ICARDA Annual Report 1996

International Center for Agricultural Research in the Dry Areas

About ICARDA

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

In the context of the challenges posed by the physical, social and economic environments of the dry areas, ICARDA's mission is to improve the welfare of people in the dry areas of the developing world by increasing the production and nutritional quality of food while preserving and enhancing the resource base. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

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 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.

Much of ICARDA's research is carried out on a 948-hectare farm at its headquarters at Tel Hadya, about 35 km southwest of Aleppo. ICARDA also manages other sites where it tests material under a variety of agroecological conditions in Syria and Lebanon. However, the full scope of ICARDA's activities can be appreciated only when account is taken of the cooperative research carried out with many countries in West Asia and North Africa and elsewhere in the world.

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.

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Cover: ICARDA at work.

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Foreword

One of the major activities during 1996 was the development of a new Medium-Term Plan (MTP) for 1998-2000, designed to enhance food security while protecting the natural resource base in the fragile environments of dry areas. It involved working together with our national partners and stakeholders; scientists, managers and the Board of Trustees of ICARDA; and members of the Technical Advisory Committee. Water is the key natural resource in the dry areas and is accorded the highest priority in ICARDA's research; biodiversity and land as natural resources are all closely linked to water and its availability, and receive major research attention.

Guided by its new MTP, ICARDA will increase its efforts to make the most efficient use of rainfall by employing appropriate water-harvesting techniques and exploiting the catchment potential. In areas of extreme water scarcity, attention will be given to the safe and efficient use of non-conventional water resources. Research on land and soil management will target areas at high risk of degradation due to climate and human mismanagement, particularly under pressure of poverty. The focus will be on integrated watershed management to enhance on-farm water-use efficiency, and the development with local communities of systems to control erosion and salinization. The regional mandate will cover all dry areas of West Asia, North Africa, and the newly-independent republics of Central and West Asia.

Located in the center of genetic diversity for some of the most important food and feed crops of the dry areas in the world, ICARDA will continue to accord high priority to research in genetic resources conservation. In the new MTP the strategic shift suggested is to increase emphasis on characterization, evaluation, documentation, and use of genetic resources, and on *in situ* conservation.

For germplasm enhancement, ICARDA has developed a new breeding strategy that involves decentralization and farmer participation. On the recommendations of the Center-commissioned External Review, held in 1996, ICARDA reestablished research on faba bean improvement, as part of its global mandate. Major faba bean production areas extend beyond WANA, particularly in China. The work will focus on germplasm characterization and generation of variability for use by national programs.

To implement its new MTP, ICARDA will make use of the opportunities offered by modern advances in science. Remote sensing and the electronic information revolution provide greatly enhanced access to data, and systems to manipulate and interpret it; and to transform location-specific research to international public goods. Biotechnology offers opportunities to develop cultivars resistant to biotic and abiotic stresses. Computer expert systems can help accelerate adoption of new technology. To maintain a critical mass in all fields of research, ICARDA will initiate a system of Affiliate Research Fellowship for national scientists, and will also use widely recognized international scientists as mentors for specific disciplines.

Another major step forward in 1996 was ICARDA's role as the liaison Center to support the activities of the CGIAR Task Force Committee on Central-Eastern European States

(CEES) and the Former Soviet Union (FSU-NIS). The Center provided active assistance in organizing the CGIAR Central Asia NARS meeting in Tashkent, and in the preparation of the CGIAR Task Force Report on CEES and FSU-NIS. In Central Asia, a Plant Genetic Resources Network was founded, jointly with the International Plant Genetic Resources Institute (IPGRI), in collaboration with NARS—including the prestigious Vavilov Institute.

In the WANA region countries, NARS scientists, farmers and others came together again during 1996 to review and discuss natural-resource conservation measures in the field as part of the Dryland Resources Management Project. In Egypt, the year saw the start of the Mersa Matrouh Natural Resource Management Project, supported by the World Bank, for which ICARDA is providing the technical backstopping.

The importance of farmer participation in setting the research agenda cannot be overemphasized. The participatory barley-breeding project in Syria, planned during 1995, was implemented in 1996, and early results are very encouraging. ICARDA barley breeders also continued to work closely with farmers in Ethiopia and Ecuador. The barley project in Ethiopia was reviewed by an External Review Team, which included donor representation; the Team commended the Project's progress. In Ecuador, crop selection and development of agronomic practices in cooperation with farmers has offered exciting possibilities; at the same time there is a growing market for barley products for urban consumption. Both the Ethiopian and Ecuadorean projects have a strong element of working with women farmers; as a result, we are gaining new insights of the role of women in agriculture.

Globalization of agricultural research must move hand in hand with inculcating a sense of "global citizenship" in those who own the natural resources and use them. Improvement of farming systems is not enough if appropriate "farming ethics," which takes into account the sustainability of the natural resource base, is not followed by the growers and consumers of food. Every citizen is a stakeholder in protecting the environmental health of our planet. We must work together to develop environmentally-responsible behavior in one and all.

We believe that ICARDA's research during 1996 reflects progress in our goal of building sustainable agriculture, protecting the natural-resource base, contributing to poverty alleviation, and enhancing the well-being of the people.

