ICARDA
Annual Report 1999




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 West and Central 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. The CGIAR receives support from a wide variety of country and institutional members worldwide. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South-North partnership to reduce poverty and hunger.

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

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

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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; drought resistance; genetic maps; genetic markers; 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; Kyrgyzştan; Latin America; Pakistan; Sudan; Tajikistan; Turkmenistan; Uzbekistan.

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

Foreword

Agricultural systems in the dry areas are dynamic. Global linking of national economies, along with urban market development, is creating new, more intensive and more diverse demands on agricultural producers. Shaping change in the research strategy of an international center in a globalizing world is, therefore, no more an easy task. In 1999, the Fourth External Program and Management Review (EPMR) Panel assessed ICARDA's success in dealing with this task. The Panel, consisting of eight international experts and chaired by Dr Donald Plucknett, examined ICARDA's mandate and mission, research and training programs, and management structure and policies, and found that the "Center had been transformed over the last five years and was now ready to take off into 2000." It highlighted once again the pressing need for the continuation of the agricultural research and capacity building carried out by ICARDA as the center of excellence in the dry areas.

The Panel singled out water as the most important ingredient to consider in the Center's work in crop improvement and natural resource management. In the dry areas of Central and West Asia and North Africa (CWANA), water—not land—is the most limiting factor for agricultural production. ICARDA's research has demonstrated that substantial stable increases over rainfed wheat production are possible through the use of supplemental irrigation (SI). Now optimization studies with farmers have shown that water used for SI conjunctively with rain is far more efficient than when applied alone in full irrigation. The studies show that guidelines for determining irrigation water requirements in areas with limited water resources should not be based on satisfying full crop water requirements, but rather on maximizing water productivity and farmers' return.

The Center continues to make increased use of the Geographic Information Systems (GIS) in enhancing water-use efficiency. A project to study the agroecology of the CWANA region has been started, and a digital Agroecological Atlas of Syria is being developed. ICARDA is also providing technical assistance to Morocco, which plans to produce land suitability maps for planning and policy needs.

Drought is one of the key stresses at the forefront of crop variety improvement, and ICARDA continues to develop improved drought-tolerant barley, wheat, and food and feed legume germplasm in collaboration with its national partners. Studies measuring the impact of ICARDA's germplasm program in developing countries confirm that 54% of the barley varieties released in 23 developing countries from 1980 to 1999 originated from ICARDA crosses. Half of the 52 lentil varieties released in 22 countries were from crosses made by ICARDA, while a further 31% were attributable to ICARDA germplasm.

Activities in Central Asia are now closely woven into the Center's program of work. Several projects are being implemented, including the 'Integrated Feed and Livestock Production in the Steppe of Central Asia,' supported by the International Fund for Agricultural Development (IFAD). This is particularly vital, given the breakdown of the earlier system of livestock production, support services such as veterinary care, and traditional markets in Central Asia and the Caucasus.

On the other hand, the entire CWANA region stands to benefit from the results of the 'Conservation and Sustainable Use of Dryland Agrobiodiversity' project, supported by the Global Environment Facility (GEF) of the United Nations Development Programme, in which

Jordan, Lebanon, Syria and Palestine are participating. ICARDA has taken the lead role in its implementation on two sites in each country where farmer and community participation will conserve landraces and crop wild progenitors *in situ*.

The EPMR Panel gave a vote of confidence to ICARDA for its ability to undertake these and other tasks aimed at reversing the cruel impacts of poverty. Statistics painfully reveal that more than two billion people in the world are malnourished, and in the dry areas nearly 700 million must eke a living out of US$ 2 per day.

At ICARDA we are at the forefront of the battle against the misery that poverty and hunger cause, and we remain steadfast in our determination to provide scientific and technological solutions to alleviate this misery in the dry areas of the world. It was in recognition of ICARDA's capability to meet this challenge that the External Program and Management Review Panel, in its report to the CGIAR, stated that:

"ICARDA is a Center in successful transition and one that is perhaps needed more in CWANA now than when it was founded in 1977."

Prof. Dr Adel El-Beltagy
Director General

Dr Alfred Bronnimann
Chairman
Board of Trustees

Contents

PART ONE

Major Developments in 1999

Contents

Major Developments in 1999

External Program and Management Review

For ICARDA the year 1999 was associated with the most appropriate event to prepare the Center to meet the challenges of 2000: the Fourth External Program and Management Review (EPMR), which began in April and ended in August. The Review Panel examined ICARDA's mandate and mission, research and training programs, and management structure and policies, and found that the "Center had been transformed under its new management over the last five years and was now ready to take off into 2000."

The Review Panel firmly supported ICARDA's increasing thrust on natural resource management. Water problems, particularly in the West Asia and North Africa (WANA) region, which had been identified by international authorities as the most water-scarce region in the world in terms of per capita supplies, were enormous. The Panel believed that water will always be the single most important factor to consider in the Center's work in crop improvement and natural resource management.

ICARDA's move into Central Asia and the Caucasus (CAC), where the problems of crop improvement and natural resource management are similar to those in WANA, was welcomed by the Panel. The Center's model of research collaboration with the National Agricultural Research Systems (NARS) and other partners fitted in well with ICARDA's strategy to decentralize its research to national partners. The Center had in place "a regional structure that allowed a continuum of research from headquarters to NARS, including NARS/NARS relationships," the Panel noted.

In his presentation of the Panel Report to the Board of Trustees, Management and staff of ICARDA, Dr Donald Plucknett, EPMR Chairman, commended the Center for its role in serving the poor people living in the dry areas of the world.

The Panel, led by Dr Donald Plucknett, said in its report that ICARDA should aspire, after a period of dynamic consolidation, to gain new positions in science, including recognition as the lead center for integrated on-farm water management for the dry areas, and to become known as the scientific center of excellence serving as the regional node for a consortium of international efforts.

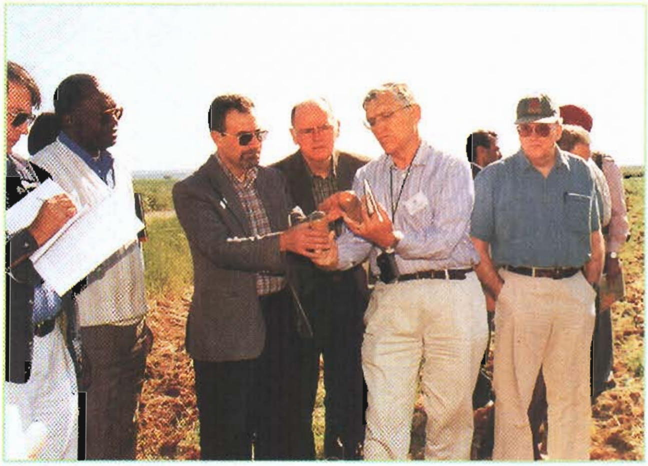
The Review Panel's first visit to ICARDA coincided with the Annual Presentation Day in April 1999, an occasion when the Panel had opportunities to hear the assessment of ICARDA's work from representatives of diplomatic missions, donors, NARS, and others who visited the Center as its distinguished guests on that day. In the company of the guests, the Panel members visited the research trials at the headquarters farm of the Center at Tel Hadya, where they interacted with the Center's researchers.

The EPMR Panel was particularly impressed by the quality of preparations by ICARDA for its visit and by the Center's use of Center-Commissioned External Reviews. Right to left: Dr Donald Plucknett, Panel Chair; Dr Peter Wolff, Panel Member; Dr Donald Marshall, Panel Member; Dr Dunstan Spencer, Panel Member; Dr Louis Paul, Panel Member; Dr Theodore Downing, Panel Member; Dr Mohammed Zehni, Panel Member; Mr Mike Collinson, Panel Secretary.

The Panel had the opportunity to participate in the Program Committee (PC) meeting of ICARDA, held in April. Comprehensive presentations on all key activities by ICARDA researchers during the PC meetings helped the Panel to place the Center's review in the right perspective of its challenges, opportunities, and aspirations.

The Panel members then traveled to ICARDA's regional programs to assess the Center's collaborative activities in the region, and the role of its regional programs.

In its report, the Panel made 12 key recommendations, which ICARDA started implementing with renewed energy and enthusiasm. The Center is employing new ways of working that foster national, regional, and international linkages to address the problems associated with achieving sustainable increases in food production and protection of the natural resource base, with poverty alleviation at the heart of its mission.



EPMR Panel Chair, Dr Donald Plucknett (second from right), accompanied by Panel members and ICARDA's Presentation Day guests, visited the Center's farm, where ICARDA scientists briefed the group on research in progress.

Changing Faces

Two key announcements marked the 1999 Presentation Day: (i) completion of the term of Board Chairman Dr Alfred Bronnimann at the end of the annual Board meeting in August, and the appointment of Mr Robert Havener to succeed him, and (ii) renewal of the appointment of Prof. Dr Adel El-Beltagy for a second term of five years as Director General of ICARDA. The Center organized a special evening at the end of the August 1999 meeting of the Board to honor the outstanding services of Dr Bronnimann, and to welcome Mr Havener as the new Chairman of its Board of Trustees.

The new Chairman of ICARDA's Board of Trustees, Mr Robert Havener (right), paid tribute to the wisdom, courage, dedication, and devotion to duty of his predecessor Dr Alfred Bronnimann at a special presentation evening in Aleppo. He presented Dr Bronnimann with an engraved silver plate on behalf of the Board and staff of ICARDA to recognize his services. ICARDA Director General Prof. Dr Adel El-Beltagy (center) also expressed his thanks and good wishes during the special event.

Mr Havener was a member of ICARDA's first Board of Trustees (1976-1978); and Co-Project Development Officer for ICARDA (1975-1978) through the Arid Land Agriculture Development (ALAD) Program of the Ford Foundation. Before rejoining the ICARDA Board of Trustees in 1998, he had been the Director General of CIMMYT (1978-1985), and interim Director General of CIAT and IRRI.

GEF Agrobiodiversity Project

With financial support from the Global Environment Facility (GEF) of the United Nations Development Programme (UNDP), ICARDA played the lead role in the development and implementation of a "Conservation and Sustainable Use of Dryland Agrobiodiversity" Project in which Jordan, Lebanon, Syria, and the Palestine Authority are participating. The Project, which is built around farmer and community participation to conserve landraces and crop wild progenitors *in situ*, recognizes that the Central and West Asia and North Africa (CWANA) region is a major world center for the biological diversity of major food crops.

Following an inaugural meeting of the Project stakeholders at ICARDA in May 1999, the first Regional Technical Planning and Steering Committee meetings of the GEF Project were held in Amman, 13-16 July, to discuss national and regional work plans and to develop and standardize the methodologies needed to implement the project activities.

The GEF Agrobiodiversity Project aims to preserve agrobiodiversity relating to wild and cultivated species of globally or regionally important crops and fruit trees (barley, wheat, lentils, vetch, almonds, and others) through the active participation of all stakeholders involved. ICARDA is the executing agency of the Project's regional component and provides technical backstopping and international consultancy, in close collaboration with IPGRI and ACSAD.

Program Implementation in Central Asia

The year saw considerable progress in strengthening ICARDA's collaboration with the Central Asian republics. Several projects are at different stages of implementaion. Among them is a project on "Integrated Feed and Livestock Production in the Steppe of Central Asia," supported by the International Fund for Agricultural Development (IFAD). For details, please see pages 14 and 23.

Focal Point for Regional and International Meetings

ICARDA was the lead organizer of a number of important international and regional conferences.

A workshop on "Farmer Participatory Research (FPR)" was held at ICARDA headquarters in May. It was co-sponsored by the Islamic Development Bank, the Food and Agricultural Organization of the United Nations (FAO), the System-wide Program on Participatory Research and Gender Analysis (SWP-PRGA) and ICARDA. The objectives of the workshop were to generate interest in FPR and promote its use as a new research strategy. The farmers were also invited to carry out selections in trials planted at ICARDA's farm and to participate in discussions with the scientists attending the workshop. Thirty-four scientists from 16 countries, as well as representatives from donor organizations and from CIAT and IPGRI, participated in the workshop.

Participants in the workshop on "Farmer Participatory Research" interacted with farmers in their fields in Syria.

In August, ICARDA helped organize the "Sixth International Conference on the Development of Dry Lands" in Cairo. Held under the auspices of the International Dry Lands Development Commission, and hosted by the Egyptian Government under the patronage of H.E. Dr Youssuf Wally, Deputy Prime

Opening session of the International Conference on the Development of Dry Lands, held in Cairo. From left to right: H.E. Dr Abou-Zeid, Minister of Public Works and Water Resources, Egypt, and Chairman of the World Water Council; H.E. Prof. Dr Youssuf Wally, Deputy Prime Minister and Minister of Agriculture and Land Reclamation, Egypt; Dr Ismail Serageldin, CGIAR Chairman; Prof. Dr Adel El-Beltagy, Director General of ICARDA and Chairman of IDDC; and Prof. Dr Idris Traylor, Vice-Chairman, IDDC.

Minister and Minister of Agriculture and Land Reclamation of Egypt, the workshop brought together 300 scientists from 32 countries. The participants developed strategies for jointly meeting the challenges of desertification beyond 2000.

In December, more than 140 delegates from 28 countries, as well as participants from eight regional and international organizations, attended the "Water Resources Management, Policy and Use in Dry Areas" conference in Amman, Jordan, at which ICARDA scientists presented a number of keynote papers, and played a lead role in organizing the event. The conference was inaugurated by His Royal Highness Prince Faisal Bin Al-Hussein, with opening statements from H.E. Mr Hashem Al-Shboul, Minister of Agriculture, Jordan, and Prof. Dr Adel El-Beltagy, Director General of ICARDA.

His Royal Highness Prince Faisal Bin Al-Hussein, the Prince Regent of Jordan (second from right), represented His Majesty King Abdullah II at the opening of the Amman Water Conference. Also listening to the opening speech by ICARDA Director General Prof. Dr Adel El-Beltagy (left) are the Minister of Water and Irrigation, Dr Kamel Mahadeen (second from left), the Head of the Royal Court, Mr Abdulkarim El Kabariti (third from right), and the Minister of Agriculture, Mr Hashem Al-Shboul (right).

Communication Infrastructure Strengthened

Links with the external world were strengthened when ICARDA obtained direct access to the Internet in August, and also joined the CGIAR IVDN (integrated voice and data network) system. The Internet connection allows ICARDA scientists access to the research resources available via the World Wide Web, and the Center is now able to upload new material directly to its web site.

By joining the IVDN system, ICARDA now has direct dial telephone access to and from the CGIAR Centers.

Closer Ties

Among the many distinguished visitors to ICARDA during 1999 were Ministers of Agriculture, Ambassadors and government officials from Iran, Jordan, the Netherlands, the Palestinian Authority, and Syria. Members of the diplomatic corps in Syria also attended the Annual Presentation Day in April.

Director General Prof. Dr Adel El-Beltagy met with the Prime Minister of Lebanon, H.E. Dr Salim El-Hoss, and the Lebanese Minister of Agriculture, H.E. Dr Suleiman Franjieh, in Beirut in July. While visiting Ethiopia in October, he met with the Minister of Agriculture, H.E. Dr Mengistue Huluka.

Director General Prof. Dr Adel El-Beltagy discussed ways of developing agriculture in Lebanon with H.E. Dr Salim El-Hoss (right), Prime Minister of Lebanon and Minister of Foreign Affairs, and Dr Mouin Hamze (left), Lebanon's representative on ICARDA's Board of Trustees.

Research and Training Highlights

Agroecological Characterization

CWANA Agroecology Project

A project to study the agroecology of the CWANA region was started. The existing spatial datasets for the region were compiled or adapted in the form of an ArcView GIS project, which currently includes the themes of agroclimatic zones, land cover, altitude, slopes, soils and derived soil properties, and weather stations. All these datasets have been either generated from, or built upon, existing public-domain information. The land cover layer was developed from the four arc-minute *Advanced Very High Resolution Radiometer Normalized Difference Vegetation Index* (AVHRR NDVI) data using a novel methodology.

As part of this project, a small dataset consisting of average climatic data for 1200 stations distributed throughout the CWANA region has been extracted from ICARDA's meteorological database (METDB). Potential evapotranspiration data, which were not available for Central Asia, have been generated for 350 stations on the basis of statistical relationships established for different agroclimatic regions. This mini-database has been converted into an Excel spreadsheet, which allows users to select a station and view charts for climate, heat unit, water balance, and growing-period summaries.

New Land-Use Map of Syria

The draft land-use map of Syria, produced in 1998, was substantially revised. Whereas the draft map had 25 pure land-use/land-cover categories, the new version has 25 homogeneous and 36 mixed legend units. This map, to be published in 2000, will be useful in farming systems research, hydrological modeling, land-use planning, and environmental monitoring in Syria.

Land Suitability Maps of Syria

Based on the characterization of physical environment of Syria, undertaken in 1998, an assessment of land suitability was undertaken for different crops at country level. The following compilations were made: derived soil property layers (AWC, depth, drainage, rockiness, salinity, stoniness, structure, texture); crop calendars, and climatic and soil suitability requirements for 18 crops; and land suitability maps for barley and wheat.

All these and previously completed layers will be part of a digital Agroecological Atlas of Syria. A sample output of the Atlas is shown in Fig. 1.

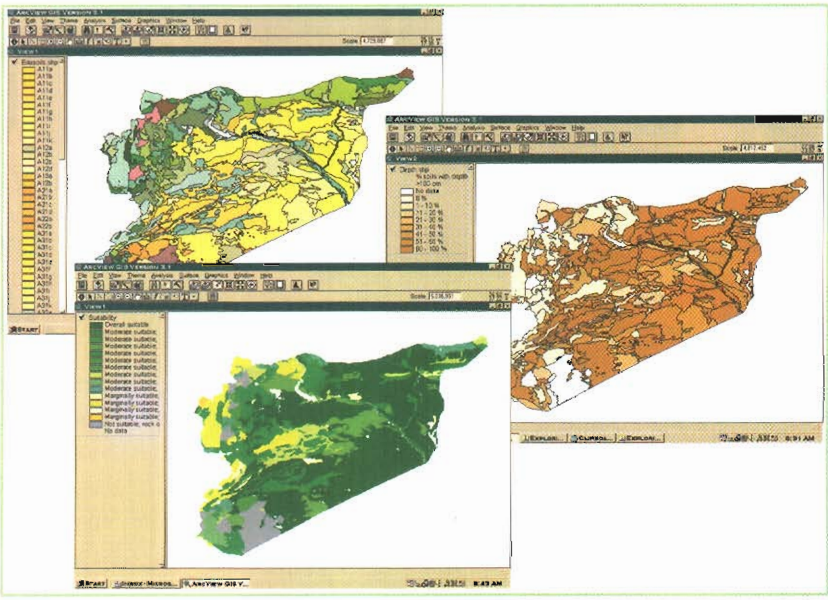


Fig.1. Syria: From soil inventory to soil suitability.

Land Suitability Maps of Morocco

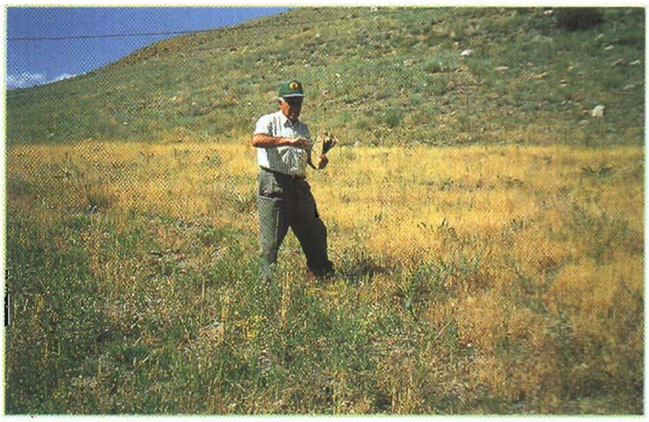
The Institut National de la Recherche Agronomique (INRA), in Morocco, has embarked upon a major project on country-level land suitability assessment. The main goal is to produce land suitability maps for planning and policy formulation at national and provincial levels. ICARDA provides technical assistance.

Outputs of the project include a software to produce Length-of-Growing-Period maps, a suite of programs for spatial quality control of climatic data, an Atlas and a CD-set of cereal yield potential in central Morocco, and a report on production potential of cereals in drought years.

Germplasm Conservation

Collection Mission in Armenia

As part of a project supported by the Australian Center for International Agricultural Research (ACIAR), ICARDA carried out a joint collection mission in Armenia in July 1999. The mission team included researchers from CLIMA, ICARDA, N. I. Vavilov All-Russian Scientific Research Institute of Plant Genetic Resources (VIR), and the Armenian Agricultural Institute (AAI). In all, 235 accessions were collected from 57 sites. The high incidence and diversity of *Aegilops tauschii*, the D-genome donor of bread wheat (29 accessions), was of particular interest. Several *Ae. tauschii* populations were sampled as single plants for a study of the species genetic diversity and bread wheat evolution. *Ae. cylindrica,* another D-genome wheat wild relative, and *Ae. triuncialis* were also frequently encountered with 26 and 25 accessions, respectively, collected. A high diversity of forms was found in bread wheat landraces (34 accessions) and in *Triticum aestivum* subsp. *compactum* (11 accessions) occurring as an admixture in bread wheat fields.



Professor P. Gandilyan of the Armenian Agricultural Institute, collecting wheat wild relatives in Central Armenia, as a team member of ICARDA's joint collection mission.

A variety of weedy races of rye, *Secale cereale,* was present in bread wheat fields, but farmers do not clean the fields and use the mixture of wheat and rye grain for bread making. Cultivated emmer wheat, *T. turgidum* subsp. *dicoccum* is still grown as a crop in high elevations and is valued for local dishes. As most fields were green during the time of the mission, only two accessions could be collected. Wild einkorn, *T. monococcum* subsp. *boeoticum* was the most common wild species (11 accessions). The mission team also visited Erebuni site near Yerevan, which was identified by N. I. Vavilov as a nature reserve for its richness in cereal wild relatives. Unfortunately, overgrazing has degraded the site, and action is needed to save the remaining populations. In forage legumes, there is still a diversity of species growing in the wild or as weeds in the field. Thirteen *Vicia* spp. and seven *Lathyrus* spp., with a total of 41 and 16 accessions, respectively, were collected.

Database of Germplasm from Arid Zones of Tunisia

The Institut des Régions Arides (IRA), Medenine, Tunisia has assembled an impressive collection of plants from arid zones of the country. A living collection of shrubs, pasture species, medicinal and aromatic plants in the Institute's fields and seed conservation facilities are also available. In 1999, as part of a cooperative program between IRA and ICARDA, a database for this valuable collection was developed in Visual FoxPro 5.0. ICARDA-developed software for handling genetic resources database was successfully used. In addition to descriptive information about the species and their distribution, the database also contains photographs of plants and/or their distinctive parts.

Germplasm Enhancement

Participatory Barley Breeding in Eritrea

Barley is one of the most important crops in Eritrea. It is grown in the central highland zone on about 40,000 hectares with an average yield of about 500 kg/ha, and represents 20% of the total agricultural production.

In 1999, ICARDA started a farmer-participatory barley improvement project in Eritrea. After consultation with farmers, three villages were identified, one in the south of the country near Senafe; a second, northeast of Asmara, near Embaderho; and a third, close to the Halhale Research Station, in Tera-emni.

In each village, 100 pure lines derived from the local landraces collected in November 1997, and 37 populations representing the landraces of the 37 collection sites visited during 1997, were introduced.

The pure lines were divided into two trials of 50 lines each, and a local check (from seed purchased from the farmer). Repeated five times, the trials were hosted by two farmers in each village. The bulks were evaluated in a different trial together with three improved cultivars, namely, 'Beka,' 'Halker' and 'HB-32.' Thus, in each village, 137 different types of barley were evaluated.

Close to crop maturity, the host farmer and a group of 9 to 12 neighbors, scored each individual plot either alone or assisted by a researcher.

There was a large variation in yield between the different locations: the highest total biomass (about 7 t/ha) was obtained at the Research Station and in Embaderho, while the lowest (about 3.5 t/ha) was obtained in Tera-emni. Grain yield varied from about 1 t/ha (Tera-emni) to nearly 3 t/ha (Embaderho). The yield advantage of the best entries over the local check ranged from 60% in Senafe to 100% in Embaderho for total biomass, and from 30% in Senafe to 100% in Embaderho for grain yield.

There were also large genotype x environment interactions with different lines and bulks being the highest yielding in different locations. In particular, data suggested that the Halhale Research Station was not a good selection site for the target environments. In the case of the grain yield, the 10 best lines on station included only one of those in Tera-emni and none in the other locations. Interestingly, the 10 lines with the lowest grain yield at the Research Station included four of the highest yielding lines in Embaderho, and two of the highest yielding lines in Senafe. Similarly, in the case of total biomass yield, the 10 best lines at the Research Station included only one of the 10 best lines in Tera-emni and none of the 10 best lines in Embaderho, and two of the 10 best lines in Senafe. The 10 lines with the lowest biomass yield at the Research Station included three of the highest yielding lines in Senafe and one each of the highest yielding lines in Tera-emni and Embaderho.

Farmers considered grain-filling as one of the major selection criteria (entries with markedly different phenology were given an equally good score because they showed good grain-filling), followed by spike length and, in some cases, plant height. Although diseases (particularly scald and net blotch) were widespread and serious, with the flag leaf left with no green tissue, farmers thought this would not cause a yield reduction.

Farmers score barley lines according to their selection criteria in a participatory barley breeding project of ICARDA in Eritrea.

Multiple Disease Resistance in Barley

In some countries, often three or four fungal diseases—scald, net blotch, powdery mildew, and leaf rust—can appear simultaneously on barley. Seedborne diseases such as barley stripe, loose smut, and covered smut are also common in some countries.

In 1998/99, of the 954 fixed barley genotypes in the advanced breeding nurseries tested for resistance to combinations of foliar and seedborne diseases, 58 showed a good level of resistance to most diseases. Over 6% of all the barley lines screened showed resistance to all the seven diseases tested, compared with 11% of the lines that showed resistance to only one disease. About 326 lines (34.2%) showed a good level of resistance to three diseases. The highest levels of resistance to three diseases were recorded in PDG 98 (Preliminary Disease Germplasm) and ADG 98 (Advanced Disease Germplasm) nurseries, whereas a high level of resistance to five diseases was recorded in PDG 99. Ten fixed progenies (in ADG 99 nursery) were identified as resistant to seven diseases, and 48 progenies and fixed lines as resistant to five diseases.

Durum Wheat Improvement in the Mediterranean Region

More than 85% of the total world area for durum wheat is located in the Mediterranean region (WANA and South Europe), where durum grain is used for several products, including pasta, *couscous*, *burghul*, and *frike*.

The Dryland Durum Breeding Program, based at ICARDA, is a joint effort with the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT). This program has contributed to the development of durum cultivars resistant to drought, cold, terminal stress, yellow rust, *Septoria tritici*, sawfly, leaf rust, stem rust, Hessian fly, and root rot. More than 80 cultivars have been released in WANA and South Europe as a result of collaborative research with NARS and advanced research institutions (ARIs).

To complement and integrate the efforts of CIMMYT/ICARDA, NARS, and ARIs in research on durum, a SEWANA (South Europe, West Asia, and North Africa) Network has been established. Another network, WANADDIN (WANA Dryland Durum Improvement Network), has also been established for the dry areas with the aim of setting up national durum research teams to make use of their comparative advantages for the benefit of the region.

The main achievement is the development of breeding methodologies for the Mediterranean temperate, continental, and high-altitude areas. The varieties adopted by farmers include 'Cham 1,' 'Cham 3,' 'Cham 5,' 'Korifla,' 'Waha,' 'Aydin,' 'Haran,' and 'Omrabi' in several countries. These are now grown on millions of hectares. Productivity per unit of land area has considerably increased (Fig. 2), and the impact achieved exceeds more than $500 million per year.

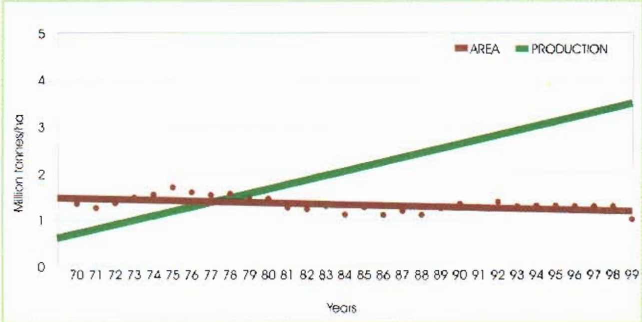


Fig. 2. Relationship between area and production of commercial durum varieties in Syria, 1970 to 1999.

The recently adopted new tools in the durum breeding program are:

1. Introgression of genes from the wild relatives to develop genotypes resistant to diseases and insect pests, and tolerant to cold and drought.
2. Adoption of seed storage protein and molecular markers to study durum diversity and to map QTLs for major desirable attributes, such as high grain quality and resistance to drought, cold, heat, diseases, and insects.
3. Development of joint research activities with major NARS in different agroecological zones, and with advanced institutes, to integrate basic research in durum breeding and enhance capacity building in the region.

Improving Disease Resistance in Winter Wheat

Yellow rust, caused by the fungus *Puccinia striiformis*, is often the most devastating wheat disease in the highlands and continental areas of CWANA and regions with similar environments. Wheat kernels may be severely shriveled and grain yield reduced by 30% to 70%. The occurrence and spread of this disease is favored by cool weather and sufficient moisture in spring, and the large-scale cultivation of susceptible cultivars.

During the past 10 years, yellow rust has caused large wheat losses in several countries of the region, including Iran, Lebanon, Pakistan, Syria, and Turkey.

In Central Asia, the disease is often observed in Azerbaijan and Tadjikistan, but is of minor importance in other countries where temperatures in spring are generally high.

An active search for genetic resistance to yellow rust in wheat has been going on at ICARDA. Adapted winter/facultative wheat cultivars lacking tolerance to the disease are crossed with resistant wheats from different sources. Screening thousands of wheat breeding lines under artificial epiphytotics at different sites in Iran, Syria, and Turkey, during 1995 to 1998, resulted in the enhancement of genetic resistance in winter wheat nurseries (Fig. 3).

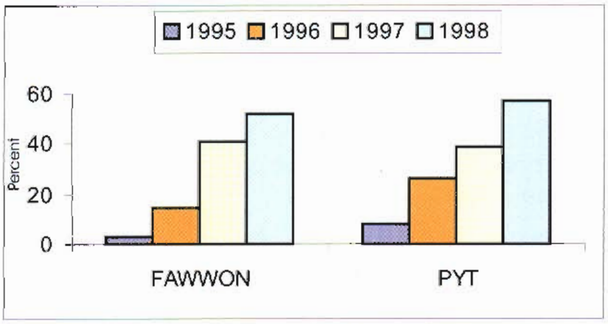


Fig. 3. Percent resistant entries in two winter wheat nurseries.
FAWWON = Facultative and Winter Wheat Observation Nursery.
PYT = Preliminary Yield Trial.

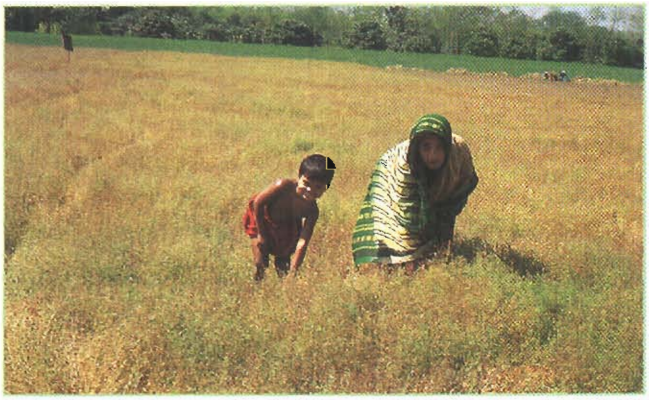
However, the fungus continuously undergoes genetic changes, through mutation and recombination, leading to new virulent races. For instance, there are currently more than 20 races of wheat yellow rust in Iran alone.

Data indicate that the highest-yielding wheat entries in research trials often have a moderate level of resistance. Under dryland conditions, moderately-susceptible cultivars generally yield higher than resistant ones. Research is under way to elucidate this enigma.

Lentil Production Boosted in Bangladesh

Bangladesh ranks fourth in the world in lentil production and, among a dozen pulses grown in the country, lentil ranks first in consumption. Lentil is grown on about 205,000 hectares, producing 162,000 tonnes per year, with a national average of 790 kg/ha. Low yield potential of the local cultivars and susceptibility to diseases are the major constraints to lentil production.

The Pulses Research Centre of Bangladesh Agricultural Research Institute (BARI) has strong linkages with ICARDA in lentil improvement. In a decentralized approach, ICARDA makes targeted crosses for Bangladesh, and single-plant selections are made from segregating populations in the agroclimatic conditions of Bangladesh. This enabled Bangladesh to release 'Barimasur-2' in 1993, a rust resistant cultivar with an average yield of 1.9 t/ha. This was followed two years later by 'Barimasur-4,' which yielded 2.3 t/ha against 1.3 t/ha for the improved variety, 'Uthfala.' 'Barimasur-4' has combined resistance to rust and *Stemphyllium* blight diseases. Genes for resistance to these diseases were introgressed from parents from ICARDA material. 'Barimasur-4' is also characterized by an erect growth habit and is, therefore, well suited for intercropping with sugarcane, as well as mixed-cropping with mustard and linseed.



A farmer with her son in their 'Barimasur 4' lentil field in Bangladesh.

