

Breeders in Georgia identified a chickpea variety 'Elixir' (ILC 533) and a lentil variety 'Pablo' (ILL 799) for Official State Yield Trials.

New Hull-less Barley Varieties for Egypt

Three hull-less barley lines (two from nurseries sent from ICARDA in 1995 and 1996, and one from ICARDA/CIMMYT nursery) were registered in October 2001 for release to farmers in Egypt. 'Giza 129' and 'Giza 130' will be released for the newly reclaimed lands. 'Giza 131,' as well as 'Giza 130,' will be released for rainfed areas.

Honors and Awards

Prof. Dr Adel El-Beltagy, Director General, was elected Academician of the Kyrgyz Agrarian Academy and of the Uzbek Research Institute of Market Reforms in recognition of his contributions in the field of crop physiology and as well as in expanding and strengthening collaborative research activities in Central Asia and the Caucasus.

Dr Mohan C. Saxena, Assistant Director General (At-large), was conferred the honorary degree of Doctor of Science by the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India for his outstanding contributions to agricultural research and development.

Dr Surendra P. Beniwal, Regional Coordinator of ICARDA/CAC and Head of the Program Facilitation Unit (PFU) of the CGIAR Program for CAC, was elected Honorary Professor of the Kyrgyz Agrarian Academy in Bishkek, Kyrgyzstan.

Dr S.V.R. Shetty, Team Leader of the World Bank funded ICARDA project in Yemen, won the Indian Society of Weed Science (ISWS) Medal in recognition of his significant contributions in the field of weed science.

Dr Rajendra Singh Paroda, the new Regional Coordinator of ICARDA/CAC and Head of PFU of the CGIAR Program for CAC won the Honorary Membership of the American Society of Agronomy and Crop Science Society of America (CSSA) in recognition of his lifetime contributions in crop agronomy and plant breeding.

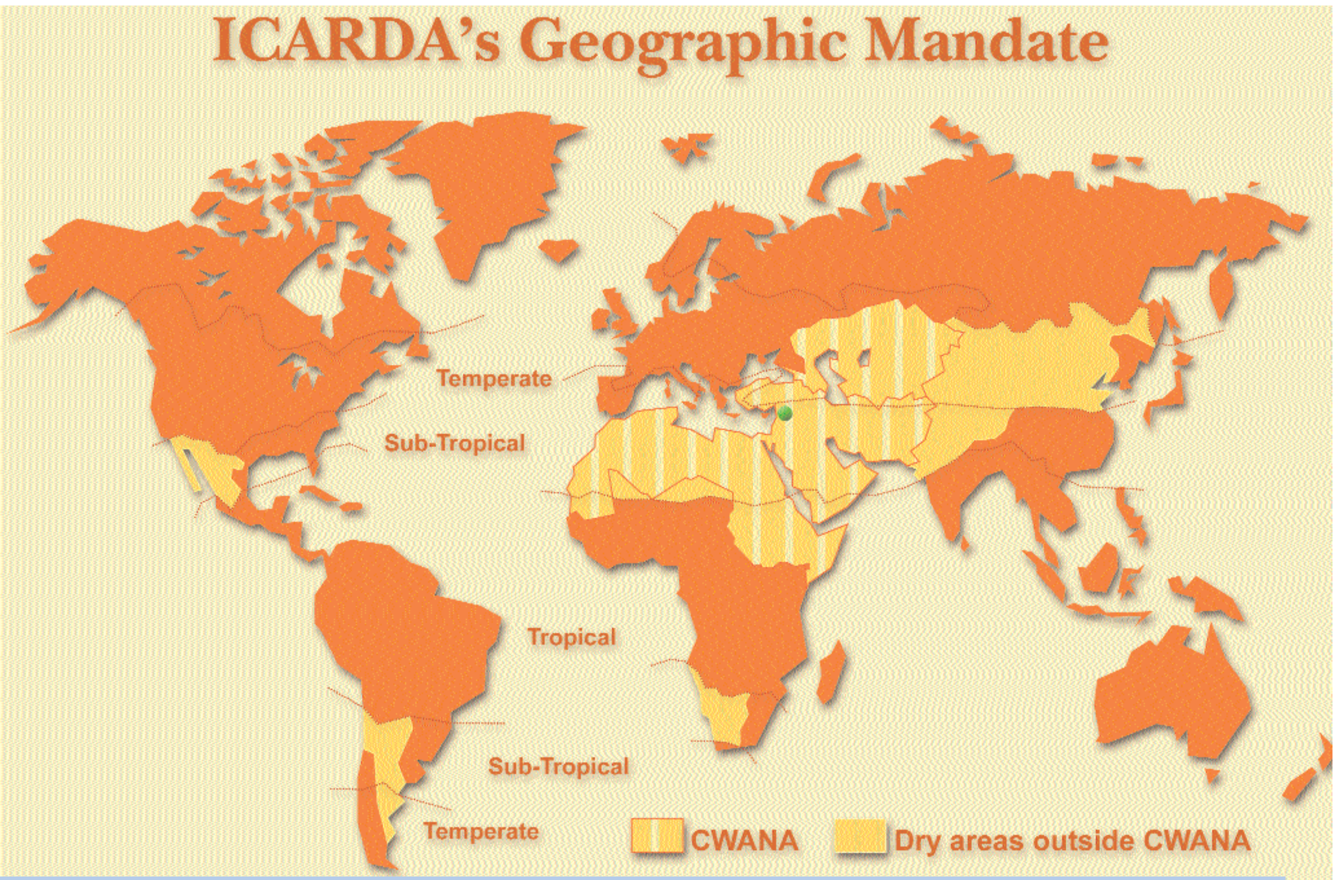
Dr Rajinder Singh Malhotra, Senior Chickpea Breeder, won the International Pulse Improvement Award from the North America Pulse Improvement Association in recognition of his outstanding contributions to international food legume research.

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

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



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, north-western China, Tajikistan, Turkmenistan and Uzbekistan are located in the temperate dry areas.

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. Strengthening National Seed Systems

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 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 outsourcing 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.

Theme 1. Crop Germplasm Enhancement

Project 1.1. Barley germplasm improvement for increased productivity and yield 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 a useful alternative to wheat as food, especially in regions of high altitude and low rainfall where many of the world's poorest people live.

In 2001 ICARDA scientists made further progress in improving barley germplasm for increased productivity and yield stability. Existing participatory barley breeding projects were scaled up to involve more farmers in the selection of improved varieties. Three new varieties of hulless barley were released in Egypt and new high-yielding lines were tested in Central Asia. Progress has also been made in understanding the genetic basis of adaptation to low-rainfall environments, and in developing lines with resistance to pests and diseases of barley such as the stem-gall-midge, yellow rust, yellow dwarf virus, powdery mildew, and seed-borne diseases.

Yellow rust is a major constraint to barley production in the highlands in the Andes. Here, scientists evaluate barley genotypes for yellow rust resistance in Peru.

Scaling up participatory barley breeding in Syria

Involving farmers in varietal selection is essential to ensure new lines are not only adapted to the local environment but also appropriate for the farmers' needs. Participatory barley breeding has been conducted in Syria since 1996 and the results have provided invaluable information and lessons for participatory research on other crops in new geographical areas.

The current study involves eight villages (Fig. 1) and began in 1999. The villages were chosen to represent different rainfall, soil types, and management practices, as well as different categories of farmers (farm size, end-use of the crop, literacy, etc.). These 'farmer initial trials' (FIT) included 200 plots (378 entries including checks) and allowed the farmers to choose the row pattern (two- or six-row), the seed color (white or black), and the type of germplasm (modern or landraces). Barley populations derived from crosses made only three years ago were included in the trial. A total of 53 farmers participated in the first year's selection, making their choices on the basis of such factors as grain yield, plant height resistance to lodging, and kernel size. After harvesting and data analysis, the quantitative results and farmers' scores were discussed in each village, and the farmers selected the varieties they desired to test further.

Larger plots were used in the second year (2000) to evaluate the lines selected by the farmers and those with the highest yields. These were called 'farmer advanced trials' (FAT). A new set of FIT was also planted in the same eight villages. After harvest, further selection was made, as before, resulting in a third level of trials: 'farmer elite trials' (FET). These included only the lines selected by the majority of the farmers and were managed entirely by the farmers.

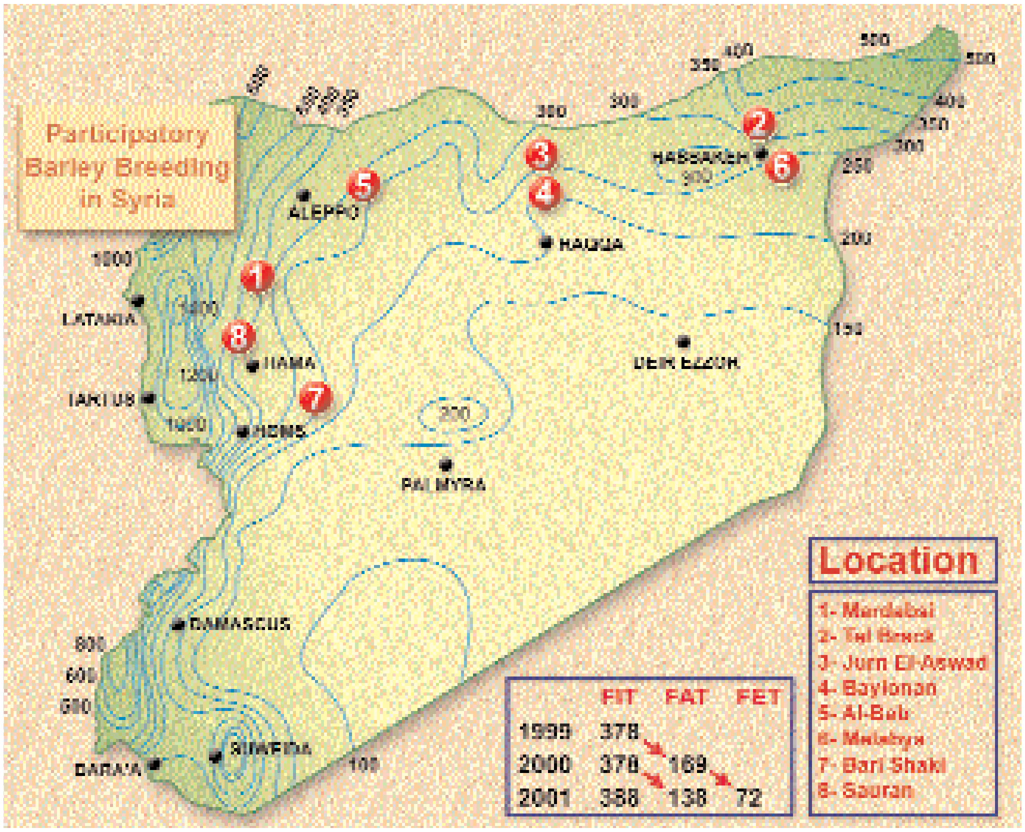


Fig. 1. Farmers from eight villages in Syria are participating in the ICARDA participatory barley breeding project, which started in 1999.

FIT: Farmer Initial Trials, 378 entries, plot size 12 m²
FAT: Farmer Advanced Trials, 169 entries, plot size 144 m²
FET: Farmer Elite Trials, 72 entries, plot size 0.3-1.5 ha

By 2001, 59 farmers had joined in 11 FIT, 45 FAT, and 39 FET. Meanwhile, complementary activities were conducted on the research station. These included seed multiplication, single-plant selection within the FIT and the rapid advancement of these selections through single-seed descent, and conventional or marker-assisted selection for desirable traits such as pest and disease resistance. Small seed units are being established in four of the villages. These will have the capability to clean and treat seed against seed-borne diseases, and it is hoped that they will develop to become permanent village-based seed production units, helping to ensure a reliable supply of improved seed.

New varieties of hull-less barley released in Egypt

Currently, the type of food barley most commonly grown is hulled. That is, the seed has a cover that has to be removed by pearling or sanding before it can be prepared as food. Hull-less barley has several advantages. It requires little cleaning, the entire kernel can be used, and the nutrient-rich bran and germ are retained. Food products made from hull-less barley are known as whole grain foods, and have received growing attention as a healthy food in developed as well as developing countries.

In response to requests from a number of national agricultural research systems (NARS), ICARDA has been investigating ways to improve the acceptability of barley as food. Scientists are looking at ß-glucans (also important in malting), hardness (also important in animal feed), and cooking time. At the same time, efforts are being made to adapt hull-less barley germplasm to the growing conditions of the Central and West Asia and North Africa (CWANA) region.

In 2001, this research led to the release of three new hull-less varieties in Egypt. Two of these varieties, 'Giza 129' and 'Giza 130,' are derived from crosses made at ICARDA in 1985 and were selected from the International Naked Barley Nursery originally distributed in 1995. The third, 'Giza 131,' was selected from the International Hull-less

Barley Screening Nursery distributed by the joint barley breeding program of ICARDA and the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) in Mexico. All three produce high grain yield under dry conditions, and are resistant to terminal heat stress. 'Giza 129' is recommended for newly reclaimed lands, 'Giza 131' for rainfed areas, and 'Giza 131' for both environments.

Promising new barley lines for Central Asia and the Caucasus

The republics of Central Asia and the Caucasus (CAC) rely heavily on rainfed farming systems in which livestock are an important component. However, feed production is severely constrained by the marked seasonality of rainfall. Barley yields and economic productivity tend to be lower than in other regions of the world with similar agroecologies.

Collaboration between ICARDA and NARS led to the identification of seven new, promising lines of barley (Table 1), each with potential to increase yields over the local landraces. The new line 'Adel' outyielded the standard check by 18%, while 'Batir-1' and 'Batir-2' showed a 20-30% yield increase over check varieties. 'Dobrinya' and 'Rubicon' were developed within the framework of the joint ICARDA-Krasnodar project, and the scientists concerned were awarded Russian Federation Author Certificates. These new varieties will be used to improve local germplasm and for direct multiplication and introduction to farmers' fields. Indeed, 'Dobrinya' has already been sown across 21,000 ha.

Table 1. Promising barley varieties for CAC

Variety	Type	Location
'Adel'	Winter	Kyrgyzstan
'Rihane 03'	Spring	Azerbaijan
'Batir-1'	Spring	North Kazakstan
'Batir-2'	Spring	North Kazakstan
'Mamluk'	Spring	Armenia
'Dobrinya'	Winter	North Caucasus
'Rubicon'	Spring	North Caucasus

Genetic adaptation to low-rainfall environments

Shortage of water is one of the most serious constraints crop production in Mediterranean-type dryland environments around the world. Tolerance to drought has been a difficult trait to characterize and quantify, and current understanding is largely based on comparative physiology. The use of molecular markers to complement field evaluation can advance researchers' understanding of drought tolerance as well as improve their ability to select for this trait in crop improvement programs.

ICARDA is working with Australian scientists to develop barley germplasm with improved adaptation to low-rainfall environments. Current research focuses on identifying molecular markers for key traits associated with drought tolerance, including novel alleles from wild relatives and landraces of barley. Recent studies were based on a population derived from crossing a Syrian barley landrace ('Arta') with an improved ICARDA line ('Harmal-02'). The two parental lines are well adapted to low-rainfall, exhibit similar time to maturity, and represent a wide genetic diversity. Last year the collaborative experimental sites of ICARDA—two in Syria and four in Jordan—were exposed to significant drought stress, allowing the scientists to measure a range of associated traits including growth habit, early vigor, tiller number, leaf chlorophyll content, plant height, days to heading, biomass, kernel weight, grain yield, and harvest index. A number of lines outyielded both the parental lines and well adapted local varieties, although the differences were not associated with maturity effects, i.e. were due to true differences in drought resistance. A molecular map was constructed with 247 molecular markers, including 73 simple sequence repeats (SSRs) and 174 amplified fragment length polymorphisms (AFLPs). This was used to genotype 94 random inbred lines from this population.

A quantitative trait locus (QTL) for biological yield was detected at one of the two sites in Syria (Tel Hadya) and at the four sites in Jordan. This locus had

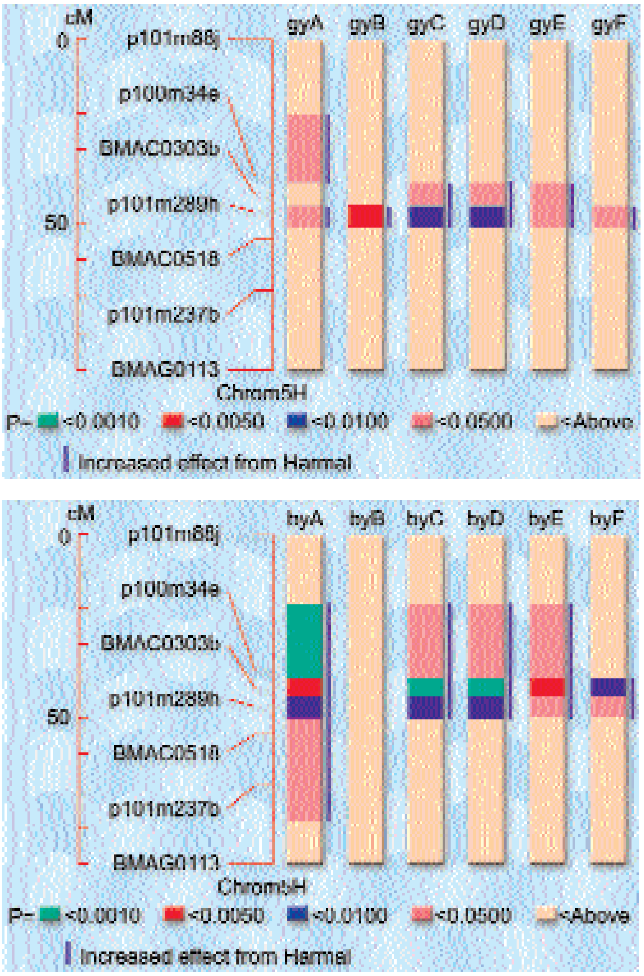


Fig. 2. QTL analysis of chromosome 5H for grain yield (gy) and biological yield (by) for each of six trial sites: Tel Hadya (A) Breda (B) in Syria; and Ramtha (C), Gweer (D), Khanasri (E), and Rabba (F) in Jordan.

a detectable, but statistically not significant, association with grain yield at all six locations (Fig. 2).

The positive allele was derived from the ICARDA improved line 'Harmal-02.' A positive allele was also conferred by the Syrian landrace 'Arta.' In this case, a QTL was detected at the same location on chromosome 1H at each of the five lowest rainfall sites, but not at Tel Hadya (Fig. 3). Quantitative trait loci for grain yield have previously been reported at the *hor1* locus on the telomeric region of the short arm of chromosome 1H, and on the telomeric region of the long arm of chromosome 1H. Further work to confirm the effect of the 1H QTL will help breeders to improve their efficiency in selecting lines with higher yields in drought-stressed environments.

Breeding for barley stem-gall-midge resistance

The barley stem-gall-midge *(Myetiola hordei)* is a destructive insect pest causing extensive damage to barley crops in North Africa. It is estimated that 30% of the crop in Tunisia and 50% in Libya is infested, while up to 35% of the grain yield in Morocco may be lost to stem-gall-midge. Identifying sources of resistance and developing resistant varieties are therefore important objectives of the ICARDA barley improvement program.

Since the problem occurs mainly in North Africa, screening of germplasm has been undertaken by the National Institute of Agricultural Research in Settat, Morocco. More than 5000 barley lines have been evaluated during the past four years, under artificial infestation in the greenhouse and at two locations in the field. In all, 99 lines have been selected for their tolerance to this pest, 55 of which performed very well under the dry conditions of the 2001 season. Seeds from these lines are now being multiplied, and a dedicated barley stem-gall-midge nursery will be dispatched to Algeria, Libya, Morocco, and Tunisia for further selection under local environments during the 2002 and 2003 seasons.

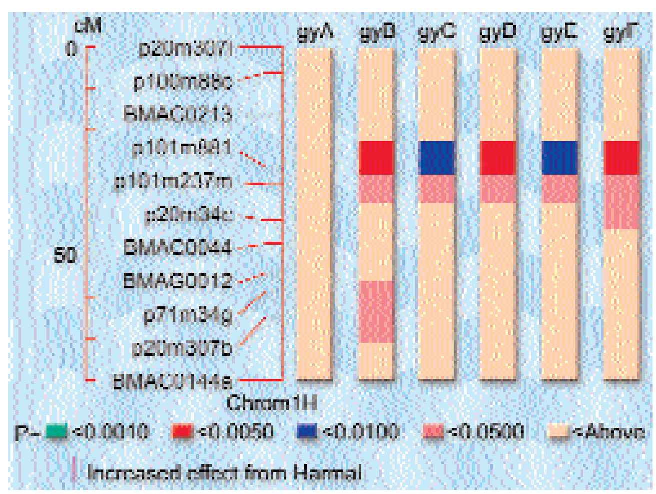


Fig. 3. QTL analysis of chromosome 1H for grain yield for each of six trial sites: Tel Hadya (A), Breda (B), Ramtha (C), Gweer (D), Khanasri (E), and Rabba (F)

Investigating barley yellow rust in Latin America

The foliar disease—barley yellow rust—also known as barley stripe rust, is caused by the fungus *Puccinia striiformis* f.sp. *hordei.* A highly virulent race of this pathogen was introduced into the Americas in 1975. From Colombia, it spread to Peru, Bolivia, Chile, Argentina, and Mexico, and it can now be found in the USA and Canada. Until the early 1980s, most barley cultivars planted in the Andes were highly susceptible local landraces, leading to yield losses of around 50% in Bolivia, and 70% in Colombia.

In 1990 scientists began extensive field screening of barley germplasm for resistance to yellow rust. Over 44,000 accessions have now been screened, and the resulting information is available through the online database of the Germplasm Resource Information Network (GRIN). Joint research by ICARDA and CIMMYT led to the development and adoption of germplasm with resistance to the most prevalent pathotypes in the Americas. Another collaborative project with Oregon State University was initiated in the early 1990s, with the goal of providing agronomically competitive, disease-resistant varieties through systematic characterization and introgression of unique sources of resistance. These activities have led to a better understanding of the genetic basis of the disease, and have accelerated the advancement of selected resistant lines.

Resistant (left) and susceptibile (right) barley lines in a yellow rust screening nursery in Mexico

Recently, changes in the resistance patterns of well-known genotypes were reported in Ecuador and Peru, and these were observed by ICARDA scientists during a visit in 2001. It is possible that a new race of the fungus has appeared, to which few sources of resistance currently exist. In response to this threat, ICARDA distributed yellow rust differentials and trap nurseries to the region. These are collections of barley lines with different disease reactions, and they can help to identify when a new race is present. New lines selected in the presence of the possible new race are also being incorporated in barley breeding programs, to guard against a future outbreak. Continuing international cooperation will be essential to understanding and combating this serious disease of barley.

New resistance gene for barley powdery mildew

Powdery mildew *(Erisiphe graminis* f.sp. *hordei)* is another important foliar disease of barley. It is particularly problematic in semi-arid regions, where early infection can affect the stand establishment of the barley crop and greatly reduce the number of tillers. Molecular mapping of resistance genes for powdery mildew at ICARDA is aimed at the selection of appropriate lines for use by barley breeding programs.

Two barley lines, 'WI2291' and 'Tadmor', both widely grown in the Mediterranean region, were studied. The European differential tester set was also evaluated (Fig. 4). Six cultures of powdery mildew, developed from single spore isolates, were tested. Four of them originated from Syrian barley and two from European barley lines. Interestingly, 'WI2291' exhibited the same disease reaction to different isolates as the line 'Villa,' which is known to carry the *Mlg* powdery mildew resistance gene on chromosome 4H (Fig. 5). The same gene may well be present in 'WI2291.'

The next step was to investigate the progeny. The parental lines and 71 doubled haploid (DH) lines originating from the cross were infected with all six isolates of powdery mildew. The isolate TH1 was found to differentiate best between the parents and DH lines (x^2=0.18) and the disease reactions it

Symptoms of yellow rust on barley leaves

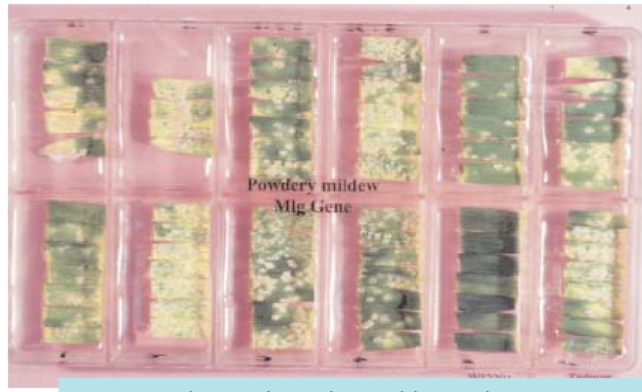


Fig. 4. Virulence of powdery mildew isolate TH1 on lines of the doubled haploid population

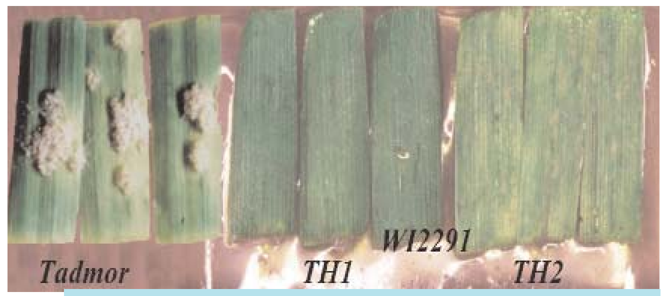


Fig. 5. Comparison between the susceptible parent (Tadmor) and resistant (WI2291) parent, which has the Mlg resistance gene for powdery mildew.

caused were used for linkage mapping. To identify markers that are tightly linked with the Mlg resistance locus, segregation analysis was performed with restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD), SSR (simple sequence repeats) and AFLP (amplification fragment length polymorphism) markers on the DH lines. Two AFLP markers with distances of 2 and 2.4 cM from the *Mlg* gene were identified and mapped on chromosome 4H. Identifying these highly specific markers represents an important addition to our knowledge of sources of resistance to powdery mildew disease.

Screening for resistance to seed-borne diseases

Seed-borne diseases such as barley leaf stripe, loose smuts and covered smuts are common in many barley-growing areas of the CWANA region. They can be particularly problematic for small-scale farmers who cannot afford or obtain chemical seed treatment. ICARDA scientists are screening for broad-spectrum resistance to the most economically damaging diseases.

A study of fixed barley genotypes within the ICARDA advanced breeding nurseries revealed several sources of resistance to seed-borne and a combination of seed-borne and foliar diseases. A total of 245 accessions showed combined resistance to smuts and barley leaf stripe. These were tested for resistance to various isolates of the pathogens. Sixteen fixed genotypes maintained a high level of resistance to smuts and nine of these showed combined resistance to smuts and barley leaf stripe (Table 2). After three years of testing, significant progress has been made in selecting resistant lines. These can now be used as parental material and can be exploited directly by national programs in areas where seed-borne diseases are a problem, for example, Central and West Asia, the Nile Valley, and the Red Sea region.

Table 2. Barley genotypes resistant to seed-borne diseases and smuts

Genotypes resistant to seed-borne diseases
Ethiopia
Api/CM67/3/Emir/Nackta//Mgh6355/4/H251/3/Api/CM67//Ore/5/Bahtim 10/LBN/3/Api/CM67//Ore/4/ BDGC/Gas//7028/Avt
Bkf/Magnelone 1604//Alouette
Plaisant/Novator
ICB-105981//Roho/Mazurka
ICB94-0806-0AP-1A
WI 2291/Tadmor
LIBYA
K-311
Genotypes resistant to smuts
Cr.270-2-3/Cota'S'
Man/Huiz//M69-69/3/Apm/Rl//H272/4/CP/ Bra/5/Joso'S' /6/Chaaran-01 /WI2291 ICB91-0109-1AP
Man/Huiz//M69-69/3/Apm/Rl//H272/4/CP/ Bra/5/Joso'S'/6/Hyb 85-6 ICB91-0209-1AP
ICB90-0573-14BO-1AP-0AP
Zanbaka//H.Spont.41-1/Tadmor
Dt//Triall/Hudson
Libya4

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 2001 major advances were made in identifying new sources of resistance to biotic and abiotic stresses, in broadening genetic diversity, and in selecting for grain quality. On-farm trials of promising lines encouraged farmers to participate with researchers in selecting for local adaptation.

Measuring water-use efficiency (leaf temperature, quantum yield, stomata resistance/conductance and transpiration) with a porometer in a durum field at Tel Hadya.

Breeding and pre-breeding successes

During the 2000/2001 cropping season, 15 international nurseries with appropriate germplasm for the three major West Asia and North Africa (WANA) environments (continental, temperate, and highland agroecologies) were distributed to NARS. Lines and populations with high tolerance to drought and heat, high yield potential, good resistance to pests and diseases, and good grain quality were shared with cooperating breeders, pathologists, entomologists, and virologists. In all, over 800 lines and 10,000 segregating populations were tested.

One objective of the breeding program is to identify durum genotypes with wide adaptation and good yield stability. Collaboration with NARS enabled candidate lines to be tested at several representative sites. Previously selected lines were advanced for large-scale testing or proposed for release in Algeria, Egypt, Jordan, Lebanon, Morocco, Syria, Tunisia, and Turkey. Three new lines, 'Syrian-3,' 'Zna-3,' and 'Mrb3/Albit-1' containing genes for resistance to a range of abiotic stress factors, have demonstrated excellent yield stability.

Durum wheat is notably poor in genetic diversity, which tends to limit the potential for genetic improvement. Efforts to broaden the genetic base involved crossing improved dryland genotypes with WANA landraces, wild relatives, and bread wheat. The wild relatives of durum, *Triticum dicoccoides* and *T. monococcum,* were used to improve grain quality and resistance to leaf rust, leaf blotch, and yellow rust. Crosses with bread wheat and *Aegilops* accessions were used to improve resistance to Hessian fly. These crosses resulted in several high-yielding lines with improved resistance. For example, the 'Telset' lines ('SD8036/ Omtel-1' // 'Awalbit-3') combine Hessian fly resistance with high grain yield under dry and hot conditions.

Further work to develop lines tolerant to biotic stresses was conducted at Tel Hadya in Syria, Terbol in Lebanon, and Marchouch in Morocco. Screening of segregating and advanced lines for yellow rust, wheat stem sawfly, leaf blotch, barley yellow dwarf virus, leaf rust, stem rust, Russian wheat aphid, common bunt, and dryland root rot resulted in the selection of promising genotypes

Conventional breeding for drought tolerance is time-consuming, and requires a large number of testing sites and seasons to determine whether a genotype is susceptible or tolerant. In addition, dryland crops such as durum wheat require a complex set of interacting developmental and physiological strategies to survive and grow under conditions of moisture stress. The CIMMYT/ICARDA durum wheat improvement program combines the use of molecular markers and the exploitation of *Triticum* wild relatives in its research on drought tolerance. In recent years, grain yield, yield components, and physiological traits indicating a response to stress have been associated with specific molecular markers. These may be used in marker-assisted selection, which can considerably speed up the development of drought-tolerant varieties and track the presence of traits that are difficult to identify phenotypically. Research has shown that the markers CDO395 and BCD1661 are associated with high grain yield, osmotic adjustment, canopy temperature, and chlorophyll inhibition. In addition, a positive correlation between grain yield, yield components, and carbon isotope discrimination (CID, indicating water-use efficiency) was found. Screening for water-use efficiency is particularly useful when selecting varieties for adaptation to dry environments. The association of CID with grain yield was similar to the association of number of fertile tillers and number of spike kernels with grain yield. Molecular markers associated with grain yield also showed a link with CID.

Scientists selected for grain quality by analyzing all advanced genotypes for protein content, gluten strength, yellow pigment (indicating vitamin A content), and kernel weight. Over 90% of lines contain a glutenin allele for low molecular weight (LMW-2), an indicator of good processing quality. The use of DNA-LMW screening is now routine in the testing of durum wheat lines for grain quality in the ICARDA laboratories. In one population ('Omrabi5/T.dicoccoides600545' // 'Omrabi5'), transgressive inheritance for yellow pigment was detected, especially under conditions of climatic stress. The identification of a strong genetic effect on yellow pigment content confirmed earlier findings by this project. Using simple and simplified composite interval mapping, three QTLs were detected on chromosomes 7A and 7B (Figs. 6 and 7).

Several promising genotypes with resistance to biotic and abiotic stresses were selected by NARS scientists. After their local adaptation is confirmed, these genotypes are advanced to on-farm trials or used as parental material in national breeding programs. In 2001, on-farm trials were conducted in Algeria, Lebanon, Morocco, Syria, Tunisia, and Turkey, resulting in large-scale evaluation and adoption by farmers. Two cultivars were released in Syria and one in Lebanon. In Morocco, cultivars with heat tolerance and resistance to Hessian fly were registered in the national catalog. These results confirm earlier findings that stress tolerance enhances local adaptation and yield stability.

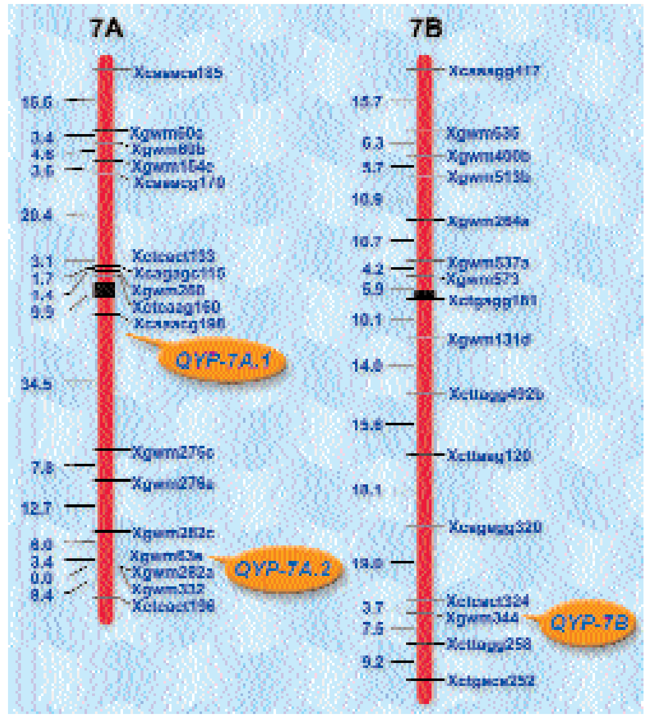


Fig. 6. Positions of yellow pigment genes detected by QTL analysis on the 'Omrabi5/T.dicoccoides600545' // 'Omrabi5' *genetic linkage map.*

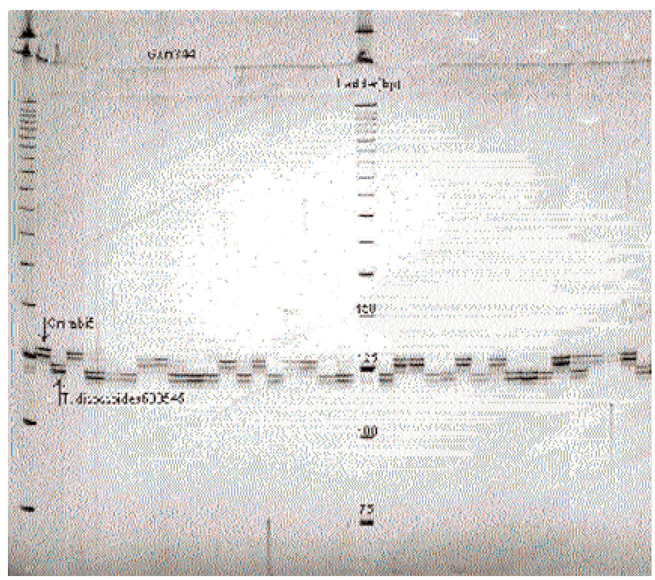


Fig. 7. Probe for the major yellow pigment QTL (gwm344) on Omrabi5/ T. dicoccoides600545 // Omrabi5

Collaboration and training

Close collaboration with NARS plays an important part in the ICARDA durum wheat breeding program. Several joint screening and evaluation activities were accomplished in 2001:

- Algeria: cold tolerance, yellow rust resistance, and ideotype characterization for the Atlas plateaus
- Lebanon: cold tolerance, yellow rust resistance, and grain quality
- Morocco: Hessian fly, root rot, tan spot, powdery mildew, leaf rust, and terminal drought stress
- Syria: abiotic stress tolerance, leaf rust, and grain quality
- Tunisia: grain quality and resistance to leaf blotch
- Turkey: cold tolerance and grain quality.

In addition, training and further education of staff and students was carried out in such subjects as stress physiology, grain quality, entomology, pathology, virology, and marker-assisted 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 the WANA region. The average person consumes more than 185 kg per year, the highest per capita consumption of wheat in the world. However, productivity and total wheat production are generally low and are not rising fast enough to meet the growing demand. Many countries in the region import large quantities of bread wheat. Demand is expected to continue to rise due to increasing urbanization and high rates of population growth. Abiotic stresses (drought, heat, and cold) and biotic stresses (rusts, septoria diseases, Hessian fly, and sunn pest) are the main constraints limiting domestic production. National programs are addressing these constraints by identifying adapted cultivars that are tolerant or resistant to the prevailing stresses in their countries. More emphasis is now being placed on improving the quality of wheat grain for various end-uses, in line with the changing demands of international trade.

Better quality wheat for bread-making

Wheat in WANA is generally consumed as flat (Arabic) or leavened (French) bread. Gluten strength and extensibility are the main determinants of quality in both cases. Gluten strength is measured by the farinograph test and is associated with glutenin subunits with a high molecular weight (HMW). The composition of HMW glutenin is determined by sodium dodecyle sulphate polyacrylamid gel electrophoresis (SDS-PAGE). Gluten extensibility is determined by the alveograph test.

In 2001 the CIMMYT/ICARDA bread wheat improvement program evaluated the bread-making qualities of 30 varieties from seven countries in the WANA region. Farinograph results revealed a lower frequency (19.5%) of strong gluten types compared to medium (41.5%) and weak (39%) gluten types, suggesting considerable room for improvement.

Alveograph for evaluating gluten extensibility, an important quality for making bread.

The observed levels of gluten strength were barely acceptable for making the traditional flat bread. Electrophoresis results confirmed the farinograph results and showed that alleles associated with strong gluten, known as 5+10 alleles, occurred less frequently than weak-gluten 2+12 alleles. Moreover, alveograph results revealed that only 27% of the evaluated cultivars exhibited acceptable levels of gluten extensibility. Table 3 shows the quality attributes of some major bread wheat varieties in WANA. These results emphasize the need to improve bread-making quality of wheat.

