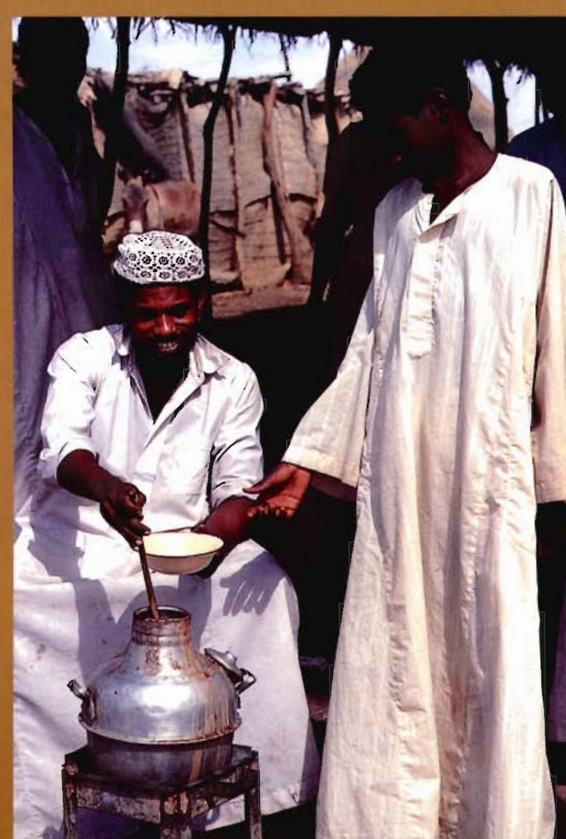
ICARDA Annual Report 2000

International Center for Agricultural Research in the Dry Areas



ICARDA

About ICARDA and the CGIAR

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

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production; and the 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 CGIAR centers 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), and the United Nations Development Programme (UNDP) are cosponsors of the CGIAR. The World Bank provides the CGIAR System with a Secretariat in Washington, DC. A Technical Advisory Committee, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

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

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

Foreword

This Annual Report of ICARDA for 2000 is the first to reflect the new structure of reporting, which is based on the five CGIAR themes: Germplasm Enhancement, Production Systems Management, Natural Resource Management, Socioeconomics and Policy, and Institutional Strengthening. Within these themes research is organized into 19 interlinked projects that seek to integrate, or at least harmonize, the management of different agroecosystems in the dry areas.

To understand the mosaic of crop, livestock and people, and the environment in which they live and interact with, ICARDA is using the concept of integrated research sites in the Central and West Asia and North Africa region (CWANA). An integrated research site is selected based on its characteristics representing the various agroecological conditions in a given region. The sites are well characterized for their biophysical and socioeconomic features. This characterization helps in the development of technology packages that could be used as international public goods in other similar regions in the dry areas. For West Asia, the Center has identified a site in Khanasser, near Aleppo in Syria; and for the Central Asia and the Caucasus region, at Boykozon, in Uzbekistan.

ICARDA's research seeks to integrate gene management with natural resource management to develop crop varieties and technologies that can withstand the harsh and often variable climate of the dry areas. Both conventional and new techniques are used to deal with the various abiotic and biotic stresses to crops. The year under report saw increased use of new tools of science, which included remote sensing, Geographic Information Systems (GIS), biotechnology, crop modeling systems, computer expert systems, and participatory research.

Simultaneously, in partnership with the national agricultural research systems (NARS), the Center increased its engagement in preparing action plans for the implementation of the recommendations of global conventions, particularly those related to biodiversity conservation and mitigation of drought. ICARDA participated in the Third Regional Meeting of the UNCCD (United Nations Convention to Combat Desertification) National Focal Points in Asia in Bangkok, Thailand in November 2000, and in the UNCCD Conference of Parties in Bonn, Germany in December 2000, acting as the CGIAR focal point for UNCCD.

Foundations were laid for ICARDA's increased research attention to poverty alleviation and to better understand the connections between poverty and resource degradation. Socioeconomic studies were strengthened to provide information for developing appropriate strategies and options, and improved technologies. New partnerships were forged with advanced research institutes in both industrialized and developing countries to conduct research in this and other areas of the Center's research agenda.

This Annual Report provides glimpses of the changing focus of ICARDA's research agenda and its partnerships in harmony with the dynamic nature of agricultural research in the dry areas.

ICARDA is grateful to its donors for supporting its research and to its partners throughout the world for their collaboration in helping to fulfill the mandate and mission of the Center to serve the people living in the dry areas.

Adel El-Beltagy
Director General

Robert Havener
Chairman, Board of Trustees

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- H.E. Mr Robert Mayor, the Swiss Ambassador in Syria, visited ICARDA on 18 April to sign an agreement on behalf of the Swiss Government, to support the second phase (2000-2001) of its "Arid Margins in Syria" project. This project is designed to strengthen decision-making tools and national capacities in sustainable dryland resource management in Syria.
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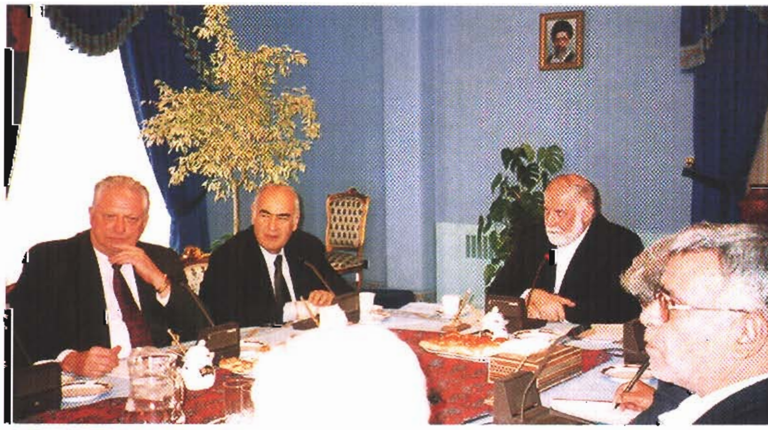

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ICARDA's Research Portfolio

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. Rural to urban, as well as international migration, is widespread, particularly in the Mediterranean region, and threatens social, political, and economic stability. The demographic pressure on the land combined with the need to produce more food from a limited resource base is forcing producers to follow practices that maximize short-term returns at the expense of long-term sustainability. Environmental resource degradation and human poverty are most pronounced in low-potential agricultural environments, particularly those with low and uncertain rainfall, in mountainous areas, and in the rangelands.

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

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

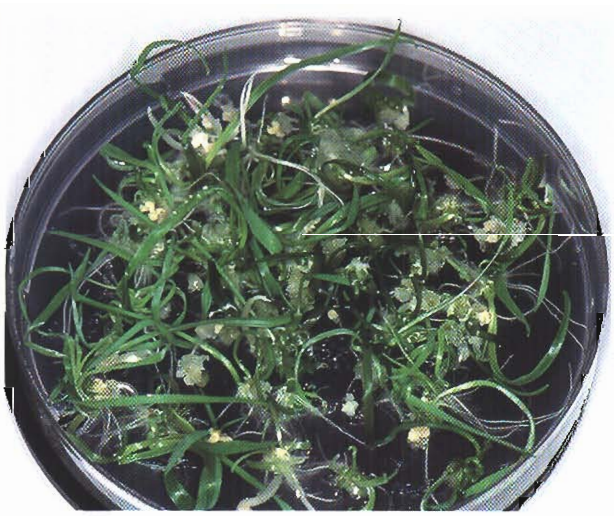
Theme 1. Crop Germplasm Enhancement

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:

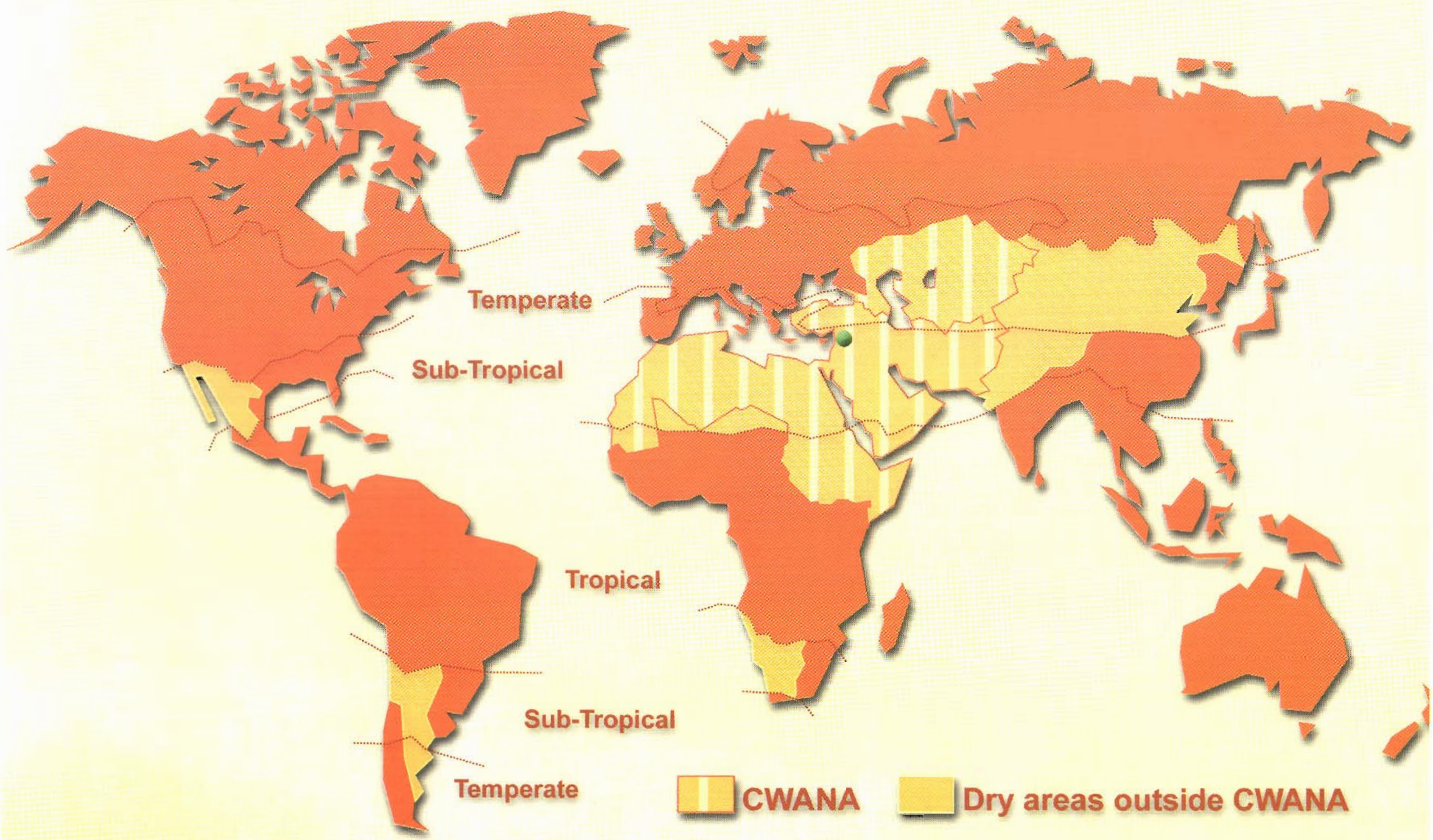
Project 1.1. Barley Germplasm Improvement for Increased Productivity and Yield Stability

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



Both conventional methods of breeding (left) and biotechnology techniques (right) are employed for developing improved germplasm. The strategy is to produce new cultivars well adapted to the harsh environments of the dry areas where they will be grown by farmers.

ICARDA's Geographic Mandate



The 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 sub-tropical 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. 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, Azerbaijan, Georgia, Kazakstan, Kyrgyzstan, Mongolia, northwestern China, Tajikistan, Turkmenistan and Uzbekistan are located in the temperate dry areas.

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 Highland Central and West Asia and North Africa

Project 1.5. Food Legume Germplasm Improvement (Lentil, Kabuli Chickpea, Faba Bean, and Pea) 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 System-wide 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 System-wide Integrated Pest Management Program."

The following projects are in operation under this theme:

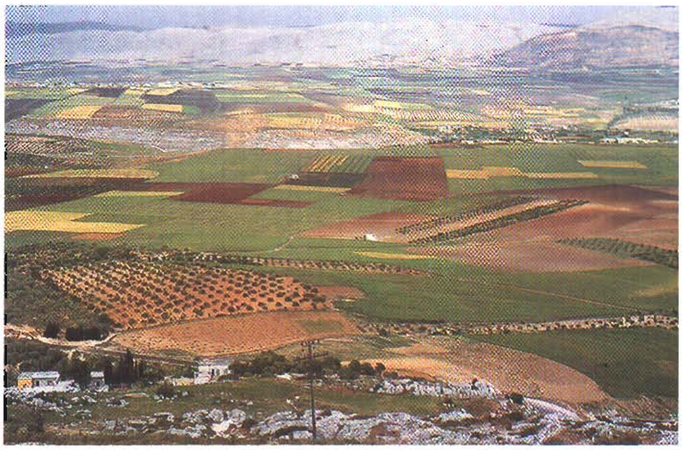
Project 2.1. Integrated Pest Management in Cereal and Legume-based Cropping Systems in Dry Areas

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



Production systems in the dry areas are diverse (left), but they all face the challenge of water scarcity and poor soils. Since livestock constitute a key component of farming systems, ICARDA's strategy is to integrate crop and livestock in the production systems (right) and optimize the use of soil and water resources for sustainability of agriculture.

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 "System-wide review of 1999." While water and its availability are the key issues in the dry areas and are accorded the highest priority, soil, biodiversity, and land use are all closely linked. ICARDA maintains a strong Genetic Resources Unit and participates in the "System-wide Genetic Resource Program."

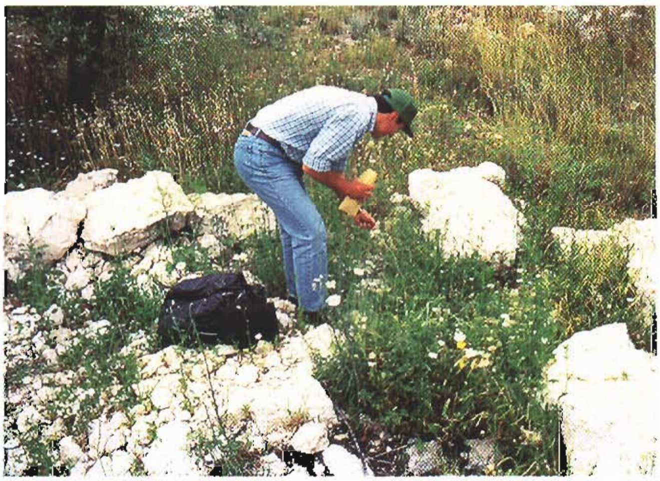
ICARDA is responding to the urgent need for higher productivity using less water by substantially increasing its research investment on improved and sustainable water-use efficiency at the farm level. The Center leads the work in this field and contributes to the "CGIAR System-wide Program on Water Management," 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:

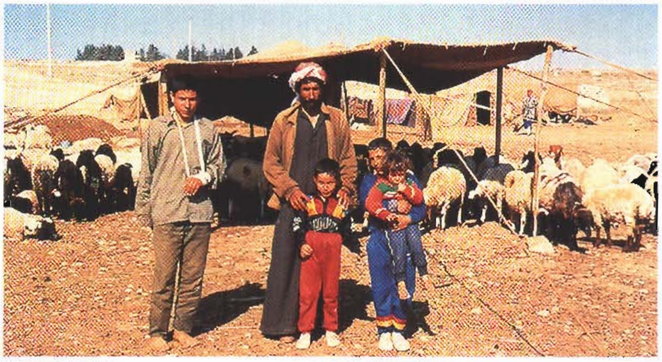
- Project 3.1. Water Resources Conservation and Management for Agricultural Production in Dry Areas
- Project 3.2. Land Management and Soil Conservation to Sustain the Agricultural Productive Capacity of Dry Areas
- Project 3.3. Agrobiodiversity Collection and Conservation for Sustainable Utilization
- 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 adaptation 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.



The key natural resources—water, soil and biodiversity—receive the highest priority in ICARDA's research agenda. The Center is developing new technologies geared to produce more food without damaging the soil health and depleting water and biodiversity resources.



ICARDA's socioeconomic and policy research provides gender, market, cultural and end-user perspectives that can help in promoting the adoption of new technologies to benefit the poor, particularly in the rural communities.

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

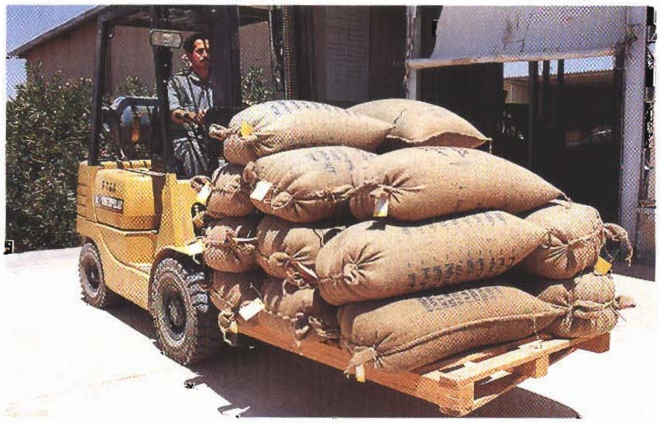
Theme 5. Strengthening National Seed Systems

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.

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.

The following project is in operation under this theme:

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



Easy availability of quality seed of improved varieties is the key to increased food production. ICARDA emphasizes the development of informal seed sector to make seed available to farmers easily.

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. This is the first Annual Report of the Center structured to reflect its new project-based research program.

While detailed descriptions of all projects can be found at ICARDA's web site (www.icarda.cgiar.org), the pages that follow present some key achievements made in each project during 2000.

Theme 1. Crop Germplasm Enhancement

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

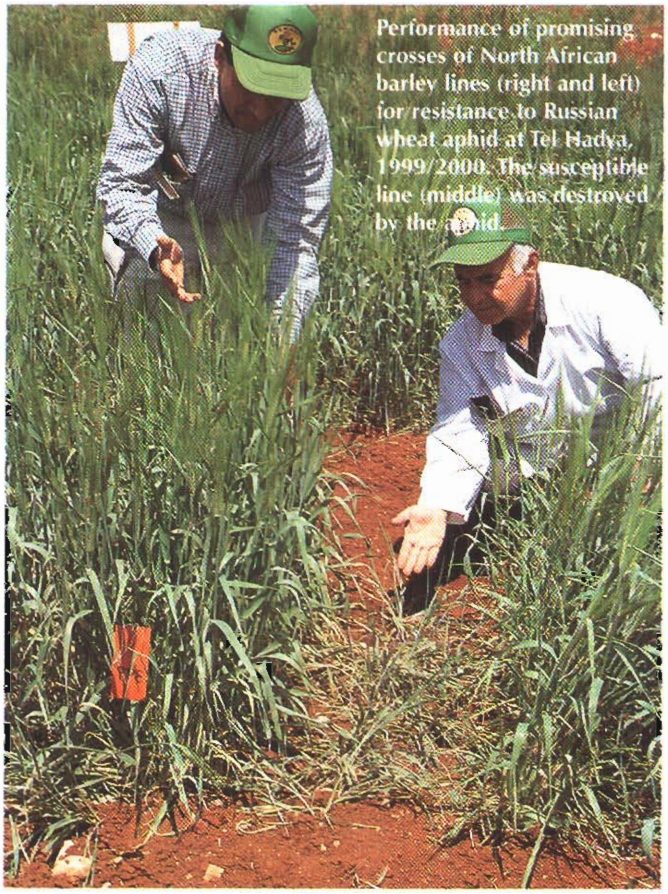
ICARDA's barley germplasm improvement program continued to make good progress during 2000. New lines with resistance to Russian wheat aphid were identified, a new farmer participatory project on varietal development began in Egypt, new levels of drought tolerance in barley were discovered in Syria, and a new drought-tolerant, high-yielding line was selected by farmer participation in Tunisia.

Better Resistance to Russian Wheat Aphid

The Russian wheat aphid, *Diuraphis noxia*, is an important pest of barley, found in several countries in the CWANA region. Economic levels of damage have been reported in Morocco, Tunisia, Algeria, Ethiopia, Yemen and parts of Turkey. The pest is most common in highland regions, where 100% of barley fields may be infested and 46% of plants affected. Recent dry years have exacerbated the problem by allowing the pest to spread, and yield losses of up to 70% have been reported in Ethiopia.

Host plant resistance is the only practical method of control, due to the high cost of chemical insecticides and their polluting effect on the environment. ICARDA has made good progress in introducing sources of genetic resistance into locally adapted barley germplasm. Field and greenhouse screening at ICARDA has provided 41 sources of resistance.

The first crosses to incorporate resistance to Russian wheat aphid into North African barley were made in 1997. Five sources of resistance were used in crosses with six barley cultivars grown in North Africa. Segregating populations were advanced (F_2 to F_4) at ICARDA's Tel Hadya experiment station in Syria. Seventy-one resistant lines (F_4) were identified during the 1999/2000 growing season and sent to Morocco, Algeria, and Tunisia for further evaluation under local conditions, and selecting best adapted types.



Performance of promising crosses of North African barley lines (right and left) for resistance to Russian wheat aphid at Tel Hadya, 1999/2000. The susceptible line (middle) was destroyed by the aphid.

Farmer Participation in Barley Improvement in Egypt

In the North West Coast of Egypt, barley is estimated to cover about 50,000 ha. The production systems include different combinations of barley, orchards, horticultural crops, and livestock. Only 6-row type barley is grown in the area; some farmers were exposed in the past to a 2-row variety distributed by a development project, but the variety was not found to be well adapted to the region.

Barley is used mainly to feed small ruminants. Its grain is also used to make a variety of foods. The crop is currently grown without any inputs of fertilizer, herbicide or pesticide. This is due both to the shortage of the inputs and the inability of resource-poor farmers to buy them.

ICARDA launched a new barley improvement project in the North West Coast region of Egypt in 1999/2000, with the long-term objective of increasing barley production and the short-term objective of using a farmer participatory approach to develop new cultivars. After consultation with farmers, eight locations were chosen to represent different agroecological zones within the region: El-Karamis and El-Hebella in Ras El-Hekma; El-Shawaier and Ghout Rabbah in Marsa Matrouh; El-Magroun and El-Dawaia in El-Negeila; West Barrani; and East Barrani. Fifty-three barley lines were planted at each site, along with a local check for which the farmers supplied seed. The trial was unreplicated and arranged in six blocks of 10 plots each. Selection was conducted in each farmer's field by the host farmer and by a group of five expert farmers. No inputs were used, in line with farmers' current practice.

Yields varied widely both between and within locations. The locational differences were because of rainfall and soil conditions. The average grain yield (Fig. 1) varied from about 200 kg/ha in West Barrani to more than 1000 kg/ha at El Negeila. Similarly, the average total biomass yield varied from about 700 kg/ha at El-Hebella to nearly 4000 kg/ha at El Negeila. Some of the entries outyielded the local check by 30% to 300% both in grain and biomass yield.

The host farmers and local 'expert' farmers, who were identified by their own farming communities, selected a total of 28 promising lines. Criteria for assessment included plant height, tillering ability and grain size. The involvement of local farmers made a positive contribution to the long-term objective of increasing barley production.

The World Bank end-of-year review mission visited one of the sites, while farmers were carrying out the selection. The mission was very positive about the role of farmer participation in this barley improvement project.

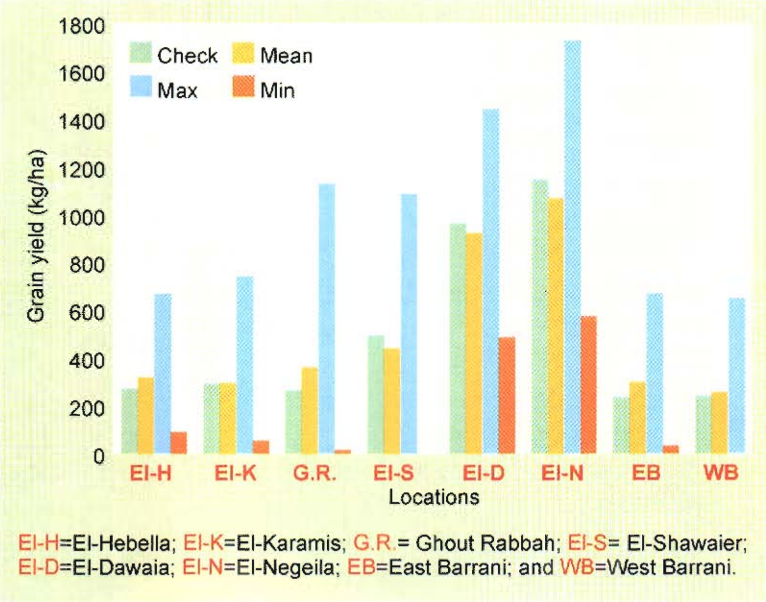
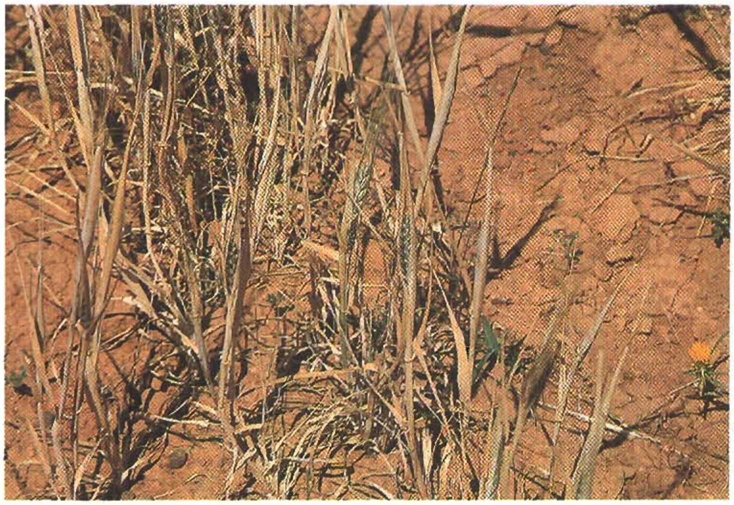


Fig. 1. Barley grain yield (kg/ha) in participatory plant breeding trials in eight locations in Egypt.

New Levels of Drought Tolerance in Barley

Rainfall in Syria during 2000 was 20-30% below the long-term average, so barley yields were severely affected. In some areas the crop failed to produce grain, and in others it did not even germinate. The low rainfall, however, provided a good opportunity to assess the relative drought-tolerance of new lines.



Farmers' varieties of barley completely failed due to severe drought in some parts of Syria during the 1999/2000 season.

The ICARDA trials planted in eight farmers' fields in Syria (Fig. 2), to begin the second phase of the participatory barley breeding program, were affected by different intensities of drought: one extreme was Melabya (Hassakeh province) with only about 50 mm rainfall in the entire season and no germination, and the other extreme was Sauran with 252 mm rainfall and an average grain yield of 1.8 t/ha (ranging from 1.0 to 3.2 t/ha). However, the highest yielding location was Mardabsi with an average grain yield of 3.4 t/ha (ranging from 2.7 to 4.4 t/ha), even though it received a total rainfall of only 221 mm. This demonstrates once again that differences in total rainfall only partly explain the differences in grain or biomass yields.

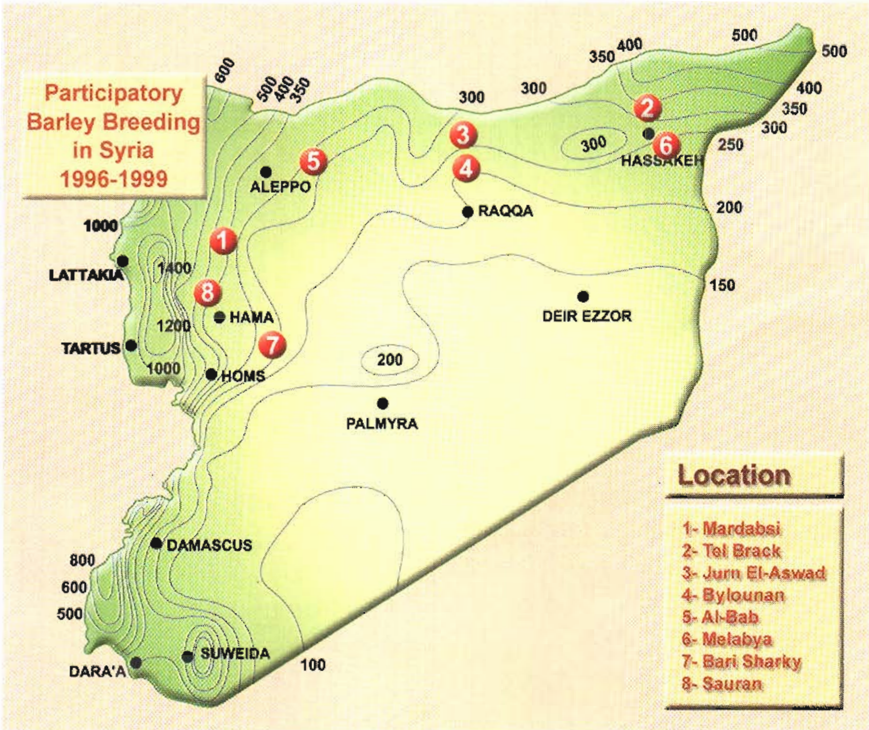


Fig. 2. Locations of farmer-participatory barley breeding trials in Syria.

Average grain and biomass yield across the driest locations were very low but some lines were able to produce between 300 and 500 kg/ha of grain (Fig. 3 and 4) and between 500 and 3000 kg/ha of biomass yield.

Drought tolerance was assessed in the field when the plots were close to maturity with a score from 1 (the majority of plants in a plot with a spike and seed and no symptoms of leaf rolling or wilting) to 5 (absence of spikes, leaf desiccation and/or wilting).

In four driest sites—Tel Brack in northeast Syria (87 mm), Jurn El Aswad (121 mm) and Bylounan (87 mm) in central Syria and Bari Sharky (130 mm) in central/western Syria—a few varieties were still

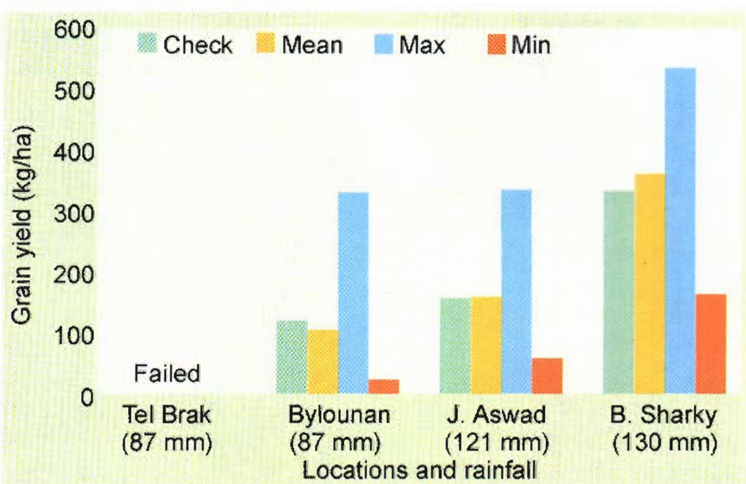


Fig. 3. Barley grain yield (kg/ha) under severe drought stress in four locations in Syria, 2000.

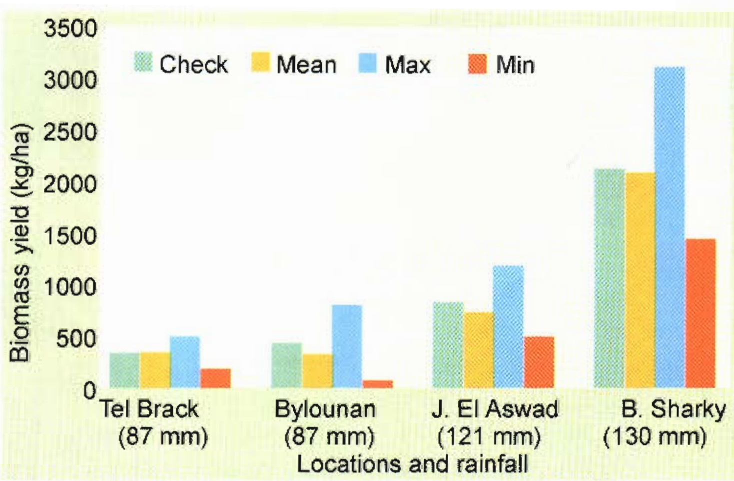


Fig. 4. Barley biomass yield (kg/ha) under severe drought stress in four locations in Syria, 2000.

able to produce grain. The crosses between *Hordeum spontaneum* line 41 and landraces were the most drought tolerant, compared with the modern lines. The crosses between *Hordeum spontaneum* 41 and landraces were also more frequently selected by farmers than the modern lines.

A drought-resistant barley line (left), developed by crossing a barley landrace with *Hordeum spontaneum*, produced satisfactory yield at Jurn Al Aswad (right), a dry site in Syria, where the rainfall received during the 1999/2000 season was only 121 mm.

This study confirmed previous findings that carefully selected *Hordeum spontaneum* lines could contribute significantly to enhancing drought-tolerance in cultivated barley.

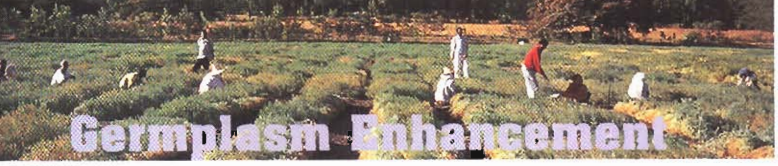
New Barley Variety Selected in Tunisia with Farmer Participation

Efforts to improve barley productivity in Tunisia through breeding began over 100 years ago. To date, 15 new varieties have been officially registered and released for commercial cultivation. However, farmers still prefer to grow traditional landraces, which have become well adapted to local conditions through thousands of years of evolution. Farmers prefer six-row varieties. However, in the dry central and southern areas of Tunisia, adoption of new six-row varieties, such as 'Rihane,' 'Manel' and 'Martin,' has been limited, because they were selected at a research station where the climate is wetter.

In the early 1990s, therefore, the barley project at ICARDA developed a new approach to breeding, based on decentralization and farmer participation. It was hoped that this approach would increase the relevance of new lines to small-scale farmers and ensure specific adaptation of new cultivars to dry areas. Thousands of lines have been evaluated since then, at a wide range of locations. 'Momtaz,' a six-row barley genotype with ideal characteristics for the dry areas of Tunisia, is one of the products of decentralized farmer participatory barley improvement project. It is tolerant to foliar diseases (net blotch, scald and powdery mildew), and to drought. While in favorable years, both 'Rihane' and 'Manel' outyielded 'Momtaz' by 5 to 30%, in dry years, 'Momtaz' showed a distinct yield advantage of 14 to 21% over the checks. In semi-dry seasons 'Momtaz' yielded 30% higher than the checks.

'Momtaz,' therefore, has great potential to improve barley yields in the dry areas of Tunisia. It can also be grown in wetter areas as a safety crop, to ensure good yields even in relatively dry years.

Farmers in Beja, Tunisia select barley lines according to their criteria. Crosses with *Hordeum spontaneum* (with resistantce to drought and tall plants) were generally preferred over modern lines.



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

Molecular Studies on Durum Wheat

Genetic linkage map

Durum wheat (*Triticum turgidum* L. var *durum*) is important both economically and nutritionally in the Mediterranean region. Research at the molecular level could contribute greatly to plant breeders' efforts to improve the crop. Yet the durum wheat genome has been little studied compared to that of other cereals.