The Government of Bangladesh has initiated a massive technology transfer campaign for pulse crops. A survey conducted by BARI showed that, on average, 'Barimasur-2' produced 24% and 'Barimasur-4,' 43% higher yields than the traditional varieties. During 1999, BARI conducted more than 2000 farmers' field demonstrations covering 11 lentil-growing districts in Bangladesh. In some areas, farmers were expecting to harvest 3 t/ha from

'Barimasur-4.'As a result of technology transfer efforts over the past three years, 30% of the lentil area is now estimated to be grown with improved varieties.

Narbon Vetch: A Potential Feed Legume for Dry Areas

The 1998/99 growing season in West Asia was constrained by low rainfall and prolonged periods of drought. The total precipitation was 197, 243, and 292 mm at Breda (Syria), Kfardan and Terbol (Lebanon), a mere of 58, 65, and 55% of the long-term average, respectively. Improved lines of narbon vetch (*Vicia narbonensis*) gave more than 1.8 t/ha grain and 4.5 t/ha straw yield, under these adverse conditions. This yield is much higher than for other legumes; for example, lentil produced only 0.5 t/ha grain under Breda conditions.

Narbon vetch, successfully grown in Gansu province, China.

Results obtained from Gansu province in China confirmed narbon vetches's adaptation to the area. It produced more than 1.3 t/ha grain under drought conditions. In Saudi Arabia, at Dierab near Ryadh, *Vicia narbonensis* Sel. #2380 showed high adaptability. In Cyprus, after five years of testing breeding lines, the national program released the line IFLVN568 as a variety for cultivation in dry areas.

These results demonstrate that narbon vetch is a dependable legume crop where other legumes are not successful. Its seed contains around 30% protein that has an amino acid composition nearly equivalent to that of soybean. It is considered a good source of high-protein feed for poultry. This crop can substantially increase feed production and farm income in rotation with barley, particularly in areas where barley monoculture is becoming more common due to pressure on land availability and is leading to low barley yields.

Coming to Terms with Plant Variety Protection

Efforts to protect the rights of plant breeders have been in progress for some 40 years but, in practice, only a limited number of industrialized countries have participated in this activity. As a consequence of the Trade Related Intellectual Property Rights (TRIPS) provisions of the World Trade Organization, many more developing countries are now considering this matter and some of them have already introduced their own legislation. Within the WANA region, a few countries are well advanced and have prepared draft plant variety protection (PVP) legislation, others are considering it, while some have largely ignored the subject.

ICARDA has an interest in this subject for two key reasons. First, at the policy level, the new legislation on varieties may be linked to an existing or new seed legislation. This is an opportunity to promote regional harmonization, which is a key objective of the WANA Seed Network, organized by ICARDA. Second, at the technical level, PVP demands an effective system for describing new varieties. This is a well-established activity at ICARDA, but it remains a weak point in many countries due to the lack of attention given to variety registration.

To raise awareness of these issues, ICARDA organized a workshop on "Plant Variety Protection" in Cairo in May 1999. Representatives of nearly all countries in the region attended, and two international consultants were invited. The International Union for Protection of New Varieties of Plants (UPOV), the organization which promotes PVP, was an active contributor. The workshop provided an excellent opportunity to understand the current status, and to answer questions from the country representatives.

Seed Health Activities

During the 1999 season, the Seed Health Laboratory (SHL) tested 41,000 samples for seedborne pathogens, of which about 28,000 were sent to ICARDA cooperators and 13,000 were received from outside sources.

The SHL, in collaboration with the CIMMYT/ ICARDA Durum Wheat Breeding Project, has worked actively for the second year in plastic-house experiments on selection of durum wheat germplasm for resistance to *Anguina tritici* and black point diseases. A large number of resistant accessions have been identified.

Resource Management and Conservation

Strategies for Producing More Food with Less Water

ICARDA's research on supplemental irrigation of wheat over the last decade has demonstrated substantial increases in, and stabilization of, rainfed wheat production. Furthermore, analysis has shown that water used in supplemental irrigation conjunctively with rain is far more efficient than when applied alone in full irrigation.

Optimization strategies were developed to maximize water-use efficiency. It was found that the return from water applied as deficit irrigation is higher than that applied to meet full irrigation requirements of the crop. In collaboration with the Syrian NARS, improved water scheduling was applied at 14 farmers' fields across the country. Farmers were given the options of growing portions of their farms as rainfed, with full supplemental irrigation (SI), or with deficit SI in which only 50% of full irrigation requirements were met. Farmers' yields increased on the average by 250% with full irrigation, over rainfed conditions, but when irrigation was cut by half, the yield loss was only about 10%.

Reducing the irrigation amount by 50% allowed farmers to irrigate additional areas that would have otherwise remained only rainfed. With this strategy, farmers were able to increase their total farm production by an average of 38% (Fig. 4).

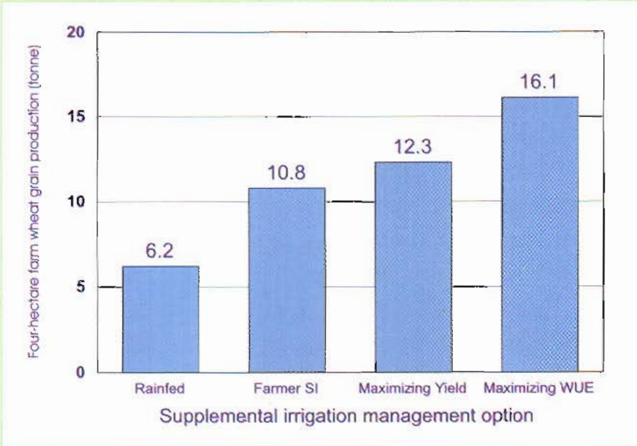


Fig. 4. Total production of a four-hectare farm with different SI management options under limited water resources in Syria.

In the dry areas of WANA, water—not land— is the most limiting factor for agricultural production. Under these conditions, maximizing water productivity is more important than maximizing yields. This strategy will save water resources and allow to irrigate increased areas with higher total production. The study recommends that guidelines for determining irrigation water requirements in areas with limited water resources should not be based on satisfying full crop water requirements, but rather on maximizing water productivity and farmers' return.

Barshaya Water Management Project Initiates GIS Component

The expansion of irrigation using groundwater, during the last 30 years, has provided substantial benefits to many countries in WANA, including higher farm incomes, food security, and rural employment. However, the high rates of groundwater abstraction, which led to these benefits, are often unsustainable. Groundwater levels are dropping. Wells have dried up in some areas and irrigated land is being returned to rainfed agriculture.

Research to address this challenge has been initiated in the village of Barshaya, in northern Syria. The aim of this research is to understand local and policy level factors leading to groundwater depletion, harness local and expert knowledge, and transform it—through computer simulation models—into a decision-support tool that allows water users as well as researchers, policy makers, extension agents, and water resources administrators to analyze different courses of action and their consequences.

A Geographic Information System (GIS) was constructed to incorporate all of the project data. Once included, researchers can investigate possible spatial relationships between the data layers from different scientific disciplines. Using an initial cadastral map of Barshaya dating back to 1947, a village base map was created. Obviously, this required extensive updating to make it accurate for 1999. This was done through fieldwork to identify present land-use and field patterns (Fig. 5).

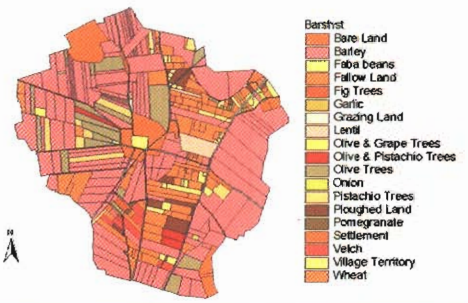


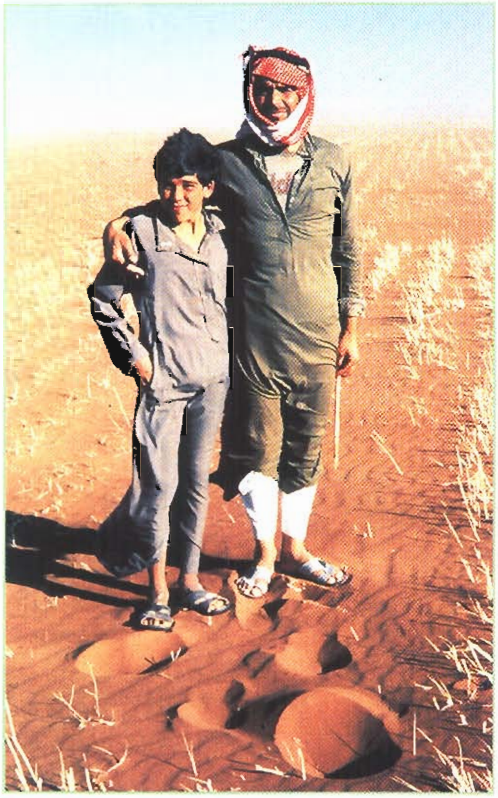
Fig. 5. Barshaya village land use during the summer of 1999.

The data collected will be used to generate a village water availability/requirements map based on existing wells, their known discharges, and current cropping patterns. By combining these data with land ownership information, ICARDA will be able to illustrate to the village stakeholders potential water management strategies that may assist in the sustainability of Barshaya's future agricultural production.

The Optimizing Soil Water Use Consortium

Given the challenges of agriculture in the arid and semi-arid regions, the agricultural priority across all dry-area farming systems in sub-Saharan Africa (SSA) and CWANA is to increase biological and economic yield per unit of water. In rainfed areas, improvement can come only from conserving rainfall water in the rooting zone of crops (including shrubs and trees), and from managing the field and the crops to use this water more efficiently. However, actual water-use efficiency in current farming systems in the drought-prone countries of CWANA and SSA is often very low, and a surprisingly small proportion of the available water is actually transpired by the crop.

Farmers in the dry areas need urgent help with improved water management and conservation technologies for their water-thirsty fields.



In general, the main agronomic strategies to intensify crop production systems are (i) soil and water management, and (ii) cropping system management, with strong emphasis on soil fertility management.

One of ICARDA's activities directed at improving the productivity of water use in dry areas aims precisely at achieving this task. ICARDA is one of the co-convenors of the Optimizing Soil Water Use (OSWU) Consortium, a constituent of the CGIAR System-wide Soil, Water, and Nutrient Management Program (SWNMP). The overall goal of the Consortium is sustainable and profitable agricultural production in dry areas based upon the optimal use of available water. The Consortium brings together two international centers, ICARDA and ICRISAT, and the national agricultural research and extension systems of member countries: Burkina Faso, Egypt, Iran, Jordan, Kenya, Mali, Morocco, Niger, South Africa, Syria, Turkey, and Zimbabwe.

Implications of Land-Use Dynamics for Land Degradation

Im Mial is a typical agro-pastoral village at the fringe of the steppe in northwestern Syria. It is one of 11 villages in the Khanasser Valley Integrated Research Site, which ICARDA has selected for its participatory and integrated natural resource management research program.

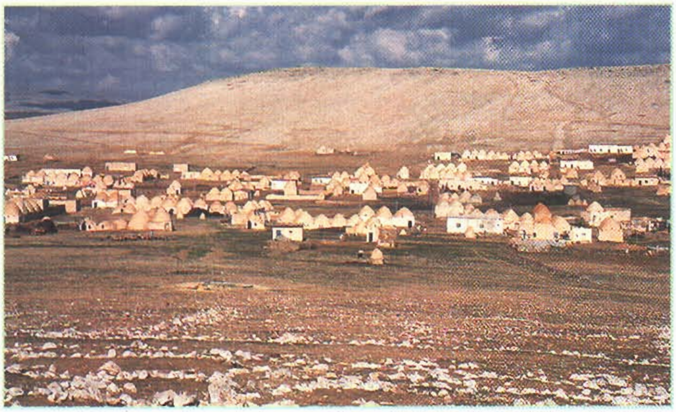
In Im Mial, both land degradation and agricultural intensification have led to changes in land use. The reduced fallow with no application of manure or fertilizer has caused a loss of soil fertility and correspondingly led to decreasing yields.

Migration also plays an important role in the management of the land. With the out-migration of villagers induced by the limited available land resources for the growing population and favorable earning opportunities from off-farm work, farmers are increasingly encouraged to invest in small-scale irrigation systems. However, irrigation activities in the village are just emerging.

Larger livestock numbers and the expansion of arable land into grazing land are putting increasing pressure on the natural vegetation and have led to decreased and less diverse vegetation cover. Therefore, the natural vegetation now plays a less important role in the diet of animals. Consequently, stall-feeding with crop residues and stubble grazing is of increasing importance and the interaction between crop and livestock has been intensified, encouraged, and facilitated by the market forces.

A large number of villagers believe that out-migration for off-farm work will continue to increase and that more people in the village will take up sheep fattening for meat, not for milk, mainly on purchased crop residues.

A survey has shown that any land-rehabilitation measures in the Valley must be adapted to fit into the land utilization and living traditions of the farmers. Efforts to conserve the natural resources in the area can be initiated with only a small financial and labor input from the farmers. The major activities should be in the winter period after the sowing of the rainfed fields, when the farmers are present in the village.



A view of the landscape of the Im Mial village, in the Khanasser Valley, near Aleppo, Syria — one of 11 villages in ICARDA's Integrated Research Site in the Valley.

Tree plantations in the fields located on the mountain slopes can conserve the soil and prevent erosion. Some trees, such as olives, require only minor inputs when the plantation is established. The harvest time for olives is in November, when most of the farmers have returned to the village.

Farmers spend a large amount of money to buy crop residues to feed the livestock. Increased on-farm integration between crop and livestock, where fodder crops could be cultivated instead of fallow, can increase fodder availability and improve soil fertility.

Study of Land Use and Vegetation Cover in the Arid Margins of Syria

With financial support from the Swiss Agency for Development and Cooperation (SDC), a study of land use and vegetation cover of the arid margins of Syria was carried out by a multidisciplinary team from ICARDA, the La Maison de l'Orient Méditerranéen (Université Lyon 2 - CNRS), the Graduate Institute of Development Studies (IUED, Geneva), the Institut de Géographie et d'Aménagement Regional of the University of Nantes (IGARUN), the Syrian Department of Antiquities, the Institute of Arab Studies, Damascus, and the University of Aleppo.

The study covered a total area of 800,000 ha in the Aleppo-Hama region. It focused on the human-environment relationship, the dynamics of transformation in the physical and human environment, and their interactions in arid and semi-arid areas. It addressed such questions as the effects of human activities on the resource base, the extent of desertification processes, the sustainability of current forms of resource exploitation, and the strategies adopted by farmers and herders to adjust to the profound changes in their physical and social environments.

A map of the land use and vegetation cover for the entire study area was produced using satellite imagery in conjunction with topographical maps and statistical data from the Syrian Ministry of Agriculture and Agrarian Reform (Fig. 6). The map, first of its kind, provides spatial information for the region, and fills an important knowledge gap.

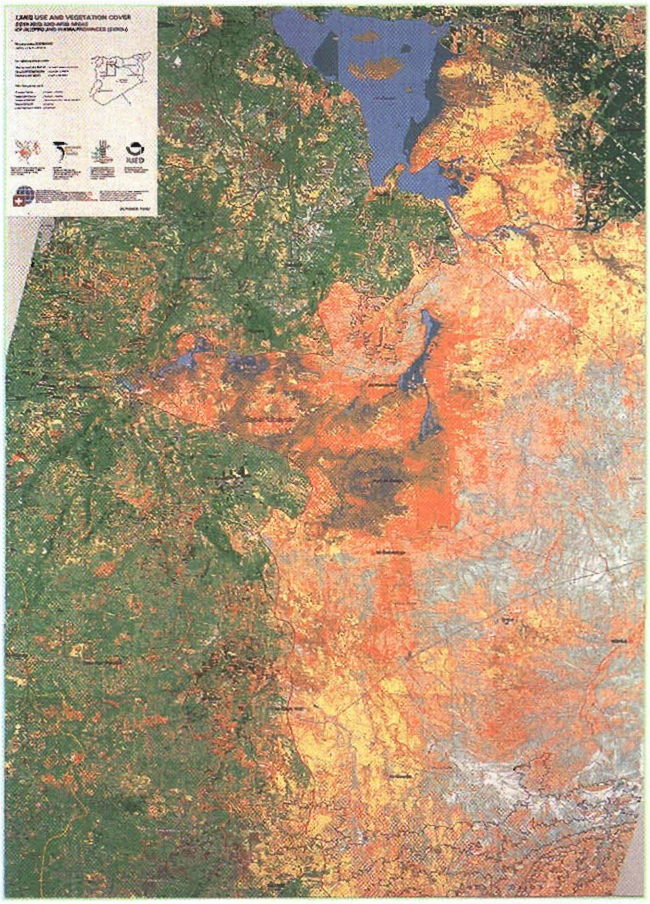


Fig 6. Map of land use and vegetation cover of the Aleppo-Hama region, Syria.

A total of 11 thematic maps ranging from the geographic units to the protected areas in Zone 5 were produced. These include official agricultural zoning, geomorphology, rainfed wheat-lentils, fruit trees, irrigation systems, summer irrigation, ancient water harvesting systems (*qanats*), barley cultivation, and protected steppe areas.

Concerning steppe areas, which are now of high priority with the recently initiated "*Badia* (rangeland) Project" by the Syrian Ministry of Agriculture and Agrarian Reform, one important result of the study is to precisely locate and quantify degraded areas.

Integrated Livestock Production Improvement in Central Asia

New systems of animal production and land tenure are emerging in Central Asia in a scenario of disrupted markets and minimal production supporting services. Research results and technology transfer services do not reach farmers, and small-ruminant productivity is low in addition to an alarming degradation of natural resources. The impacts of the transition have been serious.

- Kazakstan alone has lost 27 million heads of sheep in less than a decade (from 36 million to nearly 9 million heads).
- Extensive areas of range are inadequately utilized now that rotational seasonal grazing has given way to different forms of land degradation.
- Sheep farmers cannot sell wool and pelt products, because of low prices and limited marketing opportunities. The human population faces nutritional problems in view of reduced availability of

Livestock play a key role in the Central Asian economies. ICARDA is working with CAC NARS to address the problems of declining small-ruminant production and natural-resources degradation.

livestock products, aggravated by lower purchasing power.

To address these issues, ICARDA launched an IFAD-funded project on "Integrated Feed and Livestock Production in the Steppes of Central Asia" (IFL-CA) in October 1999. The first step was to develop work plans for Kazakstan, Kyrgyzstan, Turkmenistan, and Uzbekistan. ICARDA scientists, along with over 100 scientists from Central Asia, diagnosed production problems and devised a strategy to mitigate them. Elements of the strategy involve (i) research on socioeconomic issues and markets, (ii) testing and application of available technologies to improve feed and livestock production, and (iii) providing training to scientists and farmers.

The IFL-CA project involves collaboration with the United States Agency for International Development (USAID)-funded Global Livestock-Collaborative Project Support Program (GL-CRSP), which allows ICARDA to link itself to two advanced research institutions: University of California, Davis, and University of Wisconsin, Madison. In addition, ILRI has been invited to contribute to epidemiology, and IFPRI to policy and property rights research.

Impact Assessment and Enhancement

An Innovative Approach for Community Participation

ICARDA and IFPRI, in collaboration with NARS of eight WANA countries (Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, and Tunisia) have made an important shift from the conventional technology transfer approach in the dry areas, which mainly focused on farms and herds, to the community. A wider group, including poor farmers, who often did not benefit from technical innovations, is now targeted.

With active community involvement and sustained dialog and interaction between local communities and the Mashreq & Maghreb (M&M) Project national team, each country has selected two communities to implement the agreed research activities.

In the first phase of the M&M Project, scientists determined the technology boundaries and decided which would most benefit the community, particularly the bigger farmers and larger sheep breeders who were most likely to adopt new ideas. The scientists also determined the success of this approach.

In the on-going second phase, farmers and the community are involved in decision-making, and selecting objectives and technologies. Community expertise, such as farmers' indigenous knowledge, is taken into account, and success or otherwise of the new techniques is determined by the community. Unlike the judgmental approach of scientists in the first phase, the community approach is oriented to problem solving.

Impact of Barley and Lentil Germplasm Improvement

Developing countries in CWANA and in Latin America grow about 17 million hectares of barley. The worldwide lentil area in 1998 was 3.32 million ha, of which 2.69 million ha (81%) were planted in developing countries. Studies measuring the impact of ICARDA's germplasm program in developing countries were carried out using data collected by national programs and experimental data from research centers.

Barley

About 54% of 111 varieties released in 23 developing countries from 1980 to 1999 originated from ICARDA crosses. A noticeable rise in NARS varietal selection indicates increased research capacity, and is consistent with the decentralization of the barley-breeding program to NARS, while maintaining access to a continuous flow of genetic variability through collaboration with ICARDA.

ICARDA advanced lines and released cultivars represent the major part of NARS crossing blocks, increasing from 46% in 1987 to about 60% in 1997. The overall average of the diffusion of improved barley varieties, weighted by area, for eight countries is 15%, of which 10% are planted with ICARDA crosses or varieties with parents from ICARDA material, and 5% are planted with NARS varieties.

Lentil

Landraces from ICARDA's collection have been released as cultivars for the WANA region and beyond. From 1980 to 1999, ICARDA made the crosses for 50% of 52 varieties released by 22 collaborating countries, but a further 31% of released lentil varieties are attributable to ICARDA germplasm accessions or parents. ICARDA advanced lines increased from 21% in 1987 to 55% in 1997 in NARS crossing blocks.

The immediate yield advantage of switching from unimproved to improved varieties is as high as 928 kg/ha in China, and 200-250 kg/ha in other countries. Released varieties also have important traits such as resistance to disease, including root rot, wilt, and drought.

Although diffusion curves indicate that improved lentil varieties have not yet reached their full adoption potential in many countries, the average adoption rate increased from 2% in 1990 to 29% in 1997.

Factors Affecting Women's Access to "Security Assets"

A case study in Atareb community in northwestern Syria examined the nature and extent of women's use of, and access to agricultural land in livestock-crop production systems.

Although the study included the entire female population, it focused more on widows and divorcees. Such vulnerable women need access to 'security assets' such as land and gold for use in times of hardship.

The changing agricultural and social environment in the WANA region calls for a fresh look at women's access to their "security assets."

Land is an important source of livelihood, especially for women with fewer off-farm work opportunities. About 71% of the women interviewed were currently or previously engaged in cropping. However, few women held legal titles to land. Only 19% of those who could inherit land, actually did so. Just under half (49.5%) of this sub-sample of women declined their share, 3.4% were compensated for not inheriting, and inheritance was blocked for 10%.

Reasons for declining inheritance included the number of brothers, and the size of paternal land holdings. Most gave up property rights expecting family support in times of crisis (widowhood, divorce, etc.). However, the study indicated that women accepting a decline in their property share did not benefit from assurances of support from their brothers and were unlikely to get any compensation. This breakdown of customary mechanisms is prompting some women to take legal action to claim their rightful share of paternal land.

Furthermore, gold is often used during the early years of marriage to cover household expenses or investments in a husband's farming enterprise. Agricultural labor is the most accessible income source for unsupported, uneducated women. Low wages, the seasonal nature and insecurity of wages, and low status stand in the way of women agricultural laborers to invest in the gold or land that might secure their future.

Human Resource Development

During 1999, ICARDA offered training opportunities to 715 national scientists from 45 countries from the CWANA region, Africa, Asia and the Pacific region, and Europe. Of these, about 48% participants were trained in 16 courses organized at ICARDA headquarters in Aleppo, while the remaining were trained in 23 in-country, sub-regional, and regional training courses. About 18% of these were women. In addition, 68 national scientists from the developing and industrialized countries, registered with various universities, have been conducting their graduate research training for MSc and PhD at ICARDA.

The Center also coordinated implementation of different training needs for several external-funded projects. For instance, 77 scientists and progressive farmers from an IFAD's funded project in Egypt were trained in two specialized training courses at NCARTT, Jordan. In addition, a training course on "Women in Development" involving 19 participants from the Matrouh Resources Management Project (MRMP) in North-west, Egypt, was organized in collaboration with Jordanian institutes.

To respond to a request from the Egyptian Ministry of Agriculture and Land Reclamation, 32 senior scientists and extension specialists, funded by IFAD, were trained at ICARDA headquarters in "Soil and Water Management" and "Farm Mechanization and Experimental Station Operation Management." Three regional/international training courses on water-related subjects were jointly organized with CIHEAM-Bari.

A course on "Human Resources Development for Biodiversity Conservation" was jointly organized with the Arab League, and another in cooperation with the University of Birmingham, UK, on "Conservation and Utilization of Plant Genetic Research."

Inter-Center collaboration was strengthened through participation in the Inter-Center Training Group (ICTG) and the exchange of the ICARDA training database with sister centers.

Information Dissemination

ICARDA's presence was firmly established on the World Wide Web with direct access to the web site permitting fast update of information and features. The site was redesigned and enriched with pictures and new information material, including three issues of *Caravan*, the 1998 Annual Report, and several other documents.

Several press releases were issued, many of which were taken up by print and electronic media. New public awareness material was produced for the CGIAR meeting with US congressmen at Capitol Hill, and for International Centers Week held in October in Washington DC. A new English/Arabic video on "Seed Processing" for use in training and extension work, and another on "Wheat in Syria" for increased public awareness of ICARDA's achievements were produced. Information material specially designed for the EPCOT International Flower and Garden Festival, held in Florida, USA, was produced.

Nabil Trabulsi (left) from ICARDA and a participant from IRRI exhibiting posters at the EPCOT International Flower and Garden Festival in Florida, USA, highlighting the importance of land and water conservation for agriculture.

Two training courses— "Agricultural Information Management Using New Technology" and "Scientific Writing and Data Presentation"—were offered for NARS colleagues from West Asia and North Africa.

Among the key publications produced during the year were "The Synthesis: 1993-1998," to meet the information needs of the EPMR Panel, the corporate Annual Report for 1998, the condensed "Major Developments in 1998," and four workshop proceedings, including "The Origins of Agriculture." *The Week at ICARDA* was published on schedule.

The library added 975 new books to its collection, 1480 issues of journals and Annual Reports, and regular updates of AGRICOLA, AGRIS, and ISI Current Contents databases on CD-ROMs. Most of these databases were mounted on CD-ROM towers and made accessible on-line. In addition, the Library continued to play an active role in conducting literature searches and providing photocopies of documents to NARS scientists.

Computer and Biometric Services

All Y2K non-compliant machines were upgraded for Y2K compliance at headquarters as well as in the Regional Program offices. A 24-hour leased line from ICARDA to CGNET was put in operation and, in July, ICARDA got connected to the Internet. A Policy for the Internet Use was developed and implemented.

With the availability of the IVDN line, the Center installed MS Exchange Server 5.5, and implemented the migration of the users' mail folders and the shared folders with support from the CGNET. MS Outlook is the client interface with this server.

Migration of the Management Information Systems from VAX to a clustered Compaq Proliânt 3000 with dual CPU and Windows NT Enterprise environment was completed. The development and implementation of an out-sourced Payroll system was also completed.

The local-area network was extended to the Sheep Unit at the headquarters.

Biometric consultancies and assistance on data management and analyses were provided to researchers in various areas including cropping systems, germplasm improvement, and land degradation. Alternative methods of modeling spatial variability using Fourier series and polynomial regressions in lentil trials were developed. Expressions for estimates of the parameters of a model to detect the QTLs for disease data and minimum number of plants required for estimating diversity were obtained.

An Information Technology Strategy and Implementation Plan was jointly developed for the Ethiopian Agricultural Research Organization (EARO).

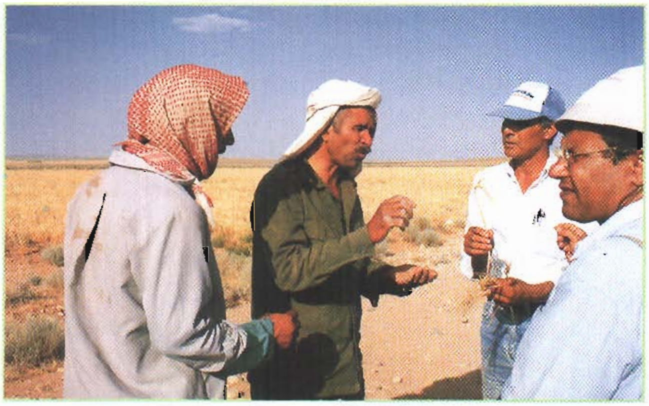
International Cooperation

As a "center without walls" ICARDA promotes partnerships with NARS in the dry areas, as well as with regional and international organizations and advanced research institutes throughout the world. The seven Regional Programs of the Center play an important role in this effort. Collaboration includes exchange of technology and germplasm, as well as human resource development.

During 1999, ICARDA in collaboration with FAO, AARINENA and CIHEAM, completed a WANA NARS Review Study. The Study, which covers 19 countries in WANA, provides a comparative analysis of the organizational structure, mandate, research program, human and physical resources of national research, and educational institutions in those countries.

North Africa Regional Program

The North Africa Regional Program (NARP) covers countries of the Maghreb region (Algeria, Libya, Morocco, and Tunisia) and, since 1998, Mauritania. Emphasis was given to developing new projects. A draft strategy for NARS and ICARDA cooperation in North Africa was developed for review and approval.



Farmers from Ghdama community in the M&M Project explain how rangelands are used in Libya.

Cooperative Research

New, improved germplasm of barley, legumes, wheat, and forages from ICARDA was extensively used by NARS in their breeding programs. ICARDA's outsourcing of research to Morocco on resistance to, and biotype characterization of Hessian fly, and resistance to Russian wheat aphid and to the barley stem gall midge continued to serve the WANA region. ICARDA agrometeorologists backstopped INRA, Morocco in producing land suitability maps.

Regional activities with national partner-institutions included implementing work plans of the "Regional Program on Development of Integrated Crop/Livestock Production Systems in Low-rainfall Areas of the Mashreq/Maghreb Region Phase II (M&M)," funded by IFAD, AFESD and IDRC; "WANADDIN," supported in Morocco by IFAD; "Farmer Participation in Barley Breeding," supported by IDRC; and the "Rangeland Management Project" in Morocco, supported by the Swiss Government. In addition, collaborative programs continued on "On-farm Water Husbandry," and on "Use of Shrubs and Fodder Trees in WANA and Sub-Saharan Africa (SLP)." Project activities in "Biotechnology for Arab Countries," supported by AFESD, and "Optimizing Soil Water Use (OSWU)" were initiated.

Meetings, Workshops, and Training

Annual National Coordination Meetings were held in Algeria, Libya, Morocco, and Tunisia to evaluate the results of collaborative research in 1998/99 and develop work plans for 1999/2000. Three regional coordination meetings were also held: (i) SLP in Morocco, in which scientists from nine countries in WANA and Sub-Saharan Africa participated; (ii) On-Farm Water Husbandry Steering Committee Meeting in Tunisia, including a traveling workshop; and (iii) Improvement of Barley in North Africa and Egypt, in Tunisia, in which barley scientists from North African countries met to evaluate the progress and initiate new collaborative activities.

Two traveling workshops were conducted for farmers: (i) "Farmer Participation in Barley Breeding" in Morocco, and (ii) visit of Egyptian farmers from MRMP to Morocco to see techniques of water management in arid areas. A WANADDIN workshop on "Durum Wheat in the Mediterranean Region" was jointly organized by ITGC/IFAD/CIMMYT/ICARDA in Algeria for more than 45 policy makers, managers, and scientists. NARP scientists participated in a meeting to start a new Maghreb network on cereals, REMACER. Discussions on joining the legumes network, REMALA, also began.

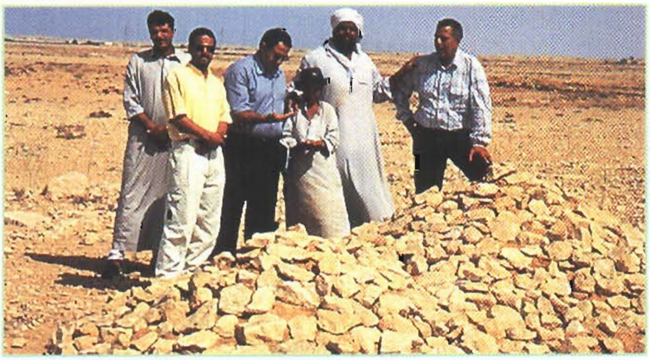
In-country and regional training courses were held on alternative feed resources and small-ruminant management, variety description and breeder seed production, and molecular biology. NARP/ICARDA contributed to an advanced course on water-use efficiency, organized by CIHEAM/Bari in Morocco.

Nile Valley and Red Sea Regional Program

The Nile Valley and Red Sea Regional Program (NVRSRP), which operates from ICARDA's Regional Office in Cairo, Egypt, implements and manages several projects in Egypt, Eritrea, Ethiopia, Sudan, and Yemen with the overall objective of increasing the income of smallholder farmers.

Collaborative Projects

In Egypt the ongoing projects are: "Cereals, Food Legumes, and Natural Resource Management"; and "Weed Control in Wheat Fields," both funded by the European Union (EU) and the Egyptian Government; and the "MRM Project," funded by the Egyptian Government through a World Bank loan. In Ethiopia, a project on legume improvement is supported by the Netherlands Government. In Yemen, the "Agricultural Sector Management Support Project (ASMSP)" is financed by the Yemeni Government through a World Bank loan.



These farmers in Wadi Ginewa, Community 5, in Ras El-Hekma, Egypt keep barley seed stock for three years in heaps protected by chopped straw, a thick layer of mud, and stones.