Gluten strength can be improved by adjusting the HMW glutenin composition through the introduction of high-quality bread wheat germplasm into the crossing program. Similar efforts are needed to improve gluten extensibility.

The CIMMYT/ICARDA bread wheat program has intensified its screening efforts to prevent poor-quality germplasm from being included in the international nurseries. Screening for gluten strength is now carried out at a much earlier stage (F_7-F_8 and preliminary yield trials) of varietal development. This change presented no practical difficulties, since only small quantities of seed are needed to test for this

Table 3. Bread-making Quality Attributes of some WANA bread wheat varieties

Variety Name	Country	Protein %	FAB %	FDT min	FST min	FMT BU	P mm	L mm	P/L	W (X 10^{-4} J)
'Gemmeza-9'	Egypt	12.5	62.5	3.5	3.2	140	62.9	113.0	0.56	181
'Giza-164'	Egypt	12.3	68.0	4.0	2.2	145	97.2	61.2	1.59	182
'Sids-1'	Egypt	12.7	68.5	2.8	2.7	125	91.9	89.0	1.03	220
'Cham-8'	Syria	11.9	68.5	3.8	1.7	155	83.6	64.0	1.31	158
'Bohouth-6'	Syria	11.9	66.0	3.2	3.8	125	85.3	82.5	1.03	199
'Cham-6'	Syria	11.9	68.0	3.4	2.0	150	79.9	65.0	1.23	145
'Imam'	Sudan	11.8	64.0	2.7	3.3	135	64.4	107.0	0.60	144
'El nielin'	Sudan	11.5	66.0	2.5	1.6	200	62.3	56.5	1.10	85
'Debeira'	Sudan	11.3	63.5	3.2	3.5	110	77.0	95.0	0.81	199
'Hidab'	Algeria	11.5	63.0	3.8	4.0	100	74.3	105.0	0.71	193
'Byrsa-87'	Tunisia	13.2	67.0	5.0	2.7	125	92.7	79.0	1.17	217
'Utique-96'	Tunisia	11.7	63.0	3.3	3.2	130	62.2	114.5	0.54	150
'Vaga-92'	Tunisia	11.9	65.0	4.8	4.1	120	80.9	76.0	1.06	182
'Marchouch-8'	Morocco	13.7	69.5	4.7	3.2	110	98.3	86.5	1.34	239
'Achtar'	Morocco	12.3	66.5	3.5	5.2	80	109.5	87.0	1.26	305
'Arrihane'	Morocco	11.3	56.0	2.4	2.8	100	41.4	130.5	0.32	118
Acceptable quality		>11.5	<63	>4.0	>5.0	<100	-	-	0.6 - 1.0	>200
Good quality (e.g. ANGI-2)		11.9	60	5.7	10.6	35	83.2	100	0.83	297

FAB: flour absorption, FDT: farinograph development time, FST: farinograph stability time, FMT: farinograph mixing tolerance, P: tenacity measure, L: extensibility measure, W: baking strength, BU: Berbender Unit.

grain quality. Another change in approach is to emphasize protein quality rather than total protein content. However, evaluation of gluten extensibility by alveograph requires large amounts of seed, so this is still carried out at a later stage (advanced yield trials). A number of lines suitable for leavened bread have been identified, for example the spring bread wheat line 'ANGI-2' (Table 3). Electrophoresis was also used to determine the HMW glutenin composition of potential parental lines (Fig. 8). The results will aid the design of future crosses to improve bread-making quality. With increased use of high-quality bread wheat germplasm and rigorous quality screening at an early stage, it is hoped that by 2005 all the germplasm distributed to NARS in WANA will combine high productivity and good agroecological adaptation with good bread-making qualities.

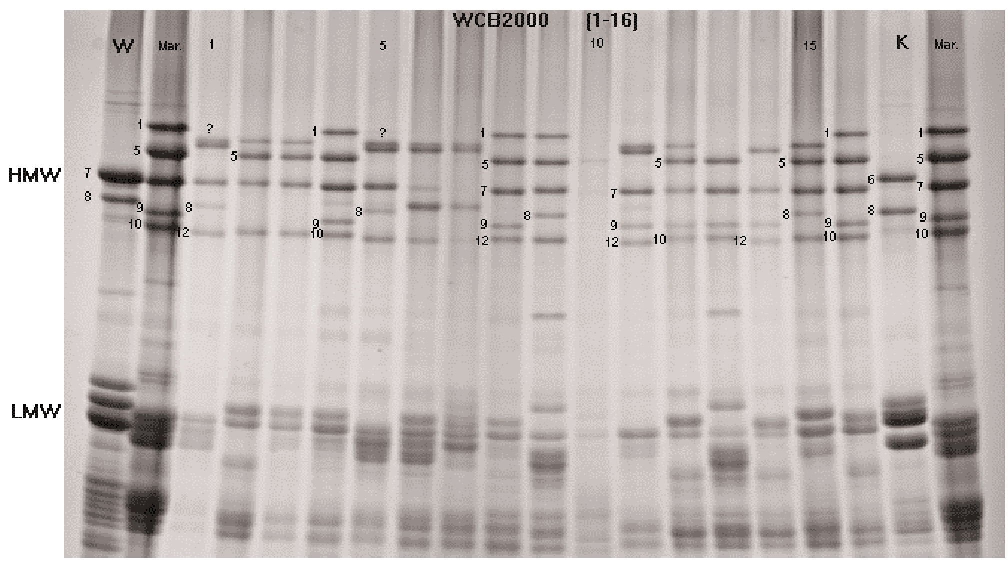


Fig. 8. Regional Wheat Crossing Block: Composition of HMW-GS in potential parental lines.

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 within the past twenty years, but production of winter and facultative wheat, grown predominantly in developing countries, has lagged behind. In an effort to redress the balance, the ICARDA winter and facultative wheat breeding program is developing germplasm for the CWANA region that is broadly adapted, disease resistant, and high yielding. Exchange of germplasm between the various national programs is a second important objective.

Identification of broadly adapted, high-yielding varieties

In 2001, national programs in the region released four winter and facultative wheat varieties, selected directly from the material developed by the ICARDA Highland Regional Program.

The variety 'Rana 96' was released in Afghanistan, 'Izgi' in Turkey, 'Mtskhetskaya 1' in Georgia, and 'Tacica' in Tajikistan. Several cultivars selected from the Turkey/CIMMYT/ICARDA International Winter Wheat Improvement Project (Table 4) have been identified for future release or are under seed multiplication.

Progress in combining resistance to Russian wheat aphid and yellow rust

Russian wheat aphid (*Diuraphis noxia*) is an economically important pest common in the highlands of the WANA region, affecting cereal yields in Algeria, Ethiopia, Morocco, Tunisia, Turkey, and Yemen. During dry seasons, high levels of infestation have also been reported in Iran and Central Asia. Most winter and facultative wheat cultivars grown in the region are susceptible. Yellow rust (*Puccinia striiformis* f. sp. *tritici*) is another serious constraint on cereal production. It is the most damaging disease of winter and facultative wheat in CWANA, causing losses of between 30 and 70%. The development and spread of yellow rust is encouraged by cool, damp weather during the growing season, and by large-scale cultivation of genetically susceptible cultivars. Recent yellow rust epidemics have led ICARDA and national scientists to increase their efforts to develop resistant varieties.

Winter and facultative wheat with combined resistance to Russian wheat aphid and yellow rust undergoing evaluation at Tel Hadya.

Field and greenhouse screening of winter and facultative wheat germplasm from ICARDA and Colorado State University has already been undertaken, resulting in the identification of two sources of resistance in populations derived from five adapted varieties. In 2001, five F_4 populations of these crosses were further evaluated under artificial infestation in the field at Tel Hadya. Out of 145 F_4 winter wheat families carrying resistance to Russian wheat aphid, 24 were selected because they combined resistance with desirable agronomic characters. These are the first winter and facultative wheat lines with such a combination of desirable traits to be developed in CWANA.

Table 4. Winter and facultative bread wheat cultivars that have been released or are approved for seed multiplication.

Registered Varieties	Year	Pedigree	Cross	Country Released
'Gul96'	1996	ID800994.W/VEE	SWM15134	Afghanistan
'Rana96'	1996	CA8055/6/PATO(R)/CAL/3/7C//BB/CNO/5/CAL// CNO/ SN64/4/		
		CNO//NAD/CH	ICWH840431	Afghanistan
'Buck Oportuno'	1996	PI/FUNO*2//VLD/3/CO723595	SWO802012	Argentina
'Zarrin'	1996	HATUSHA = NAI60/HEINE VII//BUC/3/F59.71/GHK	SWO791095	Iran-Myandoab
'Kinaci97'	1997	YMH/TOB//MCD/3/LIRA	SWM12289	TR-Konya
'Yildiz 98'	1998	55-1744/P101//MAYA/3/MUS/PRM//MAYA/ALD"S"	SWM8340587F	TR - Eskisehir
'Goksu99'	1999	AGRI/NAC	SWM6599	TR-Konya
'Cetinel 2000'	2000	MLC/4/VPM/MOS95//HILL/3/SPN	OWC852672	TR - Eskisehir
'C73-5'	2000	SPN/MCD//CAMA/3/NZT	SWM777627	Iran Mashad
'Alpaslan'	2001	TX69A509-2//BBY2/FOX	TX78V2154	TR-Erzurum
'Izgi'	2001	CA8055/KUTLUK	ICWH900312	TR - Eskisehir
'Alpu01'	2001	ID800994.W/VEE	SWM15134	TR - Eskisehir
'Sönmez'	2001	BEZ//BEZ/TVR/3/KREMENA/LOV29/4/KATIA1	TE4732A	TR - Eskisehir
'Nenehatun'	2001	ND/P101//Blueboy	SWM584	TR - Erzurum
Included in Registration Trials				
'Mtskhetshaya 1'		TAST/SPRW//ZAR	ICWH840048	Georgia
'Tacica'		TAST/SPRW//ZAR	ICWH840048	Tajikistan
'Guncha'		HAMSI = HYS/7C//KRC(ES84-16)/3/SERI	SWM17323	Turkmenistan
'Bitarap'		BITARAP=AKULA-1=SN64//SKE/2*ANE/3/SX/4/BEZ/5/SERI	SWM866442	Turkmenistan
'Garashsyz 10'		TEL-143/Landrace		Turkmenistan
'Garagum'		TRAKIA/KNR	TE3093	Turkmenistan
'Bdme98-3S'		AKULA-2	SWM866442	TR-Konya
'Dostlik'		YMH/TOB//MCD/3/LIRA	SWM12289	Uzbekistan
'Bdme98-3K'		HN7/OROFEN//BJN8/3/SERI82/4/ 74CB462/TRAPPER//VONA	EWT8913	TR-Konya
'Mtskhetis-1'		5th FAWWON		Georgia
'Ani-326'		Kseniya 226/Armyanka-60		Armenia
'Jamin'		NS-5558/VEE	TCI	Kyrgyzstan

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

Researchers, farmers, extensionists, and processing industry representatives evaluate chickpea for producing leblebi *(a popular snack) in Turkey.*

Chickpea, lentil, and faba bean are highly 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. ICARDA's food legume research in 2001 focused on several projects. In chickpea research, farmers became more involved in the selection process, thereby increasing the pace of adoption of new varieties. New sources of resistance to nematodes and tolerance to cold were introduced into cultivated chickpea from wild relatives, and scientists gained further understanding of the role of mutation in increasing genetic variability. For lentils, efforts were made to enhance the design and analysis of field experiments, new varieties were released in Ethiopia, and the linkage map of lentil was improved. Finally, further progress was made in breeding faba bean with better resistance to chocolate spot and ascochyta blight.

Farmer involvement in chickpea selection

Although the ICARDA chickpea breeding program has successfully developed several improved cultivars, the adoption of these by farmers has been lower than expected. This is due to a number of factors, including time-consuming testing and release procedures in different countries, little incentive for local seed production, and inadequate attention from national extension services. In an effort to increase adoption, a process of participatory varietal selection was initiated in Turkey and Syria. The aim was to encourage chickpea growers to evaluate the new varieties, to select according to their own preferences, and to become more involved in seed production.

Leblebi on sale in Turkey.

Denizli province in southwest Turkey has seen a marked reduction in the chickpea producing area in recent years. The decline has been attributed to problems with late-season drought and the ascochyta blight disease, which together can cause complete crop failure in a bad year. In this part of Turkey, chickpea is mainly consumed as *leblebi* and *nohut,* two products with different methods of processing. *Leblebi* is a snack food prepared by steaming the chickpea, an industrial process involving heat treatment to soften the seed. *Nohut* is made from white or cream chickpea, which is boiled, then used as a dressing in different dishes. ICARDA has played a pivotal role in bringing together researchers, chickpea farmers, extension agents, and representatives from the processing industry by initiating a participatory evaluation and selection program. In the 1999/2000 season, a wide range of cultivars was grown, from which 11 were selected by the farmers and industry group. As a result of their field evaluation, the farmers selected the improved cultivars 'SARI 98' and 'Gokçe,' and the local variety.

However, when evaluated by the processing industry, the two improved lines were found to be unsuitable for making *leblebi* as the seeds were too hard, even after processing. In spite of this, the farmers still wanted to grow these large-seeded varieties, as they have a ready market for local consumption and for export. These insights highlight the value of involving both farmers and industry representatives in varietal evaluation and selection.

In the 2000/2001 season, a second trial was initiated to evaluate 48 new lines. Some of these (e.g. 'FLIP 98-121C') have a high yield and large seed size, and will be evaluated further for their suitability for *leblebi*. Researchers still know little about the selection criteria for this chickpea product, so will need to gather further information.

In Syria too, farmer participatory trials were conducted during 1999/2000. These trials elicited enormous enthusiasm from the farmers, who selected 25 out of 49 lines for the second phase (2000/2001). Altogether, 40 farmers participated in evaluation and selection. The Syrian local cultivar was widely affected by ascochyta blight, while most of the improved varieties proved resistant. This experience made farmers fully aware of the value of the improved materials, and four promising types with large seeds, tall habit, and high yield (FLIP 97-588C, FLIP 97-657C, FLIP 97-677C, and FLIP 97-706C) have been selected for large-scale evaluation on the fields of 10 farmers during 2001/2002.

Using chickpea wild relatives to improve stress resistance

Cultivated chickpea (*Cicer arietinum*) belongs to the genus *Cicer*, which includes 43 species, 9 of which (including cultivated chickpea) are annual while the remaining are perennial.

Evaluation of the eight wild annual species has revealed some desirable sources of resistance to biotic and abiotic stresses. ICARDA scientists have been trying to incorporate these desirable traits into the cultigen, but success so far has been limited to only a few traits. The main reason for slow progress is the incompatibility between cultivated chickpea and most wild species; only two of the wild species, *Cicer echinospermum* and *Cicer reticulatum*, have so far been successfully crossed with cultivated chickpea.

Table 5. Reaction of cultivated chickpea germplasm accessions to some biotic and abiotic stresses at Tel Hadya

Scale[1]	Ascochyta blight	Fusarium wilt	Leaf miner	Seed beetle	Cyst nematode	Cold	Drought
1	0	11	0	0	0	0	0
2	0	3	0	0	0	0	0
3	10	65	3	0	0	3	3
4	22	31	5	0	0	10	82
5	9	591	485	0	20	1191	265
6	1444	174	710	164	0	1023	1925
7	1833	713	1269	185	494	1014	1151
8	1185	636	13	1551	1104	2284	599
9	14867	2950	3540	3253	7639	3570	140

[1]Scale from 1 to 9 where 1 = free, no visible damage, and 9 = all plants killed by the stress.

Table 6. Reaction of wild chickpea germplasm accessions to some biotic and abiotic stresses at Tel Hadya

Scale[1]	Ascochyta blight	Fusarium wilt	Leaf miner	Seed beetle	Cyst nematode	Cold
1	0	0	2	20	3	1
2	1	0	36	12	1	29
3	4	13	36	4	17	45
4	2	0	33	3	0	46
5	22	62	61	3	28	21
6	29	0	26	8	0	12
7	24	51	23	18	49	11
8	30	0	1	52	0	8
9	81	74	3	10	144	65

[1]Scale from 1 to 9 where 1 = free, no visible damage, and 9 = all plants killed by the stress.

Tables 5 and 6 show the response of wild and cultivated chickpea to various stresses. The genetic resources of cultigen exhibit a lack of resistance to cyst nematodes (*Heterodera ciceri*) and a low tolerance to frost when compared to the wild species. Scientists at ICARDA and the Institute of Nematology in Bari, Italy have had considerable success in improving resistance to cyst nematodes through hybridization and selection, using 'ILWC 292,' a *Cicer reticulatum* accession. In the first phase, 19 pure lines with resistance were selected and two of these (ILC 10765 and ILC 10766), which also have good agronomic traits, have been registered as improved genetic stocks. These lines are now being used in the ICARDA chickpea improvement program to incorporate cyst nematode resistance into desirable kabuli chickpea lines.

Root system of a resistant chickpea line in contrast to that of the susceptible.

Most chickpea landraces in the Mediterranean region cannot withstand winter cold, so farmers plant them in spring. However, ICARDA studies have demonstrated that winter sowing can double the seed yield if the cultivars are sufficiently tolerant to cold. Wild species generally have a higher level of cold tolerance than do cultivated varieties, and ICARDA scientists have been successful in transferring this trait from *C. reticulatum* and *C. echinospermum*. Some of the lines derived from interspecific crosses also have high biomass, high pod number, and high seed yield when grown in winter. They are being used in the ICARDA breeding program to combine such desirable traits with resistance to ascochyta blight and fusarium wilt. Seeds of these derived lines are now being shared with, and evaluated by, NARS through the Chickpea International Cold Tolerance Nursery.

Chickpea reveals a high mutation rate

Genetic mutations help to increase genetic variability in both plants and animals. Scientists at ICARDA have used chickpea as a model to try to understand more about genetic mutation, particularly the role of simple sequence repeats (SSRs). Studies of mutation in chickpea revealed a very high rate of change, being 10 to 10,000 times higher than in humans, mice, pigs, and the fruit fly (*Drosophila melanogaster).* In addition, a study of the rate of change at different parts of the genome showed that not all parts of the genome change at the same rate. Mutation rate also differs between cultivars, for example a long duration variety, such as 'Ghab 2,' undergoes more DNA replications and can accumulate more mutations than a short duration variety, in this case, a Syrian landrace. The data also provide direct evidence for bias in the mutational process itself. Microsatellite alleles of the Syrian landrace (which are relatively small) tend to gain repeats, while the alleles of 'Ghab 2' (relatively large) tend to lose repeats during the process of mutation. These findings represent an important advance in our understanding, as it is the first time that differential mutational rates and mutational bias have been found in a plant species.

Spatial analysis to improve breeding efficiency in lentil

Field trials are generally based on standard experimental designs, such as randomized complete block (RCB) or incomplete block. While these designs help to reduce experimental error, considerable variation still exists within the blocks. Since there are normally spatial patterns in the plot errors of most field trials, modeling the spatial pattern should improve the efficiency of comparative varietal trials.

A total of 18 models were evaluated, including the effects of block structures, linear trends along rows, random smoothing cubic spline (a statistical function for expressing fertility trends in a field layout in a given direction), and independent and first order autoregressive (AR1) plot errors. These plot error models are commonly used to measure error behavior in statistical analyses. The residual maximum likelihood (or equivalently restricted maximum likelihood) method was used to fit these models and the best model was selected on the basis of deviance. Data from a set of 53 lentil yield trials conducted between 1995 and 1998 in three contrasting locations (Breda and Tel Hadya in Syria, and Terbol in Lebanon) were used to determine any additional benefit from conducting an analysis based on the most suitable spatial error structure for each specific trial data set. The improvement in efficiency in comparing a pair of genotype means and the expected gain due to selection was also evaluated.

The results showed that incomplete block analysis of lentil yield trials in lattice block designs substantially reduced the variability due to experimental error compared to RCB analysis. Spatial models where the plot error was modeled as AR1 in columns, or as AR1 x AR1 in rows and columns after allowing for random effects of lattice blocks, were found to be suitable in most of the trials.

The study shows accuracy of results can be improved by about 50% if the best models are used at the analysis stage (compared to the standard RCB analysis). The efficiency of selection and the rate of genetic gain can also be improved, as use of spatial models may lead to different genotypes being selected.

The process is not a complicated one, requiring only a change in computation together with knowledge of the field layout. Therefore, the use of spatial models combined with good experimental design can be highly cost-effective in improving the efficiency of genotype comparison trials.

More lentils for Ethiopia

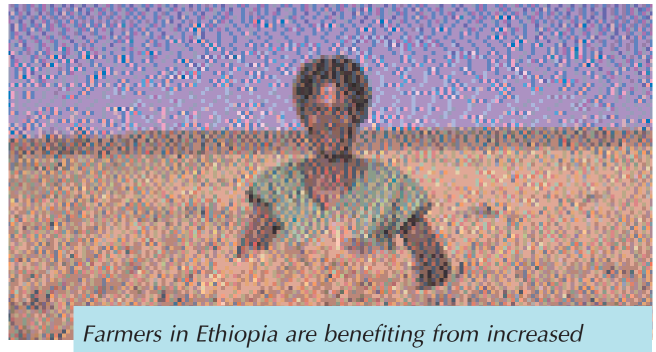
Lentils provide a valuable source of protein in the diet of Ethiopians. Many smallholder farmers grow lentil in rotation with cereals, even on the high-altitude vertisols where waterlogging is a problem.

Increasing demand from both domestic and export markets has led to a dramatic increase in the lentil-growing area, from 48,000 ha in 1998 to 90,000 ha in 2001. However, productivity remains low because the varieties being cultivated are predominantly landraces, which have low yield potential and are susceptible to a wide range of pests and diseases as well as abiotic stresses, such as waterlogging and drought. In addition, lack of knowledge of good agronomic practices prevents farmers from obtaining the maximum yield.

ICARDA has been working with the Ethiopian lentil improvement program since the early 1980s, and continues to provide improved lentil germplasm. To date, five new varieties derived from ICARDA materials have been released. The variety 'Alemaya' has proved especially popular, as it is resistant to rust and wilt-root-rot complex, and produces a good yield under a wide range of agroclimatic conditions. Additional lines with high yield potential are currently undergoing testing.

An intensive technology transfer program is now in place to increase adoption of the new varieties. Activities include seed production and free distribution, farmer training, and field days. Farmer-to-farmer seed supply and training are helping to disseminate seeds and knowledge to new areas. As a result, the new varieties 'Alemaya' and 'Adaa' now cover an area of about 4,000 ha in the Chefe Donsa district in central Ethiopia, a high altitude area where cold and waterlogging pose constraints to production. Farmers have also improved their crop management techniques and are now using an appropriate seed rate, sowing early, and adopting broad-bed and furrow planting to avoid waterlogging. Through the adoption of improved varieties and better agronomic practices, the national average yield has increased from 593 kg/ha in 1998/1999 to 613 kg/ha at present.

"*'Alemaya'* is a blessing to me and I will continue to cultivate it as it puts more cash in my pocket" says Dima, a progressive farmer in Chefe Donsa. She expects to harvest 2.5-3.0 t/ha compared to 0.5-0.6 t/ha with the local cultivars. In addition, increased production will benefit local village-



Farmers in Ethiopia are benefiting from increased yields when they plant 'Alemaya,' an improved variety of lentil.

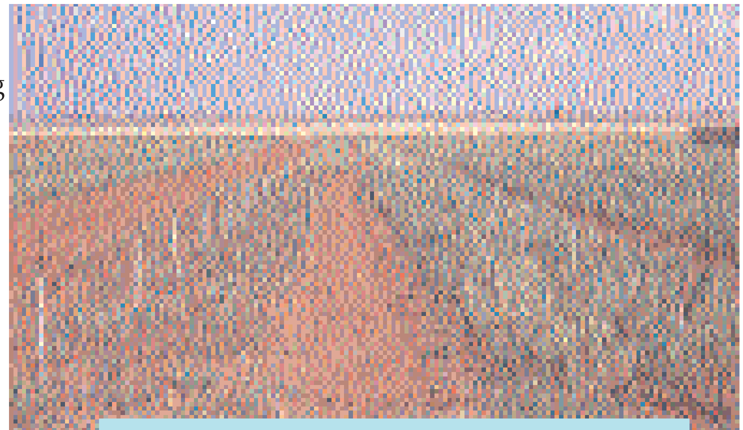
based de-hulling industries, and generating employment among rural people, especially women.

Further development of the linkage map of lentil

A genetic linkage map of lentil has been developed at ICARDA using a population of 81 recombinant inbred lines produced by single seed descent from the parents 'ILL5588' and 'L692-16-1.' A total of 177 morphological and DNA markers, together with sources of resistance for fusarium wilt and frost tolerance, have been mapped. Further work is needed to enrich the current map to allow comparison with other legumes, a process that is likely to help plant breeders to source other desirable traits. Scientists therefore tested SSR markers from other species, including wheat, soybean, and chickpea. Only nine SSR primers of wheat were amplified without polymorphism and also the chickpea marker did not yield any useful polymorphism in the lentil population. This implies that SSR primers developed for one species cannot (or can only to a very limited extent) be transferred to another species and so scientists need to identify polymorphism (differences) for genetic mapping.

Resistance to chocolate spot and ascochyta blight in faba bean

Faba bean (*Vicia faba*) provides a valuable source of protein for millions of people in developing countries. It also provides a useful alternative to soybean meal for animals in developed countries. In cereal rotation systems, faba bean is an important source of biological nitrogen, helping to maintain soil fertility. It is grown predominantly in temperate and sub-tropical climates, but is susceptible to fungal diseases such as chocolate spot (*Botrytis fabae*) and ascochyta blight (*Ascochyta fabae*).



Screening for resistance to chocolate spot at Tel Hadya. Left: susceptible lines; right: improved lines with good resistance.

ICARDA scientists have made considerable progress during the past five years in breeding faba bean with improved resistance to fungal diseases. At the end of the 2000/2001 growing season, a total of 305 F_2 single plants, 28 F_3, and 44 F_4 families, derived from different improved populations, had been selected under heavy artificial infection with chocolate spot and/or ascochyta blight disease at Lattakia, Syria. Table 7 shows the reaction of the selected F_3 and F_4 families compared to the resistant checks. An ascochyta disease nursery has also been established at Tel Hadya. The improved germplasm will be used to incorporate genes for resistance to both diseases.

Table 7. Performance of improved germplasm and susceptible checks under infection with fungal diseases at Lattakia.

	Reaction* to	
Tested Entries	Chocolate spot	Ascochyta blight
Selected F_3 and F_4 Families	2.6	1.1
'ICARUS' (resistant to chocolate spot)	1.9	2.5
'Ascot' (resistant to Ascochyta)	4.6	1.9
'Reb. 40' (susc. check)	6.3	5.7
'Giza 4' (susc. check)	6.2	5.2

* On a 1 to 9 scale, where 1 = free, 9 = highest damage.

Project 1.6. Forage legume germplasm improvement for increased feed production and systems productivity in dry areas

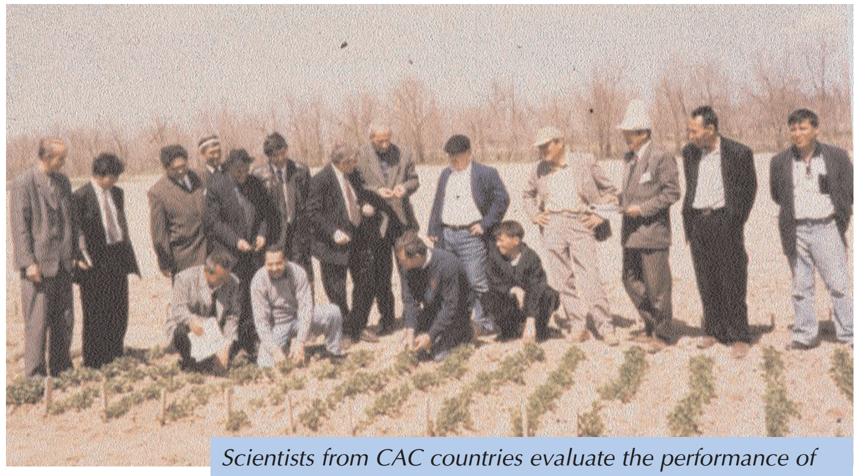
Forage legumes are receiving increasing attention from scientists and farmers. They are valued for their ability to provide high-protein animal feed while at the same time maintaining or improving soil fertility. Replacing traditional fallow rotation systems with alternative crops, such as forage vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.), will help farmers to intensify and diversify their production systems in a sustainable manner.

Testing promising lines of chicklings in the Almalybak area, Kazakstan.

Diversification and sustainable agriculture in Central Asia and the Caucasus (CAC)

In the republics of CAC there is an urgent need to increase agricultural productivity in order to revitalize national economies. Livestock are an integral component of most farming systems, but feed production is severely limited by seasonal variations in rainfall. Increased productivity could be achieved by introducing forage legumes into the traditional cereal-fallow rotation systems.

ICARDA began to introduce more productive forage crops to the CAC region in 1998, with particular emphasis on replacing cereal monocropping systems in dry areas (annual rainfall 250-300 mm). Large numbers of improved lines of *Vicia sativa, V. panonica, V. narbonensis, V. villosa, Lathyrus sativus and L. cicera* were introduced. During the past two seasons scientists from national programs and ICARDA have evaluated the germplasm and selected the best-adapted lines for seed multiplication. Selection was based on such characteristics as productivity, seedling vigor, seed and biomass production, resistance to pests and diseases, and tolerance to cold and drought, and palatability to sheep.



Scientists from CAC countries evaluate the performance of narbon vetch (Vicia narbonensis) lines for cold tolerance and autumn planting at Gallal-Arar research station, Uzbekistan.

In Uzbekistan, selected lines were evaluated at four rainfed locations. The ICARDA-derived cultivars of winter vetch (*Vicia villosa* spp. *villosa*), woolly-pod vetch (*Vicia villosa* spp. *dasycarpa*), common vetch (*Vicia sativa*), and Hungarian vetch (*Vicia panonica*) produced over 40% higher yields than the local check, 'Bistok-84.'

These lines are well adapted to local high-altitude environments due to their tolerance to cold and late growth habit. The evaluation also showed that winter vetch, Hungarian vetch, and narbon vetch are suitable for autumn planting, which gives a yield increase of more than 50% over traditional spring planting. Grasspea *(Lathyrus sativus)* was also well accepted by farmers for its drought tolerance and high yield.

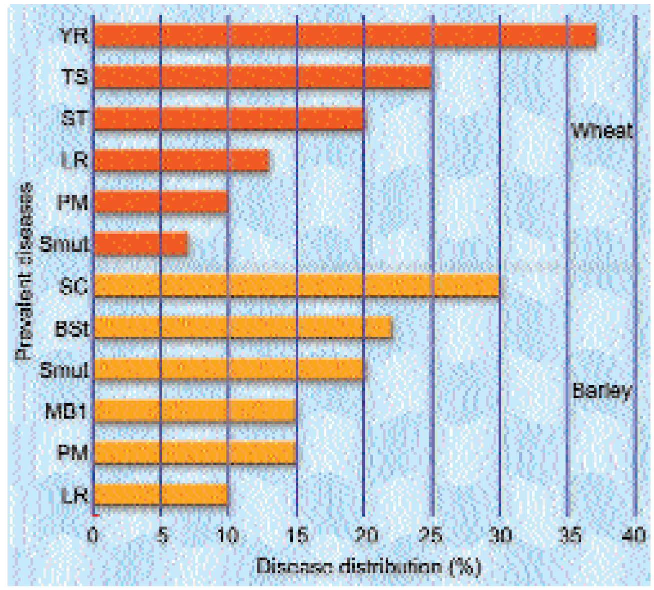
In Kazakstan, both common vetch and grasspea showed excellent local adaptation, with grain yields exceeding those of the local landraces. Good levels of drought tolerance were recorded in selected lines of vetches and chicklings in Armenia, Azerbaijan, and Georgia.

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 2001, ICARDA scientists continued to gather knowledge and information on current pest and disease threats throughout the CWANA region. Further studies on natural enemies of sunn pest, an insect that attacks wheat and barley crops, revealed interesting possibilities for biological control. Pilot sites were established in Egypt and Morocco to identify and validate 'best bet' IPM options for these locations. An integrated disease management package was developed to protect chickpea from fungal attack by ascochyta blight.

Pest and disease surveys in Central Asia and the Caucasus

Cereal growing areas in Central Asia and the Caucasus (CAC) are particularly susceptible to pest and disease attack as they are characterized by large-scale monoculture of a limited number of wheat and barley varieties. The prevailing climate is also conducive to the spread of disease. The most common diseases observed in 2001 in Azerbaijan, Kazakstan, Kyrgyzstan and Uzbekistan were yellow rust, tan spot, powdery mildew, scab, leaf rust, root rot, *Septoria tritici*, *Septoria nodorum*, and common bunt on wheat; and leaf rust, scald, net blotch, barley stripe, smuts, and powdery mildew on barley. The frequency of occurrence of the most prevalent diseases showed a common trend across the region (Fig. 9).



YR= Yellow rust, TS= Tan spot, ST= *Septoria* (*tritici* and *nodorum*), LR= Leaf rust, PM= Powdery mildew, SC= Scald, BSt= Barley leaf stripe, NBl= Net blotch.

Fig. 9. Frequency of occurrence of wheat and barley diseases in Azerbaijan, Kazakstan, Kyrgyzstan and Uzbekistan.

Yellow rust (*Puccinia striiformis* f.sp. *tritici*) is still the most widely spread disease of bread wheat in Central Asia. New races are spreading rapidly, and there is a danger that current sources of resistance will become ineffective. Most commercially grown wheat varieties are already highly susceptible. Tan spot (*Pyrenophora tritici repentis*) is another rapidly evolving disease of both durum and bread wheat. The disease was found in virtually all fields that are cropped in the traditional system, consisting of a succession of spring and winter wheat in rotation with fallow. Scald and powdery mildew are the most apparent diseases in case of barley, but seed-borne diseases (smuts and barley stripe) are also prevalent throughout Azerbaijan, Kazakstan, Kyrgyzstan, and Uzbekistan.

A preliminary survey to identify virus diseases affecting wheat in Uzbekistan was conducted during 2001. The survey covered 12 wheat fields in two cereal growing regions (Tashkent-Angren and Tashkent-Samarkand). A total of 250 wheat samples with virus symptoms were collected and tested for the presence of nine different viruses using tissue blot immunoassay. Results indicated that barley yellow dwarf virus was the most common disease, while barley yellow striate mosaic virus and cereal yellow dwarf virus were reported for the first time.

Insect surveys were conducted in Uzbekistan, Kyrgyzstan, and Kazakstan. Samples from 19 wheat and barley fields in Uzbekistan revealed that sunn pest (*Eurygaster integriceps*), cereal leaf

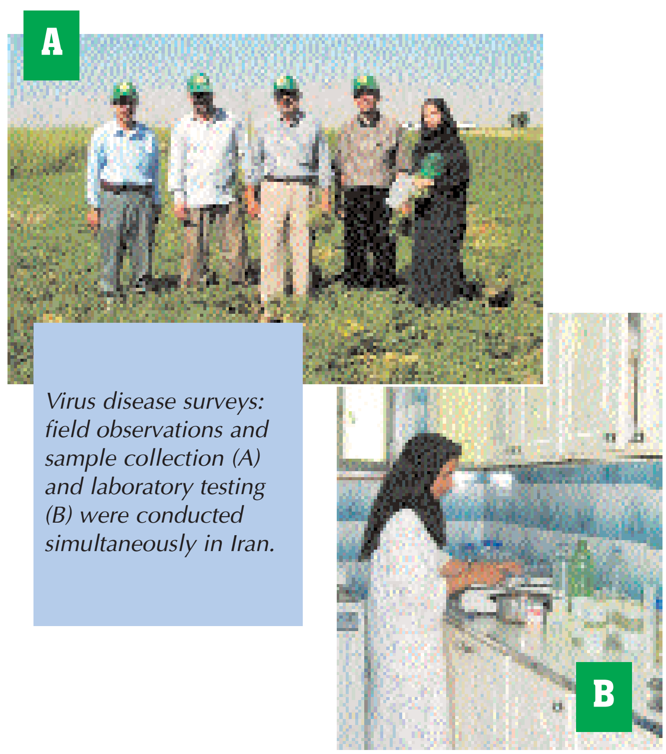
Heavy infestation of sunn pest on wheat in Central Asia.

beetle, thrips, and aphids were the major pests. Interestingly, the sunn pest population was lower than in 1999, but the level of damage was expected to increase before harvest due to feeding by the remaining nymphs and the new generation adults. Cereal leaf beetle damage was high (40%) in most areas surveyed except in the east, while infestation by thrips and aphids was highest in the Tashkent area. In Kyrgyzstan, 25 wheat and barley fields were surveyed. Here, the major insect pests were sunn pest, cereal leaf beetle, thrips, shoot fly, and Russian wheat aphid. Major insect pests in Kazakstan (from a survey of 32 wheat and barley fields) were sunn pest, thrips, aphids, cereal leaf beetle, frit fly, and Hessian fly. Here sunn pest damage was less severe than in the other two countries. Cereal leaf beetle damage was high in Syram region but low in other regions. Heavy thrips infestation was observed on spring wheat and barley, the latter being also severely affected by frit fly in some areas. In Taras region, about 80% of wheat spikes had aphids feeding on them. Hessian fly and green bug damage were observed on wheat in Almaty region, but in general, Hessian fly damage was more pronounced in rainfed fields.

Pest and disease surveys in Iran and Tunisia

In Iran, a survey was conducted to identify virus diseases affecting chickpea and lentil. A total of 8739 random and 1443 symptomatic samples were collected and tested for the presence of 10 legume viruses by the tissue blot immunoassay procedure. In chickpea fields, chickpea chlorotic dwarf virus was the most common, followed by bean leaf roll virus, faba bean necrotic yellows virus, and beet western yellows virus. In lentil fields, pea enation mosaic virus and bean leaf roll virus were the most common.