Prof. Dr Adel El-Beltagy
Director General, ICARDA

Dr Alfred Bronnimann
Chairman, Board of Trustees

PART ONE

Major Developments in 1996

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Major Developments in 1996

Continuity and Change

The worldwide fight against desertification is an inevitable concern of ICARDA, given the harsh agro-climatic environment in the dry areas that the Center seeks to serve. In 1996, this concern was reflected in ICARDA's increased attention and resource allocation to research on agriculture's basic ingredients – soil, water and biodiversity – on which sustainable food production depends. The team of farm resource management researchers was strengthened in the areas of land management and soil conservation, agroclimatology, and water conservation and management. Partnerships were expanded with national, regional, and international bodies of researchers involved in resource management and conservation. Concurrently, increased use of modern tools of research, including biotechnology, Geographic Information Systems (GIS), and computer modeling was made to speed up the pace of research and improve its efficiency.

ICARDA's Board Chairman Dr Alfred Bronnimann (with camera) and the DG, Prof. Dr Adel El-Beltagy, exchange notes, as the Center's researchers review with them how Geographic Information Systems (GIS) help to understand the soil and vegetation patterns on land under threat of desertification.

Early in 1996, ICARDA scientists met their partners from all over the West Asia and North Africa (WANA) region and from Sub-Saharan Africa in a consortium for Optimizing Soil Water Use. ICARDA is coordinating this consortium in collaboration with its sister center, ICRISAT, as part of a wider initiative on soil, water and nutrient management, led by a third center, CIAT. ICARDA's Director General, Prof. Dr Adel El-Beltagy, presented the keynote address at the International Conference on Desert Development held in Kuwait in March. As Secretary General of the International Desert Development Commission (IDDC), Prof. Dr El-Beltagy participated in, and delivered the keynote address at the Fifth International Conference of IDDC – "Desert Development: The Endless Frontier" – held in Lubbock, Texas. The meeting elected him as Chairman of the IDDC, which was renamed as International Drylands Development Commission. Also, ICARDA signed an agreement to provide technical assistance to the Marsa Matrouh Natural Resource Management Project in Egypt, funded by the World Bank.

ICARDA strengthened its regional cooperation in rangeland conservation. In addition to participants from WANA, researchers from West African countries joined the workshop on fodder shrubs which took place at the Center's headquarters as part of a System-wide Livestock Initiative. ICARDA is leading the shrubs sub-project.

Plant genetic resources are as fundamental to agricultural productivity as soil and water. The Center played a lead role in the planning of a plant genetic resources network for the Newly-Independent Republics of Central Asia, and established cooperation with the distinguished Vavilov Institute in Russia. It also played an active part in the Conference on International Plant Genetic Resources in Leipzig. A workshop was organized to finalize a major new project, *Conservation and Sustainable Use of Dryland Agro-Biodiversity in the Near East.* The project activities will involve the protection of wild relatives and landraces *in situ*, so that they continue to evolve in nature, as opposed to those saved in cold stores in gene banks. This will be done at sites in Palestine, Syria, Jordan, and Lebanon.

Collaboration was further strengthened with the Newly Independent Republics of Central Asia. ICARDA hosted the CGIAR/Central Asia coordination meeting in Tashkent in September jointly with the Uzbekistan Academy of Agricultural Sciences. The Center also became a partner in the initiatives of the United States Department of Agriculture and USAID to assist small-ruminant and rangeland farmers in Central Asia. Links with Iran were strengthened in 1996, and a senior scientist from headquarters was posted in Tehran.

As the executing agency of a World Bank project on agricultural sector management, ICARDA established an office in Yemen. This office, with a Team Leader, a Livestock Specialist and a Farming Systems Specialist, started operations in May 1996. The year also saw the beginning of Phase II of the Arabian Peninsula Regional Program. Following cordial discussions between the Center's Director General, Prof. El-Beltagy, and the UAE's Minister of Agriculture and Fish Resources, HE Mr Saied Al-Raqabani, in January, ICARDA was able to open an office in Dubai. The emphasis of this Program will be on the desert-margin and protected agriculture.

Another new area of cooperation has been with the Palestinian Authority. In August, a delegation from the Authority led by the Minister of Agriculture, HE Mr Abdul Jawad Al Saleh, visited ICARDA. It was decided that cooperation with Palestine would include training in germplasm conservation and documentation; conservation of marginal land and rangeland; and water harvesting.

HE Dr Abdul Jawad Al-Saleh (left), Minister of Agriculture, Palestinian Authority, and Prof. Dr Adel El-Beltagy, DG, discuss areas of cooperation to promote agricultural research and development in the Palestinian Authority.

All this does not mean, however, that crop-improvement efforts were neglected. The Center carefully balanced the shift in its focus to the natural resources against the crop-breeding research that needs to be continued. During the year, for example, 10 high-yielding chickpea lines giving, on average, 90% higher yield were identified by NARS from ICARDA's germplasm; a bread wheat variety, Dong-feng, was released in China; a drought-tolerant, six-row spring barley, Giza 126, was released in Egypt, and a botrytis-resistant chickpea line, Pant G88-6, developed partly from ICARDA germplasm, was released in India.

Meanwhile, ICARDA continues to shift towards a plant-breeding policy that both uses biodiversity, and maintains diversity of landraces in farmers' fields. This has had its benefits in 1996; for example, Ethiopia released a barley variety, 3336-20, which is a selection from a local landrace. Other barley varieties, such as Arta, which ICARDA developed from Syrian landraces, also proved themselves in 1996. So did lentil varieties produced at ICARDA using methods that have permitted the crossing of exotic lines with low-yielding, but locally-adapted, South Asian germplasm. This has broken a genetic bottleneck and opened the door to far greater productivity of lentil in India, Pakistan, Bangladesh, and Nepal. In Nepal, ILL 2580 and ILL 4402 were ready for release in 1996; and in Pakistan, Masoor-93 looked promising.