Meetings, Workshops, and Training

National Coordination Meetings were held in Ethiopia in May, Sudan in August, and Egypt and Yemen in September, together with the Annual Management Meetings. The NVRSRP Regional Coordination Meeting was held in Addis Ababa, Ethiopia, in October, and included a one-day field visit to EARO. The Meeting was inaugurated by the Minister of Agriculture and ICARDA Director General. It was followed by the NVRSRP Steering Committee Meeting, in which representatives from the four countries, ICARDA, and donors, discussed and approved the work plans and budgets for

1999/2000. The MRMP/ICARDA Annual Coordination Meeting was held in Matrouh in June. A meeting for 30 specialists from MRMP and ICARDA, and consultants, was held to develop a strategy and a medium-term (five-year) plan for the northwest coast of Egypt.

In Egypt, a training workshop on resource management was attended by 29 researchers, and 100 extension agents were trained in wild oat control in wheat. A regional training course on "Utilization of Expert Systems in Agricultural Research and Production" was jointly organized by ICARDA and the Central Laboratory for Agricultural Expert Systems (CLAES) of ARC, Egypt, in October, for 12 participants from 11 countries.

Three traveling workshops on wheat, barley, and food legumes, each attended by more than 30 Egyptian scientists, were organized in Egypt in March. "A Barley Regional Workshop" in Ethiopia in October brought together 35 participants from Ethiopia and ICARDA.

Farmers are the pillars of the M&M Project. Here, Syrian farmers are seen attending a meeting organized by the Project to discuss the implementation of its activities.

An international workshop on "Strategies and Technology for Conservation and Sustainable Use of Biodiversity in Large West Asian and North African Landscapes" was held in Matrouh, Egypt, in March, with 85 participants from 14 countries and 10 national, regional, and international organizations.

West Asia Regional Program

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

Collaborative Projects

The Mashreq and Maghreb (M&M) Project, funded by AFESD, IFAD, and IDRC, started its second phase in 1998/99 in Iraq, Jordan, Lebanon, and Syria. It now has strong community focus and integrates technology transfer, socioeconomics, and policy and property rights issues across ecological zones and disciplines. Through special funding from the Ford Foundation, in-depth studies on policy and property rights are conducted to identify options to contribute to sustainability of the natural resources base.

Collaborative project activities continued in on-farm water husbandry and improvement of barley under dry conditions and the production and utilization of multi-purpose fodder shrubs and trees. Activities of the new UNDP/GEF Project on Conservation and Sustainable Use of Dryland Agro-Biodiversity in Jordan, Lebanon, Syria and the Palestinian Authority were implemented as planned.

Meetings, Workshops, and Training

Coordination Meetings were held with Iraq and Syria, and a pre-coordination meeting was held with the Lebanese Agricultural Research Institute in Lebanon. The Second Regional Technical Planning and Coordination Meeting of the M&M Project-Phase II, held in October in Aleppo, Syria, was attended by national coordinators and representatives from Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, and Tunisia.

A stakeholders' meeting was held in May at ICARDA headquarters to begin implementing the UNDP/GEF Agrobiodiversity Project. The Regional Planning and Steering Committee Meetings were held in Jordan in July to finalize technical work plans for the four countries involved in the project. The Steering Committee Meeting of the Project on "Optimizing Soil Water Use (OSWU)" was held in Amman in May, with 13 participants from nine countries, and from ICRISAT and ICARDA.

An AARINENA/ICARDA taskforce meeting was held in ICARDA headquarters in August to finalize a regional project proposal on non-conventional alternative feed resources.

A workshop on "Studies on Local Communities of the M&M Project," held in Aarsal village, Lebanon, was attended by farmers and herders from Aarsal and Deir El-Ahmar communities, as well as officials and scientists from Lebanon, Syria, and ICARDA. A regional workshop on "Feed Block Technology" was held in Iraq with the participation of researchers from the Mashreq and Maghreb countries, the private sector, farmers, and sheep owners.

A regional training course on "Community Approach and Gender Analysis" was held in Amman, with 20 participants from Mashreq and Maghreb countries.

Outsourcing

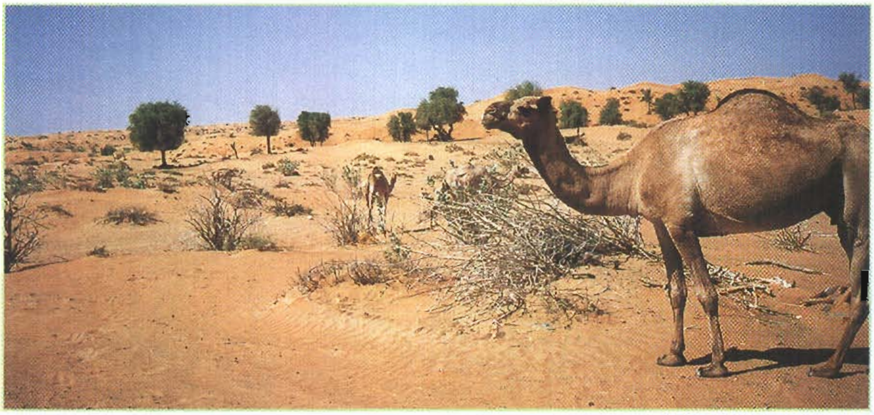
Socioeconomics experts from Iraq were contracted to assess the regional impact of ICARDA's achievements in germplasm improvement; and specialists from Jordan provided consultancies to ICARDA research and development projects in soil conservation and extension. The National Center for Agricultural Research and Technology Transfer (NCARTT) in Jordan was outsourced to provide training to 58 farmers from MRMP of Egypt in "Adoption of Modern Irrigation and Intensive Agricultural Systems." Cooperation with the Economic and Social Commission for Western Asia (ESCWA) continued on important aspects of water use and policy.

Arabian Peninsula Regional Program

ICARDA's Arabian Peninsula Regional Program (APRP), funded by AFESD and IFAD, which was formally opened in January 1997, successfully completed its first phase.

Collaborative Research

Most of the objectives were met for the four main collaborative research themes: (i) rangeland, shrubs, irrigated forages, and livestock; (ii) protected agriculture; (iii) abiotic stresses; and (iv) on-farm water use and irrigation management. Substantial technical input continued to be provided within the themes. Particular emphasis was given to the evaluation and seed increase of selected indigenous desert grasses and the development of maps on ecological characterization of the region. In March, an IFAD expert carried out a successful supervision mission on rangeland and conservation research. In protected agriculture, an integrated management program was implemented in all the countries.



Nothing left to graze, these camels must be wondering. Overgrazing is a serious problem leading not only to feed shortages but also to land degradation in the Arabian Peninsula. ICARDA is working with NARS to identify suitable desert species to rehabilitate the degraded lands.

Research on conservation and utilization of forages in the Arabian Peninsula continued. A collection mission was completed in the eastern plateau of Yemen. In collaboration with the Natural History Museum of Sharjah, all the herbarium specimens of the collected plants were labeled and mounted. A database on the collected forage species was completed and is being used to identify useful germplasm for evaluation and seed increase.

In collaboration with the United Arab Emirates (UAE) University and the Ministry of Agriculture and Fisheries, measurements were made on the nutritive value of previously-collected desert forages. Initial results from five indigenous desert grasses show they have values as high as introduced material. Data on germination and establishment of these grasses were collected, and a seed multiplication program for three of these grasses was initiated in Bahrain, the Kingdom of Saudi Arabia, the Sultanate of Oman, and UAE.

Meetings, Workshops, and Training

The APRP Regional Coordination Meeting, held in the Sultanate of Oman in mid-June, was attended by over 60 scientists and managers from the Arabian Peninsula. NARS and ICARDA scientists made over 40 presentations. The achievements were presented during the Regional Steering Committee Meeting, and a project document for the next phase of APRP was finalized.

A training program on "Integrated Management of Greenhouses" was held in Doha, Qatar. Twenty-two scientists from the Arabian Peninsula NARS were trained in different aspects of greenhouse management and crop production and protection. During the year, 52 scientists from the Arabian Peninsula were trained in various disciplines both at ICARDA headquarters and in the region.

Highland Regional Program

The Highland Regional Program (HRP) addresses the constraints to agricultural production in some of the harshest and neglected agricultural environments in the CWANA region, covering the highlands and continental areas of Iran, Pakistan, Turkey, most of the CAC countries, and the Atlas Mountains.

A major component of HRP's work is conducted in Iran and Turkey, where ICARDA has posted staff. In 1999, new activities were initiated in Turkey and some old ones phased out. Activities in Iran, largely NARS-funded, were strengthened. A Memorandum of Understanding was signed with the Economic Cooperation Organization (ECO) with the aim of promoting agricultural research and development in ECO member countries.

Collaborative Research

Collaborative research with Turkey's Central Research Institute for Field Crops (CRIFC) included testing germplasm of barley, lentil, durum wheat, and annual forage legumes at Haymana and other sites in Turkey for tolerance to cold and drought. Some of the selected forage species were shared with CAC countries.

Facultative and winter wheat, developed under the umbrella of the IWWIP (International Winter Wheat Improvement Program, a joint effort between Turkey, CIMMYT, and ICARDA) was tested at Konya, Cumra, Eskisehir, Ankara, and other sites in Turkey, and at ICARDA in Syria. The dry season was useful in selecting drought-tolerant germplasm. International facultative and winter wheat nurseries were prepared at Konya Institute and sent to collaborating institutes in Turkey and other countries, including those in CAC. Some of the breeding lines were selected in Uzbekistan, Turkmenistan, and Georgia for nationwide testing and on-farm demonstration in 2000.

Traveling workshop in Turkey on winter wheat improvement. Forty-three researchers from CWANA countries, ICARDA and CIMMYT visited farmers' fields and research stations in Ankara, Konya and Eskisehir.

Collaborative research in Iran led to the release of a winter wheat and a barley cultivar, and to the identification of promising lines of wheat, barley, lentil, and chickpea for Iran's dry rainfed areas.

Meetings, Workshops, and Training

ICARDA researchers participated in the Annual Planning Meeting of the Winter Wheat Improvement Program at Eskisehir, and in a related meeting at Ankara on root-rot diseases of wheat. An ICARDA-organized traveling workshop visited Turkey in May to evaluate and select winter barley at Haymana Research Station, and to discuss barley improvement issues with researchers from Turkey and ICARDA. Another traveling workshop on winter wheat improvement was jointly organized in Turkey, where 43 wheat researchers from CWANA countries, ICARDA, and CIMMYT visited farmers' fields and research stations in Ankara, Konya, and Eskisehir.

Meetings were held in Aleppo, Syria, and Sanliurfa, Turkey, with the participation of delegates from ICARDA and Southern Anatolia Research and Development Agency (GAP-RDA), to discuss collaboration between the two institutions. Two projects with funding from GAP-RDA are due to start in 2000.

Two in-country courses were held in Iran, one on "Application of Molecular Marker Techniques" and the other on "Management of Yield Trial Data."

Central Asia and the Caucasus Regional Program

In its second year of establishment, the Central Asia and the Caucasus Regional Program (CACRP) continued to enhance ICARDA's partnerships with the eight NARS of the CAC region: Kazakstan, Kyrgyzstan, Tadjikistan, Turkmenistan, and Uzbekistan in Central Asia, and Armenia, Azerbaijan, and Georgia in the Caucasus. The Program was further strengthened in 1999 by the posting of an ICARDA senior barley breeder in its Regional Office in Tashkent. During the year, ICARDA signed bilateral agreements of cooperation with Armenia, Azerbaijan, and Georgia. As mentioned before (page 14), a project on crop/livestock integration was initiated in Central Asia, with financial support from IFAD. Financial support for a project on "On-Farm Soil and Water Management in Central Asia," to be initiated early in 2000, was approved by the Asian Development Bank.

Collaborative Research

The Program continued to strengthen collaborative activities in five areas in the CAC region: (i) productivity of agricultural systems; (ii) natural resource conservation and management; (iii) conservation and evaluation of genetic resources; (iv) socioeconomic and public policy; and (v) strengthening national programs. Work on germplasm conservation, evaluation, and documentation (in collaboration with IPGRI) was strengthened through the ACIAR-supported project, and through the CGIAR Program for CAC. Similarly, the collaborative work on germplasm enhancement of wheat (in collaboration with CIMMYT), barley, and food and feed legumes was further strengthened with financial support from the CGIAR Program.

On-going collaborative activities in Uzbekistan were continued in cooperation with USDA/ARS (on Karakul sheep) and GL-CRSP/University of California, Davis, on rangeland management and carbon sequestration. On-station breed characterization in small ruminants began in four Central Asian and three Caucasian countries.

ICARDA also actively participated in study missions in CAC, including participation in the World Bank-supported project on "Seed Component of the Agricultural Support Services Project in Kyrgyzstan."

Participants in the Second Program Steering Committee Meeting of the CGIAR Collaborative Research Program for Sustainable Agricultural Development in Central Asia and the Caucasus, 23-25 June 1999, Tbilisi, Georgia.

The report on "Seed Sector Study in Kazakstan" was finalized with COWI of Denmark, and the Ministry of Agriculture, and the National Academic Center for Agricultural Research of Kazakstan, and was jointly presented at a seminar in Astana in November.

CGIAR Collaborative Research Program for CAC

CACRP Office, which hosts the CGIAR Program Facilitation Unit (PFU), continued to provide support to the CGIAR Collaborative Research Program for CAC. In 1999, the CGIAR Program, in which nine CG Centers (CIMMYT, CIP, ICARDA, ICRISAT, IFPRI, ILRI, IPGRI, ISNAR, and IWMI) are participating, became fully operational in the eight CAC countries. The Program successfully organized two meetings during the year: the Second Program Steering Committee Meeting in Tbilsi Georgia in June; and a luncheon meeting during the International Centers Week, in Washington, DC in October.

Meetings, Workshops, and Training

The CACRP Regional Coordination Meeting was held in Tashkent, Uzbekistan, in September. Fifty senior scientists from the NARS discussed results of the 1998/99 season and finalized work plans for the 1999/2000 season. The Program also organized a meeting for stakeholders of the project on "Integrated Feed and Livestock Development in the Steppes of Central Asia" at ICARDA headquarters in June. This was followed by four National Coordination Meetings for the IFAD-supported feed/livestock project in Kazakstan, Kyrgyzstan, Turkmenistan, and Uzbekistan, and a Regional Coordination Meeting in September to discuss regional activities of the project. A project Steering Committee Meeting was held in October in Tashkent. The Program also organized the meeting of the "Central Asia and Trans-Caucasus Network of the Plant Genetic Resources (CATN-PGR),"in collaboration with IPGRI-CWANA, in April in Tashkent, followed by its Steering Committee Meeting.

A regional workshop on "On-Farm Soil and Water Management in Central Asia" was held in May in Tashkent. Two regional traveling workshops were organized to enhance information exchange and regional collaboration in the CAC countries: (i) "Barley in Syria, Turkey, and Russia," in May, and (ii) "Winter Wheat in Turkey," in June (in collaboration with CIMMYT).

Six short-term training courses for 45 scientists were organized in the CAC region or at ICARDA headquarters.

Latin America Regional Program

With support from the Peruvian Technical Secretary for Coordination (SCT) and the CGIAR, ICARDA's Latin America Regional Program (LARP) was deployed from CIMMYT, Mexico to CIP in Lima, Peru, in March 1999. The objective of LARP is to develop alliances with Latin American NARS and IARCs in ICARDA mandate crops and natural resource management in dry areas. At the same time, research on barley improvement within the ICARDA/CIMMYT program based in Mexico continues to be of high priority because of its impact on resource-poor farmers in Mexico and the Andes. ICARDA is consolidating research projects in food legume improvement (lentil, faba bean, and Kabuli chickpea) in collaboration with public and private sectors and other international organizations.

The dry areas of the Peruvian northern coast are in need of attention to natural resource management. Goat production systems and agroforestry are pivotal for the research agendas related to desertification, food security, and strategies to cope with El Niño effects. Spillovers of this research to the southern part of Ecuador and northern Mexico are expected. ICARDA will continue to pursue range management issues in the Andean highlands where water management and common property issues constrain small ruminant production among the poorest sectors of the rural population.

In collaboration with CONDESAN/CIP, universities, and NGOs, ICARDA has pursued competitive funds to investigate the comparative advantage of organic faba bean cultivation in irrigated and non-irrigated terraces in Peru and Bolivia. This is in response to the need to assess the economic viability of agroecological principles in the era of global markets. Likewise, INIFAP and ICARDA are collaborating to enhance the production of goat meat and milk through the use of native vegetation of semi-arid environments of Zacatecas, Mexico.

PART TWO

Research and Training Overview

Contents

Research and Training Overview

Research and Training Overview

Introduction

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

At its headquarters at Tel Hadya, about 35 km southwest of Aleppo, Syria, ICARDA conducts research on a 948-ha farm. Within the CWANA region, it conducts research at collaborative sites with NARS in over 42 countries that represent the various dry-area agroecologies covered by its mandate. The report that follows represents only a selection of important results achieved in collaboration with NARS during the 1998/99 cropping season. Progress in transfer of technology and strengthening partnerships with NARS is summarized under "International Cooperation" on pages 18-24.

The Weather in CWANA in the 1998/99 Season

Drought conditions prevailed across the entire Mediterranean region during the 1998/99 growing season, except in Algeria and Tunisia in the west, and the western half of Turkey and Cyprus in the east. Precipitation was below normal in late spring, but enough for a record cereal harvest in Algeria and average yields in Tunisia. In Turkey, good yields in the western half were offset by a poor, drought-stricken crop in the east.

In Morocco, the drought was most pronounced during the autumn of 1998/99, leading to below-average yields of cereals and other crops. In the eastern Mediterranean region, autumn and winter rainfall was below average from Sinai through Jordan, Palestine, and Syria to eastern Turkey and Iraq; only the coastal strip of Syria and Lebanon was less affected. In February, the drought-stricken area expanded eastward into the northern half of Iran, Afghanistan, and northern Pakistan. March and April brought relief to the western part of this zone, first to eastern Turkey and northern Syria (Fig. 1), then to regions further south down to Jordan and Egypt, while the drought in the eastern part of the zone continued to expand and intensify. The lack of moisture, which was exacerbated by above-normal temperatures during autumn, winter, and spring, increased evaporative demand and favored the development of pests. Worst affected by the drought were Iraq, Iran and Jordan; for Iraq this was the worst drought of the century.

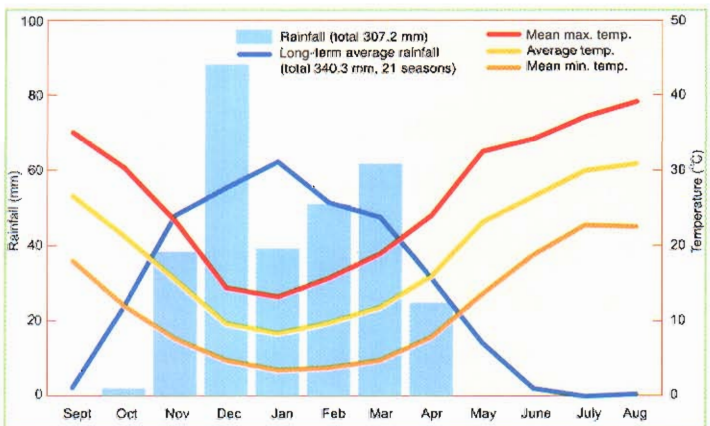


Fig. 1. The weather at Tel Hadya, ICARDA's main research station, northern Syria, during 1998/99.

Unusually warm temperatures in the Arabian Peninsula, with few intermissions, persisted into the autumn of 1999. Agricultural production, however, was not much affected and was near average across the Peninsula. On the other side of the Red Sea and the Gulf of Aden, the spring rains from March to May were average in northeastern Ethiopia and northern Somalia, but below average elsewhere. Worst affected were southern Somalia and the adjacent areas of Ethiopia and Kenya, where spring rains failed completely. Summer rains from about June to October, which is the main rainy season in Ethiopia, Eritrea, and Sudan and the minor season in Somalia, were generally adequate to abundant, producing a good crop; the notable exceptions being once again Somalia and parts of eastern Ethiopia. In contrast, heavy rains in August and September in central Sudan caused widespread flooding, reducing the output of irrigated areas. At the other end of the Sahelian zone, in Mauritania, although rainfall was late during the summer of 1999, it was abundant along the coast, but remained up to 50% below normal in inland areas.

In Central Asia, growing conditions were satisfactory to favorable in Kazakstan, Kyrgyzstan, and Uzbekistan. The winter was rather mild and precipitation was ample in the north and east; and around average elsewhere in this zone. Turkmenistan, Tajikistan, Azerbaijan, Armenia, and Georgia suffered to some extent from the same spring drought that affected Iran and other countries further south.

Agroecological Characterization

Cereal Production Potential of Morocco

ICARDA, in collaboration with the *Institut National de la Recherche Agronomique (INRA)*, Morocco–on behalf of the Moroccan Ministry of Agriculture, Rural Development and Marine Fisheries–has started a Land Suitability Project (LSP) in Morocco. Other Project partners include the National Meteorological Service (DMN). The goal of the Project is to provide information that enables decision makers to enact policies that encourage sustainable and socially equitable use of land, safeguard the productivity of natural resources, and increase the income of the rural population. Farmers are also provided with information on appropriate crop and land management alternatives.

One of the on-going activities of this Project is the analysis of the yield and production potential of cereals, and the impact of drought on cereal production. Maps of the country's main cereal production areas showing the yield potential as function of drought severity have been prepared. These maps also examined the gap between the potential and actual production levels. The potential yield of rainfed durum wheat in a year characterized by conditions of moderate drought is shown in Fig. 2.

The approach to the characterization of agricultural environments underlying all analyses of the LSP has evolved in more than 10 years of collaboration between ICARDA, INRA, and DMN, starting in 1989, with support from the International Development Research Centre (IDRC) for a Project on Agroecological Characterization. The key element

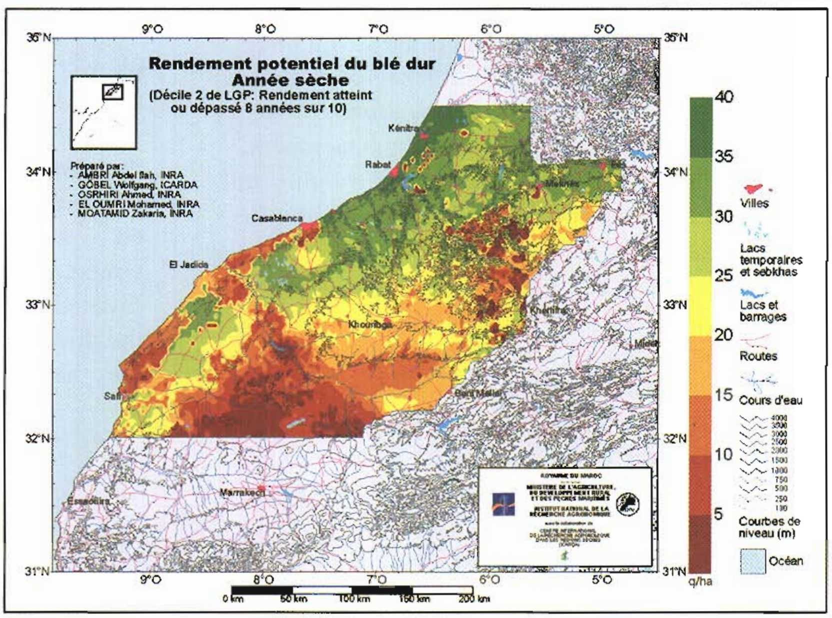


Fig. 2. The potential yield of rainfed durum wheat in central Morocco.

of the methodology is a stochastic climate model called Spatial Weather Generator (SWG) developed at ICARDA. In combination with advanced spatialization techniques, it is used to create space-time models of climate; and in combination with suitable simulation models, it is used to create maps of static land properties of various weather-driven phenomena such as soil moisture availability or crop yields. The resulting maps are amenable to post-processing using a Geographic Information System (GIS).

ICARDA's contributions to the system used by the LSP include: SLGP, a model to compute the available length of the growing period (LGP) as defined by the Food and Agricultural Organization of the United Nations (FAO); SIMTAG, a simulation model of wheat; VIFOR, a simulation model of faba bean with or without infestation by the parasitic weed broomrape; and MULTISIM, a tool to quantify the gap between potential crop yields and those actually achieved by farmers. Other activities include developing software for qualitative land suitability evaluation for crops based on the FAO approach and for computing a drought index based on the Palmer Drought Severity Index (PDSI). A space-time model, which has been used to study the production potential of cereals in Central Morocco, is available. Another model of the climate of the entire country is being developed jointly by ICARDA, DMN, and INRA. It will permit to expand the analysis of the cereal production potential to the remaining parts of the country and be used in the analysis of the production potential for food legumes and other crops.

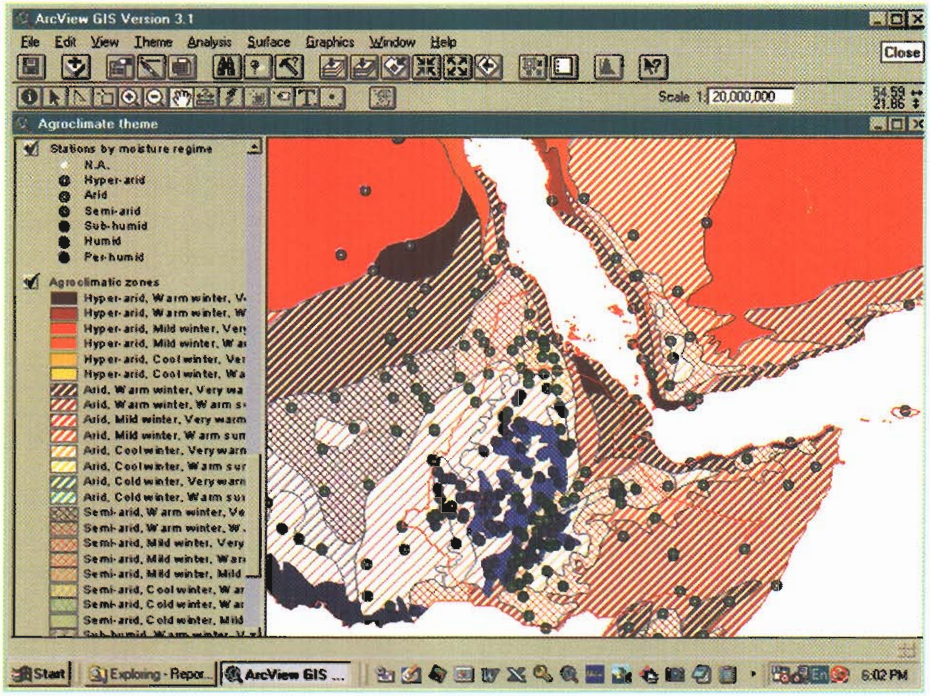


Fig. 3. Agroclimatic zones of the Horn of Africa and the Arabian Peninsula.

CWANA Agroecology Project

A study of the agricultural ecology of the whole ICARDA mandate region, that is, Central and West Asia and North Africa (CWANA) and the Horn of Africa (Ethiopia, Somalia) has been started. The study, which covers agricultural climates, soils, topography, and land-cover, involves compiling and adapting public-domain spatial datasets for the CWANA region. The integration of these datasets is implemented through a GIS project, using ArcView software.

Spatial datasets currently incorporated into the CWANA GIS include altitude, slopes, agroclimatic zones, major soil types, land cover, and climate stations. The layers of altitude and slopes have been obtained from the United States Geological Survey (USGS) global digital elevation model with 1 km (30 arc-second) resolution GTOPO30. An extract of the agroclimatic zones layer for the Horn of Africa is shown in Fig. 3.

For the land-cover theme, global or regional land-cover datasets were considered insufficiently accurate. For this reason, a new land-cover layer from four arc-minute Advanced Very High Resolution Radiometer Normalized Difference Vegetation Index (AVHRR NDVI) data, using a new methodology, was developed.

The methodology for land-cover classification is built on the recognition that in a large area like CWANA, with many different climatic domains, it is not possible to adopt a single set of NDVI thresholds for different land-cover types. The current method relies on linking carefully selected NDVI indicators with climate and land-use information.

Through this approach it was possible to identify, with a high degree of accuracy, 11 land-cover types. A sample of the classification for the Horn of Africa is shown in Fig. 4. The distribution of the major land-cover classes in CWANA, which demonstrates the dominance of barren or other sparsely vegetated areas, is shown in Fig. 5.

As part of the CWANA Agroecology Project, a small dataset consisting of average climatic data for 1200 stations distributed throughout the CWANA region has been extracted from ICARDA's meteorological database (METDB). Potential evapotranspiration data, which were not available for Central Asia, were generated for 350 stations on the basis of statistical relationships established for different agroclimatic regions. This mini-database was then converted into an Excel spreadsheet which allows users easy access to individual station data and visualization of derived agro-climatic information such as climate charts, heat unit, water balance, and growing period summaries (Fig. 6).

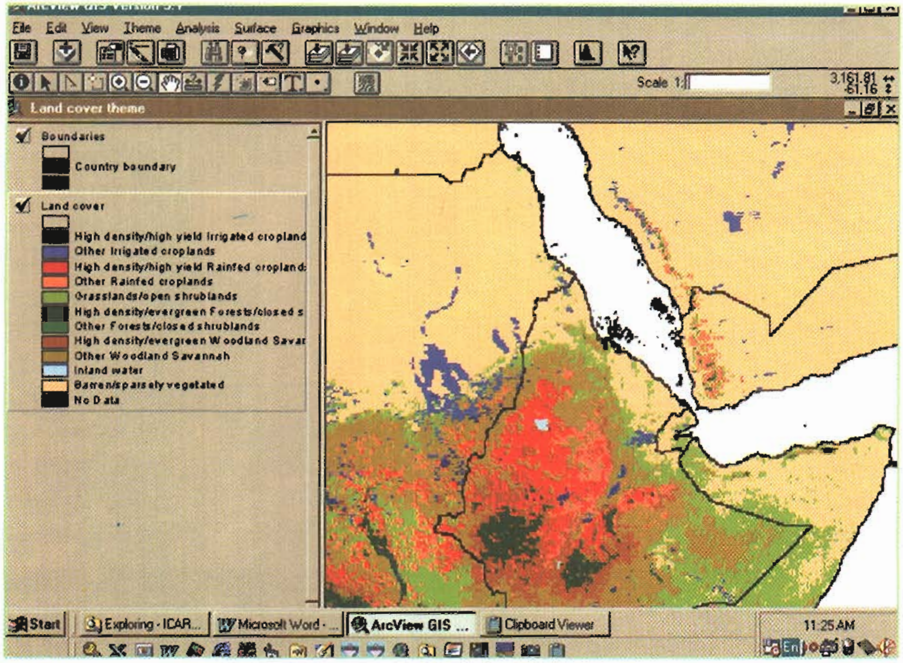


Fig. 4. Land-cover of the Horn of Africa and the Arabian Peninsula.

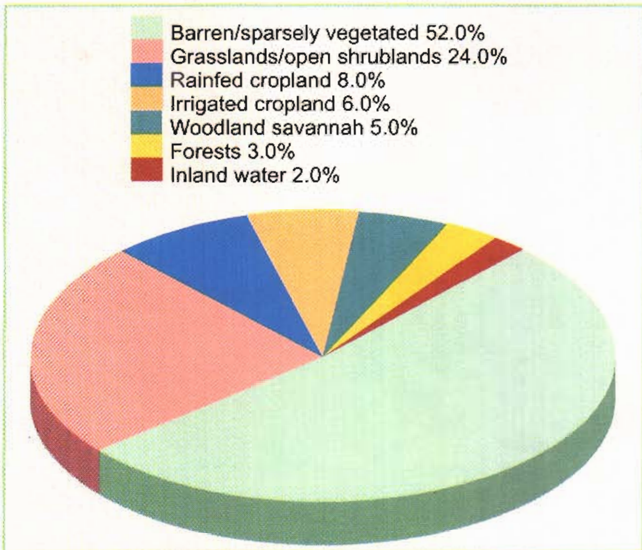


Fig. 5. Relative importance of different land-cover classes in CWANA.

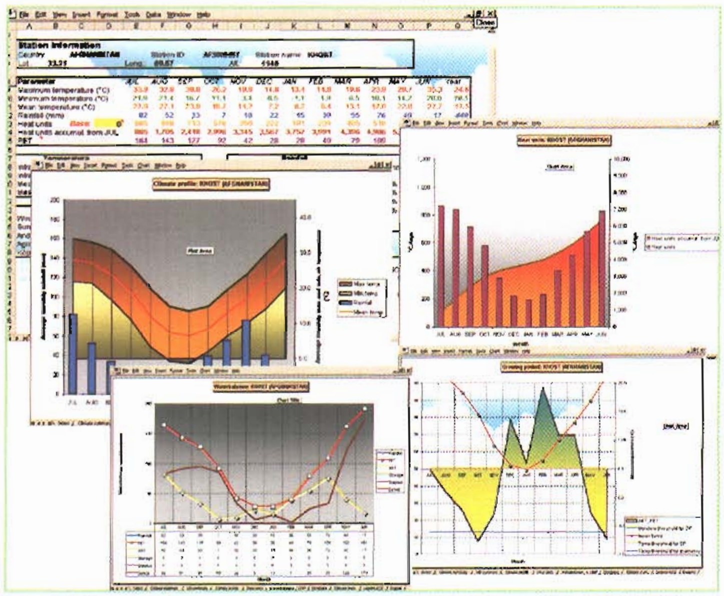


Fig. 6. CWANA meteorological database: station-specific views of derived agroclimatic information (example of Khost, Afghanistan).

New Land-Use Map of Syria

The draft land-use map produced in 1998 has been substantially revised. The revised map, to be published in 2000, is a vital input for farming systems research, hydrological modeling, land-use planning, and environmental monitoring in Syria. The map is based on the Syria Space Atlas, published by the General Organization of Remote Sensing (GORS) in Damascus, which contains a georeferenced mosaic of Landsat TM images, representing the late summer land-cover situation of 1990.