A survey to identify virus diseases affecting faba bean, chickpea, barley, bread wheat, and durum wheat was conducted in Tunisia as a continuation of the 2000 survey. The main objective was to determine which viruses affect legume and cereal



Virus disease surveys: field observations and sample collection (A) and laboratory testing (B) were conducted simultaneously in Iran.

crops in the different production areas. In faba bean fields, faba bean necrotic yellows virus was the most common, followed by luteoviruses and broad bean mottle virus. In contrast, only luteoviruses were detected in chickpea fields. In cereal fields, barley yellow dwarf virus was the most common followed by barley stripe mosaic virus and barley yellow striate mosaic virus. In general, virus disease incidence in both cereal and legume crops was higher during April 2001 than in April 2000 and economic losses due to virus infection are expected to be high.

Changes in yellow rust race distribution

The disease surveys conducted in Central Asia highlighted the threat of recurrent epidemics of yellow rust. In fact, this disease has been observed in most wheat growing areas in the CWANA region. It is important to keep track of the development of new races of the pathogen, so that new sources of resistance can be identified and deployed. In 2001, yellow rust samples from Central and West Asia, and from the Nile Valley and Red Sea regions, were characterized. A total of 95 races were identified (Table 8), with different races occurring in the two regions.

Table 9 lists some examples of common races and the corresponding defeated resistance genes associated with each. In Central and West Asia, race 166E150 is one of the most noteworthy as it combines virulence for the Yr9+, Yr8, and YrA resistance genes that were deployed in many bread wheat varieties in the early 1980s. Race 6E0 was first observed in the region in 1972 and has been recovered every year in Syria since then. It is virulent for the Yr6 and YrA genes, common sources of resistance deployed in Lebanon, Syria, and Turkey. Yellow rust races with broad virulence, such as 198E150, 166E158, and 238E190 in Lebanon, and 230E150, 102E210 and 450E109 in Syria, Iran, and Egypt, respectively, should be carefully monitored. Clearly, yellow rust populations in CWANA are highly diverse genetically, with considerable differences in virulence. Future collaborative research projects are needed to identify more durable sources of resistance to yellow rust.

Table 8. Yellow rust races occurring in West and Central Asia, and the Nile Valley and Red Sea regions.

Egypt	Pakistan	Lebanon	Iran	Syria
0E0	64E0	4E0	0E0	2E0
458E45	66E0	6E0	4E0	4E0
128E61	67E0	82E16	6E0	6E0
242E100	2E16	6E18	20E2	18E0
194E101	2E16	38E22	38E2	38E0
192E109	6E16	38E134	66E2	38E6
234E109	7E16	38E128	38E4	6E16
450E109	38E16	6E144	6E6	82E16
	6E16	134E46	14E6	134E16
	66E16	172E146	2E14	6E18
	7E150	20E148	6E14	6E20
	134E150	70E148	6E22	38E128
		134E150	6E30	68E130
		166E150	4E32	70 E 130
		182E150	230E62	6E134
		198E150	6E64	38E134
		166E158	6E134	166 E 134
		238E190	134E134	230E134
			166E142	238 E 134
			34E148	6E144
			134E148	134 E146
			134E166	172E146
			102E210	6E148
				20E148
				6E150
				38E150
				134E150
				166E150
				230E150

Other reported races:
Yemen: 4E148 and 119E158, Iraq: 230E150,
Uzbekistan: 130E0, Kazakstan: 0E0.

Table 9. Examples of races occurring in CWANA and respective defeated yellow rust resistance genes.

Physiologic race	Corresponding defeated Yr. genes	No.
0E0	2	1
18E0	7, 10	2
2E0	7, 2, A	3
2E16	7, 8, A	3
6E0	6, 7, A	3
82E16	7, 10, SU, 8, A	5
2E14	7, 7^{+}, 6^{+}, 3N, 2	5
6E20	6, 7, 7^{+}, 8, 2, A, 9	7
242E100	6, 2, 9, 10, SU, SP, CV	7
134E16	6, 7, 9^{+}, 8, 2, A, 9, 18	8
458E45	6, 2, 4, 3, 5, 9, SU, CV	8
6E134	6, 7, 6^{+}, 7^{+}, 2^{+}, A, 9, 18, 2	9
38E134	6, 7, SD, 6^{+}, 2^{+}, 2, A, 9, 18	9
20E148	6, 10, 6^{+}, 8, 2^{+}, 2, A, 9, 18	9
134E146	6, 7, 9^{+}, 7^{+}, 8, 2^{+}, 2, A, 9, 18	10
166E142	6, 7, SD, 9^{+}, 7^{+}, 6^{+}, 3N, 2^{+}, 9, A, 2	11
38E150	6, 7, SD, 6^{+}, 7^{+}, 2^{+}, 8, A, 9, 2, 18	11
166E150	6, 7, SD, 9^{+}, 7^{+}, 8, 2^{+}, 2, A, 9,18	11
172E146	6, 3V, SD, 9^{+}, 7^{+}, 8, 2^{+}, 2, A, 9, 18	11
182E150	6, 7, 10, SD, 9^{+}, 6^{+}, 7^{+}, 8, 2^{+}, 2, A, 9,18	13

Exploiting natural enemies of sunn pest

Sunn pest (*Eurygaster integriceps*) is a serious pest of wheat and barley in the CWANA region, contributing to both yield losses and processing problems. Only 2-3% of wheat grains contaminated by sunn pest feeding can lead to the rejection of the whole batch, as the flour will have an unpleasant flavor and the bread will not rise properly. Scientists from ICARDA are working together with various national partners, universities, and government research organizations to develop suitable IPM options for the control of sunn pest. Habitat management to support populations of insect killing fungi in field borders and overwintering sites is a promising strategy for reducing sunn pest populations to levels that do not cause economically significant damage.

Sunn pest infected with Beauveria bassiana*, an insect killing fungus collected in Turkey.*

Several insect killing fungal isolates were collected from sunn pest in Russia, Syria and Turkey, and sprayed on litter in overwintering sites. After 10-15 days, most of the insects were either killed or immobilized and prevented from feeding. Researchers are planning further trials to evaluate the efficacy of this biological control option in field situations.

Pilot sites established in Egypt and Morocco

Pilot sites in Egypt and Morocco were established in 2001 by ICARDA with support from the CGIAR system-wide program on IPM. The objective was to build an effective partnership among farmers, scientists, and extensionists in order to formulate and validate 'best bet' IPM options for these sites.

The Egyptian site was located in Beni Suef Governorate, where faba bean is a traditional crop. Unfortunately, a devastating virus epidemic hit the area in 1991/1992, reducing yields by 80% and destroying farmers' confidence. From 20,000 ha before the epidemic, the area planted to faba bean was reduced to just 800 ha by 1999. Preliminary meetings between farmers, scientists, and extension workers identified the major constraints to growing faba bean as virus diseases (especially faba bean necrotic yellows virus), aphids (especially the cowpea aphid, *Aphis craccivora*), and the parasitic weed *Orobanche*. The following IPM 'best bet' options were selected:

- Sowing the improved cultivars 'Giza 429' and 'Giza 843', which are tolerant to *Orobanche*
- Sowing during the second half of October
- Using a seed rate of 150 kg/ha
- Applying a systemic aphicide
- Roguing of infected plants early in the growing season

The IPM package was evaluated in the fields of 10 farmers in two districts (El-Fashn and Somosta). The average increase in yield achieved by participating farmers was 68% in El-Fashn and 52% in Somosta. This success is likely to encourage more farmers to return to faba bean production next year.

The second pilot site was established in the Settat area of central Morocco. The main crop rotation in that area is rainfed wheat and chickpea. Consultation between farmers, scientists, and extension specialists indicated that the major production constraints for wheat are Hessian fly and weeds, and for chickpea, ascochyta blight and weeds. Stakeholders agreed on the following IPM options:

Wheat
- Planting a wheat variety tolerant to Hessian fly
- Weed control
- Adequate fertilizer application
- Optimal planting date
- Using a drill for planting

Chickpea
- Planting an improved variety tolerant to ascochyta blight
- Optimal planting date

His Excellency Moulary Ismail Alaoui (front left), Minister of Agriculture, is offered a sample of chickpea by one of the scientists involved in the IPM pilot site in Morocco.

- Weed control
- Using a drill for planting

After harvest, the yields obtained using IPM options were compared with those of neighboring farmers who followed traditional practices. The best IPM option in wheat produced a yield increase of around 100%, i.e. 1630 kg/ha compared to an average of 800 kg/ha for the neighboring farmers. This success was largely due to planting the variety 'Aguilal,' which is resistant to Hessian fly. Excellent results were also obtained with chickpea, where the best IPM option produced 945 kg/ha compared to an average of 350 kg/ha for the traditional spring-planted varieties. A combination of approaches was responsible for this success, including planting 'Rizki,' a variety with good tolerance to ascochyta blight and suitable for early planting, and pre-emergence application of the herbicide Granstar (tribenuron-methyl).

Both pilot sites were used for training farmers and for publicity, and were visited by policy- and decision-makers, journalists, and over 500 farmers. Discussions between participating farmers, non-participating farmers, and researchers during the field days proved extremely beneficial for all involved.

Managing ascochyta blight in chickpea

Early planting of chickpea is known to increase yields, which can be as much as double those of later plantings. Winter chickpea is also much less vulnerable to attack by vascular wilt and leaf miner. However, during the moist, cooler winter months there is a greater threat of attack from the fungal disease, ascochyta blight (*Didymella rabieie*). The fungus continually develops new races to which previously tolerant cultivars succumb. Disease management practices that rely completely on genetic resistance are therefore unlikely to prove satisfactory.

ICARDA and Syrian national scientists have been working to develop an integrated disease management package for chickpea. Results from three years' testing at three sites (Tel Hadya, El-Ghab, and Hemo), representing different agroecological zones, have allowed scientists to identify the following options:

- Use of tolerant cultivars adapted to early sowing
- Seed dressing with fungicides to prevent seed-borne disease
- Application of a single foliar spray of the fungicide Bravo or Clortosip (chlorothalonil) at seedling or early vegetative growth stages
- Sowing in January for lower disease impact

An integrated management package using these components was tested at five sites, and compared with traditional spring planting using the local variety without seed dressing or foliar spraying. The weather during the 1999/2000 season did not favour an epidemic of the disease, but even so, plots where the complete package was applied performed far better than those planted with tolerant cultivars only. The spring planting was a complete failure as germination was poor due to drought. The package was tested again during the 2000/2001 cropping season. Heavy rain in May (>100 mm) was accompanied by relatively high temperatures, providing ideal conditions for ascochyta blight to develop. Within a week, the disease had affected large areas of spring and winter chickpea, with disastrous results. The only plots to survive and give an acceptable yield (1500-1700 kg/ha) were those where the full package was applied. The spring chickpea was completely blighted and yielded only 50 kg per hectare at the most.

The environmental conditions forced the researchers to intervene quickly and modify the package to cope with the situation. A second foliar spray after the onset of rain proved vital in rescuing the crop. Researchers also observed that planting in the second fortnight of January gave better results than planting in the first week of the month.

These two modifications will be incorporated when the package is re-tested during the coming season. Additional cultural practices are being recommended to farmers to minimize disease damage. These include deep plowing, field burning of debris, and crop rotation to prevent carryover of disease in chickpea residues to the next crop.

Project 2.2. Agronomic management of cropping systems for sustainable production in dry areas

One of ICARDA's main aims is to work closely with national programs in the CWANA region to help them overcome obstacles to development. The two studies described here are concerned with increasing agricultural productivity in a sustainable manner. In the first, collaboration between ICARDA and the Dryland Agricultural Research Institute (DARI) in Iran has led to the introduction of new technologies to tackle the problem of low grain yield in the country's drought-prone areas where cereal-based systems are predominant. The second involved ICARDA and various local institutions in developing innovations to alleviate poverty and restore degraded environments in a resource-poor, mountainous region of southern Turkey.

Improved technology for cereals in the dry highlands of Iran

Scientists from ICARDA have been providing technical advice and support to DARI since it was established in 1993. Together, the two organizations are planning, designing, and testing new crop production and soil management technologies with the aim of improving cereal yields in the dry highlands of Iran.

A farm survey conducted in 1995 provided useful baseline data. Farmers generally had a low expectation of the yield potential of their crop as they were growing predominantly low-yielding local varieties, such as 'Sardari' wheat and 'Akarpa' barley. In addition, their traditional crop and soil management practices were not the most suitable for such a dry area.

On-farm evaluation and demonstration of new technologies for cereal production, in Iran, which include improved varieties, are proving effective in promoting farmers' interest in adopting them .

The main factors limiting crop productivity were:

- Sub-optimal soil management in terms of timing, frequency, and method of tillage
- Extensive use of local varieties (with low yields, and lacking tolerance to cold)
- Seeding by hand and variable seed rates
- Spring sowing of barley, chickpea, and lentil
- Unavailability and high prices of fertilizers
- Limited weed control
- Unfamiliarity with improved practices
- Poor transfer of improved technologies due to ineffective links between researchers, extensionists, and farmers

Various options for overcoming these constraints were evaluated. Several 'best practice' tillage options were identified, i.e. early plowing with a moldboard plow to increase rainwater penetration, secondary tillage with a ducks-foot cultivator to create an isolation layer (dust mulch) and minimize evaporation, and good seedbed preparation to encourage stand establishment. Use of a seed drill was found to be more productive than the traditional practice of broadcasting seed by hand, especially when combined with an application of fertilizer and early sowing with cold-tolerant varieties. On-farm evaluations and demonstrations were effective in creating awareness and improving knowledge among farmers of the benefits of the new technologies. Researchers and farmers alike were encouraged by the potential of improved varieties to increase productivity.

Between 1999 and 2001, severe drought affected cereal production across the whole of Iran, providing a 'worst case' scenario for the evaluation of new technologies. Results were very encouraging, with improved management on the research station continuing to give two to three times higher yields than nearby farmers' fields under traditional management (Table 10).

Table 10. Yields of the local wheat cultivar 'Sardari' in Sanandaj, Iran.

Rainfall	Research station	Farmers' fields
<300 mm (bad year)	0.5-1.0 t/ha	0.0-0.4 t/ha
300-400 mm (normal year)	1.0-1.5 t/ha	0.5-1.0 t/ha
>400 mm (good year)	> 3.0 t/ha	1.5-2.0 t/ha

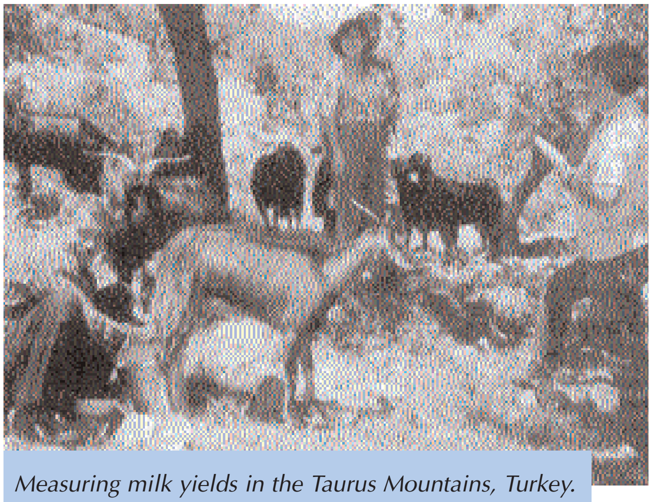
The success of the on-farm evaluations and demonstrations prompted ICARDA and the Iranian national extension system to organize a training course. The course, entitled "Transfer of Technology through On-farm Trials" was held in Iran in May 2001 and brought together researchers and extension agents. Participants learned how to conduct successful on-farm trials, increase farmers' awareness of new technologies, and design adoption and impact studies. Classroom sessions were combined with visits to on-farm testing and demonstration sites. Discussion with farmers suggested that productivity gains were limited by the unfavorable climate, while adoption of new technology was constrained by unavailability of improved seed and adequate machinery, low awareness, and a general lack of resources.

The project highlights the value of active participation by researchers, extension agents, and farmers in enhancing knowledge and paving the way for more effective technology transfer. At present, use of improved technologies is limited to a small number of farmers close to the research stations. Additional resources and dissemination efforts will be needed to create impact further afield. Improving the availability of crucial inputs, such as machinery, fertilizer, and improved seed is also essential if adoption is to be encouraged and productivity improved on a wider scale. These issues will start to be addressed during the 2001/2002 season, when the number of on-farm demonstrations will be increased to include new areas.

Addressing rural poverty and resource degradation in Turkey

More than two million people live in the Taurus Mountains of southwest Turkey, a resource-poor region where agriculture is the main activity. Yields and incomes are low due to small farm sizes, steep slopes, and poor soil. Soil management problems are exacerbated by deforestation and overgrazing; malnutrition and diseases are common; there are few employment opportunities; and infrastructure is generally lacking. In addition, mountainous areas such as this are often overlooked by researchers and government officials due to their relative inaccessibility.

In 1990 a collaborative project between ICARDA, Çukurova University, and the Ministry of Agriculture and Rural Affairs began to address these issues with the aim of improving the standard of living of farmers in the area. A farming systems approach was used, with scientists and farmers working together to identify the major constraints and solutions to overcome them. The project's aims were to increase the income of small farmers through introducing new varieties to increase yields as well as new enterprises, together with reducing soil erosion and decreasing the amount of land left fallow.



Measuring milk yields in the Taurus Mountains, Turkey.

The traditional crops are wheat, barley, and chickpea grown in rotation with a fallow period. Livestock (goats, sheep, and cattle) provide the major source of income, but a shortage of feed, and the need to buy expensive concentrates, severely limit profitability. Researchers therefore introduced new varieties of wheat, barley, and chickpea to increase yields (Table 11), while new crop rotations, including vetch, oats, triticale, and sainfoin, eliminated the need for fallowing and improved soil fertility in addition to providing livestock feed.

Table 11. Yields of wheat and barley (kg/ha) in the Taurus Mountains, Turkey

	Before project	After project	Increase (%)
Wheat	1800	3150	75
Barley	1490	2740	84

Farm income was increased by introducing new breeds and by cross-breeding with the local types. New breeds of dairy cows, together with improved fodder crops, resulted in a dramatic increase in milk production, from 693 litres/year to 1976 litres/year. Fruits, such as cherries and grapes, were introduced to improve human nutrition and provide an additional source of income. The practice of bee-keeping was introduced with modifications to suit the locality. Researchers discovered that changing the queen in the beehives every year, or once in two years, significantly increased honey production.

These improvements have had a dramatic effect on farm incomes, which rose from an average of US$ 1,999 per year at the start of the project to US$ 3,290 four years later—a 65% increase. However, shortages of seeds of improved wheat and vetch proved to be a significant problem. The positive aspect was that development agents and agricultural administrators became more aware of the need to ensure local availability of new technologies at reasonable prices.

Farmers and scientists work together to improve techniques of bee-keeping, Taurus Mountains, Turkey.

Human health was also improved. Doctors from Çukurova University discovered that a lack of iodine in the diet was causing a high incidence of goiter. This was remedied by distributing iodized salt. Training courses were run for the women to improve their knowledge of nutrition, while their role and status in rural life were assessed through sociological research.

The project therefore had a very positive impact on the lives of the people living in the Taurus Mountains region. The participating scientists also gained experience and benefited from working as a team with the farmers. Experience gained during this project will prove useful in future attempts to address similar problems of rural poverty and natural resource degradation.

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, the soil fertility will improve and cereal yields are likely to increase, resulting in a more sustainable production system. Common vetch (*Vicia sativa*) has long been a popular forage legume in the low-rainfall areas of West Asia, but demographic and economic pressures have encouraged farmers to moncrop barley in a way that is not sustainable. By increasing awareness of the benefits of vetch in barley rotations, ICARDA and its national partners are succeeding in restoring the crop to favor among farmers in CWANA countries and beyond.

At Deir El Ahmar in the Beka'a Valley in Lebanon, vetch is mainly grown mixed with barley for hay-making.

The benefits of common vetch

The benefits of rotating vetch with barley have been demonstrated at three ICARDA benchmark sites: Tel Hadya and Hemo in Syria, and Terbol in the Beka'a Valley, Lebanon (Table 12). In all three trials, common vetch rotations produced significantly higher barley grain and straw yield than did barley/barley rotations. Total crude protein and metabolizable energy were also higher when vetch was included, while organic matter and total mineral nitrogen content were highest with vetch and lowest with continuous cereal systems. In addition, vetch rotations gave a higher gross income than continuous cereal or fallow rotations (Fig. 10).

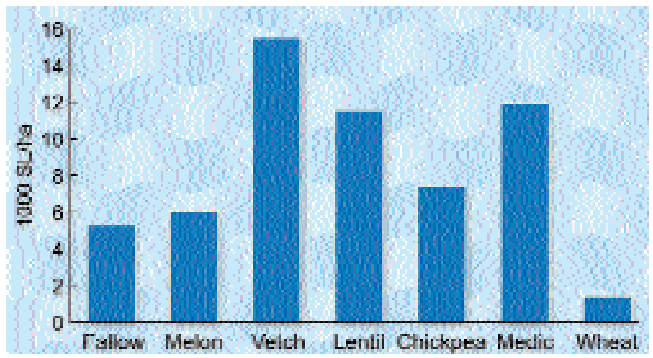


Fig. 10. Gross margin (SL/ha) from different rotations at Tel Hadya, Syria, when wheat is grown in rotation with fallow, melon, vetch, lentil, chickpea, medic, and wheat. US$ 1 = 46 SL

Scaling-up vetch rotation technology

Encouraging on-station results with vetch led ICARDA and its national partners to devote considerable attention to dissemination of the technology. A transfer program was initiated within the scope of the Mashreq/Maghreb Project of ICARDA, a wider adaptive research project whose objective is to develop integrated crop/livestock production systems in the low-rainfall areas of WANA. The Mashreq/Maghreb project is funded by IFAD and AFESD, coordinated by

Table 12. Mean barley seed and straw yield between 1995/1996 and 2000/2001 under different rotations in the Beka'a Valley, Lebanon.

Rotation	Grain yield (kg/ha)	Straw yield (kg/ha)
Barley/barley	590	2010
Barley/lentil	1010	2900
Barley/bitter vetch	1060	3070
Barley/common vetch for seed	1050	2800
Barley/common vetch for grazing	830	2800
Barley/common vetch for hay	1060	2850
Barley/common vetch + barley for hay	970	2580
Barley/medic	850	2770
LSD	259	552

ICARDA, and jointly implemented by eight NARS and the International Food Policy Research Institute (IFPRI). The aim is to evaluate and adapt improved technologies with the full participation of the intended beneficiaries and other stakeholders. Dissemination of the vetch technology has benefited from this project and farmers are already adapting the technology to fit their local production systems. The eight NARS are: Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia.

Progress in Iraq, Jordan, Lebanon, and Syria

In Iraq, haymaking from common vetch proved highly successful. Results obtained at two farms indicated that using common vetch hay to replace 30% of the usual feed supplement benefited ewes and their lambs (Table 13). Ewe milk yield increased by up to 55%, while lamb growth rate increased by up to 12%. In crop rotations, a barley/common vetch+barley rotation gave a higher net return than barley/common vetch alone, barley/medic, barley/barley, or barley/fallow rotations. In Ain Talawi community, northern Iraq, 120 tonnes of hay was produced from a common vetch+barley mixture and stored for use during periods of fodder shortage.

Field demonstrations were held in targeted communities throughout Jordan to evaluate the performance of common vetch grown alone or mixed with barley as an alternative to fallow/barley rotations. At Ramtha, northern Jordan, sheep grazing on common vetch for 23 days made an average liveweight gain of 135 g/head/day (compared to 0-100 g/head/day when grazing weedy fallow). Growing cereal+common vetch mixtures also proved suitable for haymaking, and the area planted to vetch is increasing. Before 1991, there was no vetch grown there, but the area cultivated with vetch had grown to 1668 ha in 1997 with a total production of 2892 tonnes.

In Lebanon, collaborating farmers are adding value to their farming systems by intercropping vetch with fruit trees. In Aarsal, eastern Lebanon, cherries and apricots occupy 75% of the arable land and provide a valuable income. Livestock are also important for income-generation, so farmers have developed a win/win option by growing vetch between the fruit trees. The double crop maximizes land use and is particularly beneficial in dry areas where farm sizes are generally small. Other farmers are also improving their livestock systems and generating income by growing barley+vetch mixtures as a highly nutritious fodder, both for their own animals and as a cash crop.

Table 13. Effect of using vetch hay as supplementary feed on the performance of sheep in two farms in Iraq.

	Farm 1		Farm 2	
	Without vetch hay	With vetch hay	Without vetch hay	With vetch hay
No. of ewes	20	20	20	20
Days on test	47	47	70	70
Initial ewes wt (kg)	35.00	35.00	41.19	42.03
Final ewes wt (kg)	38.68	39.10	37.00	37.14
Ewe wt changes (kg)	3.68	4.00		
Initial lambs wt (kg)	7.93	7.10	3.73	3.45
Final lambs wt (kg)	13.35	14.43	16.92	17.18
Lambs growth rate (g/d)	115	155	178	194
Ewes milk yield (g/d)	480	520	900	1410
Supplement intake (g/ewe/day)				
- Barley grain	500	350	-	-
- Wheat bran	-	-	500	350
- Vetch hay	-	150	-	150
Total intake	500	500	500	500

US$1 = 46 Syrian Lira (SL)

Farmers in Aarsal, Lebanon intercropping common vetch between cherry and apricot trees.

Sheep grazing vetch in spring, traditionally a lean time for forage.

The success of common vetch in El Bab district in Syria (see ICARDA Annual Report, 2000), prompted the Ministry of Agriculture and Agrarian Reform to increase the vetch area in 2000/2001, with very encouraging results. In Hama province, sheep grazing on vetch gained 200-240 g/head/day, a figure that compares well with that for sheep fed on concentrates. Farmers were enthusiastic about vetch as it provides useful green fodder during dry spring periods, when other feed is scarce. Vetch can also eliminate the need to move sheep to distant places to feed. A widespread increase in demand for vetch seed is another clear indicator of success.

Common vetch is a versatile crop that offers several utilization options, such as green manure, grazing, hay, and conserved seed and straw from plants harvested at maturity. The crop not only stimulates greater rotational productivity of dry matter and proteins for animal feed, but also improves whole farm profitability, ensures the long-term sustainability of production, and confers a degree of biological protection against pests that otherwise tend to build up in land cropped every year to barley. It is therefore not surprising that the cereal/vetch technology is taking off in West Asia.

Project 2.4 Rehabilitation and improved management of pastures and rangelands in dry areas

In many dry areas of CWANA, the increasing population pressure is bringing about 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 have been addressing in several countries. Between 1998 and 2000, a study was undertaken in the Ain Beni Mathar rural community in Morocco to assess the changes occurring in land use patterns. The study revealed alarming trends in the loss of natural vegetation and consequent soil degradation, problems that need to be addressed as a priority.

Intercropping with wide-spaced hedgerows of drought-tolerant fodder shrubs in eastern Morocco.

A study of land use change in eastern Morocco

The Ain Beni Mathar rural community is located in the highlands of eastern Morocco. It covers 168,000 ha and has a population of 7,300 inhabitants. Rangelands occupy 95% of the landscape and livestock provide the major source of income. The average annual rainfall is low (180 mm/year) and very variable.

Interviews and workshops with livestock owners revealed a pattern of intensification over the past 20-30 years. Traditional management used to be based on the movement of flocks over large areas, with the animals feeding on natural range vegetation. This ensured rotation of grazing, with areas grazed in one season left to regenerate in the next. Now, more and more livestock owners are adopting agropastoral systems, which destroy the natural rangeland vegetation and create a dependence on cereal crops. In addition, unsustainable farming practices are leading to a reduction in soil fertility. New breeds of sheep, such as the Algerian Ouled Djellal, are being introduced. These sheep are larger than the local Beni Giel breed and have higher production, but are more dependent on feed supplements. Overgrazing near villages is getting more serious as smallholders are becoming increasingly sedentary. In the past, tribal elders designated grazing rights and controlled access to land, but now new forms of organization, such as pastoral cooperatives, are more common. Interestingly, pastoralists' explanations of rangeland degradation differed according to their flock size. Smallholders believed rangeland cultivation to be the main cause, while those with larger flocks attributed the problem to continuous grazing of the same site.

The decline in forage production from rangeland resources, the high price of concentrate feeds, and the keen competition in local markets have forced many pastoralists to abandon livestock production altogether, resulting in rural exodus.

Study of land use patterns using satellite imaging and Geographic Information Systems

Using a Geographic Information Systems (GIS) framework, local knowledge was compiled and information documented on topics such as land tenure status, type of soil, topography, extent of cultivation, number of people that cultivate crops on the rangeland, type of crops, and details of the existing infrastructure (Fig. 11).

Desertification resulting from population pressure, overgrazing, and cultivation in areas too dry to sustain crop production in eastern Morocco.

Satellite images of Ain Beni Mathar recorded in 1988 and 2000 were analyzed for changes in land use and a GIS database was then used to assess the encroachment of agriculture into traditional rangeland (Fig. 12). Comparison of the two images showed that the area of rangeland in good condition had reduced from 22,457 ha to 15,929 ha, while degraded rangeland (characterized by low plant density, reduced productivity and more bare soil) had increased from 53,541 ha to 72,228 ha. Around 20,000 ha had been turned over to crops. Increases in the cultivated area occurred primarily in the north, where conditions for crop production are more favorable due to slightly higher rainfall and lower soil salinity. However, newly cultivated rangeland is highly likely to suffer from depletion of nutrients and organic matter, breakdown of soil structure, and erosion.

Introducing new technologies

The natural resource base will continue to degrade unless suitable alternatives are introduced. To combat the situation, ICARDA and its Moroccan partners are testing the suitability of fodder shrubs, such as *Atriplex halimus*, *A. nummularia*, and spineless cactus *opuntia* spp., to improve the sustainability of crop production. Encouraging results have been achieved and 6000 ha have already been established in an alley-cropping system in eastern Morocco.

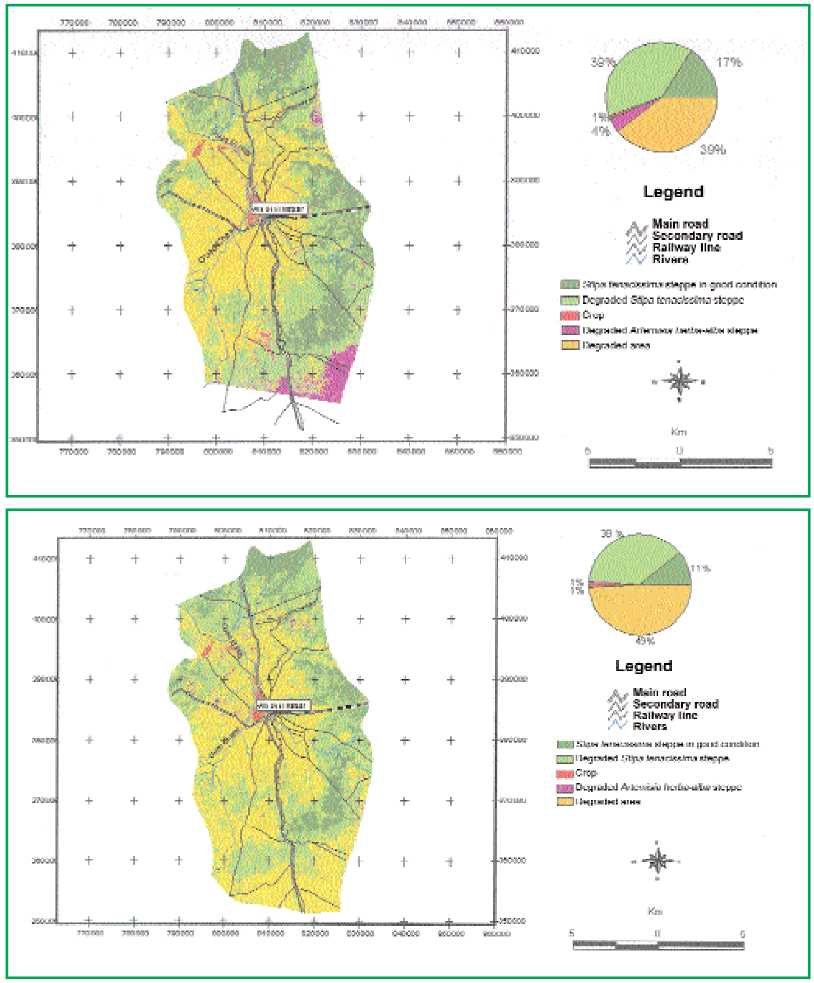


Fig. 12. Changes in land use in Ain Béni Mathar rural community between March 1988 (above) and March 2000 (below).

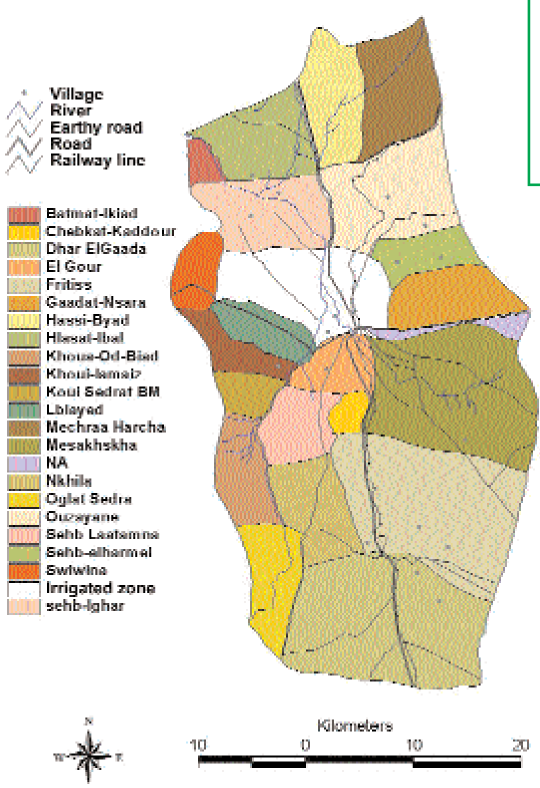


Fig. 11. Classification of rangelands by the local population of Ain Beni Mathar, Morocco.

Collaboration between several research and development projects, including one led by the CGIAR Systemwide Livestock Program on multi-purpose fodder shrubs and trees, the Mashreq/Maghreb project, and the Taourirt-Tafoghalt project, are widening the scope of the technology being researched and extended to farmers. A further 8000 ha have been identified for planting with fodder shrubs in the next two years.

Changes in land use and the condition of natural resources give a good indication of the sustainability of different production systems. The maps and documents generated in this study not only highlight the extent of the problem, but also serve as important decision-making tools.

Project 2.5 Improving small-ruminant production in the dry areas

The CWANA region is home to a wide range of livestock with a rich genetic diversity. There are almost 243 million small ruminants of diverse breeds in the region, the majority of which are managed on rangeland. These breeds are well adapted to their environments, where drought and feed shortages are common. The genes associated with these adaptive traits are likely to become increasingly valuable as global climate change raises temperatures still further and expands the dry areas of the Mediterranean basin. More immediate changes, such as rising human populations, the development of new markets, and reduced prices for traditional products, are also challenging traditional production systems. In many cases existing biodiversity is not being fullly exploited to improve production, so that farming communities can benefit from new market opportunities. Characterization of small-ruminant genetic resources is therefore important if farmers are to make the most of their present opportunities and prevent genetic erosion in the future.

Assessing small-ruminant diversity

This ICARDA project has undertaken an extensive characterization of the CWANA region's small-ruminant genetic resources. In on-station research, scientists described the breeds present in each country on the basis of productive performance, morphological data, production systems, market demand and opportunities, present condition of genetic resources, and prospects for the future of small-ruminant production. The most important breeds in the CAC region are now being characterized on-farm to validate the on-station research and to explore production opportunities under the challenges of real farming environments. It is hoped to extend this work to the WANA region and to collaborate with other programs, such as the global initiative for management and conservation of animal genetic resources being coordinated by the Food and Agriculture Organization of the United Nations (FAO). Another program on the characterization of small-ruminants in CWANA using molecular genetic techniques is in its early stages.

Results from on-station characterization

Around 100 different small-ruminant breeds have now been characterized, although information on some breeds of sheep is still lacking and there has been little investment in the characterization of goat genotypes (with the exception of the Shami or Damascus goat). Some sheep are considered to be different breeds, even when closely related, while the same breed can be found in several countries. For example, Karakul sheep are found in Iran, Kazakstan, Turkmenistan, and Uzbekistan, while Awassi sheep occur in Iraq, Jordan, Lebanon, Syria, and Turkey.

Most sheep in CWANA are fat-tailed, and it was interesting to note that these are found across a wide range, from the Mediterranean coast of West Asia to the borders of Mongolia and China, a distribution that coincides with the ancient 'Silk Road' trading route. It would seem that the ability of fat-tailed sheep to withstand drought and fodder shortages has been exploited throughout the dry and harsh environments of CWANA. Considerable variation in the characteristics and specialization of fat-tailed sheep was found. For example, the Gissar breed from Uzbekistan and Tajikistan is the largest fat-tailed sheep and an excellent producer of lambs; the Karakul from Central Asia produces fine pelts; and the Awassi from West Asia has earned favor as a dairy breed.

Threats to the integrity of genetic resources

The genetic integrity of many indigenous breeds is under threat. Several breeds in the Caucasus have small populations and are threatened with extinction due to a lack of organized breeding schemes. Changing market trends are also responsible for the decline; for example, the collapse of the wool and pelt market has dramatically reduced the numbers of fine and semi-fine wool synthetic breeds (originating from crossbreeds) in the Caucasus, Tajikistan, Turkmenistan, and Uzbekistan. In Tunisia, increased demand for lean meat has prompted farmers to dilute the genetic pool of the traditional Barbarine sheep by crossbreeding with the thin-tailed Queue Fine de l'Ouest. Table 14 illustrates the extent of the problem.

Maximizing production potential

Dairy breeds of sheep, such as the Awassi, have been developed through thousands of years of selective breeding. Now, increasing market demand is prompting intensification of dairy sheep enterprises in West Asia. For example, about 40% of Syria's milk is supplied by sheep. The dairy production traits of the Awassi would benefit from further study, particularly with a view to improving quality. In addition, characteristics to suit more intensive production systems may be required in the future. Interestingly, the potential for dairy sheep has not been explored in North Africa, and only a few breeds, such as the Mengrel goat from Georgia, and the Balbass sheep from Azerbaijan and Armenia, have been evaluated for milk production in CAC.