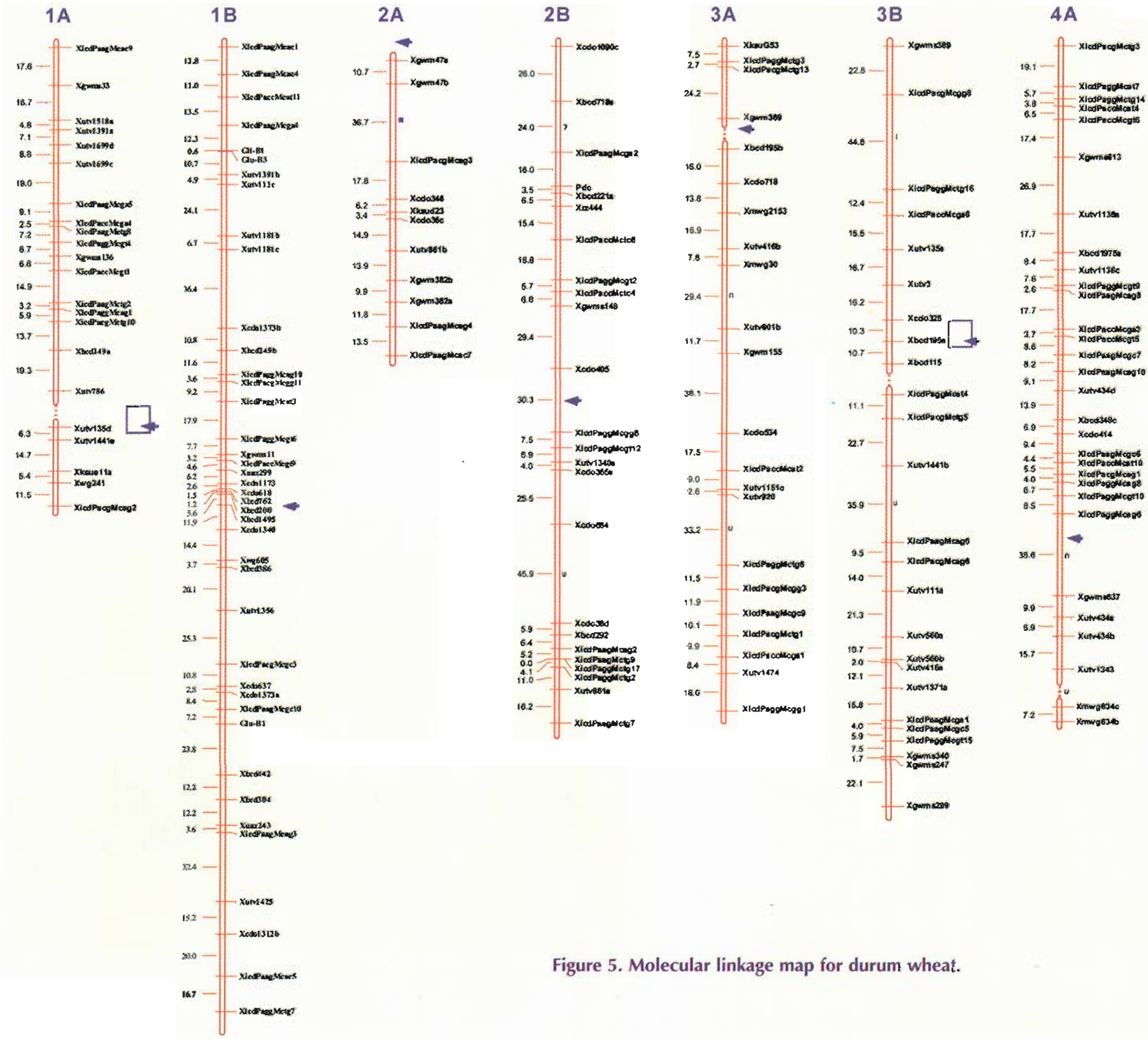
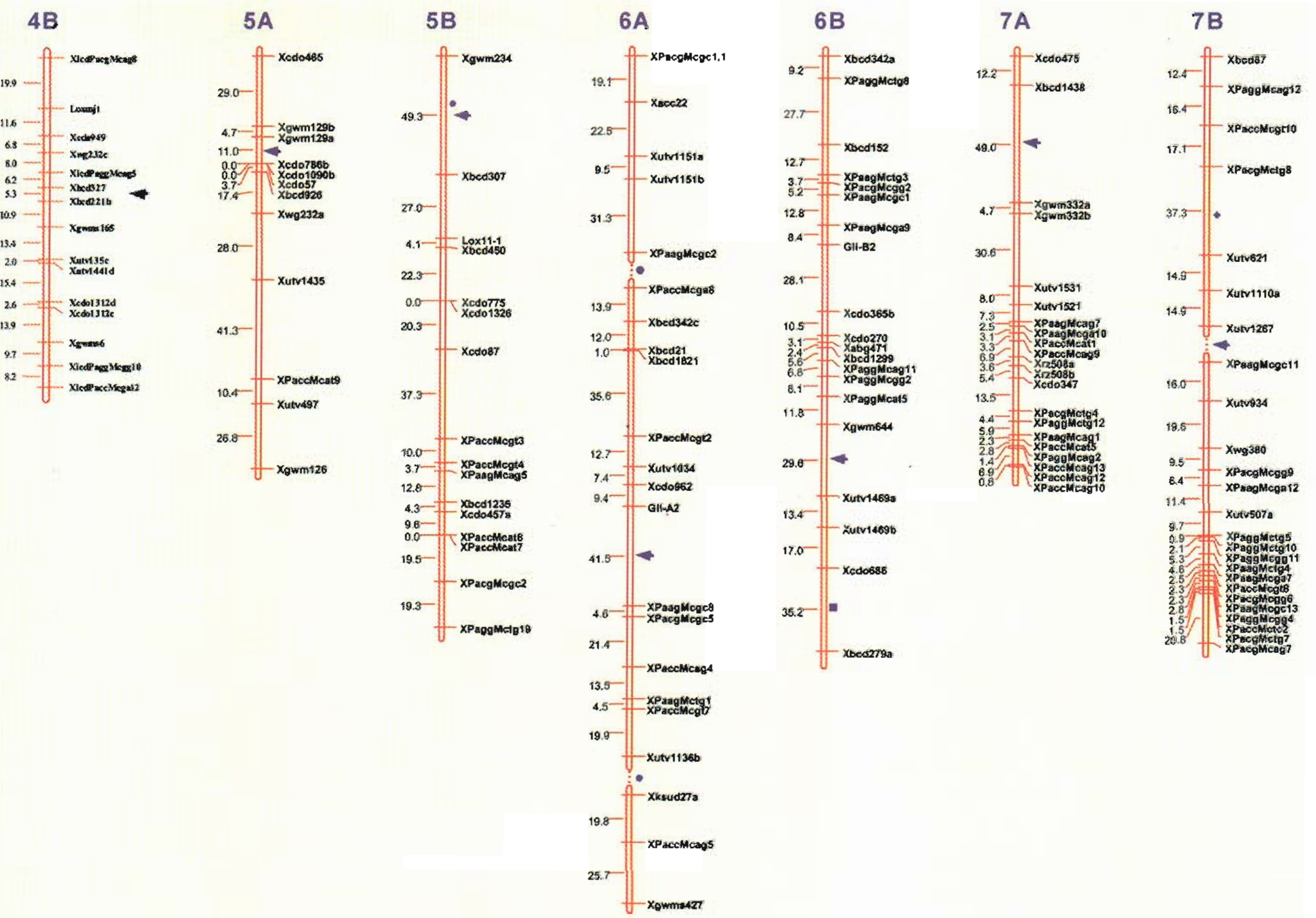


Figure 5. Molecular linkage map for durum wheat.

In 2000, ICARDA continued its work on a genetic linkage map of durum wheat (Fig. 5). To develop the map, two durum cultivars, 'Jennah Khetifa' and 'Cham 1', which have contrasting traits for grain quality and resistance to biotic and abiotic stresses, were crossed. The progeny was advanced to the F_9 generation to study the distribution of traits and their correlation with a range of genetic markers.

A total of 301 markers have now been placed on the map: 138 restriction fragment length polymorphisms (RFLPs), 26 simple sequence repeats (SSRs), 134 amplified fragment length polymorphisms (AFLPs), and three genes have been identified (one pyruvate decarboxylase and two lipoxygenases). The map was 3598 centimorgans (cM), with an average distance between markers of 11.8 cM, and 12.1% of the markers deviated significantly from expected Mendelian ratio of 1:1. The molecular markers were evenly distributed



Note: The approximate locations of the centromeres are indicated by arrows. Markers preceded by X are DNA or seed storage protein markers, those with no X indicate genes controlling specific traits that were assayed within the population. Map distances (cM) and marker names are shown on the left and right sides of each chromosome, respectively. Markers mapped with an LOD<3 (Logarithm of Odds) are shown as •1.560.15, •2.560.15, •260.15.

between A and B genomes. The chromosome with the most markers was 1B (41 markers), followed by 3B and 7B, with 25 markers each. The chromosomes with the fewest markers were 2A (11 markers), 5A (12 markers), and 4B (15 markers). The map obtained in this study agreed well with the *Triticeae* genus consensus map being developed by pooling the results of global research on individual species.

Understanding the crop's genome will help selection and breeding programs to develop new lines with resistance to pests, diseases and climatic stresses, as well as better grain quality.

Measuring grain yield of newly developed drought-tolerant durum genotypes.

Drought tolerance

Genetic markers are particularly useful when attempting to develop drought tolerance, as conventional selection for this trait is both costly and time-consuming, having to be conducted over many sites and seasons. Given the characteristics of ICARDA's mandate region, drought tolerance is a specially important breeding objective for the CIMMYT/ICARDA collaborative project on durum wheat.

Using the same mapping population as above, project scientists correlated various markers with some of the morpho-physiological traits associated with drought tolerance. These traits included the temperature of the crop's canopy, chlorophyll inhibition in foliage, proline content of the grain, and the ability to adjust osmosis. The same markers were also correlated with grain yield and with some of the components of grain yield (number of fertile tillers and number of kernels per spike). The main aim is to identify simple traits that can be quickly and easily used in the field, by farmers as well as researchers.

The project has now identified several markers with strong relationships to both yield and drought tolerance. In addition, carbon isotope discrimination (CID), found in previous research to be useful in screening for water-use efficiency in durum wheat, has been shown to be positively correlated with grain yield and yield components. Indeed, the association of CID with grain yield was just as strong as that of the number of fertile tillers and the number of kernels per spike with grain yield. Analysis of quantitative trait loci (QTL) has revealed the approximate location of the genes coding for the CID trait, which is thought to be found on chromosome 4B (Fig. 6). The project is now using microsatellites to define the location more accurately.

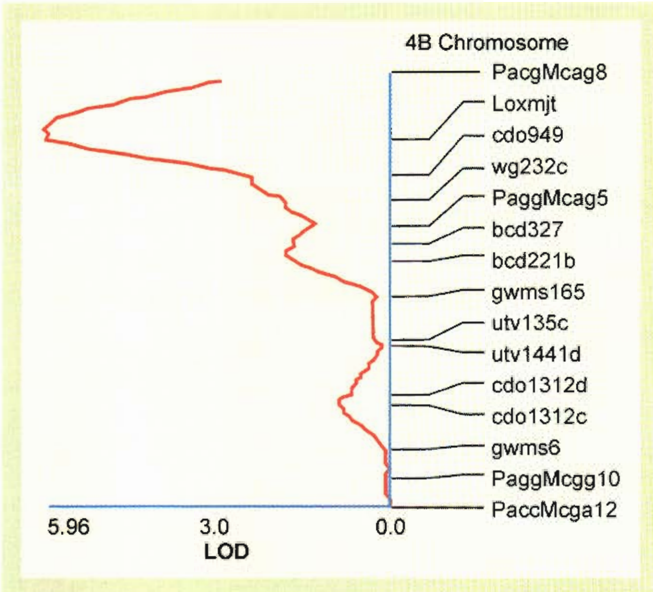


Fig. 6. Interval analysis for carbon isotope discrimination (CID) Breda, Syria, 1999.

Understanding how different molecular markers are linked with the physiological traits associated with yield under drought conditions should greatly speed up the selection of germplasm to suit the dry environments of the CWANA region.

Resistance to Russian wheat aphid

Russian wheat aphid (*Diuraphis noxia*) is a serious pest of durum wheat, for which few sources of resistance are available. During the past four years, ICARDA scientists have screened thousands of lines of durum wheat and its wild relatives, both in the field and under artificial infestation in the greenhouse. This effort has led to the identification of eight resistant lines, which are now being used in a breeding program to develop new varieties for release to farmers (Table 1). Nineteen accessions of wild relatives have also been identified as resistant, and these will be employed to broaden the genetic base of resistance and to provide resistance genes for use against the development of new biotypes. The highest levels of resistance were found in two wild relatives, *Aegilops biuncialis* and *Aegilops ovata,* and in two durum wheat lines Haucan/*Aegilops columnaris* and RSP Car. The progeny of crosses between these materials has shown good levels of resistance.

Table 1. Durum wheat lines with resistance to Russian wheat aphid, identified at Tel Hadya, Aleppo, Syria.

Entry No.	Name	Origin
3155	Aouej	Tunisia
3200	Jennah Khetifa	North Africa
3242	Mahmoudi Pubescent	Tunisia
3251	Medea	Tunisia
15465	Frigui	Tunisia
15506	Sinlikat	Tunisia
421	Terbol 97-1	CIMMYT/ICARDA
712	Altar 84/Stn/Wdz-2	CIMMYT/ICARDA

The data from this research also show that antibiosis and antixenosis are the two most important mechanisms exhibited by the resistant accessions. Interestingly, a few lines, including Haucan/Aeg. 400020//Omtel-1/3/Omlahn-3, combined a high level of antibiosis with a moderate level of antixenosis. Combining different mechanisms of resistance is important, as this should slow down the development of new, more damaging biotypes of the pest. Marker studies are now under way to determine the number of genes at work and their location.

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

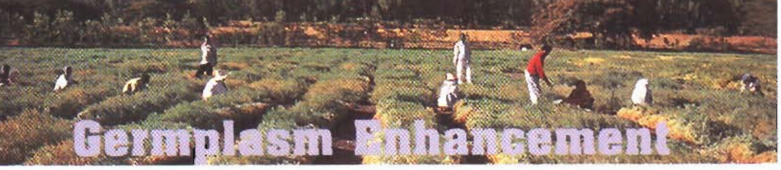
Spring Bread Wheat Improvement

Spring bread wheat is the principal food source for the majority of the population in North Africa. However, production is highly variable and does not meet the ever-increasing demand. Efforts by ICARDA and its national partners to improve spring bread wheat germplasm include enhancing its tolerance to stresses. Two major stresses under investigation during 2000 were heat stress and attack by Hessian fly.

Tolerance to heat

Spring bread wheat is normally grown between 25 and 40 degrees North and South of the equator, where the average temperature during the growing season remains below 20 °C. However, rising population pressure and increasing demand for food is forcing farmers to grow spring bread wheat in non-traditional, hotter environments, where heat stress is the main factor limiting productivity. Heat stress is anticipated to become more important in the future with climate change. Considerable variability in tolerance to heat stress has been reported in wheat. For example, the crop is grown successfully in the Nile Valley and Red Sea regions of Egypt, despite average temperatures exceeding 25°C throughout the growing season. ICARDA has established a Thermo-Tolerance Network of the Nile Valley and Red Sea Program to enhance wheat productivity by improving its adaptation to high temperatures. The network's main approach is to exploit existing genetic diversity for this characteristic, by identifying simple and practical morphological and physiological traits that can be used as selection tools.

The project established a network of sites along a thermal gradient, extending from Shandweel



(26º 36′N) in Egypt to Sennar (13º 35′N) in Sudan (Fig. 7). The network established a Nile Valley and Red Sea Regional Heat Stress Yield Trial (RHSYT) to identify genotypes adapted to the hot environments of the participating countries and to identify simple and practical morphological and physiological traits that can be used as efficient selection tools. The effects of heat stress were reflected in significant reductions in biomass, crop cycle length, kernel size, plant height, and grain yield between higher and lower latitudes along the thermal gradient (Fig. 8). Evaluation studies led to the identification of several high-yielding cultivars that were adapted to heat stress, including 'Seri 82', 'Anza', 'El Neilain', 'Condor's'/Baladi #18', 'Attila' and 'Pfau/Vee#5'. High grain yield was associated with genotypes that had high biomass and high harvest index, and cool crop canopy temperatures in heat-stressed environments. These traits appear to be promising selection tools that can be used to improve the adaptation of wheat to hot environments. The study also revealed other traits, including number of spikes per m^2, number of grains per spike, kernel weight and plant height, which could be useful for selection in severely heat-stressed environments such as Central Sudan.

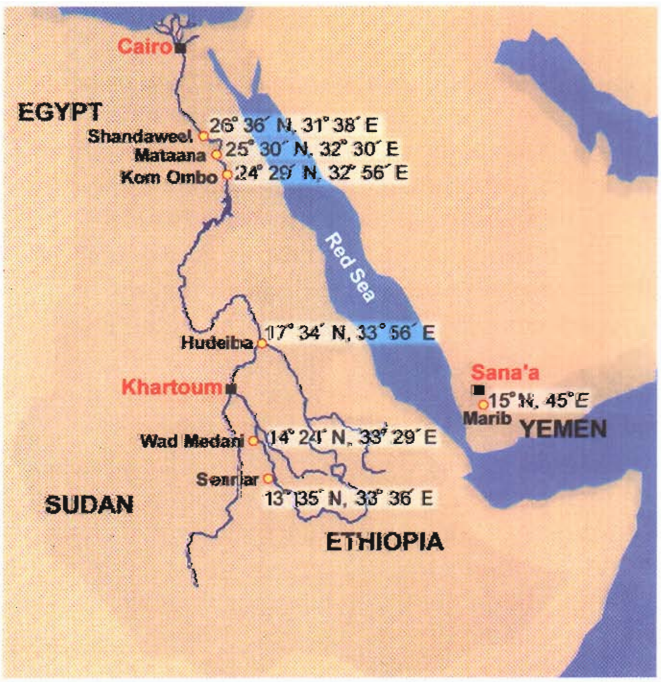


Fig. 7. Locations of the Regional Heat Stress Yield Trial.

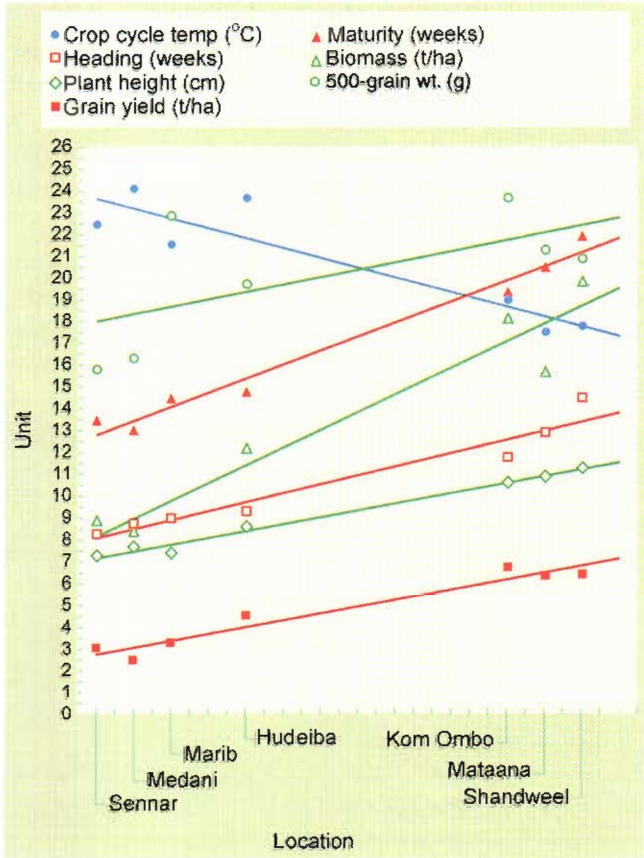


Fig. 8. Effect of location (thermal environment) on wheat growth, development, and productivity.

Hessian fly resistance

Crop damage due to Hessian fly (*Mayetiola destructor*) is considered to be the single most important factor limiting wheat productivity in North Africa, particularly in Morocco, Algeria and Tunisia. In Morocco, Hessian fly can destroy a whole crop if high infestation occurs in the early stages of plant development. On average, bread wheat yield losses due to the pest are around 36%. Chemical control has been investigated, but insecticides are expensive and pollute the environment. Cultural control methods such as plowing-under infested wheat stubble can greatly reduce infestation, but this is not compatible with current farming practices, since the wheat stubble is required for grazing animals. Breeding host plant resistance is therefore the most practical and economical method for long-term control. A study carried out in Morocco showed that the development of Hessian fly-resistant varieties would give an internal rate of return of 39%, indicating that

Table 2. Hessian fly (HF) resistance sources and chromosome location of resistance genes.

Resistance source	Origin	HF resistance gene	Chromosome location
JOUDA/SAADA	INRA-MOROCCO	H5	1A
JOUDA/KS811261-5	INRA-MOROCCO	H13	6D
NASMA*2/261-9	INRA-MOROCCO	H13	6D
POTAM*2/KS811261-8	INRA-MOROCCO	H13	6D
NASMA*2/14-2	INRA-MOROCCO	H22	1D
SAIS*2/14-2	INRA-MOROCCO	H22	1D
ALTAR 84/*Aeg. squarrosa* (TAUS)//OPATA	CIMMYT	?	?D

this is a highly cost-effective method. The CIMMYT/ICARDA project, in collaboration with the National Institute of Agricultural Research (INRA), Morocco, has made significant progress in developing host plant resistance to Hessian fly. Since 1990, one tolerant line ('Massira') and two resistant lines ('Arrehane' and 'Aguilal') have been released, and additional promising lines are being studied.

The evolution of new biotypes of pest is a phenomenon that is challenging breeders and entomologists, who must continually find new sources of resistance and must combine and deploy existing resistance genes in such a way as to increase their durability. Several new sources of resistance were identified during 1999/2000. Inheritance studies will be carried out to determine whether the genes coding for resistance in these sources are also new or are similar to those in existing sources. The vulnerability of crops to new biotypes is increased by using the same source of resistance across large areas. For example, the H5 gene for Hessian fly resistance has recently been introduced from bread wheat into durum wheat. INRA and CIMMYT/ICARDA are now attempting to broaden the genetic base of Hessian fly resistance by using resistant sources from the D-genome (Table 2). An example is a synthetic bread wheat derived from crosses with goatgrass (*Triticum tauschii* or *Aegilops squarrosa*). The aim is to increase genetic diversity in farmers' fields, which will reduce crop vulnerability and the need for chemical control, and promote higher and more stable yields.

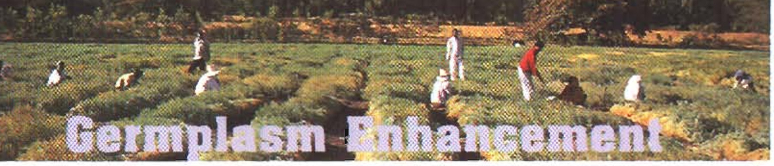
Project 1.4. Winter and Facultative Bread Wheat Germplasm Improvement for Increased Yield and Yield Stability in Highlands and Cold Winter Areas of Central and West Asia and North Africa

Improving Winter Wheat in the CWANA Region

Bread wheat is grown extensively throughout Central and West Asia and North Africa (CWANA), in lowlands and coastal zones as well as highlands and continental areas. Many types and strains therefore exist, with different characteristics to suit cultivation in a wide range of environmental conditions. During 2000, ICARDA plant breeders with their national partners made considerable advances in identifying specific cultivars that are well adapted to different growing areas. They also developed improved strains of winter wheat with good tolerance to drought, and selected lines with enhanced resistance to Russian wheat aphid, a major pest of winter wheat in the region.

Adaptation to local conditions

Bread wheat is sown either in winter or in spring, depending on local climatic conditions. Spring wheat is generally confined to a relatively low altitude (0-800m) where winters are mild, such as the Arabian Peninsula, the Nile Valley, North Africa and parts of Central and West Asia. Winter wheat (and semi-winter or facultative wheat) is more suit-



ed to continental or highland areas such as those in Iran, Uzbekistan, and Afghanistan. Both winter and facultative wheat contain genes for vernalization, which enable the plants to tolerate cold conditions and promote a longer growing period. Crosses between spring, facultative, and winter wheat can expand the variety of germplasm available for selection and provide cultivars that are ideally adapted to local environmental conditions.

ICARDA and its national partners have recently conducted research to identify the ideal characteristics for bread wheat in different regions. For example, the majority of winter wheat areas have cold winters, are rainfed and prone to drought. Here, the most successful types of wheat have a good level of tolerance to cold, some response to soil warming and increasing day length to help them escape a late spring frost, and rapid development of grain, to avoid heat and drought stress late in the growing season. Some areas have special local climates, for example, the Central Anatolian Plateau (CAP) of Turkey. Here, the late spring to early summer period is quite cool, favoring late-maturing types of wheat. ICARDA and national researchers have also identified other factors of importance in the choice of variety of wheat to suit a particular location. For example, irrigation can lessen the effect of summer heat, allowing high-yielding cultivars to perform well in a less than ideal environment.

Tolerance to drought

Over 60% of wheat in Iran is grown under rainfed conditions. Drought spells are frequent, for example, a prolonged drought occurred in the 1999/2000 season. The landrace 'Sardari' is widely grown in Iran, due to its ability to withstand such harsh conditions. Although improved cultivars are now grown in irrigated areas, until recently 'Sardari' remained the only choice available to Iranian farmers cultivating wheat in drought-prone areas.

ICARDA and Iranian researchers have been working hard to broaden farmers' choices by developing new breeding lines. Among these lines is 'Azar 2', a new cultivar developed from a cross involving 'Sardari' itself. Released in 1999, 'Azar 2' retains the drought tolerance of 'Sardari' and has additional advantages. It is less liable to damage by strong winds, it is resistant to yellow rust (a major disease of winter wheat in this area) and it gives a yield advantage of 4-18% over 'Sardari' (Fig. 9). Other improved breeding lines recently developed include 'Ogosta/Sefid' and 'Fenkang 15/Sefid'. These are tolerant to drought and yield slightly higher than 'Sardari', and are due for release to farmers in the near future.

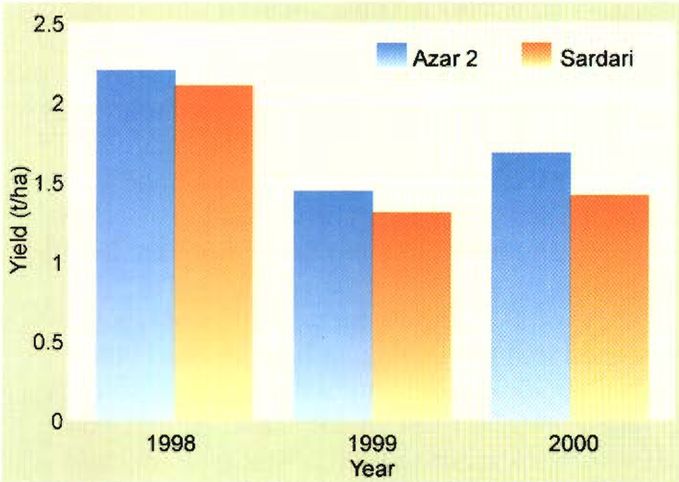


Fig. 9. Yield performance of 'Azar 2' and 'Sardari' wheat.

Resistance to Russian wheat aphid

Russian wheat aphid, *Diuraphis noxia*, is a common pest also in most of the highlands of West Asia and North Africa and affects wheat crop yields in Morocco, Algeria, Tunisia, Ethiopia, Yemen, and parts of Turkey. High levels of infestation have also been reported in Iran and Central Asia during dry years. Most of the commercial winter wheat cultivars grown in the region are susceptible, although some show moderate resistance. Developing host plant resistance is the most economical and practical means of control, as pesticides are expensive for farmers, difficult to obtain in some countries, and have both human and environmental health risks.

ICARDA has conducted field and greenhouse screening of local germplasm and material obtained from Colorado State University, USA. Several sources of resistance were identified, and

Screening winter bread wheat lines at Tel Hadya, Syria, for their resistance to Russian wheat aphid, 1999/2000.

two of these were used to incorporate resistance in five locally adapted cultivars in 1997. Five segregating F_2 populations of these crosses were evaluated in field trials at Tel Hadya during 1999. Plants were infected at seedling stage each with 10 nymphs of the aphids. Resistant plants were harvested individually. The resulting seed was grown and the plants were similarly subjected to further aphid challenge and assessment during 2000. A total of 145 F3 lines were found to carry resistant genes. These have been kept for further screening and additional selection, with the objective of identifying those with superior agronomic performance and also resistance to diseases.

Non-genetic factors

Although improving germplasm through plant breeding can have significant benefits, it is important to remember that the performance of both old and new cultivars is greatly influenced, in fact largely determined, by crop management practices. ICARDA scientists continue to conduct trials to quantify the effects on yield of non-genetic factors, such as sowing method and time of sowing, use of fertilizers, crop rotation, and supplementary irrigation. The resulting knowledge will then enable farmers to fully exploit the advantages provided by plant breeding research.

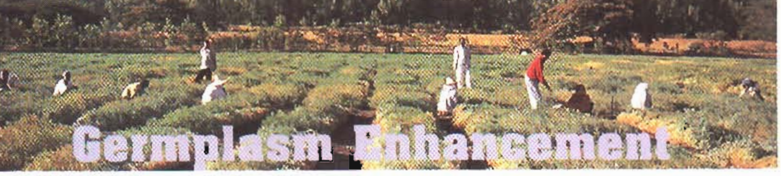
Project 1.5. Food Legume Germplasm Improvement (Lentil, Kabuli Chickpea, and Faba Bean) for Increased System Productivity

Food Legume Research and its Wide Impact in CWANA and Beyond

Food legumes are rich in protein and, therefore, highly nutritious. They form an important part of the diet of the low-income group in many countries, and are a substitute for meat, which the poor often cannot afford. For this reason they are popularly referred to as "poor man's meat." They also benefit agricultural systems, since they fix atmospheric nitrogen for their own use as well as for crops that follow them in the field. During 2000, the impact of ICARDA's food legume research increased both in CWANA and beyond. Lentil lines developed by ICARDA are not only benefiting our national partners in the developing world, but are also supporting a flourishing agricultural industry in Australia, thereby leading to increased availability of lentil in the developing world. A technique of modern biotechnology, agrobacterium-mediated transformation, is providing an alternative to classical plant breeding in developing host-plant resistance in lentil. Chickpea research has identified new sources of resistance to fusarium wilt, and is encouraging a change in traditional crop management to promote sustainability against a background of possible global climate change. Faba bean improvement benefited a wide range of countries, from the CWANA region to China and South America.

Australia: A beneficiary of ICARDA's lentil research

Lentils (*Lens culinaris*) have been grown in Australia for less than a decade, but cultivation has expanded dramatically during this time—from just



300 ha in 1992 to approximately 110,000 ha in 2000. The rapid increase in production has been driven mostly by the genetic material supplied by ICARDA. The similarities in climate and soils between parts of Australia and parts of CWANA have allowed successful introduction of nine varieties of lentil, all derived from lines that were products of ICARDA research.

Strong demand from overseas markets and a high net profit continue to generate significant interest among Australian farmers, who grow lentil as an alternative pulse in rotation with cereals. The Victorian Institute for Dryland Agriculture (VIDA), with ICARDA as a partner, has been instrumental in achieving successful lentil introduction, with the main areas of production located in medium-rainfall zones within Victoria and South Australia. Here, three key varieties, namely, 'Cobber', 'Digger' and 'Matilda' are grown. The release of 'Cassab' and 'Cumra' in 1998 and 'Nugget' in 1999 has further increased the production in drier and medium-rainfall areas. A yield potential of up to 3.5 t/ha has been achieved in farmers' fields with 'Nugget,' which is also suitable for mechanical harvesting. Lentil is now grown commercially in parts of Western Australia, New South Wales, Queensland, and Tasmania. Red lentils are currently dominating Australian production, representing eight of the nine varieties cultivated.

Most of these varieties are moderately resistant to ascochyta blight and botrytis gray mould, the most common local diseases. Australian scientists have also identified lines with tolerance to boron toxicity, waterlogging, drought and salinity, from the ICARDA-supplied genetic material.

Lentil variety 'Nugget' produces up to 3.5 t/ha in farmers' fields in Australia and is suitable for mechanical harvesting.

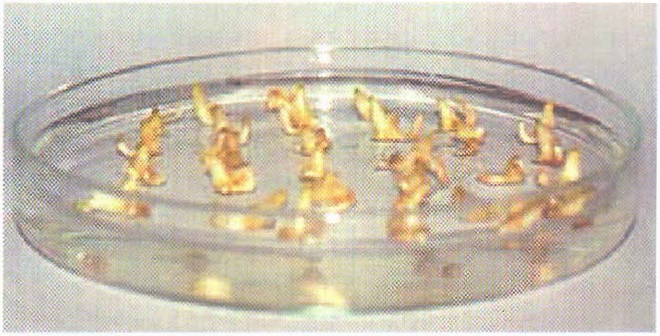
Australian lentils have proved popular with several major lentil-consuming countries, including Sri Lanka, Bangladesh, Pakistan, India, Egypt, Morocco, Algeria, and Tunisia. Thus, these developments are leading to supplying protein in the diet of people in developing countries, and are reflecting an indirect contribution of ICARDA's lentil improvement efforts.

Lentils transformed

Another partnership between ICARDA and Australia promises to produce new lines of lentil with resistance to a wide range of stress factors, such as the pea leaf weevil (*Sitona crinitus*). This is an economically important pest in West Asia and North Africa region that has proved difficult to combat through classical plant breeding, due to a lack of sufficient genetic variation in both cultigens and wild relatives of the host plant.

Scientists at the Center for Legumes in Mediterranean Agriculture (CLIMA) at the University of Western Australia have developed a protocol to transfer characteristics of resistance by introducing genes through agrobacterium-mediated transformation. Agrobacterium occurs widely in nature where it infects trees and plants through wounds, causing tumours or galls at the site of infection. It injects its own DNA into the host plant, a characteristic that has been taken up by scientists and used to transfer useful genes across species. Successful transformation experiments using the agrobacterium method have been reported for cotton, soybean, potato and tomato, and have also been conducted on lupin (*Lupinus angustifolius*), an important feed crop in Australia. The technique has now been adapted and modified for lentils.

The techniques of agrobacterium-mediated transformation have been transferred to ICARDA through training. Until biosafety regulations are in place in Syria, transformation activities are being implemented at the Agricultural Genetic Engineering Research Institute (AGERI) in Egypt, where such regulations are in place and contained environment facilities exist. The current project is conducting experiments on a reporter gene derived from a bacterium. If this gene can be successfully introduced into lentil, it is a good indication that the technique of gene delivery is feasible. Further experiments are aiming to introduce a fungal resistance gene derived from a grape vine, and a drought-resistance gene derived from wheat (obtained from Dr A. Markis, Greece). The first transformed plants are now being grown in rooting media and, if they root successfully, will be transferred to bio-containment units for further assessment.



Explants of lentil line FLIP 88-85C on subculture media 1, four days after inoculation with pCGP1258/Aglo construct.

Explants of FLIP 82-150C on selection media with Kanamycin, two day after inoculation with pROK2/GST construct.

Winter sowing of chickpea to fight drought

During 1999 and 2000, low rainfall caused severe crop losses in most of the countries in the West Asia and North Africa (WANA) region. Chickpea suffered heavy yield losses (up to 100% in parts of Syria, Morocco, Jordan, Algeria, Tunisia, and Iran) as a result of drought and heat stress. Chickpea is traditionally sown in spring and grown on residual soil moisture, with many farmers deciding to grow the crop only when there is sufficient early spring rain.

Earlier sowing is likely to become essential in order to sustain productivity with increasing frequency of drought. Researchers at ICARDA, together with national partners, have clearly demonstrated the superiority of early spring or winter sowing. Only farmers who planted chickpea early in the season obtained a good harvest. For example, farmers in Syria harvested around 1000 kg/ha from winter-sown chickpea as opposed to 300 kg or less from spring-sown. In addition, the quality of the seed harvested from spring-sown crops was poor, with small seeds and a low market value. Average seed yields from trials conducted with winter and spring sowings in the 1999 and 2000 growing seasons are shown in Figure 10. The crop makes efficient use of water, escapes heat and drought stresses by flowering and maturing early, and competes less with other crops for labor and machinery at harvest time. However, traditional varieties lack tolerance to cold as well as to ascochyta blight, the two major stresses to which early-sown crops are susceptible. ICARDA scientists have successfully developed cultivars with the required tolerances, and these have been evaluated and released for cultivation in several coun-

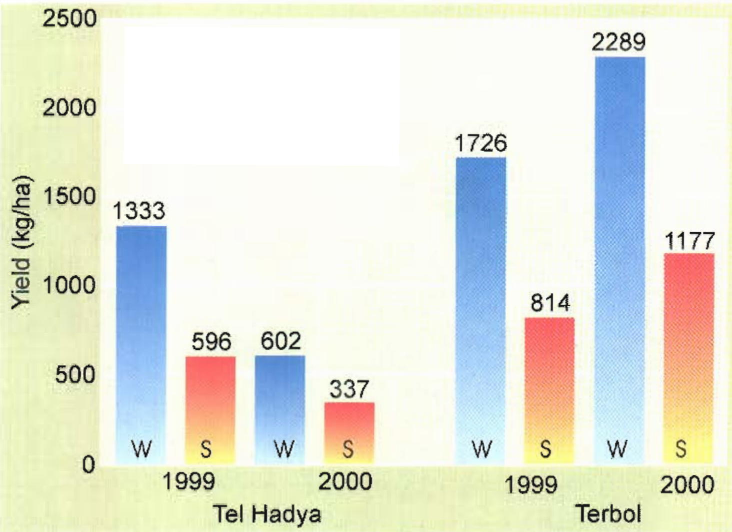
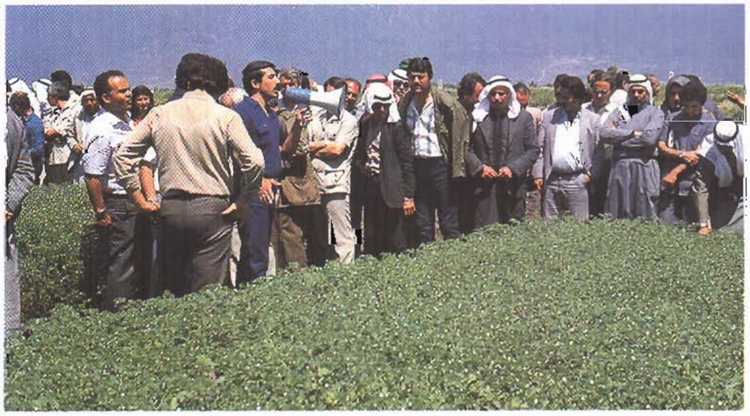


Fig.10. Average chickpea seed yield in trials conducted in Syria during winter and spring in 1999 and 2000.

tries. Although efforts have been made to promote winter planting, adoption of the practice has been slow, mainly due to a lack of availability of improved seed.

Field assessment of winter/early spring planting continued during 2000 and further cold-tolerant lines were developed (including an Iranian line which can survive temperatures as low as -20ºC). The benefits of early sowing are now being actively promoted. For example a documentary is being shown on Syrian television, and national governments and NGOs are producing improved seed and conducting demonstrations. A farmers' participatory selection scheme was started in Turkey and Syria in 1999, and will soon be extended to additional countries, with the objective of disseminating improved cultivars and encouraging seed production.

Scientists from Australia, Germany, USA, WANA countries and ICARDA examine newly developed tall and high-yielding winter chickpea lines at the principal research station of ICARDA at Tel Hadya, Syria.



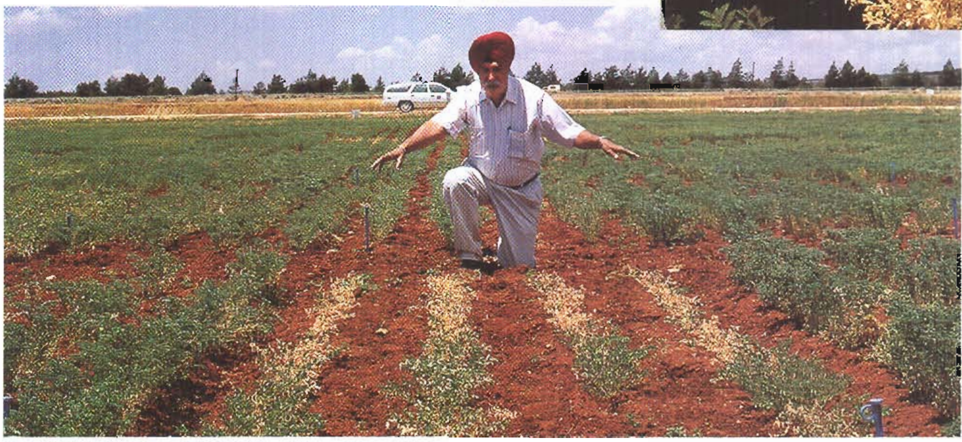
Farmers' Day in El-Ghab, Syria to promote the adoption of winter sowing of chickpea.

Identifying sources of resistance to fusarium wilt in chickpea

Fusarium wilt, caused by *Fusarium oxysporum*, is the second most important disease of chickpea worldwide, after ascochyta blight. Hot dry summers promote the development of this disease. Yield losses in the field can reach up to 100% where there is heavy infestation. Fusarium wilt therefore represents a significant problem, especially where people rely on chickpea as their main source of dietary protein.

ICARDA scientists have been screening for resistance to fusarium wilt for 10 years, in collaboration with national programs in Spain and Tunisia. The major bottleneck to progress has been the prevalence of different races of the pathogen. Consequently, a wilt-sick plot has been developed at Tel Hadya in Syria, specifically to identify resistant sources of germplasm to the races prevalent in the country. During the year 2000, significant infestation with fusarium wilt occurred, both in the sick plot and in other experimental plots, providing excellent conditions for screening. A total of 717 newly developed lines and 396 lines produced in earlier seasons were evaluated. Over 180 lines were found to be completely free from infestation. In addition, out of 238 lines previously identified as resistant or tolerant, 218 maintained their resistance (117 were completely free from disease). These results indicate that there is enough genetic material available for breeding resistance to fusarium wilt.