The classification used for the map incorporates elements of land cover as well as land use. The map compilation was essentially a GIS exercise, based on visual interpretation of observed features rather than supervised classification using image analysis software and digital imagery. Whereas the 1998 draft map had 25 homogeneous land-use/land-cover categories, the new version has 24 homogeneous and 43 mixed categories. Homogeneous units can be considered relatively pure (80-90%), whereas mixed units are complexes of homogeneous units.

Land-Cover Patterns

One-third of agriculture in Syria is under rainfed systems. Considering the semi-arid and arid conditions in the country, this is a very high proportion of agriculture to the total land area. Of the cultivated area, about 11,500 km^2 is irrigated.

Striking is also the very limited extent of forested or wooded areas (about 3%). According to the satellite images, rangelands occupy only about 10% of the country. This is a major under-representation of the land that is being used for grazing. Many areas classified as "bare land" are in fact grazed, particularly in winter and spring (Fig. 7).

Degradation Features

The imagery shows a clear vegetation degradation in the coastal mountains (Fig. 8). This is obvious from the intertwining of original forest vegetation and mosaics of agricultural areas mixed with degraded forms of the original forest vegetation.

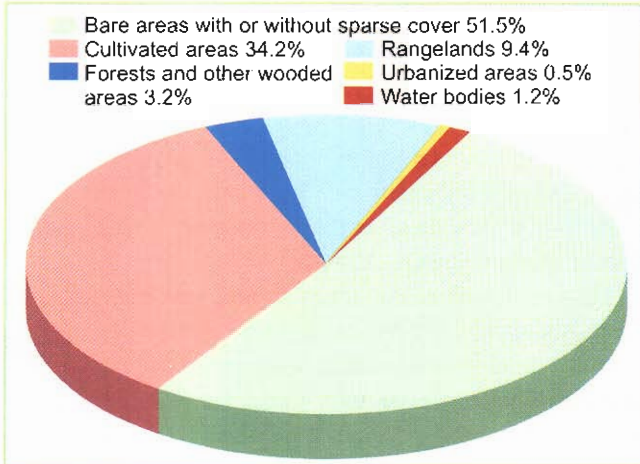


Fig. 7. Distribution of major land-cover categories in Syria.

The imagery also provides evidence that perennial grasses have disappeared almost entirely, except in some depression areas, where their presence may be linked with saline conditions. Whatever the winter/spring conditions for range, the rangelands are largely composed of annual grasses. This is a form of degradation caused by overgrazing.

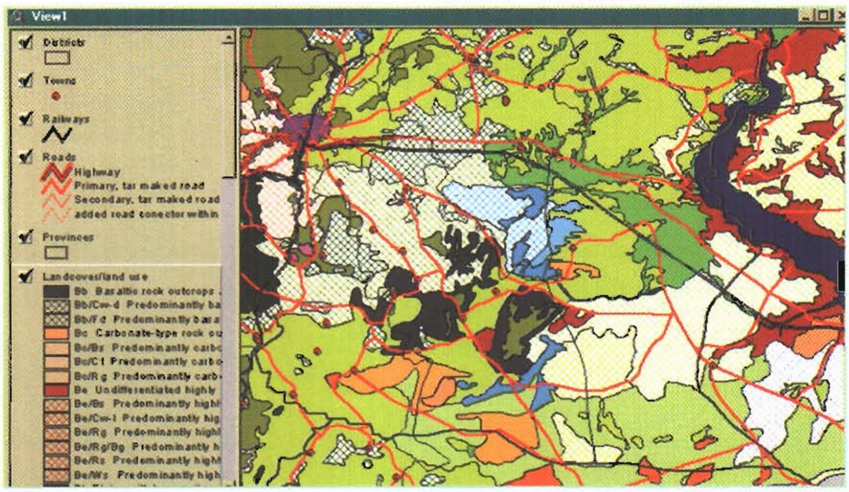


Fig. 8. Detail of land-cover/land-use map of Syria.

Wind erosion is evidenced by the presence of widespread sand sheets in the arid interior, particularly around the eastward extension of the Palmyrenian range, where it covers a combined maximal width of 80 km. This form of wind erosion can occur rapidly and is probably linked to the absence of perennials in the steppe.

Water erosion of a geological nature is obvious, particularly in the bare areas around the Euphrates

Valley (mapping unit Be in Fig. 8), and is entirely natural even in the arid interior which is criss-crossed by large *wadi* systems and other seasonal drainage lines. Large areas affected by accelerated water erosion can be observed in the south and southwest of Jebel Bishri. Gully patterns that extend over the farm blocks indicate that after the farms were abandoned, accelerated erosion took place.

Man-induced salinization cannot be observed directly on the imagery but is inferred from anomalies in the land-use pattern. Large areas in the Euphrates Valley, especially in the south of Deir-ez-Zor, are bare while the canal infrastructure and field pattern typical of an intensive irrigation system, and shortage of suitable land can be clearly seen. Bare patches are too concentrated and too ragged at the edges to be fallow land. Field observations confirm that they represent salinized land.

Germplasm Conservation

Collection Mission in Turkmenistan

In June 1999, a plant collection mission in central southern Turkmenistan (Fig. 9) was undertaken by ICARDA in collaboration with the Center for

Fig. 9. Location of germplasm collection sites in Turkmenistan.

Legumes in Mediterranean Agriculture (CLIMA) and the Turkmenistan National Institute of Deserts, Flora and Fauna, as part of a project supported by the Australian Center for International Agricultural Research (ACIAR). A total of 121 accessions were collected from 32 sites. These accessions represent 44 species including cereal wild relatives, a variety of rangeland species, and various fodder legumes (Table 1). *Aegilops kotschyi*, a drought- and salinity-tolerant species was the most frequent wheat wild relative (11 accessions); and *Hordeum spontaneum*, the wild progenitor of barley, was also common (12 accessions). The diversity of rangeland species collected

Table 1. Number of accessions of plant species collected in Turkmenistan in 1999.

Taxonomic name	No. of accessions	Taxonomic name	No. of accessions
Aegilops cylindrica	5	*Medicago rigidula*	2
Aegilops kotschyi	11	*Medicago sativa*	2
Aegilops tauschii	3	*Melica ciliata*	1
Aegilops vavilovii	2	*Melica jacquemontii*	1
Astragalus angustidens	1	*Melica persica*	6
Astragalus glabiaps	1	*Melilotus alba*	1
Astragalus turcomanicus	1	*Phalaris minor*	2
Callyoneum sp.	1	*Pisum sativum*	1
Cicer arietinum	3	*Plantago lanceolata*	9
Colutea bushsei	2	*Polypogon monspeliaca*	2
Colutea gracilis	2	*Sangisorba minor*	1
Dactylis glomerata	3	*Stipa caspia*	5
Glycyrrhiza glabra	1	*Stipa caucasica*	1
Haloxylon persicum	1	*Stipa hohenacherana*	1
Hordeum bulbosum	6	*Trifolium angustifolium*	1
Hordeum vulgare	1	*Triticum aestivum*	5
Hordeum vulgare subsp. *spontaneum*	14	*Vicia lutea*	1
Imperata cylindrica	3	*Vicia narbonensis*	1
Lathyrus aphaca	1	*Vicia sativa* subsp. *nigra*	5
Lathyrus cicera	6	*Zygophyllon atriplicoides*	2
Medicago lupulina	1		

may be valuable for research related to the rehabilitation of the extensive rangeland areas of Turkmenistan and other Central Asian countries.

Database of Uzbekistan's Plant Genetic Resources

The Uzbek Research Institute of Plant Industries (UzRIPI), Tashkent, maintains a large collection of plant genetic resources. The Institute was organized under the leadership of N.I. Vavilov in 1924. Through numerous collection expeditions in Central Asia, and active germplasm exchange program, UzRIPI has built up a world collection of over 50,000 accessions of cultivars, landraces, and wild relatives. Computerizing the documentation of this collection and establishing a database were initiated three years ago. ICARDA has collaborated in this effort by contributing both to infrastructure development and research program implementation. In addition to installing personal computers, the Center helped UzRIPI to develop a scheme for the database of germplasm collections, organize the data-entry process, and manage the database. Apart from participation of UzRIPI scientists in ICARDA/IPGRI group-training courses, individual training in germplasm documentation was also part of the collaboration. In 1999, the Head of the Information Department of UzRIPI visited ICARDA for three months to study database management technology and to apply it to the Uzbek system. An important component of this work was the linkage with genetic resources database of VIR (N.I. Vavilov All-Russian Scientific Research Institute of Plant Genetic Resources). The UzRIPI database is now up and running and able to "talk" to systems at ICARDA and VIR. This will facilitate future collaboration in the conservation and use of genetic resources with VIR.

Study of Diversity in Barley Landraces

A set of 30 barley landrace accessions originating from different regions of Ethiopia, Eritrea, and Yemen was studied using randomly amplified polymorphic DNA (RAPD) analysis. Nei's distance results of the matrix were subjected to cluster analysis. Seven clusters defined seven different groups at an arbitrary genetic distance 0.2 (Fig. 10). The first cluster contains mainly the six-row hulled barley collected in the transect from the center (Ars, Har, She3, She4, 6h) to the north of Ethiopia (Tig5, Tig6, 6h). The second cluster includes the two-row hulled barley from GamoGofa, Ethiopia. The third group, which is more heterogeneous than the first two, includes two-row naked, deficient, and irregular hulled barley mostly from Eritrea and Tigray. It also includes landraces collected in Ethiopia. The fourth group is more diverse because it includes two-row, six-row, and irregular barley types from the north of Ethiopia. The last three groups include the irregular, deficient, two-row barley. The means of Nei's distance ranged from 0.00 (from Arsi landrace) to 0.60 (between Shewa 2, 2n and Tigray 5, 6h).

Based on the analysis of molecular variance (AMOVA), different populations from Ethiopia showed the highest within-population diversity. The variance within population was 38% of the total variation. Accessions Gojam, Kefa, Welega, Shewa 2 from the central west region; Tigray 3 and 6, and Welo from the northeast of Ethiopia, and Eritrea 7 had the highest sum of squares, that is, highest diversity. Landraces from Arsi, Bale, Hararge, Shewa 3,

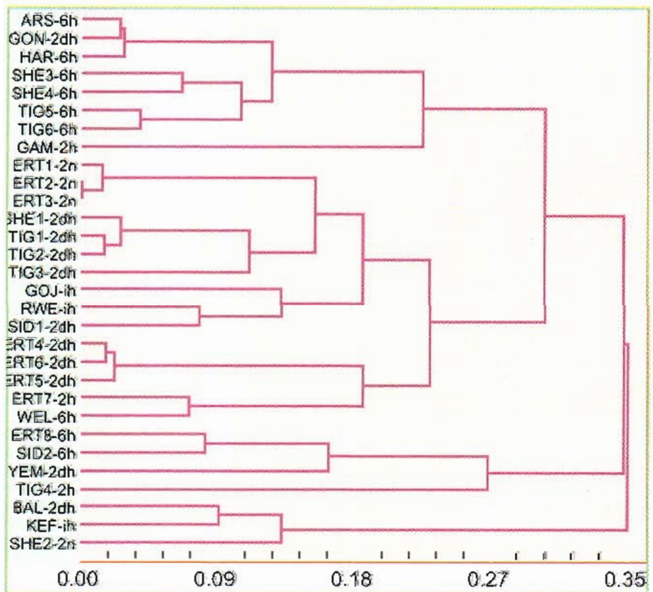


Fig. 10. Diversity in barley landrace accessions from Ethiopia, Eritrea, and Yemen.

Sidamo 1 and 2, Tigray 1 and 4, and Eritrea 2, 4 and 5 presented an intermediate within-population diversity. The remaining 10 accessions showed low within-population diversity, with the Yemen accession being the lowest. This new knowledge of the genetic diversity pattern will help in developing an optimal genetic resources conservation (both *ex situ* and *in situ*) strategy. It will also facilitate the rational utilization of indigenous germplasm in barley improvement programs for East Africa and elswhere.

Diversity in Wild Wheat in Lebanon

A study of the genetic diversity in wild wheats (*Triticum urartu* and *Triticum turgidum* subsp. *dicoccoides*) collected from 14 natural populations in Lebanon was carried out using RAPD and amplified fragment length polymorphism (AFLP) techniques. For RAPD analysis, four primers were chosen for DNA amplification. In total, 44 and 31 polymorphic fragments were identified for *T. urartu* and *T. turgidum* subsp. *dicoccoides*, respectively. Genetic diversity among and within populations was assessed by AMOVA and from dendrograms based on the Jaccard similarity index matrix using the unweighted pair group arithmetic average (UPGMA) method. This helped in assessing the geographical dimensions and evolutionary patterns of the wild wheat genetic diversity. AFLP analysis has also been carried out to compare the same populations. Differences between similarity matrices generated from the RAPD and AFLP analyses were significant in *T. turgidum* subsp. *dicoccoides*. This information on the genetic diversity of wild wheat populations in Lebanon will be useful for optimizing the future collection and *in situ* conservation strategy.

Characterization of Chickpea Using Microsatellite Markers

To initiate the characterization of ICARDA's chickpea core collection, 484 accessions collected from 27 countries were analyzed with single tagged microsatellite (STMS) markers. Several types of molecular markers have been widely used in the estimation of genetic diversity. Techniques such as RFLP, RAPD, AFLP, and STMS were used for the testing. However, the level of variability detected was very low in all techniques except in STMS. Generally, STMS are single-locus co-dominant markers, derived from small, repetitive elements called microsatellites. The mutation rate of the microsatellites is high and accounts for the high polymorphic sequences. The surrounding single-copy sequences are normally not affected, and they are used as primers to amplify the concerned microsatellites. Length differences of amplification products, normally caused by variable number of tandem repeats (VNTR), are then detected by electrophoresis on polyacrylamide gels. Efforts to improve chickpea by marker-assisted breeding have led to generating more than 150 STMS markers that were used for constructing a genomic map of chickpea and for the biodiversity study. Eight STMS loci, represented by eight primer pairs, were analyzed in the core collection. These loci were very variable, and so was the number of alleles per locus.

Only results concerning the locus TS45 are presented here. Thirteen alleles were detected for this locus (Fig. 11), some of them were frequent (e.g., alleles 8, 9, 10) while others were rare (e.g., alleles 1, 2, 13). The level of genetic variability represented by the number of detected alleles varied according to the country. The low number of alleles reflects the high level of similarity between accessions and the high number of replicated accessions (30 accessions have the allele 10). These results should be compared with those of other primers to determine if those accessions are identical or different. If the same accessions give the same results with other primers, then the number of such accessions in the chickpea core collection should be reduced.

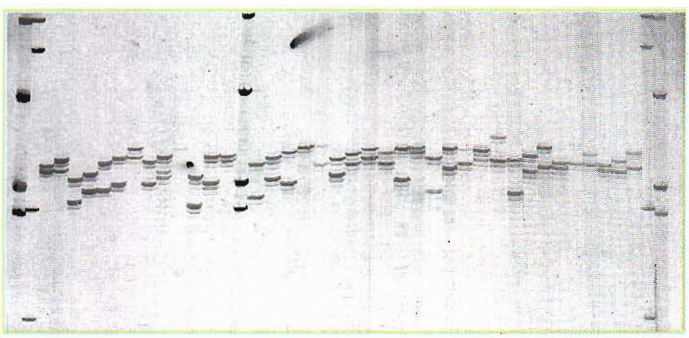


Fig. 11. Number of alleles detected for the locus TS45 and the frequency of each allele in chickpea.

Fostering Linkages with VIR

During the 1998/1999 season, 400 lentil, 500 pea, 399 faba bean, 299 chickpea, and 207 barley accessions from the N. I. Vavilov All-Russian Scientific Research Institute of Plant Genetic Resources (VIR) collection were grown at ICARDA for safety duplication and evaluation. This germplasm represents an important addition to the ICARDA collection because many of these accessions are rare, old landraces originating from countries of the former Soviet Union. A legume scientist, Dr Larissa Prilyouk, and a cereal scientist, Dr Olga Kovaleva, from VIR visited ICARDA to evaluate the donated material. They also had the opportunity to learn new computer skills that will help them in their work at VIR.

ICARDA has also been collaborating with VIR's Documentation Department. Reciprocal visits by documentation personnel have facilitated the exchange of ideas and approaches to database management. Ms Irina Abramova, a database programmer at VIR, visited ICARDA in December 1999 to study ICARDA's documentation system. She also discussed aspects of the VIR database development and that of a documentation system being constructed, in collaboration with ICARDA at UzRIPI.

GEF/UNDP Project on Conservation and Sustainable Use of Dryland Agrobiodiversity

The implementation of the Project on "Conservation and Sustainable Use of Dryland Agrobiodiversity" in Jordan, Lebanon, Palestine and Syria, supported by the Global Environment Facility of the United Nations Development Programme (GEF/UNDP), started in June 1999 following the stakeholders meeting at ICARDA headquarters. The First Regional Technical and Planning Meeting was held in July 1999 in Amman, where country representatives and international experts discussed methodologies for assessing the causes of genetic erosion, strategies for promoting *in situ* conservation, and sustainable use of the diversity of target crops and their wild relatives.

Five types of survey formats were developed: (i) a site selection format; (ii) characterization of monitoring sites; (iii) a socioeconomic survey of cultivated crops, and a rapid rural appraisal of local knowledge related to biodiversity; and (iv) a survey of wild relatives.

ICARDA researchers and the Lebanese National Project Team members examine a site for conservation of dryland biodiversity in Baalbek area, Lebanon.

Two target areas are chosen in each of the participating countries: Ajloun and Mowaqqar in Jordan; Aarsal and Baalbeck in Lebanon; Al-Haffe and Sweida in Syria; and Jennin and Hebron in the Palestinian Authority. More than 20 sites and 40 monitoring areas have been selected in these eight target areas of the project. The project areas and sites show important differences in climatic conditions, soil, and vegetative cover and are representative of different ecosystems and farming systems prevailing in the dry areas. The vegetation at the sites is highly degraded due mainly to overgrazing and habitat destruction. The monitoring areas were selected to include samples of landraces and wild relatives of barley, wheat, lentil, vetch, lathyrus, medics, trifolium; of fruit trees (almond, olive, pistachio, plum, pears, cherries, apricot and figs), and of onion.

The characterization of the project areas and sites requires multi-scale datasets. These datasets should provide climatic, topographic, soils, and land-cover/land-use information. This information will be linked with the distribution of the target species to assess the changes in biodiversity.

The project activities are conducted by the National Project Components with technical back-stopping from ICARDA, IPGRI and ACSAD scientists.

Other activities conducted under the regional component executed by ICARDA included:

- Preparations for two regional courses, one on "Water and Soil Management" and the other on "Eco-geographic and Botanical Survey" to be held at ICARDA during January and February 2000, respectively.
- Preparations to launch a project web site in 2000.
- Contribution to Syrian national meetings on the development of a national strategy and a work-plan for the conservation of biodiversity.
- Participation in the UNESCO/ALECSO (Arab League for Education, Culture and Science Organization) "Regional Workshop on Enhancing Capacity Building for the Conservation of Biodiversity in the Arab Region Using Biosphere Concept and Sites" and "Second Regional Meeting of the Coordinating Council of the Arab MAB (Man and Biosphere) Network" and presentation of a paper on "Community based *in situ* conservation of biodiversity in the WANA region." The Palestinian Project Coordinator and Manager also attended this meeting.
- Visits to attend the National Steering Committee meetings and to discuss the implementation of the project activities in Jordan, Lebanon, and Syria.
- A consultative meeting between ICARDA, IPGRI, and ACSAD was held to discuss the implementation of the regional activities related to technical backstopping and training.

Germplasm Enhancement

Drought Tolerance in Barley

During 1999, the total rainfall in Breda (197 mm), Syria, was well below the long-term average (258 mm). Rainfall started in the middle of November, and reached only 63 mm by the end of December (about 30 mm less than long-term average). Eventually, the crop suffered a period of drought which lasted nearly 40 days, from the beginning of February to mid-March, receiving only 4 mm. At this time, with only 113 mm of rainfall, a number of barley lines, which were already heading, did not show any symptom of drought stress such as wilting, leaf rolling, or leaf senescence.

The drought tolerance was scored visually (Fig. 11) on a 1 (tolerant) to 5 (susceptible) scale. Most of the highly tolerant lines were early, but not all the early lines were drought tolerant. This indicates that lines such as 'Sara' and 'Zanbaka'/ *Hordeum spontaneum* may have a combination of escape and resistance mechanisms. Figure 11 also shows the heading date of some of the known barley varieties.

Drs Salvatore Ceccarelli (left) and Michael Baum, Senior Barley Breeder and Biotechnologist, respectively, at ICARDA, examine a new barley variety (right) that produced good yield with as little as 113 mm of rainfall in Breda, Syria.

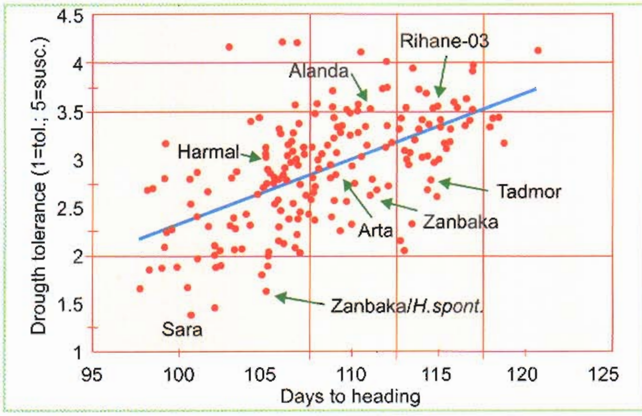


Fig. 11. Relationship between the score for drought tolerance and earliness in nearly 200 barley lines. Most drought-tolerant lines were also early (bottom left quadrant) but not all early lines were drought tolerant (left upper quadrant).

Many of the lines that performed well with 113 mm rainfall did not take much advantage of the subsequent rains: the most notable exception was a line derived from the cross between 'Zanbaka' and *H. spontaneum* which was top yielding at Breda with nearly 1.5 t/ha of grain and a yield advantage of 9% over 'Arta,' 40% over 'Sara,' 'Zanbaka,' and 'Tadmor,' and 50% over modern cultivars such as 'Harmal' and WI2291. The performance of this line in Breda, and of some of the most drought-tolerant material developed in the past, is shown in Fig. 12.

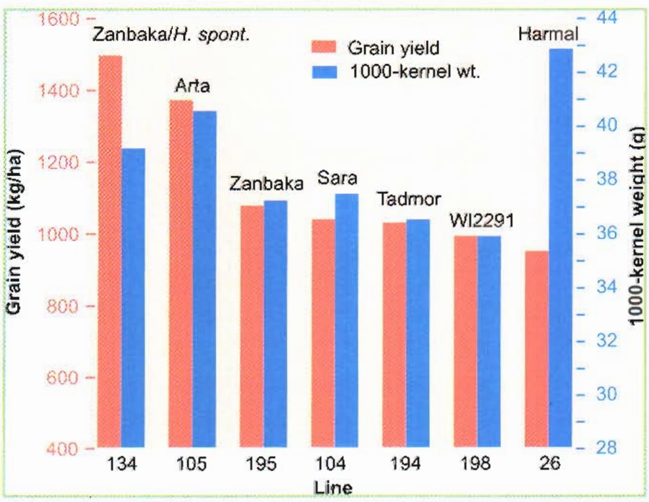


Fig. 12. Grain yield (kg/ha) and 1000-kernel weight (g) of a new drought-tolerant line (a cross between 'Zanbaka' and *H. spontaneum*) compared with the best barley lines available for the dry continental areas of the Near East.

Drought tolerance results were confirmed in a farmer's field in the Raqqa province in Syria, where the rainfall was only 187 mm rainfall, with its distribution similar to that in Breda, and where a total of 117 lines (including a check) were tested. In this location, the crop was at the limits of survival with an average grain yield of 365 kg/ha and an average biomass yield of 1536 kg/ha. Seventeen lines failed to produce any grain. The maximum grain yield (between 670 and 750 kg/ha) was obtained with three lines: WI 2291/Tadmor, 'Sara', and 'Zanbaka'/*H. spontaneum*. This represented an increase of up to 35% over 'Zanbaka'–a barley line adopted by some farmers, and 23% over 'Arta.'

The yield advantages obtained in the severe drought conditions of 1999 confirmed the benefits of using locally adapted landraces and wild barley in breeding for stress environments.

Diversity in Barley Landraces

The Near East region is recognized as a center of genetic diversity and one of the three nuclear centers of agricultural origin. This area corresponds geographically to a region which extends from Palestine through Syria, southern Turkey into Iraq, and western Iran.

It is estimated that 38% of the world's food is provided by crops which originated in the semi-arid regions of the Near East. It is now widely recognized that wild progenitors, wild relatives, and landraces of these crops are still available in this region, and offer a rich reservoir of genes for adaptation and survival in harsh environments.

ICARDA maintains a collection of about 6000 pure lines derived from Syrian and Jordanian barley landraces.

To describe the population structure of these landraces from a morphological, agronomic, and molecular standpoint, 500 barley lines were used, of which 480 had been derived from landraces collected from four to five sites in each of five geographic regions (Fig. 13).

These regions represent the south, the center-west, the northeast, and the central steppe of Syria, and the south and north of Jordan, which are the main barley-growing areas of these countries. Each

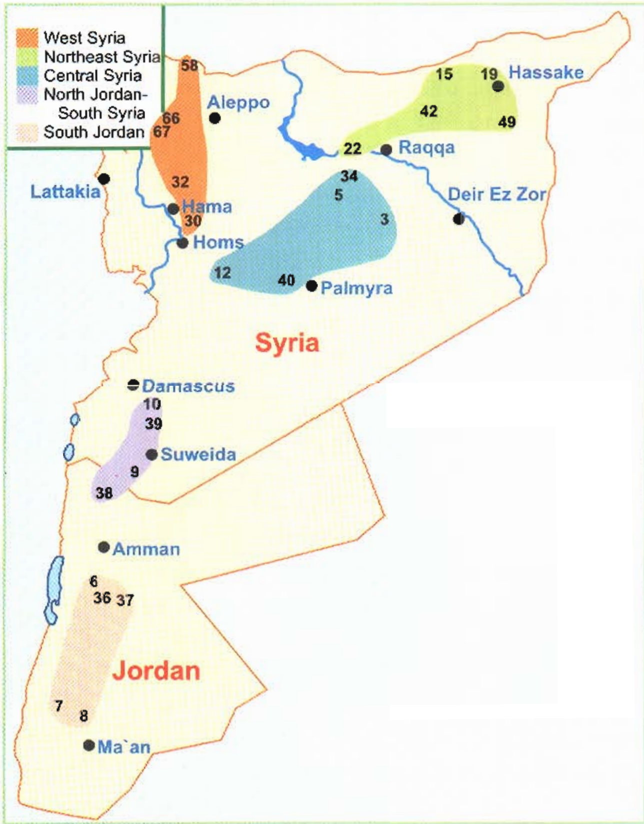
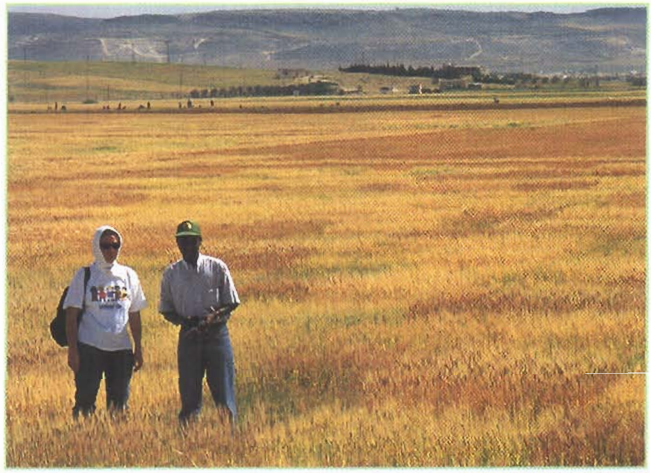


Fig. 13. Map of Syria and Jordan showing the five regions of origin of barley landraces.



Dr Stefania Grando (left), ICARDA Barley Breeder, and Mr Berket Tekle, an Eritrean scientist, examine variability in barley lines extracted from Syrian landraces, and grown at Breda, Syria, 1998/99. The work reported here is based on Mr Tekle's field work at ICARDA, carried out as part of his M.Sc. thesis accepted for the award of the degree by the University of Copenhagen, Denmark.

collection site was represented by 20 pure lines, each derived from a single head of the original collection. In addition, 10 modern varieties developed for favorable conditions, and 10 lines developed for specific adaptation to the harsh environments of the Near East were included. The trial was planted for two consecutive seasons, both at Tel Hadya and Breda in Syria.

A large variation for most of the recorded characters was observed between regions, between sites within regions, and between lines within sites.

Lines originating from northeast Syria were the most prostrate, the poorest in vigor in the early stages of growth, and the most cold tolerant. Lines collected from Jordan had an erect growth habit, and were vigorous in the early stages, and the most cold susceptible.

Lines from Jordan and south Syria were on average 3-5 days earlier in heading than those from west, central, and northeast Syria. Lines from northeast Syria were the tallest and the lowest yielding, while lines from west Syria were the shortest and the highest yielding at Tel Hadya. At Breda, lines originating from north Jordan and south Syria yielded more than lines from other regions.

The information on variability of landraces generated by this study will be used to construct mixtures with various degrees of heterogeneity, which will provide a model of utilizing agricultural biodiversity. These models can be used for other crops and/or countries, and will help in formulating collection strategies.

Osmotic Adjustment in Barley

Osmotic adjustment (OA) is recognized in several crop plants as an effective component of drought resistance. Osmotic adjustment results from the active accumulation of solutes within cells, which lowers the osmotic potential (OP) beyond the level dictated by mere "concentration effect" of tissue water loss on OP. Osmotic adjustment helps maintain turgor of both shoots and roots as plants experience water deficit. This allows turgor-driven processes such as stomatal opening, cell enlargement, and expansion growth to continue, though at reduced rates, to progressively lower leaf water potentials (LWP). Growth and yield under limited-water conditions can be improved by selecting lines with higher levels of OA in wheat, sorghum, and barley.

Studies were carried out to determine the magnitude of OA capacity in barley genotypes and to see if there was any difference in OA among the genotypes. The information will be used to select populations for tagging QTLs (Quantitative Trait Loci)/genes associated with osmotic adjustment and drought tolerance in barley.

The OA capacity of the tested genotypes is presented in Fig. 14. Variation in OA capacity for these genotypes ranged from 0.27 MPa to 1.06 MPa. Although only 11 genotypes were evaluated in this experiment, the magnitude of OA in them was larger than that found in previous studies (-0.17 to 0.46 MPa), suggesting that the ICARDA genotypes are very diverse in OA capacity.

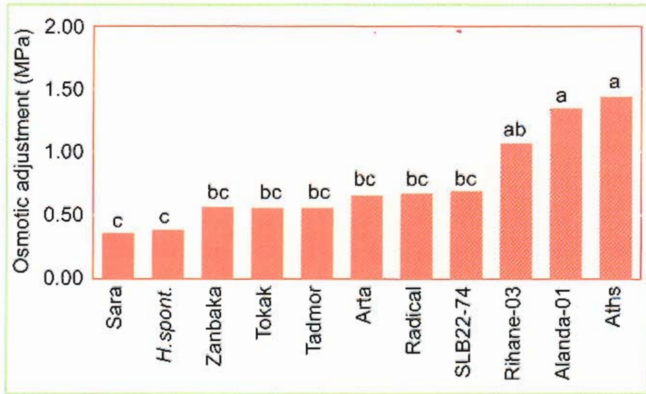


Fig. 14. Osmotic adjustment in 11 barley genotypes as evaluated in the spring of 1999 at Texas Tech University, USA. The bars with common letters are not different at the level of 5% (LSD at 5% = 0.39 MPa).

Quantitative Trait Loci for Disease Resistance and Agronomic Traits in Barley

The success of breeding barley for yield stability in stressful environments has been limited because of the high variability in the timing, duration, and severity of a number of climatic stresses. In northwest Syria, the most important abiotic stresses affecting rainfed crops, such as barley, are low temperatures in winter and terminal drought and heat in spring. A number of biotic stresses such as the foliar diseases, powdery mildew, and scald also limit yields.

A population of 245 lines (F_6) recombinant inbred from the cross 'Tadmor' and 'Sel 160' was mapped using RFLP, RAPD, and microsatellite markers (Fig. 15). An 882 cM linkage map consisting of 15 individual linkage groups was constructed. With this linkage map, quantitative trait loci (QTL) analysis was performed for a number of agronomic, physiological, disease resistance, and straw quality traits.