Meat production from small ruminants is widespread and market demand is increasing throughout the region. In addition to being consumed locally, meat from WANA is in great demand in the Gulf States, particularly during Muslim ceremonies. Researchers have examined the potential of meat breeds to produce under intensified conditions, which are likely to become more prevalent in the future. However, if market opportunities are to be fully exploited, more knowledge is needed concerning the lamb growth rate potentials, prolificacy rates, and meat quality of different breeds. The possibilities for producing out of season and so gaining a higher market price also need to be explored, the main problem being supply of feed resources.

The breeds of sheep and goats found in the CWANA region are well adapted to their environments and are, therefore, a valuable source of genes. But several of these breeds face the threat of extinction due to a lack of organized breeding schemes. ICARDA has launched a major project on breed characterization of sheep and goats in CWANA. The information generated will be used for conserving the genetic diversity as well as for improving breed quality.

Table 14. Breeds subject to genetic erosion and risk of disappearance in CWANA.

Breed and country	Threats
Indigenous sheep breeds	
Cyprus fat-tailed (Cyprus)	Crossbreeding with Chios sheep
Beni Guil (Morocco)	Crossbreeding
D'man (Morocco)	Accumulated inbreeding
Beni Ahsen (Morocco)	Substitution by other species
Atlas Mountain (Morocco)	Crossbreeding
Barbarine (Tunisia)	Crossbreeding and breed substitution
Noire de Thibar (Tunisia)	Accumulated inbreeding
Karakul sheep lines (Uzbekistan)	Lack of breeding schemes
Bozag (Azerbaijan)	Crossbreeding and lack of breeding schemes
Lezgin (Azerbaijan)	Crossbreeding and lack of breeding schemes
Tushinskaya (Georgia)	Crossbreeding and lack of breeding schemes
Emeritinskaya (Georgia)	Crossbreeding and lack of breeding schemes
Indigenous goat breeds	
Megrel (Georgia)	Crossbreeding and lack of breeding schemes
Zaraibi (Egypt) Small population	Damascus (Syria) Accumulated inbreeding
Synthetic breeds	
All fine and semi-fine wool breeds in the Caucasus	Crossbreeding and lack of breeding programs
Fine and semi-fine thin-tailed wool breeds of Tajikistan, Turkmenistan, and Uzbekistan	Crossbreeding with and grading up to indigenous fat-tailed sheep

Theme 3. Natural Resource Management

Project 3.1. Water resources 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. Several ICARDA research projects have been directed towards improving water-use efficiency to encourage more sustainable crop production. The Soil and Water project in Central Asia, funded by the Asian Development Bank, is one that has been producing promising results in Uzbekistan.

Irrigation innovations in Uzbekistan

In 1998, ICARDA established an integrated research site near Boykozon, in the Tashkent Province of northeastern Uzbekistan. The site represents the typical agroecologies and mixed farming systems of the steeply sloping hill country of Central Asia. It was selected as a suitable place at which to conduct the integrated research needed to address the common problems of low agricultural productivity, degradation of the natural resource base, and the difficult socioeconomic conditions of the transitional economies emerging in the post-Soviet era.

The climate of Boykozon shows the extremes of weather, typical of continental locations. In winter, temperatures frequently fall below freezing, while in summer they approved nearly forty degree centigrade.

The soils are mainly moderate to heavy loam, with low to medium nutrient contents. The ICARDA research farm has integrated crop and livestock enterprises. Winter wheat, vegetables, and grapes are the main crops; and beet, alfalfa, and fodder grains are also grown. Irrigation water is provided from the Parkent main canal, which comes from the Chirchik River.

Two problems prevail at the site, as throughout much of Uzbekistan's irrigated area: low productivity from the water available and loss of soil by erosion due to runoff from irrigated fields. Considerable amounts of water flow off the fields during irrigation, taking away large amounts of soil and nutrients. The result is low and declining crop yields, in addition to the negative environmental impact. Annual soil erosion in Uzbekistan averages 51 t/ha, while irrigation efficiency is less than 60%.

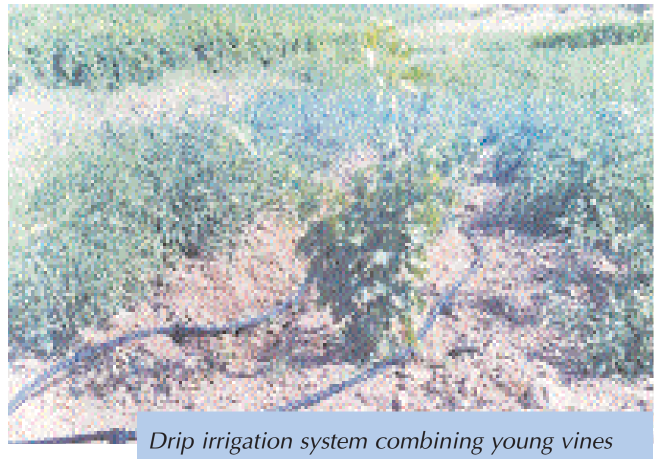
Locally manufactured portable polyethylene chutes at Boykozon farm in Uzbekistan.

Two interventions were tested to address these problems. First, locally manufactured portable polyethylene chutes were installed at the heads of

Vegetables irrigated by drip irrigation at Boykozon farm in Uzbekistan.

the field furrows, replacing the inefficient ditches normally used to supply water. The chutes eliminated seepage and ensured uniform distribution of water among the furrows, in addition to providing full control over the timing and amount of water applied to each furrow. This technology was used on potato fields. As a result, the amount of irrigation water needed to produce the same yield was reduced by about 50%. Due to reduced runoff, soil erosion was also substantially reduced.

The second trial evaluated the potential of intercropping vegetables with vines under drip irrigation. Vines are an important crop in Uzbekistan. At the Boykozon farm, as in many other locations, they are grown widely spaced on steep slopes. During the first years most of the soil surface remains uncovered and is therefore susceptible to soil erosion. The soil also remains unproductive during this period. A drip irrigation system was installed to provide irrigation water to vegetables grown between the vine rows. Tomatoes, peppers, melons, and cucumbers were grown during the first two seasons. These enterprises earned an additional profit of about US$ 800/ha, besides having a positive impact on soil conservation. The vines also benefited from the intercropping, through improved soil moisture and addition of fertilizer for the vegetables.



Drip irrigation system combining young vines and vegetables at Boykozon farm.

These interventions demonstrate that the goals of increasing production and protecting the natural resource base are not incompatible in the short term. They require small initial cash outlays and some extra labor, but produce an attractive return on these investments. They will be suitable wherever there is a large nearby urban market for vegetables, such as Tashkent or other cities in Central Asia.

Project 3.2. Land management and soil conservation to sustain agricultural productive capacity of dry areas

In 2001, this project focused on two areas in northwestern Syria. The biophysical environments in these two areas are very diverse, but they both are characterized by marginal and degrading land.

Khanasser Valley is located about 80 km southeast of Aleppo in the transition zone between the agricultural area and the steppe. Rainfall is very low and unreliable (average 200 mm per year) and resource pressure is relatively high. The cropping system is dominated by continuous barley (or wheat) and barley (or wheat) – fallow. Sheep raising and fattening are important livelihood sources. Natural resource degradation is caused by soil fertility depletion, overgrazing, water and wind erosion, salinization and groundwater depletion. A BMZ-sponsored inter-disciplinary research project started in 2001. The main goals are to develop technologies relevant to the area, and to design a participatory methodology, in collaboration with the Syrian national program, for assessing land degradation and develop sustainable solutions, which can be used in other marginal arid areas. Khanasser is recognized by ICARDA and the Syrian authorities as an integrated research site for sustainable natural resource management.

Yakhour is a steep mountainous area northwest of Aleppo, and is nearly solely planted with olive trees. Annual rainfall is limited (about 450 mm), but it is more reliable than at Khanasser. Frequent up-and-down tillage and water erosion results in land degradation of the steep hill slopes. Activities focus on assessing tillage and water erosion and designing sustainable olive orchard management approaches, in collaboration with the Olive Bureau of Syria.

Agroecological characterization

For Khanasser, soil types, present land-use and land suitability maps were prepared and land degradation was assessed. This information is complemented with farmers' perceptions about status and changes in soil and water quantity and quality. Two small catchments for detailed runoff and erosion monitoring were selected and measuring equipment was installed. Researchers surveyed surface water resources and assessed groundwater resources by measuring groundwater levels and by conducting pumping tests. Groundwater quality was evaluated by taking samples of well water. The biodiversity of the overgrazed slopes has been studied for four years by monitoring the rehabilitation capacity at six sites. A comparison is made every spring between fenced plots and plots open to grazing. This year's results confirmed that plant diversity is higher in the protected plots, while the grazed area is dominated by poisonous and unpalatable species. Information concerning agronomic management of the main cropping systems, irrigation practices, and agricultural calendar were also collected.

Indigenous Roman-type cisterns are being used in Khanasser village to collect runoff water to irrigate olive trees during summer.

At Yakhour, assessment of soil erosion and tillage erosion in olive orchards was initiated.

Socioeconomic characterization

A rapid socioeconomic survey in 58 villages in the Khanasser Valley, Jabel El-Hoss and the *badia* (steppe) was conducted to identify different livelihood categories and potential constraints to the adoption of different land use strategies. The survey confirmed the general poverty of the area. The practice of sheep fattening, using bought fodder, is an important source of income, especially in the most resource-poor areas. Cotton is another cash crop, but one that has now been banned for this area by the government due to its high water requirement.

Participatory testing of land management technologies

By working together, researchers and farmers are designing economic and acceptable land management strategies for the area, thereby maximizing food security, generating income and sustaining the available natural resources:

- Olive tree establishment on denuded hill slopes by runoff harvesting methods was continued, and there is evidence of adoption of this technique by land users. At two experimental sites (Serdah and Al Qura'a villages), scientists used a Roman-type cistern to collect runoff water, which was used to test and demonstrate pitcher irrigation for olive trees.
- Phospho-gypsum (PG) is used to improve soil physical quality and to add nutrients to the soil. PG is known to improve infiltration and soil water storage, and thus reduce runoff. Scientists are checking the suitability of PG in continuous barley and fallow-barley fields in Khanasser.
- For pasture improvement, continuous vetch and vetch+barley mixture are introduced as alternative for fallow and to increase grazing potential in the valley; while the barren hillside is restored with improved grazing plantation.
- At Yakhour, stabilization methods for marginal steep land in olive groves are being tested.

Farmers and researchers inspect a stone and earth crescent barrier built to harvest water to feed a young olive sapling in Khanasser.

Communication and capacity building

Information about the Khanasser project has been widely disseminated by posters and publications. The project also has created its own intranet site at ICARDA, which includes all research papers related to Khanasser. Two information meetings were organized: one for agricultural research and extension institutions, and for farmers. A Farmer's Day was organized to promote interaction between farmers, extension staff and researchers. In 2001, a total of 10 students (from Syria, Eritrea, Germany, Netherlands and Belgium) were conducting their research within the framework of Project 3.2.

Project 3.3. Agrobiodiversity collection and conservation for sustainable production

Further progress in collecting, documenting, and conserving plant genetic resources was made by ICARDA in 2001 and the Center's germplasm collection continued to grow. Attempts were made to clarify the molecular taxonomy of the *Vicia* series, and GIS tools were used for ecological characterization of collection sites of wild *Triticum* and *Aegilops* species. In CAC, ICARDA supported the establishment of national genetic resources units to conserve crop and pasture germplasm. The project on the conservation and sustainable use of dryland agrobiodiversity continued to promote community-based *in situ* conservation of landraces and their wild relatives in two target areas each of Jordan, Lebanon, Syria, and Palestine. Scientists developed a biodiversity survey database to help manage the large amounts of data collected. Seed health testing continued, and ICARDA scientists trained colleagues from national programs in screening techniques for identifying the presence of seed-borne pests and diseases.

Germplasm collection

ICARDA's germplasm collections grew by 2,902 new accessions to reach a total of 127,247 in 2001. Among the most valuable new acquisitions was a large set of bread wheat, chickpea, lentil, and pea landraces (totaling 899 accessions) donated by the Vavilov Institute, St. Petersburg, Russia. This germplasm was collected before World War II by Vavilov himself and his colleagues, mostly in the former USSR but also in the WANA region.

Another unique set of germplasm resulted from a plant collection mission undertaken in Azerbaijan and Georgia. The mission participants included scientists from the national programs of Australia, Azerbaijan, Georgia, and Germany, in addition to those from the Vavilov Institute and ICARDA. They covered over 3000 km, moving through a variety of agroecological zones and collecting seeds from a total of 80 sites. Four hundred accessions representing 75 taxa were collected, including wild relatives and landraces of cereals, food legumes, and fodder and range species. These accessions were shared between the national programs involved and ICARDA. The material will be multiplied to produce sufficient seed for the ICARDA gene bank.

Table 15. Number of accessions of various indigenous forage and rangeland species collected in Dhofar, Sultanate of Oman, in November 2001.

Acacia etbaica	1	*Dyschoriste dalyi*	1
Apluda mutica	2	*Anogeissus dhofarica*	2
Acacia gerardi	1	*Loudetia flavida*	1
Cenchrus sp.	1	*Belepharispermum hirtum*	1
Acacia nilotica (ssp. *indica)*	1	*Setaria* sp.	1
Dactyloctenium scindicum	1	*Euphorbia balsamiphora*	1
Acacia laeta	1	*Themeda quadrivalis*	2
Dichanthium aristatum	1	*Ormocarpum dhofarense*	1
Acacia senegal	2	*Trigonella* sp.	1

This mission in CAC was conducted as part of a project funded by the Australian Center for International Agricultural Research (ACIAR).

Another collection mission conducted in 2001 focused on the Dhofar Province of the Sultanate of Oman. This took place in response to a recommendation of the Expert Consultation Meeting on the Conservation and Sustainable Utilization of Plant Genetic Resources, held in Muscat, Oman. The objective of the mission was to collect indigenous forage and rangeland species with potential to restore degraded rangeland. It was conducted with the participation of staff from ICARDA and Oman's Ministry of Agriculture and Fisheries and

Heavily degraded rangeland ecosystem in Jebel Semhan, Oman

covered three areas of Dhofar, namely, the Eastern Heights, the Central Heights and the Western Heights. Soil samples were taken to help describe each site for the purposes of developing accurate passport data. The samples will be analyzed for their physical and chemical characteristics at the soil laboratory at Salalah, on the country's southern coast. Herbaria samples were also taken at all the sites visited. The herbaria were shared between the national research and extension departments at Rumais, Oman and ICARDA's Arabian Peninsula Regional Program (APRP), while all the seeds were held in 'black box' storage until suitable national storage facilities become available. In total, 22 large samples of seed representing 18 plant species were collected during the mission (Table 15). In addition, on-the-job training was provided for support staff in all aspects of germplasm collection, the use of global positioning systems (GPS), and the handling and storage of herbaria samples. The mission also yielded valuable information on the presence of various species in different rangeland ecosystems, but the ubiquitous degradation of the rangeland resulting from overstocking is alarming.

Molecular taxonomy of *Vicia* series

One-hundred and nine accessions representing the taxa in the *Vicia* series and originating from a wide geographic area were evaluated using molecular markers to clarify the taxonomy of *V. sativa*. The accessions were analyzed using amplified fragment length polymorphisms (AFLPs). However, two primer combinations, rather than the conventional one, were used, to provide still greater accuracy. The study concluded that four species exist in the series (Fig. 13). *V. incisa* should be considered as a separate taxon and does not belong to the *V. sativa* aggregate. Within the series, *V. pyrenaica* appears to be the most closely related to *V. sativa*. Within the aggregate, six taxa can be recognized. They are very closely related, and for none of the taxa in the aggregate is there a taxon-specific absence or

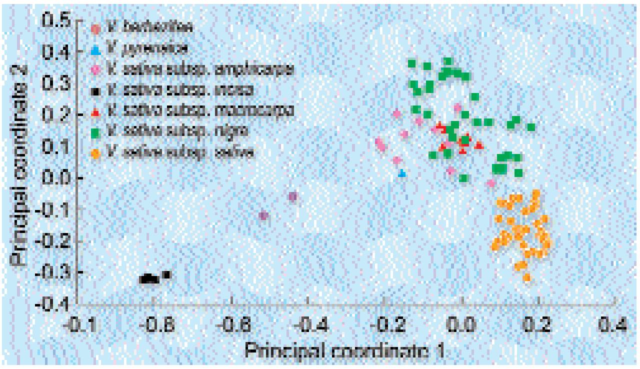


Fig. 13. Scatter diagram of the first two principal coordinates accounting for 29.6% of the variation obtained by AFLP analysis of 109 accessions of the Vicia *series.*

presence of AFLP bands.

Maxted, in his classification of the *V. sativa* aggregate, lumped three taxa (*V. angustifolia* Reichard subsp. *angustifolia, V. angustifolia* subsp. *segetalis* (Thuill.) Gaud., and *V. cordata* Wulf.) into one subspecies, namely *nigra.* The different groups found within *nigra* in the current study can be related to these other taxa: group 1 refers to subsp. *angustifolia,* group 2 to subsp. *cordata,* and group 3 to subsp. *segetalis.* These three groups appear to be quite different genetically, suggesting that they should be recognized as separate.

This study showed that, to separate more distantly related species, one primer combination can be sufficient for reliable distinction. However, for more closely related taxa, such as the members of the *V. sativa* aggregate, the results obtained when using only one primer combination can still lead to some misclassification, so in this case a minimum of two primer combinations is necessary.

Use of GIS tools for ecological characterization of wild *Triticum* and *Aegilops* species

Data on 67 climatic and four edaphic variables were generated for 381 germplasm collection sites in Syria using the Almanac Characterization Tool developed by the Texas Agricultural Experiment Station and ICARDA. The data were subjected to a series of multivariate statistical analyses designed to reveal relationships with the genomes of wild *Triticum* and *Aegilops* species and elucidate geographical distribution of these wheat wild relatives. In *Triticum-Aegilops* complex, a basic set of seven chromosomes is a genome and specific single-letter symbols are assigned to different genome types. Dendrograms—diagrams showing the genetic distance between species—from these analyses indicated highly similar ecological adaptation between the U-genome diploid *Ae. umbellulata,* and the U-genome tetraploids *Ae. biuncialis, Ae. triuncialis, Ae. geniculata,* and *Ae. columnaris.* Similarly, the D-genome diploid *Ae. tauschii* clustered with the D-genome polyploids *Ae. crassa* and *Ae. vavilovii. Ae. searsii* was closely linked to *T. dicoccoides,* whereas *Ae. speltoides* was associated with *T. araraticum.* When all the species were analyzed together, monthly precipitation and evapotranspiration variables were shown to explain most of the differences between species, while only a few of the 24 monthly temperature extreme variables and none of the eight annual climatic variables were implicated.

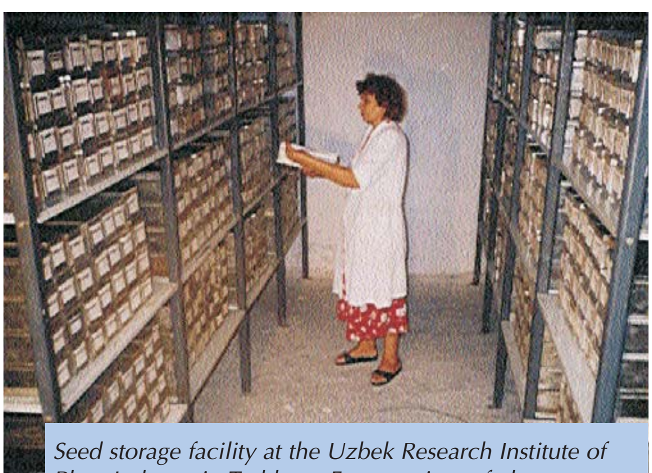
Germplasm characterization, preliminary evaluation, and multiplication

In the 2000/2001 growing season, a total of 2,700 accessions were characterized in the field for 12 to 30 descriptors. The largest trials were on faba bean and durum wheat, comprising 1,200 and 500 accessions, respectively. Germplasm supplied by the Vavilov Institute was characterized with the help of some of its curators, who visited ICARDA in spring 2002. They also assisted in the identification and study of multiple accessions of four old durum wheat landraces of Russian origin. A visiting scientist from Armenia participated in the characterization of material obtained during collection missions to Kazakstan, Kyrgyzstan, and Tajikistan in 2000. High priority was given to seed multiplication to replenish seed stocks, since more than 10,500 accessions were distributed to breeders and scientists at ICARDA, and an additional 7,100 seed samples were requested by external applicants. A total of 9,000 accessions were multiplied in the field and greenhouse to replenish ICARDA stocks and ensure compliance with international gene bank standards.

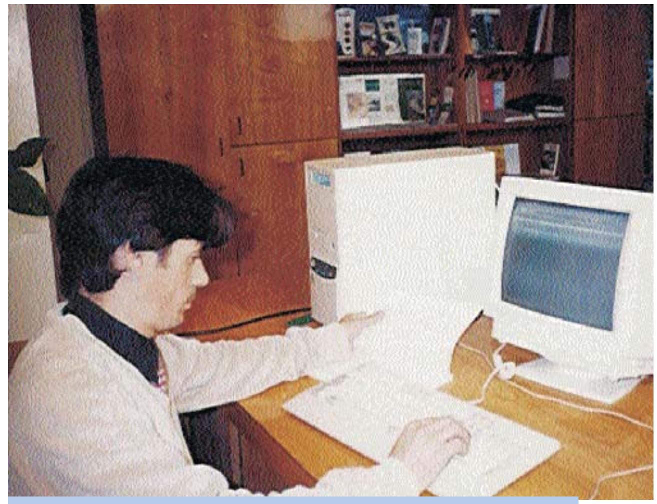
Developing national genetic resources centers

ICARDA has a mandate to collect, conserve, and document crop and pasture plant genetic resources and to support the national programs in this activity. The Center has launched a number of initiatives to fulfill this mandate in CAC countries.

Following the establishment of project groups for the CAC region's major crops, there is a need for additional support for activities on the ground. To meet this need, national coordinators and key scientists from each country came together with representatives from Russia's Vavilov Institute, ICARDA, and the CGIAR CAC Program Facilitation Unit at a meeting held in Tashkent, Uzbekistan, in December 2000. The meeting resulted in an agreement to establish national genetic resources project units, each with a minimum of three staff, with the aim of collecting, conserving, and documenting national plant genetic resources for both crops and pastures. The initial tasks will be to conduct an inventory and document existing *ex situ* collections. ICARDA is supporting the formation of these units by providing computer equipment, operational funds, and training.



Seed storage facility at the Uzbek Research Institute of Plant Industry in Tashkent. For ensuring safe long-term storage of the valuable germplasm here, efforts are underway to improve the facility.



The Head of Documentation at UzRIPI at his computer recently provided under ICARDA/UzRIPI collaborative Project.

Training began in May 2001 with a workshop for the Caucasus, where the ICARDA database on plant genetic resources was modified to meet the needs of the participants. Workshop participants also developed a comprehensive task list for each national unit, which focused on implementing the unit's broader and long-term aims. A similar training workshop was undertaken in November 2001 for the Central Asian countries.

Funding was obtained from Australia to send staff from the Armenian and Georgian units to an Australian gene bank after they had completed an ICARDA-supported diploma in the use of geographical information systems (GIS) as an aid to germplasm collection and classification. These scientists will use their newly acquired GIS skills to contribute to joint ICARDA, national, and Australian collaborative projects. It is also planned to send a member of the Azeri unit to the Vavilov Institute in St. Petersburg for further training.

Financial constraints continue to be the most significant obstacle to the development of sustainable national plant genetic resources programs in this region. To obtain the funding needed to sustain and build on the achievements so far, a three-year extension of the Australian-funded project was proposed. This has now been agreed by ACIAR. The extension will allow capacity development to continue and new collecting missions and germplasm evaluation activities to be carried out. Additional funding is also being sought to modernize the seed storage facilities at the Uzbek Research Institute of Plant Industry, in Tashkent.

Factors affecting agrobiodiversity in West Asia

The agrobiodiversity of the drylands, which supports the livelihoods of most of the people who live there, is well known for its high intraspecific diversity and endemism and for its adaptation to harsh conditions, especially extremes of temperature and drought. The West Asian drylands are of special significance in this respect since they contain much of the diversity of several plant species of global importance, including wheat, barley, lentils, and many forage and fruit tree species. Both the landraces and the wild relatives of these species are still found in the region, but their area and abundance are diminishing.

ICARDA's project on the conservation and sustainable use of dryland agrobiodiversity is funded by the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP). The project, which is in its pilot phase, aims to promote community-based *in situ* conservation of landraces and their wild relatives in two target areas each of Jordan, Lebanon, Syria, and Palestine. Over the past two years, socioeconomic and ecogeographic surveys have been conducted in 63 monitoring areas over 24 project sites in order to assess the status of agrobiodiversity and the main factors responsible for its degradation.

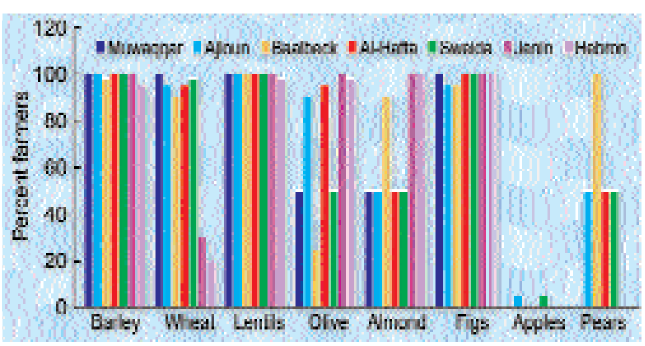


Fig. 14. Use of landraces of different crops by farmers in Jordan, Lebanon, Syria, and Palestine.

The results of these surveys showed that landraces of wheat, barley, lentils, olives, figs, and almonds are still widely used by farmers, while improved varieties are mainly used in the case of apples, apricots, and plums (Fig. 14). However, the area covered by the landraces of barley, wheat, and food legumes is shrinking rapidly. These crops are being replaced by new plantations of apples (for example at Sweida in Syria and Ajloun in Jordan), cherries (at Aarsal in Lebanon and Berin in Syria), and olives (at Ajloun and Muwaqqar in Jordan, Jenin in Palestine, and Sweida in Syria). Another important finding concerned the wild relatives of both field crops and fruit trees and the principal rangeland and pasture species (*Lathyrus*, *Medicago*, *Vicia* and *Trifolium*). It was found that the number of species and their frequency and abundance had been severely affected by overgrazing and by the loss of communal land, either to private tenancies or to local communities, for the planting of trees, mainly olives. On average, local communities reported the presence of around six landrace varieties for wheat and barley and more than 10 for olives, grapes, and figs. The numbers of wild relatives and target rangeland species revealed by the botanical surveys were far lower than was expected on the basis of data from previous surveys and flora studies. In the case of wild *Triticum* species, *T. baeoticum* was not found at all and the abundance of both *T. dicoccoides* and *T. urartu* was greatly reduced in the Nabha and Ham sites of Lebanon, at Sweida in Syria, and at Ajloun in Jordan. None of these *Triticum* species were found in the project sites at Jenin and Hebron in Palestine. The surveys revealed for the first time the presence of *T. dicoccoides* at an altitude of over 1700 m. This population could harbor useful genes for cold tolerance and winter hardiness, which are needed for the improvement of durum wheat.

The socioeconomic studies found that local communities greatly appreciate the adaptation to harsh environments and the good food and processing qualities of landraces, compared to the improved varieties of barley, wheat, chickpea, lentil, olives, figs, grapes, and apricots that were covered by the survey. However, people cited marketing opportunities as major constraints to the more widespread cultivation of landraces. Project scientists plan to promote local products as a means of encouraging the *in situ* conservation of local agrobiodiversity. The activities will include:

- Advertisement of local products, through the organization of, or participation in, local and national agricultural and biodiversity fairs, such as those already organized at Beirut in Lebanon, Ajloun in Jordan and Lattakia in Syria.
- Training of women in food processing to make local products and discussion with local communities on alternative sources of income, such as from apiculture and growing medicinal plants.
- Raising public awareness of the importance of conserving dryland agrobiodiversity by introducing the concept in school curricula, organizing extra-curricula activities (such as participation in afforestation projects), and forming biodiversity clubs for painting, theater, and so on.
- Contacting forestry departments in participating countries and asking them to consider the use of local tree species in their afforestation and landscape management projects.
- Demonstrating within local communities appropriate techniques for enhancing the productivity and abundance of key species, including water harvesting techniques and low-cost input packages. The project is also helping individual farmers and local NGOs to develop nurseries for the multiplication of local fruit tree varieties and their wild relatives.
- The development of policies and legislation to empower local communities and ensure their implementation of activities in line with international agreements (such as the Convention on Biological Diversity and the International Treaty for Plant Genetic Resources for Food and Agriculture).

Ecogeographic surveys revealed existence in some project sites of a number of crop and fruit tree wild relatives such as Pistasia atlantica, *a close relative of cultivated pistachio.*

Participants are also trying to draw lessons from the project's experiences in order to strengthen the scientific basis for promoting *in situ* conservation in the dry areas. They are analyzing the advantages and disadvantages of introduced species and improved varieties compared with local landraces, on the basis of experiences reported by local communities, with particular reference to the spread of apples and improved varieties of olives and grapes.

Database of agrobiodiversity surveys

Agrobiodiversity surveys are an important component of the dryland agrobiodiversity project, and are conducted periodically at selected monitoring sites in each participating country. The surveys yield a comprehensive array of ecogeographical data, which help project staff to describe the dynamics of vegetation and monitor key plant populations. To facilitate management and use of the survey data, and the analysis of time-series data at country and regional levels, the Genetic Resources Unit of ICARDA has developed a survey database. The database is installed and used in each country, but maintained by ICARDA, whose staff periodically update it with the data sent by national survey teams.

Botanical surveys, and hence the database, follow standardized methodology. In each of the 67 monitoring areas at 25 project sites in 4 countries, project staff collect data on the species (their growth stage, cover/density, health status, etc.) found growing on plots located along a transect. Data on ecology and land use are also gathered.

Seed health testing

ICARDA's seed health laboratory aims to guarantee the safe movement of outgoing and incoming genetic materials. By the end of November 2001, more than 10,000 seed samples had been received and tested for health status during the year. The vast majority of samples proved to be free of seedborne pathogens or pests. However, a few teliospores of *Tilletia controversa* (dwarf bunt) and *Tilletia indica* (karnal bunt) were detected in 32 incoming bread wheat samples, which were all destroyed. The laboratory has made considerable efforts over the past 10 years to transfer knowledge of seed health testing to national programs. These efforts took the form of training courses and assistance in laboratory establishment. Egypt, Iran, Iraq, Jordan, Pakistan, Syria, and Turkey are among the many countries that have received this kind of assistance.

Project 3.4 Agroecological characterization for agricultural research, crop management, and development planning

Researchers involved in integrated natural resource management need to take action on a wide range of factors in pursuit of sustainable agricultural production. The first step in most projects is to compile a detailed description of the study region. A collaborative project involving ICARDA, the University of Bonn, and the Atomic Energy Commission of Syria has undertaken a comprehensive description of the land resources, land capability, and land degradation issues in the Khanasser area of northwestern Syria (Fig. 15).

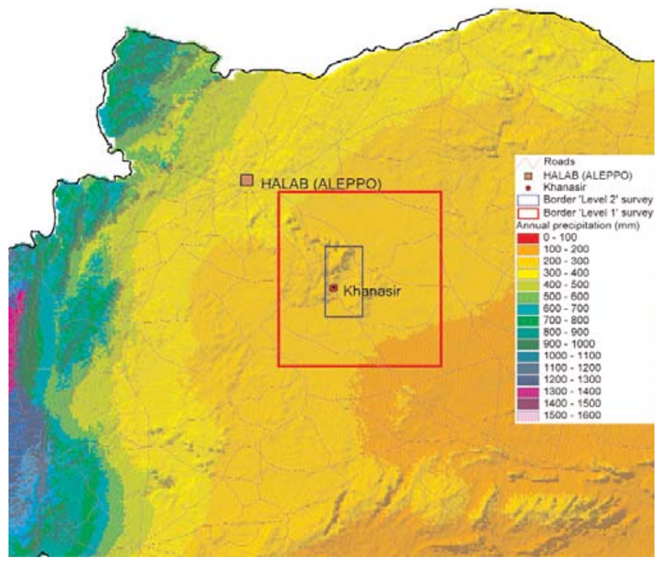


Fig. 15. The Khanasser area, northwest Syria

Multi-scale land resource assessment in Khanasser, Syria

The project undertook a land and soil classification study at three levels of detail:

- Reconnaissance survey, covering the area southeast of Aleppo, particularly the Khanasser Valley, the Jebel El-Hoss and Jebel Shbeith
- Semi-detailed survey of the Khanasser Valley
- Detailed participatory survey in Khanasser village.

The first stage provided an agroecological characterization of the whole Khanasser area, at a scale of 1:200,000 (red frame in Fig. 15). The objective of this 'level 1' assessment was to obtain an overview of the major soil types, including their location and management properties, and to identify areas for more intensive survey work. The inventory included soil resources, land use, and land cover. Soil resources were assessed by interpreting Landsat imagery from 1998 and 1999, and the data were supplemented by terrain observations and soil sampling. The land use/land cover map was developed using the same Landsat imagery.

The second stage provided a meso-scale inventory of the land resources of the Khanasser Valley, at a scale of 1:50,000 (blue frame in Fig. 15). This 'level 2' assessment was carried out to define landscape units with different management requirements and land use options. The inventory was, therefore, more intensive, relying heavily on fieldwork, with further soil sampling and analysis. Land suitability maps were prepared for several important crops and land use categories. The soil map and land suitability map for rainfed barley are shown in Figs. 16 and 17, respectively.

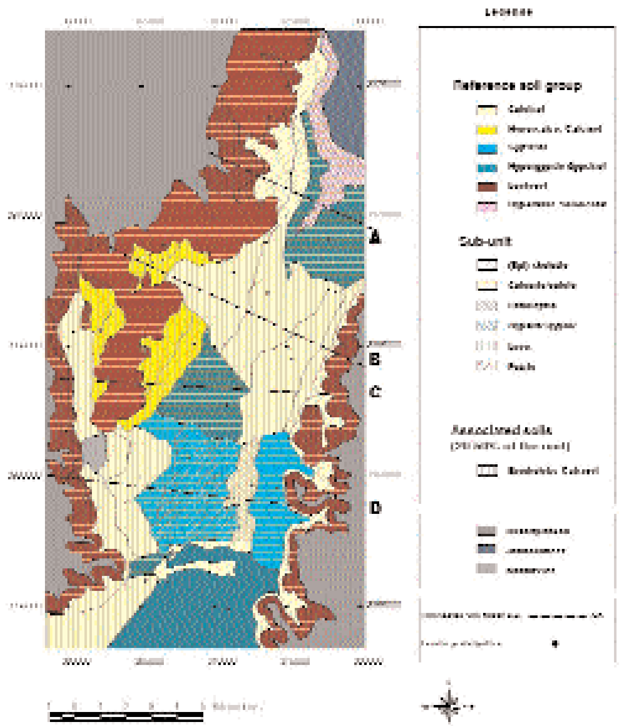


Fig. 16. Soil map for the Khanasser Valley, Syria

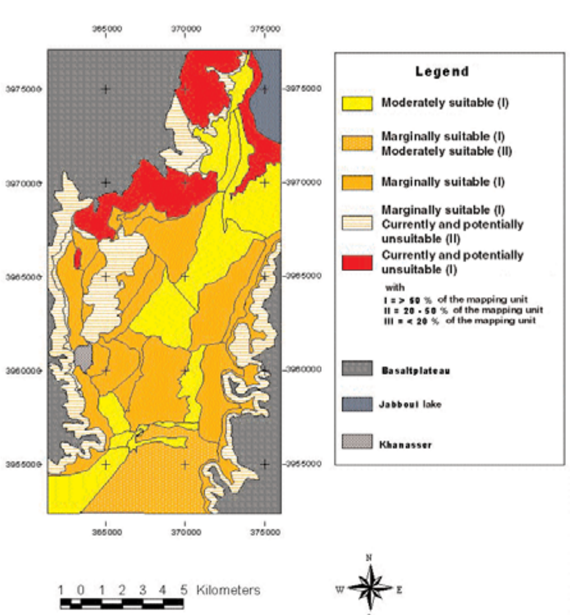


Fig. 17. Land suitability map for rainfed barley, Khanasser, Syria

The 'level 3' assessment focused on Khanasser village. Its aim was to understand farming systems and farmers' perceptions of resource-related problems. Farmers, particularly those who had been farming in the area for over 40 years, were asked to provide information about land quality, productivity, production risks, resource degradation, and land use in the area surrounding the village.

The study generated some important lessons, which can be put to good use in other sites where similar research is needed. Firstly, a multi-scale approach offers a very efficient and cost-effective framework for conducting land resource studies and up-scaling research results. It also offers an efficient methodology for integrating farmers' knowledge with scientific mapping procedures. Secondly, researchers should adapt their land evaluation methods to local conditions, taking account of different scales and study objectives. Different crop or system requirements should be linked to land characteristics and qualities that can be mapped with confidence, thereby avoiding the danger of reaching unrealistic conclusions.

Land degradation assessment

The Khanasser area represents a transition zone between rainfed and irrigated crop production and livestock systems. Land degradation issues include salinization in irrigated fields, water and wind erosion, groundwater depletion and contamination, and a decline in the cover and quality of the natural vegetation. In dry areas it is often difficult to distinguish human-induced land degradation from natural processes of deterioration, such as gully formation, wind erosion and deposition of soil, and salinization of depressions. Changes in the landscape, vegetation, or land use can provide evidence for land degradation, but what time scale should be considered? Land can degrade rapidly or slowly, depending on its resilience and the pressure exerted on it. There are usually no datasets available that go back far enough to monitor slow degradation processes. In addition, some forms of degradation may have occurred in the distant past, with the area having since found a new equilibrium. Land degradation in the Khanasser Valley was studied by comparing aerial photographs taken in 1958 (Fig.18) with Landsat satellite imagery dating from 2000 (Fig.19). Changes in settlement patterns, land cover and use, gully distribution, and the wind deposition of soil were noted and the data supplemented with field observations and interviews with farmers who could remember back to 1958. The most significant change in land use was marked by an expansion of rainfed agriculture from about 30% of the valley in 1958 to nearly 100% in 2000. This expansion occurred at the expense of rangelands, which were the predominant land cover in 1958. There has been little change in the area under irrigation (compare Figs. 18 and 19).