Partnership with Farmers

Partnership with farmers for effective research and transfer of technology is inherent in ICARDA's research agenda, but some examples from 1996 deserve a mention. The participatory barley-breeding project in Syria, supported by Germany, got under way (and participatory barley research continued in Ethiopia). In Ecuador, the Latin America Regional Program is also carrying out participatory barley-breeding. A cookery workshop for women was organized there to assess the value of barley recipes. In Jordan, the ICARDA Mashreq and Maghreb Project, for the first time, held a traveling workshop for 15 farmers from Syria, Jordan, Lebanon, Iraq, and Palestine.

ICARDA is increasingly involving farmers in the planning and execution of its research projects. During the year the Center welcomed a party of farmers from Iran, shared with them its ongoing research work, and obtained their feedback.

New Medium-Term Plan

Considerable efforts were invested during the year in the development of a new Medium-Term Plan (MTP) for 1998–2000. Transparent, participatory mechanisms were used to develop this document, taking into account the shifts in the Center's focus summarized above. Indeed, the priorities for the MTP emerged at the end of 1995 at the NARS Forum held at the Center's Aleppo headquarters, during which the participants from the region expressed deep concern over the continuing degradation of the natural resource base. Besides the input from the NARS Forum, ICARDA had the benefit of counsel from its Board of Trustees, which reviewed the draft twice during the year. The MTP also benefited from the input of one of the most distinguished figures from ICARDA's past: Mr Robert Havener, who was instrumental in founding the Center and who visited the Center in the spring of 1996. In December 1996, Dr S. Keya, TAC Executive Secretary, Drs Maria Zimmermann and Hanumanth Rao, TAC members, and Mr Ravindra Tadvalkar, Finance Officer, CGIAR Secretariat, visited the Center to review the draft MTP and made valuable suggestions for its improvement. The draft MTP is now at an advanced stage. It will be reviewed and finalized by ICARDA's Board of Trustees early in 1997 for submission to TAC.

Presentation Day

Ambassador Robert Blake, a former United States Ambassador to the United Nations, gave the keynote address at ICARDA's Annual Presentation Day in April. Ambassador Blake, who now chairs the Committee on Agricultural Sustainability and co-chairs the CGIAR's special committee on NGO cooperation, expressed concern over the decline in funding for international agricultural research. ICARDA's work with farmers prompted Ambassador Blake to comment: "I have found few of the CGIAR's international research centers that spend as much time and care as ICARDA does in working with farmers... my hat goes off to ICARDA for the emphasis its staff puts on working with farmers."

Another distinguished speaker, Dr Earl Kellog, Senior Vice-President of Winrock International, who visited the Center later in the year, also expressed concern over the declining donor funding.

The Presentation Day in April was a chance for ICARDA to honor Dr Giro Orita, the Japanese veterinarian, who has made a substantial contribution to the Center's research on small-ruminants for many years, and who remains a valued collaborator. It was also an occasion to remember Dr Harry S. Darling, ICARDA's first Director General, who passed away in 1995. Mrs Vera Darling and one of her daughters, Ruth Triffitt, visited the Center on the occasion of naming a new executive conference room in memory of the late Dr Darling.

Board of Trustees

The Board of Trustees and its Program Committee met twice in 1996, in Cairo in January and in Aleppo in July, primarily to guide the development of the new MTP. Prof. Iwao Kobori of the United Nations University, Tokyo, and Dr Magdy Makdour from Egypt, were elected as new Board Members. Prof. Kobori will join the Board at the February 1997 meeting, but Dr Makdour, having been elected as a TAC member, declined to join the Board. Prof. Tomio Yoshida completed his term on the Board.

The Weather in WANA

The 1995/96 cropping season was a good one for most of the countries in West Asia, North Africa, and the Horn of Africa. Rainfall was plentiful during winter and spring in the Maghreb from Morocco through Algeria to Tunisia, and in West Asia from southeastern Turkey through Syria and Iraq to parts of Iran, the Gulf countries, and Pakistan. Spring and summer rains were equally above-average further south in Sudan, Ethiopia, Eritrea, and Yemen.

The favorable rainfall enabled the farmers to achieve high yields. Morocco and Tunisia harvested bumper cereal crops – for Morocco it was the best harvest in the country's history. Pakistan and Syria also achieved high cereal crop yields.

In Jordan and Palestine, crops were stressed by heat waves. These less-favorable conditions also occurred in Libya, Egypt, Lebanon, most of Turkey, the northern half of Iran, and Afghanistan. Although yields in these areas stayed around or below average, nowhere in WANA did crops fail on a large scale during 1996.

Agroecological Characterization

Comparison of CropSyst and SIMTAG Simulation Models for Durum Wheat

One function of agroecological characterization is to build accessible, spatially-referenced environmental databases; another is to describe and explore dynamically, through modeling, the interactions between environments and specific crops (and varieties), cropping systems and management practices, to assist the targeting of technologies. For this, it is important to have models that can accurately simulate the performance of specific crops or, more generally, of a range of crops and cropping systems under the harsh and variable conditions prevailing in WANA.

Two models, SIMTAG and CropSyst, were compared for their ability to simulate the performance of Cham 1, a durum wheat cultivar, under different irrigation and fertilization treatments over three seasons, against matching historical data from a Tel Hadya field trial. SIMTAG, designed to simulate the growth of durum and bread wheat genotypes, combines a water-balance module with modules for the simulation of development, growth, and yield of the crop. CropSyst is a multi-crop, management-oriented cropping systems model able to simulate a range of soil and crop growth parameters under different weather and management scenarios on the basis of data from only a few experiments.