A major QTL (RF-1) for scald was identified and localized on chromosome 4Hc, explaining about half of the phenotypic variation, and a second QTL (RL-2) was found on 4Hd, explaining 3.4% of the phenotypic variation. In the case of powdery mildew, one QTL (P1-1) was identified and localized on chromosome 1Ha, explaining 22.6% of the phenotypic variation. Both alleles from 'Sel 160' resulted in 26% less powdery mildew infection than the lines with two alleles from 'Tadmor.' This QTL was also found in the analysis of the data of the second powdery mildew scoring (P2-1), which explained 18.1% of the phenotypic variance. For this second scoring, another QTL was localized on 2Hb (P2-2) explaining

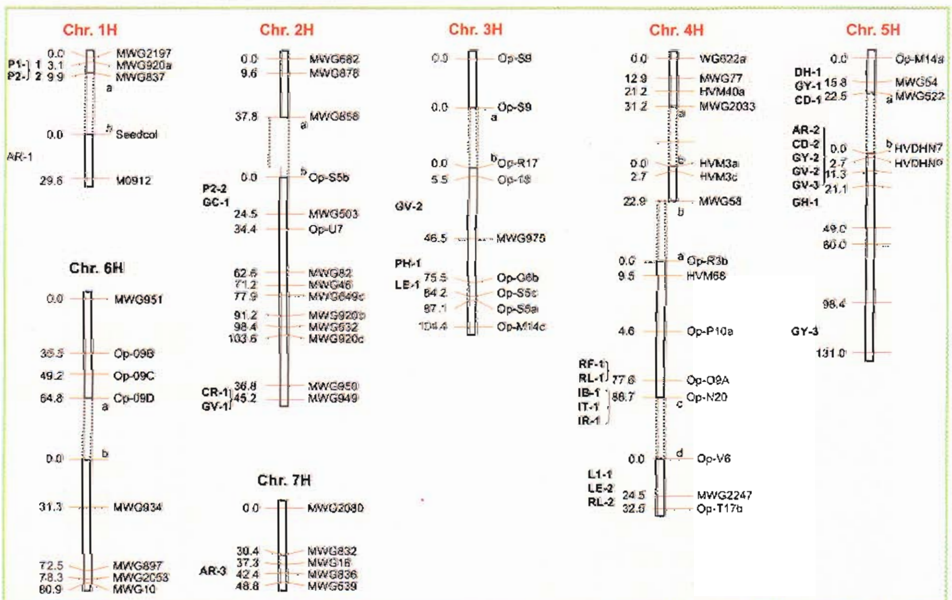


Fig. 15. Molecular map of barley constructed with 245 lines (RIL) from the cross 'Tadmor'/'Sel160.'

4.6% of the phenotypic variance; both QTLs explained 18.4% of the phenotypic variance. In this case, the lines with the 'Tadmor' allele were more resistant.

A number of QTLs related to yield under stress conditions clustered on chromosome 5H such as QTLs for days to heading (DH-1 on chromosome 5Ha, which explained 4.5% of the phenotypic variation), cold damage (CD-1 on chromosome 5Ha and CD-2 on chromosome 5Hb, explaining together 32.5% of the phenotypic variance and 37.5% of the genetic variance), growth habit (GH-1 localized on chromosome 5Hb, explaining 6.8% of the phenotypic variation), and early growth vigor (GV-1 on chromosome 2Hb, GV-2 on chromosome 3Hb, and GV-3 on chromosome 5Hb, explaining together 12.4% of the phenotypic variation). All three QTLs for grain yield (defined as average grain yield across locations and years) were also localized on chromosome 5H, one on 5Ha (GY-1) and two on 5Hb (GY-2 and GY-3). The three QTLs explained 23.3% of the phenotypic variation and 70.0% of the genetic variation. The group with the highest grain yield has Tadmor-alleles on GY-1 and GY-2 and Sel 160-alleles on GY-3, and it outyields the best parental combination with Tadmor-alleles on all QTLs.

A QTL for plant height was located on chromosome 3Hb, in the vicinity of the location of the *denso* gene.

A QTL for lodging (LI-1) was localized on 4Hd and explained 4.3% of the phenotypic variance. The QTL showed a highly significant QTL ˘ environment effect and the lines with both alleles from 'Sel 160' were more lodging-resistant than the one with the 'Tadmor' alleles.

Two QTLs were detected for leaf color, one on 3Hb (LE-1) and one on 4Hd (LE-2). The effect of both QTLs was similar. The 'Sel 160' alleles caused darker color. LE-1 and LE-2 together explained 14 % of the phenotypic variance.

Three QTLs for awn roughness (AR-1, localized on 1Hb, AR-2 localized on 5Hb, and AR-3 localized on 7H) together explained 40% of the phenotypic variance. Only for AR-1, 'Tadmor' contributed the allele with high roughness, while for the other two QTLs the alleles from 'Sel 160' showed a higher roughness.

The clustering of QTLs related to the expression of yield in marginal environment (DH-1, GY-1 and CD-1 in the interval Op-M14a-MWG54-MWG522 on chromosome 5Ha and CD-2, GY-2 and GV-3 in the interval HVDHN7-HVDHN9 on chromosome 5Hb) was one of the most interesting findings of this study. The two QTLs for grain yield and days to heading and the QTL for cold tolerance originate from 'Tadmor,' while the QTL for early growth vigor only originates from 'Sel 160.' A QTL for growth habit, originating from 'Tadmor,' is also located on chromosome 5Hb in the interval MWG533 BMWG569. Additionally, one of the three QTLs for awn roughness (AR-2), which maps in the same region as the roughness gene *R* or *raw1*, is also localized on chromosome 5Hb. The relatively high correlation between grain yield and awn roughness (-0.28) could be due to the reduced evaporation associated with awn roughness.

All these traits, which appear to be concentrated in a relatively restricted chromosomal region, are those which, in the past studies, were found to be associated with the consistently good performance of landraces in the Syrian type of stress environments. It is also interesting to note the close association of these traits with the dehydrin genes on chromosome 5Ha.

These results could partly explain why genotypes with 'Tadmor' as a common parent have a higher yield under stress than the population mean. The use of molecular markers associated with the three QTLs for grain yield on chromosome 5H, together with the markers for quantitative resistance to powdery mildew on chromosome 1H and to *Rhynchosporium* on chromosome 4H, can considerably improve the efficiency of selecting barley genotypes with combined tolerance to abiotic and biotic stresses.

Multiple Disease Resistance in Barley

In the major barley-growing areas of the CWANA region, foliar and seed-borne diseases are widespread. Scald, net blotch, powdery mildew, and leaf rust are common in many countries of this region. Seed-borne diseases such as barley stripe and smuts are also very common.

At ICARDA, screening for a broad spectrum of disease resistance has been under way. Barley breeding nurseries that are grown by NARS collaborators were evaluated against five to seven barley diseases (Table 3). Fixed barley genotypes within the advanced breeding nurseries were tested for combinations of foliar and seed-borne diseases.

Table 3. Nurseries tested for multiple disease resistance at ICARDA.

Nurseries	No. of entries	Diseases
PDG 98	255	scald, net blotch, powdery mildew, barley stripe, leaf rust, loose smut, covered smut
PDG 99	350	scald, powdery mildew, barley stripe, loose smut, covered smut
ADG 98	55	scald, powdery mildew, barley stripe, loose smut, covered smut
ADG 99	254	scald, powdery mildew, barley stripe, loose smut, covered smut
Net blotch 99	35	net blotch, leaf rust, scald, powdery mildew, covered smut
Total	954	

The distribution of resistant lines in the barley-breeding nurseries grown in the WANA region is shown in Table 4. The Preliminary Disease Germplasm (PDG) 99 nursery showed an improved level of resistance to at least three diseases in WANA. The highest levels of resistance to three diseases were also recorded in PDG 98 and Advanced Disease Germplasm (ADG) 98 nurseries, whereas a high level of resistance to five diseases was recorded in ADG 99 (Fig.16). The available resistance sources to specific diseases were selected in PDG 99 nursery (Fig.17). Complete resistance to all diseases was relatively low as compared to resistance to individual disease (Table 4).

Among the material tested in this study, 10 fixed progenies (in ADG 99 nursery) were identified as resistant to seven diseases (Tables 4 and 5) and 48 progenies and fixed lines as resistant to five diseases.

Table 4. Barley lines that showed multiple disease resistance in five selected barley breeding nurseries at ICARDA.

Nurseries	No. of diseases[1]	Resistant to seven diseases	Resistant to three diseases	Resistant to one disease
PDG 98	7	10	60	14
PDG 99	5	3	21	7
ADG 98	5	28	125	45
ADG 99	5	16	110	26
Net blotch 99	5	1	10	16
Total		58	326	108

[1]Diseases listed in Table 3

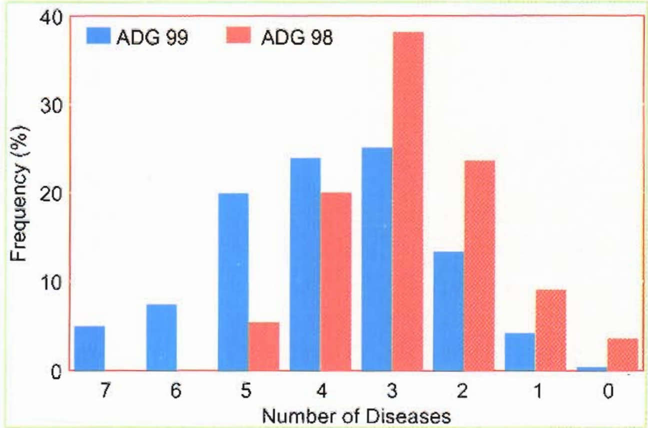


Fig. 16. Multiple disease resistance in two barley nurseries tested at ICARDA.

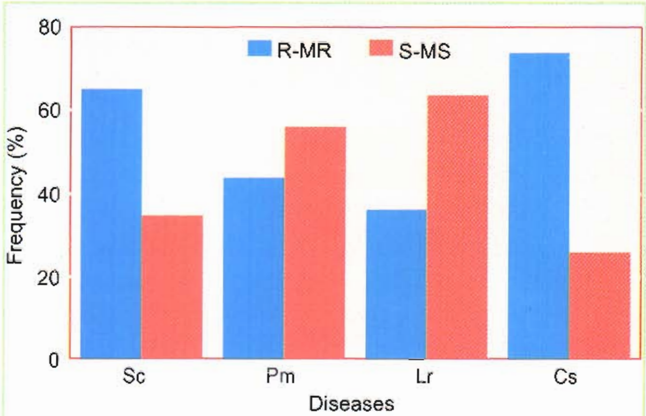


Fig. 17. Available resistance sources in PDG 99 nursery tested at ICARDA.

R-MR = Resistant/Moderately resistant.
S-MS = Susceptible/Moderately susceptible.

Table 5. Barley genotypes resistant to seven barley diseases[1].

- 24569 = (80-5138/Aths)
- Halcyon
- Plaisaut
- Th.Unk.7//WI2197/Cr.272-3-4 ICB90-0942-2BO-1AP-0AP
- Eagle
- Vavilon
- Antares/Ky63-1294/3/Roho//Alger/Ceres 362-1-1 ICB90-0148-0AP-1AP-0AP-3AP-0AP
- Tipper/ICB-102854 ICB90-0032-0AP-5AP-0AP-2AP-0AP
- Line 49-14 D30 IPA-Iraq
- Gloria'S'/Celo'S'//Teran 78 CMB84A-0236-0AP-1AP-0TR-1AP-0TR-0AP

[1]Diseases listed in Table 3 (PDG 98)

Sunn Pest Control with Fungal Isolates

Sunn pest (*Eurygaster integriceps* Puton) is one of the most damaging pests of wheat and barley in West Asia. Annual yield loss is estimated at 20-30% in barley and 50-90% in wheat. Efforts are under way at ICARDA to develop an integrated pest management package, based on entomopathogenic fungi, to replace the existing chemical control methods estimated to cost over US$ 42 million annually in West Asia.

Twenty-eight fungal isolates recovered from the collections in Syria and Turkey were tested against field-collected Sunn pest adults. The fungal dosage used was 5 ˘ 10^7 spores/ml. There were 20 Sunn pest adults per test, five in each of the four bioassay containers. The adults were immersed in fungal suspension for five seconds. Mortality reading was taken 12 days after treatment. Two bioassays per strain were conducted.

The mortality ranged from 30 to 100% among the 28 test strains. Four isolates of the fungus *Beauveria bassiana* and one of *Paecilomyces farinosus* gave a high mortality (>95%), which was 10% higher than that of a commercial strain of *Beauveria bassiana* used as check. These five isolates will be tested further.

Evidence of Slow Rusting in Winter Wheat

Studies conducted at ICARDA during 1998 and 1999 showed evidence of a slow yellow rust infection of wheat. Fifty winter wheat entries of diverse origin were artificially infected at tillering. Disease development and progress was monitored from the onset of first visible pustules on foliar tissues up until flowering. Scores on disease reaction, severity, and incidence were taken. Although each test entry had its own specific behavior, data analysis made it possible to divide the entries into four contrasting groups designated as G1, G2, G3, and G4.

Entries in G1 did not show any visible disease stress. The pathogen either could not multiply on the host plant, or spread but to a very limited leaf area (up to 15%) with only minute, necrotic-spots, visible on the affected leaves. The affected area was therefore nil or very small throughout the season. Entries in this group (e.g., the Turkish cultivar 'Sultan') were classified as resistant.

The other extreme group, G4, included typically susceptible entries. Startup sporulation occurred about five days earlier than in other groups, and leaf coverage by the disease progressed rapidly, reaching 80% or more by heading, and 90-100% by flowering. Examples of G4 entries are the Turkish and the Iranian cultivars 'Gerek' and 'Sardari,' respectively.

Group G3 included susceptible types that are similar to G4 entries for their initial infection, but the fungus multiplication and appearance on the leaves was subsequently slower. The disease severity curve of G3 plateaued at a lower level compared to G4 (Fig. 18), with the leaf coverage by the disease towards heading. Examples of entries belonging to this category are the Russian cultivar 'Bezostaya' and the Turkish cultivar 'Dagdas.'

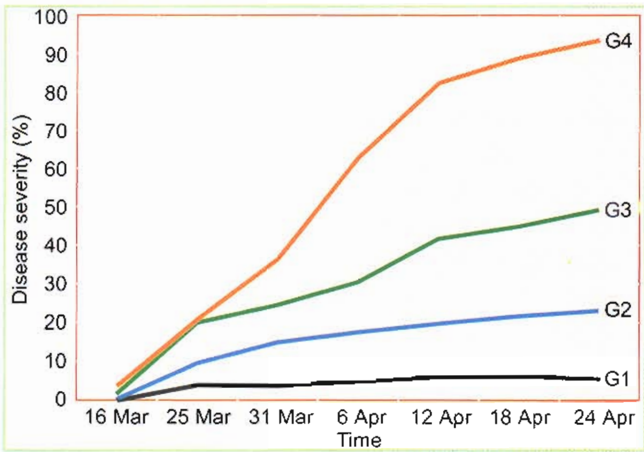


Fig. 18. Four types of wheat response to yellow rust.

Finally, in group G2, plant behavior in response to the pathogen was intermediate between G1 on one hand, and G3 on the other. Plant reaction was generally of moderate susceptibility, or susceptibility with low severity. Although clear yellow rust pustules were visible on the leaves, they were both slower to develop initially and to progress over the leaf area subsequently. The leaf coverage by the rust pustules at heading was about half less than that of group G3, or one-fourth that of G4. Examples of G2 entries include the Turkish cultivar 'Kinaci' and the ICARDA line Tast/Sprw//Zar.

In both G2 and G3, the rate of increase in the infected leaf area decreased with time, as did the speed of the disease progress on plant tissue. However, the slow rusting was more intense in the case of G2, leading to a much more limited yield depression in G2 as compared to G3. The expected yield loss due to yellow rust was negligible in G2, but considerable in G3. This was confirmed by results from small plots grown at ICARDA in 1999, where G3 and G4 yields represented 68 and 54% of the yield of G1. In contrast, G2 yield did not significantly differ from G1. It was also interesting to note that some of the highest yielding types in the CWANA region belonged to the G2 group.

Genetically, the G2 types would be less conducive to new rust races, as they exert less selection pressure on the fungus than do G1 types, and therefore would contribute to enhancing the durability of host plant resistance to yellow rust. Further research is being conducted to understand the inheritance of this slow-rusting attribute to exploit it more effectively in breeding new, improved wheat cultivars for cold- and cool-winter areas of the CWANA region, where yellow rust is a major biotic stress.

Harvest Mechanization for Sustainable Lentil Cultivation in West Asia

Lentil is an important component of the rainfed farming systems in the dry areas of WANA. The cost of lentil production in West Asia has increased tremendously in recent years due to high hand-harvesting costs. This is posing a severe threat to the cultivation of this major cash crop.

In its first decade, ICARDA developed economic machine harvesting systems for lentil production. The Center is cooperating with Çukurova University, Turkey; Aleppo University; and the General Organization of Agricultural Mechanization, Syria, in this research.

A survey on adoption of different harvesting systems in Syria and Turkey was carried out. The harvesting options for the lentil growers in these countries are hand harvest, double-knife cutter bar, small/large self-propelled mower and combine harvester. Small farmers used hand harvesting but the medium and large producers used different machine harvesting systems (Table 6).

Table 6. Harvesting systems used by farmers in Syria and Turkey.

Farmers' category (ha)	Hand harvest		Mower-swather or Double-knife cutter bar		Combine harvester	
	No.	%	No.	%	No.	%
< 3	59	94	2	3	2	3
3 – 30	34	39	23	26	30	35
>30	3	14	8	38	10	48

In Syria, farmers have adopted the combine, while the double-knife cutter bar is the dominating system in Turkey. Harvest-loss studies showed that the double-knife cutter bar gives higher straw yield than the combine or self-propelled mowers (Table 7), and is, therefore, preferred by those growers who use their lentil straw for animal feed.

Table 7. Average yields (kg/ha) and losses (as percentage of yield) with different harvesting systems.

Harvest systems	Seed		Straw	
	Yield	% loss	Yield	% loss
Hand-pulling + thresher	1347	11	1969	8
Double-knife cutter bar + thresher	1160	18	1440	17
Large self-propelled mower + thresher	1243	24	1354	24
Combine harvester	1217	17	1513	10

A side-mounted, tractor-operated, double-knife cutter bar in operation for harvesting lentil in Urfa, Turkey.

However, mechanization alone is not the total answer to improving economic returns from lentil in West Asia. The traditional lentil cultivars are prone to lodging and, therefore, unsuitable for mechanical harvesting. ICARDA, in collaboration with national partners, has developed new varieties, including 'Idleb 1' in Syria and 'Sayran 96' in Turkey, which have good standing ability and resistance to mechanical damage.

Improved cultivars harvested with machine provided a saving of 17-20% on harvest costs. For the grower, this was worth an extra US$ 100 per hectare; for the local economy in the two areas surveyed it was worth about US$ 13 million a year.

Effect of Melia Seed Water Extract on Sitona Feeding

Sitona crinitus H. is an important insect pest of lentil in the WANA region. *Sitona* adults feed on leaflets, but the larvae feed on nodules and cause most damage. Insecticides effective against this pest have been identified, but their use in farmers' fields is limited because of their high cost and the environmental hazards associated with their use.

An experiment was carried out to find alternatives to the use of insecticides. Powder from *Melia azedarach* dry fruits was soaked in tap water for 24 hours; three concentrations were prepared, 15, 25, and 50 g/l. Deltamithrin (0.1 %) and water were used as checks. Ten seedlings of lentil/pot at about 10 cm height were infested with six pairs of *Sitona* adults. Plants were infested 30 minutes after the spraying.

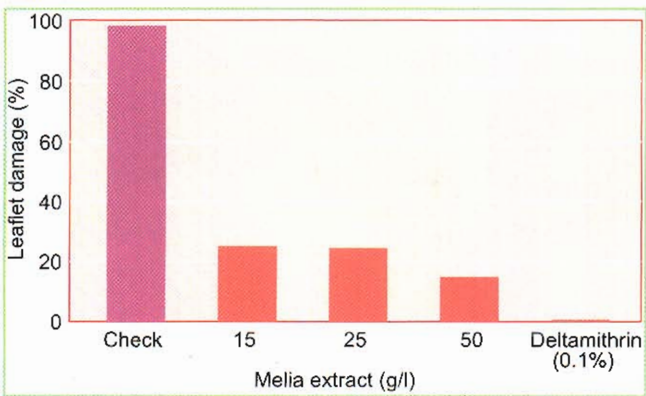


Fig. 19. Effect of three concentrations of water extracts from dry fruits of *Melia azedarach* on *Sitona crinitus* adult feeding.

The percentage of leaflet damage was assessed three days after infestation.

The insect feeding activity was significantly reduced on treated plants, and the leaflet damage for the three concentrations was 24.8, 24.2, and 14.7%, respectively, compared with 98% for the unsprayed check (Fig. 19).

Since *M. azedarach* tree is common in WANA, water extracts from its fruits could provide a cheap and environment-friendly means of controlling this lentil pest. Further studies are being carried out to determine whether there is any residual effect of Melia fruit extracts on seeds of treated plants and any side-effect on beneficial insects.

Drought Tolerance in Chickpea

Kabuli chickpea is one of the most important cool-season food legumes grown in spring in Central and West Asia and North Africa. However, terminal drought often hits the spring-sown crop, and reduces yield. Efforts are under way at ICARDA to develop improved cultivars of spring-sown chickpea that can withstand the terminal drought and produce good yield.

A reliable screening technique involving delayed sowing of chickpea by three weeks during spring at a relatively dry site at Tel Hadya was used to evaluate 1000, 544, and 600 germplasm lines in 1997, 1998, and 1999, respectively. The material was scored using a 1 (= resistant) to 9 (= susceptible) scale. The lines found resistant in 1997 and 1998 were reevalu-

Chickpea drought tolerance nursery at Tel Hadya, Syria, 1999. The genotypes susceptible to drought showed no or poor pod development.

ated in 1999. Rainfall in 1999 was both low and unevenly distributed in WANA, and led to a severe drought and caused heavy losses of the spring-sown chickpea. This provided an opportunity to screen improved lines against drought stress. Of the 39 lines tested for confirming their resistance, 22 were found resistant with a rating of 3 (Table 8). It was evident from the data that there was no association between the country of origin and drought tolerance of these lines. These resistant lines have been shared with NARS through the Chickpea International Testing Program of ICARDA for the evaluation of their performance in different countries. In the preliminary screening of an additional 600 lines at Tel Hadya, 89 were rated 3. These will be further evaluated in 2000.

Table 8. Drought-tolerant sources in kabuli chickpea at Tel Hadya, Aleppo, Syria, 1999.

Entry Name	Pedigree	Origin
ILC 19	-	Jordan
ILC 588	NEC 1628-1	India
ILC 1306	PI 339221	Turkey
ILC 1799	NEC 2904	Syria
ILC 3101	ICC 10315	Turkey
ILC 3105	ICC 10319	Turkey
ILC 3182	ICC 10736 PIC	Turkey
ILC 3210	ICC 10769, CRIC-37092	Turkey
ILC 3216	ICC 10776 PIC	Turkey
ILC 3321	No. 38 (Collection from Jissr Shaghour	Syria
ILC 3832	Pch 80	Morocco
ILC 3843	Pch 102	Morocco
ILC 4291	INIAM	Mexico
ILC 4945	FLIP 81-387C/X79TH123/ILC 1929 x ILC 200	ICARDA/ ICRISAT
ILC 5766	IP 1138-1	Pakistan
ILC 6023	PI 468928	Mexico
ILC 6056	WRPIS	USA
ILC 7067	FLIP 86-45C/X82TH101/ILC 215WH x ILC 195WH	ICARDA/ ICRISAT
FLIP 87-51C	X85TH146/ILC 2398 x FLIP 83-13C	ICARDA/ ICRISAT
FLIP 87-58C	X85TH264/ILC 3777 x FLIP 83-46C	ICARDA/ ICRISAT
FLIP 87-85C	X85TH248/ILC 3398 x FLIP 83-46C	ICARDA/ ICRISAT
FLIP 88-42C	X85TH230/ILC 3395 x FLIP 83-13C	ICARDA/ ICRISAT

Gene-Pyramiding to Control Ascochyta Blight of Chickpea

Ascochyta blight (*Ascochyta rabiei*) is one of the most devastating fungal diseases of chickpea in the world. Although various chemical and cultural practices have been developed to control this disease, these are not economical and often do not work. Thus, host resistance is the only reliable means to control this disease.

At ICARDA, efficient field and laboratory screening techniques for ascochyta blight resistance have been developed, and over 25,000 accessions of chickpea germplasm and improved genetic materials have been evaluated. These evaluations have resulted in only a few resistant sources, which have been shared with NARS for testing under local conditions. The multilocation testing of these materials has revealed a differential reaction to the existing races of the pathogen in different areas, suggesting a large variability in the pathogen.

The shifts in the pattern of resistance or breakdown of resistance reported in some countries seem to be due to the presence of a perfect or sexual stage of the pathogen leading to a large variability in the pathogen and making the selection for resistance difficult. Earlier studies on inheritance of ascochyta blight resistance indicated that a single gene controls the disease. But recently it was observed that more than one gene is involved in controlling the disease. Variability in the pathogen has been characterized at ICARDA using DNA molecular techniques and the isolates have been grouped into Pathotype 1, Pathotype 2, and Pathotype 3. Most of the lines identified as resistant and released for general cultivation by NARS are tolerant or resistant to Pathotype 1 or 2, but none is resistant to Pathotype 3, which is more aggressive. Research at ICARDA has demonstrated that Pathotype 3 is widely distributed throughout the WANA region. Therefore, the work on ascochyta blight is concentrated on the evaluation of germplasm and breeding materials against the mixed population of three pathotypes under field conditions, and Pathotype 3 under controlled conditions.

To improve the level of tolerance to ascochyta blight, efforts are being made to pyramid or combine different genes from different sources through multi-

Scientists from Central Asia and the Caucasus, and Eritrea, examine improved chickpea lines at ICARDA's main experimental station, developed through gene-pyramiding.

ple crosses. This scheme has resulted in greater improvement in ascochyta blight-resistance of the improved breeding lines than the single or two-way crosses. The pedigrees involved are: Cross 1 = [[(ILC 95 x ILC 2956) x (ILC72 x ILC215)] x [ILC 95 x ILC 2956]] x ICC 12004; Cross 2 = [(ILC72 x ILC 1922) x ILC 4921] x [ILC 3856 x ILC 4246]; Cross 3 = [ILC 5342 x (ILC 72 x ILC 215)] x ICC 13555.

The derived lines from the pyramiding project have shown better resistance than the standard checks (Table 9). It is interesting to note that some of these newly developed lines possess a reaction of 3 or 4 on

Table 9. Performance and pedigree of some of the elite lines developed through gene-pyramiding at ICARDA.

Name of Genotype	Pedigree	Reaction to stress (on 1-9 scale) AB	CT	FW	SW (g)	Yield (kg/ha)	Rank
S98756	Cross 2	4	4	5	29	2064	1
S98736	Cross 2	4	4	5	25	1804	2
S98753	Cross 2	4	4	5	25	1772	3
S98734	Cross 2	3	3	4	22	1660	4
S98767	Cross 2	4	4	4	25	1617	6
S98798	Cross 2	4	4	3	25	1512	7
S98754	Cross 2	4	3	3	25	1456	8
S98761	Cross 2	3	4	4	26	1392	9
S98758	Cross 2	4	5	5	22	1380	10
S98763	Cross 2	4	4	4	25	1371	11
S98801	Cross 2	4	3	4	24	1362	12
S98739	Cross 2	4	4	5	20	1323	13
S98790	Cross 2	4	4	4	30	1323	14
S98735	Cross 2	4	3	4	25	1292	16
S98752	Cross 2	4	4	4	23	1285	17
S98729	Cross 1	3	4	5	30	1236	19
S98740	Cross 2	3	3	5	20	1228	20
S98757	Cross 2	4	4	5	23	1219	21
S98738	Cross 2	4	3	5	21	1131	22
S98728	Cross 1	3	4	5	23	1110	23
S98764	Cross 2	4	4	4	24	1075	24
S98755	Cross 2	3	4	5	24	1060	25
S98765	Cross 2	4	4	4	24	1054	26
S98805	Cross 2	4	2	3	23	1045	27
S98766	Cross 2	4	2	4	30	961	28
S98799	Cross 2	4	4	4	27	854	29
S98730	Cross 3	3	NA	NA	NA	NA	NA
S98762	Cross 2	3	NA	NA	NA	NA	NA
S98731	Cross 3	4	NA	NA	NA	NA	NA
S98732	Cross 2	4	NA	NA	NA	NA	NA
S98751	Cross 2	4	NA	NA	NA	NA	NA
S98769	Cross 2	4	NA	NA	NA	NA	NA
Ghab 1	Standard check 1	8	6	9	26	1321	15
Ghab 2	Standard check 2	7	5	7	23	1267	18
Ghab 3	Standard check 3	6	4	5	25	1628	5

AB = *Ascochyta* blight; CT = Cold tolerance; FW = *Fusarium* wilt; SW = 100-seed weight.

a 1 to 9 scale (where 1 = free of any damage, 9 = killed), compared with a rating of 6 for the improved check, under controlled conditions. The pedigree, ascochyta blight reaction, seed size and seed yield/hectare of some of the newly developed lines are given in Table 9. It is encouraging to note that some of the lines which have a high level of tolerance and good seed size are also good in seed yield.

Faba Bean Improvement

Faba bean is an important legume crop in the WANA region, the Nile Valley countries, and China. Since re-launching the Faba Bean Pre-breeding Program at ICARDA in the 1996/97 season, research has covered the following aspects:

- Identification of new genetic resources for resistance to fungal and virus diseases.
- Development of improved, high-yielding populations with single and multiple stress resistance for use by NARS.
- Building gene pools for particular stresses by recombining sources of resistance to chocolate spot, ascochyta blight, *Orobanche* and rust, and early maturity.
- Multiplication of 81 germplasm accessions for resistance to chocolate spot (41), ascochyta blight (12), *Orobanche* (18), and resistance to ascochyta blight combined with tolerance to frost and high-yielding ability (10). A total of 400 faba bean germplasm accessions were multiplied for distribution to NARS on request.

Faba bean breeding lines with combined resistance to ascochyta blight, tolerance to frost, and high-yielding ability, compared to susceptible check.

Faba bean accessions tolerant to frost (right, background) compared to susceptible accessions.

The distribution of targeted crosses, genetic resources for resistance to biotic and abiotic stresses, improved populations, and different international nurseries is shown in Table 10.

Table 10. Distribution of new sources of resistance and segregating populations of faba bean.

Year	CB	F_1	S0P	S1P	SH	OF	ICSN (1)	ION (2)	IASCBN (3)	IS1PN (4)	Total (1+2+3+4)
1997	161	-	-	-	175	120	7	5	-	-	12
1998	106	82	5	-	28	233	20	15	-	-	35
1999	89	106	4	1	69	255	30	14	24	28	96
Total							57	34	24	28	143

CB: crossing block (no. of new proposed crosses); F_1: no. of F_1 crosses; S0P: no. of improved populations grown in isolated field plots and exposed to honey bees; S1P: first generation of the improved populations ; SH : no. of germplasm accessions grown under screenhouses for seed multiplication; OF: no. of ILB's and FLIP's grown under the open field conditions; ICSN: no. of international chocolate spot nurseries; ION: no. of international *Orobanche* nurseries; IASCBN: no. of international Ascochyta blight nurseries; ISIPN: no. of international S1 populations.

Survey of Viruses Affecting Forage Crops in Syria

A survey was conducted in collaboration with the University of Aleppo during April-May 1999, in different governorates of Syria, to identify viruses which affect different forage species (*Medicago* sp., *Trifolium* sp., *Lathyrus* sp., *Pisum* sp., *Vicia* sp.).

Symptomatic and random samples were collected from all the fields surveyed. The most commonly encountered viruses were pea enation mosaic virus, broad bean mottle virus, pea seed-borne mosaic virus, alfalfa mosaic virus, and cucumber mosaic virus. The overall virus incidence, estimated from testing the randomly collected samples, was 17%. The total virus incidence range among the forage species surveyed was from 7.5% (*Vicia ervilia*) to 44% (*Lathyrus* sp.). Around 75% of the infected samples had a single virus and 25% had a mixed infection. Since most of the viruses detected are seed-borne in one or more forage legume species, seed quality could be an important factor in forage production in Syria.

The WANA Seed Network Council Meeting

The WANA Seed Network was established in 1992 as a vehicle for regional collaboration and exchange of information among member countries. Since then, members have carried out a substantial program of activities as agreed in the Network meetings. A regular Newsletter "*Seedinfo*" and several technical publications are produced every year. The main decision-making body of the Network is the Council, which comprises the official representatives of all member countries. The Council met in Cairo in May 1999 to review the progress of the various activities. As a result, some changes in the program of work were agreed for the next three years.

Besides reviewing Network activities, the specific theme of the meeting was to find ways to support the National Seed Associations in promoting the development of the private seed industry. Accordingly, representatives of those associations, which now exist in four countries (Egypt, Morocco, Pakistan, and Turkey), were invited to participate in the Council meeting and to give presentations of their progress. This was the first time the private sector had been directly represented in a Council meeting. This helped in addressing the various matters affecting the emerging private sector, and its relations to government.

Policy Advocacy in a Changing Seed Industry

ICARDA participated in a preparatory meeting in Lilongwe, Malawi, for establishing an African Seed Trade Association. The Center presented a paper on "The Experiences of the WANA Seed Network as a Catalyst for Regional Development."

Another major event of the year was the World Seed Conference held in Cambridge, UK, in September to celebrate the 75th anniversary of the International Seed Testing Association (ISTA). This conference was supported by major international organizations involved in seed, and attracted over 400 participants, including many from developing countries. ICARDA presented a paper entitled "Prospects for Privatization of the Seed Sector in Developing Countries," which is a key issue in many countries now as economic liberalization proceeds. The same topic of privatization was presented as a working paper at a regional workshop organized by FAO in Cyprus, in June, to discuss regional initiatives in seed policies and programs.

A new research project on the efficiency of seed supply, which is partially funded by the German Agency for Technical Cooperation (GTZ), was also started. Under this project, ICARDA will carry out studies on the seed supply system in eight countries. The main purpose is to identify the strengths and weaknesses of different seed supply systems, and the effects of changing policies on the seed supply, particularly for small farmers. In the region served by ICARDA, agriculture in marginal and risky environments discourages the farmers from purchasing seed. As a result, those areas are relatively unattractive to the existing private sector and there is a need to devise ways in which farmers can benefit from research innovations.