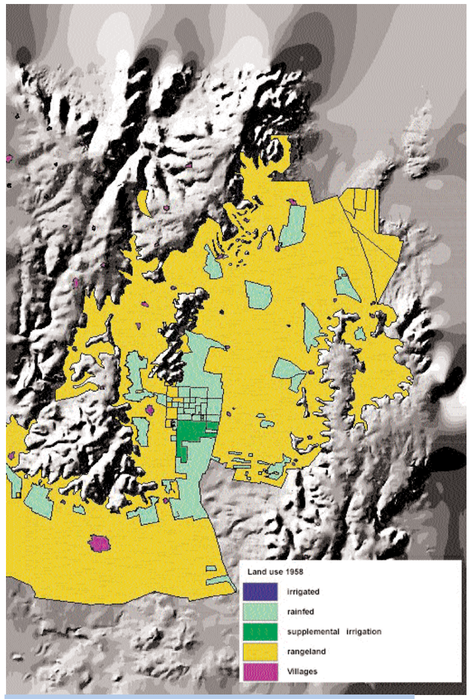


Fig. 18. Land use in the Khanasser Valley in 1958

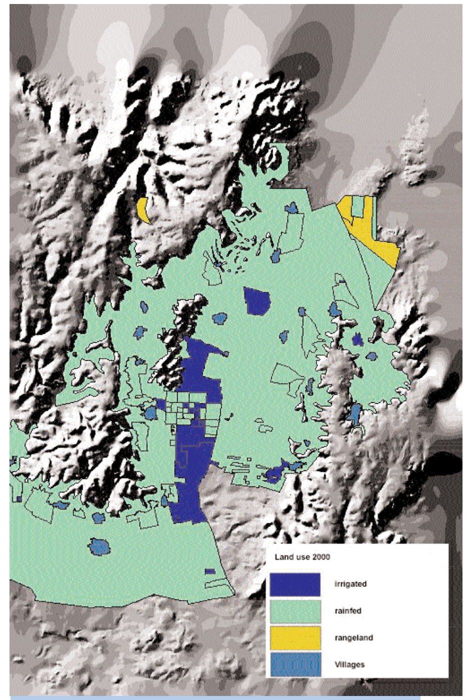


Fig. 19. Land use in the Khanasser Valley in 2000

Interviews with older farmers indicated that barley has been the dominant crop and farm sizes have changed little in the 40-year period. Although land ownership is passed down from father to son, families continue to farm the land in common operations. Fertilizer use has been non-existent and soil fertility has been maintained by observing a fallow period. However, fallow frequency has reduced from 1 year in every 2 in 1958 to 1 in 4 in 2000, and the farmers felt that fertility had declined. They also observed that both the area and diversity of natural vegetation had reduced, due to the encroachment of farmland and the destructive effects of tractor cultivation. Farmers who did not own livestock believed that sheep had a negative effect on soil quality. They also claimed that they have no control over the numbers of sheep and the grazing intensity. Farmers who did own livestock, unsurprisingly considered the economic benefits to outweigh the negative effects on the land.

Farmers' management practices to combat the decline in fertility have been ineffective. Fertilizer use is widely considered uneconomic in a dry environment with a high risk of crop failure. Deep plowing every four years was mentioned as a 'nutrient pumping' practice to replace nutrient-depleted topsoil with less depleted subsoil. The effect of this practice on longer-term nutrient availability requires further study. Other forms of land degradation appear less important. Gullies are very common on hill slopes in the area. However, the interviews with farmers indicated that the gullies probably existed before 1958 and had extended only slightly in the past 40 years. A comparison of current measurements with the 1958 aerial photographs will indicate whether any significant elongation has in fact occurred.

The combination of information sources used in this study (remote sensing, field surveys, and farmer interviews) was able to provide indirect evidence of a decline in soil fertility and production capacity, a major form of land degradation. The study's results can now be used to develop suitable strategies for reversing the decline.

Theme 4. Socioeconomics and Policy

Project 4.1. Socioeconomics of natural resource management in dry areas

Water is a vital natural resource, and its efficient management is particularly important in the dry areas. In Syria, groundwater is likely to be tapped more and more if agriculture is to meet the demands of growing populations and expanding markets. Between 1999 and 2001, ICARDA scientists conducted a detailed study of groundwater exploitation, bringing together major stakeholders to discuss the problem of groundwater depletion. In addition, a small pilot project was begun to revive the ancient Persian *qanat* system of groundwater utilization.

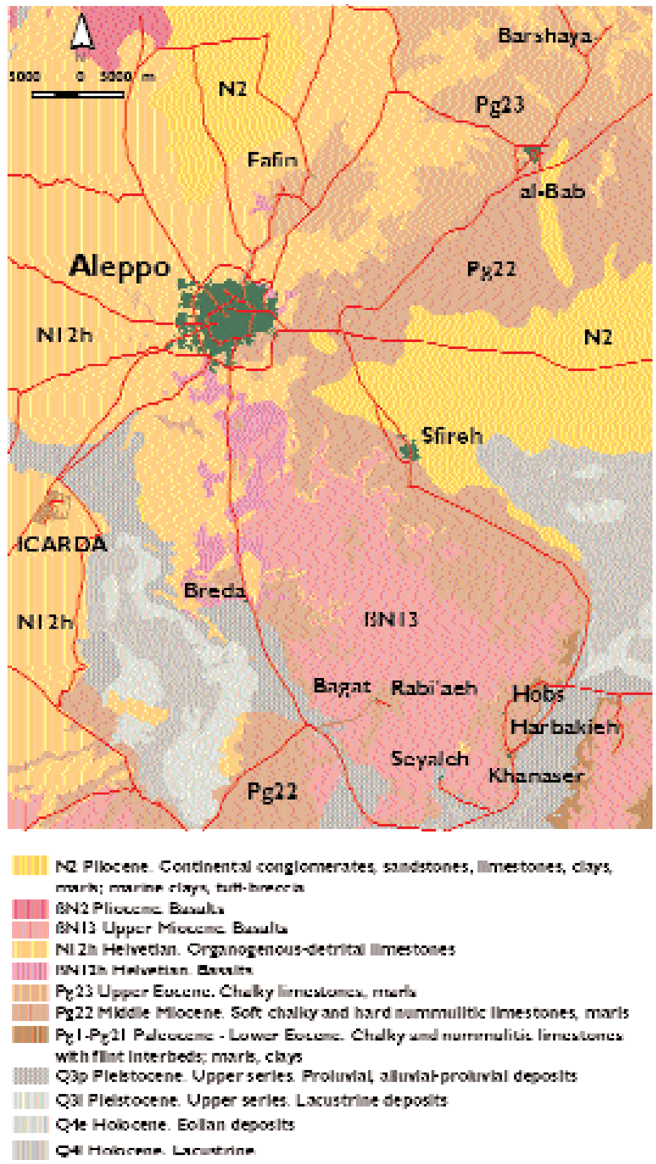


Fig. 20. Geological characteristics of the study area, Aleppo Province, northern Syria

Meeting the challenge of groundwater depletion

Groundwater resources are facing a serious threat in the dry areas of WANA. Wells are drying up, aquifers are being polluted, and extraction costs are rising. More sustainable use of water is required to safeguard the future of agriculture and the communities who depend on it. The most pressing challenge is to implement sustainable and efficient management of groundwater in order to deal with the growing problem of water scarcity. In an effort to identify major areas of concern, researchers at ICARDA investigated several aspects of water use:

- Allocation of water between different crops and seasons
- Reasons for groundwater exploitation and how these relate to crop profitability and water productivity
- Institutions concerned with groundwater
- Needs of stakeholders

Table 16. Long-term annual precipitation and potential evapotranspiration for five villages in Aleppo Province, Syria

Village	Stability zone	Elevation	Average precipitation	Average potential evapotranspiration
		(m)	(mm/yr)	(mm/yr)
Fafin	1	416	349	1500
Barshaya	2	461	309	1493
Baggat and Rabia'a	3	362	264	1544
Hobs and Harbakieh	4	416	237	1576
Seyaleh	4	390	225	1571

The researchers conducted their fieldwork in four different stability zones near Aleppo (Fig. 20; Table 16). Rainfall at the five sites exceeds potential evapotranspiration only during December, January, and February and groundwater levels are higher in winter than in summer. The groundwater-bearing formations are predominantly limestone, yielding good quality water but giving rise to poor soils and low agricultural productivity. Many farmers have insufficient water to irrigate their crops in summer and are drilling wells, but the pattern of water flow through fractures in the limestone means the supply to these wells is erratic and they may compete with each other. A simple computer simulation model was used to illustrate the effects of different crops, well interference, and competition for water. Researchers created a forum for stakeholders (farmers, researchers, government regulators, and people with indigenous knowledge, such as well drillers) through workshops, where they discussed problems and generated ideas for more sustainable agricultural production in areas of water scarcity.

Researchers discovered that groundwater has been depleted as a result of increased support for agricultural activity, unrestricted access to water, and introduction of improved drilling and pumping technologies. As it has become more profitable, irrigated agriculture has expanded and farmers have pumped more and more water from aquifers (Fig. 21). Unfortunately, as more farmers have turned to irrigation, wells have dried up and water tables have fallen. If these trends continue, farm incomes and rural employment will be badly affected and migration from rural to urban areas will accelerate. However, the farmers' response to depleted groundwater has been to search further by drilling more and deeper wells. The farmers

Drilling a well in the study area

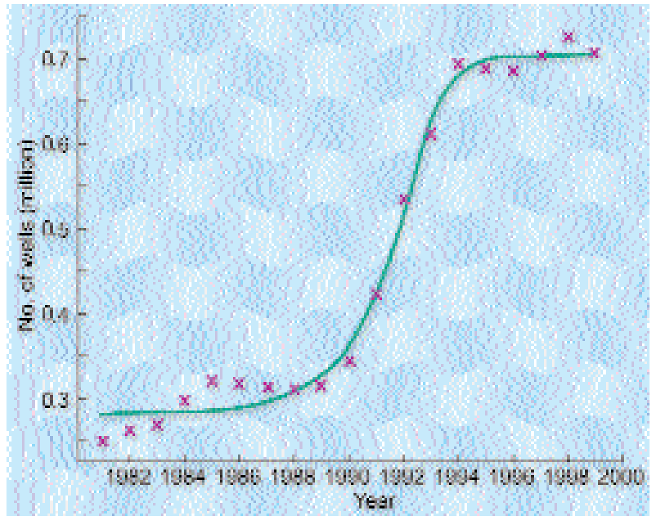


Fig. 21. The trend of ground water exploitation for irrigation in Syria.

have been slow to adopt water-saving technologies and introduce water-efficient crops.

Despite the overall problem of water scarcity, farmers who had sufficient water consistently over-irrigated their winter and summer crops, applying up to 62% more water than was needed. However, during the critical growth stages (April for wheat and July for cotton), they were not applying enough water. Lack of water in the drier villages (zone 4) meant that summer crops were not irrigated and the farmers incurred substantial financial losses. The gross profit margins of wheat and cotton fell as rainfall decreased and the worsening groundwater situation led to higher irrigation costs (Table 17). Farmers who tried to grow cotton in zones of unreliable water either abandoned the crop completely or achieved only a low gross margin.

Farmers do not account for the value of water, basing their allocation on total gross return rather than on productivity per unit of water. For example, because cotton has a relatively high gross profit margin, it was cultivated in zones 3 and 4, despite having low water productivity and being banned by the government (because of groundwater shortage). Both cotton and wheat crops ceased to be viable when the diesel subsidy was reduced by 75% and fuel for the irrigation pumps became too expensive. Vegetables had the highest gross profit

Table 17. Water use and gross margins of crops in four agroecological zones in Aleppo Province, Syria.

Zone	Village	Crop	Crop area/ total holding (%)	Water use (m^3/ha)	Excess water use (%)	Irrigation cost/ total cost (%)	Gross profit margin (SL/ha)	Water productivity (SL/m^3)
1	Fafin	Cotton	25	16800	29	45	42000	2.48
		Cucumber	3	6500	48	16	40000	6.14
		Faba bean	20	3300	30	30	21500	7.05
		Wheat	40	4533	38	35	9000	2.99
2	Barshaya	Beans	5	8600	30	16	85000	13.11
		Cotton	7	14500	20	58	40500	2.80
		Cucumber	4	6500	43	19	81000	12.43
		Faba bean	10	3450	89	23	9500	2.25
		Wheat	20	5100	56	39	19000	3.61
3	Baggat and Rabia'a	Cotton	7	16000	30	54	30000	1.86
		Wheat	17	6500	29	34	13250	2.02
4	Hobs and Harbakieh	Cotton	5	10300	-8	61	400	0.02
		Wheat	10	8250	71	57	-5500	-0.66
	Seyaleh	Cotton	5	16500	-17	61	20000	1.39
		Wheat	2	6500	8	41	7000	1.05

* US$ 1 = 46 SL

margin as well as the highest productivity per unit of water, but were grown only on small plots.

The workshops, attended by researchers, farmers, well drillers, and officials concerned with groundwater, were a major success as stakeholders were able to meet for the first time on common ground. The officials tried to discourage the drilling of new wells, but the farmers, while showing their awareness of the problem, asked for alternative solutions. They wanted to learn more about modern irrigation systems and improve their water-use efficiency, but were unaware of existing government programs offering credit facilities to enhance adoption of new technologies.

A dried well at a site in the study area

Although public awareness of the groundwater problem is growing and several policy measures (more stringent control of drilling, restricting crops with high water requirements in water-scarce areas, and registration of wells) have been taken, further research is needed to determine the full range of possible options and their potential impacts.

Learning from traditional systems of water supply

*Qanat*s are underground tunnels that tap groundwater and direct it to human settlements or agricultural land. The technique originated in ancient Persia and over the centuries, *qanat*s provided a lifeline to irrigated agriculture and settlements in dry areas. Teheran, capital of Iran, was fed by twelve *qanat*s until 1930 and the ancient city of Palmyra in Syria grew and prospered because of its reliable *qanat* water supply. *Qanats* rely on gravity alone to transport water from underground aquifers and do not deplete groundwater resources. In the past, social structures also regulated water use and ensured that the system was properly maintained. Changes in society and the introduction of new technologies, such as groundwater pumping, have led to many *qanats* drying up and falling into disrepair.

The *qanat* is an intrinsically sustainable technique of groundwater extraction and as such, could provide useful lessons in efficient water management. Consequently, researchers from ICARDA initiated a small pilot project to understand the traditional management systems of *qanats*. They based their research on the village of Shallaleh Sakhireh, south-west of Aleppo. The community there still relies on an ancient *qanat* system (Fig. 22), now in a poor state of repair, as the sole source of water for its 25 households.

In this community, as in many others in West Asia, water and land ownership go together and the largest landowner is also the largest holder of irrigation rights. Water rights are measured according to the flow over time from a central collection point *(berka)*. At present, irrigation rights are divided among 30 people, but other members of the community are entitled to use the water for other purposes. In recent years, water flow from the

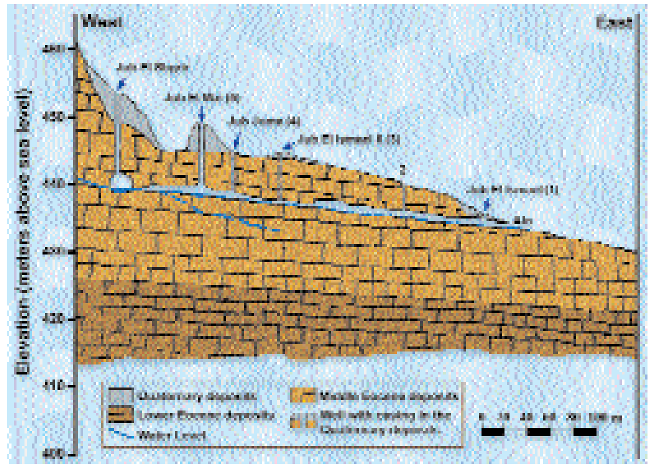
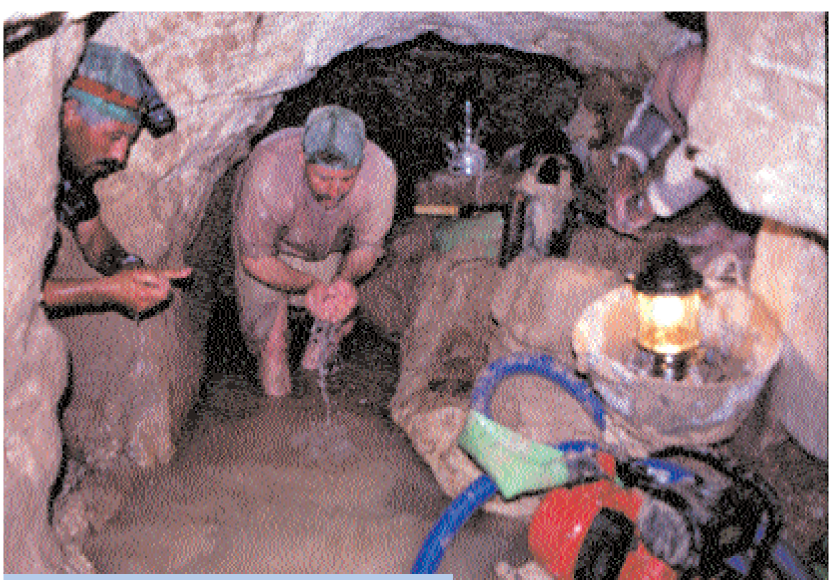


Fig. 22. A cross-section of the Qanat *of Shallaleh Sakhireh, south-west Aleppo, Syria. Lightfoot (1996).*

qanat has been declining due to deposits of silt and stones in the tunnel and parts of the floor have broken, allowing the water to drain away. The villagers thought that water flow would increase if the tunnel was cleaned and the floor re-lined. Unfortunately, they were unable to organize any collective action to maintain the *qanat*. Reasons included weak community leadership, inadequate financial resources, and migration to cities, together with community disputes and a perception that the transfer of land had led to an unequal distribution of water rights.



Cleaning work inside the qanat *tunnel*

The researchers decided that rehabilitation of the *qanat* would help to restore the community's social systems as well as their water supply, and sought help from the Syrian General Directorate of Antiquities and Aleppo Museum, as well as bringing in an anthropologist, an economist, and a hydrologist. Meetings with the community led to the development of a plan. The villagers themselves carried out the work and some of them were trained to continue the maintenance work. As a result, water flow increased by 25% in the following winter season, although it is not known if this improvement will be suistainable.

In the second phase, the research team interviewed local experts and representatives of government institutions and documented the geographical, socioeconomic, and hydrological characteristics of 42 sites in Syria using a map from Lightfoot (1996) as a reference (Fig. 23). The team identified 91 *qanats*, of which 30 are still flowing. They also developed georeferenced databases to record the characteristics of each *qanat*. It appears that the Syrian *qanat*s are drying up and being abandoned as water tables fall due to excessive pumping of groundwater. Once a *qanat* dries up, the local people lose interest in agriculture and drift into other occupations and off-farm employment. Inevitably, with the abandonment of *qanats*, much of the indigenous knowledge about their management is also lost.

Although many *qanats* in Syria have been permanently lost, those still flowing could be renovated and the local communities are generally willing to do the work. For example, in Dmeir, 45 km northeast of Damascus, villagers were keen to renovate their three flowing *qanats*. Using the experience gained in restoring the Shallaleh Sakhireh *qanat*, the team was able to design a renovation plan for the villagers to implement. They used their experience and the survey data to define criteria to identify the suitability of other *qanats* for rehabilitation. Criteria included the community's willingness to invest in future cleaning and renovation, local technical knowledge, the ability of water users to cooperate, and absence of excessive pumping around *qanat* sources.

The *qanat* project has important implications beyond the renovation of ancient community

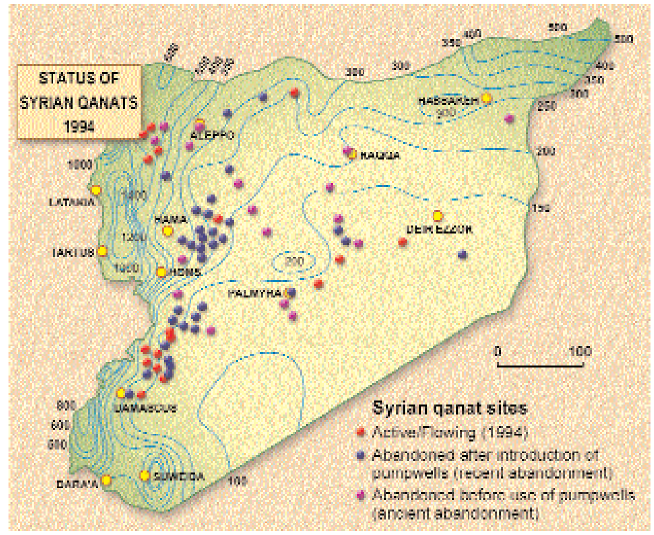


Fig. 23. Status of Syrian Qanats
(Source: Lightfoot, D.R. (1996). Syrian qanat Romani: history, ecology, abandonment. Journal of Arid Environments 33, (321-336).

water systems. It highlights how ancient systems can help to identify solutions to current problems of water management. The project shows how social organization and institutional mechanisms can be harnessed for effective community action. Lessons for improved management of *qanats* may also be applicable to other traditional systems, such as the *wadi* (stream) diversion systems of Yemen and Oman.

The project was funded by the governments of the Netherlands, Germany and Switzerland.

Socioeconomic studies such as the one reported above help scientists understand the different human influences on farming systems.

Project 4.2. Socioeconomics of agricultural production systems

Knowledge gained through socioeconomics studies can be applied when researchers work with farmers to develop improved, more sustainable production systems and household livelihood strategies. In 2001, ICARDA scientists studied the role of farmer-to-farmer seed exchange in distributing new varieties of barley, and examined the influence of different production systems on the nutritional status and pattern of growth in local children. The growing role of women in farming systems was the subject of two studies: the first examined their role as a source of agricultural labor and the second focused on the contribution of women to household livelihoods. All four studies were conducted in Syria.

Farmer-to-farmer seed tracer study

Barley, mainly two local landraces, 'Arabic Abiad' and 'Arabic Aswad,' covers about 1.5 million hectares of cultivated land in Syria. However, the average yield from these landraces is less than 1 t/ha. Barley breeders have developed several promising new varieties that can increase yields by an average of 20% over local landraces, without the need for additional inputs. For these new varieties to be successfully adopted, the seed should be easily and widely available to farmers.

Scientists from ICARDA assessed the role of farmer-to-farmer seed exchange in the distribution of new varieties by tracing the flow of seeds from 52 farmers in 24 villages in Syria. Barley breeders supplied each farmer with 100-200 kg of seed of the new varieties in the 1994/95 season, and traced the ensuing distribution for five years. The researchers also examined the reasons for farmers' acceptance of promising new barley varieties in different agroecological zones, and the extent to which farmer-to-farmer distribution of the seed was an autonomous process.

Most of the farmers involved in the study had already collaborated with the ICARDA barley improvement program, either through on-farm trials or by attending field days. Five promising new barley varieties ('Arta', 'Rihan', 'Zanbaka', 'Tadmor', and 'WI 2291') were distributed to them in the first year. Some farmers selected more than one variety and others chose only the one they considered most suitable for their environment. Farmers grew the new varieties in the same way as their local barley and without any supervision from ICARDA or national extension agents.

After five years, seeds of the new varieties had spread to 60 villages (Fig. 24). The process of technology transfer is summarized in Table 18. The total number of farmers monitored over the course of the study continued rising to reach 206 in the last year, but the number receiving new seeds each year declined after reaching a peak in the 1996/97 season.

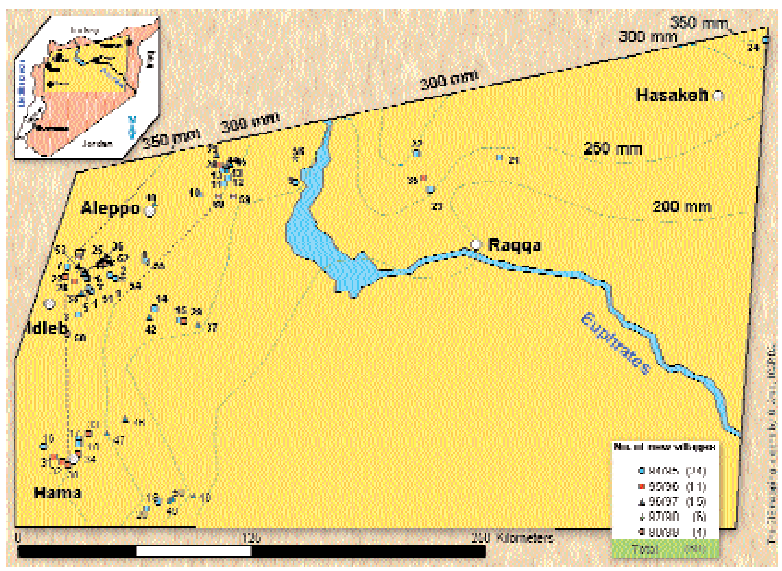


Fig. 24. Location of villages exposed to new varieties of barley for five years in Syria.

Growers were divided into two types: 'new growers,' planting the varieties for the first time, and 'adopters' who planted the new varieties again after evaluating them. The adoption rate peaked at 75% in the second year and then declined slowly, with no significant difference between the different agroecological zones studied. About 30% of grow-

Table 18. Diffusion of seed of new barley varieties.

	Cropping year					
	1994/95	1995/96	1996/97	1997/98	1998/99	Total
Farmers monitored:						
*Zone 1	1	12	25	28	28	**94**
Zone 2	37	58	86	115	134	**430**
Zone 3	14	27	38	43	44	**166**
Total	**52**	**97**	**149**	**186**	**206**	**690**
Growers:						
Adopters (at least second time growers)	—	39	58	59	48	**204**
New growers	52	45	52	35	20	**204**
Total	**52**	**84**	**110**	**94**	**68**	**408**
Adoption rate[1] (%)	**—**	**75**	**69**	**54**	**51**	

* Zone 1 (rainfall >350 mm per annum); Zone 2 (rainfall 300-350 mm per annum); Zone 3 (rainfall <300 mm per annum)

[1] Number of adopters/total number of growers in the previous year

ers in the first year grew more than one promising barley variety and some planted up to four varieties. This percentage dropped to only 4% in the last year, suggesting that farmers deliberately test several new varieties before selecting those best suited to their environment. This finding also suggests that they are retaining some of their traditional varieties in order to reduce losses in bad years. Although some farmers discontinued the new varieties, they did not necessarily reject the new seeds. Researchers discovered that about 35% had stopped growing barley altogether, choosing to introduce other options, such as fruit trees, particularly on stony and shallow soil. The average grain yield for the new barley varieties was higher than for the local landraces in all zones; the increase ranged from 53% in zone 1 to 160% in zone 2.

Farmers' opinions about new crop varieties they see in the field or grow themselves are important in that they reflect their own experience and judgment. In this study, farmers were asked to identify their reasons for continuing to grow the new barley varieties (Table 19). Higher yield was an important factor, and was the most frequently cited reason for growing 'Arta', 'Rihan', and 'Tadmor'. The lodging resistance of 'Rihan', a variety with good adaptation to relative-

Table 19. Subjective reasons (%) indicated by farmers for adoption of new barley varieties.

	'Arta'		'Rihan'			'Zanbaka'		'Tadmor'		'WI2291'
	Z2	Z3	Z1	Z2	Z3	Z2	Z3	Z2	Z3	Z3
1.Better yield than local	65.5	67	75.0	54.2	25.0	8.3	17.6	46.7	50.0	28.6
2.Early maturing	0.8	—	—	—	—	—	11.8	6.7	—	4.1
3.Cold resistance	2.5	—	—	—	—	—	—	—	—	—
4.Good size of grain	23.5	11	2.1	19.4	—	8.3	11.8	26.7	29.2	—
5.Good quality for sheep	26.1	11	—	4.5	—	—	—	20.0	—	—
6.Lodging resistance	6.7	22	75.0	52.9	25.0	—	—	6.7	—	18.4
7.Good tillering	7.6	11	—	0.6	25.0	—	—	—	12.5	—
8.Good purity	11.8	—	2.1	0.6	16.7	11.8	20.0	12.5	—	
9.Good plant height	1.7	—	—	13.5	50.0	25.0	35.3	—	12.5	32.7
10.Drought resistance	3.4	11	—	—	—	—	29.4	—	41.7	14.3
11.Black seed color	—	—	—	—	—	—	11.8	33.3	37.5	—
12.Disease resistance	1.7	—	—	1.3	—	—	—	—	—	—
13.Grain shattering resistance	0.8	2	—	1.3	—	—	—	—	—	—
14.White seed color	11.8	—	—	1.3	—	—	—	—	—	—
15.Good tall heads	4.2	—	—	—	—	—	—	—	—	—
Total number of observations	**119**	**9**	**48**	**155**	**4**	**12**	**17**	**15**	**24**	**49**

ly high rainfall, was highly valued. Many farmers in drier areas believed good plant height to be important, as this trait is thought to reduce the risk of total crop failure in a drought.

On average, farmers sold 60% of grain as feed, kept 13% to feed their own sheep, and retained 7% as seed for the next season. They sold only 3% as seed to other farmers. Barley is therefore regarded principally as a cash crop in this area. In the markets, grain from the new varieties fetched similar prices to that from landraces when sold as feed, but farmers were able to obtain higher prices when selling it as seed.

The high adoption rates achieved in this study illustrate the importance of farmer participation in evaluating new varieties and distributing seed. Farmer-to-farmer seed transfer appears to be a viable option for the dissemination of new varieties of cereals such as barley, especially when seed companies have been unable to meet local demand. Community-level seed technology needs to be developed to guarantee quality and to establish trusted local seed experts who can ensure a constant flow of new germplasm into communities. Such experts could be key partners in participatory germplasm improvement programs.

Child growth patterns and socioeconomic status of rural households with different production systems

In the WANA region, the number of people living below the poverty line is increasing. An estimated 72% of those affected live in rural areas, with agriculture being their main source of livelihood. Rural people, particularly women and children, bear the brunt of poverty, suffering from under-nutrition and high rates of infant morbidity and mortality. Under-nutrition is manifested in three main ways. Firstly, wasting, or rapid weight loss, resulting from acute dietary inadequacy or infections, affects about 5% of the rural poor in non-disaster situations but considerably more in emergencies. Secondly, stunting, or unsatisfactory linear growth, reflects prolonged poor nutrition and health and is the most prevalent manifestation of child under-nutrition worldwide. Thirdly, being underweight, although not necessarily leading to wasting, is a sign of both acute and chronic under-nutrition, and can have adverse long-term effects on health. In 2001, ICARDA researchers focused on an area in northwest Syria, aiming to trace the relationships between food systems, the socioeconomic status of agricultural households, and the nutritional wellbeing of children.

Villages and households, home to children of less than 10 years of age, were selected from three different production systems: irrigated agriculture, barley/livestock, and olive/fruit trees. In total, the researchers interviewed 207 households, and measured different nutritional and growth indicators for 538 children. They also conducted a participatory socioeconomic characterization exercise to identify the key criteria defining the wellbeing of village households (Table 20). Based on these criteria, the sampled households were classified into different wellbeing categories. Quantitative household data were collected on the most important variables identified by the key participants. The researchers then calculated the mean values for specific assets, labor, and growth variables and compared these for the different production systems.

The indices calculated for weight and height were compared to the international reference values recommended by the World Health Organization (WHO) and to the values obtained for a group of local school children. The highest incidence of stunting was found in the barley/livestock households, especially in girls, and the lowest in the irrigated system households (Fig. 25). The difference in the prevalence of stunting is very striking: the barley/livestock households have a much higher probability of suffering from poor nutrition and health than the other two groups, with the girls being particularly vulnerable. The reasons are likely to be associated with poor access to food and poor household food production, leading to poor overall food security. A similar distribution was found for underweight children (14.3% in barley/livestock compared with only 3.5% in irrigated systems). The percentage of boys who were underweight was higher than that of girls in all

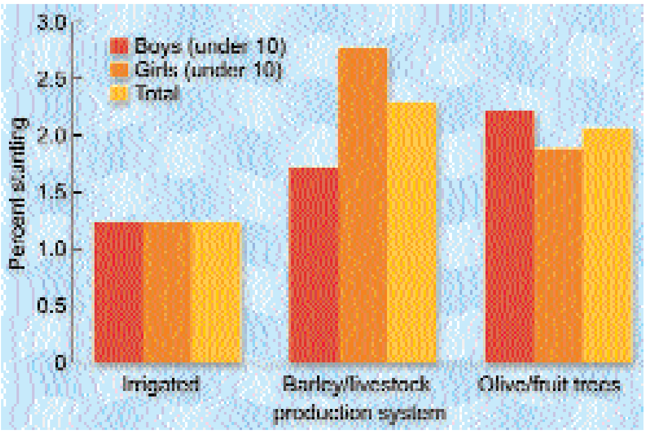


Fig. 25. Percentage of children under 10 years of age with moderate and severe stunting in different production systems in northwest Syria.

three systems, the highest being within the barley/livestock system (15.4%). Interestingly, wasting was uncommon, and was not found at all in the irrigated system.

These variations in the nutritional status of children can be explained partly by the socioeconomic conditions of the different households. Table 20 shows the proportion of households in each welfare category. The barley/livestock villages, where children had the highest incidence of stunting and wasting, also had the highest percentage of worst-off households (for example 49% in Serdah and 72% in Ruwayhib). Fewer of the poorest households were found in the olive/fruit tree and the irrigated systems, where stunting was also less prevalent.

Table 20. Criteria for socioeconomic classification, and percentage of households (HHs) per category for each surveyed village, by production system

Village	Production system	Category definition	*HHs per (%)	Criteria for wellbeing classification
Trinda	Irrigated	Rich Medium Poor	25 53 22	Total and percent of irrigated land ownership Access to water Supplementary income and type (e.g. shop owner versus wage labor) Wage labor in lower categories only Olive tree ownership
Al Staro	Irrigated	Upper medium Medium Lower medium	36 59 5	Total and percent of irrigated land ownership Type of supplementary income (wage labor only in lower categories) Olive tree ownership Land fragmentation
Serdah	Barley/livestock	Upper medium Medium Economic fatigue	22 30 49	Land ownership (rainfed only) Livestock ownership Wage labor (agricultural and non-agricultural) in all categories–absolute number important.
Ruwayhib	Barley/livestock	Medium Poor Very poor	8 19 72	Land ownership (rainfed only) Livestock ownership Wage labor (agricultural and non-agricultural) in all categories–absolute number important. Land fragmentation
Yakhor	Olive/fruit tree	Medium Lower Medium Poor	17 24 59	Olive tree ownership Quality of land Supplementary income and type Wage labor only in lower categories Land fragmentation

* Households

Analysis of socioeconomic variables indicated that many factors were implicated in making the barley/livestock households more vulnerable to under-nutrition. These households tend to have a higher dependence on wage labor, less productive land, fewer assets (50% of the families in Serdah have only one sheep), and, lacking irrigation and skilled labor, they have less opportunity to diversify their income. Although the barley/livestock systems had more cultivated land, more sheep, and more agricultural wage laborers than the other two systems, the income potential of these assets is lower than that of the irrigated and olive/fruit systems, which have more irrigated land, a larger area under fruit trees, and more employees. Growth variables, such as the number of children per household suffering from low height for age and low weight for age, differed significantly from system to system. Researchers are now looking at food intake patterns and associated health conditions in the three production systems.

The qualitative results indicated large differences in diet and lifestyle between the three systems. Households in the irrigated and olive/fruit systems had access to a greater variety of fresh fruit and vegetables, and were more likely to store or process food, than the barley/livestock households. Researchers observed a higher level of awareness of the nutritional content of different foods and the importance of variety in the diet. Factors such as higher levels of education, income, access to markets, health provision, sanitation facilities, and lower birth rates gave a distinct advantage to households in the irrigated and olive/fruit systems over the barley/livestock households. Different production systems therefore can influence child growth, a fact that underlines the importance of improving productivity and income generation in the poorer production systems.

Female agricultural labor is increasing

Population growth and changing demographic distribution affect the balance between urban and rural populations and the organization of agriculture. In Syria, population growth has been high since the 1960s. If these trends continue, the population is set to rise by about one third in the next 30 or 40 years, an increase of between seven and eight million people. Urban populations are growing faster than rural ones, and this trend is likely to continue in the future (Fig. 26). The needs of the growing population have led to widespread agricultural intensification, with the introduction of new crops and additional inputs such as fertilizers and irrigation. The demand for labor has also increased, leading to the emergence of a waged labor force. Since many men are migrating to urban areas to seek better paid work, the rural labor force is becoming predominantly female.

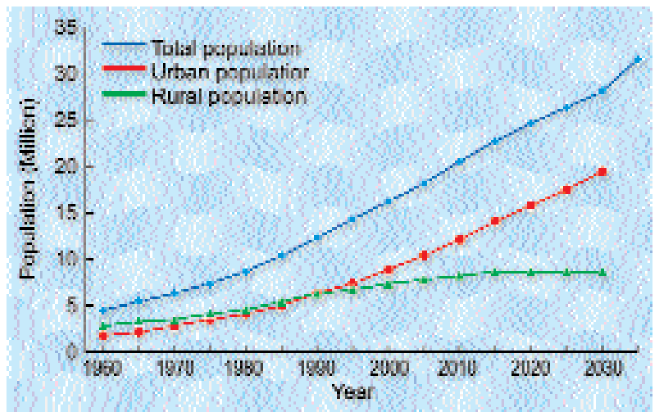


Figure 26. Projected population growth in Syria

To improve the design and target of new technology, researchers at ICARDA needed to find out how family and wage labor is allocated by gender within different farming systems. They also needed to identify labor supply and employment patterns in relation to agricultural intensification and assess the implications of male migration on women's involvement in agriculture. To meet these needs, they collected data from the Aleppo and Idlib provinces of northwest Syria, using qualitative and quantitative tools to investigate and record significant changes in agricultural production and labor supply in recent years.

The first noticeable change was that holding sizes have decreased as land is divided up among the members of expanding families. The most common size of holding is now just 10 hectares. Smaller holdings have encouraged farmers to intensify their production and reduce the amount of fallow land. Farmers are growing new varieties, using more fertilizer, making greater use of crop rotation systems, and expanding tree production. Irrigation has spread, with 40% of farming households now using it; these are mainly the smaller farms (<8 ha). Many wells were drilled in the drier areas during the 1990s, bringing benefits such as increased income and availability of crop residues as feed for livestock. The disadvantage is that farmers have decreased or completely stopped fallowing and this has had an adverse effect on livestock production, as household members have to stay on the farm looking after the irrigated crops instead of managing their grazing animals in the rangelands.