However, international evaluations have demonstrated a high degree of variability in the fungus, with different physiologic races of *Fusarium* occurring in different areas. This finding indicates a continuing need to identify and combine a variety of different resistance genes, in order to maintain host plant resistance and broaden the applicability of resistant varieties. Collaboration between ICARDA and national programs in Tunisia, Morocco, and Spain has been very successful in identifying different races of *Fusarium*. The following races have been characterized to date: race 0, race 1, race 2, race 3, race 4, race 5, and race 6. Sources of resistance to these races have been identified in collaboration with the University of Cordoba in Spain. Some of these lines have been used in breeding and inheritance studies at ICARDA. The results of inheritance studies based on four crosses using generation mean analysis indicated that resistance to *Fusarium* wilt race 0 is governed by both additive and dominance genes and by their interactions. The study suggested that selection for fusarium wilt resistance would be more effective in F_3 when some of the dominance gene effects are reduced. Research is continuing in an effort to combine genes for resistance to different races of *Fusarium* into cultivars through hybridization and selection.

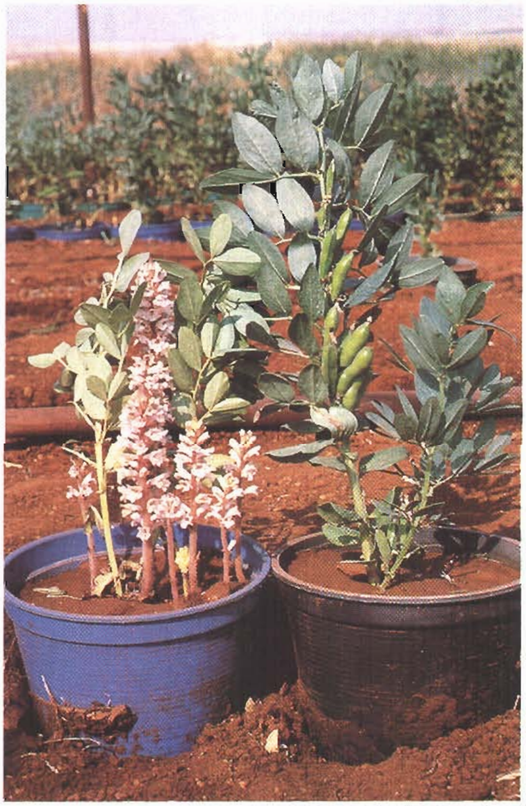


Heavy infestation of fusarium wilt can completely destroy chickpea crop (above), but ICARDA has developed resistant lines (left).

Improving host plant resistance in faba bean

Faba bean is an important cool-season food legume in the cereal-based cropping systems of WANA, as well as China and South America. It can be grown in a range of different soil and climate conditions and can tolerate low temperatures; it can also be highly productive under irrigated conditions. However, it is susceptible to a range of fungal diseases, including chocolate spot, ascochyta blight and rust, particularly during wet seasons with high humidity. *Orobanche*, a parasitic weed, also causes severe yield losses in some areas.

During 2000, the ICARDA faba bean improvement program made significant progress in identifying genetic resources and building gene pools with resistance to fungal diseases and *Orobanche*. ICARDA scientists and their NARS partners chose to incorporate resistance into local landraces rather than existing improved



Orabanche **is a pretty looking but harmful weed (left) that sucks nutrients from the faba bean plant and kills it. ICARDA has developed** ***Orobanche*****-resistant lines which are being increasingly used by national programs to increase production of this important food legume.**

varieties, to ensure that improved germplasm retained local adaptive traits. New lines with high resistance to ascochyta blight, chocolate spot, and rust were identified at ICARDA and distributed to national programs. The development of accessions with combined resistance to cold and ascochyta blight as well as high yielding ability was particularly noteworthy. An *Orobanche* nursery at ICARDA facilitated the identification of nine lines with high resistance compared to a local control. One new breeding line in Ethiopia, and two in Egypt, derived from ICARDA material, were selected following multiple crosses made to combine early maturity and high yield with resistance to chocolate spot and rust. These lines are likely to be released soon.

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

Grasspea—Savior or Sickener?

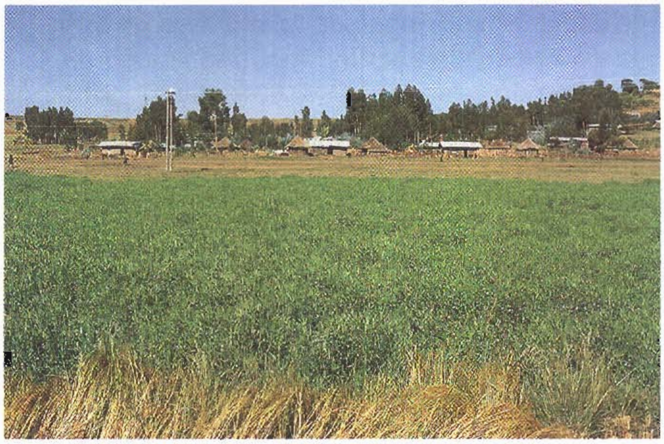
Lathyrus sativus or grasspea has been cultivated in South Asia and Ethiopia for over 2500 years for food as well as animal fodder. It is tolerant to drought but can also be grown in areas where there is excessive rainfall. Its ability to provide economic yield under adverse conditions has made it a popular crop in subsistence farming in many developing countries and it has great potential for use in marginal low rainfall areas. In Bangladesh, India, Nepal, and Pakistan it is often broadcast into a standing rice crop where it flourishes on the residual moisture left after rice has been harvested. In Ethiopia it is planted as a second crop after harvesting barley during years when late-season rains are abundant. It is a very hardy crop with a deep penetrating root system, and can be grown on a wide range of soil types including very poor soils and heavy clays. It also has the ability to fix atmospheric nitrogen, thereby improving soil fertility. When other crops fail, grasspea often becomes the principal food source for the poor. Indeed, it may be the only food available in times of drought and famine.

However, eating large amounts of grasspea can be a health hazard. Although grasspea seeds are tasty and rich in protein (containing about 30g protein per 100g edible seeds), over-consumption can cause neurolathyrism, an irreversible paralysis of the lower limbs. There have been three epidemics of neurolathyrism in Ethiopia and Eritrea during the past 50 years, the most recent occurring in Northeastern Ethiopia, following the drought of 1995/96 and the subsequent widespread crop failure. In this area, over 2000 people are estimated to be affected, and some can now walk only with the support of two sticks. The causative agent for this disease was first identified in the 1960s and has been confirmed as the neurotoxin ODAP (3-(N-oxalyl)-L-2, 3-diaminopropionic acid).

Reducing the level of neurotoxin in grasspea would allow safer use of this hardy legume. ICARDA holds a rich collection of *Lathyrus* spp. germplasm from different parts of the world and is collaborating with several national partners to develop new grasspea lines, aiming to improve yield potential and adaptability, as well as to reduce neurotoxicity. Three approaches are currently being investigated: germplasm evaluation and breeding for low-toxin genotypes (genetic detoxification), exploitation of somaclonal variation (*in vitro* culturing to induce mutations and increase variability), and manipulation of environmental factors (such as levels of soil micronutrients, notably zinc, iron, and phosphorus).

Identifying low-toxin genotypes

ICARDA scientists have analyzed a large number of germplasm accessions of *Lathyrus sativus*, concluding that none of them is completely toxin-free. However, the level of toxin varies widely between strains. Accessions from Bangladesh, India, Nepal and Pakistan showed the widest range (from 0.4 to 2.9%), while lines from North Africa, Turkey, Syria, and Cyprus showed the lowest levels (0.07 to 0.4%). The variation in level of toxin appears to be environment-related. For example, high toxin lev-



Grasspea 'IFLLS 502', a new low-neurotoxin line, being grown in a farmer's field in Ethiopia. This was the highest yielding of all lines tested by ICARDA and Ethiopian researchers, with a neurotoxin level as low as 0.15%.

els were found in most of the accessions collected from soils that were depleted in micronutrients as a result of flooding by monsoon rains. Grasspea grown on heavy soils, such as the Ethiopian vertisols, which have low levels of zinc and a high iron content, also showed higher than average levels of neurotoxin. However, existing low-toxin varieties tend to have undesirable traits such as late flowering, susceptibility to insects and diseases, and low yields. ICARDA scientists and their national partners therefore launched a hybridization program to transfer the characteristics of low neurotoxin levels to locally adapted germplasm. Ethiopia, Bangladesh, Pakistan, and Nepal are among the countries taking part in the program. A total of 100 new lines have been evaluated, several of which have demonstrated beneficial characteristics, such as high yield and cold tolerance, in addition to low levels of neurotoxin (Table 3).

Exploiting somaclonal variation

Tissue culture has the potential to increase variability, and ICARDA is using this technique to develop new lines that have low toxin levels as well as resistance to pests and diseases. A total of 75 lines derived from tissue culture of three landraces, two from Ethiopian and one from Bangladesh, have recently been tested. A significant reduction in neurotoxin has been achieved over the original landraces, and there was a wide variation in the agronomic and morphological characteristics examined. The only unfavorable variation seen was the time to maturity, which showed an increase. These lines are currently being evaluated at Debre Zeit, Inewari, and Adet in Ethiopia.

New low-neurotoxin grasspea lines, jointly developed by ICARDA and Ethiopian researchers, being evaluated at Debre Zeit Research Center in Ethiopia. Performance of these lines has renewed the interest of Ethiopia in grasspea improvement research.

Table 3. Grasspea lines with low-neurotoxin (ODAP) content selected at Inewari, Ethiopia.

Line (IFLLS#)	ODAP (%)	Grain yield (kg/ha)
565	0.24	1942
567	0.25	2045
553	0.19	1400
516	0.26	2282
522	0.26	2510
529	0.20	2112
483	0.20	1317
502	0.15	2700
665	0.18	1500
Local checks		
'Adet'	0.60	1400
'Ginchi'	0.47	1200
'Inerwari'	0.36	1200
'Molale'	0.41	1900
Mean	0.28	1808
SE±	0.035	141

Applying zinc to the soil

Zinc deficiency in the soil is a recognized agronomic problem in several countries where grasspea is grown, including Bangladesh and Ethiopia. It is particularly common in soils that have been leached by heavy rains. Grasspea is often grown on such soils during the drier winter period. ICARDA is working in collaboration with Ethiopia's national program to investigate whether manipulating soil and other environmental conditions can help develop a solution for neurolathyrism. Preliminary trials have revealed that the addition of zinc sulphate to the soil has a moderate effect in reducing toxicity in grasspea, with greater application of zinc resulting in a corresponding decrease in ODAP concentration. In addition, adding zinc to the soil generally results in increased yield and heavier seeds (Table 4).

During 2000, significant progress was made in the selection of low-neurotoxin, high-yielding lines of grasspea, which are well adapted to local environmental conditions. This research has the potential to benefit many thousands of resource-poor subsistence farmers in marginal farming areas, especially during times of hardship such as drought.

Table 4. Effect of zinc application on three lines of grasspea.

Added Zinc mg/kg	Parameter	Grasspea lines LS 512	LS 560	LS 562	Mean±SE
0	100-seed weight (g)	7.4	13.5	11.2	10.7±3.0
5		9.7	11.2	12.3	11.4±1.5
50		10.4	13.5	12.2	12.0±1.6
0	Grain yield/25 plants (g)	29.9	52.3	48.2	43.5±11.9
5		49.4	57.0	53.9	51.5±2.3
50		63.9	70.9	56.8	63.8±7.0
0	ODAP content (%)	0.253	0.331	0.228	0.291±0.04
5		0.199	0.200	0.214	0.200±0.08
50		0.151	0.160	0.177	0.163±0.02

Theme 2. Production Systems

Project 2.1. Integrated Pest Management in Cereal and Legume-based Cropping Systems in Dry Areas

Progress in Integrated Pest Management

Developing host plant resistance is a major ICARDA strategy for the protection of crops. However, rapid development of new virulent races and biotypes of diseases and pests has placed growing emphasis on Integrated Pest Management (IPM). In this approach, host plant resistance is combined with other control options, including agronomic practices, biological control and limited strategic use of chemicals, mainly as seed treatments and well-timed foliar sprays. The ICARDA IPM project is linked to all the breeding projects at the Center through host-plant resistance work, to the Agrobiodiversity Collection and Conservation project through the evaluation of crop wild relatives, and to several projects of the Natural Resource Management Program through collaborative work on agronomic practices.

Activities during 2000 included collecting a wide range of data on pest and disease incidence through international surveys. This information will help to design breeding strategies and to decide which disease species and races to target. Research on the sunn pest of wheat identified egg parasitoids as a possible component in IPM to replace the present insecticide-based strategy. Plant breeders will be better placed to target sources of resistance, as a result of the monitoring work on new races of yellow rust in wheat. Finally, research on the role of the sexual stage of the fungus in creating variability in ascochyta blight was conducted with the objective of enhancing screening systems and identifying future sources of resistance in faba bean.

Insect pest and disease surveys

Extensive surveys were conducted in Central Asia, Eritrea and Tunisia with national partners, to obtain up-to-date information on the incidence of pests and diseases and their economic importance. A number of first-time occurrences were recorded.

In the Central Asia region, yellow rust was encountered in wheat at different incidence levels in all the countries visited, with severe disease development observed in Azerbaijan and Kyrgyzstan. In Uzbekistan, high infection occurred early in the season, but disease development stopped when temperatures increased during the months of April and May. In Turkey, high infection was observed on the variety 'Gerek', on an area covering about one million hectares of the Anatolian Plateau. Here, yield losses of at least 30% were expected. Common bunt was a problem in most of the experimental stations in Azerbaijan, and a high fusarium wilt infection was observed in Zaqatala region. Powdery mildew and tan spot were severe in most farmers' fields in Kyrgyzstan.

Exploratory activities to collect sunn pest from overwintering sites in Kazakstan and Kyrgyzstan were undertaken in collaboration with the University of Vermont and national research partners. Forty-nine insect-killing fungal isolates were recovered from the 500 sunn pest adults collected. Twenty-five were *Beauveria bassiana*, 8 were *Paecilomyces farinosus*, and 7 were *Verticillium lecanii*. Several species of *Paecilomyces*, *Hirsutella* and *Fusarium* were also represented. Use of fungal pathogens as biological control against insect pests has been successful, for example, against desert locusts in Africa. However, further work will be required before this approach is proven to be a practical and economical solution to sunn pest infestation.

In Eritrea, the disease survey included 53 fields in 25 sites, covering barley, wheat, and hanftse. Yellow and leaf rusts of wheat were present at high

incidence levels, and smut diseases were common on barley. In the high-rainfall area, yellow rust and *Septoria tritici* occurred. In some fields where a mixture of bread wheat varieties was grown, genotypes with high resistance as well as high susceptibility to yellow rust were observed. The most prevalent barley diseases were scald (particularly on late-planted six-row barley) and net blotch (net and spot forms), with sporadic incidence of septoria (*Septoria passerinii*).

In Iraq, the virus disease survey covered 54 legume and 23 cereal fields, where a total of 7663 legume and 3455 cereal samples were collected. Samples were tested for the presence of 12 legume and 5 cereal viruses. In faba bean fields, bean yellow mosaic virus (BYMV) was the most common, followed by bean leaf roll virus (BLRV) and beet western yellow virus (BWYV), which had not been seen in Iraq before. The highest virus disease incidence was 80-100%, recorded in 18 fields. In cereal fields, only barley yellow dwarf virus (BYDV) was detected, with an incidence of around 1%. Other viruses were rarely detected in legume crops, although faba bean necrotic yellow virus (FBNYV) and chickpea chlorotic dwarf virus (CCDV) were detected for the first time in Iraq.

In Tunisia, several cereal production areas were surveyed for disease incidence. Surveys on wheat indicated a severe infestation of common root rot at all sites, with the highest incidence at Le Kef. Moderate infection with *Septoria* spp. was recorded at Bizerte, Jendouba and Beja, and cereal cyst nematodes were recorded at Seliana and Le Kef. On barley, net blotch was observed at all sites, but severe infection was recorded only at Zaghouan. Moderate infection of powdery mildew and scald was also observed at all sites.

An insect survey was conduced in several regions. The two predominant pests found were Hessian fly and barley stem gall midge. The latter was found in all the regions surveyed, and the average infestation rate was 40%. Hessian fly was found mostly in Morgane, Soussa and Kef, with average infestation of 25-30%. The results of this survey support those of previous years, indicating that barley stem gall midge and Hessian fly are economically important pests of barley and wheat in Tunisia.

A survey to identify virus diseases of legumes (chickpea, faba bean, and lentil) and cereal crops (bread and durum wheat and barley) at different locations in Tunisia was also conducted. The survey covered 38 legume and 44 cereal fields. In faba bean fields, broad bean mottle virus (BBMV) and beet western yellow virus (BWYV) were the most common, followed by faba bean necrotic yellow virus (FBNYV). Two faba bean fields had a viral disease incidence of 21% or higher. In cereal fields, barley stripe mosaic virus (BSMV) was the most common, followed by barley yellow dwarf virus (BYDV) and barley yellow striate mosaic virus (BYSMV). Two cereal fields had a virus dis-

Virus disease surveys by NARS and ICARDA scientists included field observations and sample collection (left) and laboratory testing (above).

ease incidence of 6% or higher. Other viruses, such as broad bean stain virus (BBSV), bean leaf roll virus (BLRV) and cucumber mosaic virus (CMV) in legumes, and wheat dwarf virus (WDV) in cereals, were rarely detected. In this survey a number of viruses were detected in Tunisia for the first time, namely, BWYV and FBNYV in legumes, and BSMV, BYSMV and WDV in cereals, the last two being vectored by leafhoppers. Further monitoring of these viruses will be conducted in future seasons.

Harnessing natural enemies of sunn pest

Sunn pest (*Eurygaster integriceps*) is a very damaging insect pest of wheat and barley, which affects around 15 million ha of cereal crops in West and Central Asia. ICARDA is collaborating with national partners to develop IPM options for sunn pest to replace the present insecticide-based control strategy. One approach currently being studied is the effect of egg parasitoids. These small insects (Order: Hymenoptera) are natural enemies of the sunn pest. They lay their eggs on sunn pest eggs and effectively kill them. They become active in the spring, about two weeks after the sunn pest starts laying eggs. The level of parasitism in 1999 and 2000 was high, reaching 100% in the Azaz region of Syria during May (Fig. 11).

Surveys conducted in Syria from 1997 to 2000 showed that six parasitoid species belonging to two families in the order Hymenoptera were found to attack sunn pest eggs. Four species of the family Scelionidae are *Trissolcus grandis*, *T. simoni*, *T. vassilievi*, and *Gryon fasciatus*. *Ooencyrtus fecundus* and *O. telenomicida* were the only species which belonged to the family Encyrtidae. *Ooencyrtus fecundus* and *Gryon fasciatus* were reported for the first time in Syria as sunn pest egg parasitoids.

It seems that these parasitoids could play an important role in reducing sunn pest populations. However, a major factor that currently limits their activities is large-scale aerial spraying of broad-spectrum insecticides. These kill both the sunn pest and its natural enemies. Applying more selective insecticides, and better timing of insecticide use to avoid spraying when the egg parasitoids are active, are possible ways forward. Another way to enhance the role of these parasitoids would be to improve their habitat. Avoiding overgrazing would increase the biodiversity of natural vegetation and support other insects with the same natural enemies. Improving the availability of refuges for overwintering, such as coarse-barked trees, would also promote population growth of natural enemies to sunn pest.

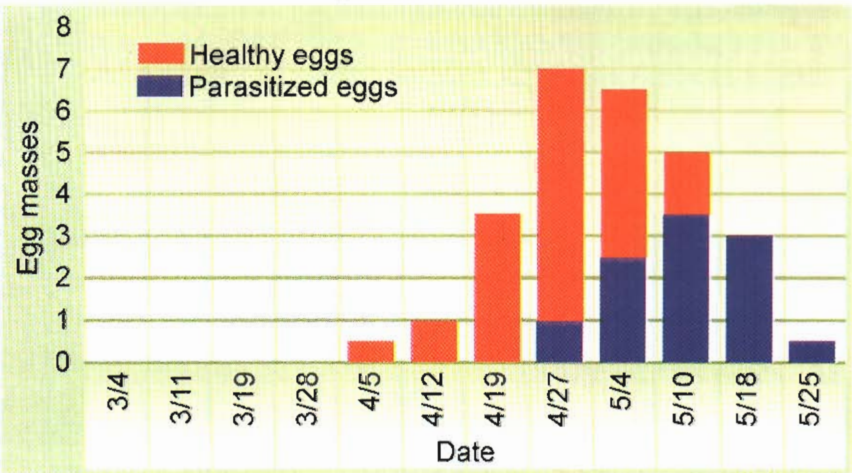


Fig. 11. Sunn pest oviposition and egg parasitism at Azaz, Syria during 1999 and 2000.

New races of yellow rust of wheat

Monitoring of yellow rust disease in wheat revealed that new virulent races are evolving in Central and West Asia, causing the breakdown of widely used sources of resistance in wheat. Several physiologically distinct races have been identified in Syria and Lebanon, some of them virulent to a number of resistance genes that have not yet been deployed in the region. Virulence levels ranged greatly, between 70% and under 5% (Fig. 12). New virulence was also observed in Kyrgyzstan and Azerbaijan. The breakdown of the yellow rust resistance genes (Yr) means that the yellow rust pathogen could spread rapidly and eventually cause significant losses in crop production. Monitoring the development of new races helps ICARDA scientists to target suitable sources of resistance and select appropriate resistance genes in locally adapted cultivars of wheat.

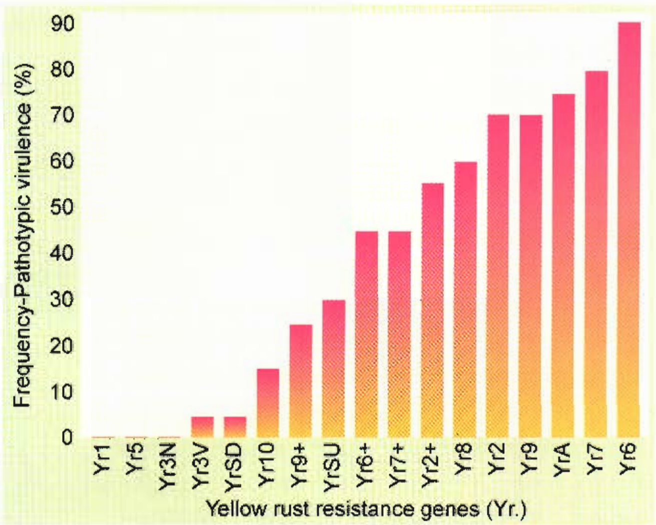
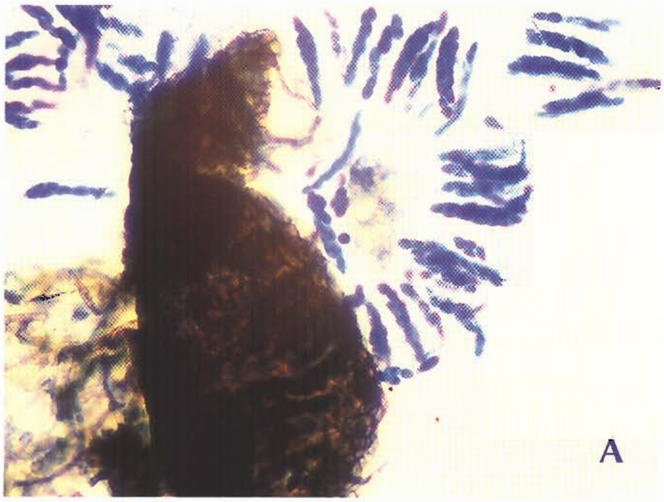


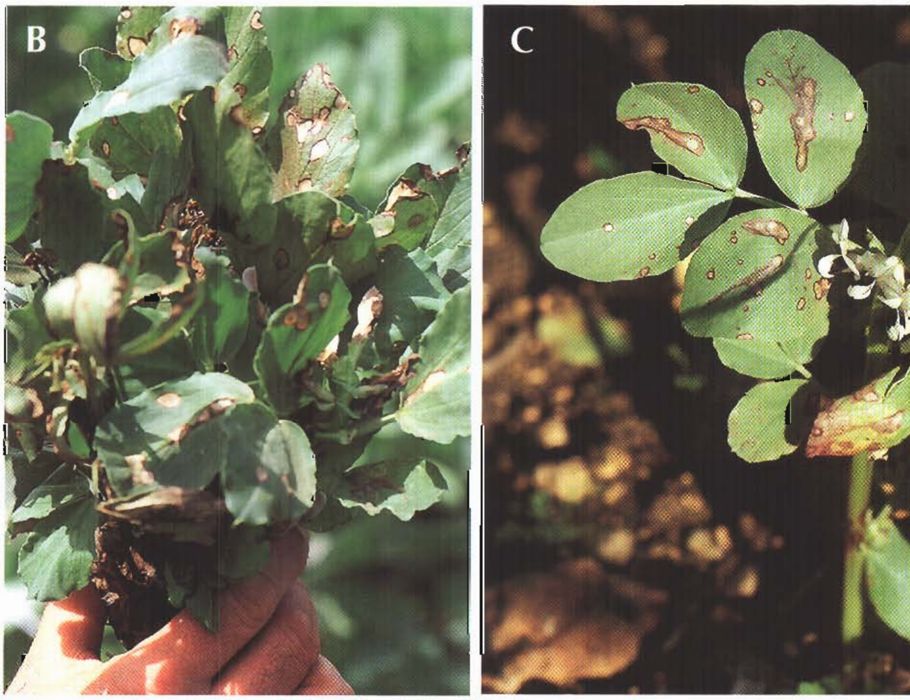
Fig. 12. Frequency of pathotypic virulence on yellow rust resistance (Yr) genes in Syria and Lebanon.

Sexual stage of *Ascochyta fabae* detected for the first time in Syria

Ascochyta blight is a widespread disease of faba bean, causing high yield losses and reducing the commercial value of seeds in heavily infected areas. In Syria, the severity of the disease at Tel-Hadya, which has dry, cold winters, was found to be higher than that at Lattakia, where winters are wet and mild. This could be due either to pathogen variability, or to the effect of different environmental conditions, or to both factors. In 2000, the sexual or perfect stage of the pathogen (*Didymella fabae*) was detected for the first time on faba bean debris at Tel Hadya. When a fungus reproduces sexually, a new variant may appear due to DNA recombination in the cell nucleus. This is what creates the considerable variability found in the pathogen population. Although the same inoculum was used to artificially inoculate the plants at both sites, the perfect stage was not found at Lattakia. Again, this may be due to the presence of different mating types of the fungus or to the different environmental conditions.

Every year since 1997, ICARDA and national scientists have evaluated around 350 lines of faba bean, to identify new sources of resistance to ascochyta blight. The natural occurrence of the sexual stage of the fungus, and the variability this induces, makes northern Syria an ideal location for screening for resistance, increasing the chances that the resistance genes identified at ICARDA will also be resistant to ascochyta blight throughout the region.





Ascomata, asci and ascospores of *Didymella fabae* (A); pathogenicity test (B) and close up of leaf spots (C).

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

Preserving the Nile Valley Productivity

Egypt has a long history of agriculture dating back 6-7000 years, when one of the earliest agricultural civilizations in the world developed in the Nile Valley. Present day agriculture in Egypt is almost entirely dependent on irrigation and is generally highly productive and ideally suited to intensive cropping. However, the sustainability of this system is threatened by several problems, including low groundwater quality and salinity, over-use of chemical fertilizers, low inputs of organic manure, and low water-use efficiency. In 1996, ICARDA and Egyptian national partners launched a project to tackle these problems. The project's objective was to sustain high agricultural productivity by protecting the natural resource base. Extensive long-term monitoring of farmers' activities, together with long-term trials on research stations, were undertaken in the Nile Valley's three different production zones: Old Land in the Middle and Northern Delta, newly reclaimed land with sandy and calcareous soils, and rainfed areas in the Rafah-El Barth area (northeastern Sinai).

Along with the long-term on-station trials (LTT), extensive long-term monitoring (LTM) activities in farmers' fields, in villages close to each LTT site, are conducted to obtain information on farmers' practices and management and their effect on productivity, profitability, and the condition of soil and water resources. Preliminary results (1996 to 2000) provided valuable information concerning farmers' management practices and their effects on productivity, profitability and the condition of soil and water resources:

- Higher yields and a 25-30% reduction in water use were obtained by applying the theoretically required irrigation regime, instead of farmers' current practices.
- In rainfed areas, applying organic manure resulted in cereal yields that were as high as those obtained using chemical (NP) fertilizers. Introducing legumes as a rotation crop into continuous cereal cropping systems reduced weed infestation in wheat and increased water-use efficiency in barley. For example, only 0.38 kg of barley grain/m^3 water was obtained in barley-barley compared with 0.73 kg in barley-lentil and 0.72 kg in barley-forage pea rotations.

A long-term trial in New Lands in Egypt.

Establishment of a long-term trial in sandy soils in New Lands.

Development of the rainfed areas in North Sinai, Egypt.

- In all zones, the majority of farmers were using nitrogen fertilizers at higher than optimum levels. In irrigated areas, nitrogen-use efficiency for wheat in farmers' fields was about half of that recorded in research plots, but values were increased when organic manure was applied.
- Water-use efficiency for wheat grown under irrigation was generally lower in farmers' fields (0.6 kg grain/m^3 water) than on research plots (1.5 kg grain/m^3 water). This was probably due to farmers' generally poor management techniques, such as applying too much water to land near the canals and not enough farther away. The negative effects of over-watering include raised water tables and increased salinity, both of which reduce yields.
- Monitoring the quality of inlet water from canals and wells and comparing this to field drain water revealed a worrying amount of nitrate leaching and water pollution. For example, nitrate content increased from 1.6 to 12.1 mg/l from source to drain in farmer's fields.
- These multidisciplinary long-term research and monitoring activities helped to improve our knowledge of the farming systems studied. In-depth analysis of the data will provide valuable information that can be used to promote sustainability within the Egyptian agricultural system, ensuring continued high productivity in the future.

Promoting Agricultural Diversification in Central Asia

It is nearly 10 years since the breakdown of the Soviet Union. During this time, the Central Asian Republics of Kazakstan, Kyrgyzstan, Turkmenistan, and Uzbekistan have been making the transition from a centrally organized to a market-driven economy. In spite of the high agricultural potential of the region, yields and production of crops and livestock vary greatly from year to year and are generally below those of other regions of the world with similar agroecologies. The many small-scale farmers starting up their farms need assistance with enterprise development and introduction to new crops and rotations. In both rainfed and irrigated production systems, farmers need to diversify the crops they grow so as to restore sustainability, which has been severely damaged by the large-scale monocropping approach of the Soviet era. The ICARDA Soil and Water Management Project, therefore, places special emphasis on promoting agricultural diversity in this region.

Over the last two years, ICARDA and national scientists have conducted field experiments to assess the potential for diversification in three main agricultural systems: rainfed semi-arid areas with spring wheat-based cropping, rainfed semi-arid areas with winter wheat-based cropping, and irrigated systems. Legume crops were introduced into common cereal rotations, such as fallow-wheat-wheat and fallow-wheat-wheat-barley in North Kazakstan and irrigated cotton- and wheat-based rotations in Uzbekistan. Promising results were achieved by introducing dry pea, chickpea, lentil, and safflower in rainfed areas and mash (*Phaseolus mungo*) in irrigated systems. However,

Conservation tillage in action in northern Kazakstan.

it is still too early to draw firm conclusions, as weather conditions have been better than normal during the past two years. Further emphasis will now be placed on germplasm enhancement for tolerance to drought, which is common in the region. Safflower has good drought tolerance and appears to be a particularly promising diversification crop.

Tillage practices that minimize soil disturbance are another possible approach to improving sustainability. For example, by using a cultivator, farmers could till the soil to a depth of 12-15 cm and retain the stubble on the surface, instead of tilling it to a depth of 25-30 cm, as they do with a conventional mold-board plow. A direct drill (no-till planter) is another option. However, in order to conduct effective studies on these options, soil conservation tillage machinery would need to be imported into the region. The project will be linked with "Direct Sowing, Mulch-based Systems and Conservation Tillage," being promoted by the Global Forum on Agricultural Research.


Researchers evaluate the results of a joint tillage trial in northern Kazakstan.

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

Improving Forage Production in Dry Areas

ICARDA's forage production improvement project is closely linked with Project 1.6 (see page 26) and 3.3 (see page 45) of the Center's MTP. The project covers a wide range of crops and natural grazing systems. Forage legumes have been introduced into cereal crop rotations, resulting in improved production of fodder, increased cereal yield, and a more sustainable system. In addition, rare germplasm from dry rangelands has been collected and preserved. This is important for conservation and rehabilitation of degraded rangelands.

Scaling up cereal/vetch rotation in Syria

Common vetch (*Vicia sativa*) is a forage legume that can be grown in rotation with cereals to improve crop yields as well as produce nutritious fodder for grazing or stall-feeding of small ruminants. Vetch has been grown successfully in El-Bab village in northern Syria since 1984, where it was introduced through an ICARDA research project. At that time, economic and demographic pressures forced farmers to monocrop barley, an unsustainable system that led to declining soil fertility, reduced cereal and livestock-feed yields, as well as mounting pressure from pests and diseases.

Researchers from the Syrian national program have been closely working with ICARDA in the El-Bab project. Farmers and extension agents from El-Bab and Aleppo, and representatives from Farmers' Association and the Agricultural Bank are closely involved in the project activities.


Mr Ghasan Zaida, Head of Extension Department, Aleppo Directorate of Agriculture, discusses with farmers the benefits of introducing vetch into their crop rotations.

An appraisal of the project, conducted in 2000, reconfirmed that vetch has enormous potential for increasing cereal yields (Table 5) and improving livestock productivity. Growing vetch in rotation with barley led to an increase in the level of nitro-

gen and organic matter in the soil, and a reduction in pests and diseases. Total output of crude protein, one of the main factors limiting livestock productivity in West Asia, was doubled in a vetch/barley rotation, compared to barley/barley or barley/fallow. Significantly, farmers participating in the project understood the importance of crop rotation to ensure the long-term sustainability of production and expressed an eagerness to extend vetch cultivation. The main constraints to expansion of vetch were the lack of seed, and the need for inexpensive but efficient mechanized harvesting.

Table 5. Cereal yields in farmers' fields at El-Bab, northern Syria.

	1996/1997 kg/ha	1997/1998 kg/ha
Deep soil		
Barley after vetch	1574	2874
Barley after barley	945	2239
Wheat after vetch	897	3241
Wheat after barley	648	859
Shallow soil		
Barley after vetch	1068	1946
Barley after barley	521	996

As a result of the success of this project, the Ministry of Agriculture and Agrarian Reform in Syria decided to increase the area planted to vetch in their 2000/2001 plans. The need to facilitate mechanized harvesting will also be addressed, by increasing production and reducing the price of mowers, and by making loans available to farmers to allow them to purchase the machinery.

Filling the gap—collecting rangeland germplasm

Loss of biodiversity (genetic erosion) is occurring at a rapid rate in many areas of the world. Although ICARDA has extensive holdings of pasture germplasm, CWANA's rich flora is far from adequately represented. ICARDA scientists have identified the gaps in the Center's collection and are now placing a strong emphasis on collecting germplasm from native pastures and rangelands in low-rainfall areas.

A wide range of germplasm was collected during 2000 from the deserts of Central Asia and the Syrian steppe. A total of 69 species belonging to 41 genera have now been transplanted at Tel Hadya in Syria for *in situ* conservation. These genetic resources, which are available to national scientists throughout the CWANA region, have enormous potential to reverse land degradation in fragile desert environments.

Dr S. Khusainov, Director of the Aral Sea Area Experiment Station, Kazakstan collects range species in Kazakstan while on a collection mission.

Enhanced cooperation with national partners extended the scope of germplasm exchange and evaluation. An international workshop held at Ashkabad, Turkmenistan in June 2000, identified key species with a potential for conservation in desert rangeland. For each genus, a different country took responsibility for assembling genetic diversity from the region as well as from other parts of the world, as a basis for developing locally adapted cultivars and producing a nucleus of seed (Table 6).

Table 6. Common priority range species suggested for plant collection, characterization and evaluation, and country responsible.

Genus	Country responsible
Haloxylon	Uzbekistan
Callygonum	Turkmenistan
Kochia	Kazakstan
Salsola	Uzbekistan
Eurotia	Kazakstan
Artemisia	Uzbekistan
Astragalus	Uzbekistan

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

Saltbush—a Useful Shrub for Intercropping

Barley is widely grown in the low-rainfall areas of WANA. As well as providing grain for human food, the stubble remaining after harvesting is an important fodder for sheep and goats. In areas of poor soil, barley is predominantly used as a fodder crop, with grain being harvested only after a good rainy season, which occurs as infrequently as one in every five or ten years. The drawback to using barley stubble as a major source of animal feed is its low nutritional value. Farmers' increasing dependence on barley straw as fodder has prompted ICARDA and its partners to investigate alternatives. The aim is to increase the quality and quantity of fodder available to farmers without adversely affecting grain production.

Saltbush (*Atriplex halimus*) is a hardy, drought-tolerant shrub that grows naturally in the Mediterranean region. ICARDA is evaluating different varieties of saltbush for their palatability to sheep, and is investigating the cultivation of saltbush as an intercrop with barley. Preliminary results showed that yields of barley grain and stubble both increased in an intercropping system. This is probably due to the creation of a microclimate, providing better growing conditions for the barley crop. Sheep consumed similar quantities of stubble on monocropped and intercropped plots, but where saltbush was also available they consumed an additional 0.26 kg/day of foliage. The saltbush provided them with a valuable source of additional protein to complement the energy they obtained from barley. The animals also grazed the intercropped plots longer, resulting in increased weight gain, compared with those grazing barley alone.

In cooperation with Moroccan scientists, encouraging results have also been obtained by intercropping saltbush with other grain crops, including oats, a barley/fodder pea mixture and an oats/vetch mixture. Total biomass and grain yields

Sheep grazing barley stubble and saltbush in a barley-saltbush intercropping system.

Table 7. Average dry matter biomass yields of different forage alternatives under intercropping as compared to those of monoculture barley and weedy fallow in Morocco.

Forage alternatives	Dry matter yield (t/ha)	Dry matter yield Relative(%)
Barley	4.43	100
Weedy fallow	3.07	69
Barley + shrub	5.04	114
Oats + shrub	8.04	181
Barley/peas + shrub	6.96	157
Oats/vetch + shrub	7.39	167
Annual medics + shrub	4.94	112

Saltbush intercropping in barley helps to reduce wind erosion.

were higher in intercropped systems, as were yields of energy and crude protein (Tables 7 and 8). In addition, intercropping improved the land-equivalent ratio (LER) in every case (Table 8). A LER of greater than 1 is desirable, and indicates that growing more than one crop on the same land gives a higher output than a single crop. Intercropping with saltbush is therefore particularly beneficial in the dry areas of WANA, where farm sizes are generally small.