Regional Seed-Training Program

Training staff from national seed programs has been a key activity of ICARDA since 1985. Currently, all training is supported by a special project funded by the Dutch Government through the Directorate General for International Cooperation (DGIS). This project incorporates a "Train-the-Trainers" approach. For "Train-the-Trainers" courses, the host organization makes all the logistical arrangements, plans the teaching program, and sponsors the participants. ICARDA sends one of its staff as a 'resource person' to provide technical back up during the course. ICARDA also provides some teaching materials and contributes to the local costs.

Ms Arafa Ahmed (center), Economist, Ministry of Agriculture, Sudan, chairs a working group on alternative methods of seed multiplication in Sudan.

In the early years of the project, there were several primary courses but the program is now reaching maturity and most of the training consists of in-country follow up courses. A total of seven of these courses were held during 1999 in Egypt, Iraq, Morocco, Sudan, Syria, and Yemen.

This approach to training has many advantages. The most important one is the opportunity to tailor the teaching directly to the needs of the participants by placing it in the context of their own seed program. Specific problems can be discussed in detail and experience from different areas or organizations within the country can be shared. In fact, these courses provide a forum for interaction between staff who do not normally meet in their daily work.

The subject matter of the courses is shifting from such disciplines as crop inspection, seed testing and processing to seed economics and management.

Resource Management and Conservation

Barshaya Water Management Project Initiates GIS Component

The expansion of irrigation using groundwater, during the last 30 years, has provided many countries in the WANA region with considerable benefits, including higher farm incomes, increased food security, and rural employment. However, high rates of groundwater extraction are often unsustainable. Groundwater levels are dropping; wells have dried up in some areas and irrigated land is returning to rainfed agriculture. Droughts further aggravate the situation. For instance, the drought in1998/99 in Syria affected rainfed crops, livestock, and reduced irrigated acreage. This adversely affected food and feed production and, therefore, farm income. Groundwater depletion is the cumulative result of production choices of individual producers.

ICARDA– in collaboration with the Christian Albrecht University (CAU) at Kiel, GTZ, and BMZ, Germany– has started a study on sustainable groundwater use in the dry areas. The study site is a transect crossing five agroecological zones in northern Syria, each with differing degrees of water availability. Six villages have been selected as locations to conduct research, including Barshaya (Fig 20). The research approach is interdisciplinary and aims to stimulate actions that involve stakeholders in analyzing causes of, and finding solutions for, water scarcity. The research activities cover: (i) water use and hydrology (water use survey and well monitoring); (ii) farmers' knowledge and practice of well-drilling; (iii) institutional factors (participatory research methods); (iv) enterprise budget analysis and cropping pattern; and (v) well investment decisions.

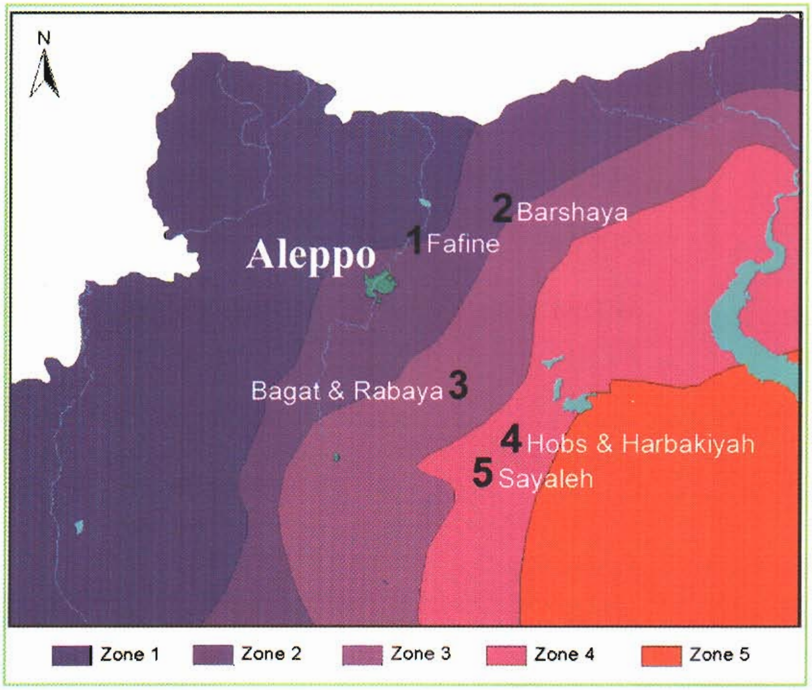


Fig. 20. ISGW Project Transect locating Barshaya village in northwest Syria.

Simulation of micro-level (community) cropping patterns and water-use scenarios will be used to test different institutional and technological options. The simulation model will be used as a learning tool for stakeholders. This approach establishes a dialog among water users within a community and between water users and government regulatory bodies. The first interaction is anticipated to create greater common awareness of the problem, which could support collective action. The second interaction is expected to improve the policy formulation process by providing farm-level information on institutional and technological options and user's reactions to different regulations.

GIS tools are being used for determining the changes in many variables at the village level, such as irrigated area, as water depletion worsens. GIS provides a flexible tool for the storage, manipulation, and analysis of the project's varied datasets as well as a means to present results in simple graphical form. These data will be used to generate a village territory water availability/requirement map based on existing wells, their known discharges, and current cropping patterns. By combining this data with land ownership information, ICARDA will be able to meet with the village stakeholders and illustrate potential water management strategies that may assist in the sustainability of Barshaya's future agricultural production (Fig. 21).

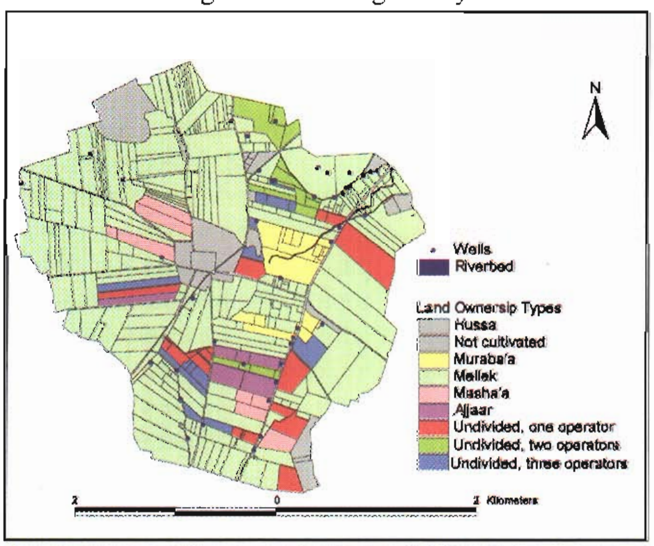
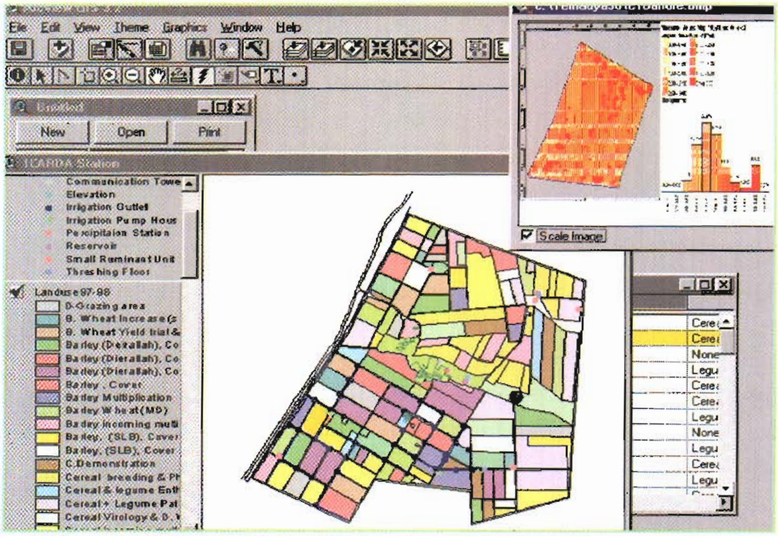


Fig. 21. Land ownership in the Barshaya village in northwest Syria in 1999.

Managing Farm Information On-line Using GIS

An integrated geo-farm system approach is being developed at ICARDA's Tel Hadya Station. Experimental trials related to crop breeding and different field management regimes have been managed individually, and the majority are fully documented. However, decision-making for field management requires analyzing derived information such as soil, crop type, tillage, hydrology, fertilizers, and yield. Analyzing these data requires the information to be fully integrated. Previously, on-line spatial (maps) and non-spatial (fields attributes) linkages were not available. This left collected data of limited value for decision-making and also limited the sharing of this information with other users.

Geographic Information Systems (GIS) are becoming useful tools in agricultural systems planning and management. One of the ways that GIS can



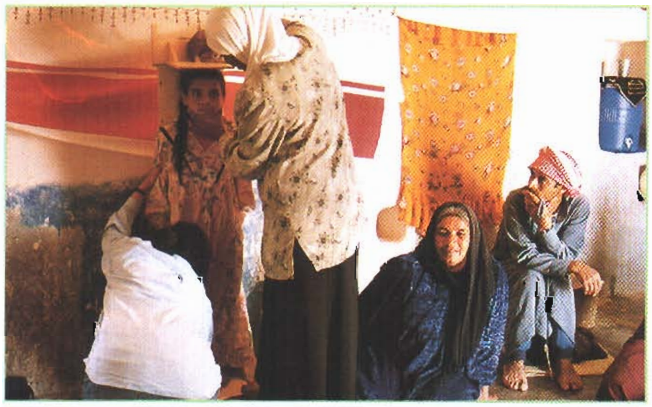
Combine-generated yield map of a field incorporated in GIS. The user can click on any field within the farm to display the related yield measurement map or inquire above the field management history.

help in planning is by producing spatial data (maps) showing fields with input and management history. In response to the need for an efficient data management tool, field histories were collected and incorporated into a GIS. Yield maps at the field level, generated by sensors on ICARDA's combine harvesters, were also included. The user can now display any yield image by clicking on the field displayed. The field management data is located within a separate database management system. Data linkage is provided through a custom-built User Interface. The system was checked, and is now running for the first season. Data are being entered on a yearly basis The system and the data are to be installed on ICARDA's server. The final products of the developed GIS will provide the farm manager and the scientific users with an advanced tool to obtain up-to-date digital and geo-referenced field information. Although the final results can only be concluded after an intensive system test, the application indicates that GIS is effective in integrating various data sources.

Poverty, Food Systems, and Nutritional Well-being

Child undernutrition is a serious and widespread problem in developing countries. As of 1995, about 160 million children under the age of five were defined as underweight. In addition, an estimated 2,000 million adults and children suffer from micronutrient deficiencies. Although immediate causes of child malnutrition may differ, depending on the specific groups, the basic cause is poverty.

Poverty affects nutrition of the rural household and that of the child through its effects on food production, supply, and distribution within the household. These, in turn, could affect the food system, which could be considered as a process consisting of the components of production/acquisition, preparation/processing, and distribution/consumption. These components could directly or indirectly affect the availability of essential nutrients required for normal growth and development. Therefore, a project to determine the variations in food systems across and within different production systems of northwest Syria was started. Their effects and that of socioeconomic status on the food system and the nutritional status of children of rural households are part of this study. To accomplish these goals, food systems of rural families in three distinct production systems, namely, the barley-livestock, the mixed cropping system (wheat, sugar beet, potato, cotton),



Height measurement of a girl under 10-year age in Serdah village, Khanasser, Syria.

and the fruit-tree system (olive, apricot, pomegranate, walnut, and fig) are being studied. Families involved in these different production activities belong to three different villages, two in the north of the Aleppo province (an area called Afrin) and one in the southeast in the Khanasser Valley. The cropping and fruit-tree systems in the villages (Trinda and Yakhor, respectively) are located in the Afrin area, and the barley-livestock system village (Serdah) is located in the Khanasser Valley.

The methodology involves use of both qualitative and quantitative techniques. These include participant observation techniques, informal interviews, participant observation, and participatory techniques. Data on food intake and growth of children will be collected using food frequency questionnaires and anthropometry, respectively.

Initial phase of fieldwork involved preliminary appraisals to help facilitate the choice of research sites followed by informal discussions and rapport building with village families. This has been followed by a card-sort activity in which mothers of households sorted food cards into self-perceived categories. This will help to determine the perceptions and/or knowledge of nutrition in these households as well as to establish a pattern for classification of foods, which could then be used in subsequent surveys. Currently, studies on seasonal calendars and anthropometry are being conducted in all three communities. Through qualitative observations, the most important pattern emerging so far is a distinct difference in diet, income and lifestyle of the three systems. Besides differences in major agriculture practices, household food production and acquisition practices vary between the groups. The croppers and fruit-tree households have greater access to a larger variety of fresh foods, such as fruits and vegetables, as compared to the livestock households. Storage and processing practices are found to be more developed in the former as well. Differences have also been observed in the level of awareness of nutritional content of foods and the importance of the variety of foods in the diet. However, the food intake of all the groups is subject to seasonal patterns and cultural rules. Higher education levels, better access to cash income, markets and health and sanitation facilities and lower birth rates give a distinct advantage to the cropper and fruit-tree households over the livestock households. Quantitative work is currently underway to determine incidence of underweight children as well as the exact food and nutrient intake pattern of these children and households.

Conducting seasonal calendar with a mother in Serdah village, Khanasser, Syria.

Implications of Land-Use Dynamics for Land Degradation

Successful rehabilitation of degraded land requires examination of the location-specific conditions and characteristics. Knowledge of the farmers' understanding of their environment and their perception of land degradation helps to develop and adapt land-use practices suited to the capability and carrying capacity of the land.

Im Mial is a typical agro-pastoral village at the fringe of the steppe in northwestern Syria. It is one of 11 villages in the Khanasser Valley Integrated Research Site, which ICARDA has selected for its participatory and integrated natural resource management research. The village of Im Mial is an example to illustrate the relation between the changes in land use and the land degradation perceived and observed by the land users in the Valley (Fig. 22). Located at the foot of the eastern mountain, Jebel Shbith, it has an area of 2702 hectares, of which 979 hectares (36%) are arable land, 1695 hectares (63%) are grazing land, and 28 hectares (1%) are taken up by the village itself. The main components of agriculture in the village are rainfed barley cultivation and livestock rearing.

After the land reform in 1968, the land of the Khanasser Valley was allocated to the villages in the area. Farmers were allocated pieces of land in both high-and low-productive areas, which were identified on the basis of their land characteristics. According to the farmers, the quality or importance of the area for cultivation depends mainly on soil and water (i.e.,

Fig. 22. The situation of the Khanasser Valley, between the Jabul Salt Lake in the north and the vast steppe areas in the south, in Syria, inhibits the expansion of arable farming land.

moisture) conditions. Also, the slopes of the fields are important. Flat areas are given higher ranking than sloping areas. The size of the fields was also seen as important. The farmers believe that on larger fields the productivity is higher.

Land-Use Changes and Farmer-Perceived Degradation

Farmers in Im Mial identified two main signs of degradation of the land resources: decreasing yields of rainfed barley and deterioration of the plant cover

The arable land resources of Im Mial village in the Khanasser Valley, Syria, are limited and many families are forced to outmigrate in search of alternative sources of income.

of the grazing areas. They attributed the decreasing yields to reduced soil moisture and poorer soil fertility.

With the introduction of continuous cultivation without adequate nutrient supply and the reduction of fallow, soil fertility has decreased. Another reason for decreased yields is that the reduced fallow has increased the incidence of root pests, such as ground pearls (*Porphyrophra tritici*), which damage the crops. These changes in the natural vegetation are seen as a result of "a shorter spring period and the general dryness," but also the "increased number of livestock" in the area.

In Im Mial, both degradation and intensification led to changes in land use. The reduced fallow with no application of manure or fertilizer has caused a loss of soil fertility and correspondingly decreasing yields. The expansion of fields into the sloping areas of the mountain foot slopes and, with it, the complete removal of the protective stones from the soil surface are leading to increased soil erosion. The expansion of the land and reduction of fallow is due to the increased demand for outputs as the population grows.

This has changed the cultivation practices from being labor-intensive to labor-extensive and allowed for an increase in the area of land to be cultivated. The continuous cultivation also has the aim to secure good overall yields in years with high rainfall. Whether this is also a response to the observed decreasing yields needs to be studied.

Migration also plays an important role. With the out-migration of villagers induced by the limited land resources and favorable earning opportunities from off-farm work, farmers are increasingly encouraged to invest in small-scale irrigation.

Larger livestock numbers and the expansion of arable land into grazing land increasingly put pressure on the natural vegetation and have led to decreased and less diverse vegetation cover. Therefore, the natural vegetation now plays a less important role in the diet of the animals.

For the arable land, the high population growth and the inheritance system in the village have caused a fragmentation of land to an extent that a reclassification of the land is taking place. Farmers who live and work outside the Valley may not claim land nor receive a share of the yields to make more resources available for the permanent members of the village.

The extensification of land does not only involve an enlargement of the arable area, it also involves a rural-to-rural out-migration. The villagers rent land and are engaged in rural labor work in other regions of the country. A large number of villagers believe that in the future more people will out-migrate for off-farm work and that within the village territory, more people will take up sheep fattening. These two trends of development can already be observed in the village. An increasing number of households are depending totally or mainly on off-farm incomes, particularly cultivation of rented irrigated fields in irrigation schemes outside the Valley. These people live outside the village for the larger part of the year and return only for the winter period. For them, cultivation in the village has turned into 'hobby farming' of little financial importance. Some farmers do not cultivate any land in Im Mial or get any of the returns for the on-farm cultivation at all. The other trend is that some farmers have started raising sheep for the meat, not for milk. The sheep are fattened mainly on purchased crop residues.

Implications for Land Rehabilitation Work in the Valley

Surveys have shown that any land-rehabilitation measures in the Valley must be adapted to fit into the land utilization and living conventions of the farmers. The conservation of the natural resources in the area—the establishment as well as the maintenance of the conservation measures—should require only a small financial and labor input from the farmers. The major activities should be in the winter period after sowing rainfed fields, when the farmers are present in the village.

Tree plantations on the upper parts of the fields located on the mountain slopes can conserve the soil and prevent erosion. Trees such as olive require only minor inputs when the plantation is established. The harvest time for olives is in November, when most of the farmers have returned to the village.

Farmers spend a large amount of money to buy market crop residues to feed the livestock. Increased on-farm integration between crop and livestock, where fodder crops could be cultivated instead of fallow, can increase fodder availability and improve soil fertility.

The Optimizing Soil Water Use Consortium

For millions of resource-poor dryland farmers in sub-Saharan Africa (SSA) and the CWANA region, low, erratic and unevenly distributed rainfall makes it difficult to achieve stable, sustainable production systems that would provide them with satisfactory, low-risk livelihoods.

In rainfed agriculture, improvements are mainly dependent on the conservation of rainfall water in the rooting zone of crops (including shrubs and trees), and on the management of the field and the crops to use this water more efficiently. However, actual water-use efficiency in current farming systems in the drought-prone countries of CWANA and SSA is often very low, and a surprisingly small proportion of the available water is actually transpired by the crop. Hence, the agricultural priority across all dry-area farming systems in sub-Saharan Africa and CWANA is to increase biological and economic yield per unit of water.

One of ICARDA's activities directed at improving the productivity of water-use in dry areas aims at achieving this task. ICARDA, together with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the National Research Organization of South Africa (ARC-SCW), is a co-convener of the "Optimizing Soil Water Use (OSWU) Consortium," a constituent of the CGIAR System-wide "Soil, Water, and Nutrient Management Program (SWNMP)." The overall goal of the Consortium is to achieve sustainable and profitable agricultural production in dry areas based on the optimal use of the available water. It brings together two international agricultural research centers and 12 national agricultural research and extension systems (NARES) from Burkina Faso, Egypt, Iran, Jordan, Kenya, Mali, Morocco, Niger, South Africa, Syria, Turkey, and Zimbabwe. By bringing together researchers and farmers from different environments, the OSWU Consortium promotes fruitful exchange of ideas, experience and, most importantly, practical techniques to combat the effects of water scarcity, and to sustainably improve production, security, and livelihood of the farmers in dry areas of CWANA and SSA.

The overall objective of the OSWU Consortium is the integration of land management techniques, which capture and retain rainwater with crop husbandry techniques. These techniques will maximize productive transpiration and minimize evaporative and drainage losses, within water-efficient, productive and sustainable cropping systems to improve the productivity of the cropping systems.

Recent agricultural research by ICARDA and other international and national centers has enabled farmers to overcome many of the constraints previously limiting their crop yields. However, in most rainfed farming systems, the major constraint that farmers face is low and erratic precipitation. Technolnologies required to increase output- and input-use efficiencies (e.g., water- and nutrient-use efficiencies) must fit the land-use system of resource-poor farmers, and must conserve the natural resource base. The main agronomic strategies to intensify crop production systems are (i) soil and water management, and (ii) cropping system management, with strong emphasis on soil fertility management.

Cropping systems management to improve water productivity is first concerned with the type and sequence of the crops being grown. The choice of appropriate rotations, intercropping or relay-cropping determines to a great extent the productivity of rainfed farming systems. In the dry areas of CWANA, introducing legume crops to replace fallow can increase production system's water-use efficiency considerably. Fig. 23 provides an example of improved system's water-use efficiency for wheat-based crop rotations in this region.

However, the effectiveness and feasibility of all management practices aiming at improved water-use efficiency depend on site- and situation-specific conditions. Crop production systems are characterized by their production objective, with yield being determined by climate, the degree of exploitation of natural resources (including human expertise), and management. Rainfall, in combination with temperature, soil, and socioeconomic factors, is the major determinant for the multiplicity and complexity of the systems.

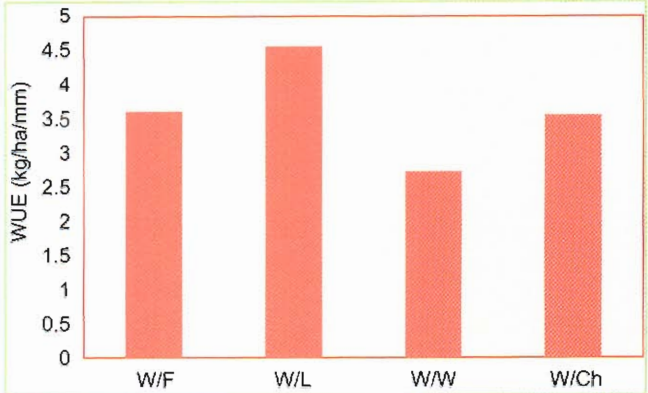


Fig. 23. System water-use efficiency (WUE) means for two-year rotations involving legume crops in the CWANA region.

W = Wheat, F= Fallow, L = Lentil, Ch = Chickpea.

International centers such as ICARDA, and CGIAR System-wide programs such as SWNM and the OSWU Consortium, have a comparative advantage to pursue such a task due to their broad expertise in many disciplines and their extensive linkages to other research and extension institutions, development organizations, NGOs, and farmers. Future outputs of the OSWU Consortium will, therefore, include generic tools that can be used to adapt strategies and technologies for optimizing soil water use to site- and situation-specific biophysical and socioeconomic conditions, to enhance the impact of research at the farm level.

Impact Assessment and Enhancement

Impact of Barley and Lentil Germplasm Improvement

Barley

Barley is of great economic value to farmers in the dry areas. They use it both for food and feed. About 15% of the barley grain produced in Morocco and about 10% in the highlands of Bolivia is used for human consumption. However, the more important use of barley grain is as animal feed. Barley straw is used as animal feed, and barley stubble is grazed in summer in large areas of WANA.

The average area, production, and value of barley for 1994-98 are given in Table 11. Developing countries grow about 19 million hectares of barley, 72% of this is in WANA, 19% in Central Asian countries, and about 6% in Latin America. In the WANA region, the major barley production is in Turkey, Morocco, Syria, Iran, Iraq, Ethiopia, and Algeria. Most of the barley (88%) in Central Asia is grown in Kazakstan.

Table 11. Average area, production, and value of barley, 1994-98.

	Area Harvested (million ha)	Production (million mt)	Value (million US$)
World	67	150	23257
Developing countries	19	27	4017
Central Asia	4	3	
Kazakstan	4	3	251
WANA	14	19	
Turkey	4	8	1162
Morocco	2	2	299
Syria	2	1	214
Iran	2	3	321
Iraq	1	1	145
Ethiopia	1	1	341
Algeria	1	1	115
Latin America and the Caribbean	1	2	363

An impact study of ICARDA germplasm found that a total of 111 barley varieties have been released during 1980-1999 in 23 developing countries with which ICARDA collaborates in barley improvement research. About 52% of all these releases were from ICARDA crosses; 38% of them were selected at ICARDA, and 14% by NARS. In addition, 11% of the releases were NARS crosses with at least one parent from ICARDA, and 15% were ICARDA germplasm accessions. The evolution in composition of released varieties in developing countries is shown in Fig. 24.

There is a noticeable rise in the contribution of the releases from NARS varietal selection. Increasd selection activities by NARS indicate their increased research capacity. This is consistent with the decentralization strategy, while maintaining access to continous flow of genetic variability through their collaboration with ICARDA. In partnership with WANA NARS, ICARDA is exploring further improvements in selection efficiency through participatory breeding projects in certain target environments.

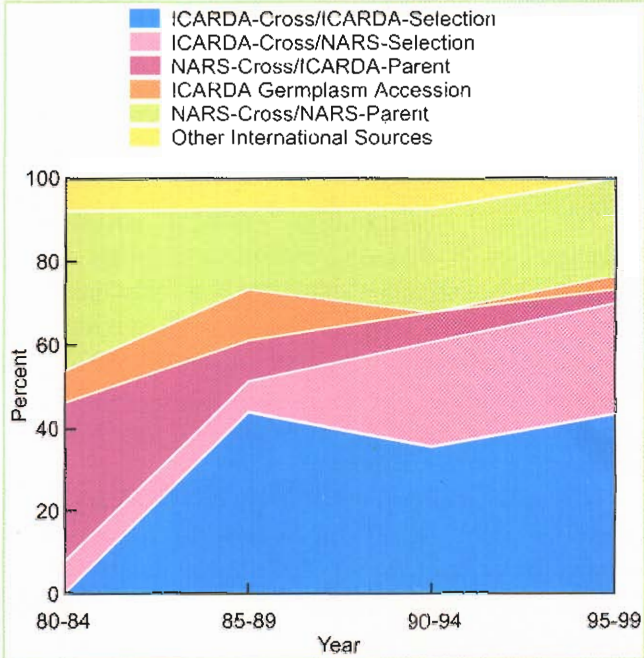


Fig. 24. ICARDA germplasm content (%) in NARS-released cultivars.

ICARDA advanced lines and released cultivars represent the major component of NARS crossing blocks. This component has increased from 46% in 1987 to about 54% in 1997 (Table 12), suggesting a

Table 12. Composition of NARS crossing blocks and crosses for 1987 and 1997 (barley).

	Crossing blocks		Crosses	
	1987	1997	1987	1997
Total	420	718	430	595
Proportions by type of germplasm source				
NARS	0.12	0.22	0.49	0.40
ICARDA	0.46	0.54	0.35	0.36
Other countries	0.38	0.14	0.13	0.09
Local landraces	0.024	0.06	0.03	0.05
ICARDA landraces	0.014	0.02	0	0.05

Countries: Iraq, Tunisia, Algeria, Ecuador, Egypt, Jordan, Morocco, Syria, Ethiopia.

substantial impact of ICARDA on variety releases. Furthermore, ICARDA advanced lines and released cultivars are a major source of parents for the NARS crosses, increasing from about 27% in 1987 to about 36% in 1997.

The diffusion of new barley varieties is growing but non-availability of seed remains a key constraint to their adoption. Two major lessons emerge from this study. First, participatory plant breeding is necessary to enhance direct access of farmers to improved germplasm. This is because the variability of the farming conditions within the dry areas does not allow any single variety to cover a large area. Second, community level or informal seed systems should supplement the participatory plant breeding, if a high adoption rate is to be achieved.

Lentil

The worldwide area planted to lentil in 1998 was 3.3 million hectares, of which 2.8 million hectares was in developing countries, representing 81% of the world lentil area. The economic significance of lentil for developing countries is shown in Table 13.

Table 13. The average area, production, and value of lentil production, 1994-98.

	Area Harvested (million ha)	Production (million mt)	Production (million US$)
World	3,328	2,803	1357
Developing Countries	2,839	2,222	1090
Latin America and Caribbean	43	39	16
Bangladesh	207	168	88
China	93	110	26
India	1, 116	806	385
WANA	1,168	980	469
Turkey	603	604	290
Iran	233	120	63
Syria	130	131	56
Ethiopia	62	34	18
Pakistan	62	32	14
Morocco	50	26	13
Egypt	5	7	4
Jordan	4	3	1
Iraq	0.4	0.3	0.2

ICARDA lentil-breeding strategy has led to a successful use of landraces for developing new cultivars. A total of 52 varieties have been released by 22 collaborating countries during 1980-99. ICARDA made the crosses for 46% of these released varieties. An additional 29% and 2% of lentil varieties released are attributed to ICARDA germplasm accessions and parents, respectively. Thus, the Center has contributed to the release of 42 of the 52 varieties (81%) released. Although ICARDA crosses have contributed greatly to the NARS-released varieties, the selections of these crosses are not necessarily made at ICARDA.

ICARDA advanced lines accounted for a major part in the composition of NARS crossing blocks in 1997 (Table 14). ICARDA contribution to NARS crossing blocks increased from 22% in 1987 to 57% in 1997, suggesting that ICARDA's likely impact on variety releases could be substantial in the near future. Parents from ICARDA advanced lines and released cultivars contributed greatly to the crosses made by NARS in 1987 and 1997.

The contribution of improved varieties to lentil yield and, thus, to the farmer's well-being, has been substantial. The yield of improved varieties is 25 to 50% higher than local varieties. Bangladesh and China are among those countries where the yield advantage has been the highest. The impact of improved germplasm is not limited to the yield advantage; the released varieties have other important traits such as resistance to disease and drought.

The diffusion profiles indicate that improved lentil varieties have not yet reached their adoption potential in many countries. However, the average adoption rate increased from 2% in 1990 to 29% in 1997. This is expected to increase further in coming years. The study also highlighted that only a small number of scientists are engaged in lentil improvement throughout the world so the crop is under-researched.

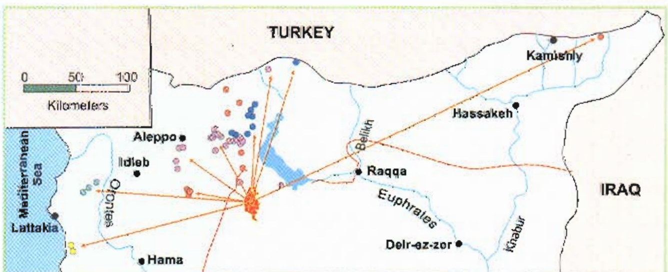
Table 14. Composition of NARS crossing blocks and crosses for 1987 and 1997 (lentil).

	Crossing blocks		Crosses	
	1987	1997	1987	1997
Proportions by type of germplasm source:				
NARS	0.45	0.22	0.25	0.35
ICARDA	0.22	0.57	0.40	0.41
Other countries	0.10	0.05	0.00	0.03
Local landraces	0.21	0.12	0.25	0.15
ICARDA landraces	0.02	0.04	0.10	0.06

Countries: China, Egypt, Iraq, Jordan, Pakistan, Sudan.

Effects of Institutional and Market-based Feeding Options on Sheep Breeders in Syrian Rangelands

In 1998, the Government of Syria, together with the International Fund for Agricultural Development (IFAD), the Arab Fund for Economic and Social Development (AFESD), and ICARDA initiated a new project aimed at assessing the effects of institutional and market-based feeding options on sheep breeders in Syrian rangelands. This project was conducted in the Jub-Jamaa community, which is located in the rangelands of the Aleppo province. A GIS was used to delimit the community boundaries and evaluate the level of cultivation followed by a complete census of the community to determine household wealth indicators (sheep, land, tractors). In 1999, a survey was conducted to monitor the migration pattern of the community members together with an in-depth survey of 69 households to assess their production strategies (Fig. 25).



	Crop residues			Vegetable residues	Pastures	
	Rainfed	Irrigated (wells)	Irrigated (river)	Green houses	Mountains	Jub-Jamaa site
%Population	22	17	29	17	14	1
%Sheep	24	26	29	11	9	1

Fig. 25. Transhumance sites for households of the Jub-Jamaa community, Aleppo steppe, summer 1999.

The community mapping revealed that 38% of the 31,283 ha of the community lands were cultivated. The community was composed of 352 households with a population of 2,918 people and owned around 53,500 sheep. However, there were considerable disparities in household sheep ownership as well as in land holding. Thirty-eight large sheep-owners had on average 614 sheep and held 36.5 hectares; 83 medium sheep-owners, on average 215 sheep and 24.75 hectares; and 231 small sheep-owners, on average 54 sheep and 15 hectares.

Mobility was one of the major features of livestock production in Syria until the settlement of the nomads and their involvement in barley production in the rangelands. However, the present transhumance is very different from the traditional one, where traditional institutions played an important role in negotiating access to resources, because each household made its own arrangements on when and where to go.

Livestock producers depend on market and institutionally based feed resources to tend their herds. Market feed resources, which include concentrate feeds and crop residues, require that sheep producers either purchase feed from the market and cooperatives, or rent from farmers. All of them use concentrate feeds to supplement their animal diets at different times of the year. Crop residues were also important feed resources. Medium-owners spent 49% of their time grazing their sheep on crop residues, while small and large spent 33% and 30%, respectively.