The main change in labor resources is the marked increase in the supply of, and demand for, female labor, as men have migrated to urban areas in search of better paid work. Researchers identified this trend in all the areas studied. Male income tends to be invested in building houses and making agriculture more productive. Male heads of the household usually continue to manage their farms and allow their sons to migrate. Women are often left behind with increasing responsibilities for managing farming activities. As activities such as harvesting cereals become more mechanized, women transfer to manual operations, while the mechanized work is performed exclusively by men. While mechanization has helped streamline men's activities, it has also decreased the demand for male labor, pushing men out of the agricultural sector.

The work of women in agriculture has also expanded as farmers have acquired more facilities to diversify and intensify their production, using more inputs and extending the growing season. As a consequence, farmers reported substantial shortages of labor, especially during April-June, July-August, and October-November. The majority (82%) of the households surveyed reported the most crucial period of labor shortage to be April-June, when the legume harvest competes with other crop-related tasks. Shortages also occur during October-November, when olive producers are especially affected.

Women harvesting lentils (left) and olives (right) in Syria.

The growing importance of female labor in agricultural production means that research and extension services will have to work more closely with women farmers and farm workers, seeking their opinions and involving them fully in technology development and transfer. Researchers may have to make more effort to involve them, as their knowledge and influence may not yet be recognized by the societies in which they live.

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

Women's contribution to household livelihoods in rural Syria

The increasingly important role of Syrian rural women in supplementing their family's income was analyzed further in 2001. Researchers conducted a study designed to describe and quantify the role of women in crop/livestock production systems, including their access to, and use of, natural resources. A further objective was to analyze how women's roles have changed and how they contribute to asset building in households of different economic status. The knowledge gained will enable the researchers to develop strategies to help rural women make the most of their opportunities. In the first phase of this study, researchers conducted rapid rural appraisals (RRAs) in 39 communities in 6 Syrian provinces. Different production systems were represented, including crop/livestock, supplemental irrigation, and fully irrigated. Interviews with male and female inhabitants provided information for characterizing the different communities, and a socioeconomic database was compiled for each community.

In phase two, researchers conducted household surveys in 12 communities (Table 21), making an in-depth assessment of household assets and livelihood strategies. The research covered:

- Quantification of the different uses of male and female labor in on-farm and off-farm activities
- Use of earned income by male and female household members in building household assets
- Identification of the key factors that determine women's involvement or disengagement in off-farm work.

Syrian rural women are playing an increasing role in supplementing their family's income and contributing to asset building.

Table 21. Surveyed communities by production system.

Crop/livestock system			Supplemental irrigation system			Full irrigation system		
Community	Annual rainfall (mm)	No. HH	Community	Annual rainfall (mm)	No. HH	Community	Annual rainfall (mm)	No. HH
Ruweiyheb	250	18	Breda	300-350	24	Ain Daraa	600	12
Djini El Albawi	250	16	Shweiha	250-350	22	Kafr El Ward	600	11
Mahmudly	200-250	30	Smariyeh	250-350	30	Hulu Abd	250	17
Makhrum	250	21	El Haraki	250-350	22	El Swatiyeh	250	24
Total		**85**	**Total**		**98**	**Total**		**64**

HH = Households

Table 22. Household female and male labor force involvement in on-farm and off-farm activities.

Activities	Crop/livestock system		Suppl. irrigation system		Full irrigation system	
	N	%	N	%	N	%
Women						
Cropping	5	0.03	63	41.2	40	28.0
Animal husbandry	24	16.0	38	24.8	25	18.1
Off-farm agricultural	72	48.0	40	26.1	45	32.6
Off-farm non-agricultural	5	3.3	4	2.6	5	3.6
No activities	44	29.3	8	5.2	23	16.7
Total	**150**	**100**	**153**	**100**	**138**	**100**
Men						
Cropping	32	22.0	70	39.8	60	46.8
Animal husbandry	23	15.8	14	7.9	16	12.5
Off-farm agricultural	34	23.4	35	19.9	32	25.0
Off-farm non-agricultural	49	33.8	46	26.1	16	12.5
No activities	7	4.8	10	5.7	4	3.0
Total	**145**	**100**	**176**	**100**	**128**	**100**

The community characterization and preliminary results of household surveys show that all males and females, aged between 12 and 65 years, normally contribute to household income through their active involvement in cropping, livestock husbandry, and paid work in both agricultural and non-agricultural off-farm activities.

In the crop/livestock system, 48% of women contribute through off-farm agricultural wage labor, a much higher percentage than in the supplemental and full irrigation systems, where most women work on their family farm (Table 22). In all three production systems, men are less involved than women in off-farm agricultural work, but more involved in non-agricultural work off the farm. Researchers are now conducting further analyses to determine how livelihood activities are influenced by the possession of different assets.

Theme 5. Strengthening National Seed Systems

Project 5.1. Strengthening national seed systems

When seed reaches farmers, it is the end product of a long process of varietal development research. ICARDA's role does not end with the development of an improved variety. A difficult task remains—to distribute the seed to farmers throughout the CWANA region, with a special need to reach the region's numerous small-scale farmers. The Center's Seed Unit collaborates with national programs to address the distribution issue, providing the backstopping they need to develop and manage their seed systems. In 2001, the Seed Unit made further progress in developing national seed supply systems, worked with small-scale farmers in Turkey to improve their access to improved seed, and organized training programs in line with the CWANA countries' needs.

Research for better seed systems

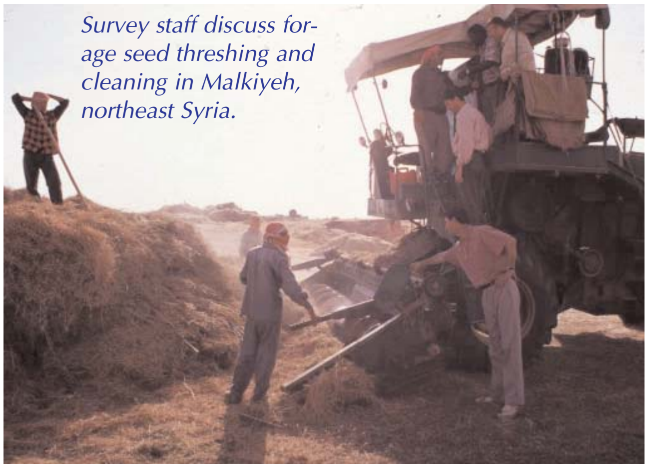
Research projects undertaken by the Seed Unit address practical problems associated with seed production and delivery. One such project, financed by the German Agency for Technical Cooperation (GTZ), is assessing the impact of policy changes on seed delivery to small-scale farmers so that recommendations on the best alternative mechanisms for seed supply can be made. National seed industries in the region are at different stages of development. Some have state-controlled seed supply systems and others have varying levels of private sector involvement. With changing macro policies, seed industry activities become more diverse, influencing the efficiency and effectiveness of seed supply to farmers. This project involved studies by local consultants in Egypt, Ethiopia, Jordan, Morocco, Pakistan, Syria, Turkey, and Yemen. The results of these studies have been analyzed and are being collated for a publication that will serve as a policy guide to seed sector development in the region.

Another research activity during 2001 examined the factors limiting the supply of forage seed. Inadequate supply of seed, linked to unfavorable economics, has constrained the uptake of forage technologies in the region. This study was based on a survey of farmers in northeast Syria and examined how the closely related issues of animal, forage, and seed production could be integrated into national livestock policies. The results of this study have also been analyzed and publications are being prepared.

The Seed Unit worked closely with ICARDA's Arabian Peninsula Regional Program, based in Dubai, to produce quality seed of native grasses for sowing in the rangelands as an alternative source of pasture. Because grass species differ widely, the standard cleaning methods used for other crop seeds may not be adequate, and the modification of equipment and/or techniques may be necessary. Chaffiness, long awns, and fragility are among the physical features of grass species that make seed processing difficult. Several tests were carried out to assess the seed-cleaning efficiency of standard equipment in order to identify and recommend changes and additions suited to the grass species concerned. Based on these results, two sets of new threshers and seed-cleaning machines were identified and are now available for processing grass seed in Oman and the United Arab Emirates.

Working with farmers to improve local seed supply

The problem of distributing new varieties amongst small-scale farmers is a key constraint to raising farm productivity and household income, maintaining food security, and helping to alleviate poverty in developing countries. Seed delivery is often a weak link between variety development and adoption by farmers, particularly for self-pollinating crops such as wheat, barley, lentil, and chickpea. The Seed Unit is collaborating with the Southeastern Anatolia Project (GAP) in Turkey to identify alternative institutional arrangements that could overcome this familiar bottleneck. As part of this effort, ICARDA organized a visit for nine farmers and technical staff from southeastern Anatolia to examine seed multiplication fields and other experimental plots on the ICARDA farm and to hold dis-


Survey staff discuss forage seed threshing and cleaning in Malkiyeh, northeast Syria.


ICARDA researchers discuss seed issues with farmers involved in the Southeastern Anatolia Project in Turkey.

cussions with other farmers working with the Syrian General Organization for Seed Multiplication (GOSM). During this visit the farmers identified crop varieties of interest for their own testing and distribution to other farmers in the region.

The Seed Unit also collaborates with the ICARDA Farmer Participatory Barley Improvement Project in the development of seed-cleaning facilities for farmers based on locally manufactured machines. These facilities could form the basis for organizing groups of farmers into small-scale enterprises as alternative seed suppliers within local communities. Following rigorous tests, four new machines are being built for delivery to farming communities in pilot sites.

Learning and training

Over the last 15 years the Seed Unit has carried out a comprehensive 'train-the-trainers' program, which has helped to establish a strong technical basis for many national seed programs in the region. This was made possible through the joint assistance of the Governments of the Netherlands and Germany through DGIS and GTZ, respectively. Seed Unit staff have learned a lot through interacting with farmers, technical staff, administrators, and policy makers at different levels.

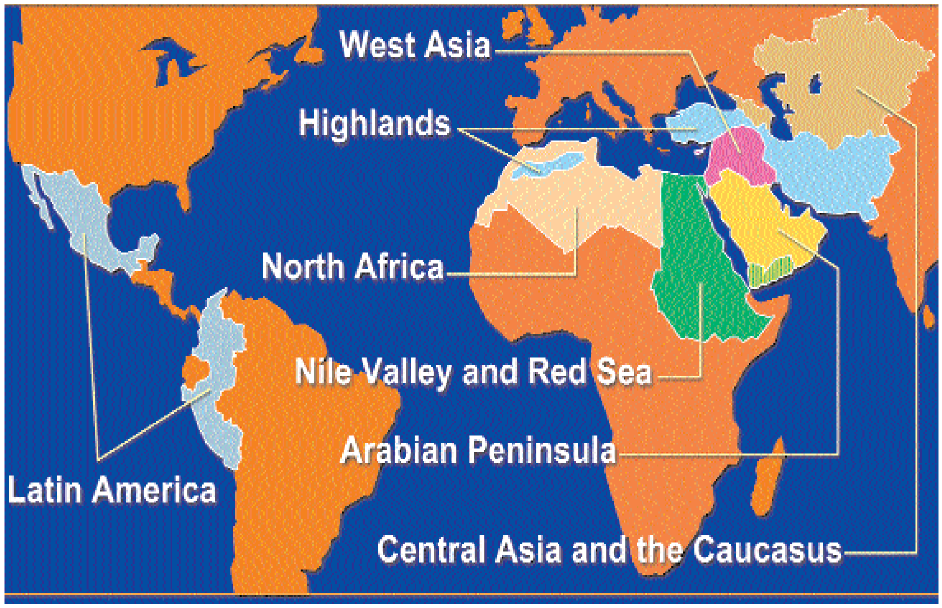
Seed programs in the region are changing as countries undergo economic reform, and ICARDA has modified its training strategy to adapt to this diversification. There is now less emphasis on instruction in specific technical subjects and more attention paid to policy and business management. The Seed Unit jointly identifies training needs with bilateral aid agencies, bringing together ICARDA seed specialists and participants from different countries to discuss and exchange ideas and experiences. Such a training program on variety management was organized in 2001 for 11 participants from 6 countries, some of them sponsored by FAO and UNDP.

Similarly, a course in Seed Production and Marketing for seed producers, dealers, and extension staff in Turkey was sponsored by GAP with technical contributions from the Seed Unit. A total of 20 leading professionals from different agricultural institutions in southeastern Anatolia participated in this course, which took the form of a week's 'retreat' on the largest state farm in Turkey. Intensive brainstorming was a major part of the course and resulted in recommendations for developing more effective alternative seed delivery systems for the main crops grown by small farmers in the region.


Round-table discussion at a training course at ICARDA on Seed Program Management.

International Cooperation

ICARDA continues to maintain strong and mature partnerships with NARS in the dry areas of CWANA and beyond. These close relationships widen the scope of the Center's research and training efforts on germplasm improvement and natural resource management, ensuring that transfer of technology is effective, and sustainable increases in agricultural productivity are made. Making the most of the strengths of national systems, ICARDA also bridges any gaps by providing new germplasm and technical backstopping, and offering human resource development programs.



ICARDA Regional Programs

In 2001, as part of a CGIAR System-wide effort, ICARDA, NARS, and sub-regional organizations in CWANA began to revisit the agricultural research priorities of the region with a view to integrating CGIAR activities within identified regional priorities. ICARDA already follows a sub-regional research approach in the different agroecologies of CWANA and plays a coordinating role in finding solutions to problems of agriculture in dry areas. The current Regional Programs address the needs of the following sub-regions in CWANA: North Africa, Nile Valley and Red Sea, West Asia, Arabian Peninsula, Highlands, and Central Asia and the Caucasus. The Latin America Regional Program implements ICARDA's global mandate in the dry areas in that region.

Two major declarations in support of agricultural research and investment in rainfed areas of CWANA occurred in 2001. The first, the Issyk-kul Declaration, resulted from a ministerial meeting in CAC, and supports investment in agricultural research to enhance development in Central Asia and the Caucasus region. The second, the Rabat Declaration, was the major outcome of a similar meeting in Morocco, and calls for increased attention to, and investment on, agricultural research in the dry areas of WANA.

North Africa Regional Program

The North Africa Regional Program (NARP) serves Algeria, Libya, Mauritania, Morocco, and Tunisia and is administered through ICARDA's regional office in Tunisia. Several projects were implemented in 2001, 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 the Arab Fund for Economic and Social Development (AFESD), the International Fund for Agricultural Development (IFAD), and the International Development Research Centre (IDRC); "Institutional Options for Rangeland Management," supported by the Ford Foundation and the Systemwide Program for Collective Action and Property Rights (CAPRi); "Utilization of Shrubs," supported by the Systemwide Livestock Program (SLP); "Development of Biotechnological Research in the

Arab States," funded by AFESD; "Optimizing Soil Water Use," supported by the Systemwide Program on Soil, Water and Nutrient Management (SWNM); and the research on Pilot IPM Site in Morocco, which was supported by the Systemwide IPM Program.

A formal agreement of collaboration was signed by H.E. Ahmady Ould Hamady (right) Minister of Agriculture, the Islamic Republic of Mauritania, and Prof. Dr Adel El-Beltagy on behalf of ICARDA.

Collaborative research activities, annual coordination meetings, specialized workshops, and exchange visits by farmers, scientists, and administrators continued to strengthen ICARDA's partnerships in North Africa. Algeria requested further technical assistance to implement its National Agricultural Development Plan. The ICARDA Seed Unit helped Moroccan plant breeders to review their seed production program. Two new collaborative projects supported by USDA/FAS, were started in Tunisia: "Biological Diversity and Cultural and Economic Value of Medicinal, Herbal, and Aromatic Plants in Southern Tunisia" and "GIS and Watershed Management in Southern Tunisia." New partnerships were forged through agreements with the Ministry of Rural Development and Environment of Mauritania, the Maghreb Arab Union, and the Institut des Régions Arides (IRA), Tunisia.

The Rabat Declaration was the outcome of a high profile ministerial meeting on "Opportunities for Sustainable Investment in Rainfed Areas of WANA," held in Morocco in June. Organized by the World Bank, the meeting brought together international organizations, donors, and ministers from 14 countries. The participants agreed to form partnerships that will promote sustainable development of dryland agriculture in the region. ICARDA will act as the secretariat and will coordinate the efforts of national, regional, and international organizations.

National coordination meetings were held in Algeria, Libya, Morocco, and Tunisia to review the results of collaborative research and plan for the future. Participants in the Mashreq/Maghreb project reviewed their latest results and discussed activities to be implemented in the final year of the

Participants in the international conference on "Policy and Institutional Options for the Management of Rangelands in Dry Areas," jointly organized by the Tunisian national program, ICARDA, IFPRI/CAPRi and ILRI, in Hammamet, Tunisia, in May 2001.

project. More than 80 delegates, including farmers, policy makers, and scientists, attended a regional workshop entitled "Technical, Policy, and Institutional Options for the Development of Communities in the Dry Areas" organized by the Mashreq/Maghreb project. They discussed their experiences in working with communities and reviewed the methodologies and tools developed for this purpose. The participants visited the community of Sidi Boumehdi in Morocco and observed how the community approach had developed. They were also able to see for themselves the difficulties and opportunities faced by communities in areas of low rainfall.

ICARDA, IFPRI, the International Livestock Research Institute (ILRI), and CAPRi jointly organized an international conference on "Policy and Institutional Options for the Management of Rangelands in the Dry Areas" in Tunisia in May. More than 60 participants attended including farmers, pastoralists, policy makers, and scientists. The participants reviewed recent studies on the policy and property rights aspects of rangeland management in the dry areas. Various institutional options had been tested, and participants made recommendations for institutionalizing the more successful approaches.

"Sustainable Management of Agro-Pastoral Resources" was the title of a workshop held in Morocco in February, with support from the Swiss Agency for Development and Cooperation (SDC). Moroccan farmers, researchers, and policy makers attended, along with scientists from ICARDA.

Collaborative projects with other ICARDA regional programs included the delivery of cactus pads for livestock feed. Three scientists from the CAC Livestock Project visited Tunisia in November to gain experience in rainfed agriculture.

Nile Valley and Red Sea Regional Program

The Nile Valley and Red Sea Regional Program (NVRSRP) coordinates ICARDA's activities in Egypt, Eritrea, Ethiopia, Sudan, and Yemen through a regional office in Cairo. Crop improvement projects in the region include: "Food Legumes and Cereals Improvement in Egypt," "Control of Wild Oats in Cereals and Other Winter Crops in Egypt," and a project on "Strengthening Client-Oriented Research and Technology Dissemination for Sustainable Production of Cool Season Food and Forage Legumes" in Ethiopia. Several activities in NVRSRP address issues of sustainable natural resource management, such as the "Resource Management Project" supported by the European Union (EU) and the World Bank; the "Matrouh Resource Management Project" in Egypt, supported by the World bank and the Government of Egypt; and the project on "Improving Natural Resources Management and Food Security for Rural Households in the Mountains of Yemen," supported by IDRC. In addition, problem-solving regional networks are operating in Egypt, Ethiopia, Sudan and Yemen, with funding from the respective national programs. Projects in Egypt span subjects such as IPM in faba bean, computer expert systems for faba bean production, and genetically engineered stress resistance in lentil. In Eritrea, scientists are studying integrated disease management in cereals and grasspea genetic improvement. Projects to investigate on-farm water husbandry and village-based participatory breeding are being

ICARDA and AGERI (Agricultural Genetic Engineering Research Institute, Egypt) signed a twinning areement in 2001 for collaboratrive research. TAC Chair, Dr Emil Q. Javier (right, front), during the course of TAC meeting held at ICARDA, visited AGERI. Here he is seen with Prof. Dr Adel El-Beltagy (right, back), ICARDA DG; Prof. Dr Saad Nassar (left, back), President of the Agricultural Research Center, Egypt; and Dr Magdi Madkour, undertaken in Yemen and Egypt, and scientists are using biotechnology in crop improvement research in Sudan and Egypt.

H.E. Prof. Dr Youssef Wally (center, right), Deputy Prime Minister and Minister of Agriculture and Land Reclamation, Egypt, discussed the strategic issues and approaches identified at the Annual Regional Coordination Meeting of the Nile Valley and Red Sea Regional Program. Present at this meeting were Prof. Dr Adel El-Beltagy (center, left) ICARDA DG; heads of delegations from Egypt, Ethiopia, Sudan and Yemen; and senior management staff of ICARDA.

The Agricultural Genetic Engineering Research Institute (AGERI) in Egypt and ICARDA signed a twinning agreement to define the framework for mutual collaborative research on genes for abiotic stress in wheat and barley, lentil and chickpea transformation, and virus diseases of figs in western Egypt. ICARDA is collaborating with the Central Laboratory for Agricultural Expert Systems (CLAES) in Egypt to develop computer systems for agricultural management and pest control in wheat, faba bean, and cucumber. A twinning agreement is expected to be signed between CLAES and ICARDA to further strengthen this collaboration.

Annual national coordination meetings were held in Sudan, Egypt, and Yemen, attended by scientists and researchers from the national systems and universities. Participants discussed the past year's activities and developed work plans for the next season.

The 11th NVRSRP regional coordination meeting was held in Egypt in September. Participants included the Directors of the NARS of Egypt, Ethiopia, Sudan, and Yemen, ICARDA senior management and about 100 scientists from these four NVRSRP countries and ICARDA. The participants discussed the results of collaborative research activities conducted during the 2000/2001 growing season and designed work plans for next year's activities. Following the steering committee meeting, H.E. Prof. Dr Youssuf Wally, Deputy Prime Minister and Minister of Agriculture and Land Reclamation of Egypt, convened in his office a meeting with NARS leaders and ICARDA Director General. He commended NVRSRP for its contributions to agricultural development in the region.

The program organized three traveling workshops. Participants in Egypt discussed resource management in connection with cultivation of wheat, barley, and wild oats, while in Ethiopia, improvements in production of lathyrus and highland cool-season legumes were discussed. Capacity building within the region was enhanced through training programs, visits, and workshops.

Ethiopian scientists visited Egypt to learn about chickpea wilt and root-rot, as well as biological control of Botrytis in faba bean. A group of 12 Sudanese farmers also visited Egypt within the framework of the IFAD-funded "White Nile Agricultural Services Project."

ICARDA scientists continued to provide technical assistance to the Matrouh Resource Management Project in Egypt on participatory barley breeding and to Yemen on natural resource management in highland terraced agriculture. An economic assessment of on-farm water-use efficiency in Egyptian agriculture, commissioned by ICARDA and the Economic and Social Commission for Western Asia (ESCWA) was outsourced to national scientists from the Soil, Water and Environment Research Institute and the Agricultural Economics Research Institute.

The EU commissioned ICARDA to undertake an evaluation mission in Egypt to assess the impact of Phase II of NVRSRP since 1994. Members of the mission examined past performance with respect to sustainable production of winter cereals and cool season food legumes, and the achievements in resource management and capacity building. They appreciated the support and interest of the Egyptian Government and ICARDA's contribution to the success of the project. The mission also noted the impact of the project on strengthening agricultural research and sustainable agricultural development in Egypt.

West Asia Regional Program

The West Asia Regional Program (WARP) promotes regional cooperation in research, training, and information dissemination in Cyprus, Iraq, Jordan, Lebanon, Palestine, Syria, and the lowlands of Turkey. The collaborative research covers barley participatory breeding, on-farm water husbandry, production and utilization of multi-purpose fodder shrubs and trees, and the development of biotechnological research. Major regional collaborative research projects in the region include the GEF/UNDP Project on "Conservation and Sustainable Use of Dryland Agro-biodiversity" and the trans-regional "Mashreq/Maghreb project."

The third regional steering committee and technical planning meetings of the dryland agro-biodiversity project were held in Syria in October. Fifty-five participants attended, representing GEF, UNDP, and the National Project Components, as well as researchers from ICARDA, IPGRI, and ACSAD. A regional workshop on "Monitoring of Adoption and Impact Assessment of Transferred Improved Technologies" was held in Iraq in March, where more than 20 participants discussed and agreed approaches and methodologies to be used in the Mashreq/Maghreb project. This project also hosted a traveling workshop for farmers. The group visited ICARDA headquarters and research stations and monitored on-farm activities in Lebanon and Syria. Farmers and extension agents involved in the dryland agro-biodiversity project were also invited to a traveling workshop. They visited the experimental stations and the project sites in Jordan, Lebanon, and Syria. Two national workshops were held in Jordan, on "Rangeland Management Strategy" and "Plant Variety Protection." Farmers and scientists from CAC were invited to a traveling workshop on "Rainfed and Irrigated Agriculture" in Jordan, Syria, and Turkey in May.

Arabian Peninsula Regional Program

The Arabian Peninsula Regional Program (APRP) supports ICARDA's collaboration with Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab

Farmers from Mashreq and Maghreb countries with some members of the ICARDA Board of Trustees—Mr Robert Havener, Dr Margaret Catley-Carlson, Dr Mamdouh A. Sharafeldin, Dr Peter S.M. Franck-Oberaspach and Dr Seyfu Ketema—and senior management staff at ICARDA headquarters.

Emirates (UAE), and Yemen. Areas of collaborative research include water resource management, forage and rangeland management, and protected agriculture. The program is currently supported by AFESD, IFAD and the OPEC Fund for International Development.

The program made excellent progress in producing seed of indigenous forages, and in identifying agronomic practices to maximize seed production in the harsh environments of the region. The recently established seed technology unit was equipped with appropriate seed scarifying and cleaning equipment and unit will serve both research and training needs.

APRP makes full use of information technology and launched its own web pages (www.icarda.cgiar.org), which can be accessed through the ICARDA website. This initiative seeks to facilitate the exchange of knowledge, information, and expertise, both regionally and internationally. The program has initiated a weather information system with a network of automated weather stations continuously collecting data and making it available via the Internet. An initial version of an expert system on protected agricultural production of vegetables has been completed. An expert system for crop protection in cucumber is under development. Development of the information system for irrigation and fertigation of greenhouse crops is also underway. Information on expert systems will eventually be integrated with the weather information network and will be available online.

Terrace farming in Yemen is highly dependent on rainfall and harvesting of water from the watersheds around the terraces. APRP is the coordinator of a new research project to introduce cultivation of cash crops in greenhouses in the mountain terraces of Yemen. Elsewhere in the Arabian Peninsula, researchers have developed appropriate solarization techniques, and tested them in research stations and on private farms with excellent results to tackle the problem of soil-borne diseases in protected agriculture.

The Arabian Peninsula Regional Program organized its first travelling workshop and its second regional technical committee meeting at Al Joul in May 2001 in the Kingdom of Saudi Arabia. Here, traveling workshop participants examine a specimen of Tragnum nudatum *(Damaran), a native fodder shrub, growing in the experimental grazing unit at Tabrajal.*

The regional technical coordination meeting for Phase II of the APRP was held in Saudi Arabia and attended by 29 scientists. The agenda focused on rangeland seed production and irrigated forages. Prior to the meeting, a traveling workshop gave the participants a chance to see seed production activities and field research on rangelands in the northern part of the country.

APRP worked with the International Center for Biosaline Agriculture (ICBA) and the Ministry of Agriculture and Fisheries of the UAE to organize a symposium on “Prospects of Saline Agriculture in the GCC Countries” in March. An expert consultation meeting was also held on “Conservation and Sustainable Utilization of Plant Genetic Resources” in the Sultanate of Oman.

Highland Regional Program

The Highland Regional Program (HRP) serves the needs of agriculture in the high-elevation areas of Afghanistan, Iran, Pakistan, and Turkey as well as the Atlas mountain area in the Maghreb region. Collaborative activities include seed relief and technical assistance in Afghanistan, germplasm improvement of cereals and food legumes and natural resource management in Iran, exchange of germplasm and the Barani Village Development Project in Pakistan, and the Winter Wheat Improvement Program and Southeast Anatolia Project (GAP) in Turkey.

A major advance in Iran was made when Parliament granted the CGIAR Centers the status and privileges similar to those for the UN agencies and other international organizations. In addition, opportunities for collaboration increased when government reorganization created a single ministry to handle all agricultural entities and activities, paving the way for ICARDA to become involved in additional areas of agriculture such as range and livestock management. The "First Regional Conference on Yellow Rust in CWANA" took place in May and was attended by some 80 researchers from different countries as well as from ICARDA and CIMMYT. Twenty-five extension personnel and researchers attended a training workshop on the "Transfer of Technology through on-Farm Trials" in May. Over 40 Iranian researchers and 9 ICARDA scientists attended the 9th coordination and planning meeting in September. Fourteen Iranian researchers participated in courses on integrated pest management, GIS, molecular markers, expert systems, computing and data management, and scientific writing at ICARDA, while 32 students pursued PhD programs outside Iran.

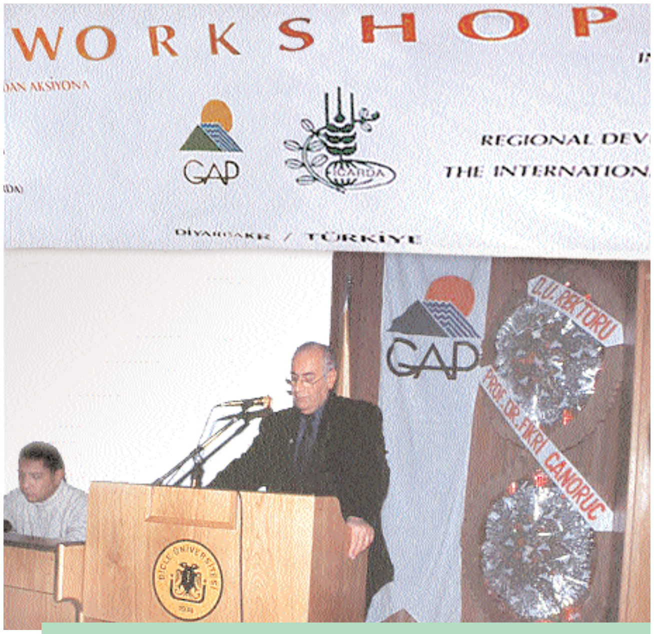
ICARDA DG, Prof. Dr Adel El-Beltagy (second from left) at the Arid Zone Research Center with Dr Umar Khan Baloch (left), PARC Chair; Dr Mahmoud Solh (third from right), ICARDA ADG (IC); the Director of AZRC (second from right); and Mr Abdul Majid (right), ICARDA's national professional officer for the Barari Village Development Project.

In Pakistan, ICARDA and national scientists have been working together to share improved germplasm and breeding material, rehabilitate rangelands, and build local capacity. The Center is also building capacity and providing technical assistance in rangeland and livestock management, on-farm water management, soil conservation, and socioeconomics to the Barani Village Development Project in Punjab Province. The transfer of technologies and research methodologies are major areas of emphasis in this project.

ICARDA has developed a strong partnership with Turkish NARS, based mainly on the decentralization of activities. During 2001, a number of projects were jointly conducted in winter and facultative wheat improvement, barley for cold areas, and winter-sown lentil. 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. A total of 116 sets of international nurseries were provided to Turkish partners for testing at research institutes and universities.

ICARDA also has a strong collaboration with the Southeastern Anatolia Project (GAP). The GAP/ICARDA collaborative activities include two projects: "On-farm Demonstrations and Seed Multiplication" and "Improvement of Natural Pastures and Forage Crops and Small Ruminant Production." Improved and adapted varieties of wheat, barley, lentil, and chickpea have been introduced, along with improved production practices. These are being transferred and adapted through on-farm trials in cooperation with progressive farmers. The introduced material is monitored and evaluated by GAP staff, local extension personnel, and ICARDA scientists. Agriculture in the GAP region is constrained by the lack of quality seed of improved varieties. A project-led workshop was held to raise awareness of the seed supply problem and discuss possible solutions.

Several meetings were jointly organized by GAP and ICARDA in 2001. The planning and the steer-



Inaugurating the GAP/ICARDA workshop, Prof. Dr Adel El-Beltagy, Director General of ICARDA, highlighted the achievements of the GAP project and the importance of partnership in achieving the common objective of improving the livelihoods of people.

ing committee meetings reviewed and discussed the achievements and approved the work plan for 2001/2002. An international workshop on rural development strategies was held in November. Participants included more than 100 scientists and administrators from GAP and ICARDA, representatives from FAO, NGOs and the Agricultural Research Center of Egypt, Egyptian officials from the Toshka Project, and universities in Turkey. The participants reviewed the existing policies, strategies, and the rural development process in the GAP region, and shared experiences in rural development.

Ten scientist and farmers from Central Asia and the Caucasus attended a regional traveling workshop, visiting on-farm demonstrations in the GAP region and exchanging information and ideas.

Central Asia and the Caucasus Regional Program

The Central Asia and the Caucasus Regional Program (CACRP) involves cooperative research with Kazakstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan in Central Asia, and Armenia, Azerbaijan, and Georgia in the Caucasus. Collaborative projects include germplasm improvement, plant genetic resources, soil and water management, and integrated feed and livestock production.
During the Fifth CAC/ICARDA Regional Coordination Meeting, participants formally agreed

On 18 September, ICARDA Director General Prof. Dr Adel El-Beltagy (left) and Academician Asad Musaev, Director General of Research and Production Association, Azerbaijan, signed an agreement outlining collaboration in plant genetic resources.

to collaborate in the collection, evaluation, conservation, and documentation of plant genetic resources in Azerbaijan. Other agreements of collaboration with ICARDA were signed in June by the National Academic Center for Agricultural Research in Kazakstan, and in Uzbekistan by the State University of Samarkand, the Samarkand Institute of Agriculture, Tashkent State Agrarian University, and Tashkent Institute of Irrigation and Agricultural Mechanization Engineers.

ICARDA scientists have been working with CAC colleagues to collect germplasm and set up national genetic resources units (see Project 3.3). In December 2000, a technical plant genetic resources meeting was organized in Tashkent to identify the practical elements of starting plant genetic resources work. The participants identified three scientists in each CAC country to work full-time on genetic resources activities.

The CAC countries agreed to adopt the Issyk-kul Declaration, committing all key partners to play a

Participants in the Issyk-Kul Meeting, Kyrgystan, 2001

proactive role in building and supporting a strong agricultural research system in the region.

Traveling workshops for CAC researchers were organized in Kazakstan and Kyrgyzstan on crop diversification and soil tillage, and in Jordan, Syria, and Turkey on water conservation technologies. CAC scientists were sponsored by ICARDA to attend the yellow rust conference in Iran, two traveling workshops in Uzbekistan, and consultation meetings on improving food legumes and spring barley in Kazakstan. Two scientists from Central Asia visited ICARDA headquarters to study the operation and maintenance of automatic weather stations.

Forty-three participants attended training workshops on "Integrated Feed and Livestock Production in the Steppes of Central Asia." In addition, regional workshops on "Improving Feed Resources in the Caucasus' and "Breed characterization of Livestock in the Caucasus" were jointly organized by ICARDA and ILRI.

Latin America Regional Program

The Latin America Regional Program (LARP) continues to support the countries of South America and Mexico in their efforts to improve production of barley and food legumes. Barley and faba bean are important components of the potato-based rotations in the high elevations of the Andes, and faba bean is important in the maize-based rotations at lower altitudes. Market globalization has encouraged the national programs to involve the private sector more in their efforts to increase local production and maximize export opportunities, while maintaining sustainable use of natural resources. In Peru, for example, international centers, national programs, and the private sector are working together to conduct food legume research linking identified markets with farmer organizations. Despite financial constraints, the Peruvian Ministry of Agriculture has approved a small grant to foster collaboration with ICARDA in food legume improvement.

LARP was active in 2001 in establishing and promoting links with NGOs, public agencies, El Colegio de Postgraduados in Mexico, and the Consortium for the Sustainable Development of the Andean Region (CONDESAN) in soil and water management. Two workshops were organized in the Peruvian semi-arid Andes in collaboration with the Cusichaca Trust and the National Program for Watershed Management and Soil Conservation, the largest public watershed management institution in Latin America. High-level decision makers and those involved in canal and terrace rehabilitation attended the workshop. LARP contributed with discussions on the socioeconomic issues of sustainable resource use and crop/livestock interactions in small watersheds. A productive exchange of experiences has been initiated with Mexican researchers working on adaptation of traditional water management systems to cope with the challenges of sustainable resource management and global markets. Some of the documents produced by LARP and its partners have been made public (in Spanish) through CONDESAN's website.

Support Services

Comunication, Documentation and Information Services

The Communication, Documentation and Information Services (CODIS) Unit is responsible for maintaining two-way communication with ICARDA's diverse audiences, including donors, research and development partners, policy makers and the general public in the CWANA region and beyond.

The year saw increased interest of the media in the Center's work. Research on crop improvement and natural resource management, particularly in the context of combating drought and climate change, was covered extensively in the regional media. The center's initiative to launch the "Future Harvest Consortium to Rebuild Agriculture in Afghanistan" received strong attention from the international media.

The Center's website (www.icarda.cgiar.org) continued to serve the important role of information dissemination and exchange. Web pages for the Center's Arabian Peninsula Regional Program were launched, and several new items were added to the site to improve its usefulness, including field guides, a list of crop varieties released, and even a legume cookbook. A new service, called e-NewsAlert, was launched to inform donors and cooperators by email when new material is posted. The website is also the gateway to ICARDA's library, with links to in-house and external databases, including the Food and Agriculture Organization (FAO) AGRIS and CARIS databases, USDA/NAL AGRICOLA, CAB International, CRIS/USDA for Current Research Projects and CGIAR's SINGER. The Unit was busy in 2001 working with CGIAR and FAO cooperators in the development of an inter-center web-based "Information Finder." The system, to be launched in mid 2002, will allow key-word searches of the library collections of the CGIAR's 16 centers.

CODIS produced a variety of publications during the year, including the Center's Annual Report. *The Week at ICARDA*, published in English and Arabic, keeps donors, research and development partners, and the press uptodate on the Center's activities and accomplishments, while *Caravan*, a glossy, full-color magazine presents the Center's research in clear and compelling style intended for a diverse audience. An uptodate list of publications is available on ICARDA's website. In addition, the Unit provided support the Center's researchers in processing their journal articles and conference presentations, as well as in designing and producing scientific posters.

Human resource development is another vital service provided by CODIS. Two national staff members from the Ethiopian Agricultural Research Organization received training in multimedia and audio-visual production. Another 13 participants from 10 countries were trained in scientific writing and data presentation. Five self-learning training modules were produced on CD-ROMs in key areas of research to support young researchers in the CWANA region.