The results of this project are very encouraging, suggesting that intercropping barley with saltbush could greatly increase both crop and animal production, at the same time as helping to protect fragile soils from wind and water erosion.

Table 8. Comparison of energy and crude protein yields and Land Equivalent Ratio (LER) of different forage alternatives under intercropping with those of monoculture barley and weedy fallow in Morocco.

Forage alternatives	Energy		Crude Protein		LER
	FU/ha	%	Kg/ha	%	
Barley	2746.6	100	443.0	100	-
Weedy fallow	1074.5	39	245.6	55	-
Barley + shrub	3060.2	111	515.4	116	1.46
Oats + shrub	4996.8	182	968.6	219	1.20
Barley/peas + shrub	5303.4	193	1233.8	279	1.39
Oats/vetch + shrub	5148.1	187	1311.2	296	1.41
Annual medics + shrub	3089.4	112	1007.0	227	1.25

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

Improving Small Ruminant Production

Sheep and goats are kept widely in the dry areas of CWANA and represent a convenient way of converting poor quality vegetation into protein-rich food and other products. Although meat is the major commodity in most sheep production systems, other useful commodities include milk, wool, skins, pelts, and manure. ICARDA is helping farmers to improve the productivity of small ruminants in a number of ways, including research on grazing management, marketing options, and alternative forages.

Better livestock productivity in Central Asia

Privatization in the former Soviet republics has resulted in widespread fragmentation of livestock holdings. Large state-run production units have been replaced by numerous small-scale enterprises, which tend to have low productivity. At the end of 1999, ICARDA launched a research project in Kazakstan, Kyrgyzstan, Turkmenistan and Uzbekistan, with a grant provided by the International Fund for Agricultural Development (IFAD). The project, which aims to improve livestock production throughout Central Asia, is addressing both marketing and resource management issues, through the study of socioeconomic problems and the introduction of technological changes to improve the use of rangelands and enhance the production of forage crops.

Eight research sites were selected to represent the different agroecologies where sheep and goats are produced. The sites are being characterized using the GIS (Geographical Information Systems) technology, and will be used for ICARDA's integrated research, with particular involvement of the livestock and water research projects. Figure 13 shows the characteristics of two sites in Uzbekistan.

Kazakh farmers and scientists at the Berlik integrated research site in Kazakstan.

Boykozon is located on the outskirts of the city of Tashkent, with direct access to the city market. This allows farmers to exploit different market options, including milk production and lamb finishing. In this area, sheep are kept on the mountain ranges and dairy cattle on the lower slopes. The project has introduced intensive production of fodder crops, such as oats, fodder beet and alfalfa, as a means of increasing productivity. By contrast, Nurata is located in an area of rangeland or steppe, where the Karakul breed of sheep predominates. These used to be farmed primarily for their pelts, but the market has declined due to falling demand from Russia. Consequently, the project is investigating the breed's potential to produce different marketable products. Farming of Karakul sheep depends largely on the productivity of the surrounding rangeland, so the project is also promoting sustainable management of this valuable natural resource.

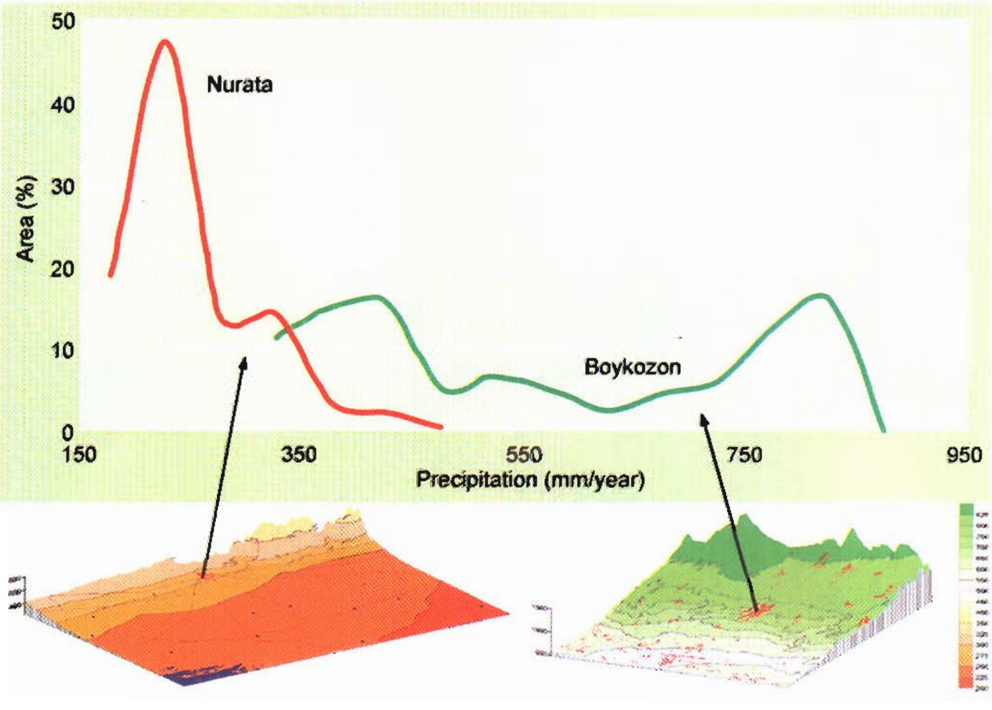
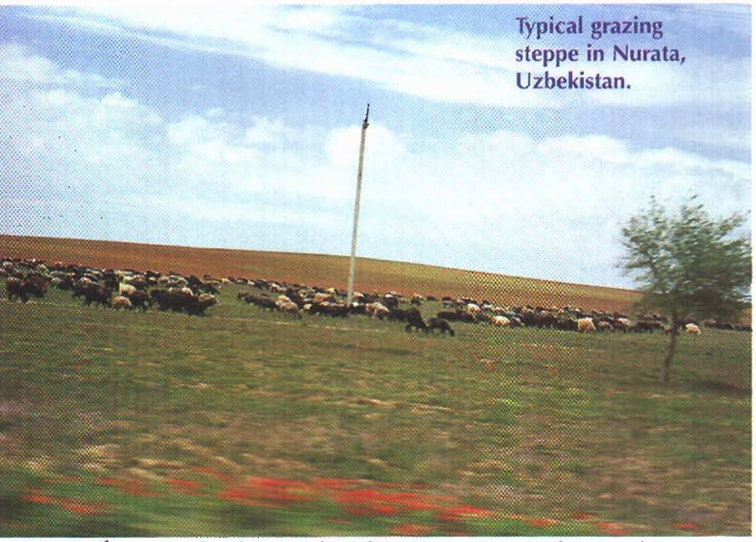


Fig 13. Nurata and Boykozon sites in two contrasting ecosystems in Uzbekistan.

Rangeland management is also being studied in Kazakstan, where the problems of both overgrazing and under-utilization are being addressed. Intensive grazing, which occurs close to the villages, results in a loss of productivity, especially in winter. A particular problem is that farmers are not storing sufficient winter


Typical grazing steppe in Nurata, Uzbekistan.

forage. Project scientists are attempting to improve feeding management by introducing cultivated forages, such as alfalfa and corn, and by using strategic supplementary feeding, for instance, during late pregnancy and lactation. Promoting a community approach to flock management with strict rotational grazing is another area under study.

Training is an important component of the project, which aims to create a critical mass of key scientists who will be able to expand training initiatives across the region. During 2000, one key researcher from each of the four Central Asian republics was trained at ICARDA headquarters for a month, in socioeconomics, small ruminant production, and forage and range production. Local training workshops were also organized in the project areas in which Central Asian farmers participated.

Introducing agricultural byproducts as alternative forage in West Asia

In West Asia, sheep traditionally provide a wide range of food products. However, rising incomes and urbanization are increasing the demand for lamb, milk and milk products, creating an opportunity for farmers to benefit from more intensive production systems and to specialize in dairy breeds of sheep such as the Awassi.

ICARDA launched two projects in 2000, to help farmers in northern Syria capitalize on this opportunity.


Karakul lamb, Uzbekistan.

The use of agricultural byproducts as supplementary feed is one of the options under study. Several byproducts are widely available in the Mediterranean regions of West Asia. For example, Syria produces about 110,000 tonnes of citrus pulp, 50,000 tonnes of tomato pulp, 92,000 tonnes of molasses and 100,000 tonnes of sugar beet pulp per annum. Although byproducts such as barley straw and cotton cake are currently fed to animals, many others, such as olive cake and citrus pulp, are underutilized. These byproducts have the potential to contribute significantly to improved productivity of livestock. Interestingly, many livestock production systems, including intensive, semi-intensive and even trashumant, are increasingly using feed supplements to augment the meager and poor quality ration obtained through grazing. The resulting increase in productivity makes the investment worthwhile, and the high demand for milk and lamb ensures a good price at market. Using agricultural byproducts could reduce the cost of supplementary feeding and improve farmers' profit margins still further.

Preliminary trials with olive cake and dried citrus pulp, given as feed blocks, showed acceptable voluntary intake by the animals. In addition, the body weight of grown animals showed a slight increase. A further trial using feed blocks based on olive cake and molasses is currently under way on farms at El-Bab in northern Syria.

Theme 3. Natural Resource Management

Project 3.1. Water Resources Conservation and Management for Agricultural Production in Dry Areas

Water Resources Management in Dry Areas

The inefficient use of water not only limits crop yields in the short term, but also undermines productivity in the longer term by contributing to soil degradation and wider environmental damage. The potential for improving water-use efficiency in CWANA is huge. In 2000, the ICARDA Soil and Water Management Project studied improved irrigation technology for cotton, investigated wastewater as a source of irrigation for fodder and industrial crops, and tested the use of Geographic Information Systems (GIS) and laboratory modeling techniques to support a new participatory watershed-based approach to natural resource management in dry areas.

Alternate furrow irrigation in Central Asia

Growing commercial crops in the dry continental climate of Central Asia is a challenge. Irrigation is essential if the crop is to generate an economic yield, but irrigation combined with high evaporation during the summer can increase soil salinity. Large-scale cultivation of cotton was introduced in South Kazakstan during the Soviet era, with irrigation from spring rainwater and snowmelt stored in the Bougoun Reservoir. An additional system of 490 vertical wells was built to supply further irrigation water and to provide proper drainage to remove excessive water and salt from the root zone. Unfortunately, the wells have now fallen into disrepair, and in dry years, the volume of water stored in the reservoir is not sufficient to irrigate the 60,000 ha cultivated area. The ICARDA Soil and Water Management Project is investigating how innovative irrigation technology can improve the management of soil and water resources and increase economic output in this region.

Alternate furrow irrigation—supplying every other furrow with irrigation water—has been introduced on a large experimental plot and is being tested against traditional surface irrigation. The role of shallow groundwater in providing sub-irrigation is also being investigated. Although shallow groundwater can provide a useful source of water, it tends to have a high salinity. Consequently, a drainage system is required to keep the root system healthy. Using a sluice gate at the low end of the field controls the amount of drainage, allowing the level of shallow ground water to be raised or lowered, according to the plants' requirements. This system makes the best use of available shallow ground water, without allowing salinity to build up in the soil.

Alternate furrow irrigation experiment in Arys-Turkestan region of Kazakstan.

Results from the first two years' experiments indicate that the new system of alternate furrow irrigation, combined with the use of shallow groundwater, is much more effective than traditional methods. Less water was applied, and less was lost due to surface runoff, resulting in a net saving of water (Fig. 14), and enhanced productivity, with a higher yield of cotton per volume of water applied. In addition, advanced irrigation technology has the potential to maintain soil quality and so to sustain production over the longer term. If this technology were applied to the entire 60,000 ha currently planted with cotton, not only would the existing yield be maintained, but a huge volume of water could be made available for irrigating additional crops.

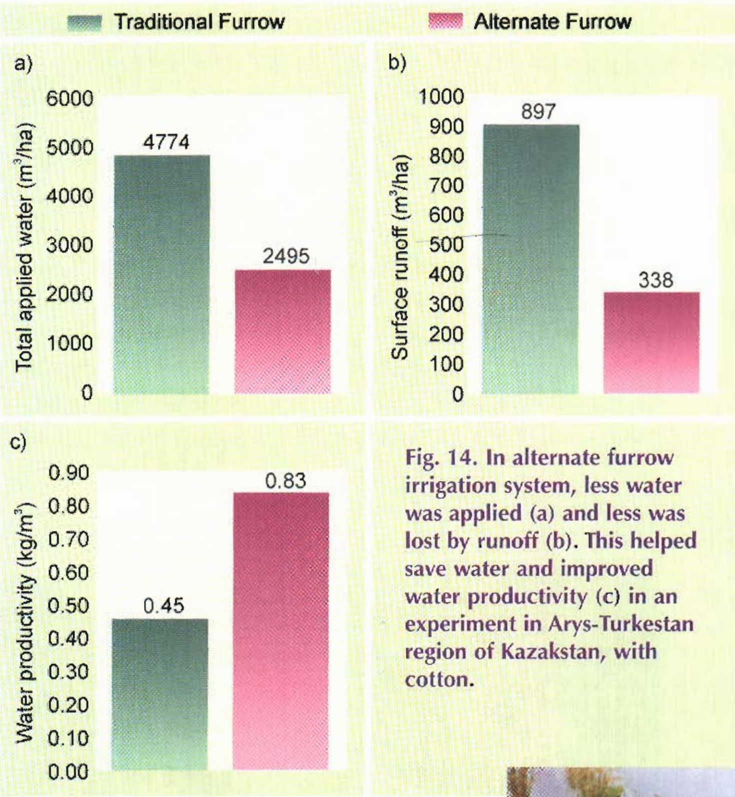


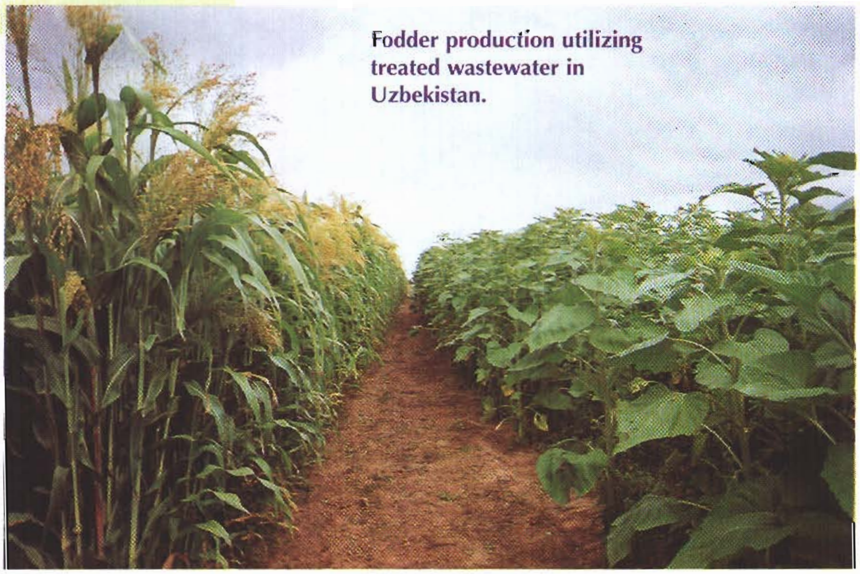
Fig. 14. In alternate furrow irrigation system, less water was applied (a) and less was lost by runoff (b). This helped save water and improved water productivity (c) in an experiment in Arys-Turkestan region of Kazakstan, with cotton.

Irrigation using wastewater

Urban populations generate large volumes of domestic and industrial wastewater, which, in dry regions, could be used for irrigation. In Kazakstan, wastewater from Almaty, the capital, is treated by mechanical and biological means, then piped to the Sorbulak Collector, a natural closed depression near the city. This reservoir, which has been created specifically to store wastewater, currently holds 1,022 million m³, forming a lake with a surface area of 62 km². Investigations by scientists from ICARDA, in collaboration with the Kazakh Research Institute of Water Management, indicate that this water would be sufficient to irrigate approximately 45,000 ha of land. Although it has been treated, the water may still contain contaminants, so its use for irrigation has to be restricted to industrial, forestry and fodder crops, rather than food crops. Good yields should be obtained with little applied chemical fertilizer, since the water already contains a reasonable level of nutrients.

In 2000, ICARDA began a five-course rotation experiment to assess the potential of growing fodder crops under wastewater irrigation. Good biomass yields of Jerusalem artichoke, Sudan grass, sweet sorghum and maize were obtained, and hay crops were cut from the Sudan grass and sorghum 2 or 3 times in a year. Preliminary soil data indicated that there was no significant build-up of salinity or accumulation of heavy metals in the soil. Further research is planned to assess the potential of exploiting the biological resources of Sorbulak Lake, including the use of fish to provide a protein supplement for livestock. The project will continue to monitor the effects of wastewater use on soil status and the quality of crops and final products (milk and meat), as well as any effects on the environment.

This project has great potential to put to good use what is at present a wasted resource.

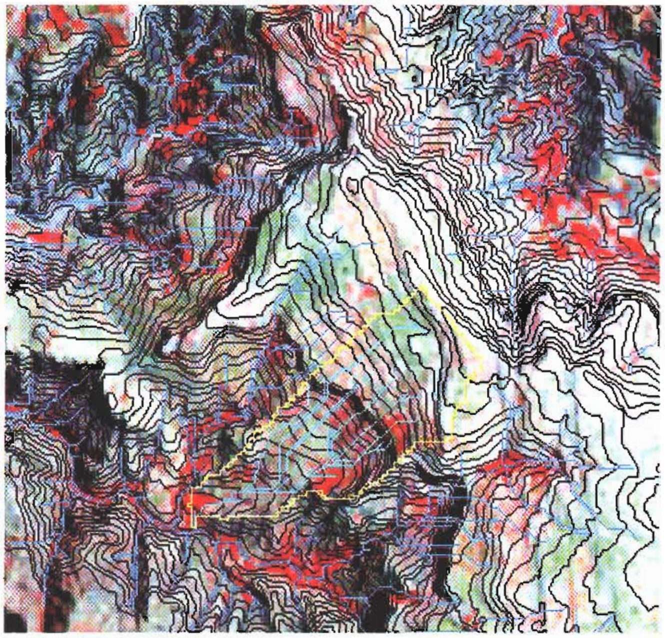


Fodder production utilizing treated wastewater in Uzbekistan.

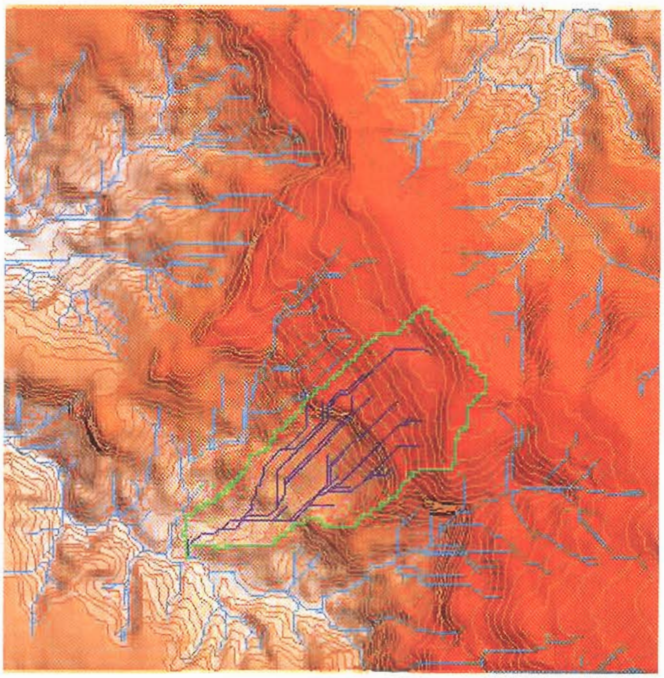
Using wastewater will not only decrease pressure on the present collection system, it will also contribute to sustainable production of livestock and feed, enable wood for fuel and building materials to be produced locally, and increase employment opportunities. If the project's approach proves successful, without adversely affecting the local environment, it could be replicated in other suitable dry areas of CWANA.

A watershed approach to natural resource management

Everybody lives in a watershed but for people living in dry areas, the location of their watershed is of vital importance. Surface runoff, which flows down the slopes or through a *wadi*, may provide just enough water to grow a crop. But if this water is used to grow crops upstream, it will not be available to the people who live downstream. Conversely, uncontrolled runoff and erosion from upland areas can lead to severe flooding and silting of reservoirs and irrigation canals further down the valley. Water, sediments, and nutrients flow across property and political boundaries. Thus, cooperation between different individuals and communities is an essential aspect of watershed management.



Landsat image, showing the boundaries and drainage pattern of a research watershed in the northern highlands of Yemen.



Digital elevation model, showing the boundaries and drainage pattern of a research watershed in the northern highlands of Yemen.

During the past two years, ICARDA has been working with researchers in various countries of West Asia and North Africa to assess the natural resources and their use in selected, representative watersheds. Different land use and management practices have been evaluated with the farmers in each watershed, with the help of Geographic Information Systems (GIS) and laboratory modeling tools. GIS allow the researchers to visualize the effects of different land use options on the people and the natural resources within the watershed. Modeling studies include the generation of digital elevation models, the preparation of digital soil maps and databases, and the assessment of land use with the help of satellite images.

ICARDA's watershed management activities apply the principles of integrated natural resource management at the watershed level. This is created through a participatory approach towards the assessment of resources, their use within the watershed, and the preparation, implementation, and evaluation of management plans. Such an approach is essential if scarce water is to be both fairly shared and efficiently used.

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

Water Conservation Tillage in Turkmenistan

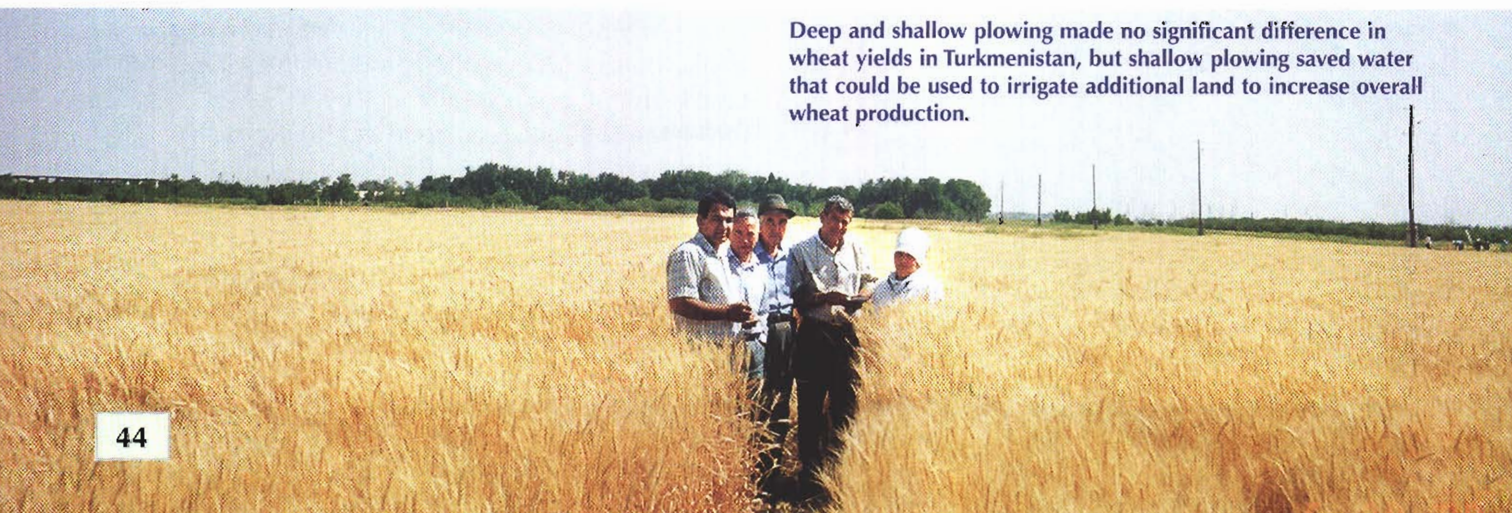
Winter wheat has been an important crop in Turkmenistan for many centuries. Around 38% of the country's total irrigated land area (700,000 ha) is currently planted to the crop. Because winter wheat is almost entirely reliant on irrigation, water availability limits the amount that can be grown. During the Soviet era, no restrictions were placed on the diversion of water for agriculture. The resulting soil salinization and loss of fertility have left large areas of land degraded and abandoned. Now, limits on water diversion, together with a scarcity of fresh land, are encouraging farmers to learn how to improve water-use efficiency and adopt more sustainable agricultural techniques.

A joint research team of ICARDA and Turkmen scientists has focused on developing the use of water conservation tillage. Traditional mold-board plowing, which turns over the sub-soil and increases the need for irrigation water, was compared with chiseling and disking (cutting the soil without disturbing the sub-soil or stubble). At one experimental site, the team compared the effects of four pre-sowing soil tillage treatments on yields of wheat and on water-use efficiency (Table 9). Results showed that disking to a depth of 10-12 cm was the most efficient practice. Although the yield of winter wheat was almost the same under all tested options, water productivity was highest after disking.

Water conservation tillage, together with an appropriate irrigation schedule, promotes water infiltration and conserves moisture within the soil profile. This helps to maintain soil fertility and prevent erosion. If this technology were adopted on only half the 700,000 ha presently cultivated, it is estimated that over 350 million m^3 of irrigation water could be made available to irrigate additional land, without any reduction (and possibly even with some improvement) in current levels of productivity.

Table 9. Effect of soil treatments on volume of water needed for irrigation, yield and water productivity of irrigated wheat in Turkmenistan.

Soil pre-sowing tillage treatments	Total applied irrigation (Irrigation + precipitation), (m^3/ha)	Yield (tonne/ha)	Water productivity (kg/m^3 of water)
Mold-board plowing to 30-32 cm (control)	5,152	5.41	1.05
Mold-board plowing to 20-23 cm	4,760	5.64	1.18
Chiseling to 15-16 cm	4,390	5.69	1.30
Disking to 10-12 cm	4,130	5.72	1.38



Deep and shallow plowing made no significant difference in wheat yields in Turkmenistan, but shallow plowing saved water that could be used to irrigate additional land to increase overall wheat production.

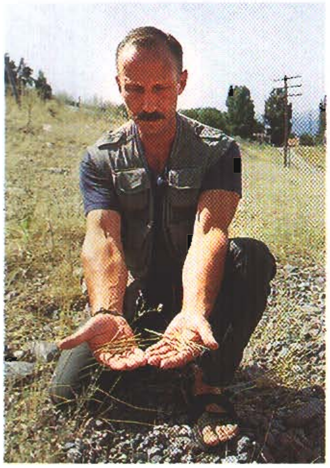
Project 3.3. Agrobiodiversity Collection and Conservation for Sustainable Utilization

Germplasm Collection

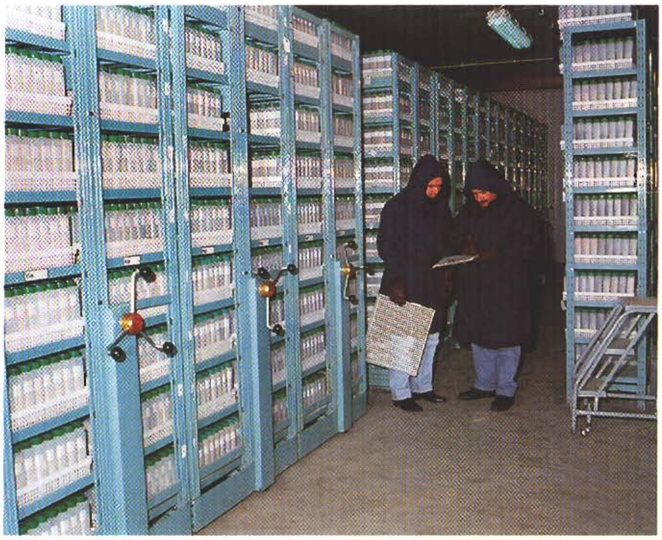
ICARDA's germplasm collection grew by 4,654 new accessions to a total of 124,363 in 2000. Among the most valuable donations from other institutions were accessions from the Vavilov Institute of Russia (VIR). These include a large set (2,454 accessions) of unique cereal and food legume landraces collected either by Vavilov himself or by his colleagues before 1941, mainly in the former USSR but also in the countries of WANA.

With special project funding, ICARDA led missions to collect germplasm in strategic areas of Central Asia and the Caucasus, targeting endemic landraces and wild relatives of food crops as well as potential forage species. The missions involved scientists from ICARDA, national programs in the countries visited, the Vavilov Institute of Russia and Australia. The material collected was transferred to relevant national collections as well as to the collection held at ICARDA headquarters.

ICARDA's collection missions with national partners and VIR scientists in Kazakstan, Kyrgyzstan and Tajikistan yielded another set of unique germplasm. These missions targeted cereal and legume crops, their wild relatives, and forage species in semi-arid and arid regions. Environments ranging from deserts to rugged mountains were covered, with distances of more than 4000 km being traveled in each country. In all, 384 accessions representing 55 species were collected. What is notable about this material is the ecotypic diversity demonstrated within a given species. This is particularly true for bread wheat landraces and wild relatives. In many cases ancient landraces were found growing among improved varieties in the fields. Farmers deliberately mix crops in this way to stabilize yields, as the landraces are tolerant to temperature extremes and fluctuations in rainfall.



Mr Sergey Shuvalov of the Vavilov Institute shows the diversity of *Aegilops tauschii* collected in a single population in Kazakstan, during a joint ICARDA/VIR/NARS collection mission.

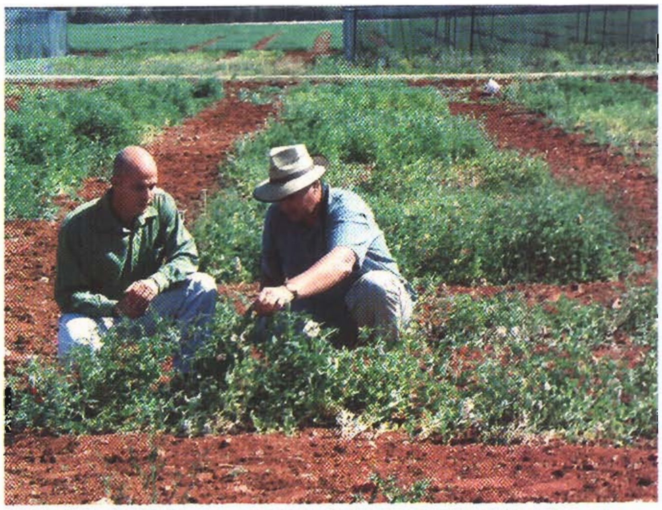


During the year the collection in ICARDA's gene bank grew by 4,654 new accessions, raising the total to 124,363 accessions.

Germplasm Characterization and Preliminary Evaluation

A total of 3,800 accessions were characterized in the field during the 1999/2000 growing season. Between 12 and 33 descriptors were used. The largest trials were on faba bean and wild barley, with 1,250 and 800 accessions, respectively. Chickpea was third, with 600 accessions, and durum wheat fourth, with 450 accessions.

VIR germplasm curators, who visited ICARDA for two to three months in the growing season, made important contributions to the characterization of material obtained from that institute in 1998. The VIR donations included 550 durum and bread wheat, 45 barley, 300 fieldpea, and 650



Dr Sergey Bulyntsev (right) of the Vavilov Institute, St Petersburg (VIR) and an ICARDA researcher examine *Pisum sativa* material from the unique VIR collection, which was grown at ICARDA in 2000 as part of a collaborative project between VIR, ICARDA, and CLIMA of Australia.

chickpea accessions. Similarly, the material obtained during the collection missions to Armenia and Turkmenistan in 1999 was characterized at ICARDA by visiting scientists from the countries concerned. In total, 325 accessions were characterized in the field at Tel Hadya.

Strengthening National Programs

Two Australia-funded special projects entitled "Development and Conservation of Plant Genetic Resources from the Central Asian Republics and Associated Regions" and "International Linkages for Crop Plant Genetic Resources" have made an important contribution to strengthening national seed programs in ICARDA's mandate region. Two scientists from VIR worked on these projects at ICARDA, characterizing material donated from the VIR collection. They were experienced scientists who benefited from being able to use facilities and resources available at ICARDA. They were also able to develop their computing and language skills.

Scientists from Armenia and Turkmenistan characterized the material collected in their respective countries. They too had the opportunity to acquire computing and language skills and to observe and learn field techniques working with ICARDA scientists.

The projects also provided national programs with the following goods or services:

- two computers for the national program in Turkmenistan,
- networking of existing computers in the documentation department at Uzbek Research Institute for Plant Industries (UzRIPI), Tashkent,
- 16,000 seed envelopes also provided to UzRIPI, and
- a collection mission vehicle, provided for the Aral Sea Research Station in Chelkar, Kazakstan.

A technical workshop on crop plant genetic resources in the Caucasus was held from 4-6 December in Tashkent, Uzbekistan with the following objectives: to discuss the present status of crop genetic resources in the region, to find ways to overcome constraints to the development of genetic resources activities in each country, and to draw up a plan of action to support the development of an independent genetic resources program in each country.

Computers provided by the ICARDA/UzRIPI project are helping to employ modern information technology for genetic resources research in Central Asia.

Conservation of Dryland Agrobiodiversity

The "Conservation and Sustainable Use of Dryland Agrobiodiversity" project completed its first year. The project is supported by the GEF of the UNDP and coordinated and implemented by ICARDA in Jordan, Lebanon, Palestinian Authority, and Syria. Partners in the project are Jordan's National Center for Agricultural Research and Technology Transfer (NCARTT), the Lebanese Agriculture Research Institute (LARI), Scientific Agricultural Research Directorate (SARD) for Syria, and the Ministry of Agriculture for the Palestinian Authority. The main activities were:

- selection of project sites and of the areas to be monitored,
- contacts with local communities and initiation of public awareness activities,
- conducting socioeconomic surveys to assess the use of target species and related local knowledge,
- conducting ecogeographic and botanical surveys to assess the distribution and abundance of target species and collecting seeds of target crops and their wild relatives, and
- training project staff and organizing farmers' workshops.

Overgrazed rangelands at the UNDP-GEF project sites at Arsal, Lebanon (above) and Wadi Saeer at Hebron, Palestinian Authority (below).

The project aims to promote community-driven *in situ* conservation of 16 target crop and forage species and their wild relatives, including barley, wheat, lentils, vetch, grasspea, medicago, and onions in addition to a range of fruit trees such as olive, almond, pear, pistachio, prune and fig. ICARDA's assistance is provided in cooperation with the regional office of IPGRI-CWANA and ACSAD in integration of nationally executed project components, which include coordination, networking, raising awareness, technical backstopping, capacity building and training, and participation in monitoring and impact assessment of project activities.

Major achievements of the project during the year were:

1. The establishment of project management units within each of the national implementing institutions. The regional component is located in the Genetic Resources Unit of ICARDA.
2. Selection of project sites: Twelve visits were made to target areas by national program scientists accompanied by international experts and

the Regional Coordinator. The visits led to the selection of 30 project sites and more than 63 areas for monitoring biodiversity across the major ecosystems and farming systems in the four participating countries.

3. Ecogeographic and botanical surveys: These were conducted in most of the areas to be monitored for annual species. The preliminary results showed clearly the effect of overgrazing and land reclamation on the biodiversity of fruit trees and wild relatives of crops.
4. Socioeconomic surveys: Two surveys covered the importance of landraces in Palestine and Syria. Similar surveys are continuing in Lebanon and Jordan. Rapid rural appraisals were also conducted in each community to gather local knowledge on germplasm and wild relatives and to find out how shared resources were managed.

Genetic Diversity of Wheat Wild Relatives

Twenty-six ICARDA gene bank accessions, which represented natural populations of four wild *Triticum (T. dicoccoides, T. araraticum, T. urartu, T. baeoticum)* and five *Aegilops* species (*Ae. geniculata, Ae. triuncialis, Ae. speltoides, Ae. tauschii, Ae. vavilovii*) were analyzed using the Amplified Fragment Length Polymorphism (AFLP) molecular marker technique in order to shed light on the evolution and geographical distribution of genetic diversity of wheat wild relatives in the Near East.

To investigate variation within and among populations, 10 individual plants per accession were chosen and analyzed using four different combinations of primer. Nucleotide diversity (ë) was estimated by averaging the estimated numbers of nucleotide substitutions per site. Variations within populations were detected in all accessions. For most species, the level of nucleotide polymorphism within populations was relatively low (*ë* < 0.005). However, *Ae. speltoides* had relatively high levels of variation within two populations (ë = 0.0151 and 0.0233). This species also had the highest value of nucleotide variation between accessions (ë = 0.0319). In the *Triticum* species, the level of variation within populations was relatively low in *T. urartu* and *T. baeoticum*. Two tetraploid *Triticum* species had relatively high levels of variation within accessions (ë > 0.005) but divergence between *T. dicoccoides* and *T. araraticum* was not complete in the phylogenetic tree. Even if the genetic variation in the gene bank accessions did not always reflect the genetic diversity of their natural population (because of numerous multiplications in a different environment and the small number of plants sampled from the original population or during multiplication), AFLP analysis revealed variation in all accessions used in this study. The conservation of such genetic variation in natural populations will be important for the future use of the genetic resources for wild species.

Information Technology: SINGER at ICARDA

The System-wide Information Network for Genetic Resources (SINGER) was established in 1994 by the CGIAR System-wide Genetic Resources Program (SGRP). One of its purposes was to serve as a single point of entry into the *ex-situ* genetic resources collections maintained by the CGIAR centers. SINGER links the germplasm documentation systems at the centers and allows them to be searched simultaneously. From 1994 to 1997, the main concerns of SINGER were:

- to define and promote data standards for coherence and compatibility between centers' databases,
- to replicate these databases at a single Internet site,
- to prepare a CD-ROM version of the databases allowing access by people without an Internet connection.

In 1998, SINGER Phase II was initiated, with the objectives of improving the accuracy and completeness of the data already available, increasing the range of characterization and evaluation data for each accession, and further developing the use of the Internet to provide access to the wider range of information now available. These tasks required SINGER to become the gateway to the genetic resources databases at the CGIAR centers, rather than the single, centralized database. Consequently, each center had to re-define its procedures for replicating data to the SINGER central point and to "web-enable" its own database, particularly for crop-specific characterization and evaluation data.

During 1999 and 2000, ICARDA made considerable progress towards meeting these requirements. Its collections were subject to rigorous analysis to improve the quality of available information. A new SINGER server was put into operation, and the development of software to deploy the ICARDA database on the Internet was initiated. This last task has been aided by the "SGRP Tool Kit," a software tool developed by the SINGER coordination office, to help bring information to life by presenting the results of queries in a variety of ways including distribution maps, statistical analysis and two- and three-dimensional graphics.

Seed Health Testing

In 1982, ICARDA established phytosanitary safeguards and facilities to prevent the entry and spread of seed-borne pests into new areas. ICARDA receives and sends out several thousand seed samples each year. Three measures to safeguard seed health are applied by ICARDA's Seed Health Laboratory (SHL): seed health testing, the production of clean seeds (including field inspection), and seed treatment.