Both models satisfactorily replicated selected growth parameters, evapotranspiration, and crop N uptake. For example, for both models, the simulated aboveground biomass closely followed the 1:1 line when plotted against the actual field data, although CropSyst values for grain yield, a more difficult parameter to predict, appeared closer to the real ones than those from SIMTAG.

Germplasm Conservation

Collection of Cereal Wild Progenitors in Syria

In the 1995 collection mission to Gaziantep Province, Turkey, a population of *Triticum timopheevi* subsp. *armeniacum* (= *T. araraticum* Jakubz.) was found 20 km north of the Syrian border (ICARDA Annual Report 1995). As the species had not been found in Syria, a survey and collection mission was undertaken in cooperation with the Agricultural Research Center, Douma, Syria to review the present status and geographical distribution of wild *Triticum* spp. and other wheat wild relatives in northern Syria. Three populations of *T. timopheevi* subsp. *armeniacum* were found in Aleppo Province, two of them were mixed with *T. turgidum* subsp. *dicoccoides*. One site, a relatively undisturbed hard-limestone rocky slope, was identified for *in-situ* conservation, because of its high diversity of plant species. The first finding of *T. timopheevi* subsp. *armeniacum* in Syria extends the geographical distribution of the species in the western part of the Near East arc further southwest. New *T. turgidum* subsp. *dicoccoides*, *T. urartu*, and *T. monococcum* subsp. *aegilopoides* (= *T. baeoticum* Boiss.) sites were identified and samples collected in Aleppo and Raqqa Provinces. Four new *Aegilops tauschii* sites were found between Ain Al-Arab at the Turkish border and Al-Koum deep in the Syrian desert. In total, the mission yielded 40 bulk and 165 single-plant samples of cereal wild progenitors and relatives.

Faba Bean Germplasm Collection in Ecuador and China

With the reestablishment of the faba bean improvement work at ICARDA there has been an urgent need to fill gaps in the germplasm collection for important traits such as disease resistance, as well as from an ecogeographic standpoint. To meet these needs, two collection missions were conducted in 1996 in collaboration with national programs of Ecuador and China, and Australian institutions – the Centre for Legumes in Mediterranean Agriculture (CLIMA) and the New South Wales Department of Agriculture.

In China, the collection mission was undertaken in the provinces of Yunnan and Sichuan in collaboration with the Yunnan Academy of Agricultural Sciences, the Sichuan Academy of Agricultural Sciences, the Zheijang Academy of Agricultural Sciences, the Chinese Academy of Agricultural Sciences, and Australia's New South Wales Department of Agriculture. This mission resulted in 67 accessions of landraces of faba bean from remote areas of the provinces visited.

Faba bean landraces being sold in a local market in Ecuador.

Previously, the best sources of resistance to chocolate spot and rust have been selected from germplasm received from the Andean region of Peru, Ecuador, and Colombia. To increase the genetic base of resistance to these important pathogens of faba bean, a collection mission for faba bean was conducted jointly with the Instituto Nacional de Investigaciones Agropecuarias (INIA) and CLIMA. The Andean region of South America has an environment highly conducive for the development of chocolate spot. The rainfall there is high, and the weather is cool during the entire growing season. This leads to a strong natural selection pressure for resistance to this disease which can cause entire crop losses. During this mission, 108 accessions of faba bean were collected from areas at elevations of 2300 to 3500 m asl. By collecting over a range of altitudes, the problems of lateness in the sources of resistance to chocolate spot in the Andean region may be solved. The accessions collected provide diverse seed size, shape, and color, and would be of great value in developing durable resistance for chocolate spot disease for different agroecological conditions.

Germplasm Enhancement

Spectacular Barley Yield Increases in Farmers' Fields

Arta, an improved barley landrace developed by ICARDA from the germplasm collected in Syria in the 1980s, in collaboration with the Syrian national program, was released to farmers in 1994. For the 1995/96 season the Directorate of Agro-Scientific Research of the Syrian Ministry of Agriculture and Agrarian Reform distributed seed of Arta to a large number of farmers in five provinces of Syria. To assess its performance, one-hectare yields of Arta and the local landrace (either Arabi Abiad or Arabi Aswad, depending on the location) were compared in 60 farmers' fields.

The data showed that, in the 23 lowest-yielding locations, the average yield of Arta was 70% more than that of the local landrace (except in one case in which the yields were similar). This demonstrates that ICARDA's efforts to breed for harsh environments are eventually benefiting the farmers in those environments.

New Sources of Resistance in Barley to Russian Wheat Aphid

Russian wheat aphid (RWA) causes serious damage to barley in several parts of the world, particularly in North Africa and Ethiopia. To identify sources of resistance to this insect pest, 2500 barley lines were field-screened at Tel Hadya. Of these, 29 had a good level of resistance (score of 3 on the DUTOIT scale of 1–6). These lines were also screened in the greenhouse, and 11 of them were found highly resistant (score of <3). Six of these lines are crosses with *Hordeum vulgare* subsp. *spontaneum*, the wild progenitor of cultivated barley. These sources of resistance will be shared with the national programs involved in breeding for RWA resistance in barley.

A promising barley line (left) resistant to Russian wheat aphid, identified in field and greenhouse screening, compared with a susceptible line.

Barley Gene Mapping Project

This collaborative project between the University of Munich and ICARDA aims to map genes for disease resistance and agronomical traits in a population of recombinant inbred lines. Two-hundred and fifty lines of a population from a cross between a powdery mildew resistant parent and a scald-resistant parent were advanced to F_7 by single-seed descent. Segregation analysis was performed for 40 RFLP and 30 RAPD markers. The markers covered almost 60% of the genome allowing interval mapping of Quantitative Trait Loci (QTLs) in that part of the genome. During 1995/96, 14 agronomical traits, four physiological parameters, and some straw quality parameters were evaluated. A major QTL was identified for scald resistance, and minor QTLs for powdery mildew resistance and some agronomical traits.