Also, CODIS took the opportunity to raise the Center's profile by mounting prominent displays of publications, posters and multimedia products at the Damascus International Agricultural Fair, and at the Annual General Meeting of the CGIAR in Washington, DC.

Human Resource Development

In 2001, the Human Resources Development Unit (HRDU) continued to provide a wide range of training and support activities. Training courses were attended by 606 scientists from 41 countries in the CWANA region and further afield, while 64 students worked towards their MSc and PhD degrees. ICARDA continued to decentralize its training activities, with 19 (out of a total of 31) courses held in different countries, in partnership with the relevant NARS.

The following additional training courses were conducted for externally funded projects:

Three courses funded by GEF/UNDP: *Use of Geographic Information System (GIS) and Remote Sensing for Agrobiodiversity Assessment*;

Molecular Characterization for Biodiversity Studies; and *In-situ Conservation and Field Gene Bank Management*.

Three courses for the joint project on *Dryland Resources Management in the Arid Margins of Syria* funded by the Swiss Agency for Development and Cooperation (SDC) and the Graduate Institute for Developing Studies (IUED): *GIS Database Tools and Utilization of Geographical Positioning System (GPS) Receivers*; *Data Management for Rangeland Research*; and *Using Digital Elevation for Water Flows*.

Four courses as part of the Southeastern Anatolia Project (GAP): *Forage, Pasture, Range, and Livestock Production*; *Seed Production*; and *Principles of Livestock On-farm Research.*

Four regional courses funded by the Asian Development Bank (ADB): *Analytical Methods of Analysis of Soil, Plant, and Water*; *Optimizing Soil Fertility and Water Benefits Using Terracing on Sloping Lands*; *Irrigation Scheduling and Soil Monitoring Techniques*; and *Sustainable Agricultural Production Systems Utilizing Marginal Waters*.

Methods in Participatory Plant Breeding funded by the Danish International Development Assistance (DANIDA), held in Eritrea.

Design and Analysis of Field Experiments funded by the Agricultural Research, Education, and Extension Organization (AREEO) of Iran.

Design and Analysis of Field Experiments and Experimental Station Operation Management, held in Ethiopia.

A specialized course*: DNA Molecular Marker Techniques for Crop Improvement* organized for The Faculty of Agriculture, University of Khartoum, Sudan.

Water Saving and Increasing Water Productivity: Challenges and Options held in Jordan and *Appropriate Modernization and Management of Irrigated Systems* in Turkey.

Utilization of Expert Systems in Agricultural Research and Production in Egypt.

HRDU collaborates with a wide range of other organizations in order to provide good quality and appropriate training courses. Effors are underway to streamline the ICARDA Training Database, which is now available on the Center's Intranet.

Computer and Biometric Services

Information technology continues to be vital to the success of ICARDA activities. In 2001, the Computer and Biometric Services Unit (CBSU) initiated a major project to replace the old computer local-area network (LAN), installed in 1992. The Center now has a high-speed LAN, giving users a 100 Mbit/sec network speed. Security and virus protection measures have been enhanced through installing a firewall and a new anti-virus distribution system. ICARDA is leading the project to implement Windows 2000 Active Directory in all CGIAR centers. The Center successfully tested Windows 2000 Professional and is prepared for rollout in January 2002 with new equipment.

ICARDA's Intranet site is widely used by its staff, visitors and trainees, and the Center has revamped the design and upgraded the software running the site. A 'Travel Access Service' was established to support scientists when they travel. ICARDA's Cairo office now has its own LAN and Internet access for all networked computers, and the Center also designed and helped to install a LAN for the Ethiopian Agricultural Research Organization. CBSU designed and developed databases to manage travel schedules, training, water resources projects, and a computer model to simulate groundwater use in Syria. Based on the recommendations of the external auditor, the Unit implemented budgetary control in the Oracle financial system, customizing sixteen new reports.

The Unit provided biometric consultancies to various researchers on the design of experiments, statistical analysis of data, and the interpretation and presentation of results. Randomized plans for experimental design were provided for several projects, including evaluation of tillage systems for cereal-legume rotations, the effect of phosphagypsum on continuous barley cropping in the Khanasser Valley, evaluation of wheat collections, and the effects of insect-killing fungi on sunn pest. The Unit support in statistical analysis of QTL data for various traits in barley, root characteristics for drought tolerance in lentils, clustering of sources of wheat diseases, and variability in the wheat seed used by Syrian farmers. The Unit developed procedures and Genstat programs for spatial variability models, selecting the best model for various trials concerned with evaluation of different barley, lentil, and chickpea genotypes. Support was also extended to a number of visiting scientists from Ethiopia, Syria, and Tunisia in analyzing their data.

Finally, CBSU organized training courses for 41 staff from various NARS, who learned about statistical design, data management, and data analysis. In addition, the Unit trained around 60 ICARDA staff on various IT services and software.

Appendices

Appendix 1

Publications

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

Journal Articles

Bekele, B., K.M. Makkouk, A. Yusuf, F. Alemayu, and A. Lencho. 2001. Occurrence and distribution of barley yellow dwarf virus (BYDV) isolates in central Ethiopia. International Journal of Pest Management 47(2): 115-119.

Ceccarelli, S., S. Grando, E. Baily, A. Amri, M. El-Felah, F. Nassif, S. Rezgui, and A. Yahyaoui. 2001. Farmer participation in barley breeding in Syria, Morocco and Tunisia. Euphytica 122(3):521-536.

Descheemaeker, K., N. Cool, E. De Pauw, J. Deckers. 2001. Farming systems in Syria: towards a methodology for characterising and mapping farming systems. The Land 5(2): 101-118.

Di Vito, M., N. Greco, R.S. Malhotra, K.B. Singh, M.C. Saxena, and F. Catalano. 2001. Reproduction of eight populations of *Heterodera ciceri* on selected plant species. Nematologia Mediterranea 29(1):79-90.

El Bouhssini, M., J.H. Hatchett, T.S. Cox, and G.E. Wilde. 2001. Genotypic interaction between resistance genes in wheat and virulence genes in the Hessian fly *Mayetiola destructor* (Diptera: Cecidomyiidae). Bulletin of Entomological Research 91: 327-331.

El-Damir, M., M.N. Al-Salti, and M. El-Bouhssini. 2001. Ecology and biology of *Sitona crinitus* H. in northern Syria. Bassel Al-Assad Journal for the Sciences of Agricultural Engineering 14: 109-119. (In Arabic, English summary).

El-Muadhidi, M.A., K.M. Makkouk, S.G. Kumari, M. Jerjess, S.S. Murad, R.R. Mustafa, and F. Tari. 2001. Survey for legume and cereal viruses in Iraq. Phytopathologia Mediterranea 40(3): 224-233.

Eujayl, I., M. Sorrells, M. Baum, P. Wolters, and W. Powell. 2001. Assessment of genotypic variation among cultivated durum wheat based on EST-SSRS and genomic SSRS. Euphytica 119: 39-43.

Haj Kassem, A., K.M. Makkouk, and N. Attar. 2001. Viruses on cultivated forage legumes in Syria. Arab Journal of Plant Protection 19(2): 73-79. (In Arabic, English summary).

Hirata, M., N. Koga, H. Shinjo, H. Fujita, G. Gintzburger, and A. Miyazak. 2001. Vegetation classification by satellite image processing in a dry area of north-eastern Syria. International Journal of Remote Sensing 22(4): 507-516.

Jarrah, M. 2001. The world 2020: an agricultural and environmental vision. Environment and Development 6(34): 46-49. (In Arabic).

Katerji, N., J.W. van Hoorn, A. Hamdy, M. Mastrorilli, T. Oweis, and W. Erskine. 2001. Response of two varieties of lentil to soil salinity. Agricultural Water Management 47: 179-190.

Katerji, N., J.W. van Hoorn, A. Hamdy, M. Mastrorilli, T. Oweis, and R.S. Malhotra. 2001. Response to soil salinity of two chickpea varieties differing in drought tolerance. Agricultural Water Management 50: 83-96.

Khalil, S.A. and W. Erskine. 2001. Combating disease problems of grain legumes in Egypt. Grain Legumes 32(2): 24-26.

Kumari, S.G., K.M. Makkouk, L. Katul, and H.J. Vetten. 2001. Polyclonal antibodies to the bacterially expressed coat protein of faba bean necrotic yellows virus. Journal of Phytopathology 149: 543-550.

Kumari, S.G., K.M. Makkouk, and B. Bayaa. 2001. Pea enation mosaic virus 1- infecting lentil in Syria, and further information on its host range, purification, serology and transmission characteristics. Arab Journal of Plant Protection 19(2): 65-72. (In Arabic, English summary).

Makkouk, K.M., M. Bashir, R.A.C. Jones, and S.G. Kumari. 2001. Survey for viruses in lentil and chickpea crops in Pakistan. Journal of Plant Diseases and Protection 108(3): 258-268.

Makkouk, K.M. and S.G. Kumari 2001. Reduction of incidence of three persistently transmitted aphid-borne viruses affecting legume crops by seed-treatment with the insecticide imidacloprid (Gaucho). Crop Protection 20: 433-437.

Makkouk, K.M., S. Kumari, A. Sarker, and W. Erskine. 2001. Registration of six lentil germplasm lines with combined resistance to viruses. Crop Science 41(3): 931-932.

Makkouk, K.M. and N. Attar. 2001. Effect of storage and heat treatment on barley stripe mosaic virus (BSMV) in barley seeds. Arab Journal of Plant Protection 19(1): 52-54. (In Arabic, English summary).

Makkouk, K.M., S.G. Kumari, and D.E. Lesemann. 2001. First record of pea enation mosaic virus naturally infecting chickpea and grasspea crops in Syria. Plant Disease 85(9): 1032.

Makkouk, K.M., A. Najar, and S.G. Kumari. 2001. First record of barley yellow dwarf and cereal yellow dwarf viruses in Tunisia. Plant Pathology 50(6): 806

Makkouk, K.M., M.A. El-Muadhidi, and S.G. Kumari. 2001. First record of beet western yellows virus, chickpea chlorotic dwarf virus and faba bean necrotic yellows virus affecting faba bean (*Vicia faba*) crops in Iraq. Plant Pathology 50(6): 793.

Makkouk, K.M., S.G. Ghulam, and S.G. Kumari. 2001. First record of barley yellow striate mosaic virus and cereal yellow dwarf virus infecting barley and wheat in Lebanon. Plant Disease 85: 446.

Makkouk, K.M., S.G. Kumari, Z. Kadirova, and A. Zueva. 2001. First record of barley yellow striate mosaic virus and cereal yellow dwarf virus-RPV infecting wheat in Uzbekistan. Plant Disease 85(10): 1122.

Nachit, M.M., I. Elouafi, M.A. Pagnotta, A. El-Saleh, E. Iacono, M. Labhilili, A. Asbati, M. Azrak, H. Hazzam, D. Benscher, M. Khairallah, J.M. Ribaut, O.A. Tanzarella, E. Porceddu, and M.E. Sorrells. 2001. Molecular linkage map for an intraspecific recombinant inbred population of durum wheat (*Triticum turgidum* L. var. *durum*). Theoretical and Applied Genetics 102: 177-186.

Nielsen, T.L. and M.A. Zoebisch. 2001. Multi-factorial causes of land-use change: land-use dynamics in the agropastoral village of Im Mial, northwestern Syria. Land Degradation and Development 12: 143-161.

Oweis, T. and A. Hachum. 2001. Reducing peak supplemental irrigation demand by extending sowing dates. Agricultural Water Management 50: 109-123.

Sarker, A., B. Bayaa, and W. Erskine. 2001. Registration of six lentil germplasm lines with resistance to vascular wilt. Crop Science 41(5): 1655.

Sarker, A., M. Singh, and W. Erskine. 2001. Efficiency of spatial methods in yield trials in lentil (*Lens culinaris* ssp. *culinaris*). Journal of Agricultural Science, Cambridge 137: 427-438.

Udupa, S.M. and M. Baum. 2001. High mutation rate and mutational bias at (TAA)n microsatellite loci in chickpea (*Cicer arietinum* L.). Molecular Genetics and Genomics 265: 1097-1103.

Valkoun, J.J. 2001. Wheat pre-breeding using wild progenitors. Euphytica 119(1-2): 17-23.

Van de Wouw, M., N. Maxted, K. Chabane, and B.V. Ford-Lloyd. 2001. Molecular taxonomy of *Vicia* ser. *Vicia* based on amplified fragment length polymorphisms. Plant Systematics and Evolution 229: 95-105.

Van Eeuwijk, F.A., M. Cooper, I.H. DeLacy, S. Ceccarelli, and S. Grando. 2001. Some vocabulary and grammar for the analysis of multi-environment trials, as applied to the analysis of FPB and PPB trials. Euphytica 122(3):477-490.

Yau, S.K., H. Machlab, and P. Kiwan. 2001. Grain legumes and their uses in Lebanon. Grain Legumes 34(4) 25-26.

Zaharieva, M., P. Monneveux, M. Henry, R. Rivoal, J. Valkoun, and M.M. Nachit. 2001. Evaluation of a collection of wild wheat relative *Aegilops geniculata* Roth and identification of potential sources for useful traits. Euphytica 119 (1-2): 33-38.

Appendix 2

Agreements signed in 2001

Agreements of cooperation with international and regional organizations

27 March 2001. Agreement between the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Water Management Institute (IWMI).

26 June 2001. Memorandum of Understanding between the General Secretariat of the Arab Maghreb Union (UMA) and the International Center for Agricultural Research in the Dry Areas (ICARDA).

Agreements of cooperation with national governments and institutions

Azerbaijan

18 September 2001. Agreement between the Agrarian Science Center of Azerbaijan and the International Center for Agricultural Research in the Dry Areas (ICARDA).

Egypt

8 April 2001. Twinning Agreement between the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Agricultural Genetic Engineering Research Institute (AGERI) of the Agricultural Research Center (ARC), Ministry of Agriculture and Land Reclamation, Egypt.

Kazakstan

6 June 2001. Memorandum of Agreement between the National Academic Center for Agricultural Research (NACAR) in Kazakstan and the International Center for Agricultural Research in the Dry Areas (ICARDA) concerning Scientific and Technical Cooperation.

Mauritania

6 February 2001. Agreement of Cooperation between the Ministry of Rural Development and Environment in the Islamic Republic of Mauritania and the International Center for Agricultural Research in the Dry Areas (ICARDA).

Tunisia

20 August 2001. Agreement of Cooperation between Institut des Régions Arides (IRA), Medenine, the Republic of Tunisia and the International Center for Agricultural Research in the Dry Areas (ICARDA).

Uzbekistan

11 June 2001. Memorandum of Agreement between the Samarkand Institute of Agriculture in Uzbekistan and the International Center for Agricultural Research in the Dry Areas (ICARDA) concerning Scientific and Technical Cooperation.

11 June 2001. Memorandum of Agreement between the State University of Samarkand in Uzbekistan and the International Center for Agricultural Research in the Dry Areas (ICARDA) concerning Scientific and Technical Cooperation.

12 June 2001. Memorandum of Agreement between the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME) in Uzbekistan and the International Center for Agricultural Research in the Dry Areas (ICARDA) concerning Scientific and Technical Cooperation.

12 June 2001. Memorandum of Agreement between the Tashkent State Agrarian University of Uzbekistan and the International Center for Agricultural Research in the Dry Areas (ICARDA) concerning Scientific and Technical Cooperation.

Appendix 3

Restricted Projects

ICARDA's research program is implemented through 19 research projects, as detailed in the Center's Medium-term Plan. Restricted projects are activities 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 6. Reports on the activities listed here are encompassed in the appropriate sections in this Annual Report. During 2001, the following Restricted Projects were in operation:

Arab Fund for Economic and Social Development (AFESD)

- 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 in the Arabian Peninsula
- Development of biotechnological research in the Arab States

Asian Development Bank

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

Australia

Australian Centre for International Agricultural Research (ACIAR)

- Near-isogenic lines for the assessment of pathogenic variation in the wheat stripe (yellow) rust pathogen
- Improvement of lentil and grasspea in Bangladesh
- 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
- Development and conservation of plant genetic resources from the Central Asian Republics and associated regions
- Conservation, evaluation, and utilization of plant genetic resources from Central Asia and the Caucasus
- Host plant resistance, epidemiology, and integrated management of faba bean, chickpea, and lentil diseases
- Impact of ICARDA research on Australian agriculture

Grains Research and Development Corporation (GRDC)

- Preservation and utilization of the unique pulse and cereal genetic resources of the Vavilov Institute
- International selection, introduction, and fast tracking of kabuli chickpea with large seed size, high biomass, high yield, and ascochyta resistance
- Selection of faba bean, chickpea, and lentils for resistance to luteoviruses
- International collaboration in barley research between ICARDA and Waite Campus Institutions
- Technologies for the targeted exploitation of the N.I. Vavilov Institute of Plant Industry (VIR), ICARDA, and Australian bread wheat landrace germplasm
- Coordinated Improvement Program for Australian Lentils (CIPAL)
- Coordinated improvement of chickpeas in Australia

Belgium

Flemish Association for Development Cooperation and Technical Assistance (VVOB)

- Has provided an Associate Expert in the utilization of remote sensing techniques for monitoring changes in land cover and land use in ICARDA's mandate region, and a Research Assistant in land resources assessment

Canada

CGIAR-Canada Linkage Funds

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

CGIAR Systemwide Programs

CGIAR Impact Assessment and Evaluation Group (IAEG) Study: 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 Initiative on Collective Action and Property Rights (CAPRi)

- Community and household-level impacts of institutional options for improving rangeland management in the low rainfall areas of Jordan, Morocco, Syria, and Tunisia

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 Livestock Program (SLP)

- Production and utilization of multi-purpose fodder shrubs and trees in West Asia, North Africa, and the Sahel
- On-farm characterization of small-ruminant breeds in Central Asia and the Caucasus
- Increasing feed resources and efficiency of utilization in Armenia, Georgia, and Azerbaijan

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

- Village-based participatory breeding in the terraced mountain slopes of Yemen

Systemwide Water Resources Management Program (SWIM)

- On-farm water use

Systemwide Program on Soil Water and Nutrient Management (SWNM)

- Optimizing soil water use

International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM)

- Collaborative Molecular Biotechnology Integrating Network (COMBINE) 2000-2002: 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 environmental conservation in Mediterranean arid and semi-arid production systems
- Development of legumes and forage screening nursery for salinity tolerance

Denmark

- Collaborative research in Eritrean National Seed Development Program (ENSDP)
- Integrated disease management to enhance barley and wheat production in Eritrea
  Has provided a Junior Professional Officer for milk transformation, and a Junior Professional Officer for characterization of small ruminant production and associated local knowledge systems

European Commission (EC)

- Nile Valley Regional Program - Egypt Phase II
- Nile Valley Regional Program Wild Oats Project – Egypt: control of wild oats in cereals and other winter crops

EC: 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

Egypt

- Nile Valley Regional Program, Egypt Phase II
- Matrouh Resource Management Project

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

- Water use in agriculture

Food and Agriculture Organization of the United Nations (FAO)

- Dryland pasture, forage, and range newsletter
- Expert consultation meeting on integrated production and management for protected agriculture in the Arabian Peninsula
- Second meeting of the Oat and Vetch Regional Network
- FAO-EU-ICARDA Expert consultation on drought mitigation
- Electronic production of agricultural documents and bibliographic database management
- Translation of AGROVOC terms into Arabic
- International workshop on food barley

Ford Foundation

- Community and household-level impacts of institutional options for improving rangeland management in the low-rainfall areas of Jordan, Morocco, Syria, and Tunisia

Germany

- DNA marker-assisted breeding and genetic engineer-

ing of ICARDA-mandated crops
- Improving seed production and marketing systems in the WANA region
- Action research for sustainable groundwater use in Syria
- An integrated approach to sustainable land management in dry areas

International Development Research Centre (IDRC)

- From formal to participatory plant breeding: improving barley production in the rainfed areas of Jordan
- Community-level impacts of policy, property rights, and technical options in the low-rainfall areas of Morocco, Tunisia, and Syria
- Improving natural resource management and food security for rural households in the mountains of Yemen

International Fund for Agricultural Development (IFAD)

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

International Nutrition Foundation

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

Iran

- Scientific and technical cooperation

Italy

- Collaborative research project in durum grain quality
- Has provided an 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

Japan: Attributed Funding

- Rehabilitation and improved management of native pastures and rangelands in dry areas
- Improving small-ruminant production in dry areas
- Germplasm enhancement for diversification and intensification of agricultural production in Central Asia and the Caucasus

Netherlands

- Strengthening client-oriented research and technology dissemination for sustainable production of cool season food and forage legumes in Ethiopia
- Training in seed technology
- Renovation of traditional water supply system: sustainable management of groundwater resources
- Has provided an Associate Expert in applied anthropological research

OPEC Fund For International Development

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

Pakistan

- Cooperation in the applied research component of the Barani Village Development Project

Switzerland

- Sustainable dryland resource management in the arid margins of Syria
- Sustainable management of the agropastoral resource base in the Oujda Region, Morocco
- Renovation of traditional water supply system: sustainable management of groundwater resources
- Sheep and milk production by smallholders in Syria:

module for intensive production systems and added-value capitalization

Turkey

- Technical assistance to Southeast Anatolia Project, Regional Development Administration (GAP)

United Kingdom

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

Department for International Development (DFID) 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 Partnership Scheme

- Rehabilitation of water cisterns in the Jub Jumaa community (Aleppo steppe)

United Nations Development Programme (UNDP)

- Sustainable environment management in Yemen

UNDP/GEF

- Conservation and sustainable use of dryland agro-biodiversity in Jordan, Lebanon, Syria and the Palestinian Authority

United Nations Environment Programme/ Regional Office for West Asia (UNEP/ROWA)

- Inventory study and regional database on sustainable water management in West Asia
- Preparation of a feasibility study on the establishment of a bank for plant genetic resources in the Arab world

United States of America

United States Agency for International Development (USAID)

- 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

USAID Agricultural Technology Utilization and Transfer Project (ATUT)

- Application of molecular genetics for development of durum wheat varieties possessing high yield potential, rust resistance, stress tolerance, and improved grain quality
- Development of high yielding, long spike bread wheat cultivars possessing high tiller number, rust resistance, and heat tolerance facilitated by microsatellite DNA markers

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

- Collection of plant genetic resources in Central Asia and the Caucasus

United States Department of Agriculture/Foreign Agricultural Service (USDA/FAS)

- 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

University of California, Davis

Acquisition and characterization of *Triticum urato* and *Aegilops tauschii*, ancestors of bread wheat

Republic of Yemen

Agriculture sector management support project (ASMSP)

Appendix 4

Collaboration in Advanced Research

International Centers and Agencies

The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD)

- 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 West 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

Centro Internacional de Agricultura Tropical (CIAT)

- ICARDA is participating in the Systemwide Program on Soil Water and Nutrient Management and in the Systemwide Program on Participatory Research and Gender Analysis for Technology Development, both coordinated by CIAT
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database

International Center for Advanced Mediterranean Agronomic Studies (CIHEAM)

- Joint training courses and information exchange
- Study (at CIHEAM-Bari) of the tolerance of ICARDA mandate crops to salinity
- ICARDA participates in the FAO-CIHEAM subprogram for nutrition and feeding strategies and the subprogram for breeding strategies in sheep and goats
- Collaboration with CIHEAM-Zaragoza in research project on evaluation of Mediterranean rainfed agricultural technologies

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

- CIMMYT/ICARDA Joint Dryland Wheat Program; two CIMMYT wheat breeders are seconded to ICARDA
- 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 in a joint facultative wheat improvement program
- ICARDA and CIMMYT jointly coordinate a durum wheat research network encompassing WANA and southern Europe

Food and Agriculture Organization of the United Nations (FAO)

- ICARDA participates in the Inter-agency Task Forces convened by the FAO Regional Office for the Near East
- ICARDA and FAO are co-sponsors of the sub-regional organization AARINENA
- ICARDA participates in FAO's AGLINET cooperative library network, AGRIS and CARIS
- 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
- Joint training courses, workshops, and exchange of information

International Atomic Energy Agency (IAEA)

- 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

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

- ICARDA and ICRISAT cooperate in a joint kabuli chickpea improvement program
- 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

International Food Policy Research Institute (IFPRI)

- ICARDA participates in the Systemwide Program on Collective Action and Property Rights (CAPRi) coordinated by IFPRI
- Collaboration in policy and property rights research in CWANA through a joint staff appointment

International Institute of Tropical Agriculture (IITA)

- ICARDA is collaborating with IITA on parasitic weeds within the Systemwide Program on Integrated Pest Management
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database

International Livestock Research Institute (ILRI)

- ICARDA is the convening center, in collaboration with ILRI and ICRISAT, for a program on Production and

Utilization of Multi-purpose Fodder Shrubs and Trees in West Asia, North Africa, and the Sahel as part of the Systemwide Livestock Program (SLP) on Feed Resources, Production and Utilization coordinated by ILRI
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database
- ILRI is a partner in a project on integrated feed and livestock production in the steppes of Central Asia, 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, supported by SLP

International Plant Genetic Resources Institute (IPGRI)

- 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
- ICARDA collaborates with IPGRI in two sub-regional networks on genetic resources (WANANET and CATN/PGR)
- ICARDA participates in developments of the SINGER project coordinated by IPGRI and contributes data to the core SINGER database
- IPGRI-CWANA is a partner with ICARDA in 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

International Rice Research Institute (IRRI)

- Joint development of CGIAR Systemwide Microbial Genetic Resources Database

International Service for National Agricultural Research (ISNAR)

- ICARDA and ISNAR cooperate in research management for NARS in WANA
- ICARDA and ISNAR are co-sponsors of AARINENA

International Water Management Institute (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

- Development and conservation of plant genetic resources in the Central Asian Republics

Australian Temperate Field Crops Collection

- Development and conservation of plant genetic resources in the Central Asian Republics

University of Adelaide, CRC for Molecular Plant Breeding

- 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

- International collaboration in grazing management

Centre for Plant Conservation Genetics, Southern Cross University

- Development of ESTs using wild barley from ICARDA

Charles Sturt University

- Soil physical characteristics in relation to infiltration and surface evaporation under conventional and no-till operations

Centre for Legumes in Mediterranean Agriculture (CLIMA)

- Faba bean germplasm multiplication
- Germplasm testing and assessment of anti-nutritional factors: *Lathyrus* spp. and *Vicia* ssp.
- International selection, introduction, and fast tracking of kabuli chickpea
- Development and conservation of plant genetic resources in the Central Asian Republics
- Preservation of the pulse and cereal genetic resources of the Vavilov Institute
- Pulse transformation technology transfer
- 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

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
- 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 grasspea 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

- 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

Canadian Grain Commission, Winnipeg

- Development of techniques for evaluating the quality of barley, durum wheat, and food and feed legumes

University of Guelph, School of Rural Development and Planning

- Role of women in resource management and household livelihood strategies

University of Manitoba

- Collaboration in tan spot disease

University of Saskatchewan

- Integrated long-term strategy for genetic improvement of resistance to ascochyta blight and anthracnose in lentil
- Evaluation of chickpea germplasm and their wild relatives

Simon Fraser University, British Colombia

- Collaboration in sunn pest pheromones

Denmark

Risø National Laboratory, Plant Biology Biogeochemistry Department

- QTL analyses in barley
- Barley pathology
- Integrated cereal disease management in Eritrea

Danish Institute of Agricultural Sciences

- Yellow rust of wheat
- Integrated cereal disease management in Eritrea

France

Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)

- Bioeconomic and community modeling studies in WANA
- Global program for direct sowing, mulch-based systems, and conservation tillage

Institut National de la Recherche Agronomique (INRA)

- Association of molecular markers with morpho-physiological traits associated with constraints of Mediterranean dryland conditions in durum wheat (with Ecole Nationale Supérieure d'Agronomie (ENSA), Montpellier and ENSA-INRA, Le Rheu)
- Water balance studies in cereal-legume rotations in semi-arid Mediterranean zone (with Bioclimatology Research Unit of INRA, Thiverval-Grignon)
- Collaboration on cereal cyst nematodes (with INRA-Rennes)
- Genotyping of wild relatives (INRA/UMR Diversité et Génomes des Plantes Cultivées, Montpellier)

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 Morphogénèse Végétale 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 Hanover

- Development of transformation protocols for chickpea and lentil

University of Hohenheim

- Simulation studies on the sustainability of Mediterranean cropping systems
- 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

Institute of Nematology, Bari

- Studies of parasitic nematodes in food legumes

Catania University

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

University of Genoa

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

University of Naples

- Development of transgenic chickpea resistant to ascochyta blight

University of Tuscia, Viterbo

- Diversity of storage proteins in durum wheat

University of Tuscia, Viterbo; Germplasm Institute, Bari; ENEA, Rome

- Evaluation and documentation of durum wheat genetic resources

Japan

Japan International Cooperation Agency (JICA)

- JICA's volunteers program supports research on animal health, animal nutrition, and improvement of drought tolerance in spring bread wheat by placing a volunteer for each of these three research areas

Kyoto University

- Collaboration in molecular characterization of wheat wild relatives

Netherlands

Vrije Universiteit, Amsterdam

- Collaboration on groundwater research in Syria

Wageningen University

- Collaboration on land and water management research in Syria

Norway

Agricultural University of Norway

- Collaboration on soil and water management research in Syria

Portugal

Estacao National de Melhoramento de Plantas, Elvas

- Screening of wheat for resistance to yellow rust, scald, Septoria, and powdery mildew
- Developing lentil, faba bean, chickpea, and forage legumes adapted to Portugal's conditions

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

Spain

Instituto Nacional de Investigacion y Tecnologia Agraria y Alimentaria (INIA)

- Barley stress physiology (with University of Barcelona)
- Bread wheat stress physiology (with University of Barcelona)

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)

- 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

McCaulay Land Use Research Institute

- Research planning on fat-tailed 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

University of Reading

- Gender analysis in the agricultural systems of WANA
- Testing woolly-pod vetch in a 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

- Global Livestock Collaborative Research Support Program (GL-CRSP) 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, Ithaca

- Use of molecular markers for genome mapping and marker-assisted selection for stress resistance in durum wheat
- RNA fingerprinting in barley

DuPont Agric. Biotechnology

- Development of EST markers in wheat and lentils

University of Massachusetts, Amherst

- 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

Texas Tech University, Plant Molecular Genetics Laboratory

- Adaptation to drought and temperature stress in barley using molecular markers

University of Vermont

- Use of entomopathogenic fungi for the control of sunn pest in West Asia

University of Wisconsin Land Tenure Center

- Small-ruminant production with emphasis in dairy sheep evaluation and crossbreeding
- Sheep production in Central Asia through the GL-CRSP

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

US Department of Agriculture/Agricultural Research Service (USDA/ARS)

- Biological diversity, cultural and economic value of medicinal, herbal, and aromatic plants in southern Tunisia

USDA/ARS National Germplasm Resources Laboratory

- Production of PCR primers for detection of viruses

USDA/ARS Beltsville Agricultural Research Center

- Development of bread wheat cultivars facilitated by microsatellite DNA markers

USDA/ARS National Soil Erosion Research Laboratory

- Technical advice on soil conservation technologies and erosion research

USDA/ARS Forage and Range Research Laboratory (FRRL)

Central Asian rangeland and sheep evaluation

USDA/ARS Texas

- Climatological analysis as a tool for agricultural decision-making in dry areas

USDA/ARS Grain Legume Genetics and Physiology Research Laboratory, 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

- Conservation of temperate food, pasture, and forage legume biodiversity

Appendix 5

Research Networks coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
International and 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
Southern Europe and WANA Durum Wheat Research Network (SEWANA)	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, Canada, France, Greece, Italy, Jordan, Lebanon, Morocco, Spain, Syria, Tunisia, Turkey, USA	ICARDA core funds; France; Italy
Soil Fertility Network	To standardize methods and exchange information and results from research on soil fertility, soil management, and fertilizer use.	ICARDA Natural Resource Management Program	Algeria, Cyprus, Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Pakistan, Syria, Tunisia, Turkey, Yemen	ICARDA core funds
Dryland Pasture and Forage Legume Network	Communication linkages among pasture, forage, and livestock scientists in WANA.	ICARDA Natural Resource Management Program	WANA; Europe; USA; Australia	ICARDA core funds; FAO.
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, Cyprus, Egypt, Iraq, Jordan, Libya, Morocco, Sudan, Syria, Turkey, Yemen	ICARDA; Germany (GTZ); Netherlands

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
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 cooperation among concerned national, regional, and international organizations, particularly the exchange of information and experience among the member countries, on issues concerning drought mitigation.	ICARDA serves as Secretariat	Countries of the Near East, Mediterranean, and Central Asia; FAO; EC; CIHEAM.	ICARDA; FAO; CIHEAM

Sub-Regional Networks

Networks operating under the Nile Valley and Red Sea Regional Program (NVRSRP)

Sources of Primary Inoculum of Stem and Leaf Rusts of Wheat: Their Pathways and Sources of Resistance	Determine disease development of leaf and stem rusts in relation to weather data. Identify prevailing races and the pathways of pathogens. Identify wheat germplasm with effective resistance genes. Identify primary sources of inoculum. Contribute to overall breeding strategy.	ARC, Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA.	Supported by national programs and ICARDA
Management of Wilt and Root Rot Diseases of Cool Season Food Legumes	Identify sources of resistance to wilt and root-rots. Incorporate resistance into germplasm with suitable characteristics. Provide segregating populations to NARS to select under their own conditions. Develop strategy for multiple disease resistance. Identify races in *Fusarium* wilt pathogens. Studies of other components of integrated disease management.	AUA, Ethiopia	Egypt, Ethiopia, Sudan, ICARDA, ICRISAT	Supported by national programs and ICARDA
Integrated Control of Aphids and Major Virus Diseases in Cool Season Food Legumes and Cereals	Assess the potential for and implement biological control of aphids. Identify and incorporate sources of resistance to, and improve chemical control of aphids. Develop improved diagnostic methods to identify virus diseases and assess their spread and relative importance. Identify germplasm for virus resistance. Develop integrated pest management program.	ARC, Egypt ARC, Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA	Supported by national programs and ICARDA
Thermotolerance in Wheat and Maintenance of Yield Stability in Hot Environments	Identify physiological and morphological traits for improving wheat adaptation to heat and verify these traits in collaboration with breeders. Identify improved management strategies through a better understanding of development and growth. Describe the	ARC, Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA,. CIMMYT	Supported by national programs and ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
	physical environment and characterize promising genotypes for development of computer simulations of crop growth.			
Water Use Efficiency in Wheat	Develop and identify wheat cultivars requiring less water and tolerant to moisture stress. Identify irrigation regimes that meet crop water requirements. Improve soil management practices for soil moisture conservation. Develop improved production packages. Calibrate crop modeling systems.	ARC, Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA.	Supported by national programs and ICARDA
Socioeconomic Studies on Adoption and Impact of Improved Technologies	Monitoring and evaluation of technology transfer to farmers with respect to adoption levels and identification of factors influencing adoption; impact of improved technology on farm income levels and production; effect of policy and institutional factors on technology transfer and adoption.	ARC, Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA.	Supported by national programs and ICARDA

Appendix 6

Financial Information

(Audited Financial Statements)

Statement of Activity (US$x000)

	2001	2000
REVENUES		
Grants (Core and Restricted)	21,712	22,894
Exchange gains/(losses) - net	(505)	(348)
Interest income	345	464
Other income	419	612
Total revenues	21,971	23,622
EXPENSES		
Research	17,058	17,617
Training	1,460	1,985
Information services	619	603
General administration	2,324	3,103
General operation	895	715
Total expenses	22,428	24,023
Recovery of indirect costs	(635)	(672)
Net expenses	21,793	23,351
EXCESS OF REVENUES OVER EXPENSES	178	271
ALLOCATED AS FOLLOWS:		
Capital invested in property, and equipment	245	215
Operating fund	(67)	56
Surplus/(Deficit)	178	271

Statement of Financial Position (US$x000)

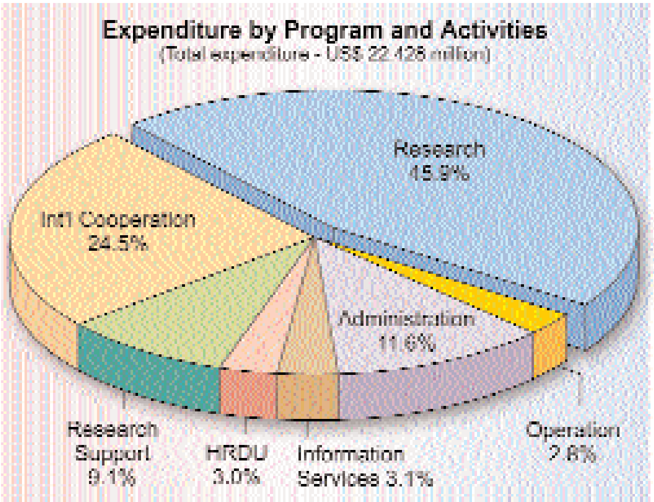
	2001	2000
ASSETS		
Current assets	20,843	19,170
Property and equipment	4,054	4,357
Total assets	24,897	23,527
LIABILITIES AND NET ASSETS		
Current liabilities	10,634	9,514
Long term liabilities	2,790	2,718
Total liabilities	13,424	12,232
Net assets	11,473	11,295

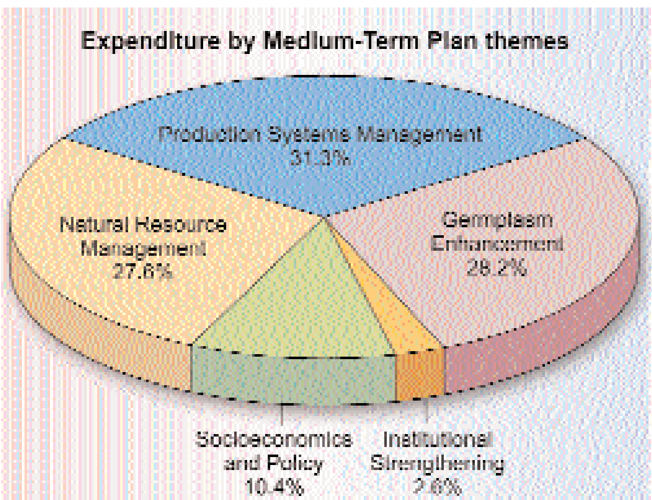
Statement of Grant Revenues, 2001 (US$x000)

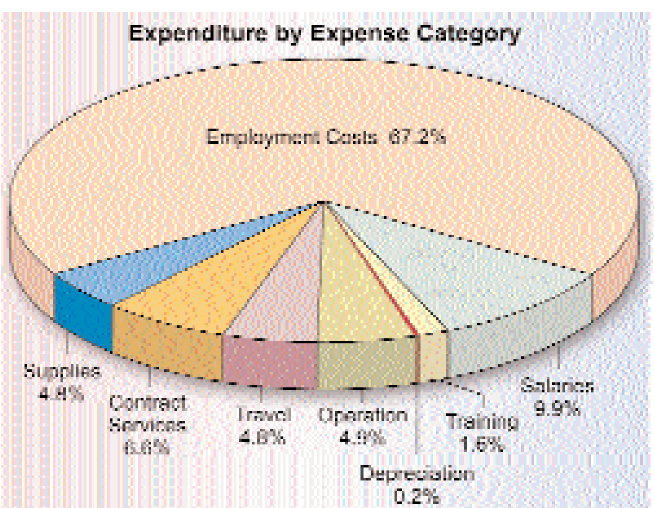
Donor	Amount
Arab Fund	1,601
Asian Dev. Bank	451
Australia•	575
Austria•	30
Belgium•	77
Canada•	428
CGIAR•	1,016
China•	10
CIHEAM	25
Denmark•	722
Egypt•	1,021
Eritrea	49
Ethiopia	213
European Commission	1,388
France•	135
Germany•	596
IBRD (World Bank)•	2,591
IDRC	273
IFAD	1,339
India•	37
Iran•	1,140
Italy•	746
Japan•	807
The Netherlands•	703
Norway•	439
OPEC	103
Pakistan	552
South Africa	25
Spain	15
Sweden•	419
Switzerland	163
Syria•	505
Turkey	43
UNEP	81
United Kingdom	1,317
UNDP	216
USAID•	1,517
USDA	33
Yemen	55
Miscellaneous	256
Total	21,712

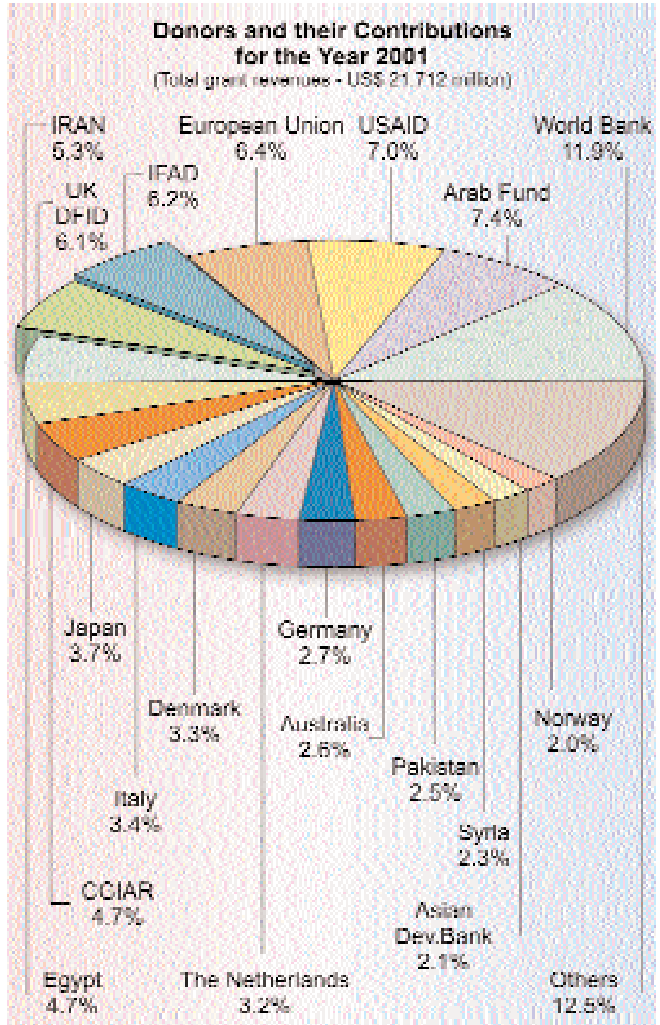
• Donors that provided core funds.