After fumigation and visual inspection, the SHL applies a number of different methods recommended by the International Seed Testing Association (ISTA) to detect pathogens. It has also developed some techniques of its own, such as the "cold blotter test" for detecting the fungus *Pyrenophora graminea* in barley seeds. Special attention is given to pathogens specified in the quarantine regulations of Syria and other recipient countries. Over the past 5 years the number of lines tested each year has ranged from 11,000 to more than 41,000.

The most common contaminants found in imported material were the fungi *Tilletia caries*, *T. foetida* and *Helminthosporium* spp. in cereals, and *Fusarium* spp. in legumes. The most frequently found exotic pathogens were *T. indica*, *T. controversa* and *Urocystis agropyri*. However, the number of cereal samples contaminated with harmful pathogens was high only in 1991 and 1992 (3,000 and 3,600 respectively). Thereafter, their frequency fell sharply to between 7 and 100 contaminated samples per year. The fungi *Ascochyta lentis*, *A. rabiei*, and *A. fabae* were found sporadically each year in exotic legume seeds. Imported seeds that proved unacceptable were destroyed, whereas clean ones were grown in the post-entry quarantine area (PQA) for a single generation.

All seeds for export are treated with appropriate fungicides and insecticides and sent out with a phytosanitary certificate, a certificate of origin, and a certificate of donation for some countries.

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

Remote Sensing: A Key Tool for Mapping Land Use and Growing Conditions in CWANA Environments

The accurate identification of land-cover/land-use is essential for assessing meteorological and environmental trends in the agroecosystems of the CWANA region. Several global or regional land-cover/land-use classifications are currently available in the public domain and can be used for this purpose (Table 10). They are all based on temporal variations in what is known as the *Normalized Difference Vegetation Index* (NDVI). This is obtained from images created by the *Advanced Very High Resolution Radiometer* (AVHRR) sensor on board the NOAA satellite. The index indicates greenness, biomass productivity, and vegetation type.

However, when the existing classifications were tested with the help of land-use maps at a more detailed scale, they were found to be insufficiently accurate. The problem lies in the classification methods used. These assessments use statistical algorithms that group key NDVI parameters such as onset, peak, and end of greenness period into a limited number of patterns with similar NDVI phenology. The classes established statistically are interpreted and translated into land-cover/land-use types using a limited number of ground truthing points.

This approach assumes that the NDVI pattern is determined only by the land-cover/land-use type (LCT). In reality land-cover/land-use is itself adapted according to different agroclimatic conditions. It is therefore quite possible that in different agroclimatic zones similar NDVI patterns could correspond to different LCTs, also that different NDVI patterns could represent the same LCT. To overcome this problem, ICARDA scientists have established a new classification scheme based on the identification of LCTs using an empirical hierarchical decision tree (Fig. 15).

The LCTs were established on the basis of ground truthing, using field surveys, together with maps and higher-resolution satellite imagery (Landsat). The number of classes is smaller than in other land-cover classifications (Fig. 16), but experience has shown that they can be identified consistently.

For pixel assignment to a particular LCT, the hierarchical decision tree uses "sliding thresholds" for the minimum, maximum and mean NDVI, which vary according to the agroclimatic zone. The fine-tuning of the NDVI thresholds was based on a careful analysis of the available CWANA climate-station data and land-use maps in different agroclimatic zones. For the purpose of this study a subdivision according to the simple UNESCO system of aridity regimes proved adequate. The UNESCO classification system subdivides dry areas into hyper-arid, arid, semi-arid, sub-humid or humid regions according to their ratio of annual rainfall to annual potential evapotranspiration. This classification scheme was first tested on low-resolution AVHRR imagery (4 arc-minute grid cell) for the year 1990 and afterwards transferred to a higher resolution (30 arc-seconds) for the period April 1992 to March 1993.

Figure 16 shows the LCTs for the border zone between eastern Uzbekistan, western Kyrgyzstan, southern Kazakstan, and Tajikistan. It shows the great extent of land under irrigation and the relatively limited extent of land under rainfed crops. The few forest areas are also clearly seen. This corresponds with ground truthing from different sources. Other classification methods give a highly fragmented land cover picture and often show irrigated land as land cover.

The accuracy of pixel allocation was tested by using the same classification procedures to aggregate areas on the more detailed land-use/land-cover map of Syria derived from Landsat imagery (see Annual Report 1999, p.31, New Land Use Map of Syria) and checking the correspondence. Seventy-four per cent of all pixels were correctly allocated, a result that compares very well with other classification systems (Table 10).

The AVHRR 4 arc-minute resolution imagery was also used to test the correspondence between

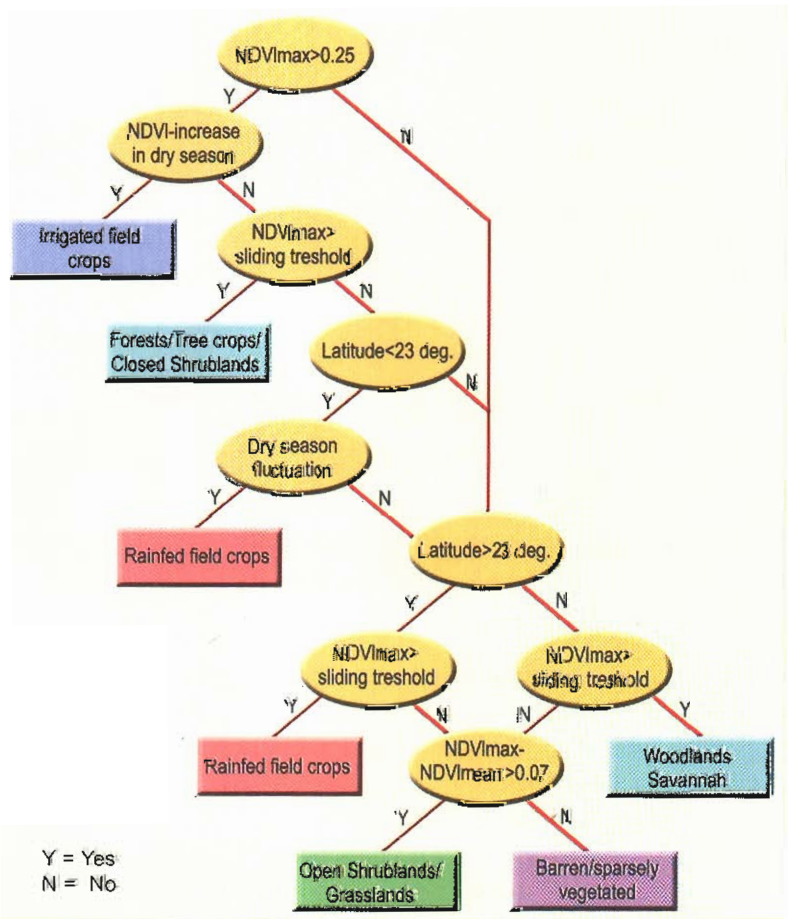


Fig. 15. Decision tree for land cover classification for AVHRR 30 imagery.

Table 10. Accuracy test of different land-cover/land-use classification systems.

Organization	Coverage	Bands used	Method	Pixel correspondence
ICARDA	CWANA	NDVI	Decision tree	74%
Asian Association for Remote Sensing (AARS)	Asia	NDVI, 4, 5	Unsupervised statistical + decision tree	52%
University of Maryland	Global	All 5 AVHRR	Supervised statistical + decision tree	47%
International Global Biosphere Program	Global	NDVI	Unsupervised statistical + post-classification stratification	32%

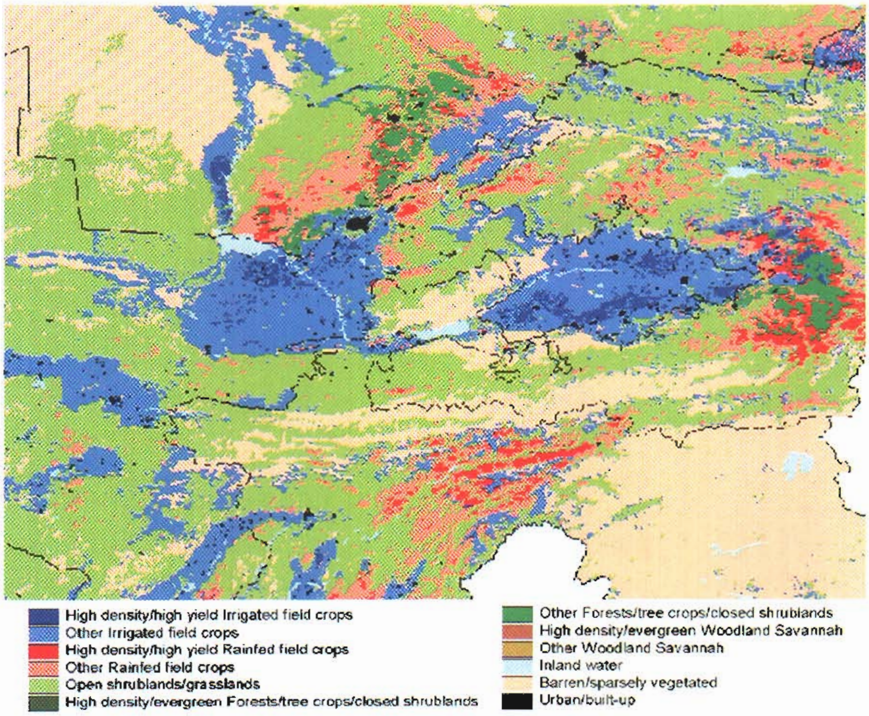


Fig. 16. Sample of land cover classification for parts of Kazakstan, Kyrgyzstan, Tajikistan, and Uzbekistan.

the growing period as calculated from remote sensing data and that estimated from climatic data. The length of growing period derived from remote sensing (LGP_{rs}) was defined as the number of days between the onset date of NDVI rise and the peak date of NDVI, corresponding with the time of maximum biomass productivity.

The growing period thus defined is strongly correlated with the maximum NDVI: the length of growing period is compared with a maximum value, as shown in Figure 17. The relationship between average maximum NDVI and LGP_{rs} explains 68% of the variation in the regression equation.

For 11 rainfed regions of CWANA the average LGP_{rs} was then compared with the average growing period modeled from climatic data. In this exercise the FAO's definition of the growing period was used, i.e. 'the period in which precipitation exceeds half the potential evapotranspiration and mean temperature exceeds 6.5°C (LGP_{FAO}).'

When the LGP calculated from remote sensing (measured LGP) was compared with the LGP modeled

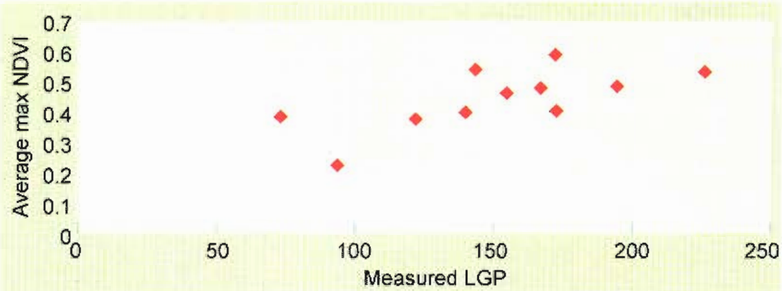
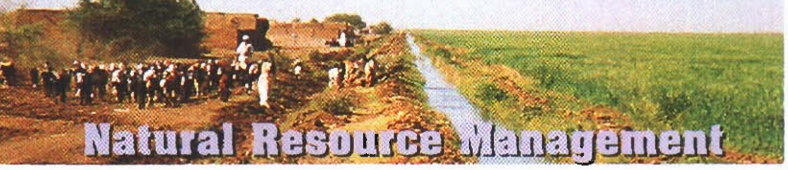


Fig. 17. Relationship between average growing period derived from remote sensing and average maximum NDVI (Normalized Difference Vegetation Index).



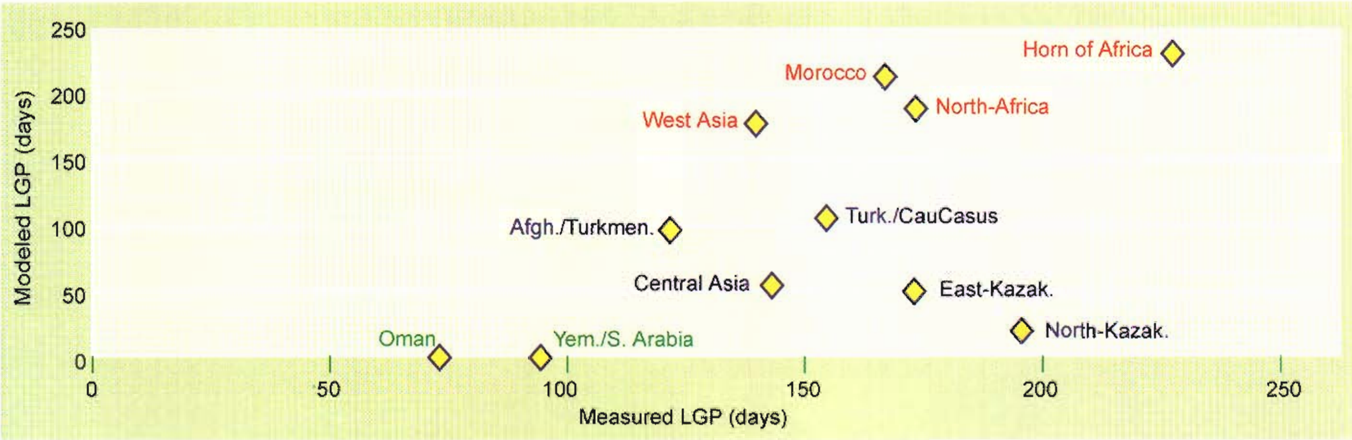


Fig. 18. Relationship between average length of growing period (LGP) derived from remote sensing and average LGP modeled from climatic parameters.

from climatic parameters (modeled LGP) for all 11 rainfed regions, three different outcomes were observed (Fig. 18). In the regions of Africa and West Asia, the two LGPs correspond or there is a small overestimation in the modeled LGP. In contrast, in the regions of Central Asia, Turkey/ Caucasus and Afghanistan/ Turkmenistan, i.e. all regions where both temperature and moisture limit the growing period, the modeled growing period is considerably underestimated. This suggests that the thresholds for modeling used by the FAO should be adjusted to reflect the occurrence of more cold-resistant crops and vegetation types in these regions.

Finally, there are the regions of Oman and Yemen/Saudi Arabia, where no rainfed agriculture is possible according to the FAO model, but where remote sensing reveals the existence of a short growing period. These areas are essentially rainfed but they receive supplemental irrigation through terrace systems or *falaj* (small canal systems that divert water from a source well).

Although these studies comparing growing period determined from remote sensing and from climatic data have only just started, they have already proved promising. They offer the possibility of determining, growing period characteristics and crop calendars from low-resolution satellite imagery rather than from climatic data that is increasingly scarce because it is no longer available free of charge. Moreover, the method can be applied over large areas, filling in the gaps between the point data obtained from weather stations. Understanding the connections between the vegetation greenness period and the climatic growing period will improve the prospects for monitoring droughts as they develop, rather than after the event.

Theme 4. Socioeconomics and Policy

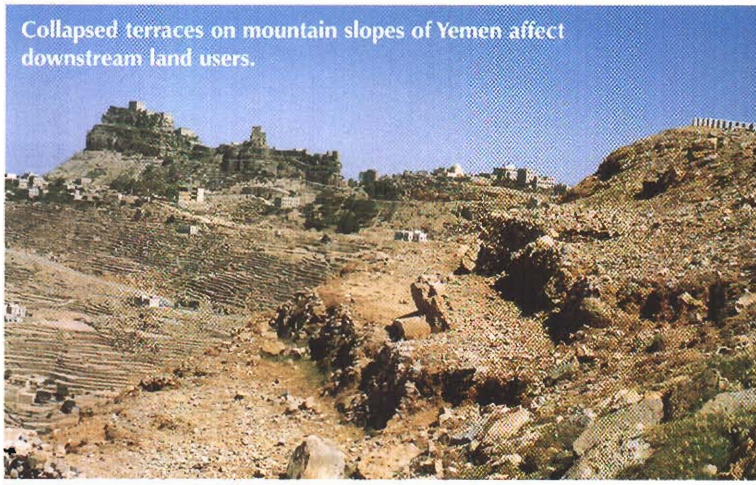
Project 4.1. Socioeconomics of Natural Resource Management in Dry Areas

Improving Rural Livelihoods in the Yemeni Mountains through Integrated Natural Resource Management

The problem

Yemen's mountains are a patchwork of terraced croplands, abandoned terraces, and grazing lands dotted with trees. Irrigated production takes place along the banks of the ephemeral streams, or *wadis*, that dissect the otherwise dry highlands. Rainfed agriculture on these steep slopes was developed centuries ago, using intricate systems of man-made terraces. However, investment in land improvement, particularly terrace maintenance, has been declining for the past 30 years. The growing number of abandoned, degraded and unrepaired terraces is clear evidence of this. If this trend continues soil erosion could lead to the permanent loss of a significant amount of Yemen's productive land. The degradation of terraces in the highlands poses a serious threat to rural households' livelihoods and to national economic development.

While the causes of degradation are generally understood, the technological and institutional innovations needed to help prevent it have not been sufficiently tested with local communities. Furthermore, insufficient information is available on the circumstances under which farmers would be willing to adopt soil and water conservation practices. The probable effects of policy and institutional changes on such an adoption also need to be examined.


Collapsed terraces on mountain slopes of Yemen affect downstream land users.


Complex landscape and terraces in the mountains of Yemen.

Terrace degradation results not only in the loss of arable land in the highlands, it also affects downstream slopes, producing erosion on *wadi* banks and leading to flash floods in spate irrigation systems. This could cause irreversible damage to Yemen's natural resource base and endanger the country's long-term food production capacity.

Project goal

ICARDA has recently launched a collaborative Mountain Terraces Project with the Agricultural Research and Extension Authority, Yemen. The project is funded by

the International Development Research Center (IDRC) of Canada. Its goal is to improve household livelihoods by increasing nutrition, food security and income, and by reducing the risks of production and rate of environmental degradation. These objectives are to be achieved through the development and transfer of cost-effective soil and water conservation practices, the introduction of productivity-enhancing technologies, and the identification of policy and institutional options that will promote the adoption of these technologies and practices.

Research sites

The project is being carried out with farming communities in three different agroecologies found in the mountains of Yemen. These are:

1. the Northern Highlands,
2. the Middle Montane, which includes Wadi Yahar (the Yahar Valley), and
3. a new site in the Southern Uplands.

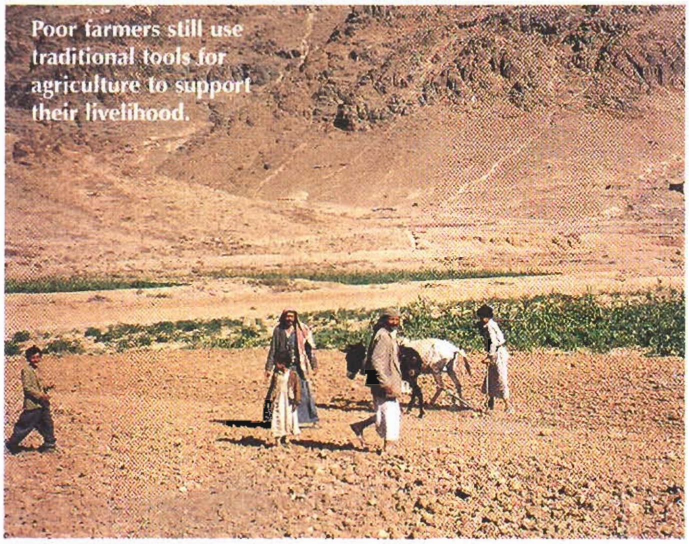
Northern Highlands. The site in the Northern Highlands is Al-Qima village in the remote Kohlan area, where the terrain is steep mountain slopes and valleys ranging in altitude from 600 m to 2700 m a.s.l. Agriculture is mainly rainfed with an annual average rainfall of 300-500 mm, falling in two seasons: March to April and August to September. The main crops include sorghum, wheat, barley, lentil, dry peas, faba beans, maize, coffee, and *qat*.

Middle Montane. The site in the Middle Montane agroecology lies in the Wadi Yahar in the Yafa'a area, with altitudes of up to 1400 m. Rainfall is highly variable with an annual average of 350 mm. The area is well known for its high-grade coffee. The main rainy season is from July to November, when the basic food crops, sorghum and millet, are grown. Maize is cultivated at lower altitudes from December to June and forage millet or maize is grown during April to June.

Southern Uplands. The site, near Ibb in the governorate of Al-Qutein, represents an agroecology with higher natural resource endowments than other sites. Altitudes are higher, up to 3000 m, and annual rainfall is over 600 mm. Some of the most productive agricultural land in Yemen lies in this area.

Research approach

The destruction of terraces is primarily caused by failure to maintain the traditional systems of diversion, collection, and storage of runoff water. Runoff may also have increased because trees have been cut down to provide timber, and natural pastures have been overgrazed by livestock. The rural population, which depends on these terraces for cropping, has limited resources to carry out the regular repairs needed. The costs of terrace repair are rising, fueled by labor scarcity as adult males



Poor farmers still use traditional tools for agriculture to support their livelihood.

migrate to cities for employment. A further problem is that farmers are not easily persuaded to change their traditional practices, even those threatening the resource base they depend on.

While this project builds on the findings and experience of earlier research in the mountains of Yemen, there are three important guiding principles for the work in hand:

- Effective stakeholder participation at individual, community, and policy levels. Full involvement of all those concerned in any proposed changes is now recognized as a prerequisite of success.
- Immediate impact on the livelihood of participating rural households. If the momentum for change is to be maintained, beneficial effects must be demonstrated without delay.

- Integrated analysis of natural resources management within a whole watershed or community. Benefits in one area must not lead to detrimental effects in another.

Local communities have a wealth of indigenous knowledge that can, through participatory research methods, be harnessed in the development of improved practices. This knowledge covers such areas as the history of land use, the degree and rate of degradation, property rights and tenure systems, and soil quality. Data on these subjects is used to prepare maps showing past trends in land use and the changes desired for the future. The maps allow effective visual presentations to decision-makers at different levels, from the village to the government.

The project has three main activities:

1. A land-information database, including all important factors on the biophysical and socioeconomic landscapes, which will be developed using GIS, with the aim of strengthening the local community's decision-making ability and raising awareness among those responsible for policy at higher administrative levels.
2. "Best bet" technologies that improve productivity, increase income, and conserve natural resources will be evaluated.
3. Land-use options and their social and economic consequences will be evaluated using composite data from: participatory resource assessment, biophysical and socioeconomic studies, trials testing various technologies and indigenous knowledge.

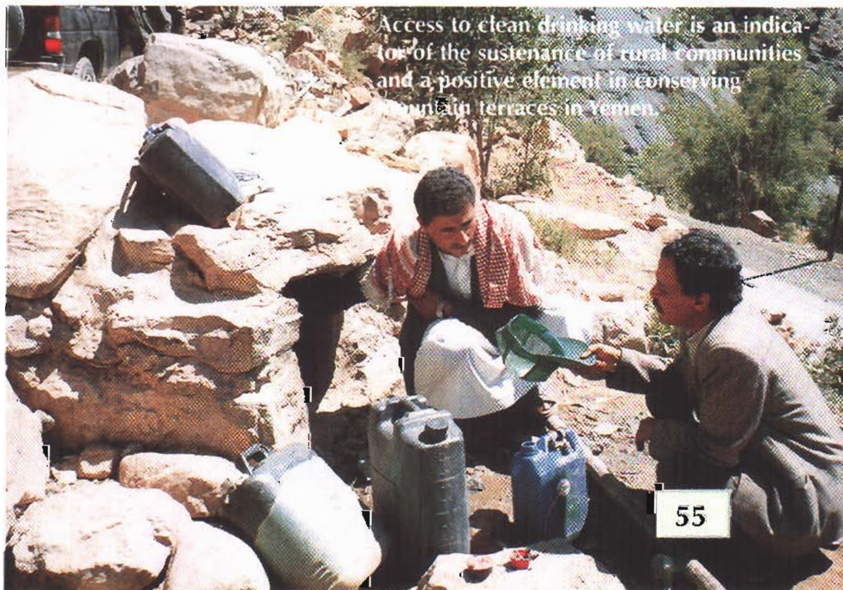
This integrated analysis will provide a basis on which to formulate widely applicable policy and developmental recommendations. The investment behavior of rural households and its determinants will also be analyzed before such recommendations are generated.

The project will also seek the collaboration of development organizations and NGOs, which will be encouraged to carry out small community development projects to solve problems identified as priorities in individual communities. Such links between research and development are essential for the success of integrated watershed management.

Case study

In an earlier phase of this project, a case study at a site in the Kholan-Affar district of Hajja province (on the western escarpment of the Yemeni highlands) investigated the effects of land tenure and other socioeconomic factors on terrace maintenance. The study found that the number of degraded terraces per hectare is increasing over time in all land tenure systems. Public land is managed by the state as well as by the Ministry for Religious Affairs, which holds in trust land (*waqf* land) donated for religious purposes. The number of broken terraces on sharecropped public land is significantly higher than those on owner-cultivated land. This can be attributed to the slow response by the state and the *waqf* authorities responsible for undertaking terrace repairs. The incidence of degraded terraces on private sharecropped land is not significantly higher than on owner-cultivated land.

The study also showed that the duration of tenure agreements is not the main factor in tenure insecurity but rather the weak position of tenants in relation to landlords. Tenant farmers suffered from various problems, including lack of clear agreements, different interpretations of customary rules governing terrace repairs, uncertain cost-sharing arrangements, and lack of mechanisms for enforcing compliance with rules and rights. The uneven distribution of power in favor of landlords has reinforced the lack of clear rules and made enforcement difficult. All of these factors have affected farmers' incentives to invest in terrace maintenance.



Access to clean drinking water is an indicator of the sustenance of rural communities and a positive element in conserving mountain terraces in Yemen.

The results of this study led to the following recommendations:

- Government action is needed to strengthen existing local institutions by documenting sharecropping contracts. This will make it easier to enforce rights stipulated by customary tenure rules.
- Improved agricultural credit services and price policies are needed to increase farm income and counterbalance the negative effects of food subsidies and rising terrace repair costs.
- Research must continue to develop more effective production technologies and more profitable land use options that will increase private investment in terrace maintenance and improvement.

Project 4.2. Socioeconomics of Agricultural Production Systems in Dry Areas

Household Livelihood Strategies in Rural Syria: How do Women Contribute?

Rural women, although traditionally confined to the domestic sphere, are believed to be contributing increasingly to their household income, as well as sustaining their families, by working on the home farm or outside. However, few studies to date have measured and documented this trend and its effects on women's access to land and other productive resources. In a collaborative project (funded by CIDA), ICARDA and the University of Guelph, Canada are examining and analyzing this phenomenon in the rapidly changing socioeconomic environments of the Aleppo, Hama, Homs, Raqaa and El-Hassakeh provinces of Syria.

Here the results of the first phase of the project are summarized. The project objective was to build up profiles of communities by examining the limitations on their resources and the livelihood strategies they adopt in response to them. Rapid rural appraisals were conducted in 39 communities in the different production systems found in the five provinces. This was followed by interviews with male and female informants using such tools as participatory mapping and calendars of activities to characterize production systems. The selected focus groups, whose size varied from 5-15 informants, included heads of households, wives, young men, and women practicing a range of occupations including farming, government jobs, and wage labor. Information was collected on the following topics:

By interviewing male and female members of rural communities in Syria, ICARDA is examining the limitations on their resources and the livelihood strategies they adopt in response to those limitations.

- access to social and farming resources,
- sources of income,
- changes to livelihood strategies in response to drought and water shortages, and
- women's contribution to rural livelihood strategies.

Production systems

The study uses a classification system developed by ICARDA that distinguishes five production systems:

- crop-livestock-range
- pure rainfed cropping
- conjunctive-water-use
- full irrigation
- peri-urban production

The study covered all these systems except the peri-urban systems. These consist of urban market gardens growing vegetables for market use. This system uses waste water to irrigate crops. The use of poor quality water affects the produce adversely. This system was omitted because the present study has focused primarily on the rural production systems in which ICARDA is currently working. Low and erratic rainfall is the main constraint to agricultural production in all the systems included in the study. Rural livelihood strategies fluctuate in accordance with the success or failure of the harvest, depending on availability of water. Table 11 shows the communities covered by the study and the production systems to which they belong.

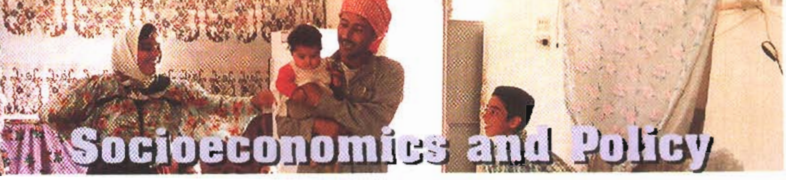
Crop-livestock-range systems

Communities dependent on the crop-livestock-range system, found in the driest areas adjacent to the steppe, are the most vulnerable to drought, i.e. Syrian Agricultural Production Stability Zones 3, 4 and 5 as indicated in Table 11. (Syria is divided into five agricultural production stability zones based on annual rainfall, which determines land use patterns.) The primary source of income for these communities is sheep husbandry. However, in recent years, prolonged droughts have forced

Table 11. List of surveyed communities by natural resource management system in Syria.

Province	Crop-livestock range sys.	Rainfed cropping sys.	Conjunctive water-use sys.	4. Full Irrigation Systems		
				Wells	River	Channels
Aleppo	Um Ghubar [3]*	Breda [2]	→			
	Ruwayhib [4]	Smariyeh [3]	→			
	Um El-Huteh [3]		Shweiha [3]			
	Djub El-Djamaa [5]					
				Djewayek [1]		
Hama						
	Abu Adjwa [3]		Talef [1]			
	Djini El-Albawi [4]		Um Amad [3]			
	El-Amyaa [4]		Bari Sharqui [3]			
	Sheikh Hillal [5]			El-Ghantu [1]	El-Ghantu [1]	
Homs	Djebab Hamed [4]			Katini [2]		
				Sukara [2]		
		Haraki [3]	→			
Raqaa	Which El-Hamud [4]			HULU ABD [3]	→	→
	Khneiz Chamali [4]			Kassrat Afnane [4]	→	→
	El-Sukariyeh [4]					
	El-Mahmudly [4-5]					
				Zur El Chamr [5]	→	→
El- Hassakeh	El-Khaburiyeh [3]			Ain Diwar [1]		
	Ridjm El-Erbidi [4]			El-Ahmadiyeh [1]		
				Hamam El-Turkman [2]		
				Um Hudjra K. [2]		
				Tel Hirmez [3]	Tel Hirmez	
	←	←	←	Makhrum [4]		
				El-Swatiyeh [4]	→	→
Deir Ezzor	←	←	←	←	Suwar [5]	
				Ramadi [5]		→
[Rainfall zone]	(→) Forward transition			(←) Backward transition		

* Numbers in square brackets refer to the Agricultural Production Stability Zones. Based on rainfall, Syria is divided into five zones: Zone 1, average rainfall over 600 mm; Zone 2, average rainfall between 350 and 600 mm; Zone 3, average rainfall between 250 and 350 mm; Zone 4, average rainfall over 250 mm; Zone 5, average rainfall between 200 and 250 mm.



them to rely increasingly on the migration of family members to wetter areas or to cities, where they provide wage labor to supplement the family's income. Most opportunities for agricultural wage labor are in activities traditionally performed by women such as weeding and harvesting. In some communities, girls as young as 12 are hired out for these purposes. In general, these communities are large exporters of female wage laborers to irrigated areas and to the high-potential, rainfed zones near the Mediterranean coast.

Rainfed cropping systems

The sample of surveyed communities does not include villages currently producing crops fed purely by rain. The study found that most of the villages, which used to mainly rely on rainfall, are increasingly relying on full-irrigation or conjunctive water-use-production systems. For instance, the communities of Breda, Smariyeh, Talef and Um Amad used to grow purely rainfed crops until the introduction of olive tree and fruit tree cultivation in the 1980s. The transformation of the production system, which was promoted by the State, was also accompanied by the multiplication of wells for watering young olive trees during the long summer season.

Conjunctive-water-use systems

Pure rainfed cropping and conjunctive-water-use systems share the same characteristics, except that the second system relies on other sources of water in addition to rainfall. These sources are usually wells but may also be rivers or streams. In contrast to the crop-livestock-range and the pure rainfed systems, communities using conjunctive-water-use systems derive most of their income from crops. In addition to barley and wheat, labor-intensive rainfed crops such as chickpeas, lentils, cumin, and fruit trees are cultivated in this system. The proximity of urban centers enables some community members to hold permanent non-agricultural jobs. Despite the greater labor requirement of a production system that is more diverse and labor-intensive, the out-migration of males from these communities is a growing trend, influenced by a rapidly growing population and the small size of land holdings (Table 12).

Table 12. Average family size and land holdings in selected communities using conjunctive-water-use system in Syria.

Community	Average family size	Average land holding (ha)
Talef	8	5
Breda	8	5
Shweiha	7	8
Um Amad	8	8

In some of these communities, women migrated to seek employment in agriculture, while others imported female agricultural labor, especially during the chickpea and lentil harvests. The analysis of the different communities suggests that communities located under the full-irrigation systems imported female labor, while communities in crop-livestock range and conjunctive water-use systems generally exported female labor (Table 13). Female labor migration, which may be directly related to poverty and household access to productive assets, will be further investigated in the household survey to identify what determines female labor migration.

Full irrigation systems

Communities practicing full irrigation are relatively rich in natural resources and have good agricultural infrastructure and services compared to those in

Table 13. Demand and supply of female agricultural labor in surveyed communities in Syria.

Production system	Number of communities	Importing (%)	Not importing (%)	Exporting (%)	Not exporting (%)
Crop-livestock range system	17	0	100	94	6
Conjunctive-water-use system	11	45	55	64	36
Full-irrigation system	11	82	18	36	64
Total number of communities	39	14	25	27	12
% of total communities		36	64	69	31

the other farming systems. They rely heavily on income from cash crops such as wheat, cotton and sugar beet, and are less reliant on income from other sources. With their larger irrigated holdings, they require more family members to work the land and women are actively involved in family crop production and cow husbandry. Families with these large irrigated land holdings have to bring in laborers from outside the village, mostly from communities with fewer irrigated land holdings. Thus, these systems are large importers of female labor from less well-endowed resource areas.

Dynamics within and between Production Systems

The classification of these communities does not remain static because, according to water availability, a community may vacillate between a rainfed system and an irrigated one. In our sample many communities have switched from one system to another (Table 11). For example, the Breda community stopped supplemental irrigation in 1990, after their wells dried up but, three years ago, they drilled deep wells and began irrigating again. Changing from one system to another has many implications for the way in which household labor is allocated. The change from rainfed cropping to conjunctive-wate-use, or from full-irrigation systems using wells to full-irrigation systems using irrigation channels, benefits households by increasing their income from crops. This means that women are required to work on family farms rather than to go out as hired labor. In some communities, such as El-Swatiyeh, households do not encourage their daughters to continue their education, as they need them to help on the family farm or look after their younger siblings while their mother and older sisters work. As one key informant from El-Swatiyeh put it, "As soon as our daughters reach sixth grade, we take them out of school to work."

In contrast, a change in the other direction, whereby farms revert to rainfed or conjunctive-water-use systems, threatens household livelihoods so that women especially are required to migrate or to sell their labor in more intensive cropping systems. Some of these communities reported girls under the age of 15 working for wages in agriculture (Table 14). For example, during the cotton harvest, laborers are paid according to the weight of the harvested cotton. This explains the involvement of mothers and daughters and the long hours they spend in the fields. Subsequent household surveys will help to clarify the different labor-use strategies and what determines women's involvement in off-farm income generating strategies.

Besides their involvement in household agricultural activities and off-farm income generation, women continue to have full responsibility for the domestic household chores. For example, the profile of activities performed by one of the daughters of Abu Mahmud's family from Ruwayhib, which is in Zone 4 of the Aleppo province, illustrates the different demands on her time for each season (Table 15). Women frequently complain about the difficulties they face in balancing domestic duties and farm and off-farm activities. Some women see education as an important route to being able to leave farm activities and seek other, off-farm, income generating activities and better paying jobs than wage labor in agriculture.

The Way Ahead

The first phase of the project found a strong correlation between the dynamic of production systems and the demand for, and supply of, female labor. However, to what extent this dynamic affects household livelihood strategies is not yet clear. The second phase of the project, which concentrates on households, will carry out an in-depth

Table 14. Distribution of agricultural female labor under 15 years old in Syria.

Production Systems	Number of communities	With female laborers under 15 years old (%)	Without female laborers under 15 years old (%)
Crop-livestock-range	17	82	18
Conjunctive-water-use	11	45	55
Full irrigation	11	55	45
Total number of communities	39	25	14

assessment of household assets and livelihood strategies in order to:

- evaluate the role of women in natural resource management and the extent of their contribution to household livelihood strategies in different production systems,
- determine the "pull and push" factors that determine women's involvement or disengagement in agricultural wage labor, and
- develop methodologies and a framework to ensure that policy is more accurately targeted, that interventions enhance women's welfare and, at the same time, improve the overall household livelihood strategies.

Table 15. Profile of activities undertaken by one of Abu Mahmud's daughters (14 years old) on a yearly basis in Syria.

Period	Location	Occupations
December-February	Ruwayhib (Permanent location)	• Sheep rearing • Milking and processing milk into yogurt
March-April-May	Ruwayhib	• Mud house-block making • Cheese making (April-May) • Agricultural wage labor during lentil and cumin harvest
June-August	Maari'(Azzaz) 130 km far from Ruwayhib.	*Agricultural Wage Labor: 6 a.m – 1 p.m.* • Mid June–Early July: Potato harvest: cut green part, select and sort potatoes • July-15 August: Sugar beet harvest • 15 August-Early Sept: Onion and vegetable harvest (20 days) *Ongoing activities:* • Household chores • Sheep rearing • Straw collection for sheep
Sept 15-October 15	El Kussayr-Deir Hafer 90 km far from Ruwayhib.	*Agricultural Wage Labor: Cotton harvest* • From 6 AM until 6 PM: involved in cotton harvest with rest of the household. • After working in the field, about 3 hours are spent on household chores (cooking, feeding the sheep).

Source: Informal visit to El-Kussayr (Deir Hafer) to observe a family at Ruwayhib harvesting cotton, October 2000.

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

Identifying the Problem

Developing the national agricultural sector has long been a priority for the countries of WANA. To this end many policy and tenure reforms have been introduced over the past 40 years to help rural households and communities improve their cropping and herding activities. Despite these measures, property rights systems in the rural areas are still thought to be a constraint to successful agricultural development because they deter farmers from investing in their land and adopting new technologies. Some of the results from research conducted as part of the 'Mashreq and Maghreb' project are synthesized here, and the extent to which these concerns are justified are explored by evaluating the effects of land rights on long-term land improvements and by assessing the levels of investment made by farmers.