Quantifying the contribution of the institutional-access options is not easy. It is assumed that these different production strategies are important only if they contribute to the reduction of the costs of hand feeding, since the purchase of concentrates is one of the major constraints for small livestock producers. Understanding some of the tradeoffs between hand feeding and other feeding resources will unveil some of the reasons that prompt farmers to revert to one over another feeding strategy.

Sheep breeders of the Jub-Jamaa community have increased the duration of their migration due to the combined effects of the cultivation ban and drought. However, they did not revert to their traditional group transhumance system. Each household decides when, where, and how long to stay on their grazing sites. Individual strategies are becoming the major feature of livestock production. Under these individualistic livestock production strategies, small and large sheep-breeders seem to have found the best transhumance strategies in minimizing production costs.

Resources for Research and Training

Finance

In 1999, ICARDA's grant revenue from donors amounted to USD 20.450 million. Combined with other income of USD 0.753 million, a loss in exchange of USD 0.271 million, and a grant-pledge write-off of USD 0.497 million, the net revenues for the year amounted to USD 20.435 million. The operating expenses for the year, net of the recovery of indirect costs, were USD 21.911 million. Thus, the year ended with a deficit of USD 1.476 million.

Staff

During 1999, the following internationally-hired senior staff members joined ICARDA: Dr Ahmed Amri, Biodiversity Project Coordinator; Mr Nicholas Bowley, School Head; Dr Mohammed El-Mourid, Coordinator, North Africa Regional Program, Tunis, Tunisia; Mr Michel Valat, Director of Administration.

The following internationally-hired senior staff members, already on board, moved to higher positions during the year: Dr Aden Aw-Hassan, Agricultural Economist; Dr Mustapha Bounejmate, Forage and Feed Legumes Production Specialist; Dr Rajinder Singh Malhotra, Senior Chickpea Breeder; Dr Ashutosh Sarker, Lentil Breeder; Dr Mahmoud Solh, Assistant Director General (International Cooperation).

The following internationally-hired P-level staff members were relocated during the year: Dr Abelardo Rodriguez, Coordinator for Latin America Regional Program, Lima, Peru; Dr Victor Shevtsov, Barley Breeder, Central Asia and the Caucasus Regional Program, Tashkent, Uzbekistan.

The following internationally-hired RA-level staff members also joined during the year: Mr David Millar, Science Writer/Editor; Mr Colin Webster, Systems Programmer/Network Administrator.

The following Post-Doctoral Fellow joined during the year: Dr Bruno Schill, Faba Bean Breeding.

The following Associate Experts joined during the year: Ir David Celis, Junior Professional Officer; Mr Kenneth Street, Associate Expert; Ms Josepha Wessels, Associate Expert, Applied Anthropology.

The following staff members moved to RA-level during the year: Dr Malika Martini Abdelali, Research Associate, Socioeconomics and Gender Analysis; Dr M. Sripada Udupa, Biotechnologist.

The following staff member moved to Post-Doctoral Fellow level during the year: Dr Imad Mahmoud Eujayl, Biotechnology.

The following P-level staff members left during 1999: Dr Zaid Abdul Hadi, Head, Computer and Biometrics Services Unit; Dr Chrysantus Akem, Legume Pathologist; Dr Michel Chenost, Animal Nutritionist; Dr Gustave Gintzburger, Range Ecology and Management Scientist; Dr Thomas Taylor, School Head; Dr Mohammad Zainul Abedin, Farming Systems Specialist.

Dr Heping Zhang, Post-Doctoral Fellow, Soil and Water, left during 1999.

The Farms

ICARDA operates four sites in Syria (including its main research station at Tel Hadya, near Aleppo) and two in Lebanon (Table 15). These sites represent a variety of agroclimatic conditions, typical of those prevailing in the WANA region.

Table 15. ICARDA sites in Syria and Lebanon.

Site	Coordinations		Area (ha)	Approximate elevation (m)	Total precipitation (mm)*
SYRIA					
Tel Hadya	36° 01NN	36° 56NE	948	284	307.2
Bouider	35° 41NN	37° 10NE	6	268	196.5
Breda	35° 56NN	37° 10NE	95	300	197.8
Maragha	35° 33NE	37° 40NE	10	370	113.2
LEBANON					
Terbol	33° 49NN	35° 59NE	50	890	292.2
Kfardan	34° 01NN	36° 03NE	50	1080	243.6

* For the 1998/99 season.

Appendices

Contents

Appendix 1

Precipitation (mm) in 1998/99

	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL
SYRIA													
Tel Hadya													
1998/99 season	0.0	2.2	38.6	88.4	39.5	51.4	62	25.1	0.0	0.0	0.0	0.0	307.2
Long-term average (21 seasons)	2.3	24	48.2	55.5	62.4	51.6	47.7	31.6	14.3	2.1	0.0	0.6	340.3
% of long-term average	0.0	9.0	80	159	63	99	130	79	0.0	0.0	0.0	0.0	90
Breda													
1998/99 season	0.0	1.8	20.2	40.8	19.6	30	72.8	12	0.6	0.0	0.0	0.0	197.8
Long-term average (42 seasons)	2.1	14.5	29.6	39.3	48.1	40.1	34.9	28.9	15.6	0.0	0.0	0.0	253.1
% of long-term average	0.0	124	68	104	41	75	204	42	4.0	0.0	0.0	0.0	78
Bouider													
1998/99 season	0.8	0.4	19.7	55.8	19.2	27.6	56	17	0.0	0.0	25.4	0.0	196.5
Long-term average (26 seasons)	0.7	17.1	27	38.5	42.2	37.2	32.1	19.4	9.2	0.3	1.8	0.0	226.3
% of long-term average	114	2.0	73	145	45	74	174	88	0.0	0.0	1411	0.0	78
Maragha													
1998/99 season	7.6	0.0	6.8	39.6	10.6	18.6	26.8	3.0	0.2	0.0	0.0	0.0	113.2
Long-term average (9 seasons)	2.6	6.4	22.2	34.8	46.2	33.9	33.1	11.3	14	0.5	0.1	0.0	177.1
% of long-term average	292	0.0	30	114	23	56	81	27	1.0	0.0	0.0	0.0	64
LEBANON													
Terbol													
1998/99 season	0.0	1.0	7.8	82.2	75.4	49.2	56.8	19.4	0.0	0.0	0.0	0.0	292.2
Long-term average (18 seasons)	0.7	20.2	71	98.2	96.6	94.8	103.8	24.9	12.5	1.5	0.0	0.0	524.2
% of long-term average	0.0	5.0	11	84	78	52	55	78	0.0	0.0	0.0	0.0	56
Kfardan													
1998/99 season	0.0	0.0	2.2	79.6	58	49.6	43.9	10.3	0.0	0.0	0.0	0.0	243.6
Long-term average (5 seasons)	0.8	13.4	50.7	78.2	85	78.2	71.8	20.7	3.6	0.0	0.0	0.0	402.4
% of long-term average	0.0	0.0	4.0	102	68	68	63	61	50	0.0	0.0	0.0	61

Note: For area and elevation of these sites, please see Table 15 on page 59.

Appendix 2

Cereal and Legume Varieties Released by National Programs*

Country/year	Variety
Barley	
Algeria	
1987	Harmal
1992	Badia
1993	Rihane-03
Australia	
1989	Yagan
1991	High
1993	Kaputar, Namoi
Bolivia	
1991	Kantuta
1993	Kolla
1994	San Lorenzo
Brazil	
1989	Acumai
Canada	
1992	Seebe
1993	Falcon
1994	Tukwa
1995	Kasota
Chile	
1989	Leo/Inia/Ccu, Centauro
China	
1988	Zhenmai 1
1989	V-24, Api/CM67//B1, CT-16
1998	S500, V06
Cyprus	
1980	Kantara
1989	Mari/Aths*2
1994	Mia Milia, Achera
1995	Lefkonoiko, Sanokrithi-79, Lysi
Ecuador	
1989	Shyri
1992	Calicuchima-92, Atahualpa-92
Egypt	
1993	Giza 125, Giza 126, Giza 127
1994	Giza 128
Ethiopia	
1973	Beka
1975	IAR/H/485
1979	Holkr
1980	Ardu 12-60B
Barley (contd.)	
1985	HB-42
1986	HB-120
1994	Shege
1996	Misratch
1998	Abay
Iran	
1986	Aras
1990	Kavir, Star (Makui)
1996	Ezeh
1997	Sahand (= Tokak), Ganub
Iraq	
1993	Rihane-03
1994	IPA 7, IPA 9, IPA 265
Italy	
1992	Salus, Digersano
Jordan	
1984	Rum
Kenya	
1984	Bima
1993	Ngao
Lebanon	
1989	Rihane-03
1997	Assy, ER/Apm
Libya	
1992	Wadi Kuf, Wadi Gattara
1997	Borjouj, Maknosa, Ariel, Irawen
Mexico	
1986	Mona/Mzq/DL71
1998	Capuchona
Morocco	
1984	Asni, Tamelat, Tissa
1988	Aglou, Armal, Tiddas
1991	Laannaceur
1997	Igrane, Safia
Nepal	
1987	Bonus
Pakistan	
1985	Jau-83
1987	Jau-87, Frontier 87
1993	Jau-93
1995	AZRI-95
Barley (contd.)	
1996	Soorab-96, Sanober-96
Peru	
1987	Una 87, Nana 87
1989	Buenavista
1994	Una-94
1996	Una-96
Portugal	
1982	Sereia, Enxara, Campones
1983	CE 8302
1990	Ancora
Qatar	
1982	Gulf
1983	Harma
1989	Harma 88
Saudi Arabia	
1985	Gustoe
Spain	
1990	Resana
Syria	
1987	Furat 1113
1991	Furat 2
1994	Arta
Tanzania	
1991	Kibo
Thailand	
1987	Semang 1, Semang 2, BRB-8
Tunisia	
1985	Taj, Faiz, Roho
1987	Rihane-03
1992	Manel 92
Turkey	
1993	Tarm 92, Yesevi
1995	Orza
USA	
n.a.	Poco, Micah
Vietnam	
1989	Api/CM67//B1
Yemen	
1986	Arafat, Beecher

* These varieties were released with the contribution of ICARDA.

Country/year	Variety
Durum Wheat	
Algeria	
1982	ZB//Fg/Loukos
1984	Timgad
1986	Sahl, Waha
1991	Korifla
1992	Om Rabi 6
1993	Belikh 2, Haider, Kabir 1, Om Rabi 9
Cyprus	
1982	Mesaoria
1984	Karpasia,
1994	Macedonia
Egypt	
1979	Sohag I
1988	Beni Suef, Sohag II
1990	Sohag III
Greece	
1982	Selas
1983	Sapfo
1984	Skiti
1985	Samos, Syros
Iran	
1996	Seimareh = Om Rabi 5,
1997	Korifla
Iraq	
1996	Waha Iraq
1997	Om Rabi 5, Korifla
Jordan	
1988	Maru = Cham 1, Petra = Korifla, Amra = N-432, ACSAD65 = STK
Lebanon	
1987	Belikh 2
1989	Sebou
1993	Waha = Cham 1
Libya	
1985	Baraka, Fazan, Ghuodwa, Marjawi, Qara, Zorda
1991	Zahra 1
1992	Khiar 92
1993	Zahra 3, Zahra 5 = Korifla
1995	Zahra 7, Zahra 9
Morocco	
1984	Marzak

Country/year	Variety
Durum Wheat (contd.)	
1991	Tensif
1992	Brachoua, Om Rabi 5
1994	Anouar, Jawhar
1997	Telset
Pakistan	
1985	Wadhanak
Portugal	
1983	Celta, Timpanas
1984	Castico
1985	Helvio
n.a.	TE 9204
Saudi Arabia	
1987	Cham 1
Spain	
1983	Mexa
1985	Nuna
1989	Jabato
1991	Anton, Roqueno
Sudan	
1996	Cham 1
1997	Waha
Syria	
1984	Cham 1
1987	Bohouth 5, Cham 3
1993	Om Rabi 3
1994	Cham 5
Tunisia	
1987	Razzak
1993	Khiar, Om Rabi 3
Turkey	
1984	Susf bird
1985	Balcali
1988	EGE 88
1990	Sam 1 = Cham 1
1991	Kiziltan
1994	Aydin, Firat 93
1997	Haran = Omrabi 5
1998	Altin 98, Ankara 98
Bread Wheat	
Algeria	
1982	Setif 82, HD 1220
1989	Zidane 89
1992	Nesser = Cham 6, Sidi Okba = Cham 4, Rhumel = Siete Cerros, Alondra = 21AD,

Country/year	Variety
Bread Wheat (contd.)	
	Soummam = DouggaXBJ, ACSAD 59 = 40DNA
1994	Mimouni, Ain Abid
Egypt	
1982	Giza 160
1988	Giza 162, Giza 163, Giza 164, Sakha 92
1991	Gammeiza 1, Giza 165
1993	Sahel 1
1994	Sids 1, Sids 2, Sids 3, Giza 166, Giza 167, Benesuef-3
1995	Sids 4, Sids 5, Sids 6, Sids 7, Sids 8
Greece	
1983	Louros, Pinios, Arachthos
Iran	
1986	Golestan, Azadi
1988	Darab, Sabalan, Quds
1990	Falat
1995	Tajan, Mahdabi, Darab 2
1996	Gaher, Zagross, Nicknejad
1997	Alrand, Atrak, Alement, Chamran, Zareen
1998	Azar 2
Iraq	
1989	Es14
1994	Hamra, Adnanya, Abu Ghraib
1998	Vee 'S'
Italy	
1996	Sibilla
Jordan	
1988	Nasma = Jubeiha, L88 = Rabba, Petra, Cham 1
1990	Nesser
Lebanon	
1990	Seri
1991	Nesser = Cham 6
1998	Towpe
Libya	
1985	Zellaf, Sheba, Germa

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

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

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

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

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

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

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

Appendix 3

Publications

The following list covers, as of the time of going to press, journal articles published by ICARDA researchers—many of them in collaboration with colleagues from national programs. Some of the titles published in 1998 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.

Journal Articles

Akem, C. 1999. *Ascochyta* blight of chickpea: Present status and future priorities. International Journal of Pest Management 45(2): 131-137.

Asaad, S. and A. El-Ahmed. 1999. Improved method for detection of *Pyrenophora graminea* in barley seeds. Phytopathologia Mediterranea 38: 144-148.

Akem, C. and S. Kabbabeh. 1999. Screening for resistance to *Sclerotinia* stem rot in chickpea: A simple technique. Pakistan Journal of Biological Sciences 2(2): 277-279.

El-Bouhssini, M., N. Nsarellah, M.M. Nachit, A. Bentika, O. Benlahbib, and S. Lhaloui. 1999. First source of resistance in durum wheat to Hessian fly (*Diptera: Cecidomyiidae*) in Morocco. Genetic Resources and Crop Evolution 46: 107-109.

El-Damir, M., M. El-Bouhssini, and N. Al-Salti. 1999. A simple screening technique of lentil germplasm for resistance to *Sitona crinitus* H. (*Coleoptera: Curculionidae*) under artificial infestation. Arab Journal of Plant Protection 17(1): 33-35. [Ar]. (English abstract).

Erskine, W. and C. Akem. 1999. Winter cropping and reaction to cold. Grain Legumes 24: 14-15.

Eujayl, I., W. Erskine, M. Baum, and E. Pehu. 1999. Inheritance and linkage analysis of frost injury in lentil. Crop Science 39(3): 639-642.

Garabet, S., M. Wood, and J. Ryan. 1998. Nitrogen and water effects on wheat yield in a Mediterranean-type climate. I. Growth, water-use, and nitrogen accumulation. Field Crops Research 57: 309-318.

Grass, L. and M. Tourkmani. 1999. Mechanical damage assessment in rejected durum wheat seed lots in Morocco. Seed Science and Technology 27(3): 991-997.

Hakim, M.S. and O.F. Mamluk. 1998. Monitoring the phenotypes and virulences of *Puccinia striiformis* f.sp. *tritici* in Syria. Phytopathologia Mediterranea 37: 106-110.

Hamwieh, A., K. Makkouk, B. Debs, and A. El-Ahmed. 1999. Production of specific antiserum to *Pseudomonas syringae* pv. *pisi* the causal organism of bacterial blight of pea in Syria. Arab Journal of Plant Protection 17(1): 26-30. [Ar]. (English abstract).

Hassan, H.T., K.M. Makkouk, and A.A. Haj Kassem. 1999. Viral diseases on cultivated legume crops in Al-Ghab Plain, Syria. Arab Journal of Plant Protection 17(1): 17-21. [Ar]. (English abstract).

Jenkinson, D.S., H.C. Harris, J. Ryan, A.M. McNeill, C.J. Pilbeam, and K. Coleman. 1999. Organic matter turnover in calcareous clay soil from Syria under a two-course cereal rotation. Soil Biology and Biochemistry 31: 687-693.

Jones, M.J. and Z. Arous. 1999. Effect of time of harvest of vetch (*Vicia sativa* L.) on yields of subsequent barley in a dry Mediterranean environment. Journal of Agronomy and Crop Science 182: 291-294.

Makkawi, M., M. El Balla, Z. Bishaw, and A.J.G. van Gastel. 1999. The relationship between seed vigor tests and field emergence in lentil (*Lens culinaris* Medikus). Seed Science and Technology 27: 657-668.

Makkouk, K.M., S.G. Kumari, and B. Bayaa. 1999. First report of pea enation mosaic virus affecting lentil (*Lens culinaris* Medik.) in Syria. Plant Disease 83(3): 303. (Abstract).

Malhotra, R.S., W. Erskine, and J. Konopka. 1999. Genetic resources of chickpea. Grain Legumes 25: 16-17.

Manschadi, A.M., J. Sauerborn, H. Stutzel, W. Goebel, and M.C. Saxena. 1998. Simulation of faba bean (*Vicia faba* L.) root system development under Mediterranean conditions. European Journal of Agronomy 9: 259-272.

Manschadi, A.M., J. Sauerborn, H. Stutzel, W. Goebel, and M.C. Saxena. 1998. Simulation of faba bean (*Vicia faba* L.) growth and development under Mediterranean conditions: model adaptation and evaluation. European Journal of Agronomy 9: 273-293.

Merah, O., P. Monneveux, M. Nachit, and E. Deleens. 1999. La composition isotopique du carbone, critère intégrateur du fonctionnement photosynthétique: Application à l'amélioration génétique du blé dur en conditions Méditerranéennes. [Isotopic composition of carbon, an integrating criterium of photosynthetic functioning: An application on the genetic improvement of durum wheat under Mediterranean conditions]. Cahiers Agricultures 8: 37-47. [Fr].

Oweis, T., M. Pala, and J. Ryan. 1999. Management alternatives for improved durum wheat production under supplemental irrigation in Syria. European Journal of Agronomy 11: 255-266.

Ryan, J., S. Garabet, A. Rashid, and M. El Gharous. 1999. Assessment of soil and plant analysis laboratories in the West Asia - North Africa region. Communications in Soil Science and Plant Analysis 30(5/6): 885-894.

Sarker, A., J. Kumar, M.M. Rahman, M.S. Hassan, W. Zaman, M.A. Afzal, and A.N.M.M. Murshed. 1999. Registration of 'Barimasur-3' lentil. Crop Science 39: 1536.

Sarker, A., W. Erskine, B. Sharma, and M.C. Tyagi. 1999. Inheritance and linkage relationships of days to flower and morphological *Loci* in lentil (*Lens culinaris* Medikus subsp. *culinaris*). The American Genetic Association 90: 270-275.

Sarker, A., W. Erskine, M.S. Hassan, M.A. Afzal, and A.N.M.M. Murshed. 1999. Registration of 'Barimasur-4' lentil. Crop Science 39: 876.

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Appendix 4

Graduate Theses Produced with ICARDA's Assistance

Master's

1999

DN The Royal Veterinary and Agricultural University

Bereket Tekle (ER). 1999. Genetic structure of barley landraces adapted to dryland agriculture. 74 pp.

IT Instituts Agronomiques Méditerranéens

Ezzeddine Hmidi (TN). Effet de la salinité du milieu sur l'émergence, le comportement hydrique, la croissance, et le rendement chez deux variétés de lentille (*Lens culinaris*). [Effect of soil salinity on the emergence, hydric behavior, growth, and yield of two lentil varieties (*Lens culinaris*)]. 83 pp. (In French).

JO University of Jordan

Yonas Sahlu W. Selassie (ET). 1999. Status and quality of barley seeds used by the northern and central Ethiopian farmers. 73 pp. (Arabic summary).

SY University of Aleppo

Aladdin Hamwieh (SY). Bacterial blight of pea (*Pseudomonas syringae* pv. *pisi*) in Syria. 89 pp. (In Arabic, English Summary).

Housam Obaedo (SY). 1999. Study on the Septoriosis of wheat in Syria: Distribution and importance, etiology, biology, and sources of resistance. 143 pp. (In Arabic, English Summary).

Mohammed Eldamir (SY). Development of rearing technique for *Sitona crinitus* Herbst (*Coleoptera*: *Curculionidae*), search for parasitoids in Syria and screening for host plant resistance. 148 pp.

Country codes: DN, Denmark; ER, Eritrea; ET, Ethiopia; IT, Italy; JO, Jordan; SY, Syria; TN, Tunisia.

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Appendix 5

Agreements

Agreements of Cooperation with International and Regional Organizations in 1999

CARDNE (Regional Centre on Agrarian Reform and Rural Development for the Near East)

4 July 1999. Memorandum of Understanding for Collaboration and Coordination between the Regional Centre on Agrarian Reform and Rural Development for the Near East (CARDNE) and ICARDA.

8 June 1999. Memorandum of Understanding between the Economic Cooperation Organization (ECO), Tehran, Iran and ICARDA.

CIHEAM (Centre International de Hautes Études Agronomiques Méditterranéennes)

8 September 1999. Agreement for Cooperation between the Centre International de Hautes Études Agronomiques Méditterranéennes (CIHEAM) and ICARDA.

Agreements of Cooperation with National Governments and Institutions in 1999

ARMENIA

16 September 1999. Agreement of Cooperation, in the Field of Agricultural Sciences, between the Ministry of Agriculture of the Republic of Armenia and ICARDA.

AZERBAIJAN

22 June 1999. Agreement of Cooperation between the Ministry of Agriculture of the Republic of Azerbaijan and ICARDA.

GEORGIA

21 June 1999. Agreement of Cooperation between the Georgian Academy of Agricultural Sciences, Republic of Georgia, and ICARDA.

22 June 1999. Agreement of Cooperation between the Ministry of Agriculture and Food, Republic of Georgia, and ICARDA.

IRAQ

19 October 1999. Agreement for Scientific and Technical Cooperation between the University of Baghdad, Iraq, and ICARDA.

IRAN

17 October 1999. Agreement of Cooperation between the Faculty of Agriculture, University of Technology (IUT), Isfahan, Islamic Republic of Iran, and ICARDA.

KUWAIT

19 April 1999. Agreement between the Kuwait Institute for Scientific Research (KISR), Kuwait and ICARDA.

19 April 1999. Memorandum of Understanding between the Kuwait Institute for Scientific Research (KISR), Kuwait and ICARDA.

LEBANON

14 February 1999. Agreement of Cooperation between the American University of Beirut (AUB), Lebanon, and ICARDA.

PALESTINE

22 June 1999. Agreement for Scientific and Technical Cooperation between the Ministry of Agriculture, Palestine, and ICARDA.

Appendix 6

Restricted Projects

ICARDA's research program is implemented through 19 research projects, as detailed in the Center's Medium-term Plan. Restricted Projects are those activities that are supported by restricted funding that is provided separately from the Center's unrestricted core budget. Restricted funding includes restricted core funding, donor directed core funding (core funds directed by the donor to specific activities) and project specific grants. The financial contributions by the respective donors are reported in Appendix 11. The reports on the activities listed are encompassed in the appropriate sections of the body of this Annual Report. During 1999, the following Restricted Projects were operational.

AFRICAN DEVELOPMENT FUND

Support to ICARDA's research agenda in Africa

AFESD (Arab Fund for Economic and Social Development)

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

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

Arabian Peninsula Regional Program - Phase II

Development of biotechnological research in the Arab States

AUSTRALIA

ACIAR (Australian Centre for International Agricultural Research)

Improvement of drought and disease resistance in lentil 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 lentil for resistance to luteoviruses

International collaboration in barley research between ICARDA and Waite Campus Institutions

CANADA

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

CGIAR Systemwide Programs

CGIAR Collaborative Program for Central Asia and the Caucasus

Program Facilitation Unit

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

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

Systemwide Initiative on Collective Action and Property Rights (CAPRi)

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

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

Village based participatory breeding in the terraced mountain slopes of Yemen

Systemwide Genetic Resources Program (SGRP)

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

Improving the quality and range of data available on ICARDA's Plant Genetic Resources Collection (SINGER II)

Systemwide Livestock Program (SLP)

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

Systemwide Water Resources Management Programme (SWIM)

On-farm water use

International Conference on Water Management

Systemwide Program on Soil Water and Nutrient Management (SWNM)

Optimizing soil water use

EC (European Commission)

Nile Valley Regional Program - Egypt Phase II

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

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

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

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

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

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

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

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

Action research for sustainable ground water use in Syria

IDRC (International Development Research Centre)

Integrated watershed development (Syria)

Farmer participation in barley breeding - North Africa
Supplemental irrigation with brackish water in Syria
Community-level impacts of policy, property rights, and technical options in the low rainfall areas of Morocco, Tunisia, and Syria

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 - Phase II

West Asia and North Africa dryland durum wheat improvement network

Arabian Peninsula Regional Program - Phase II

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

IDB (Islamic Development Bank)

International conference on water resource management

Workshop on participatory research

ITALY (Donor-Directed Core Funding)

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

Barley germplasm improvement for increased productivity

Food legume germplasm improvement for increased systems productivity: Chickpea improvement

JAPAN (Donor-Directed Core Funding)

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

Improvement of small ruminant production in dry areas

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

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

Training in seed technology

NORWAY (through United Nations Environment Programme)

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

OPEC Fund for International Development

Devolution of barley breeding to farmers in North Africa

PAKISTAN

Cooperation in the Applied Research Component of the Barani Village Development Project (BVDP)

SPAIN

Incorporating resistance to drought and upgrading the grain quality in durum wheat for the 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 steep lands in northwest Syria

SWITZERLAND

Arid margins of Syria

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

UNDP (United Nations Development Programme)

Yemen: Sustainable Environment Management

UNDP (United Nations Development Programme)/GEF (Global Environment Facility)

Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Syria and the Palestinian Authority (Regional Component)

UNEP (United Nations Environment Programme)

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

UNITED KINGDOM (Donor Directed Core Funding)

Food legume germplasm improvement for increased systems productivity

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

Socioeconomics of agricultural production systems in dry areas

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

UNITED STATES OF AMERICA

USAID (United States Agency for International Development)

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

Adaptation of barley to drought and temperature stress using molecular markers

Inheritance and mapping of winter hardiness genes in lentil

Use of entomopathogenic fungi for the control of Sunn pest

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

Simulation of phosphorus dynamics in the soil-plant system

Nutrition, food systems, and poverty

USAID Agricultural Technology Utilization and Transfer Project (ATUT)

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

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

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

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

Central Asian range and sheep evaluation

WORLD BANK

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

REPUBLIC OF YEMEN

Agriculture Sector Management Support Project (ASMSP), Yemen

Appendix 7

Collaboration in Advanced Research

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

International Centers and Agencies

ACSAD (Arab Center for the Studies of Arid Zones and Dry Lands)
- Joint workshops, conferences, and training.
- Exchange of germplasm.
- 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)
- ICARDA is participating in the Systemwide Program on Soil Water and Nutrient Management and in the Systemwide Program on Participatory Research and Gender Analysis for Technology Development, both coordinated by CIAT.
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database.
- Cooperation in joint project on development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants.

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

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

FAO (Food and Agriculture Organization of the United Nations)
- ICARDA participates in the Inter-agency Task Forces convened by the FAO-RNE (FAO Regional Office for the Near East).
- ICARDA and FAO are co-sponsors of AARINENA.
- ICARDA participates in FAO's AGLINET cooperative library network, AGRIS, and CARIS.
- Collaboration in an analytical review of NARS in WANA.
- 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)
- ICARDA and ICRISAT cooperate in a joint kabuli chickpea improvement program.
- ICARDA and ICRISAT are co-convenors of the theme Optimizing Soil Water Use within the Systemwide Program on Soil Water and Nutrient Management.
- ICARDA is collaborating with ICRISAT on insect pests of grain legumes within the Systemwide Program on Integrated Pest Management, and on Multipurpose Fodder Shrubs and Trees (see below, under ILRI).
- Cooperative task force on wind erosion in Africa and Western Asia.

IFPRI (International Food Policy Research Institute)
- ICARDA collaborates with IFPRI in the Systemwide Program on Property Rights and Collective Action.
- Collaboration in policy and property rights research in WANA: ICARDA hosts two joint ICARDA/IFPRI appointed Research Fellows.
- Collaboration within SGRP framework in the development of a costing study of ICARDA genebank operations.

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

ILRI (International Livestock Research Institute)
- ICARDA is the convening center, in collaboration with ILRI and ICRISAT, for a program on Production and Utilization of Multi-purpose Fodder Shrubs and Trees in West Asia, North Africa, and the Sahel as part of the Systemwide Livestock Program on Feed Resources Production and Utilization coordinated by ILRI.
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database.

- Cooperation in joint project on development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants.
- ILRI is a partner in a project on integrated feed and livestock production in the steppes of Central Asia, coordinated by ICARDA.

IPGRI (International Plant Genetic Resources Institute)
- ICARDA hosts and services the IPGRI Office for Central & West Asia and North Africa.
- ICARDA participates with other CG Centers in the Systemwide Genetic Resources Program, coordinated by IPGRI.
- ICARDA cooperates with IPGRI 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."
- ICARDA collaborates with IPGRI in two sub-regional networks on genetic resources (WANANET and CATN/PGR).

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

ISNAR (International Service for National Agricultural Research)
- ICARDA and ISNAR cooperate in research management for NARS in WANA.
- 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 Systemwide Water Resources Management Program coordinated by IWMI.
- ICARDA and IWMI co-sponsored the International Conference on Water Resources Management, Use and Policy in Dry Areas, December 1999.

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

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 from the Indian subcontinent.
- Improvement of lentil and grasspea in Bangladesh.

AUSTRIA

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

BELGIUM

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

University of Leuven
- Participatory agroecological characterization.

CANADA

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

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

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

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

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

DENMARK

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

Risoe National Laboratory, Plant Biology Biogeochemistry Department
- 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 morphophysiological traits associated with constraints of Mediterranean dryland conditions in durum wheat (with École Nationale Supérieure d'Agronomie (ENSA), Montpellier, and ENSA-INRA, Le Rheu).
- Studies on genetic markers in blood and milk of Syrian goats (Laboratoire de Généticque Biochimique et de Cytogénétique, INRA, Joy en Josas).
- Water balance studies in cereal-legume rotations in semi-arid Mediterranean zone (with Bioclimatology Research Unit of INRA, Thiverval-Grigon).

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

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

Université Paris-Sud, Labo Morphogénèse Végétale Experimentale
- Production of 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.

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

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

University of Hannover
- Development of transformation protocols for chickpea and lentil.

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

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

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

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

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

Kyoto University
- Collaboration in molecular characterization of wheat wild relatives.

NETHERLANDS

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

WAU (Wageningen Agricultural University)
- Collaboration on land degradation research in Syria.

POLAND

IUNG (Institute of Soil Science and Plant Cultivation)
- Collaboration on research in soil strength parameters.

PORTUGAL

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

SWITZERLAND

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

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

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

UNITED KINGDOM

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

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

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

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

UNITED STATES OF AMERICA

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

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

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

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

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

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

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

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

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

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

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

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
- Livestock and rangeland policy and property rights in Central Asia.