Virus Resistance in Wheat Derived from Cereal Wild Relatives

Barley yellow dwarf luteovirus (BYDV) is a serious disease of small-grain cereals worldwide. In WANA countries, BYDV epidemics in wheat have occurred recently in Algeria, Egypt, Iran, Morocco, and Tunisia. Work done at ICARDA over the last five years, in collaboration with CIMMYT and advanced laboratories in Canada and Australia, has resulted in the development of a number of wheat genotypes resistant to BYDV. The BYDV resistance was derived from the following cereal wild relatives: *Thinopyron intermedium*, *Aegilops* spp. and *Elytrigia repens*. The derived lines suffer only 5–20% yield loss, compared with 50–70% in susceptible wheat, and are available for breeders to use.

Wheat breeding lines resistant to barley yellow dwarf luteovirus (right and left), derived from wheat wild relative *Thinopyron intermedium*, compared with a susceptible line (center).

Winter Lentils in WANA Highlands

In the highlands (above 850 m elevation) of West Asia, mainly in Iran and Turkey, where the winter is too severe for late-autumn sowing, lentil is sown in spring on about 400,000 ha. In cooperation with the Turkish national program, sources of winter-hardiness have been identified in both wild and cultivated lentil germplasm, which allow late-autumn sowing. This has provided about 50% higher yield potential, earlier maturity, and improved water-use efficiency and biomass production (facilitating harvest) over the traditional spring sowing. More than 180 lentil lines were confirmed as winter-hardy and high yielding at three locations in the highlands of Turkey in 1995/96.

Parallel agronomic experimentation has refined the package of winter lentil technology. As seed of winter-hardy lines becomes available, on-farm evaluation of early-sowing systems will intensify in Turkey. In Iran, following similar testing for winter-hardiness, selected germplasm lines (e.g. ILL 875) have been multiplied for winter sowing. Last season, winter lentil was sown on approximately 60 ha in the Gazvin area. Efforts are under way to extend winter sowing of lentil in the highlands of West Asia for increased production of this important crop.

Iranian architects of winter lentil technology display dried samples of some promising winter lentil lines (tall). The spring lentil lines are labelled in Farsi.

Resistance to Virus Diseases in Lentil

Lentil is affected by a number of viruses in the WANA region, the most important being those transmitted by aphids such as luteoviruses, e.g. bean leaf roll virus (BLRV) and soybean dwarf virus (SbDV). Screening lentil germplasm at ICARDA revealed the presence of useful variability for virus-disease resistance to BLRV and SbDV, and genotype ILL 6810 was resistant to both BLRV and SbDV. It did not produce disease symptoms, and yield loss was below 20% when inoculated with both viruses. ILL 3614 was moderately resistant to both viruses, with yield losses of 15 to 25%. Other genotypes such as ILL 1712 and 7010 were identified as highly resistant to BLRV but moderately resistant to SbDV. A fourth group of genotypes (e.g. ILL 590, 5480, 6797, 7618, 7700 and 7966) was identified as highly resistant to BLRV but highly susceptible to SbDV.

Lentil Gene Mapping

In collaboration with Washington State University, ICARDA is mapping genes of resistance to fusarium wilt and ascochyta blight, using DNA markers. For this purpose, an F_2 population was advanced to F_8 to develop homozygous recombinant inbred lines. Segregation analysis was performed for 116 morphological, RAPD and oligonucleotide markers, which led to the establishment of 9 linkage groups, in which 82 markers were linked. Morphological, RFLP and isozyme markers are considered as anchor markers to join the ICARDA RAPD-marker map with the existing lentil gene maps. During 1995/96, the recombinant inbred-line population was field-tested for fusarium wilt (in sick plot), cold damage and qualitative traits, to add those traits to the linkage map.

Fusarium Wilt Resistance in Chickpea

Fusarium wilt is an important disease affecting chickpea in most WANA countries. Recently ICARDA has established a fusarium wilt sick plot (1.3 ha) to screen and develop chickpea lines resistant to this disease. For the first time, ICARDA-developed kabuli breeding lines (2174 of them) were evaluated in 1994/95 in this plot. Results for the 1994/95 and 1995/96 seasons revealed that seven lines were completely free from damage, and 188 showed a resistant reaction. Of 173 accessions from seven wild *Cicer* species screened, 9 accessions from *C. bijugum*, 26 from *C. judaicum*, and 11 from *C. pinnatifidum* were completely free from fusarium wilt damage. None of the accessions from *C. echinospermum* were resistant.

State-of-the-Art for Chickpea DNA Markers: Allele-specific Microsatellites

ICARDA and the University of Frankfurt, Germany have together developed locus-specific microsatellite markers, called sequence-tagged microsatellite sites (STMS), for the chickpea genome. For the first time these potent DNA markers are available for germplasm screening, diversity studies, research on the taxonomy and phylogeny of the genus *Cicer*, gene tagging (e.g. ascochyta blight resistance tagging) and, in future, for the mapping of the chickpea genome with the prospect of isolating agronomically important genes.

The development of STMS markers involves cloning and sequencing as a prerequisite for the design of microsatellite-flanking primers. Some 50 STMS are now available for breeders to use. To cite an example of the successful application of STMS in chickpea research, ICARDA's germplasm collection can now be rapidly screened with STMS markers: a specific allele length can be assigned to a specific genotype (Fig. 1), and this allele length variability (i.e. polymorphism) varies considerably among the tested genotypes. So far, 28 allele frequencies have been found in a total of 87 chickpea genotypes tested. It was interesting to note that all loci were conserved between chickpea and its wild relatives *C. reticulatum* and *C. echinospermum*. Even the smallest difference in allele lengths can be detected with this novel set of DNA markers (Fig. 2).