Solutions at Government Level

Land tenure systems in WANA reflect a blend of Islamic, colonial and post-colonial land policies. Differences in systems mostly reflect the diverse approaches separate countries have used to promote efficiency, social equity and environmental sustainability in the low-rainfall areas. Governments saw institutional and legal reforms as important instruments in providing incentives for rural households to manage and sustain their resources and production systems. However, each country had its own vision of the nature and extent of the institutional reforms needed. These included full privatization, partial privatization, and agrarian reform.

Full privatization. The governments of Morocco and Tunisia chose privatization as the major instrument for promoting rural development and, accordingly, granted private rights to both tribes and individuals. In Tunisia this process went ahead very rapidly. Tribal lands were split up and individual, private rights of ownership were granted to tribe members. In Morocco, tribes were granted ownership rights over their traditional territory, to which they could hold title, while tribe members were granted rights to use their tribal lands in perpetuity, except for those under irrigation. These were withdrawn from the tribal collective lands, which were fully privatized, with ownership allocated to individuals. In addition, the assignment of title deeds to land was an important feature of these reforms, as having legally documented tenure helped farmers gain access to formal credit.

Partial privatization. This was the main approach taken in Jordan and Lebanon. Here the government retained ownership of the land, while the beneficiaries were granted partial ownership (*meeri*) rights. The state retained the right to control resource use. For example, in Jordan, the holders of such officially registered rights can transfer them through inheritance, by renting them out or by selling them. However, they cannot build a house on these lands unless the area they want to build on is upgraded to full ownership. In Lebanon, however, the management was vested in municipalities and village committees, while village members retained *meeri* rights.

Agrarian reform. This was one of the most widespread policy instruments used to promote equity and agricultural development in Algeria, Iraq, Libya, and Syria. In these countries, land was seized and redistributed to farmers or technicians. Agrarian reform was also carried out in Morocco and Tunisia, but mainly on lands that were taken from the French colonial settlers. The equity implications of agrarian reform are very important because many poor and landless farmers and herders received land and were organized into cooperatives to help them gain access to credit and inputs.

Model

The relationship between land rights and long-term land improvements was estimated using Stata software and plot level survey data from Jordan, Morocco, Syria, and Tunisia. Probit analysis was used to estimate the ability of farmers to make long-term investments. The clustering procedure in Stata was used to obtain robust standard errors and take care of the random-effects assumption and take into consideration household effects. Tobit analysis was used to estimate the level of investment and the marginal effects of the investment.

Data Collection and Analysis

In 1997 and 1999, ICARDA and its national partners conducted surveys in Jordan, Morocco, Syria, and Tunisia to assess the effect of property rights on farming systems. Households were randomly sampled from selected villages following rapid rural appraisals in 42 communities. The surveys gathered data on households, fields, crops, and livestock (see below) as a basis for determining the livelihood and production strategies of herders and farmers. Probit analysis was used to assess the propensity of farmers to make long-term investments and Tobit analysis to evaluate the level of their investments. Variants of these analytical models were used to calculate the marginal effects of different property rights on investments.

Land Rights and their Influence on Farmers' Investments

Full ownership in the countries surveyed comprises ownership of the resource (*mulk al ayni*) and ownership of the use-rights (*mulk al manfaa*). It is equivalent to freehold tenure of private property in the Western sense. Incomplete rights, consisting of partial ownership over either the resource or its use, include the perpetual use-rights obtained on tribal collective lands (Morocco and Tunisia), and partial ownership rights (*meeri*) obtained on state lands (Jordan), agrarian reform and rented state lands (Syria), and purchased and inherited state lands (Tunisia). The State lands in Tunisia have a peculiar status because farmers, expecting to receive ownership grants from the State, have been involved in land transactions as well as investing on these lands.

The definition of land improvements covered any long-term investments made by farmers to enhance productivity since the acquisition of the field. These improvements, including de-stoning, tree planting, and the digging of wells, were found on 25% of the plots in Jordan, 29% in Morocco, 46% in Syria, and 42% in Tunisia. The propensity to make long-term improvements was significant in Jordan and Morocco for privately owned lands (*mulk*), but the ability to invest in privately owned lands was higher in Jordan (Table 16). In Syria and Tunisia, the only significant variables were, respectively, inherited private lands and titled lands. In Tunisia, in the two communities studied, the private lands were co-owned and not uniformly divided. This prevented many farmers from carrying out land improvements. In Jordan, however, the holders of these private lands, which are generally within village boundaries, may use them for housing purposes, unlike holders of partial ownership rights (*meeri*), where the land is used mainly for cropping.

The results for partially owned land showed that investment in lands held under partial ownership (Jordan) or to perpetual use-rights (Morocco) was highly likely and the marginal effects of such rights were sometimes higher than on privately owned lands. The high marginal effect on appropriated tribal lands can be attributed to the continual claims to pasture rights made on these lands. This has many negative effects on livestock production and is a source of conflict. In contrast, there were some investments, but not a significant level, as indicated (-/+) in Tables 16 and 17, on agrarian-reform lands in Syria. In Tunisia, farmers were investing on inherited State lands and purchased State lands. The significant negative tendency for co-owned fields in Jordan and Tunisia suggests that co-ownership reduces the willingness of farmers to make long-term investments.

Level of Investment

The level of investment found confirmed the results obtained from the Probit analysis. Investment in privately owned fields was significant in all four countries, with higher levels of investment in Jordan and for titled fields in Tunisia. Moreover, with the partially owned fields, the level of investment was positive and significant only for partial ownership rights (*meeri*) in Jordan and perpetual use-rights in Morocco. Holders of these types of land rights were willing to invest in their land. In Syria and Tunisia, however, the level of

Table 16. Effects of land rights on the probability of farmers' making long-term investments.*

Land Rights	Jordan	Morocco	Syria	Tunisia
Titled				0.334
Complete ownership			Mulk/Melk=Private ownership	
Inherited (divided)	0.965	0.464	0.345	
Purchased (divided)	0.955	0.562	(+)	
Inherited (co-owned)	-0.066		(+)	(-)
Purchased (co-owned)				(-)
Partial ownership	*Meeri*	Tribal collective	Agrarian reform	Tribal collective
Inherited	0.704	0.636	(+)	(+)
Purchased	0.923	0.622		(+)
Appropriated		0.811	(+)	
Rented state lands			(+)	
Purchased state lands				**
Inherited state lands				(+)
Number of fields	169	478	228	311

* Marginal effects were obtained using the Probit procedure in Stata and only significant effects (10% significantal level) are reported; (+) denotes positive but not significant at the 10% significance level.

** The variable "purchased state lands in Tunisia" was dropped because it predicted success perfectly. Plot- and village-specific characteristics, which were included in the analyses, are not reported here. These tenure variables were compared to rented or sharecropped fields, which were the control variable.

investment was not significant (Table 17). In Morocco, the level of investment was even higher on tribal collective lands than on privately owned lands.

Table 17. Total investments made by farmers in their land, 1975-96.

Land rights	Jordan (US $)	Morocco (US $)	Syria (US $)	Tunisia (US $)
Titled lands				121
Complete ownership		Mulk/Melk		
Purchased (divided)	2,442	212	(+)	
Inherited (divided)	1,224	199	111*	
Inherited (co-owned)	(-)		(+)	**
Purchased (co-owned)				
Partial ownership	*Meeri*	Tribal collective	Agrarian reform	Tribal collective
Inherited	528	279	(+)	**
Bought	253	318		
Appropriated		362	(-)	
Rented state lands			(+)	
Purchased state lands				**
Inherited state lands				**
Number of fields	169	478	203	311

1. (Base year 1975).
2. Marginal effects were obtained using the Tobit procedure in Stata. Only the unconditional expected values of the marginal effects that were significant at 10% significance level are reported; (+) denotes positive but not significant at the 10% significance level.
3. * For the case of Syria, the coefficients were significant only at the 20% significance level.
4. ** The model collapsed when an estimation of the difference between the different traditional land rights was attempted.
5. Plot- and village-specific characteristics, which were included in the analyses, are not reported here. These tenure variables were compared to rented or sharecropped fields, which were the control variable.

Conclusions

Farmers in the dry areas are very keen to improve their resource base. The visible changes in the landscape over the past few years provide an important illustration of the determination of farmers and communities to improve their productivity and livelihoods. Research results from the four countries showed that existing property rights provide sufficient incentives for farmers to invest in improvements that will enhance the productivity of their land. Moreover, the fact that holders of complete and partial ownership rights alike are removing rocks, planting trees, and digging wells is proof that the rights on croplands are considered secure. The perception that land rights on croplands in the low-rainfall areas of WANA are so insecure as to hold back productivity is not supported by the results of this survey. Even so, this does not rule out the need for new policy measures that would improve the overall decision-making environment for landholders.

Upgrading perpetual use-rights in Morocco, State lands in Tunisia and agrarian reform lands in Syria to private ownership rights would significantly affect the rural communities and farmers who rely on these lands to support their livelihood strategies. It would also allow farmers better access to land and credit markets. The process may not be very difficult because, in most cases, farmers are already acting as owners of these lands. The negative results for co-owned fields suggest that co-ownership is a deterrent to both the willingness to invest and the actual level of investment. Tunisia has many agricultural lands under this form of ownership and new policy and institutional reforms are needed to provide incentives for farmers to invest on their lands. One important policy measure would be to conduct consensual arrangements and mechanisms to enable some of the co-owners to gain full ownership over the lands that are essential for their livelihoods.

Theme 5. Institutional Strengthening

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

ICARDA is the only CGIAR center with a unit dedicated to the provision of internal specialist seed services, as well as support for the development of national seed programs in its mandate region. The specialist services, which include the description, purification, maintenance and multiplication of early-generation materials, have hitherto involved mainly cereals and grain legumes, but are now increasingly concerned with forage seeds. At the regional level, the Seed Unit's work is directed mainly at strengthening national seed programs to promote the diffusion and uptake of improved varieties, thereby achieving an impact on the lives of the poor. The goal is to improve the supply of seed to farmers so as to maximize the returns on the investments made in research by ICARDA and its national partners.

Effective seed delivery depends on the successful interaction of technology, economics, and policy. This combination of key factors becomes especially important in the less-favored areas and for those crops in which the private sector is not active. Innovative solutions are needed in these circumstances. Some examples of the work conducted by the ICARDA Seed Unit during the year are summarized below.

Supporting Policy Changes in the Seed Sector

The seed sector is evolving rapidly in many WANA countries, partly as a result of policy changes associated with economic liberalization and partly on account of the rapid developments in the global seed industry. Countries actively following market liberalization include Egypt, Turkey, Morocco, and Pakistan. National seed institutions have to adapt to these changes while maintaining their regulatory functions, and ICARDA can assist them to do so, either directly, through the provision of advice and support or, indirectly, by promoting the exchange of information and experience between countries in the region.

In February 2000, the Seed Unit organized a course in Pakistan entitled "Management Issues for the Emerging Private Seed Sector." The course was held in association with the Chamber of Private Seed Industry and the Federal Seed Certification and Registration Department (FSCRD). It attracted over 40 participants, mostly from the small seed-companies that have developed in recent years following the introduction of a new seed policy in 1994. The fact that there are now over 300 seed companies in Pakistan, mostly trading in cotton-seed and vegetables, highlights the impact of such a policy change. The creation of this commercial diversity is a positive step towards improving the seed supply to farmers without additional costs to the government. The challenge now facing the government is to maintain a favorable policy environment within which these new entrants can develop, while still ensuring high quality seed for their customers, the farmers.

Besides presenting a wealth of information on the national and international seed scene, the meeting provided an excellent forum for interac-

Dr Akhlaq Hussain (second from right), Director General, Federal Seed Certification and Registration Department, Pakistan discussing issues of seed supply to farmers with representatives of the country's private seed companies.

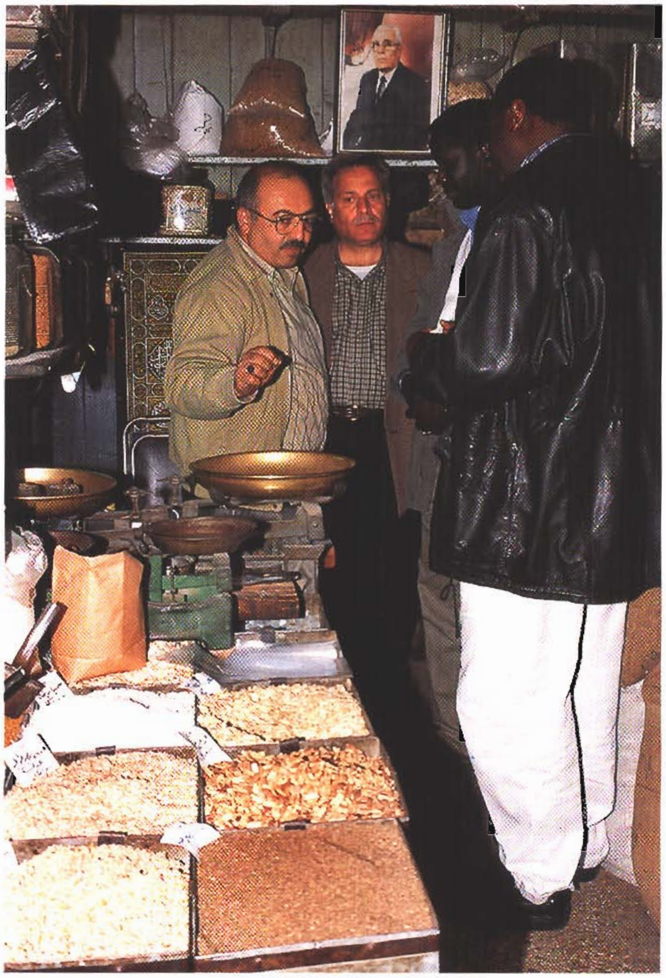
tion between company representatives and those of FSCRD, which has a key regulatory and advisory function. Intense discussion enlivened the meeting and continued afterwards in informal gatherings. There were many calls from participants to make this an annual event.

Research on Seed Supply Systems

Improving seed supplies to farmers, particularly of crops with a low commercial potential, calls for flexible and innovative solutions in which the complementary roles of the formal and informal seed systems are recognized. ICARDA has a research project financed by the Deutsche Donor Gesellschaft fur Technische Zusammenarbeit (GTZ) to study the current status of seed supply systems and the impact of policy changes upon them. Studies are being undertaken by local consultants in Syria, Jordan, Egypt, Yemen, Morocco, Ethiopia, Turkey, and Pakistan.

Southern Turkey provides a clear example of the problems of crops with a low commercial potential. The seed sector in Turkey underwent a dramatic transformation following a major change in national policy in the mid-1980s, when the government introduced a market-based economy and liberalized the seed industry. This included the withdrawal of state control on seed prices, and the liberalization of seed import and export. As a result of these changes, the private sector has expanded dramatically in recent years. However, the impact of this has been felt mostly in the more commercial crops, such as cotton, maize and vegetables, and not yet in the traditional food crops, such as wheat, chickpea and lentil, although these are nonetheless of great importance to the economy at both local and national levels.

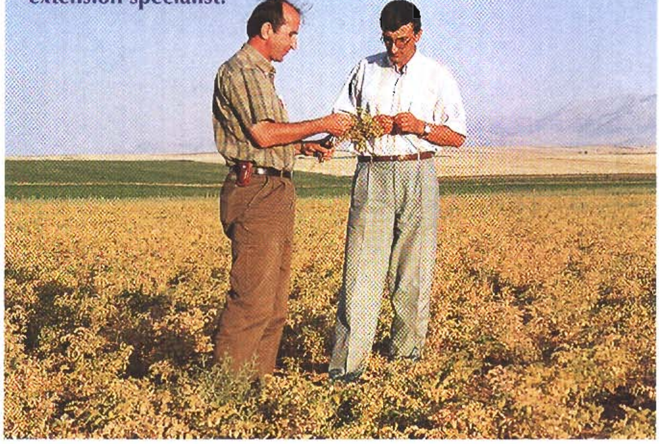
ICARDA is working closely with the South-East Anatolia Project (GAP) to develop innovative approaches to seed supply of improved varieties of crops to farmers in that region. A workshop was held in November to bring together all interested parties and discuss how such a system could be organized. Over 50 participants from several seed-related institutions, including private-sector companies, attended this meeting. Most of the discussions took place in small working groups and generated useful ideas, which now form a firm basis for seed production and distribution at community levels. The suggestions from the workshop have been proposed as elements of a work plan for 2001. ICARDA is also supporting a survey of current seed supplies in the GAP region as a baseline study for future initiatives.



ICARDA Seed Unit staff discussing seed supply issues with the owner of a small-scale local seed shop in the Bab Al-jenine market, Aleppo, Syria.

ICARDA believes that small local enterprises are able to play a useful role in many countries by supplying seed at lower prices than the larger companies because they have lower overheads and closer contacts with farmers. The proceedings of a workshop on "Finance and Management of Small-scale Seed Enterprises" were published in December 2000. It is hoped that work in this area will provide a stimulus for further initiatives by donors and national governments. Greater diversity in the seed supply system is needed because many governments are reducing their direct involvement in production and opening up the seed sector to new entrants. Small-scale producers have many advantages but often lack the basic technical and managerial knowledge to enter the business.

With this in mind, a manual on seed economics, based on experiences in training in the region, was published in September 2000. This document was used as a guide in an ICARDA/GTZ seed economics training course held in Algeria in October 2000 and will be a valuable aid to future courses on this subject.



Dr Ismail Kusmenoglu of the Mediterranean Exporters Union (Turkey), a private sector organization, discusses new chickpea varieties developed in collaboration with ICARDA with an extension specialist.

In the past, the ICARDA Seed Unit had worked mostly with the formal plant-breeding and seed systems, but it is now equally concerned to make the products of participatory plant breeding widely available to farmers. This raises important issues concerning both the organization of seed production and the regulatory framework for new varieties developed through participatory research. The Unit presented a paper on "Linking Participatory Plant Breeding to Seed Supply Systems" at an international workshop on the "Scientific Basis of Participatory Plant Breeding and Conservation of Genetic Resources," held in Oaxtepec, Mexico, in October 2000. The meeting was attended by more than 50 participants from the international agricultural research centers, national programs and universities from 16 countries in the Americas, Africa, Asia, Australia, and Europe.

Strengthening Regional Collaboration

The WANA region encompasses countries at very different stages of seed program development, presenting many opportunities for interaction and the sharing of experiences. It was for this reason that the WANA Seed Network was established in 1992. Since then it has produced a regular newsletter, "Seed Info," as well as many specialist publications. The Network acts as a platform for regional integration of the seed sector through the harmonization of technical procedures and institutional, regulatory, and policy reforms.

One theme in the regional work of the Unit is to strengthen links with the international seed organizations. With this in mind, the Unit organized a regional workshop in Amman in October on the theme of "Quality Assurance in Seed Testing Laboratories." This was organized in collaboration with the International Seed Testing Association (ISTA), which has committed itself to the ISO standards of quality assurance and now requires this approach for all accredited laboratories issuing the ISTA International Certificates of Seed Quality. Implementing ISO/ISTA procedures requires a fundamental change in the philosophy of quality control. It is no longer just the end product (the seed) that must meet stringent quality standards; instead the entire process of developing the product is subject to quality assessment. This demands a much more rigorous monitoring of equipment and procedures so that any discrepancies can be traced. The workshop attracted 15 participants from 9 countries in the WANA region, some of which are already upgrading their laboratory management procedures to meet ISTA requirements, while others have yet to start. For the latter group, the workshop provided a useful introduction to this new approach to quality management. ISTA accreditation will enhance the technical capacity of national seed programs to participate in the changing global seed industry.

International Cooperation

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

ICARDA collaborates closely with the Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA), in addition to being a co-sponsor of the Association. Activities with AARINENA in 2000 involved participating in its General Assembly, held in Beirut, Lebanon, 20–21 March, and contributing to the development of collaborative projects to promote South–South and North–South cooperation in WANA. ICARDA is also involved in the activities of the Asia Pacific Association of Agricultural Research Institutions (APAARI). In 2000, ICARDA also participated in the meetings sponsored by the Global Forum for Agricultural Research (GFAR), the European Forum for Agricultural Research for Development (EFARD), and AARINENA to promote North–South collaboration between Europe and WANA. As a result, ICARDA is now a member of the Virtual Forum for Agricultural Research for Development in the Mediterranean Basin.

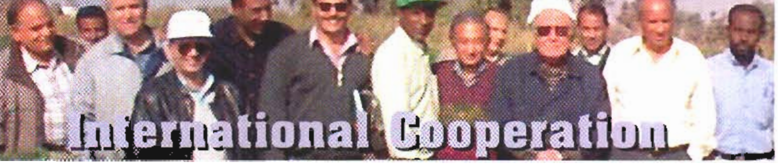
ICARDA's Medium-Term Plan (MTP) spans research activities at the Center's headquarters and collaborative projects with the NARS of CWANA. The NARS partners contribute directly to the implementation of the Center's 19 MTP projects. This cooperation covers the entire research spectrum, from basic and strategic research to applied and adaptive research and, finally, to technology transfer. ICARDA promotes its partnership with NARS through seven Regional Programs across seven geographic subregions that share similar agroecologies: North Africa, Nile Valley and Red Sea, West Asia, Arabian Peninsula, Highlands, Central Asia and the Caucasus, and Latin America.

North Africa Regional Program

The North Africa Regional Program (NARP) operates through ICARDA's Regional Office in Tunisia, serving Algeria, Libya, Mauritania, Morocco, and Tunisia. In 2000 many projects managed from ICARDA headquarters or its outreach offices were implemented through NARP. These included, among others, the Mashreq/Maghreb (M&M) Project on the "Development of Integrated Crop/Livestock Production Systems in the Low Rainfall Areas of West Asia and North Africa" (funded by AFESD, IFAD, and IDRC); "Institutional Options for Rangeland Management" (funded by the Ford Foundation and Systemwide Program for Collective Action and Property Rights—CAPRi); "Community Modeling" (supported by the *Forum Méditerranéenne des Instituts Economique*—FEMISE); "Utilization of Shrubs" (supported by the System-wide Livestock Production Program—SLP); "Biotechnology in the Arab Countries;" "On-Farm Water Husbandry;" "Devolution of Barley Breeding to Farmers in North Africa" (OPEC Fund); "Optimizing Soil Water Use;" and "Sustainable Management of the Agropastoral Resource Base in the Oujda Region of Morocco" (SDC, Switzerland). Over 100 North African scientists and technicians participated in training courses, workshops, and scientific meetings organized by ICARDA. Mauritania's cooperation with ICARDA currently concentrates on bilateral projects.

Partnerships

Partnerships between the NARS of North Africa and ICARDA are being strengthened through new



special projects to achieve objectives of mutual interest. A proposal for a program to foster wider adoption of low-cost durum technologies building on the achievements of the West Asia and North Africa Dryland Durum Improvement Network (WANADDIN) was submitted to IFAD; a proposal on "IPM in the Maghreb Countries" was prepared for submission to potential donors; proposals on "Sustainable Agriculture in the Mountain Regions of the Maghreb" and "Rehabilitation of Food Legumes in the Production Systems in the Maghreb" were finalized, and three others on rangeland, irrigation, and transfer of technology (Rapid Impact Project) for Mauritania were completed for submission to potential donors.

In addition to the current projects, bilateral projects were prepared for Libya and Algeria. A memorandum of understanding (MOU) was signed with Morocco for jointly developing land suitability maps, and a bilateral program on supplemental irrigation was under discussion. At the request of the Director of *L'Institut National de la Recherche Agronomique* (INRA), ICARDA's senior barley breeder reviewed the barley program in Morocco and her recommendations are being implemented.

Efforts to strengthen ties with donors included ICARDA's contribution to the establishment of an IFAD strategy for CWANA; development of Technical Advisory Notes (TAN) on IFAD-funded projects; and participation in an IFAD Workshop on "Impact Achievement," held in Rome in November. Meetings were also held with AFESD project officers during their visits to Tunisia and with IDRC project coordinators to discuss future collaboration.

Outsourcing

Research on resistance of wheat to Hessian fly continued to be outsourced to INRA. Selection is carried out jointly with ICARDA researchers in Hessian fly "hot spots" in Morocco.

Meetings, Workshops, and Capacity Building

In Algeria, an "International Symposium on Wheat" was held in February. Four papers were presented by ICARDA scientists. ICARDA also contributed to the "Arab Congress on Scientific Research in Arid Regions," held in October in Algeria. The "International Conference on Seed Industry," at which ICARDA scientists presented three papers, was held in Libya in March. ICARDA contributed to the "National Conference on Agricultural Research," held in Morocco in March, and to the *Centre International de Hautes Etudes Agronomiques Méditerranéennes* (CIHEAM) Conference on "New Approaches for Rural Development," also in Morocco, in April. The Center co-sponsored the "Fourth International Cactus Conference" and the "Population and Environment Conference," both held in Tunisia in October.

A Regional Traveling Workshop on Barley was organized in Tunis in May, in which 12 barley sci-

Opening session of the Mashreq and Maghreb Project Steering Committee meeting at ICARDA: Dr Klemens van de Sand (third from left), Assistant President of IFAD, Mr Samir Jarrad (second from right), Project Officer, the Arab Fund, and Dr Eglal Rashed (second from left), IDRC Regional Director, Middle East & North Africa Division, made statements confirming their support to help the rural poor. Prof. Dr Adel El-Beltagy (third from right) DG of ICARDA, assured the donors of ICARDA's commitment to alleviate poverty through technology generation and transfer. Dr Tidiane Ngaido of IFPRI/ICARDA (right) and Dr Ahmed E. Sidahmed (left), Officer-in-charge, Technical Advisory Division, IFAD, were also present on this occasion.

entists from the NARS of Algeria, Libya, Morocco and Tunisia, and ICARDA, participated. Participants visited the experimental stations in Beja and Le Kef and fields of farmers involved in participatory barley breeding. Farmers discussed their perceptions and selection criteria for improved barley genotypes with the participants. The group also discussed ways of strengthening collaboration with ICARDA and within the North Africa sub-region (South–South cooperation). A common nursery containing registered varieties of barley in each country will be initiated in the 2000/01 cropping season and distributed in the four countries.

Participants in the Barley Traveling Workshop, jointly organized by ICARDA and Institut National de la Recherche Agronomique de Tunisie/Institution de Recherche et Enseignement Supérieure Agricole (INRAT/IRESA) in Tunisia, 2-5 May. Barley breeders from Algeria, Libya, Morocco, and Tunisia participated in the workshop.

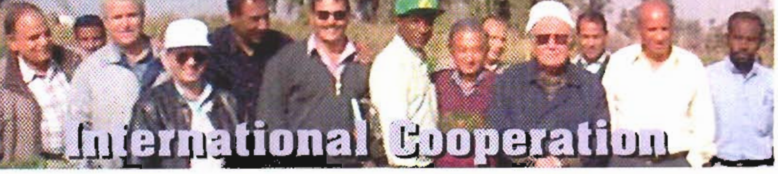
The M&M Project organized a one-week traveling workshop in Tunisia in May for farmers of Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, and Tunisia. Two farmers and one scientist from each country participated. A total of 40 participants visited several private enterprises and government projects in the northern and central regions of Tunisia. They met Tunisian farmers, mainly within the community, and saw the progress made by the Tunisian agricultural sector, especially in the rainfed zones, where soil and water conservation techniques are widely used.

The Annual National Coordination Meeting in each of the four North African countries (Algeria, Libya, Morocco, and Tunisia) was held to discuss collaborative activities with ICARDA in the previous season and develop future work plans, including human resource development. These meetings were attended by more than 250 scientists from the NARS of North Africa and ICARDA.

Subregional workshops and meetings were organized in the region to harmonize methodologies in community modeling and agroecological characterization. Scientists from Morocco helped their colleagues from Algeria and Libya to finalize community models.

The Eighth Biennial Regional Coordination Meeting for the North Africa Region took place in Algiers in November 2000, to discuss collaboration in areas of mutual interest for the four North African countries and ICARDA. Forty scientists from Algeria, Libya, Mauritania, Morocco and Tunisia, and ICARDA, participated. Achievements for 1998/99 and 1999/2000 were reviewed and new activities and approaches to collaboration were discussed. The participants recommended that policy makers and research managers supporting regional projects involving North African countries and ICARDA should address the priorities for research and attract funds to the region.

More than 100 scientists, technicians, and managers from North African NARS participated in training courses, scientific workshops, and scientific meetings, mainly in the areas of advanced technologies of GIS/AEC (agroecological characterization), biotechnology and biosafety, and water and natural resource management.



Nile Valley and Red Sea Regional Program

The Nile Valley and Red Sea Regional Program (NVRSRP) operates through ICARDA's Regional Office in Cairo, Egypt. Its overall objective is to increase the incomes of smallholder farmers in the region through the improvement of the productivity and sustainability of production systems, while conserving natural resources and enhancing the research capacity of the national scientists in Egypt, Ethiopia, Sudan, and Yemen. NVRSRP coordinates ICARDA's activities and several special projects in the member countries. The crop commodity improvement projects include: "Food Legumes and Cereals Improvement in Egypt," "Control of Wild Oats in Cereals and Other Winter Crops in Egypt," and "Legumes Improvement in Ethiopia."

Several activities in NVRSRP address sustainable natural resource management, such as the "Resource Management Project and the "Matrouh Resource Management Project (MRMP)" in Egypt, "Strengthening Client-Oriented Research and Technology Dissemination for Sustainable Production of Cool-Season Food and Forage Legumes" in Ethiopia, and "Mountain Terrace Conservation" in Yemen. In addition, problem-solving regional networks in all four countries are operating, despite lack of special funding. Other projects, undertaken in each of the countries and managed from ICARDA headquarters, cover such areas as IPM, expert systems in faba bean, genetically engineered stress resistance in lentil, on-farm water husbandry, grasspea, and village-based participatory breeding.

New Partnerships

Partnerships are being initiated or strengthened through many collaborative special projects. A project proposal on the "Improvement of Legume and Cereal Crops" was jointly developed by the Eritrean National program and ICARDA, and three project proposals on natural resource conservation and management were developed for Sudan. Donors are being approached for funding. A project proposal on the "Sustainability of the Environment and Production Systems in Egypt" was developed and submitted to the European Union (EU) for consideration for funding. Another project proposal on "Rainfed Agriculture in Yemen" was prepared, and a regional project on "Technology Generation and Dissemination to Control Biotic and Abiotic Stresses in the Nile Valley and Red Sea Region" was finalized. A project proposal on "Agroecological Characterization and Land Use in Ethiopia" was developed and submitted to the DGIC–Belgium for consideration. Several donors were contacted during the year to support national activities in the countries, including the EU, the Netherlands Government, the World Bank, the Islamic Bank, and IDRC.

Agreements of Cooperation

An agreement of cooperation was signed between ICARDA and the National Center for Research (NCR) in Sudan, and a letter of intent was signed between ICARDA and the United Nations Drug Control and Crime Prevention (UNDCCP) Regional Program in Cairo, Egypt, to conduct socioeconomic surveys in the Sinai on alternative crops.

Regional Networks

Regional activities within the problem-solving networks continued, with resources from the countries involved. Seven active networks (Wheat Rusts, Wilt and Root Rots in Food Legumes, Aphids and Viruses in Food Legumes and Cereals, Heat Tolerance in Wheat, Drought in Barley and Water-use Efficiency in Wheat, Chocolate Spot in Faba Bean, and Socioeconomic Studies) are in operation within NVRSRP, with the participation of all four countries in the region. Substantial achievements include identification of resistant genes, which were subsequently incorporated into commonly grown varieties, and the release and testing in farmers' fields of new improved varieties. Moreover, socioeconomic studies have given a clearer understanding of constraints to technology adoption, yield gap analysis, gender-related issues, and impact assessment.

Meetings, Workshops, and Capacity Building

Annual National Coordination Meetings between each country and ICARDA were conducted: in Egypt with 30 participants, in Ethiopia with 90 participants, in Sudan with 100 participants, and in Yemen with 45 participants. At these meetings the results of the previous year's activities were presented and discussed and the work plans for collaborative activities for the coming year were developed.

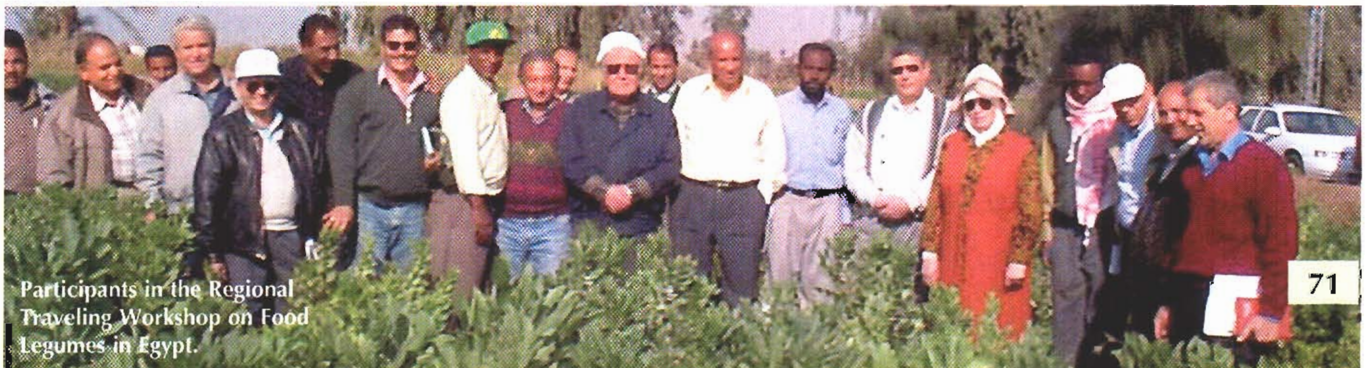
The Regional Coordination Meeting of NVRSRP was held in Khartoum, Sudan, with the participation of 50 scientists from the four Nile Valley and Red Sea countries and ICARDA. At the meeting, regional activities were discussed and agreed upon. During the Program's Steering Committee Meeting, which was also held in Sudan, new research areas were identified including integrated watershed management and crop–livestock integration in the low-rainfall areas of the region. The meeting was inaugurated by the Minister of Agriculture and ICARDA's Director General.

Traveling workshops were organized in the different countries at both regional and national levels: a Regional Legumes Traveling Workshop in Egypt, with 40 participants; a Regional Faba Bean and Pea Traveling Workshop in Ethiopia, with 35 participants; four National Traveling Workshops in Egypt (one each on wheat, barley, wild oat control and resource management), with participation of 167 researchers; and a National Traveling Workshop on Wheat in Sudan, with 30 participants.

A regional workshop on "Degradation and Rehabilitation of Marginal Lands in the Arab Region" was organized in Cairo, Egypt, in collaboration with the Center for the Environment and Development for the Arab Region and Europe (CEDARE) with 15 participants from 15 countries.

Several training courses were conducted in the NVRSRP countries in 2000, with the aim of improving the skills of researchers in these countries and enhancing regional cooperation among the countries, and between the countries and ICARDA. These included degree and non-degree courses, short courses and individual training. All the training activities were tailored to meet special needs of the national programs. Three regional training courses were implemented in cooperation with NVRSRP: "Integrated Watershed Management," with 11 participants from 8 countries; "Utilization of Expert Systems in Agricultural Research and Production," with 12 participants from 11 countries, and "*In-vitro* Haplodiploidization, Cytology and Genetic Transformation," with 12 participants from 6 countries. In addition, 14 individuals participated in other training courses, conferences, and specialized workshops at ICARDA or abroad.

Prof. Dr Adel El-Beltagy (third from right), ICARDA Director General, discussing the progress of the EU-supported work in NVRSRP with Mr Xavier Marchal (second from right), Head of EU Delegation in Sudan.



Participants in the Regional Traveling Workshop on Food Legumes in Egypt.

West Asia Regional Program

The West Asia Regional Program (WARP) promotes regional cooperation in research, capacity building and information dissemination in Cyprus, Iraq, Jordan, Lebanon, Syria, and the lowlands of Turkey. The major emphasis is on the improvement of farming systems in the 200–450 mm rainfall zones, which are characterized by shortage of water and highly erratic rainfall, large population growth, and limited agricultural resources. WARP manages a major project from its Amman Office jointly with the NARP Office in Tunis: the "Development of Integrated Crop/Livestock Production Systems in the Low Rainfall Areas of West Asia and North Africa," referred to as the Mashreq and Maghreb (M&M) Project. Other projects, namely, "Multiple-purpose Fodder Shrubs and Trees," "On-farm Water Husbandry," "Optimizing Soil Water Use," "Biotechnological Research," "Dryland Agrobiodiversity," and "Barley Production" are managed from ICARDA headquarters, but WARP provides follow-up on implementation.

Meetings, Workshops, and Capacity Building

The M&M Project, which started a second phase in 1998/1999, provides substantial support to collaborative activities in Iraq, Jordan, Lebanon and Syria, in addition to Algeria, Libya, Morocco and Tunisia. It is funded by AFESD, IFAD and IDRC. The second Steering Committee (SC) Meeting of the Project–Phase II was held at ICARDA headquarters in Aleppo in February. It was attended by leaders of NARS of the eight countries, donor representatives from AFESD, IFAD and IDRC, and representatives of ICARDA and the International Food Policy Research Institute (IFPRI). All presentations covering the results of the 1998/1999 season and the work plans for 1999/2000 clearly demonstrated how activities at the regional and subregional levels among the eight NARS involved in the project are integrated and complementary.

The Sixth Lebanon/ICARDA Biennial Coordination Meeting was held at the Lebanese Agricultural Research Institute (LARI) in Tal Amara in June, and was attended by 41 participants. The Tenth Biennial Coordination Meeting between Jordan and ICARDA was held at the National Center for Agricultural Research and Technology Transfer (NCARTT) in September, and was attended by 80 participants. At the meetings, the outcomes of collaborative activities in the previous season were discussed, and work plans for 2000/01 were developed.

Participants in the Mashreq/Maghreb Project sub-regional Workshop on Local Community Studies: Policy, Technology and Institutional Evaluation, held in Lebanon, 2-8 July 2000. The meeting was opened by Dr Khalil Khazzaka (Center), DG of LARI and Member of the ICARDA Board.

The Second Regional Technical Planning and Steering Committee Meetings of the project on the "Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Palestine and Syria" was held in Zahle, Lebanon, in July. The meeting was attended by representatives of the countries involved in the project, ICARDA, the International Plant Genetics Research Institute (IPGRI), the Arab Center for Studies of the Arid Zones and Drylands (ACSAD), and the United Nations Development Programme and Global

Environment Fund (UNDP/GEF).

The Third Regional Technical Planning and Coordination Meeting of the M&M Project–Phase II was held in November at the *Institut Technique des Grandes Cultures* (ITGC) in Algiers, Algeria. The Minister of Agriculture of Algeria inaugurated the three-day meeting, which was attended by 37 senior scientists from Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, and ICARDA. One session was devoted to discussions on a third phase for the project.