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

Appendix 8

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions Involved	Donor Support
International & Regional Networks				
International Germplasm Testing Network	Dissemination of barley, durum and bread wheat, lentil, kabuli chickpea, faba bean, vetches, and chicklings advanced lines, parental lines and segregating populations developed by ICARDA, CIMMYT, and ICRISAT, and by national programs themselves. Feedback from NARS assists in developing adapted germplasm for national programs and provides a better understanding of genotype ˘ environment interaction and of the agroecological characteristics of major cereal production areas.	Germplasm Program	52 countries worldwide, CIMMYT	ICARDA core funds
SEWANA (Southern Europe and WANA) Durum Wheat Research Network WANADDIN (WANA Dryland Durum Improvement Network)	Durum breeder and crop improvement scientists from southern Europe, West Asia and North Africa (SEWANA) complement each other's activities in developing techniques and breeding material of durum wheat adapted to the Mediterranean environment and with high grain quality.	Germplasm Program	Algeria, Jordan, Lebanon, Morocco, Tunisia, Turkey, Syria, France, Greece, Italy, Spain, Canada, USA	ICARDA core funds, France, Italy, IFAD
Soil Fertility Network	To standardize methods and exchange information and results from research on soil fertility, soil management, and fertilizer use.	Natural Resource Management Program	Algeria, Cyprus, Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Pakistan, Syria, Tunisia, Turkey, Yemen	ICARDA, IMPHOS
Dryland Pasture and Forage Legume Network	Communication linkages among pasture forage and livestock scientists in WANA.	Natural Resource Management Program	WANA, Europe, USA, Australia	ICARDA, CIHEAM, CLIMA, FAO-RNE, IDRC, USAID (CRSP)
WANA Plant Genetic Resources Network (WANANET)	Working groups specify priorities in plant genetic resources; identify and implement collaborative projects; implement regional activities.	ICARDA Genetic Resources Unit and IPGRI Regional Office for CWANA	WANA countries, IPGRI, FAO, ACSAD	ICARDA, IPGRI, FAO

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions Involved	Donor Support
Faba Bean Information Services (FABIS)	Collection and dissemination of worldwide information on faba bean, chickling, and vetch to facilitate communication between research workers. FABIS Newsletter; specialized bibliographic journals; research workers' directory.	Germplasm Program; Communication, Documentation and Information Services	Worldwide	ICARDA core funds
Lentil Experimental News Services (LENS)	Collection and dissemination of worldwide information on lentil to facilitate communication between research workers. LENS Newsletter; specialized bibliographic journals; research workers' directory.	Germplasm Program; Communication, Documentation and Information Services	Worldwide	ICARDA core funds
RACHIS	Collection and dissemination of worldwide information on wheat and barley to facilitate communication between research workers. RACHIS newsletter; specialized bibliographic journals; research workers' directory.	Germplasm Program; Communication, Documentation and Information Services	Worldwide	ICARDA core funds
WANA Seed Network	Encourages (1) stronger regional seed sector cooperation, (2) exchange of information, (3) regional consultations, and (4) inter-country seed trade.	ICARDA Seed Unit	Algeria, Morocco, Iraq, Cyprus, Turkey, Jordan, Syria, Egypt, Sudan, Libya, Yemen	ICARDA, Germany (GTZ), Netherlands
Agricultural Information Network for WANA (AIN-WANA)	Improving national and regional capacities in information management, preservation, and dissemination.	Communication, Documentation and Information Services	WANA countries, CIHEAM, ISNAR	ICARDA

Sub-Regional Networks

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

Sources of Primary Inoculum of Stem and Leaf Rusts of Wheat: Their Pathways and Sources of Resistance	Determine disease development of leaf and stem rusts in relation to weather data. Identify prevailing races and the pathways of pathogens. Identify wheat germplasm with effective resistance genes. Identify primary sources of inoculum. Contribute to overall breeding strategy.	ARC/Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA	Netherlands (DGIS)
Management of Wilt and Root Rot Diseases of Cool-Season Food Legumes	Identify sources of resistance to wilt and root-rots. Incorporate resistance into germplasm with suitable characteristics.	AUA/Ethiopia	Egypt, Ethiopia, Sudan, ICARDA,	Netherlands (DGIS)

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions involved	Donor Support
	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.		ICRISAT	
Socioeconomic Studies on Adoption and Impact of Improved Technologies	Monitoring and evaluation of technology transfer to farmers with respect to adoption levels and identification of factors influencing adoption; impact of improved technology on farm-income levels and production; effect of policy and institutional factors on technology transfer and adoption.	ARC/Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA	Netherlands (DGIS)
Barley Networks operating under the Latin America Regional Program (LARP):				
Development of Stripe Rust Resistant Barley	Producing barley resistant to stripe rust using the double haploid method (DH). DH lines produced by Oregon State University, field tested in Mexico, and superior cultivars distributed to NARS.	ICARDA Barley Breeder	Oregon State Univ., Latin American NARS, CIMMYT	ICARDA & CIMMYT core funds
Development of Hull-less Barley	Develop high-yielding hull-less cultivars and improve their nutritional value, producing cultivars with high energy and low fiber.	ICARDA Barley Breeder	CIMMYT, Canada, Australia, Colombia	ICARDA & CIMMYT core funds
Development of Barley Yellow Dwarf (BYD) Resistant Lines	ELISA testing of barley lines. Yield testing of identified resistant lines in Latin America. International testing in Chile, Ecuador, and Kenya where disease has reached epidemic proportions.	ICARDA Barley Breeder	CIMMYT, Chile, Ecuador, Kenya	ICARDA & CIMMYT
Development of Germplasm Resistant to Scab and Barley Yellow Mosaic Virus (BYM)	Development of scab-resistant barley with tolerance to BYM for China.	ICARDA Barley Breeder	CIMMYT, China	ICARDA & CIMMYT core funds
Development of Barley Lines Resistant to Spot Blotch Caused by *Helminthosporium sativum*	Crossing sources of resistance identified in Thailand and North America. International field testing in Thailand, Vietnam, Uganda.	ICARDA Barley Breeder	CIMMYT, Vietnam, Uganda, Thailand	ICARDA & CIMMYT core funds
Development of Leaf Rust Resistant Barley	Network of researchers investigating leaf rust resistance.	ICARDA Barley Breeder	Virginia Tech., North Dakota State, CIMMYT, Latin American NARS	ICARDA & CIMMYT core funds

Appendix 9

ICARDA International School of Aleppo

The ICARDA International School of Aleppo (IISA) is a co-educational day school sponsored by ICARDA. The School offers a high quality, internationally accepted program, primarily for the children of ICARDA employees. Currently, there are 280 students enrolled in grades K-12 representing 37 countries. Approximately one-third of the students are ICARDA-sponsored, with the remainder coming from the Aleppo community.

The School is governed by the School Management Committee (SMC) which is appointed by the Director General. There are over 30 full-time teachers of whom two-thirds are hired internationally while one-third are recruited from the local community.

The School is housed in what is called Office One, a delightful four-hectare site in the Aazamieh suburb of Aleppo. The school shares this site with the residence of the Director General and the ICARDA Sports and Social Club. The School facilities include two large converted residential buildings and two purpose-built buildings. Sports facilities are shared with the Sports Club.

The School is fully accredited by the Middle States Association of Colleges and Schools. It is an approved examination center for the International Baccalaureate (IB) and the International General Certificate of Secondary Education (IGCSE). All students work towards a US-style high school diploma and approximately two-thirds of graduating students also attempt the academically rigorous IB diploma.

In 1999, there was a 90% pass rate for all graduating students who attempted the IB diploma; the average score of diploma students was a very creditable 33 points, the same as the previous year. Results of the IGCSE examinations, mostly taken by students in Grade 10, were also very pleasing.

During the academic year 1998/1999, the School maintained its broad curriculum for students of all ages. In the Elementary School, the resource teacher provided assistance for 27 elementary students in need of extra help, while in the high school the new business course proved very popular among the students. The School commenced its new curriculum development cycle with the publication of new mathematics and science curricula.

The School mounted a variety of special events including an Elementary Halloween Carnival, International Week, Science Fair, and a new Language Afternoon.

The number of extra-curricular activities offered to students was expanded. The Student Government and Honor Society were especially active, and student sports teams participated in several international tournaments organized by the International Schools Activities Conference (ISAC). The Parent Teacher Association (PTA) organized several successful social events for the school community.

School facilities continue to be improved. Acoustics in the new auditorium were greatly improved by adding wall panels and textile hangings to dampen the sound. The campus was wired for a Local Area Network and 29 new computers were ordered. By the end of the academic year, all classrooms were air-conditioned. A new irrigated sports field shared with the ICARDA Sports Club was opened.

Fiscal management of the school remains tight and the school ended the academic year 1998/99 with an operational surplus.

Appendix 10

Visitors to ICARDA

In 1999, the Center received 2301 visitors in 636 groups from 54 different countries representing more than 145 national, international and private organizations from all over the world; 77.7% from WANA, 10.3% from Europe, 6.6% from areas in Asia and Africa other than WANA, and 5.4% from the USA, Australia, and Canada. The visitors included ministers of agriculture, parliament members, ambassadors, senior government officials, representatives of donor organizations, media personnel, researchers, extension specialists, farmers, representatives of farmers' unions, trainees, and students.

Among the distinguished visitors during 1999 were:

H.E. Hashem Shbool, Minister of Agriculture, Jordan
H.E. Hikmat Zaid, Minister of Agriculture, Palestine
H.E. Pascal Couchepin, Minister of Economic Affairs, Switzerland
H.E. John Waterburry, President, American University of Beirut, Lebanon
Drs Mohamed A. Nour and Nasrat Fadda, former ICARDA DGs

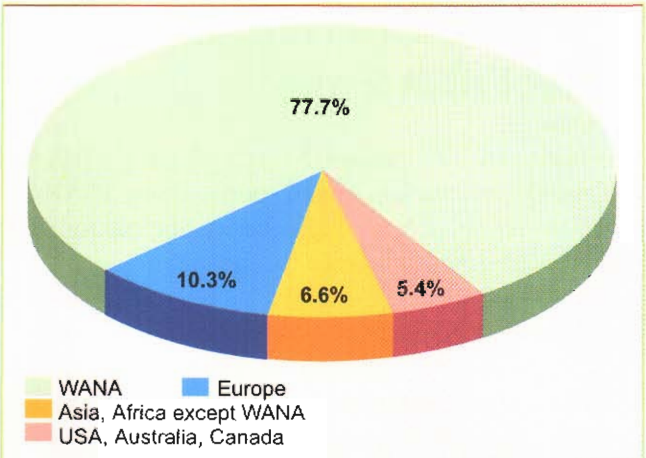


Fig. 16. Percentage distribution of visitors to ICARDA during 1999.

Appendix 11

Statement of Activity (USD x 000)

	1999	1998
REVENUES		
Grants (Core and Restricted)	20,450	23,944
Exchange gains/(losses) - net	(271)	433
Interest income	402	294
Other income	351	514
Grant write-off	(497)	–
Total revenues	20,435	25,185
EXPENSES		
Research	16,878	17,596
Training	1,903	2,060
Information services	635	689
General administration	2,476	2,996
General operation	822	1,207
Total expenses	22,714	24,548
Recovery of indirect costs	(803)	(978)
Net expenses	21,911	23,570
EXCESS OF REVENUE OVER EXPENSES	(1,476)	1,615
ALLOCATED AS FOLLOWS:		
Capital invested in property, physical plant and equipment	330	202
Operating fund	(1,806)	1,413
Surplus/(Deficit)	(1,476)	1,615

Statement of Financial Position (USD x 000)

	1999	1998
ASSETS		
Current assets	22,607	22,846
Property and equipment*	4,531	23,590
Total assets	27,138	46,436
LIABILITIES AND ASSETS		
Current liabilities	13,437	12,550
Long term liabilities	2,879	2,661
Net assets	10,822	31,225
Total	27,138	46,436

* Reduction is due to adoption of CGIAR accounting policy.

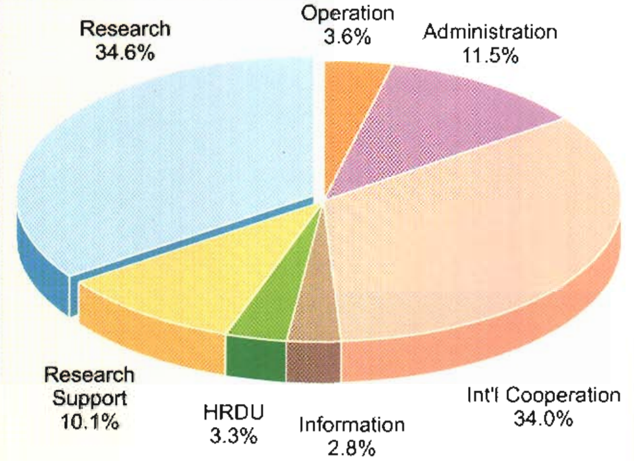
Statement of Grant Revenues, 1999 (US $'000)

Donor	Amount
African Development Fund	137
Arab Fund	1686
Australia*	442
Austria*	30
Belgium*	121
Canada*	413
China*	40
CGIAR	1159
Denmark*	583
Desertification Trust Fund	1231
Economic Research Forum	10
Eritrea	17
Egypt*	1008
Ethiopia	47
European Commission	618
France	137
Ford Foundation	88
Germany*	1074
IMPHOS	14
IBRD (World Bank)*	2100
IDRC	185
IFAD	1152
India*	38
Islamic Development Bank	33
Iran*	1084
Italy*	553
Japan*	709
The Netherlands*	795
Norway*	508
OPEC Fund for Inter. Dev.	43
Pakistan	8
Peru*	25
Spain	199
Sweden*	500
Switzerland	113
Syria	500
UNEP	33
United Kingdom	819
UNDP	188
Univ. of California-Davis	17
USAID*	1505
USDA	118
Yemen	366
Miscellaneous	4
Total	20450

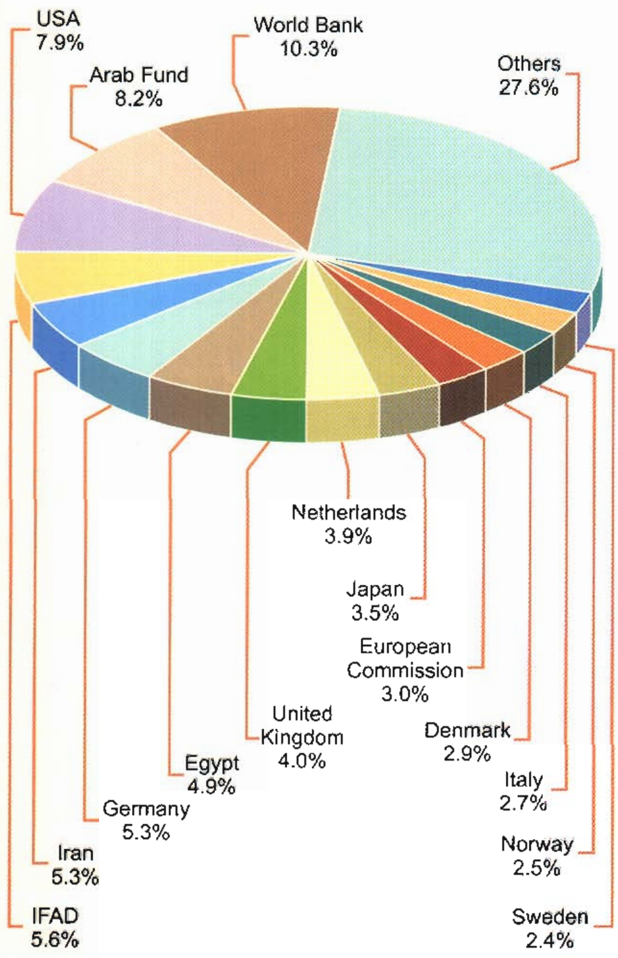
* Donors who provided core funds

Statement of Activity

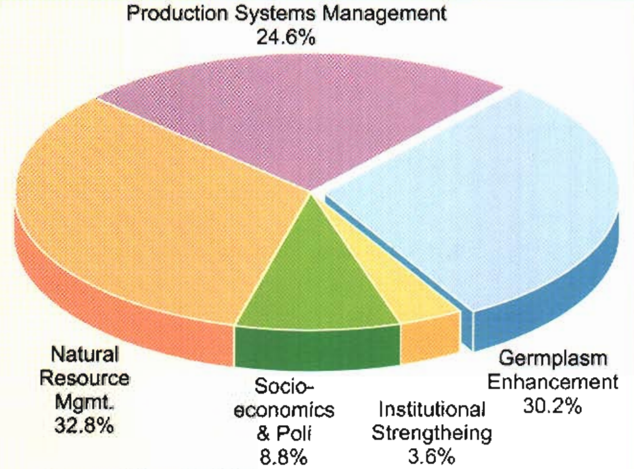
Taking a Closer Look



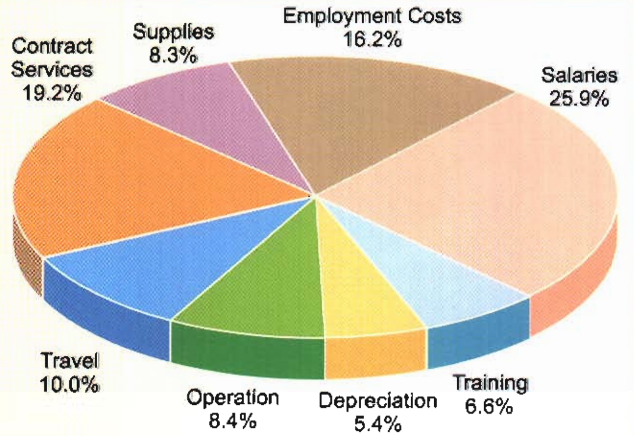
Expenditure (US $ 22.7 million) by Activities for 1999



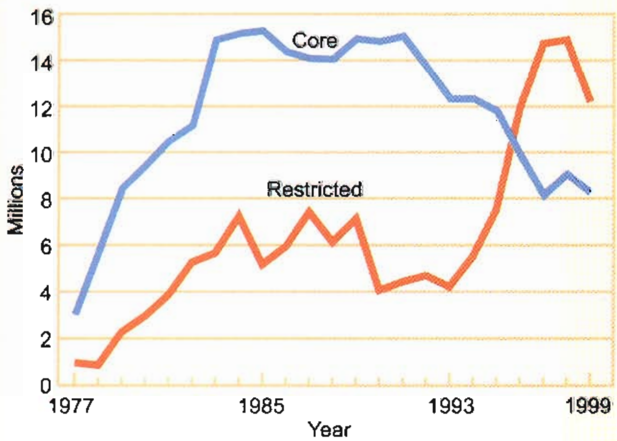
Grant Revenues for 1999



Expenditure by Medium-Term Plan Themes for 1999



Expenditure by Expense Category for 1999



Funding Trend 1977-1999

Appendix 12

Board of Trustees

At its annual meeting held on 15 and 16 August 1999 at ICARDA, Aleppo, the Board of Trustees approved the appointment of Dr Hassan Al-Ahmed, host country representative of Syria, and Dr Salman A. El-Sudairy, of Saudi Arabia, for a 3-year term starting immediately after the 1999 annual Board meeting.

Dr Mouin Hamze, the host country representative of Lebanon, and Dr Iwao Kobori, who respectively completed their fourth and first 3-year terms on the Board, were re-elected for another 3-year term starting immediately after the 1999 annual Board meeting.

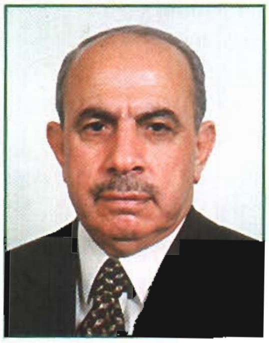
Drs Raoul Dudal, John C. Davies, and Dr Mouin Hamze were elected as Chairpersons of the Program Committee, Audit Committee, and Nomination Committee, respectively.

The Board of Trustees also approved the appointment of Dr Seyfu Ketema, Director General of Ethiopian Agriculture Research Organization (EARO), as a member of the Board for a term of three years starting immediately after the 2000 annual Board meeting. The CGIAR confirmed Dr Ketema as its nominee.

Drs Alfred Bronnimann, Board Chairperson; William Ronnie Coffman, Program Committee Chairperson; and George Some, member of ICARDA's Board, completed their term of office in August 1999. The Board expressed its deepest appreciation and gratitude for their valuable contribution to the development and progress of ICARDA. The departing trustees had joined the Board in 1994.

Mr Robert Harvener was elected as the Chairperson of the Board of Trustees.

Dr Hassan El-Ahmed



Dr Hassan El-Ahmed took his Ph.D. in agricultural economics in 1973 from the Soviet Union. He is currently Deputy Minister of Agriculture and Agrarian Reform, Syria, and is responsible for animal productivity research, land, irrigation, training, extension services, and forestry. Earlier he held the position of Director, Agricultural Research Center, and was a senior staff at the Directorate of Planning and Statistics, Syria. Between 1977 and 1985, Dr El-Ahmed worked in different Syrian companies dealing with food production.

Dr El-Ahmed has traveled extensively in Europe and the Middle East where he has attended meetings and conferences on cereal improvement, disease control, and desertification.

Dr El-Ahmed brings to the Board of Trustees a wide knowledge and experience of agriculture in the WANA region.

Dr Salman A. Al-Sudairy

Dr Salman A. Al-Sudairy, of Saudi Arabia, was Deputy Governor of Amarat Al-Jouf between 1991 and 1999. His responsibilities included monitoring and assessing the performance of the different public agencies in the region, promoting the region and its potential, implementing changes to the structure of the organization and supervising the financial and personnel matters.

Dr Al-Sudairy was also Project/General Manager of Al-Jouf Mineral Water Bottling Company (1983-1985) where he conducted and implemented market and technical analysis and dealt with the Saudi Industrial Development Fund.

Dr Al-Sudairy received his M.Sc. (1986) and PhD (1991) in Accounting from the University of Texas at Austin, where he specialized in Financial Accounting and Information Economics. He has been involved in different community activities. From 1991 to 1997, he was Chairman of the Board of the Cooperative Society of Al-Jouf where he was in charge of trading of agricultural equipment and supplies. Dr Al-Sudairy was also Chairman of the Committee for the Beautification and Betterment of Al-Jouf.

Dr Al-Sudairy has been a Board member of a number of organizations and his contributions have helped the improvement of cultural and educational projects. He brings to the Board of Trustees valuable experience in diverse fields from the WANA region.

Full Board 1999

On 31 December 1999, the membership of ICARDA's Board of Trustees was as follows:

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Board Meetings, 1999

Aleppo, Syria

18-21 April	30th Meeting of the Program Committee
21 April	Nomination Committee Meeting
	Audit Committee Meeting
22-23 April	Extra-ordinary Board of Trustees Meeting
14 August	Nomination Committee Meeting
15-16 August	33rd Meeting of the Board of Trustees

Washington, DC, USA

30-31 October	39th Meeting of the Executive Committee

Appendix 13

Senior Staff

(as of 31 December 1999)

SYRIA (Aleppo: Headquarters)

Director General's Office

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

Government Liaison

Dr Faisal Maya, Director of the Office of Government Liaison

Administration

Mr Michel Valat, Director of Administration

Finance

Mr Suresh Sitaraman, Acting Director of Finance
Mr Edwardo Estoque, Finance Officer, (Financial Reporting)
Mr Mohamed Samman, Treasury Supervisor
Mr Issam Abdalla Saleh Abd Al Fattah, Accountant

Natural Resource Management Program

Dr Richard Tutwiler, Program 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 appointment with IFPRI)
Dr Eddy De Pauw, Agroclimatologist
Dr Luis Iñiguez, Small Ruminant Scientist
Dr Fawzi Karajeh, Marginal-Quality Water Management Specialist
Dr Tidiane Ngaido, Property-Rights Specialist (joint appointment with IFPRI)
Dr Theib Oweis, Water Management/Supplemental Irrigation Specialist
Dr Mustafa Pala, Wheat-based Systems Agronomist
Dr John Ryan, Soil Fertility Specialist
Dr Christoph Studer, Plant, Water, and Soil Specialist
Dr Michael Zöbisch, Soil Conservation and Land Management Specialist
Mr Wolfgang Göebel, Agroclimatologist
Dr Ahmed Mazid, Agricultural Economist
Mr Nicholas Thomas, GIS Analyst
Mr David Celis, Junior Professional Officer
Ms Azusa Fukuki, Research Fellow
Ms Shibani Ghosh, Research Fellow
Ms Malika Martini Abdelali, Research Associate
Ms Trine Nielsen, Junior Professional Officer
Dr Andrea Pape-Christiansen, Visiting Research Fellow
Dr Safouh Rihawi, Research Associate
Ms Josepha Wessels, Associate Expert
Ms Monika Zaklouta, Research Associate

Germplasm Program

Dr William Erskine, Leader
Dr Osman Abdalla El Nour, Breeder Pathologist (seconded from CIMMYT)
Dr Ali M. Abd El-Moneim, Forage Legume Breeder
Dr Michael Baum, Biotechnologist
Dr Salvatore Ceccarelli, Barley Breeder
Dr Mustapha El-Bouhssini, Entomologist
Dr Stefania Grando, Barley Breeder
Dr Khaled Makkouk, Plant Virologist
Dr Ashutosh Sarker, Lentil Breeder
Dr Victor Shevstov, Barley Breeder (Tashkent)
Dr Amor Yahyaoui, Cereal Pathologist
Dr Rajinder Malhotra, Chickpea Breeder
Dr Miloudi Nachit, Durum Wheat Breeder (seconded from CIMMYT)
Dr Bruno Ocampo, International Trials Scientist
Dr M. Sripada Udupa, Biotechnologist
Dr Bruno Schill, Post Doctoral Fellow, Faba Bean Breeder
Dr Imad Mahmoud Eujayl, Post Doctoral Fellow
Mr Fadel Afandi, Research Associate
Ms Bianca van Dorrestein, Visiting Research Fellow (Cairo)

Genetic Resources Unit

Dr Jan Valkoun, Head
Dr Ahmed Amri, Biodiversity Project Coordinator
Dr Kamel Chabane, Biotechnologist
Mr Jan Konopka, Germplasm Documentation Officer
Ms Siham Asaad, Research Associate
Mr Bilal Humeid, Research Associate
Mr Kenneth Street, Associate Expert

Seed Unit

Dr Michael Turner, Head
Dr Samuel Bockari-Kugbei, Seed Economist
Mr Zewdie Bishaw, Assistant Seed Production Specialist
Dr Lahcen Grass, Training Officer
Mr Abdul Aziz Niane, Research Associate

Communication, Documentation, and Information Services

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

Human Resources Development Unit

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

Computer and Biometrics Services

Dr Murari Singh, Senior Biometrician and Acting Head
Mr Awad Awad, Data Base Administrator (Financial Systems)/Senior Analyst
Mr Chittem K. Rao, Financial Systems Senior-Analyst/Programmer
Mr Michael Sarkisian, Maintenance Engineer
Mr Colin Webster, Systems Programmer/Network Administrator

Personnel

Ms Verity Stiff, Personnel Officer

Farm Operations

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

Engineering Services Unit

Mr Ohannes Ohanessian, Electrical/Electronics Engineer

Purchasing and Supplies

Ms Dalal Haffar, Manager

Labor Office

Mr Marwan Mallah, Administrative and Security Officer/ Consultant

International School of Aleppo

Mr Nicholas Bowley, Head
Mr Anthony Brown, Deputy Head and Head of Secondary Section

Damascus Office, Syria

Mr Abdul Karim El Ali, Administrative Officer

Beirut Office, Lebanon

Mr Anwar Agha, Executive Manager/Consultant

Terbol Research Station, Lebanon

Mr Munir Sughayyar, Engineer, Station Operations

Regional Programs

North Africa Regional Program

Tunis, Tunisia

Dr Mohammed El-Mourid, Regional Coordinator
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Appendix 14

Acronyms

ACIAR — Australian Center for International Agricultural Research (Australia)
ACSAD — Arab Center for Studies of the Arid Zones and Dry Lands (Syria)
AFESD — Arab Fund for Economic and Social Development (Kuwait)
ALESCO — Arab League Education, Science and Culture Organization (Tunis)
ARC — Agricultural Research Center (Sudan and Egypt)
BMZ — German Ministry for Technical Cooperation
CARDNE — Regional Centre on Agrarian Reform and Rural Development for the Near East
CDE — Center for Development and Environment (Switzerland)
CGIAR — Consultative Group on International Agricultural Research (USA)
CIAT — Centro Internacional de Agricultura Tropical (Colombia)
CIHEAM — Centre International de Hautes Etudes Agronomiques Mediterranéennes (France)
CIMMYT — International Maize and Wheat Improvement Center (Mexico)
CIRAD — Centre de Coopération Internationale en Recherche Agronomique pour le Dveloppement (France)
CLIMA — Center for Legumes in Mediterranean Agriculture (Australia)
CWANA — Central and West Asia and North Africa
DFID — Department for International Development
EC — European Commission
ESCWA — United Nations Economic and Social Commission for West Asia
FAO — Food and Agriculture Organization of the United Nations (Italy)
GTZ — German Agency for Technical Cooperation (Germany)
IAM — Instituts Agronomiques Méditerranéens
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)
IITA — International Institute of Tropical Agriculture (Nigeria)
ILRI — International Livestock Research Institute (Kenya)
IMPHOS — Institut Mondial du Phosphate (Morocco)
INIA — Instituto Nacional de Investigación y Tecnologia Agraria y Alimentaria (Spain)
INRA — Institut National de la Recherche Agronomique (Morocco)
IPGRI — International Plant Genetic Resources Institute (Italy)
IRRI — International Rice Research Institute (Philippines)
ISNAR — International Service for National Agricultural Research (Netherlands)
ISRIC — International Soil Reference Information Centre (Netherlands)
IUED — Institut Universitaire d'Études du Développement (Switzerland)
IUNG — Institute of Soil Science and Plant Cultivation (Poland)
IWMI — International Water Management Institute (Sri Lanka)
JICA — Japan International Cooperation Agency (Japan)
JIRCAS — Japan International Research Center for Agricultural Sciences
NARS — National Agricultural Research Systems
NGO — Non-Governomental Organization
OPEC — Organization of Petroleum Exporting Countries (Austria)
ORSTOM — Institut Francais de Recherche Scientifique pour le Développement en Coopération (France)
SEWANA — Southern Europe, West Asia and North Africa
UNDP — United Nations Development Programme (USA)
UNEP — United Nations Environment Programme
UNESCO — United Nations Educational, Scientific and Cultural Organization (France)
USAID — United States Agency for International Development (USA)
USDA/ARS — United States Department of Agriculture, Agricultural Research Service (USA)
WANA — West Asia and North Africa
WANADDIN — WANA Dryland Durum Improvement Network
WMO — World Meteorological Organization (Switzerland)

Appendix 15

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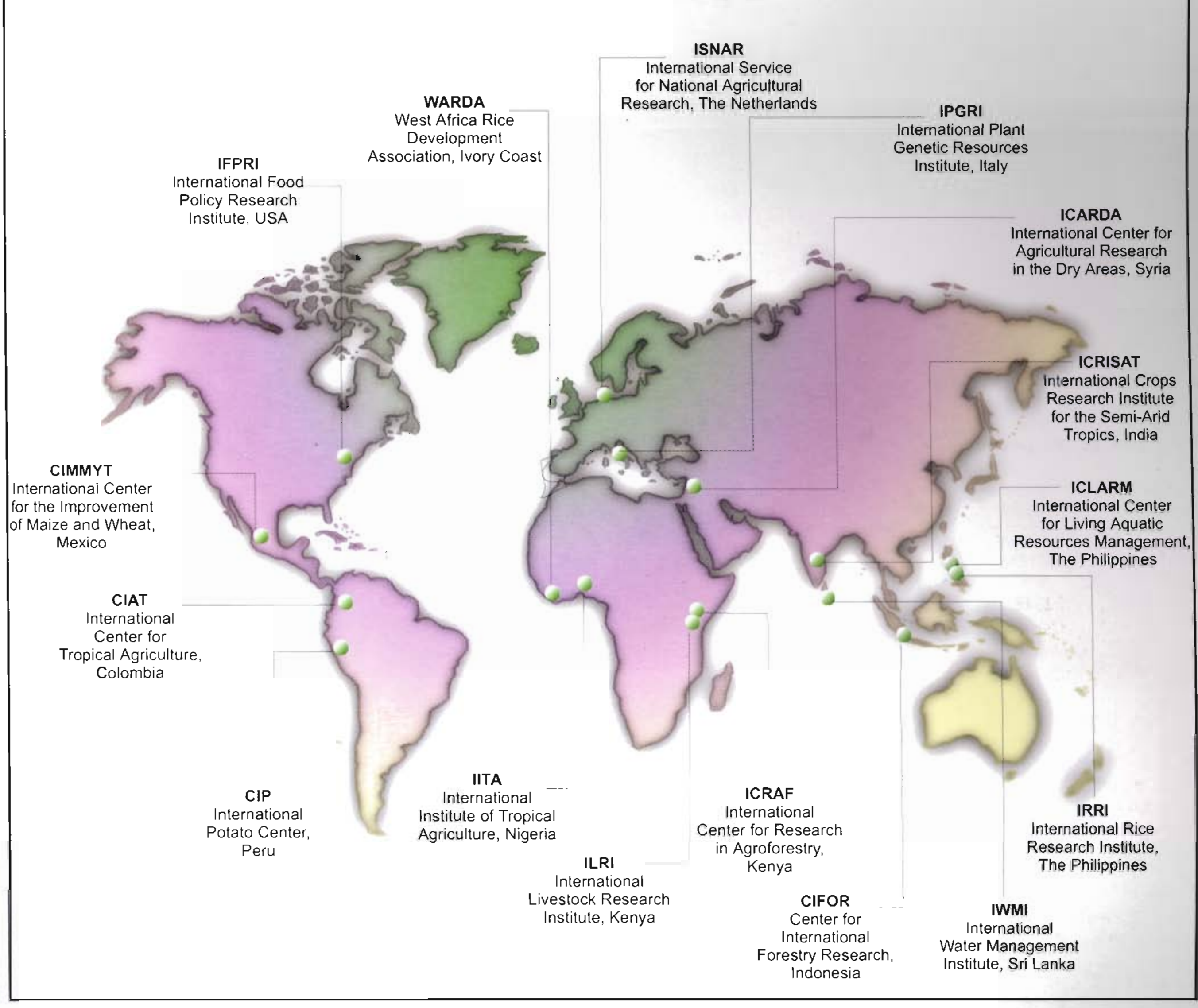
CGIAR Centers



Front cover: Cropping diversity helps bind agricultural production in the rainfed areas of Central and West Asia and North Africa into integrated farming systems of cereals, legumes, forage crops, vegetables, livestock, and fruit and nut trees. Farmers in CWANA already possess indigenous skills in farming and sheep husbandry. ICARDA supplements this with new techniques, including unlocking the potential of germplasm in the Center's genebank, for better harvests, increased small-ruminant production, and sustainable management of natural resources in the dry areas.

Back cover: Modern communication tehnologies are helping to bring researchers closer to farmers even in remote villages in the dry areas. By close cooperation between ICARDA and local television stations and other broadcasters, new technologies for increased agricultural production and protecting the natural resource base are beamed to those who stand to benefit most from new knowledge, and thereby contribute to the overall health and welfare of this planet.

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Blending the Indigenous with Modern Knowledge