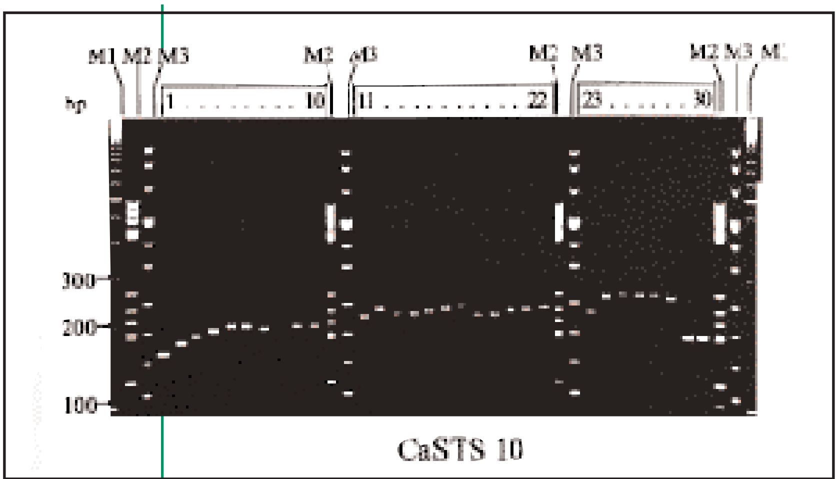

Fig.1. Allele-specific microsatellite analysis of *Cicer echinospermum* (1), *C. reticulatum* (2), and 27 *C. arietinum* genotypes (3-30) using STMS 10, showing variations in allele length.

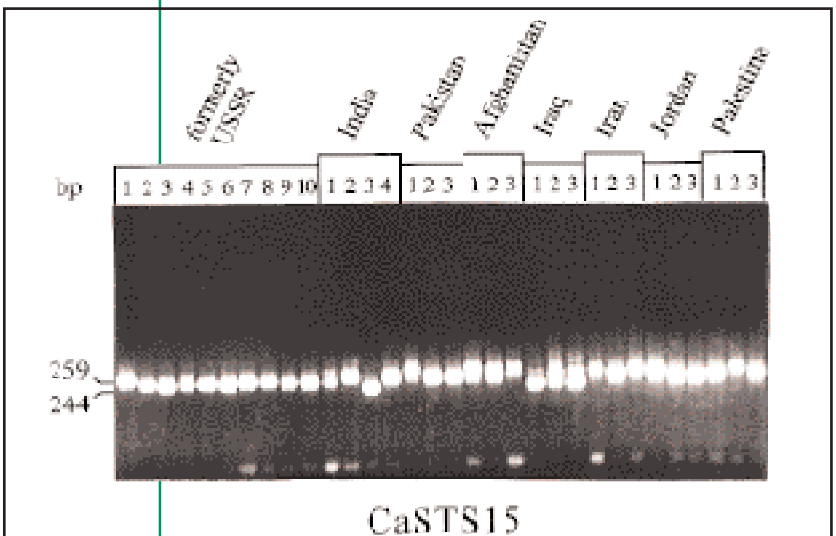

Fig. 2. Allele-specific microsatellite analysis of 32 accessions of different geographical origin, using STMS 15. Polymorphism of the allele length ranges from zero to 15 bases.

Faba Bean Revival

In 1986, the CGIAR's Technical Advisory Committee (TAC) recommended that faba bean research at ICARDA be limited to genetic resources and, accordingly, by 1992 the faba bean improvement research was transferred to the Moroccan national program. Following requests from national programs and the recommendation of the Center-Commissioned External Review in 1996, ICARDA has resumed its role in faba bean improvement. The program will focus (i) on the evaluation of germplasm to identify new resistant sources to key stresses, and (ii) in close coordination with NARS, on targeted pre-breeding work in a decentralized mode.

Forage Legumes Resistant to Parasitic Weeds

Greenhouse and field screening of six lines of woolypod vetch (*Vicia villosa* subsp. *dasycarpa* Ten.), four of ochrus chickling (*Lathyrus ochrus* (L.) DC.), and one each of common vetch (*V. sativa* L.) and narbon vetch (*V. narbonensis* L.) for resistance to the parasitic weeds *Orobanche crenata* Forsk., and *O. egyptiaca* Pers., revealed high interspecific and intraspecific variation. Lines of *L. ochrus* were free from both species of *Orobanche*, while *V. narbonensis* was highly susceptible to *O. crenata* and resistant to *O. egyptiaca*. Both species of *Orobanche* germinated underground and the haustoria did not emerge above ground in *V. villosa* subsp. *dasycarpa*, and no damage occurred to the plants. *Vicia sativa* #1448 was resistant to *O. crenata*, and moderately susceptible to *O. egyptiaca*.

Vicia narbonensis (left) susceptible to broomrape (*Orobanche crenata*); right: *Lathyrus ochrus* and *V. dasycarpa*, resistant under artificial infection.

Seed Security

A study on seed security has been initiated at ICARDA to develop a conceptual framework and assemble available experiences in disaster-preparedness to make cereal and legume seed available in the event of natural or man-made disasters. Country case studies have been initiated in six WANA countries: Afghanistan, Eritrea, Ethiopia, Pakistan, Sudan, and Yemen. The study will: (a) assess availability of varieties and seeds; (b) prepare catalogs of varieties, seed producers, and distributors; (c) summarize regulations on plant quarantine, variety, seed import and export; and (d) develop a list of NGOs and private voluntary organizations involved in agriculture and relief operations.