Opening session of the Regional Technical/Planning meeting in Zahle, Lebanon, 10-13 July 2000. From left to right: Ms D. Al Khatib, representing UNDP in Lebanon; Dr G. Ayad, Director, IPGRI CWANA Regional Office; Dr M. Solh, ADG (IC), ICARDA; Dr M. Yaghi, Chairman of the Board of Directors, Lebanese Agricultural Research Institute (LARI); and Dr H. Daraghma, UNDP/GEF regional representative.

Traveling workshops organized by the M&M Project included a Regional Farmers' Traveling Workshop in Tunisia in May. A Subregional Traveling Workshop was held in Iraq in April, and another in Syria in May. Six participants from Lebanon, Jordan and Syria, in addition to those from Iraq, took part in the first workshop, which included visits to the project activities implemented during the 1999/2000 season. An In-country Farmers' and Technicians' Traveling Workshop was organized in Lebanon in collaboration with LARI, the American University of Beirut (AUB) and ICARDA, with 69 participants from various Lebanese and Syrian institutions and ICARDA. A Subregional Workshop on "Community Studies, Policy, Technology and Institutional Evaluation for Dryland Agriculture" was organized in Lebanon in July, and was attended by 19 participants from Iraq, Jordan, Lebanon and Syria, and ICARDA. It was also attended by two participants from the UNDP/GEF "Agrobiodiversity Project."

A "Community Day" was organized in October by the M&M Project at LARI in Lebanon. More than 200 representatives of various local women's and professional associations, farmers, NGOs, members of parliament, former members of the Cabinet and representatives from the Ministry of Agriculture, researchers and scientists from the Lebanese NARS, and representatives of the UNDP/GEF-funded project on "Agrobiodiversity" attended the event.

Theme-oriented meetings of the UNDP/GEF/ICARDA "Agrobiodiversity Project" were organized in Jordan in September/October. The meetings covered policy and legislation related to issues of biodiversity conservation and use, ecogeographic botanical surveys and their analysis, and socioeconomic surveys. More than 45 representatives from the countries involved in the project attended the meetings.

ICARDA, in association with the International Seed Testing Association (ISTA) and the University of Jordan, organized a regional workshop on "Quality Assurance in Seed Testing" in Amman, Jordan, in October. The workshop aimed to help managers and senior technicians in seed-control laboratories in the region to understand the issues involved in quality assurance in preparation for the International Seed Testing Association's (ISTA) new accreditation requirements. Sixteen participants from Egypt, Ethiopia, Jordan, Morocco, Pakistan, Sudan, Syria and Turkey, and ICARDA,

attended the workshop in the Faculty of Agriculture of the University of Jordan.

Scientists from the M&M Project in Libya, Morocco and Tunisia, and a scientist from the Iraqi national program, participated in a regional workshop on "Degradation and Rehabilitation of Marginal Lands in the Arab Region," held in Cairo in July. They presented four papers on the M&M Project's experience in tackling natural resource management and in controlling land degradation.

Outsourcing

A socioeconomist from Iraq contributed to impact studies of barley and lentil germplasm. Scientists from Jordan were outsourced to assist MRMP work in Egypt on soil conservation and extension. A watershed management specialist from Jordan participated as a "resource person" in the regional training course on "Watershed Management," organized in Egypt in September 2000.

Arabian Peninsula Regional Program

The success of the first phase of the Arabian Peninsula Regional Program (APRP) was underlined by the agreement in 2000 for a further three years of funding by the two current major donors, AFESD and IFAD, and the OPEC Fund for Phase II. The project covers collaborative activities with seven Arabian Peninsula countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates (UAE), and Yemen. Areas of collaborative research include water resource management; forage and rangeland production and management; tolerance to drought, heat and salinity; and protected agriculture.

Collaborative Research

Although this was essentially a transition year between the two APRP phases, considerable progress was made with the NARS in the areas of determination of water-use efficiency, nutritive value, and seed multiplication of three indigenous forage grasses. This progress has led to the start of a major development program on seed production of these indigenous desert grasses. In protected agriculture, significant advances were also made in the important area of integrated protection and production management (IPPM), culminating in an Expert Consultation Meeting (ECM) in November. The ECM was attended by more than 50 scientists from the Arabian Peninsula countries and 10 international experts in protected agriculture from FAO, Egypt, Jordan, Morocco, UAE, and ICARDA. A strategy for IPPM in the Arabian Peninsula and a work plan for 2000/01 were developed.

New partnerships were forged with the recently established Biosaline Agriculture Center (BAC) in Dubai, to undertake an extensive research program on evaluation of indigenous grasses under saline and limited soil and water conditions. A Memorandum of Understanding was signed between ICARDA and BAC. Currently, the APRP and BAC are evaluating seed-harvesting and processing equipment for these grasses. Similar work is being done with the Governorate of Fujairah in the UAE. Following a visit to the Ahfara site in April by ICARDA's Director General, a multidisciplinary team also visited the site. The team included two scientists from ICARDA and an international rangeland ecologist from France, as well as scientists from the ICARDA–APRP. The site, which is representative of arid mountain areas in the Arabian Peninsula, was studied to assess the potential for rehabilitation and sustainable development. The mission report highlighted the importance of preventing further damage to trees and forages in the area through overgrazing by livestock, and recommended using a larger watershed area for groundwater recharge.

An important Internet-based weather-station network was initiated in APRP–Phase II and automatic weather-station equipment for six countries has been ordered, to assist the NARS with their irrigation and seed and forage production research for field and horticultural crops.

Meetings, Workshops, and Capacity Building

The new phase of APRP was discussed in detail at the Sixth Annual Regional Steering Committee Meeting of Phase I, held in May in Doha, Qatar. The meeting was attended by representatives of the NARS of the seven member countries and ICARDA, who finalized the priorities of the three themes of Phase II (rangelands and abiotic stresses, water, and protected agriculture). In October, in Dubai, the United Arab Emirates hosted the first Regional Technical Coordination Meeting, the first Regional Steering Committee Meeting of Phase II and an Expert Consultation Meeting on IPPM of Protected Agriculture with the participation of 60 national scientists and experts from the Arabian Peninsula, Egypt, Jordan, Morocco, ICARDA, and FAO.

APRP contributed to a training workshop on "Combating Desertification and Human Resources Development," organized by the Arab League and held in May in Kuwait. A total of 25 national scientists from the Arabian Peninsula countries were trained by ICARDA in various disciplines during the year. A protected-agriculture scientist from Yemen is currently involved in an extensive on-the-job training program in the UAE. Two graduate students from France completed their six-month training programs with the NARS in the UAE.

H.E. Rashid Khalfan Al Sharqi (second left), the UAE Deputy Minister of Agriculture and Fisheries, visited a joint project with ICARDA at the Central Region Research Station at Dhaid. Also seen in the picture are (left to right), Director of Soil Science Mohammed Al-Assam, ICARDA Protected Agriculture Specialist Ahmed Moustafa, and UAE Protected Agriculture Specialist Rashid Ahmed.

Highland Regional Program

Activities conducted during 2000 in the Highland Regional Program (HRP), which covers Afghanistan, Iran, Pakistan and Turkey, and the highland regions of Algeria, Morocco and Tunisia, involved joint research with some countries and exchange of germplasm with all of them. Special efforts were made to link with the Central Asian and Caucasus (CAC) Regional Program because of the similarities in agroecologies with HRP, namely, the cold winters in both regions. Details on collaboration are given below for three major partners of HRP: Iran, Pakistan, and Turkey. ICARDA has a major project with Iran supported by the Islamic Republic of Iran.

Iran/ICARDA Project

The Iran/ICARDA project covers the improvement of cereals (barley and wheat), food legumes (chickpea and lentil), oil crops, advanced technologies (biotechnology), and management of natural resources, particularly soil and water. A large number of ICARDA scientists visited Iran to provide technical backstopping to the Iran/ICARDA collaborative project. Research results and training activities in 2000 were reviewed and a plan of work for 2001 was prepared jointly at the annual Iran/ICARDA Coordination Meeting that took place in September at the Arid Lands Agricultural Research Center in Maragheh and the Karaj Agricultural Research Center, near Tehran. The meeting was attended by scientists and research managers from all collaborating Iranian research institutes and from ICARDA. Among several activities planned for the 2000/01 season, joint activities on wheat yellow rust were discussed, including a plan for a regional conference on yellow rust to be held in Tehran in 2001.

To strengthen the research partnership between Iran and ICARDA, the ICARDA Board of Trustees (BOT) Meeting was held from 30 April to 6 May 2000 in Tehran. The BOT members, senior Iranian officials, ICARDA's Director General, research managers, and scientists visited sites of joint activities in the country. The BOT met with the Vice President of the Islamic Republic of Iran, who praised ICARDA's contribution to agricultural research and development in Iran as an excellent example of true partnership between a CGIAR Center and a national partner. During the visit, the Iran/ICARDA Agreement on Collaborative Research and Training was renewed for 2001–2005 and expanded to encompass 13 projects covering crop improvement, crop management, on-farm water-use efficiency, integrated pest and disease management, salinity management, and use of biotechnological tools in crop improvement. Eight major Iranian research institutions will be involved in these research activities.

The Minister of Agriculture of the Islamic Republic of Iran visited ICARDA headquarters in Aleppo, Syria, to familiarize himself with ICARDA's research and training programs and facilities and to exchange views on the further strengthening of the collaboration between Iranian research institutions and ICARDA.

Twenty-three Iranian researchers were trained at ICARDA or under ICARDA-sponsored training programs in various disciplines and commodities (experimental station management, crop breeding, supplemental irrigation, expert systems, seed health). Three in-service researchers were sent for Ph.D. studies abroad. Eleven senior scientists and administrators from Iran visited ICARDA headquarters to familiarize themselves with advances in research and technology. Another high-level delegation of decision-makers and senior managers also visited ICARDA during the season to obtain first-hand information on ICARDA's work at its main station at Tel Hadya, Aleppo.

H.E. Dr Issa Kalantari (third from left), Minister of Agriculture, Iran, and his delegation members with the ICARDA senior management team, during their visit to the Center's headquarters to see the research and training facilities and activities.

Pakistan

Collaboration with Pakistan covers germplasm improvement of winter cereals (barley and wheat) and natural resource management (water husbandry, rangeland improvement, soil and water conservation, and watershed management). ICARDA, in collaboration with four national research institutes working in the rainfed areas of the Punjab, is implementing the "Adaptive Research Component" of the "Barani Village Development/Project" (BVDP). The Review and Planning Meeting of BVDP was held in Rawalpindi, Pakistan, in April. The meeting, which was co-organized by ICARDA and the Agency for Barani Area Development (ABAD), was attended by scientists from the four provincial research institutes in the Punjab and from ICARDA. Selection criteria and a work plan were developed for the establishment of integrated research sites (IRS). The IRS were identified and the work plan for watershed management was started by the provincial institutes in cooperation with ICARDA's National Professional Officer, who manages the project and ICARDA's long-term consultant, who completed his first three-month assignment in Pakistan in June 2000.

The Chairman of the Pakistan Agricultural Research Council (PARC) visited ICARDA and discussed areas of cooperation.

An in-country training course on the "Management of the Seed Industry" was held at Multan, Pakistan, in February. HRP also trained one person for one month on wheat improvement and provided cereal and legume germplasm to the national program.

Turkey

ICARDA's collaboration with Turkey during the year covered joint research activities in the areas of winter and facultative wheat improvement, barley for cold areas, and winter-sown lentil. Over one tonne of germplasm seed of these crops and of chickpea, faba bean, and forage legumes was provided to the Turkish partners in September for testing at research institutes and universities in various regions, including Ankara, Diyarbakir, Konya, Eskisehir, Izmir, and Adana.

Joint research was conducted on minimum tillage at the Central Research Institute for Field Crops (CRIFC) under the umbrella of the "Optimizing Soil Water Use (OSWU) Project," and on supplemental irrigation of wheat at Ankara Research Institute of Rural Services.

A disease survey was organized in Turkey in collaboration with Turkish and CIMMYT partners, in May and June. Participants visited wheat-farm fields and research sites in Adana, Konya, Eskisehir, and Ankara. Symptoms of cereal cyst nematode, dryland root rot, Russian wheat aphid, and barley yellow dwarf virus were observed to varying degrees in the fields visited; however, yellow rust was not a major problem this season because of conditions unfavorable for its development.

Collaboration with the development project in the southeastern Anatolian region (GAP-RDA) was strengthened with the signing of a revised agreement in February. On-farm testing and demonstration of improved wheat and lentil cultivars took place in Southeastern Anatolia with farmers' participation. Vetch seed, delivered by ICARDA, was sown and harvested at the GAP Koruklu Research Station. Two workshops were conducted, one in June and the other in August, in collaboration with GAP-RDA and other Turkish organizations, in the area of rangeland management and monitoring. As a result of the first workshop, participants were able to assess biomass in rangeland and assemble herbaria from the target area. The second workshop focused on diverse vegetation in fragile and shallow soils in certain areas of the study site at the Koyulu village of the Adiyaman district.

Eight ICARDA scientists provided technical backstopping and on-the-job training at research sites in Turkey during the year in relation to joint research with Turkish partners.

A GAP scientist participated in an ICARDA-organized course on "Utilization of Expert Systems in Agricultural Research and Production." A training program was arranged for two senior GAP-RDA staff members, who visited UC-Davis to upgrade their knowledge in agricultural project management. A total of eight Turkish scientists visited ICARDA to participate in the regional workshop on "Biosafety Regulations" and to be trained in seed production and the improvement of wheat and chickpea.

A regional traveling workshop concerning rangeland, pasture and livestock was jointly organized with CRIFC in July, with the participation of 15 scientists from Turkey, Central Asian countries and ICARDA. The participants visited range rehabilitation sites, a private seed company, and milk- and meat-processing factories in Central Anatolia. A national workshop was organized in November at Sanliurfa on "Sustainable Seed Production Systems for Winter Cereals and Grain Legumes in the GAP Region." Participants came from public seed institutions, farmers' organizations, private companies, NGOs, research institutions, GAP-RDA, and ICARDA. They discussed and recommended action on critical issues that would solve the problem of shortage of improved seed of winter cereals and lentil in the GAP region. It was apparent that the problem was primarily due to regulations controlling seed marketing.

Central Asia and the Caucasus Regional Program

The Central Asia and the Caucasus Regional Program (CACRP) completed its first two years and continued its mission of strengthening ICARDA's partnership with the eight NARS of Central Asia and the Caucasus (CAC) region: Kazakstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan in Central Asia; and Armenia, Azerbaijan, and Georgia in the Caucasus. During the year, ICARDA signed a trilateral agreement for cooperation in agricultural research and development with Kyrgyz Academy of Agricultural Sciences and the Ministry of Agriculture and Water Management of Kyrgyzstan.

The Program continued to strengthen five main areas of collaborative activitities in the CAC region: productivity of agricultural systems, natural resource conservation and management, conservation and evaluation of genetic resources, socioeconomic and public policy, and strengthening national programs. These activities were carried out under four projects: "Conservation and Evaluation of Crop Genetic Resources," "Germplasm Enhancement," "Livestock/Feed Integration," and "On-farm Soil and Water Management."

A new project on "On-Farm Soil and Water Management for Sustainable Agricultural Systems in Central Asia" was initiated in April with financial support from the Asian Development Bank. This further strengthened the work initiated in 1999 with support from the CGIAR seed money for CAC. Other projects managed from ICARDA headquarters, and funded from the CGIAR seed money, or with contributions from other investors, are on germplasm enhancement of wheat, barley, food legumes and feed legumes (CGIAR), livestock/feed production (IFAD), germplasm collection (ACIAR/Australia), and sheep/range management in Uzbekistan (USDA/ARS).

A new on-farm water specialist from the region was appointed and based in the Regional Office in Tashkent to support the project activities. The project "Karakul Sheep and Range Management" that had been under way in collaboration with the USDA/ARS since 1997 was completed during the year.

Collaborative Research

Work on crop germplasm collection, conservation, evaluation, and documentation was supported by the funds from ACIAR of Australia and the CGIAR Program for CAC.

A notable contribution of these activities was the establishment of a Germplasm Documentation Unit at the Uzbek Research Institute for Plant Industry (UzRIPI) in Tashkent. The collaborative work on germplasm enhancement of wheat in collaboration with CIMMYT, and of barley and food and feed legumes was further strengthened. A barley variety, 'Mamluk', was released for commercial production in Armenia. Other winter wheat varieties were submitted for the official state variety trials in Azerbaijan, Tajikistan, Turkmenistan, and Uzbekistan. Surveys for wheat and barley diseases and insect pests were carried out for the second successive year.

The "Integrated Feed/Livestock Project," with emphasis on technology transfer, continued as a collaborative activity in Kazakstan, Kyrgyzstan, Turkmenistan, and Uzbekistan. The on-station breed characterization of small ruminants that was started in 1999 was further extended to the on-farm work. Collaborative activities in the "On-Farm Soil and Water Management Project" were initiated under four themes in all of the five countries of Central Asia. These included activities for development of improved strategies for on-farm soil, water and crop management, assessing and improving farm-level irrigation and drainage management to ensure the sustainability of irrigated cropping systems, assessing and improving the use of marginal water sources, and capacity building of NARS. A notable development was the establishment of two integrated research sites in the region: one at Boykozon farm (near Tashkent) in Uzbekistan, and the second at Sorbulak (near Almaty) in Kazakstan. Also, work on the characterization of the two sites using the geographic information system (GIS) was completed during the year with local collaborators.

New Regional Networks

In addition to the existing networks in CAC on "Plant Genetic Resources (CACTN-PGR)" and "Winter Wheat (CACWWINET)," three new networks for CAC were established during the year. These are: (1) "Central Asia and the Caucasus Barley Improvement," (2) "Central Asia and the Caucasus Legumes Improvement," and (3) "Yellow Rust Network for Central Asia and the Caucasus." These networks aim to further strengthen collaboration of CAC national partners among themselves and with ICARDA.

Meetings, Workshops, and Capacity Building

The Fourth Annual CACRP Regional Coordination Meeting (RCM) was organized in Bishkek/Issyk-Kul, Kyrgyzstan, in September. Seventy-five senior collaborating scientists from eight CAC countries, together with ICARDA senior scientists, discussed results of the 1999/2000 season and finalized work plans for 2000/01. The program organized a meeting for the stakeholders in the project on "On-Farm Soil and Water Management for Sustainable Agricultural Systems in Central Asia" at ICARDA headquarters in April. It also organized five National Coordination Meetings for this project and four for the IFAD-supported "Feed/Livestock Project" to discuss work plans and budgets, and a Regional Coordination Meeting for each in September to discuss regional activities of the projects. Project Steering Committee Meetings for the two projects were organized in Bishkek in conjunction with the RCM.

An international workshop on "New Approaches to Water Management in Central Asia" was organized in Aleppo in November in collaboration with NRMP and the United Nations University in Japan. The workshop participants visited the Syria/ICARDA collaborative work on soil and water management in Syrian steppes. In col-

Turkmenistan scientists, Prof. Omar Redjepov (fourth from left) and Dr Eziz Khankuliev (right) at a soil tillage and water management experiment site at Akhal station, near Ashgabat, with Dr M. Suleimenov (left), Dr F. Karajeh (second from left), Prof. Dr Adel El-Beltagy (DG of ICARDA, third from left), Dr S. P. S. Beniwal (third from right), and Dr Jitendra Srivastava (from the World Bank, second from right).

laboration with UzRIPI, the Program organized a Regional Meeting on "Field Plant Genetic Resources in Central Asia and the Caucasus," in Tashkent, Uzbekistan, in December. Eighteen scientists from CAC, as well as representatives from Vavilov Institute of Research, St. Petersburg (VIR), ICARDA, and CGIAR's Program Facilitation Unit (PFU), identified activities to collect, evaluate, conserve, and document genetic resources of field crops in the CAC countries.

Human resource development in CAC received greater emphasis during the year. Seven short training courses (two at ICARDA headquarters and five in CAC) were organized. Through these, 63 researchers were trained. In addition, long-term training in English-language skills was provided to 22 scientists, and eight study visits were arranged for 17 CAC scientists. Thirty-two CAC scientists took part in regional and international conferences and meetings. In addition, two traveling workshops were organized mainly for farmers: one focused on conducting on-farm cereals trials and demonstrations for the cereal farmers in Uzbekistan, and the other on ICARDA/West Asia's collaborative work in livestock/feed production for livestock farmers of Central Asia in Jordan, Syria, and Turkey.

CGIAR Collaborative Research Program for CAC

The CGIAR Collaborative Research Program for CAC is facilitated by a Program Facilitation Unit (PFU), which is hosted by CACRP of ICARDA Regional Office in Tashkent. The Program's collaborative activities, which are supported by nine CG Centers (CIMMYT, CIP, ICARDA, ICRISAT, IFPRI, ILRI, IPGRI, ISNAR, and IWMI), were further strengthened during the year and support was provided by the CACRP Office. The Program organized two meetings during the year: the third Steering Committee Meeting in Ashgabat, Turkmenistan, in May–June, and a breakfast meeting during the International Centers Week in Washington, DC, in October.

Latin America Regional Program

The Latin America Regional Program (LARP) activities are coordinated by a Regional Coordinator posted at the Centro Internacional de la Papa (CIP) in Lima, Peru. LARP has initiated collaborative projects in natural resource management, and barley and food legume improvement, particularly for the dry areas of Peru and Bolivia. The barley improvement program for favorable areas continued its activities from CIMMYT, where an ICARDA breeder is posted.

Operational small projects managed through LARP are the "Food Security and Increased Income for Small Ruminant Producers in Northern Peru through the Multiple Use of the Dry Forest," sponsored by the Secretariat for Technical Cooperation of the Ministry of Agriculture of Peru, with the CGIAR from March 2000 to February 2001, and "An Economic Study of Agricultural Crop Potential and Post-harvest Issues of Food Legumes in Traditional Andean Agricultural Systems," sponsored by the Cusichaca Trust, from August 2000 to July 2001.

LARP's Regional Coordinator presented a paper entitled "Import Substitution of Food Legumes and Improvement of Faba Bean, Lentils and Chickpea" at the "Third International Encounter of Food Legumes: Trends in Production and International Markets," organized by the Peruvian Food Legume Institute in November 2000.

Inter-Regional Cooperation

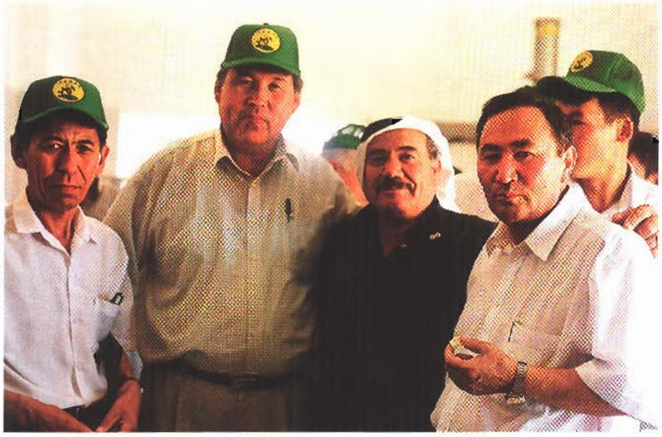
Biotechnological research in WANA is supported in seven Arab countries through direct funding of joint projects by AFESD, and through training courses and individual training at ICARDA headquarters. The projects are: "Double Haploid Production in Wheat and Barley" in Sudan, Morocco and Iraq, the "Application of DNA Molecular Marker Techniques" in Syria, Jordan, Tunisia, Algeria, Morocco and Iraq, and the "Development of a Transformation System in Lentils" in Egypt. Project scientists are trained at ICARDA headquarters through individual training or group training courses, or in-country training courses. During 2000, a regional training course was conducted on "Double Haploid Production, Cytogenetics, and Genetic Transformation" at the Agricultural Genetic Research Institute (AGERI) in Cairo, Egypt, and a workshop on "Developing and Harmonizing Biosafety Regulations for Countries in WANA" was held at ICARDA, Aleppo. The latter was jointly organized by ICARDA, AGERI, FAO, USDA, and the Syrian Atomic Energy Commission, and financial support came from AFESD, USDA, FAO, and GTZ. UNEP/GEF and USDA–Aphis representatives participated in support of the project.

Trainees from Algeria, Egypt, Iraq, Jordan, Lebanon, Morocco, Palestine, Syria, Tunisia, Turkey, and Sudan came to ICARDA headquarters to be trained in DNA marker applications or double haploid production; they also reported on the current state of biotechnology and biosafety in their respective countries. The Biotechnology Steering Committee that monitors the progress of project activities was held in September at AGERI in Cairo, Egypt. The project also assists with the purchase and procurement of equipment and chemicals.

Cooperation was strengthened between NVRSRP and WARP. Twenty-two students from Ethiopia are undergoing degree training related to their MSc and PhD studies at the University of Jordan. One researcher from MRMP visited Iraq and Jordan and benefited from the experiences of the national programs on by-product feed-block production and use for livestock feed.

Links with WARP, NVRSRP, and MRMP in Egypt were strengthened through study tours to Jordan and Iraq and visits to explore degree training opportunities. In the context of the technical and scientific backstopping provided by ICARDA to IFAD-funded projects in WANA, a high-level delegation from Sudan visited ICARDA headquarters and Jordan in November as part of a visit to learn more about ICARDA's research projects and modern irrigation systems used in Jordan. The delegation also visited different institutions of the Jordanian NARS.

WARP and CAC strengthened their links through a regional traveling workshop organized in Jordan and Syria in July for a group of seven farmers and four scientists from Uzbekistan,



Visitors from Central Asia with a Jordanian farmer at a milk processing cooperative facility in Jordan.

Turkmenistan, Kyrgyzstan and Kazakstan, who are involved in the project on "Feed/Livestock Integration in Central Asia." The participants visited activities conducted by the M&M Project in Jordan as well as NGOs and cooperatives involved in livestock and milk production and transformation systems. They also met officials at the Ministry of Agriculture in Jordan, the National Center for Agricultural Research and Technology Transfer (NCARTT), and the Jordan Cooperative Corporation.

Links with WARP and NARP were further strengthened through the various M&M Project activities. These included field visits for a group of Jordanian farmers, researchers, and extensionists to Morocco to familiarize themselves with the Moroccan experience in the rehabilitation and development of rangelands and improvement of livestock.

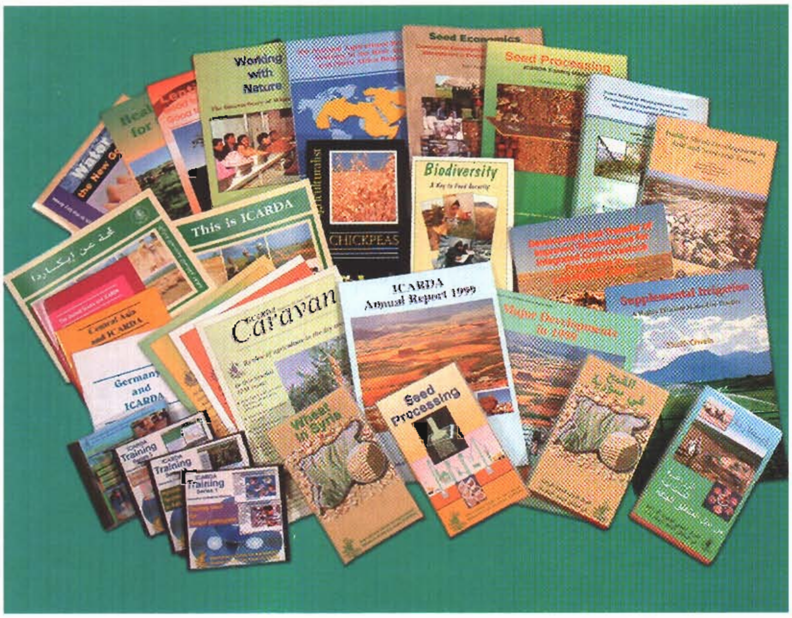
Research Support Services

Communication, Documentation and Information Services

The Communication, Documentation and Information Services (CODIS) Unit acts as a two-way bridge between ICARDA and the outside world, and seeks to provide information tailored to meet the needs of the diverse audiences of the Center.

CODIS placed a major emphasis during the year on enriching the web site of ICARDA (www.icarda.cgiar.org) with new information. Also, the web site was redesigned to improve its appearance and to make it more user-friendly. In addition to the information about the research strategy, facilities, program at headquarters and with NARS and major achievements of the Center, ICARDA's web site now provides links to several major databases. These include the United Nations Food and Agricultural Organization's (FAO) AGRIS and CARIS, USDA/NAL AGRICOLA, CAB International, CRIS/USDA for Current Research Projects and CGIAR'S SINGER. This initiative allows NARS partners to access millions of records free of charge via ICARDA's web site. The Virtual Library (CD-ROMs) on the ICARDA Intranet received over 200 hits per month, reflecting its increasing usefulness to the headquarters-based scientists. The Library acquired about 850 new books and 1,300 journals and annual reports during the year. It also provided Selective Dissemination of Information (SDI), literature search and document photocopy services to both ICARDA and NARS scientists and trainees.

Promotion of ICARDA's work in the media received increased attention. Linkages with Future Harvest were strengthened. Within the framework of this cooperation, and in collaboration with the Story Development Initiative (SDI) of the CGIAR, a news story on ICARDA's research on developing low-neurotoxin varieties of grasspea, safe for human consumption, was offered to the international media through the web site of Future Harvest. The story received extensive coverage in both regional and international media (see also page 4). A daily newspaper in Switzerland published a feature story on ICARDA for the first time, and a large number of other ICARDA stories appeared in English and Arabic in national, regional and international newspapers and magazines.



ICARDA produces a variety of information material, using both print and electronic media, to meet the needs of its diverse audiences.

Two training courses, one on information management and the other on science writing, were offered to NARS colleagues. Three multimedia CD-ROMs were developed for training in research, in collaboration with the training experts at ICARDA.

Participation in AGRIMEX 2000 Fair in Aleppo, the Agritex 2000 exhibition and the Tenth Agricultural Book Fair in Damascus, Syria, as well as the Sixth International Exhibition for

Agricultural Technology, Farming and Irrigation (AGRITECH) in Beirut, Lebanon helped raise ICARDA's profile.

Training

During 2000, ICARDA provided training to a total of 616 national scientists from 51 countries in Africa, Asia and Europe, as well as the CWANA region. In addition, 71 national scientists were involved in graduate research training for M.Sc. and Ph.D. degrees, hosted jointly between ICARDA and universities in their home countries.

The Human Resources Development Unit (HRDU), of which Training is a component, facilitated and coordinated a range of different training activities for several externally funded projects, including those funded by UNDP/GEF and IFAD.

Based on a request from the Egyptian Ministry of Agriculture and Land Reclamation, 23 senior scientists and extension specialists, funded by IFAD-APIP (Agricultural Production Intensification Project), were trained on "Agriculture Extension and Technology Transfer." Eight scientists from the same project participated in a second course on "Scientific Writing and Data Presentation." Three other regional training courses were organized with different collaborating institutes in Egypt. For example, "*In-Vitro* Biology/Transformation Technology" was jointly organized with the Agricultural Genetic Engineering Research Institute (AGERI) in Cairo, and the University of Paris.

ICARDA and the University of Birmingham, UK, collaborated to organize an international course on "Conservation and Utilization of Plant Genetic Resources." Another important training course on "Feeding Formulation Techniques and Purchasing Planning Methods," fully funded by the American Soybean Association and Brill Corporation in USA, was organized in Syria for the private sector representatives. Three important regional/international training courses were organized jointly with CIHEAM-IAM.Bari (Italy).

A self-financed "Study Tour to Tunisia" was organized in collaboration with the North Africa Regional Program for 20 senior participants from the Ismailia Agricultural Cooperative for Production and Marketing of Vegetables and Fruits. A second "Study Tour to Egypt" was organized in collaboration with NVRSRP in Cairo for eight progressive farmers from the White Nile Agricultural Services Project in Sudan. The tour was sponsored by the ICARDA/IFAD Project and was implemented in partnership with the Egyptian International Center for Agriculture in Cairo.

Collaboration in Human Resources Development was further extended, not only with NARS, but also with several sister regional and international agricultural research and training institutes.

Computer and Biometric Services

ICARDA's computer systems benefited from several updates, including migration to MS Exchange and conversion of files to ASCII format. A new corporate anti-virus system proved useful in minimizing damage as a result of the infamous "I Love You" virus, which affected networks all over the world. New equipment at the ICARDA Computer Center, including a scanner and CD-writer, was offered to ICARDA scientists on a "help yourself" basis, which proved highly popular. Database administration and development was conducted, including a new Access system for managing seed information.

Biometric services included offering consultancy on experimental designs, and assistance to scientists on data management and statistical analysis. A total of three biometric reports and six journal articles were published jointly with scientists in different programs. A training program on statistical analysis of data involved 15 NARS scientists. ICARDA staff were trained on a variety of IT topics.

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 (Table 18). These sites represent a variety of agro-climatic conditions, typical of those found in the WANA region.

Table 18. 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	260.7	334.2 (22 seasons)
Bouider	35.41° N	37.10° E	268	6	201.6	NA
Breda	35.56° N	37.10° E	300	95	230.1	266.4 (21 seasons)
Maragha	35.33° N	37.40° E	370	10	166.8	NA
LEBANON						
Terbol	33.49° N	35.59° E	890	23	339.1	514.5 (20 seasons)
Kfardane	34.01° N	36.03° E	1080	11	335.9	393.9 (6 seasons)

* For the 1999/2000 season

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.

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. Some of the titles published in 1999 but not captured for reporting in the Center's Annual Report for that year are also included. A complete list of publications, including book chapters and papers published in conference proceedings, is published separately and is available on request from ICARDA. The list is also available on ICARDA's web site: www.icarda.cgiar.org.

Journal Articles

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Appendix 2

Graduate Theses Produced with ICARDA's Assistance

Master of Science

2000

University of Jordan

Ghaida Tawfiq Jbara. Ecology and screening for resistance of faba bean necrotic yellows virus in some leguminous crops. 112 pp.

University of Aleppo

Fatih Mahmoud Khatib. Head sterility (Ubu-Ulaiwi) and its relation to seed gall nematodes (*Anguina* sp.) in barley (*Hordeum* spp.) in northern Syria. 72 pp. (In Arabic, English summary).

Mohamed Hassan Rahmoun. Socioeconomic analysis of natural resources exploitation and changes in zone 2 in Homs and Hama provinces. 152 pp. (In Arabic, English summary).

Doctor of Philosophy

1999

University of Reading

Malika Abdelali-Martini. An analysis of female wage labour in northwest Syria in the context of agricultural intensification. 445 pp.

2000

University of Baghdad

Ahmed Adnan Ahmed Al-Falahi. Status and behavior of boron in Iraqi saline soils. 138 pp. (In Arabic, English summary).

University of Aleppo

Siham Asaad. Inheritance of resistance in barley to stripe disease *Pyrenophora graminea* and environmental effect on seed infection and symptoms expression. 195 pp.

University of Cukurova

Yehia El Saleh. Research on lentil and chickpea harvest mechanization in Syria and Turkey. 193 pp. (In Turkish, English summary).

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Appendix 3

Agreements signed in 2000

Agreements of co-operation with international and regional organizations in 2000

International Institute for Aerospace Survey and Earth Sciences (ITC), The Netherlands

10 May 2000. Agreement between ICARDA and the International Institute for Aerospace Survey and Earth Sciences (ITC).

Biosaline Agriculture Center (BAC)

5 April 2000. Memorandum of Understanding between the Biosaline Agriculture Center (BAC) and ICARDA.

Agreements of cooperation with national governments and institutions in 2000

BOLIVIA

4 February 2000. Cooperation Agreement between the Ministry of Agriculture, Livestock and Rural Development of the Republic of Bolivia (MAGDR) and ICARDA.

IRAN

3 May 2000. Agreement between the Government of the Islamic Republic of Iran, through the Agricultural Research Education and Extension Organization (AREEO), and ICARDA.

KYRGYZSTAN

20 September 2000. Agreement between ICARDA and the Ministry of Agriculture and Water Resources of Kyrghyzstan and the Kyrgyz Agrarian Academy on cooperation in the field of agricultural science.

PALESTINE

25 April 2000. Agreement for scientific and technical co-operation between the Ministry of Environmental Affairs in Palestine and ICARDA.

PERU

10 May 2000. Agreement between the Technical Secretariat for Coordination with the CGIAR, Ministry of Agriculture, Peru and ICARDA.

RUSSIA

22 February 2000. Agreement between the Federal Scientific Center - N.I. Vavilov All-Russian Institute of Plant Breeding (VIR) and ICARDA.

SUDAN

8 October 2000. Agreement between the National Center for Research (NCR), Sudan and ICARDA.

SYRIA

1 October 2000. Agreement on scientific cooperation between the Atomic Energy Commission of Syria (AECS) and ICARDA.

TURKEY

20 February 2000. Agreement between the Southeastern Anatolia Project, Regional Development Administration (GAP-RDA), Turkey and ICARDA.

Appendix 4

Restricted Projects

ICARDA's research program is implemented through 19 research projects (see pages 5-9), as detailed in the Center's Medium-Term Plan. Restricted projects are those activities that are supported by restricted funding provided separately from the Center's unrestricted core budget. Restricted funding includes donor directed funding (core funds allocated by the donor to specific activities) and project-specific grants. Financial contributions and their respective donors are reported in Appendix 7. These projects contribute to one or the other of the 19 projects in ICARDA's research portfolio. During 2000, the following Restricted Projects were in operation:

AFESD (Arab Fund for Economic and Social Development)

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

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

Sustainable management of natural resources and improvement of major production systems of 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

ACIAR (Australian Centre for International Agricultural Research)

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

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

Pulse transformation technology transfer

Improvement of lentil and grasspea in Bangladesh

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

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

GRDC (Grains Research and Development Corporation)

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

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

Selection of faba bean, chickpea and lentils for resistance to luteoviruses

International collaboration in barley research between ICARDA and Waite Campus Institutions

BELGIUM (Flemish Association for Development Cooperation)

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

CANADA (CGIAR-Canada Linkage Funds)

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

CGIAR System-wide Programs

CGIAR Collaborative Program for Central Asia and the Caucasus

Program Facilitation Unit

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

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

System-wide Initiative on Collective Action and Property Rights (CAPRi)

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

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

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

System-wide Genetic Resources Program (SGRP)

On-station production characterization of small ruminant breeds in WANA: literature review and assessment of characterization needs

Improving the quality and range of data available on ICARDA's plant genetic resources collection (SINGER II)

System-wide 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

System-wide Program on Integrated Pest Management

Inter-Center IPM Adoption Initiative: Pilot sites in Egypt and Morocco

System-wide Water Resources Management Programme (SWIM)

On-farm water use

System-wide Program on Soil Water and Nutrient Management (SWNM)

Optimizing soil water use

CUSICHACA TRUST, U.K.