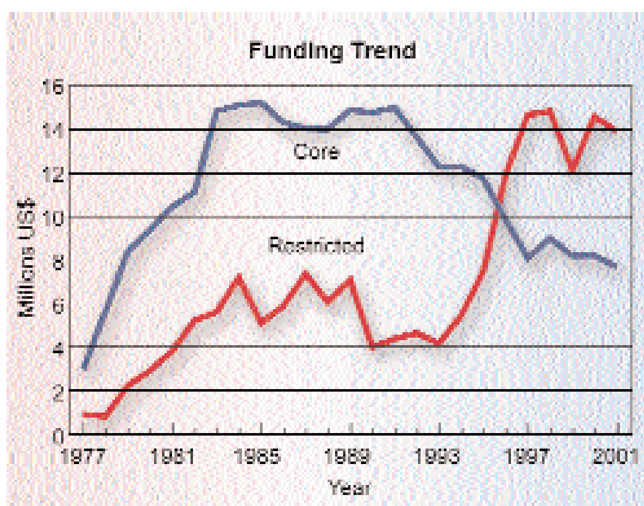
Financial Information











Appendix 7

Board of Trustees

Two new members joined the Board in 2001: Dr Teresa Christina Fogelberg and Dr Rosa Rao. Dr Raoul Dudal, and Dr Luigi Monti completed the term of their offece on the Board.

Dr Teresa Christina Fogelberg

Dr Teresa Christina Fogelberg is Director, Climate Change, and Deputy Director, Industry, in the Netherlands Ministry of Environment. From 1990, and prior to taking up her current post, she held various positions with the Directorate General for International Cooperation, Ministry of Foreign Affairs, including Senior Policy Advisor, West Africa Division; Coordinator International Womens Affairs; Head, Special Programme on Women and Development; Head, Research Department; and Deputy Director and then Acting Director of the Cultural Cooperation, Education and Research Department. In 1987-1990, Ms Fogelberg was First Secretary in the Netherlands Embassy in Dakar, and was responsible for the Netherlands Women in Development and Gender Policy in the Western Sahel region. Prior to that she led a United States Agency for International Development project developing a famine early warning system for Mauritania, and was an International Labor Organization Technical Advisor to the Ministry of Social Affairs in Mauritania. In 1980-1983, Dr Fogelberg was Associate Professor, Women in Development, University of Leiden. In the latter half of the 1990s, she was Head of the Netherlands Delegation to the Consultative Group on International Agricultural Research and a member of the Group's Oversight Committee. Since 1999, she has been a member of the Board of Trustees of the International Center for Tropical Agriculture. Her diverse international experience in public policy, international cooperation, governance and teaching is an invaluable addition to the expertise of the Board of Trustees.

Dr Rosa Rao

Dr Rosa Rao is Professor of Plant Biotechnology in the Department of Agronomy and Plant Genetics, University of Naples, Italy. Since earning her PhD in 1980, Dr Rao has held numerous positions, including research and teaching assignments at the International Institute of Tropical Agriculture, Ibadan, Nigeria; University of Edoardo Modlane, Maputo, Mozambique; University of Durham and University of Reading, England; Polish Academy of Sciences, Poznan; and Institut National de la Recherche Agronomique, France. She has also been principal investigator or chief scientist of more than 10 research projects: among them, in 1998-2000, 'DNA fingerprinting of broad bean germplasm with high attractiveness to parasitoids and selection of DNA markers useful for faba bean breeding', and, in 2000-2002, China-Italy science and technology cooperation for the project entitled 'Application of marker-assisted selection for genetic improvement of resistance to rice blast'. Dr Rao is co-author of 70 papers published in national and international journals and books. She has promoted and organized international symposia and workshops, and, since 1995, has been responsible for the National Plant Genomic Research Network in Italy. Dr Rao brings to the Board of Trustees experience that will be an asset as the Center strives to make best use of emerging biotechnologies.

Full Board 2001

On 31 December 2001, the membership of ICARDA's Board of Trustees was as follows:

Mr Robert D. Havener
Chairperson
625 Regency Circle
Sacramento, CA 95864
USA

Tel: (1-916) 487 2837
Fax: (1-916) 978 0870
E-mail: r.havener@cgiar.org

Dr Iwao Kobori
Vice-Chairperson
The United Nations University
53-70, Jingumae 5-chome
Shibuyaku, Tokyo 150
Japan

Tel: (Off) (81-3) 5467 1257
(Res) (81-3) 3816 1025
Fax: (81-3) 3499 2828
E-mail: Kobori@hq.unu.edu

Dr Hassan Al-Ahmed
Deputy Minister of Agriculture and Agrarian Reform

Hijaz Square
Damascus, Syria

Tel: (Off) (963-11) 2223 796
Fax: (963-11) 2237 766

Dr Margaret Catley-Carlson
Chair, Global Water Partnership
The Chrysler Bldg, 5128 (UNOPS),
405 Lexington, NYC, NY 10174
USA

Tel: (Off) (1-212) 457 1862
Fax: (1-212) 457 4044
Mobile: (1-917) 582 3149
E-mail: M.Catley-Carlson@cgiar.org
MargaretCC@unops.org

Dr Adel El-Beltagy (ex-officio)
Director General
ICARDA, P. O. Box 5466
Aleppo, Syria

Tel: (Off) (963-21) 2225 517/223 1330
(Res) (963-21) 574 1480
Mobile: (963-094) 240 220
Fax: (963-21) 2225105/2213490
E-mail: A.El-Beltagy@cgiar.org

Dr Ismail El-Zabri
Director General
Welfare Association
P. O. Box 840888
Amman 11184
Jordan

Tel: (Off) (962-6) 5519800
Fax: (962-6) 5526902
E-mail: elzabrii@awelfare.org.jo

Dr Teresa Christina Fogelberg
Head of Climate Change Department,
Ministry of Housing,
Spatial Planning & Environment
Directorate General for Environment
IPC 650
Protection 8, Rijnstraat, P.O. Box 30945
2500 GX, The Hague
The Netherlands

Tel: (Off) (31-70) 3394386
Mobile: (31-6) 15017609
Fax: (31-70) 3391310
Email: teresa.fogelberg@minvrom.nl

Dr Peter S.M. Franck-Oberaspach
Oberlimpurg
D-74523 Schwaebisch Hall
Germany

Tel: (Off) (49-791) 931180
Fax: (49-791) 47333
E-mail: Franck.PZO@gmx.de
Or, PZOberlimpurg@gmx.de

Dr Toufik Ismail
Deputy Minister of State for Planning Affairs
State Planning Commission
Damascus, Syria

Tel: (Off) (963-11) 511 1547
(Res) (963-11) 6112 851
Fax: (963-11) 512 1415

Dr Khalil Kazzaka
Director General
Agricultural Research Institute
Tal Amara Station
Rayak, Lebanon

Tel: (Off) (961-8) 900037
Fax: (961-8) 900077
E-mail: iraltal@cnrs.edu.lb

Dr Abbas Keshavarz
Director General
Seed & Plant Improvement Institute (SPII)
Mahdasht Road, P.O. Box 31585-4119
Karaj, Islamic Republic of Iran

Tel (Off) (98-21) 3130737/ (261)2706286
Fax: (98-261) 2709405
Email: seed.plant@abdnet.com
a-keshavarz@abrii.ae.ir

Dr Seyfu Ketema
Director General
Ethiopian Agricultural Research Organization (EARO)
P. O. Box 2003
Addis Ababa, Ethiopia
Tel: (Off) (251-1) 612 572
Fax: (251-1) 611 222
E-mail: iar@telecom.net.et

Dr Michel de Nuce de Lamothe
President of AGROPOLIS-Museum
Avenue Agropolis
F-34394 Montpellier Cedex 5
France

Tel: (Off) (33) 467 047550
Fax: (33) 467 047599
E-mail: denuce@agropolis.fr

Dr Rosa Rao
Professor, Department of Agronomy and Plant Genetics
University of Naples, Federico II
Via Universita 100, 80055
Portici, Italy

Tel (Off) (39-081) 788 5444
Fax (39-081) 7753579
Email: RAO@UNINA.IT

Prof Dr Mamdouh A Sharafeldin
Technical Counsellor
Ministry of Agric. and Land Reclamation
Chairperson,
Livestock, Poultry, and Fisheries Research Council
Egyptian Academy of Science & Technology
P O Box 42, Giza
Cairo, Egypt

Tel: (Off) (20-2) 3372 470/3366 408
(20-2) 5723 618/5709 970
Tel: (Res) (20-2) 7608 939
Fax: (20-2) 7609 399/5735 927

Dr Richard Gareth Wyn-Jones
Center for Arid Zone Studies
University of Wales, Bangor
GWYNEDD LL57 2UW
U.K.

Tel: (Off) (44-01248) 382346
Fax: (44-01248) 364717
E-mail: cazs@bangor.ac.uk

Appendix 8

Senior Staff (As of 31 December 2001)

SYRIA (Aleppo: Headquarters)

Director General's Office

Prof. Dr Adel El-Beltagy, Director General
Dr Mohan C. Saxena, Assistant Director General (At-Large)
Dr Mahmoud B. El-Solh, Assistant Director General (International Cooperation)
Dr William Erskine, Assistant Director General (Research)
Dr John Dodds, Special Advisor
Dr Elizabeth Bailey, Project Officer
Mr Vijay Sridharan, Internal Auditor
Ms Houda Nourallah, Administrative Officer to the Director General and Board of Trustees

Administration

Mr Michel Valat, Director of Administration and Personnel Services

Government Liaison

Dr Faisal Maya, Director of the Office of Government Liaison
Dr Nour-Eddine Mona, Consultant

Finance

Mr Carlos Nino Neira Ramos, Director of Finance
Mr Ahmed El-Shennawy, Associate Director of Finance
Mr Mohamed Samman, Treasury Supervisor

Natural Resource Management Program

Dr Richard Thomas, Director of NRMP
Dr Aden Aw-Hassan, Agricultural Economist
Dr Mustapha Bounejmate, Forage and Feed Legumes Production Specialist
Dr Adriana Bruggeman, Agriculture Hydrology Specialist
Dr Eddy DePauw, Agroclimatologist
Dr Luis Iñiguez, Senior Small-Ruminant Scientist
Dr Hiroaki Nishikawa, Honorary Consultant (Animal Parasitology)
Dr Brien Edward Norton, Range Management Scientist
Dr Theib Oweis, Water Management/Supplemental Irrigation Specialist
Dr Mustafa Pala, Wheat-based Systems Agronomist
Dr John Ryan, Soil Fertility Specialist
Dr Abdul Bari Salkini, Agricultural Economist/Liaison Scientist

Dr Akhtar Ali, Water and Soil Engineer
Dr Ahmed Mazid, Agricultural Economist
Dr Malika Martini Abdelali, Research Associate, Socioeconomics and Gender Analysis
Ms Azusa Fukuki, Research Associate, Antropology
Dr Safouh Rihawi, Research Associate, Animal Nutrition
Ms Monika Zaklouta, Research Associate, Animal Nutrition
Dr Sota Kobayashi, Associate Expert, (JICA), Animal Health
Dr Tsuyoshi Takahashi, Associate Expert, (JICA), Animal Health
Mr David Celis, Junior Professional Officer, Agroecological characterization
Ms Birgitte Larsen Hartwell, Junior Professional Officer. Animal Science
Mr Kristof Scheldman, Junior Professional Officer, Agroecological characterization
Ms Inger Waldhauer, Junior Professional Officer, Animal Science
Ms Shibani Ghosh, Research Fellow, Human Nutrition
Ms Rahmouna Khelifi-Touhami, Research Fellow, Social Science
Dr Ahmed Yousif Hachum, Water Management Consultant
Mr Roberto Telleria Juarez, Consultant Socioeconomist
Dr Hiroaki Nishikawa,Honorory Consultant (JICA), Animal Parasitology

Germplasm Program

Dr Thomas Blake, Director of GP
Dr Osman Abdalla El Nour, Breeder/Pathologist (seconded from CIMMYT for CIMMYT/ICARDA wheat program)
Dr Ali M. Abd El-Moneim, Forage Legume Breeder
Dr Michael Baum, Senior Biotechnologist
Dr Bassam Bayaa, Consultant Lentil Pathologist
Dr Salvatore Ceccarelli, Barley Breeder
Dr Wafa Choumane, Consultant Biotechnologist
Dr Mustapha El-Bouhssini, Entomologist
Dr Stefania Grando, Barley Breeder

Dr Khaled Makkouk, Plant Virologist
Dr Rajinder Singh Malhotra, Senior Chickpea Breeder
Dr Miloudi Nachit, Durum Wheat Breeder (seconded from CIMMYT for CIMMYT/ICARDA wheat program)
Dr Ashutosh Sarker, Lentil Breeder
Dr Khalil Shaaban, Consultant Faba Bean Breeder
Dr Amor Yahyaoui, Senior Cereal Pathologist
Dr Majid Khlaif Al-Kummer, Visiting Scientist
Dr Moussa Guirgis Mosaad, Visiting Scientist Coordinator, ICARDA/Turkey Activities
Dr Bruce Parker, Visiting Scientist (Entomology)

Dr M. Sripada Udupa, Biotechnologist

Dr Bruno Schill, Post-Doctoral Fellow, Faba Bean Breeder
Mr Fadel Al-Afandi, Research Associate
Mr Takahiro Sato, Visiting Research Associate (JICA)
Ms Aixa Del Greco, Junior Professional Officer
Ms Ismahane El-Ouafi, Research Fellow
Ms Bianca van Dorrestein, Research Fellow
Ms Elena Iacono, Research Fellow
Ms Daniela Mongione, Visiting Research Fellow

Genetic Resources Unit

Dr Jan Valkoun, Head
Dr Ahmed El-Ahmed, Consultant Seed Pathologist
Dr Kamel Chabane, Biotechnologist
Mr Jan Konopka, Germplasm Documentation Officer

Dr Kenneth Street, Associate Expert
Dr Siham Asaad, Research Associate
Mr Bilal Humeid, Research Associate

Seed Unit

Dr Samuel Bockari-Kugbei, Seed Economist and Acting Head
Mr Zewdie Bishaw, Assistant Seed Production Specialist
Mr Abdul Aziz Niane, Research Associate

Communication, Documentation, and Information Services

Dr Surendra Varma, Head
Mr David Abbass, Science Writer/Editor
Mr Moyomola Bolarin, Multimedia/Training Material Specialist
Mr Nihad Maliha, Library and Information Services Manager

Human Resources Development Unit

Dr Samir El-Sebae Ahmed, Head
Mr Faik Bahhady, Consultant
Mr Mohamed A. Hamwieh, Administrative Officer (Visitors Services)

Computer and Biometrics Services

Dr Zaid Abdul Hadi, Head
Dr Murari Singh, Senior Biometrician
Mr Awad Awad, MIS Team Leader/Database Administrator
Mr Michael Sarkissian, Senior Maintenance Engineer
Mr Colin Webster, Network Administrator

Station Operations

Dr Jürgen Diekmann, Farm Manager
Mr Ahmed Shahbandar, Assistant Farm Manager
Mr Bahij Kawas, Senior Supervisor (Horticulture)

Engineering Services Unit

Mr Ohannes Ohanessian, Physical Plant Manager

Purchasing and Supplies

Mr Essam Abd Alla Saleh Abd El-Fattah, Manager

Labor Office

Mr Marwan Mallah, Consultant

International School of Aleppo

Dr Thomas Taylor, Head

Damascus Office/Guesthouse, Syria

Ms Hana Sharif, Administrative Assistant

Beirut Office/Guesthouse, Lebanon

Mr Anwar Agha, Executive Manager/Consultant

Terbol Research Station, Lebanon

Mr Munir Sughayyar, Engineer, Station Operations

Regional Programs

North Africa Regional Program

Tunis, Tunisia

Dr Mohammed El-Mourid, Regional Coordinator
Dr Abdul Razzak Belaid, Socioeconomist
Dr Véronique Alary, Socioeconomist

Nile Valley and Red Sea Regional Program

Cairo, Egypt

Dr Mohamed Habib Halila, Regional Coordinator

West Asia Regional Program

Amman, Jordan

Dr Ahmed Amri, Biodiversity Project Coordinator

Arabian Peninsula Regional Program

Dubai, United Arab Emirates

Dr Ahmed Tawfik Moustafa, Protected Agriculture Specialist and Acting Regional Coordinator
Dr Ahmed El Tayeb Osman, Range/Forage Scientist/Ecologist

Highland Regional Program

Tehran, Iran

Dr Habib Ketata, Coordinator of the Iran Project/ICARDA Collaborative Project
Dr Javed Rizvi, Post-Doctoral Fellow

Central Asia and the Caucasus Regional Program

Tashkent, Uzbekistan

Dr Rajendra Singh Paroda, Head of the Program Facilitation Unit, CGIAR Program for CAC and Regional Coordinator
Dr Mekhlis Suleimenov, Assistant Regional Coordinator
Dr Zakir Khalikulov, Consultant Scientist
Dr Victor Shevstov, Cereal Breeder

Latin America Regional Program

CIP, Peru

Dr Abelardo Rodríguez, Regional Coordinator

CIMMYT, Mexico

Dr Flavio Capettini, Post-Doctoral Fellow (Barley Breeder)

Consultants

Dr Giro Orita, Honorary Senior Consultant
Dr Hisham Talas, Medical Consultant (Aleppo)
Dr Edward Hanna, Legal Advisor (Beirut)
Mr Tarif Kayyali, Legal Advisor (Aleppo)

Appendix 9

The Farms

ICARDA operates four 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 WANA region.

ICARDA and the Lebanese Agricultural research Organization (LARI) now share the use of the sites in Lebanon. ICARDA continues to use these sites, as before 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
	Latitude	Longitude				
SYRIA						
Tel Hadya	36.01° N	36.56° E	284	948	428.6	338.2 (23 seasons)
Breda	35.56° N	37.10° E	300	95	368.6	271.0 (22 seasons)
LEBANON						
Terbol	33.49° N	35.59° E	890	23	407.6	517.4 (21 seasons)
Kfardane	34.01° N	36.03° E	1080	11	424.3	395.2 (7 seasons)

* For the 2000/2001 season

Appendix 10

Acronyms

AARINENA	Association of Agricultural Research Institutions in the Near East and North Africa
ACIAR	Australian Center for International Agricultural Research
ACSAD	Arab Center for Studies of the Arid Zones and Dry Lands
ADB	Asian Development Bank
AFESD	Arab Fund for Economic and Social Development
AGERI	Agricultural Genetic Engineering Research Institute, Egypt
APRP	Arabian Peninsula Regional Program
AZRC	Arid Zone Research Center
CAC	Central Asia and the Caucasus
CACRP	Central Asia and the Caucasus Regional Program
CAPRi	Collective Action and Property Rights
CDC	Center Directors Committee
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	International Potato Center
CLAES	Central Laboratory for Agricultural Expert Systems, Egypt
CONDESAN	Consortium for the Sustainable Development of the Andean Region
CWANA	Central and West Asia and North Africa
DARI	Dryland Agricultural Research Institute, Iran
DGIS	Directorate General for International Cooperation, Ministry of Foreign Affairs, Netherlands
EC	European Commision
ESCWA	United Nations Economic and Social Commission for West Asia
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GAP	Southeastern Anatolia Project, Turkey
GCC	Gulf Cooperation Council
GEF	Global Environment Facility
GEF/UNDP	Global Environment Facility/United Nations Development Programme
DFID	Department for International Development, UK
GOSM	General Organization for Seed Multiplication, Syria
GIS	Geographic Information Systems
GRU	Genetic Resources Unit
GTZ	German Agency for Technical Cooperation, Germany
GFAR	Global Forum on Agricultural Research
HRP	Highland Regional Program
IAEA	International Atomic Energy Agency
ICBA	International Center for Biosaline Agriculture
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IPGRI	International Plant Genetic Resources Institute
IPM	Integrated Pest Management
IRA	Institut des Régions Arides, Tunisia
IWMI	International Water Management Institute
LARP	Latin America Regional Program
M&M	Mashreq and Maghreb
NARP	North Africa Regional Program
NARS	National Agricultural Research Systems
NGO	Non-Governmental Organisation
NVRSRP	Nile Valley and Red Sea Regional Program
OPEC	Organization of Petroleum Exporting Countries
OSWU	Optimizing Soil Water Use Program
PARC	Pakistan Agricultural Research Center
PFU	Facilitation Unit/CGIAR-Program for CAC
SLP	Systemwide Livestock Program
SDC	Swiss Agency for Development and Cooperation
SWNM	System-wide Soil Water Nutrient Management Consortium
TAC	Technical Advisory Committee of the CGIAR
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNU	United Nations University
USAID	United States Agency for International Development
WANA	West Asia and North Africa
WARP	West Asia Regional Program

Appendix 11

ICARDA Addresses

Headquarters at Tel Hadya, near Aleppo, Syria
International Center for Agricultural Research in the Dry Areas (ICARDA)
P.O. Box 5466, Aleppo, Syria
Tel.: (+963) (21) 2213433, 2213477, 2225112, 2225012
Fax: (+963) (21) 2213490, 2225105
E-mail: ICARDA@cgiar.org
WebSite: http://www.icarda.cgiar.org

City Office, Aleppo and ICARDA International School of Aleppo
Tel.: (+963) (21) 5743104, 5748964, 5746807
Fax: (+963) (21) 5744622
E-mail(School): IISA@Net.SY

Damascus Office
Hamed Sultan Bldg., 1st floor, Abdul Kader Gazairi Street
Malki Area, Tishreen Circle
P.O. Box 5908, Damscus, Syria
Tel.: (+963) (11) 3331455, 3320482
Fax: (+963) (11) 3320483
E-mail: ICARDA-Damascus@cgiar.org

Regional Offices

AFGHANISTAN
ICARDA
First Section of Carta-e-parwan
Near Baharistan Movie House
In Front of Power Distribution Station
House No. 262
Kabul
Tel.: (+93) (702) 30868
Mobile: (+93) (702) 74381/74365
Satellite: +8821688846001 (Manan)
+8821688846004 (Wassimi)
E:mail: icardafg@psh.paknet.com.pk
n.wassimi@cgiar.org

EGYPT
ICARDA, 15 G. Radwan Ibn El-Tabib Str.
P.O. Box 2416, Cairo, Egypt
Tel.: (+20) (2) 5724358
Fax: (+20) (2) 5728099
E-mail: ICARDA-Cairo@cgiar.org

IRAN
Agricultural Research, Education & Extension Organization (ICARDA/AREEO), Ministry of Agriculture
Tabnak Avenue, Evin
P.O. Box 19835-111, Tehran, Iran
Tel.: (+98) (21) 2400094/2408761
Mobile: (+98 (91) 32018972 (Habibe Ketata)
Mobile: (+98 (91) 12068427 (Anita Saadi)
Fax: (+98) (21) 2401855
E-mail: icarda@dpimail.net

JORDAN
ICARDA, P.O. Box 950764, Amman 11195, Jordan
Tel.: (+962) (6) 5525750, 5538602, 5517561
Fax: (+962) (6) 5525930
E-mail: ICARDA-Jordan@cgiar.org

LEBANON

Beirut Office
ICARDA, Dalia Building, 2nd Floor, Bashir El Kassar Street
Verdun area
P.O. Box 114/5055, Beirut, Lebanon
Tel.: (+961) (1) 813303
Mobile: (+961) (3) 607583
Fax: (+961) (1) 804071
E-mail: ICARDA-b@destination.com.lb

Terbol Office
ICARDA, Bekaa Valley, Terbol, Lebanon
Tel.: (+961) (8) 955127
Mobile: (+961) (3) 211553 (Munir Sughayyar)
Fax: (+961) (8) 955128
E-mail: ICARDA-terbol@destination.com.lb

MEXICO
ICARDA, c/o CIMMYT Int., Apartado Postal 6-64,
106600 Mexico, D.F., MEXICO
Tel.: (+52) (5) 58042004/9521900
Fax: (+52) (5) 9521983/84
E-mail: CIMMYT@cgiar.org

MOROCCO
ICARDA, B.P. 6299, Rabat-Instituts, Rabat, Morocco
Tel.: (+212) (37) 682909, 675496
Mobile: (+212) (61) 810034 (El-Mourid)
Fax: (+212) (37) 675496
E-mail: ICARDART@maghrebnet.net.ma

PAKISTAN
ICARDA Applied Research Implementation Unit
Barani Village Development Project - BVDP
Agency for Barani Areas Development - ABAD
Government of the Punjab
Murree Road, Rawalpindi
Tel.: (+92) (51) 4454740
Mobile: (+93) (0300) 8554740
Fax: (+92) (51) 4454775, 9290339
E-mail: icarda@isb.sdnpk.org

PERU
ICARDA c/o CIP
Av. La Universidad S/N La Molina
Apartado 1558 – Lima 12
Tel.: (51-1) 3496017/3495783
Fax: (51-1) 3495638

TUNISIA
ICARDA, B.P. 435, El-Menzah 1, 1004 Tunis, Tunisia
Tel.: (+216) (71) 710115, 710240
Mobile: (+216) (98) 464104
Fax: (+216) (71) 707574
E-mail: ICARDA-Tunis@cgiar.org,
secretariat.icarda@email.ati.tn

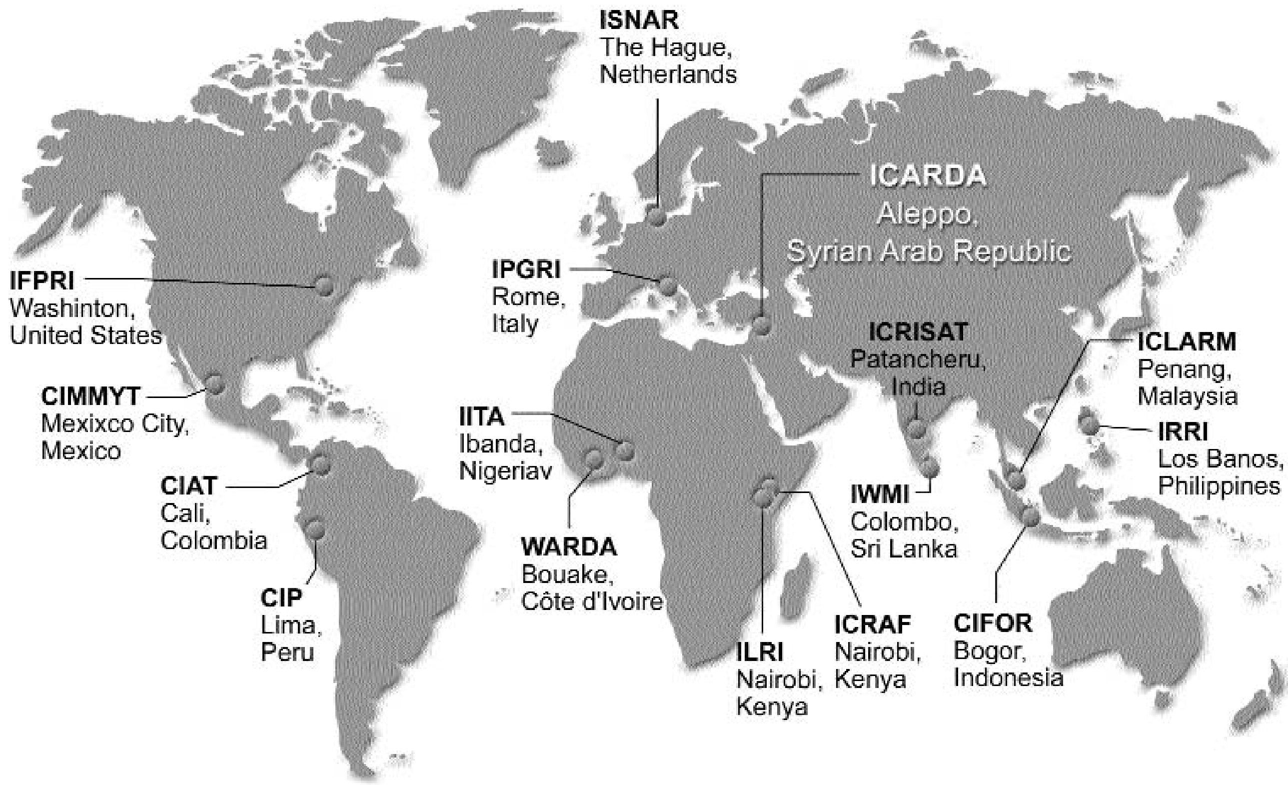
TURKEY
ICARDA, P.K. 39 Emek, 06511 Ankara, Turkey
Tel.: (+90) (312) 2873595, -96, -97
Fax: (+90) (312) 2878955
E-mail: ICARDA-Turkey@cgiar.org

UNITED ARAB EMIRATES
ICARDA-APRP, P.O. Box 13979, Dubai, U.A.E.
Tel.: (+971) (4) 2957338
Fax: (+971) (4) 2958216
E-mail: icdub@emirates.net.ae

UZBEKISTAN
ICARDA, P.O.Box 4564, Tashkent 700 000, Uzbekistan
Telfax: (+967) (6) 500767
E-mail: CAC-Tashkent@ICARDA.org.uz
PFU-Tashkent@cgiar.org.uz

YEMEN
ICARDA/AREA - Yemen Program, P.O. Box 87334
Dhamar, Yemen
Tel.: (+967) (6) 500767
Fax: (+967) (6) 500767
E-mail: APRP-Yemen@cgiar.org

Sana'
Tel.: (+967) (1) 417556

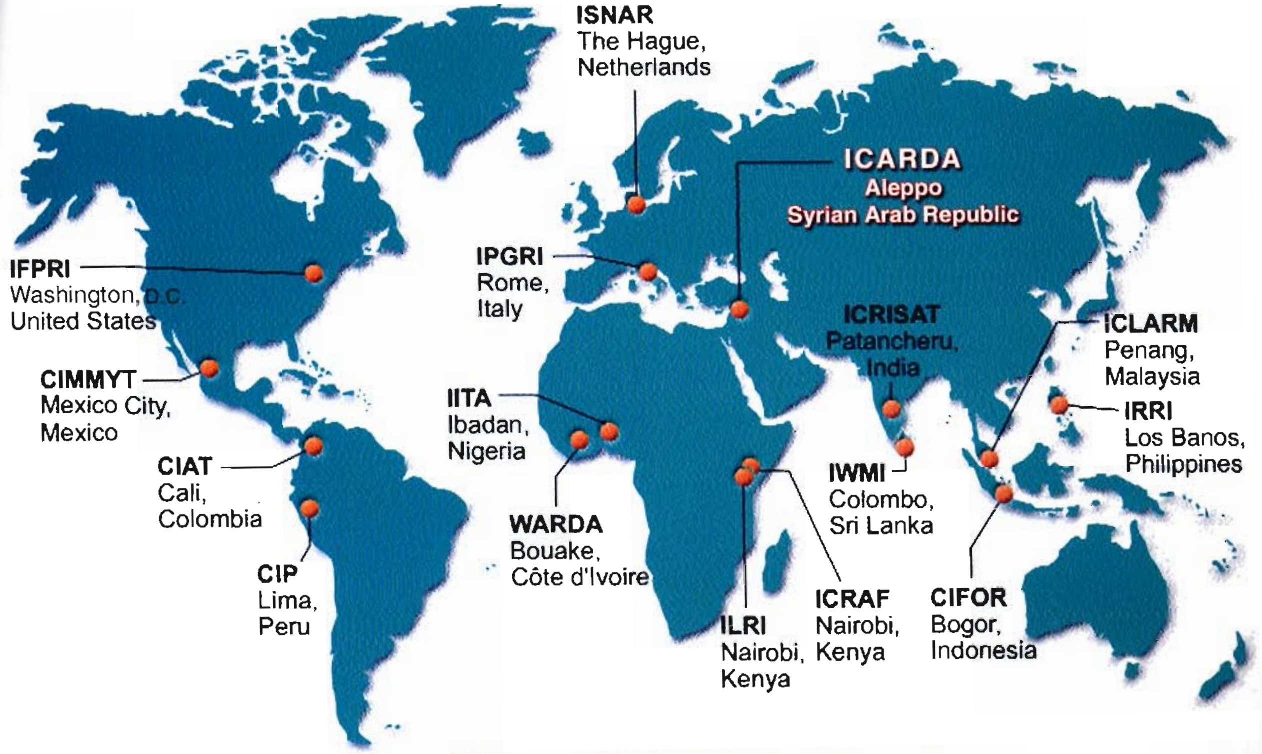


Cover (front and back):

The pictures show ICARDA's diverse research and training activities in crop improvement and natural resource management. Research on conservation and efficient use of water and combating desertification, including rehabilitation of rangelands and small-ruminant management and nutrition in the context of crop/livestock systems, receives special emphasis. The Center has a global mandate for the improvement of barley, lentil and faba bean, and a regional mandate in the Central and West Asia and North Africa for the improvement of wheat (in collaboration with CIMMYT), chickpea (in collaboration with ICRISAT), pasture and forage legumes, and farming systems in diverse agroecologies, including high-elevation areas.

International Center for Agricultural Research in the Dry Areas (ICARDA)
P.O. Box 5466, Aleppo, Syria. Tel.: (+963) (21) 2213433, 2213477, 2225112, 2225012
Fax: (+963) (21) 2213490, 2225105, 5744622.
E-mail: ICARDA@cgiar.org
WebSite: http://www.icarda.cgiar.org

ICARDA-/5000/June 2002



The CGIAR Centers

Cover (front and back):

ICARDA's diverse research and training activities in crop improvement and natural resource management. Research on conservation and efficient use of water and combating desertification, including rehabilitation of rangelands and small-ruminant management and nutrition in the context of crop/livestock systems, receives special emphasis. The Center has a global mandate for the improvement of barley, lentil and faba bean, and a regional mandate in Central and West Asia and North Africa for the improvement of wheat (in collaboration with CIMMYT), chickpea (in collaboration with ICRISAT), pasture and forage legumes, and farming systems in diverse agroecologies, including high-elevation areas.

International Center for Agricultural Research in the Dry Areas (ICARDA)
P.O. Box 5466, Aleppo, Syria. Tel.: (+963) (21) 2213433, 2213477, 2225112, 2225012
Fax: (+963) (21) 2213490, 2225105, 5744622.
E-mail: ICARDA@cgiar.org
Website: http://www.icarda.cgiar.org

ICARDA-/5000/June 2002