Seed Health Laboratory

The Laboratory received 44 seed shipments from 22 countries, containing over 14000 cereals and food and forage legumes samples. Also, it dispatched 397 consignments to cooperators in 75 countries.

In a yield loss assessment experiment at Tel Hadya, *Pyrenophora graminea* was found to significantly affect yield of barley. The average yield of Roumi and Faiz cultivars was reduced by about 11%, 24%, 34%, and 48% when 15%, 19%, 22% and 32% plants were infected, respectively.

Resource Management and Conservation

Participatory Research Approach for Natural Resource Management

Since 1990, ICARDA's Dryland Resource Management Project (DRMP) has sought to assist national research systems to initiate studies of dry-area production systems and their impact on the natural resource base, with a view to identifying acceptable and sustainable improvements. The project's second phase, which started in 1995, involves case studies in six countries: Iraq, Jordan, Lebanon, Syria, Tunisia, and Yemen. Field visits, discussions with end-users and researchers, and interactions between national scientists at a workshop at Tel Hadya in 1996 led to the formulation of a common research approach with the following main features: multidisciplinarity, participation, problem-solving, and partnerships. This approach is being applied to the following case studies.

Iraq: diagnostic analysis of the status of the natural resources (rangelands and biodiversity) of the Jebel Sinjar area.

Jordan: examination of farmers' attitudes to a recent land-development project (including terracing) and their willingness to adopt and sustain these improvements.

Syria: analysis of recent changes in land use in a rocky, hilly area of Idleb governorate and their implications for soil erosion.

Farmers at work in Tunisia. The Dryland Resource Management Project works with farmers to help them use their limited natural resource base sustainably.

Tunisia: on-farm testing of research-led improvements to traditional techniques of water retention and soil-erosion control, in relation to the technical and socioeconomic factors that affect farmers' acceptance.

In Lebanon and Yemen, bilaterally-funded projects have followed from earlier, Phase-I case studies. They have now a wider range of activities, but the research approach is essentially similar.

Trends in Yields and Soil Properties in Long-term Cropping

Long-term trends in sustainability of the production systems may be studied in two ways: directly, through the analysis of crop yields over time, and indirectly by monitoring changes in soil properties.

Crop yield trends. The main problem in establishing crop-yield trends is the large year-to-year variation arising from seasonal factors, especially rainfall. ICARDA has now developed a simple model that allows for the effects on yield of rainfall (linear and quadratic components) and of planting date. Applied to nine years of data from trials annually cropped to barley, it suggested that:

- at Breda (a dry site in Syria), the trend over time in grain yield is generally downward, but that for straw is upward except where no N-fertilizer is applied;
- at Tel Hadya, all trends appear positive except where N is applied in the absence of P.

The implications of these findings are that, for continuous barley, over a nine-year period, N and P fertilizers can maintain (and increase) grain and straw yields under moist conditions (Tel Hadya) but only straw yields under drier conditions (Breda). At Tel Hadya, grain and straw yields appear to be maintained even without fertilizer, but a longer period is needed to establish the significance of this trend.

Soil trends. While seasonally-compensated yield trends provide an essential check on production sustainability, measurements of long-term changes and in soil properties give other, more basic, indicators of crop and management effects on the resource base. After 10 years of cropping, appreciable differences are evident in topsoil organic matter and total nitrogen contents among seven 2-year wheat-based rotations in a long-term trial at Tel Hadya. In general, values of these two parameters are higher where the alternate crop is a legume, and annual medic appears particularly effective in maintaining high soil organic matter and nitrogen contents. There are implications here for improved soil aggregation, and reduced nitrogen fertilizer needs in the wheat phase of the rotation.

Tillage Systems and Soil Moisture Management

To test the moisture-saving hypothesis, a “tillage and barley residue management” trial was set up at Breda in 1989 to compare five treatments, applied to rotations of barley–barley [B-B] and barley–vetch (*Vicia sativa*) [B-V], involving combinations of: tillage (ducksfoot) *vs* no tillage; time of tillage; straw retention; and stubble retention.

In the B-B rotation, barley yields showed no significant effect of these treatments, although zero-till planting into retained stubble and straw tended to produce slightly more grain. In the B-V rotation, highest yields were again after zero tillage, although no vetch residues had been retained; and vetch yields were also higher after zero-till planting, significantly so in two years, irrespective of whether or not barley straw had been retained as well as stubble. However, none of these differences exceeded 10% of the yield mean.

Direct-drill planting on tilled (foreground) and untilled (background) stubble land in a moisture-saving trial at Breda, Syria.

Monitored soil moisture values showed that, in the B-V rotation, the mean seasonal evapotranspiration (ET) of vetch was 20 mm less than that of barley, but barley ET values were only about 3 mm greater than those from the B-B rotation. Thus, most of the extra water left unused in the soil profile by the vetch crop (mean, 17 mm) was lost during the intervening summer. Further, the effects of tillage/ residue management treatments on ET values were negligible for both barley and vetch crops.

It may be provisionally concluded that the zero-till technology may confer a small advantage over sweep tillage under Breda conditions. The initial hypothesis, that residue retention (with zero tillage) would improve the soil moisture regime, by increasing infiltration and reducing evaporation, remains unproven; but such an improvement, on a small scale, may indeed be the cause of the marginal yield effects. The small differences observed imply slightly greater water-use efficiency in the zero-till treatments. This result suggests that zero tillage and/or surface residue retention have reduced evaporative losses from the soil, probably early in the growth period, thereby allowing a slightly higher proportion of the rainfall to be transpired by the crop.