An economic study of agricultural crop potential and post-harvest issues of food legumes in traditional Andean agricultural systems

DENMARK

Collaborative Research in Eritrean National Seed Development Program (ENSDP)

EC (European Commission)

Nile Valley Regional Program - Egypt Phase II

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

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

Community-level impacts of policy, property rights and technical options in the low rainfall areas of West Asia and North Africa

* Barley germplasm improvement for increased productivity

* Spring bread wheat germplasm improvement for increased yield and yield stability in West Asia and North Africa

* Winter and facultative bread wheat germplasm improvement for increased yield and yield stability in highland West Asia and North Africa

* Food legume germplasm improvement (lentil, kabuli chickpea, faba bean, and pea) for increased systems productivity

* Socioeconomics of natural resource management in dry areas

EGYPT

Matrouh Resource Management Project

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

Water use in agriculture

FAO (Food and Agriculture Organization of the United Nations)

Analytical Review of NARS in West Asia and North Africa

Dryland Pasture, Forage, and Range Newsletter

Expert Consultation Meeting on Integrated production and protection management for protected agriculture in the Arabian Peninsula

Workshop on developing and harmonizing biosafety regulations for countries in West Asia and North Africa

Meeting of the Oat and Vetch Regional Network

FORD FOUNDATION

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

GERMANY

DNA marker-assisted breeding and genetic engineering of ICARDA mandated crops

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

Raising efficiency and efficacy of seed production and marketing systems in the WANA region

Action research for sustainable ground water use in Syria

Workshop on developing and harmonizing biosafety regulations for countries in West Asia and North Africa

IDRC (International Development Research Centre)

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, Syria and Tunisia

Improving natural resources management and food security for rural households in the mountains of Yemen

Dryland Pasture, Forage, and Range Newsletter

IFAD (International Fund for Agricultural Development)

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

West Asia and North Africa dryland durum wheat improvement network

Sustainable management of natural resources and improvement of major production systems of the Arabian Peninsula.

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

Integrated feed and livestock production in the steppes of Central Asia

IMPHOS (Institut Mondial du Phosphate)

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

IRAN

ICARDA/Iran - scientific and technical cooperation

ITALY

Collaborative research project in durum grain quality

Visiting Scientist in participatory barley improvement

* 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 added value returns

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

* Improvement of small ruminant production in dry areas

* Water resource conservation and management for agricultural production in dry areas

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 ground water resources

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 of the Arabian Peninsula

PAKISTAN

Cooperation in the Applied Research Component of the Barani Village Development Project

PERU (Secretariat for Technical Cooperation with the CGIAR, Ministry of Agriculture)

Food security and increased income for small ruminant producers in northern Peru through the multiple use of the dry forest

SPAIN

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

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

Exchange of fodder, pasture and range plant germplasm

Stabilization of marginal steppelands in northwest Syria

SWITZERLAND

Sustainable dryland resource management in the arid margins of Syria

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

Renovation of traditional water supply system: sustainable management of ground water resources

Sheep and milk production by smallholders in Syria: module for intensive production systems and added value capitalization

UNITED KINGDOM

* 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

DFID (Department for International Development) Competitive Research Facility

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

UNDP (United Nations Development Programme)

Yemen: Sustainable Environment Management

UNDP/GEF (Global Environment Facility)

Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Syria, and the Palestinian Authority

* Donor-directed funding

UNITED NATIONS UNIVERSITY, Tokyo, Japan

International Workshop on new approaches to water management in Central Asia

UNITED STATES OF AMERICA

USAID (United States Agency for International Development)

Adaptation of barley to drought and temperature stress using molecular markers

Inheritance and mapping of winter hardiness genes in lentil for use in marker-assisted selection

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

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

Simulation of phosphorus dynamics in the soil-plant system

Poverty, agricultural household food systems and nutritional well-being of the child

USAID Agricultural Technology Utilization and Transfer Project (ATUT)

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

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

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

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

Central Asian range and sheep evaluation

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

Workshop on developing and harmonizing biosafety regulations for countries in West Asia and North Africa

WORLD BANK

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

REPUBLIC OF YEMEN

Agriculture Sector Management Support Project (ASMSP), Yemen

Appendix 5

Collaboration in Advanced Research

International Centers and Agencies

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

- Joint workshops, conferences and training
- Exchange of germplasm
- Cooperation in formulation of research programs for UN Convention to Combat Desertification (CCD) Sub-Regional Action Program on Combating Desertification and Drought in Western Asia
- Cooperation in providing technical backstopping and training requested by the National Components of the GEF/UNDP project on "Conservation and sustainable use of dryland agro-biodiversity in Jordan, Lebanon, Palestinian Authority and Syria"

CIAT (Centro Internacional de Agricultura Tropical)

- System-wide Program on Soil Water and Nutrient Management and System-wide Program on Participatory Research and Gender Analysis for Technology Development
- Joint development of CGIAR System-wide Microbial Genetic Resources Database
- Cooperation in joint project on development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants

CIHEAM (International Center for Advanced Mediterranean Agronomic Studies)

- Joint training courses and information exchange
- An analytical review of NARS in WANA
- Study of the tolerance of ICARDA mandate crops to salinity at CIHEAM-Bari

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

- CIMMYT/ICARDA Joint Dryland Wheat Program. CIMMYT has seconded two wheat breeders to ICARDA
- ICARDA has seconded a barley breeder to CIMMYT
- CIMMYT's outreach program in Turkey and ICARDA's Highland Regional Program share facilities in Ankara, Turkey and collaborate in a joint facultative wheat improvement program
- ICARDA and CIMMYT jointly co-ordinate a durum wheat research network encompassing WANA and southern Europe

FAO (Food and Agriculture Organization of the United Nations)

- ICARDA participates in the Inter-Agency Task Forces convened by the FAO-RNE (FAO Regional Office for the Near East)
- ICARDA and FAO are co-sponsors of AARINENA
- ICARDA participates in FAO's AGLINET cooperative library network, AGRIS and CARIS
- An analytical review of NARS in WANA
- Joint planning in areas of feed resources and strategies
- Joint training courses, workshops and exchange of information

IAEA (International Atomic Energy Agency)

- Management of nutrients and water in rainfed arid and semi-arid areas for increasing crop production

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

- Joint kabuli chickpea improvement program
- ICARDA and ICRISAT are co-convenors of the theme Optimizing Soil Water Use within the System-wide Program on Soil Water and Nutrient Management
- Insect pests of grain legumes within the System-wide Program on Integrated Pest Management
- Cooperative Task Force on Wind Erosion in Africa and Western Asia

IFPRI (International Food Policy Research Institute)

- System-wide Program on Property Rights and Collective Action
- Policy and property rights research in WANA: ICARDA hosts two joint ICARDA/IFPRI Research Fellows
- Development of a costing study of ICARDA gene bank operations

IITA (International Institute of Tropical Agriculture)

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

ILRI (International Livestock Research Institute)

- ICARDA is the convening center, in collaboration with ILRI and ICRISAT, for a program on Production and Utilization of Multi-purpose Fodder Shrubs and Trees in

West Asia, North Africa and the Sahel as part of the System-wide Livestock Program on Feed Resources Production and Utilization coordinated by ILRI
- Joint development of CGIAR System-wide Microbial Genetic Resources Database
- Joint project on development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants
- 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

IPGRI (International Plant Genetic Resources Institute)
- ICARDA hosts and services the IPGRI Regional Office for Central and West Asia and North Africa (IPGRI-CWANA)
- System-wide Genetic Resources Program, coordinated by IPGRI, in both plant and animal genetic resources
- Two sub-regional networks on genetic resources (WANANET and CATN/PGR)
- SINGER project coordinated by IPGRI. ICARDA contributes data to the core SINGER database available on the Internet
- 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 Agro-biodiversity in Jordan, Lebanon, Palestinian Authority and Syria

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

ISNAR (International Service for National Agricultural Research)
- Research management for NARS in WANA
- ICARDA and ISNAR are co-sponsors of AARINENA

IWMI (International Water Management Institute)
- ICARDA is the convening center for a project on Efficient Use of Water in Agriculture within the System-wide Water Resources Management Program co-ordinated by IWMI

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

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

AUSTRALIA

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

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

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

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

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

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

NSW Agriculture, Agricultural Research Centre
- Durum wheat improvement
- Selection of legume germplasm for virus disease resistance

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

Victorian Institute for Dryland Agriculture
- Improvement of drought and disease resistance in lentils in Nepal, Pakistan and Australia
- Improvement of lentil and grasspea in Bangladesh
- Improvement of narbon vetch for low rainfall cropping zones in Australia

AUSTRIA

Federal Institute for Agrobiology, Linz

- Safety duplication of ICARDA's legume germplasm collection

BELGIUM

University of Ghent

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

University of Leuven

- Participatory agroecological characterization

CANADA

Canadian Grain Commission, Winnipeg

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

University of Guelph, School of Rural Development and Planning, Ontario

- Role of women in resource management and household livelihood strategies

McGill University, Montreal, Quebec

- Use of brackish water in supplemental irrigation in Syria

University of Manitoba, Winnipeg

- Tan spot disease

University of Saskatchewan, Saskatoon

- Improvement of ascochyta blight resistance and standing ability in lentil
- Information services on lentil
- Evaluation of chickpea germplasm and their wild relatives

Simon Fraser University, British Columbia

- Sunn pest pheromones

DENMARK

Risoe National Laboratory, Plant Biology Biogeochemistry Department

- QTL analyses in barley

FRANCE

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

- Bioeconomic and community modeling studies in WANA

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)

Institut Francais de Recherche Scientifique pour le Développement en Coopération (ORSTOM)

- Co-operation in the establishment of a network on water information

Université de Paris-Sud, Labo Morphogenese Végétale Experimentale

- Production of doubled haploids in bread wheat and barley

GERMANY

University of Bonn

- QTL analysis in barley

University of Frankfurt am Main

- Development and use of DNA molecular markers for indirect selection in chickpea

University of Hannover

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

University of Naples
- Development of transgenic chickpea resistant to ascochyta blight

University of 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 Co-operation Agency (JICA)
- JICA's volunteers program supports research on animal health and animal nutrition

Kyoto University
- Collaboration in molecular characterization of wheat wild relatives

NETHERLANDS

WAU (Wageningen Agricultural University)
- Collaboration on land degradation 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

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

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

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

INIA (Instituto Nacional de Investigacion y Tecnologia Agraria y Alimentaria)
- Barley stress physiology (with University of Barcelona)
- Improvement of drought tolerance and semolina and pasta quality of durum wheat (with University of Cordoba; Jerez de la Frontera; University of Barcelona; Centre UdI-IRTA, Lleida)
- Race identification of *Fusarium oxysporum* f. sp. *ciceri* in chickpea in the Mediterranean region (with University of Cordoba)
- Exchange of Fodder, Pasture and Range Plant Germplasm
- Stabilization of Marginal Steeplands

SWITZERLAND

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

Institut Universitaire d'Études du Dévelopement (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

UNITED KINGDOM

University of Birmingham
- Joint study tour in Lebanon and Syria on eco-geographic survey of vegetation

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

Mcaulay Land Use Research Institute
- Research planning on fat-tail sheep as a trait to be used in strategic feeding systems

University of Reading
- Gender analysis in the agricultural systems of WANA
- Testing woolly-pod vetch in hillside project in Uganda

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

UNITED STATES OF AMERICA

University of California, Riverside
- Biodiversity of wheat wild relatives

University of California, Davis
- GL-CRSP (Global Livestock Collaborative Research Support Program): rangeland production and utilization in Central Asia
- Developing chickpea cultivars with resistance to ascochyta blight
- Study of genetic diversity in natural populations of *Aegilops tauschii*

Colorado State University
- Testing for stripe rust in barley

Cornell University, 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

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

North Carolina State University, Department of Statistical Genetics, Raleigh, North Carolina
- QTL estimation for disease data

Oklahoma State University, Stillwater, Oklahoma
- 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 A&M University, Blacklands Research Center (BRC-TAMU), Temple, Texas
- Development and release of an Almanac Characterization Tool (ACT) for Syria

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

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

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

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

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

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

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

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

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

University of Wisconsin, Land Tenure Center, Madison
- Rangeland production and utilization in Central Asia through the GL-CRSP

Washington State University, USA
- 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

Appendix 6

Research Networks Coordinated by ICARDA, involving WANA countries, regional and international organizations, Australia, Europe, and North America

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
International & Regional Networks				
International Germplasm Testing Network	Disseminates advanced lines, parental lines and segregating populations of barley, durum wheat, bread wheat, lentil, kabuli chickpea, faba bean, vetches and chicklings developed by ICARDA, CIMMYT, ICRISAT and national programs. Feedback from NARS assists in developing adapted germplasm and provides a better understanding of GxE interaction and of the agroecological characteristics of major production areas.	Germplasm Program, ICARDA	52 countries worldwide; CIMMYT; ICRISAT	ICARDA Core funds
SEWANA (Southern Europe and WANA) Durum Wheat Research Network WANADDIN (WANA Dryland Durum Improvement Network)	Cooperation between durum breeders and crop improvement scientists from southern Europe, West Asia and North Africa (SEWANA) in developing techniques and breeding material adapted to the Mediterranean environment and with high grain quality.	Germplasm Program, ICARDA	Algeria, Jordan, Lebanon, Morocco, Tunisia, Turkey, Syria, France, Greece, Italy, Spain, Canada, USA	ICARDA Core funds; France; Italy; IFAD
Soil Fertility Network	To standardize methods and exchange information and results from research on soil fertility, soil management, and fertilizer use.	Natural Resource Management Program, ICARDA	Algeria, Cyprus, Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Pakistan, Syria, Tunisia, Turkey, Yemen	ICARDA IMPHOS
Dryland Pasture and Forage Legume Network	Communication linkages among pasture, forage and livestock scientists in WANA.	Natural Resource Management Program, ICARDA	WANA; Europe; USA; Australia.	ICARDA, CIHEAM, CLIMA, FAO-RNE, IDRC, USAID (CRSP)
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; IPGRI; FAO; ACSAD	IPGRI, ICARDA, FAO

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
WANA Seed Network	Encourages stronger regional seed sector cooperation, exchange of information, consultations, and inter-country seed trade.	ICARDA Seed Unit	Algeria, Morocco, Iraq, Cyprus, Turkey, Jordan, Syria, Egypt, Sudan, Libya, Yemen	ICARDA; Germany (GTZ); Netherlands
Agricultural Information Network for WANA (AINWANA)	Improve national and regional capacities in information management, preservation and dissemination.	Communication, Documentation & Information Services	WANA; CIHEAM; ISNAR	ICARDA

Sub-Regional Networks

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

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
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 races and the pathways of pathogens. Identify prevailing 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 & ICARDA budgets
Management of Wilt and Root Rot Diseases of Cool Season Food Legumes	Identify sources of resistance to wilt and root-rots. Incorporate resistance into germplasm with suitable characteristics. Provide segregating populations to NARS to select under their own conditions. Develop strategy for multiple disease resistance. Identify races in *Fusarium* wilt pathogens. Studies on other components of integrated disease management.	AUA, Ethiopia	Egypt, Ethiopia, Sudan, ICARDA, ICRISAT	Supported by national & ICARDA budgets
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 & ICARDA budgets
Thermotolerance in Wheat and Maintenance of Yield Stability in Hot Environments	Identify physiological and morphological traits for improving wheat adaptation to heat; verify these traits in collaboration with breeders. Identify improved management strategies through a better understanding of development and growth. Describe the physical environment and characterize promising genotypes for development of computer simulations of crop growth.	ARC, Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA, CIMMYT	Supported by national & ICARDA budgets

Title	Objectives/Activities	Coordinator	Countries/ Institutions	Donor Support
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 modelling systems.	ARC, Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA.	Supported by national & ICARDA budgets
Socio-Economic 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 & ICARDA budgets

Appendix 7

Financial Information

(Audited Financial Statements)

Statement of Activity (US$x000)	2000	1999
REVENUES		
Grants (Core and Restricted)	22,894	20,450
Exchange gains/(losses) - net	(348)	(271)
Interest income	464	402
Other income	612	351
Grant write-off	-	(497)
Total revenues	23,622	20,435
EXPENSES		
Research	17,617	16,878
Training	1,985	1,903
Information services	603	635
General administration	3,103	2,476
General operation	715	822
Total expenses	24,023	22,714
Recovery of indirect costs	(672)	(803)
Net expenses	23,351	21,911
EXCESS OF REVENUE OVER EXPENSES	271	(1,476)
ALLOCATED AS FOLLOWS:		
Capital invested in property, physical plant and equipment	215	330
Operating fund	56	(1,806)
Surplus/(Deficit)	271	(1,476)

Statement of Financial Position (US$x000)	2000	1999
ASSETS		
Current assets	19,170	22,607
Property and equipment'	4,357	4,531
Total assets	23,527	27,138
LIABILITIES AND ASSETS		
Current liabilities	9,514	13,437
Long term liabilities	2,718	2,879
Total liabilities	12,232	16,316
Net assets	11,295	10,822

' Reduction is due to adoption of CGIAR accounting policy.

Statement of Grant Revenues, 2000 (US$x000)

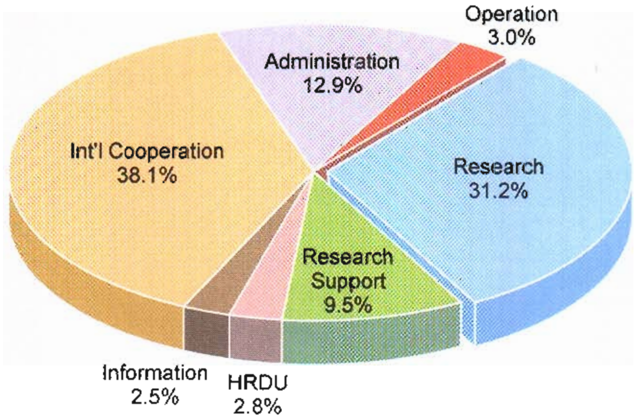
Donor	Amount
Arab Fund	1673
Asian Dev. Bank	250
Australia'	439
Austria'	30
Belgium'	70
Canada'	437
China'	10
CGIAR'	1967
Denmark'	475
Desertification Trust Fund	1920
Economic Research Forum	44
Eritrea	17
Egypt'	1018
Ethiopia	141
European Commission	2209
France'	115
Ford Foundation	84
Germany	438
IMPHOS	18
IBRD (World Bank)'	2460
IDRC	74
IFAD	1319
India'	38
Iran'	1078
Italy'	463
Japan'	705
The Netherlands'	923
Norway'	465
OPEC Fund for Inter. Dev.	27
Pakistan	148
Peru'	15
Spain	104
Sweden'	444
Switzerland	77
Turkey	77
UNEP	3
United Kingdom	860
UNDP	198
Univ. of California-Davis	17
USAID'	1487
USDA	43
Yemen	439
Miscellaneous	92
Total	22894

' Donors that provided core funds.

Appendix 7 (Cont.)

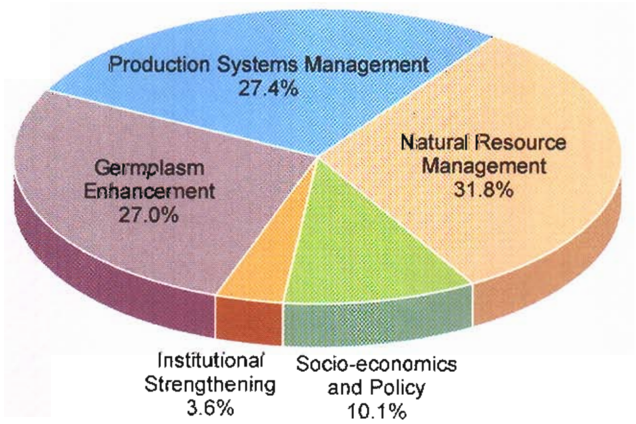
Financial Information

Expenditure by Program and Activities

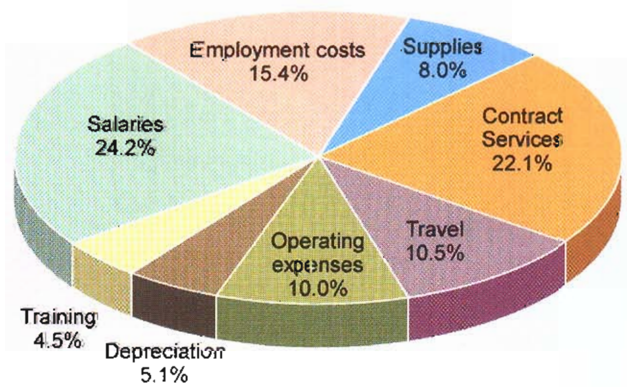


Expenditure by Medium-Term Plan Themes

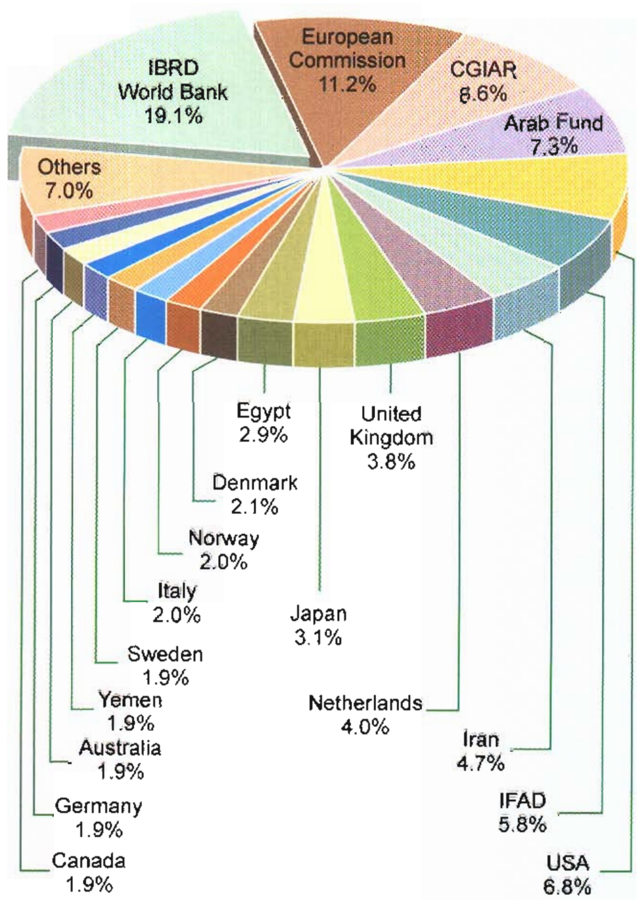
(Total Expenditure US$ 24.023 million)



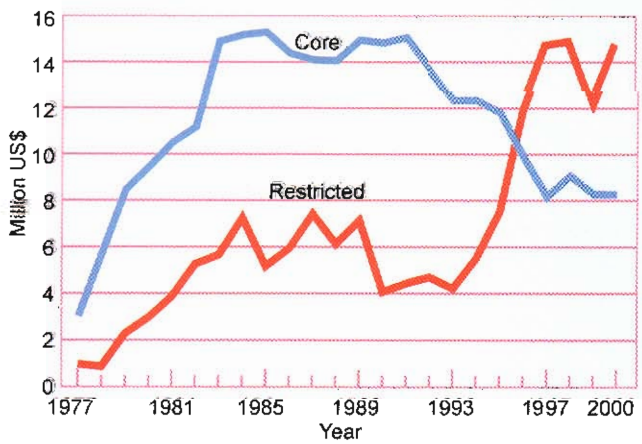
Expenditure by Expense Category



Donors and their Contributions for 2000



Funding Trend



Appendix 8

Board of Trustees

Five new members joind the Board in 2000: Dr Margaret Catley-Carlson, Dr Khalil Kazzaka, Mr Abbas Keshavarz, Dr Seyfu Ketema, and Dr Richard Gareth Wyn-Jones. Dr Peter S.M. Franck-Oberaspach, who joined the Board in 1999, participated in the first full-Board meeting in 2000.

Dr Salman A. El-Sudairy resigned from the Board in April 2000.

Dr Margaret Catley-Carlson

Dr Margaret Catley-Carlson currently chairs the Global Water Partnership, and is an advisor to or Director of many international organizations: International (CABI) Development Research Centre in Ottawa (Vice-Chair); the Overseas Development Council in Washington; and the Centre for Agriculture and Biosciences International (CABI) in the UK (Chair, Board of Governors). She is a Commissioner for the World Bank Commission on Water for the 21st Century and for the International Advisory Committee -2020 Vision, of International Food Policy Research. She is a member of the Canadian Advisory Council to the International Ocean Institute, and the Inter-American Dialogue. She is the immediate past president of the Population Council (1991-99), and past President of CIDA, the Canadian International Development Agency (1983-89). She was earlier Deputy Director (Operations) of UNICEF, with the rank of Assistant Secretary-General of the United Nations; and Deputy Minister, Health and Welfare, Canada. Her international career began in the Department of External Affairs, Canada, with diplomatic posts in Sri Lanka and London.

Dr Catley-Carlson graduated from the University of British Columbia, did postgraduate work at the University of West Indies, Trinidad and Tobago, and holds eight honorary doctoral degrees.

Dr Catley-Carlson brings to the Board of Trustees her broad expertise in promoting human welfare.

Dr Peter S.M. Franck-Oberaspach

Dr Peter S.M. Franck-Oberaspach, from Germany, obtained his Ph.D. in agricultural sciences from the University of Hohenheim.

A CSGA plant breeder since 1988, Dr Franck-Oberaspach is currently the President and Chief Executive Officer (CEO) of the "PZO Pflanzenzucht Oberlimpurg" and CEO of ACS-Seeds Ltd. and PZO Saat GmbH.

From 1983 to 1996 he chaired the GFP, an association for financing research and continues to hold that office in an honorary capacity.

He is currently also Vice-Chair of the Association of Southwest German Plant Breeders (VSWP) and was Vice Chair of the Malting Barley Association from 1981 to 1996.

Dr Franck-Oberaspach brings to the ICARDA Board of Trustees his vast linkages with advanced plant breeding institutions with interest in assisting international agricultural scientific research.

Dr Khalil Khazzaka

Dr Khalil Kazzaka is currently the Director General of the Agricultural Research Institute in Lebanon. He obtained his Ph.D. in agronomy in Montpellier, France. His other specialization is the management of soil database and characterization of agroecological zones. He has contributed to the development of land resources inventory under the aegis of the United Nations Food and Agriculture Organization (FAO), United Nations Development Programme (UNDP) and the Arab Centre for Studies of Arid Zones and Dry Lands (ACSAD).

Dr Kazzaka was the Director of the Tal Amara station of the Institute at Rayak, Lebanon from 1978 to 1992. From 1993 to 1998, he was National Director of FAO-TCP Projects. He served as a hydro-pedologist for "the drainage of South Beka'a" project from 1974 to 1975.

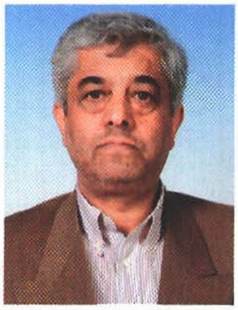
Dr Kazzaka is a member of scientific committees and councils of prestigious international organizations including the International Association of Soil Science, Lebanese Association for the Progress of Science, and the Arab Union of Agricultural Engineers. He also served as editor of the FAO Technical Bulletin and as consultant for the

Cultural and Technical Cooperation Agency for Soil Study in Seychelles in 1981.

He represented the Government of Lebanon in major international and regional meetings between 1967 and 1987, including the FAO seminars in Beirut and Baghdad on land and water use and salinity and waterlogging, respectively, and the establishment of soil database in Canada in 1979.

Dr Kazzaka brings to the Board of Trustees a broad experience in agricultural science from Lebanon and other parts of the world.

Mr Abbas Keshavarz



Mr Abbas Keshavarz obtained his B.Sc. and MSc. in irrigation engineering from Tehran University in Iran. He is currently the Deputy Minister of Agriculture and Head of Agricultural Research, Education & Extension Organization (AREEO), in Iran.

Mr Keshavarz served in AREEO in various capacities, as Specialist for Agricultural Development and Dean of the Iranian Agricultural Engineering Research Institute (IAERI) from 1988 to1989, Deputy of Technical Services from 1989 to1995, and then as Deputy Director General from 1995 to 1997. He also held various government positions. From 1983 to 1985, he was Irrigation Specialist in the Rural Services Deputy Minister's Office and then Director General of Agricultural Planning, Ministry of Agriculture, from 1985 to 1988.

Mr Keshavarz has two registered inventions in Iran, namely, the design and development of a tractor mower-binder and a crankless cutter-bar mower. He has published numerous scientific papers in scholarly publications on subjects ranging from irrigation systems, water use, and application of satellite image to large-scale water use systems.

He is a permanent representative of AREEO in the Iran/ICARDA Technical Cooperative Project, and in the Asian Pacific Association of Agricultural Research Institutions (APAARI).

Mr Keshavarz brings to the Board of Trustees his vast experience in directing national agricultural research and education programs in the field of irrigation and drainage engineering.

Dr Seyfu Ketema

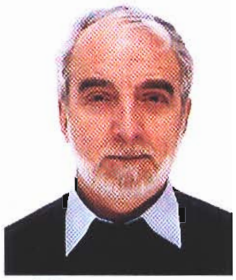
Dr Seyfu Ketema obtained his M.Sc. and Ph.D. in Plant Breeding from the University of London. He is currently the Director General of the Ethiopian Agricultural Research Organization. Earlier, he served as Minister of Agriculture, and as Director of the Institute for Biodiversity Conservation and Research and National Coordinator of the *Tef* Commodity Research Institute of Agricultural Research, in Ethiopia.

He is currently the regional representative of Africa in the CGIAR, the African Regional Coordinator for the Community Biodiversity Development and Conservation Project and a member of the Committee of Directors on Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA).

Dr Ketema served as head of various Ethiopian delegations in international conferences including the Second and Third Extraordinary Session of the Commission on Genetic Resources for Food and Agriculture in Italy and the Conference of the Parties to the Convention on Biological Diversity, Argentina. He also served as a member of a regional working group that established ASARECA under the Framework for Action Initiative of the World Bank.

Dr Ketema brings to the Board of Trustees his broad experience in crop improvement and agricultural research management in WANA.

Dr Richard Gareth Wyn-Jones



Dr Richard Gareth Wyn-Jones is currently Associate Director of the Centre for Arid Zone Studies, University of Wales, Bangor, United Kingdom.

He is an adviser in the International Foundation of Science, Stockholm and a member of the ODA Plant Science Program Advisory Committee.

As Deputy Chief Executive Director of the Countryside Council of Wales and as Director (chief scientist) of Science and Policy Development from 1991 to 1995, Dr Wyn-Jones planned and established the "Tir Cymen" Agri-environmental Pilot Scheme. He also served as Chair of the ODA Plant Sciences Research Program and Manager of the ODA Natural Resources and Environment Division Study Program for Plant Sciences (Crop Physiology and Plant Breeding).

In 1996, Dr Wyn-Jones was a World Bank consultant in the Global Change and Terrestrial Ecology Initiative: Sustainable Rangelands in Southern Africa.

He took his D.Sc. from Oxford University and is a fellow of the Royal Society of Chemistry, the Institute of Biology and the Royal Society for Arts, Manufacturers and Commerce in UK.

Dr Wyn-Jones brings to the Board of Trustees rich experience in stress physiology research and research management from the U.K. and other parts of the world.

Full Board 2000

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Board Meetings, 2000

27 April	Audit Committee Meeting, Dubai, UAE
1-2 May	Program Committee Meeting, Tehran, Iran
2 May	Nomination Committee Meeting, Tehran, Iran
3-4 May	Meeting of the Board of Trustees, Tehran, Iran
29-30 October	Executive Committee Meeting, Washington, DC

Appendix 9

Senior Staff

(As of 31 December 2000)

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 John Dodds, Special Advisor
Dr William Erskine, Acting Assistant Director General-Research
Dr Giro Orita, Honorary Senior Consultant
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Mr Vijay Sridharan, Internal Auditor and Acting Director of Finance
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Mr Ahmed Medhat Abouzeid, Consultant Internal Auditor

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Mr Michel Valat, Director of Administration and Personnel Services

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

Finance

Mr Ahmed El-Shennawy, Finance Officer
Mr Mohamed Samman, Treasury Supervisor
Mr Essam Abd Alla Saleh Abd El-Fattah, Finance Officer (Outreach)

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Dr John Ryan, Soil Fertility Specialist, Acting Leader
Dr Aden Aw-Hassan, Agricultural Economist
Dr Mustapha Bounejmate, Forage and Feed Legumes Production Specialist
Dr Adriana Bruggeman, Agriculture Hydrology Specialist
Dr Nabil Chaherli, Policy Economist (joint IFPRI/ICARDA appointment)
Dr Eddy De Pauw, Agroclimatologist
Dr Luis Iñiguez, Senior Small-Ruminant Scientist
Dr Fawzi Karajeh, Marginal-Water Management Specialist
Dr Hiroaki Nishikawa, Honorary Consultant (Animal Parasitology)
Dr Tidiane Ngaido, Property-Rights Specialist (joint IFPRI/ICARDA appointment)
Dr Theib Oweis, Water Management/Supplemental Irrigation Specialist
Dr Mustafa Pala, Wheat-based Systems Agronomist
Dr Christoph Studer, Plant, Water, and Soil Specialist

Dr Ahmed Mazid, Agricultural Economist

Mr David Celis, Junior Professional Officer
Ms Azusa Fukuki, Research Associate
Ms Shibani Ghosh, Research Fellow
Dr Sota Kobayashi, Associate Expert
Ms Malika Martini Abdelali, Research Associate, Socioeconomics and Gender Analysis
Dr Safouh Rihawi, Research Associate
Dr Tsuyoshi Takahashi, Associate Expert
Ms Rahmouna Khelifi-Touhami, Research Fellow
Ms Josepha Wessels, Associate Expert-Applied Anthropology
Ms Monika Zaklouta, Research Associate

Germplasm Program

Dr Khaled Makkouk, Plant Virologist, Acting Leader
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, 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 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 Amor Yahyaoui, Senior Cereal Pathologist

Dr Imad Mahmoud Eujayl, Post-Doctoral Fellow (Biotechnology)
Dr Bruno Ocampo, International Trials Scientist
Dr Bruno Schill, Post-Doctoral Fellow, Faba Bean Breeder
Dr Khalil Shaaban, Consultant Faba Bean Breeder
Dr M. Sripada Udupa, Biotechnologist

Mr Fadel Al-Afandi, Research Associate
Ms Ismahane El-Ouafi, Research Fellow (seconded from CIMMYT)
Ms Elena Iacono, Research Fellow
Ms Daniela Mongione, Visiting Research Fellow

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

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

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

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Dr Surendra Varma, Head
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)

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Dr Murari Singh, Senior Biometrician and Acting Head
Mr Awad Awad, Database Administrator (Financial Systems)/Senior Analyst
Mr Michael Sarkissian, Maintenance Engineer
Mr Colin Webster, Systems Programmer/Network Administrator

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

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Ms Hana Sharif, Executive Secretary

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Mr Anwar Agha, Executive Manager/Consultant

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Mr Munir Sughayyar, Engineer, Station Operations

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

Nile Valley and Red Sea Regional Program

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Mr Akhtar Ali, Water and Soil Engineer
Ms Bianca van Dorrestein, Visiting Research Fellow
Dr Mohamed Abdul Moneim, Soil Scientist

Dr Abdul Bari Salkini, Agricultural Economist/Liaison Scientist

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Dr Mohamed Habib Halila, Regional Coordinator

Arabian Peninsula Regional Program

Dubai, United Arab Emirates

Dr John Peacock, Regional Coordinator
Dr Ian McCann, Irrigation Management Specialist
Dr Ahmed Tawfik Mustafa, Protected Agriculture Specialist

Highland Regional Program

Ankara, Turkey

Dr Habib Ketata, Acting Regional Coordinator/Winter Wheat Breeder

Tehran, Iran

Dr Muhammed Tahir, Project Coordinator

Central Asia and the Caucasus Regional Program

Tashkent, Uzbekistan

Dr S.P.S. Beniwal, Regional Coordinator, and Head CGIAR Program Facilitation Unit
Dr Mekhlis Suleimenov, Deputy Head of CGIAR Program Facilitation Unit
Dr Zakir Khalikulov, Consultant Scientist
Dr Victor Shevstov, Barley Breeder

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Dr Abelardo Rodríguez, Regional Coordinator

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

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Mr Tarif Kayyali, Legal Advisor (Aleppo)
Dr Hisham Talas, Medical Consultant (Aleppo)

Appendix 10

Acronyms

ACIAR	Australian Center for International Agricultural Research (Australia)
ACSAD	Arab Center for Studies of the Arid Zones and Dry Lands (Syria)
AARINENA	Association of Agricultural Research Institutions in the Near East and North Africa (Egypt)
AFESD	Arab Fund for Economic and Social Development (Kuwait)
AGERI	Agricultural Genetic Engineering Research Institute (Egypt)
ARC	Agriculture Research Center
BAC	Biosaline Agriculture Center (UAE)
CAC	Central Asia and the Caucasus
CEDARE	Centre for Environment and Development for the Arab Region and Europe (Egypt)
CGIAR	Consultative Group on International Agricultural Research (USA)
CIAT	Centro Internacional de Agricultura Tropical (Colombia)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico)
CIP	International Potato Center (Peru)
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (France)
CWANA	Central and West Asia and North Africa
EU	European Union
FAO	Food and Agriculture Organization of the United Nations (Italy)
GTZ	German Agency for Technical Cooperation (Germany)
GFAR	Global Forum on Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
IDRC	International Development Research Centre (Canada)
IFAD	International Fund for Agricultural Development (Italy)
IFPRI	International Food Policy Research Institute (USA)
ILRI	International Livestock Research Institute (Kenya)
INRA	Institut National de la Recherche Agronomique (Morocco)
IPGRI	International Plant Genetic Resources Institute (Italy)
ISNAR	International Service for National Agricultural Research (Netherlands)
IWMI	International Water Management Institute (Sri Lanka)
M&M	Mashreq and Maghreb
NARS	National Agricultural Research Systems
NCARTT	National Center for Agricultural Research and Technology Transfer (Jordan)
NGO	Non-Governmental Organisation
OPEC	Organization of Petroleum Exporting Countries (Austria)
TAC	Technical Advisory Committee of the CGIAR
UNESCO	United Nations Educational, Scientific and Cultural Organization (France)
UNCCD	United Nations Convention to Combat Desertification (Germany)
UNU	United Nations University (Japan)
WANA	West Asia and North Africa

Appendix 11

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The CGIAR Centers

Front Cover

Top: ICARDA's research uses a holistic approach that takes into account the limitations of resources faced by rural communities and the livelihood strategies they adopt within those limitations. Right: *Foul muddamis*, the popular faba bean recipe, rich in protein, being sold on roadside in Sudan. Left, bottom:Women making *tannour* bread in Syria. Left, middle: Poverty is an offense against humanity. But there are solutions. Poverty alleviation in the dry areas is at the heart of ICARDA's research agenda.

Back cover

Top: ICARDA's mandate crops (clock-wise):Barley, lentil, faba bean, wheat, chickpea, vetch, and grasspea. Bottom: Water is the key resource for agriculture in dry areas, but it is getting scarcer at an alarming rate. ICARDA's research focuses on increasing on-farm water-use efficiency to produce more with less water.

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ICARDA-/5000/May 2001