Water Quality Criteria for Supplemental Irrigation

Supplemental irrigation of winter crops in Syria is increasing rapidly, with more than 200,000 ha newly brought under irrigation in the last decade. Much of this expansion has been based on the exploitation of groundwater, which varies locally in quality. Some aquifers supply brackish, even saline, water. Others, initially fresh, are deteriorating.

The response of wheat to salty irrigation water was evaluated under field conditions at three semi-arid locations in northern Syria. Locations were chosen to compare soils of different texture: the low plains of the Khabur watershed (loamy clay, with clay at depth), the Shedadeh plains (loamy, sandy loam), and the southern plains of the Aleppo basin (clay loams, grading to clay at depth). Samples of well-water and soil, and yield data, were taken from a total of 65 farms having similar irrigation history and cultural practices and growing the same wheat cultivar, Cham 3.

Threshold values of water salinity, above which the yields of supplementally irrigated wheat were lowered, differed widely between locations: 1.2 dS/m for the Khabur low plains, 3.5 dS/m for the southern Aleppo plains, and 6.5 dS/m in the Shedadeh area. These differences are attributed to the local differences in soil texture and structure, which affect infiltration capacity, water retention and, hence, salt accumulation in the soil profile.

Salinity profiles at one farm in each location having well-water of approximately similar salinity were studied. The differences suggested that, due to superior internal drainage, salt accumulation in the Shedadeh sandy loam was much less than in the heavier Aleppo and Khabur soils. Further, the pattern of data across all sampled farms showed accumulations of salt in the poorly-drained Khabur to be greater than in the Aleppo plains over the whole range of water salinity.

Range Resources Inventory and Mapping

Since more and more rangelands and marginal lands are being brought under cultivation, those that remain are being overgrazed and becoming degraded. The development of sustainable, socially and environmentally acceptable rehabilitation and management measures for these lands can only be achieved through integrated research, including ecological assessments and inventories of rangeland resources.

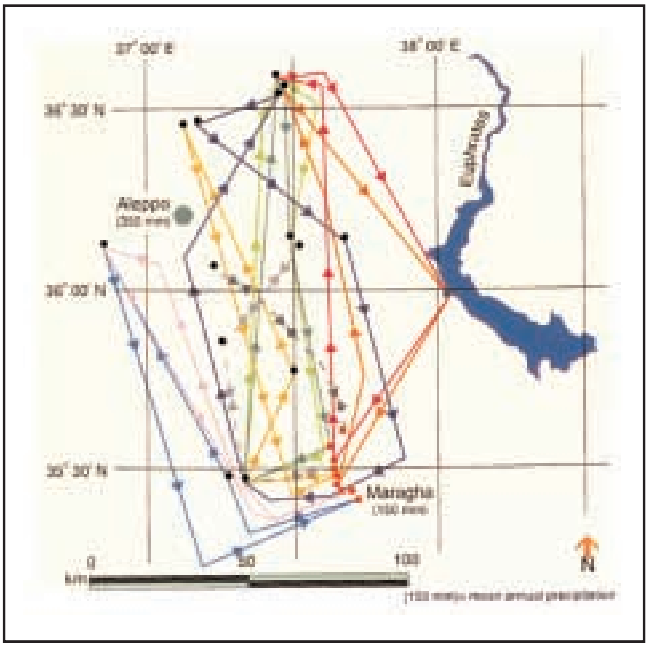

Fig. 3. Migration of 10 sample flocks (each in separate color) from winter/spring bases near Maragha, 1995/96, Aleppo Province, Syria.

ICARDA's work is focused on determining the productivity of rangelands improved by native and exotic fodder shrubs; monitoring the effect of stocking pressure on rangeland biomass, sustainability of livestock production, and economic returns; and development of rehabilitation techniques using direct-seeding methods. Emphasis is being given to experimentation with flocks in steppe areas with the participation of communities, using rangeland surveys and GIS tools to extend the work to new areas, and for local community planning and management.

The study revealed complex interactions of range and crop lands through seasonal migration patterns of the Bedouins. These movements allow sheep herders to make use of the most abundant and low-price feeds becoming available in particular months of the year. Flocks are brought back to the same traditional winter bases in the steppe rangelands each year where mean annual rainfall is between 125 and 200 mm in the Maragha area.

In the 1980s the Steppe Directorate established a number of shrub plantations (*Atriplex* spp. and *Salsola vermiculata*) in the Bedouins' traditional winter-based rangelands. In 1995 and 1996, grazing of these reserves by Bedouin flocks was allowed for the first time under contract-controlled terms. Their locations and the reported movements were plotted with a GIS system. Examples of flock movements from the Maragha reserve (6500 ha, 77 km southeast of Aleppo) are shown in Figure 3.

Impact Assessment and Enhancement

Farmer Participatory Selection of Barley Germplasm

Barley breeders in ICARDA and national programs have been increasing their efforts to involve farmers in research as an important means for achieving wider adoption of improved varieties. Large numbers of new varieties and promising lines have been exposed to farmers through on-farm testing, demonstrations, and field days.

In 1996, a study was conducted on farmers' field in the low-rainfall zone of Jordan with a group of participating farmers representing both commercial barley producers and those who grow barley primarily to feed their own sheep.

The most important traits farmers consider in choosing a cultivar are high grain yield, high straw yield, plant height, and drought tolerance. Although all farmers placed the greatest emphasis on high grain yield, there were significant differences in ranking the other criteria between those growing barley for sale and those growing barley for on-farm feed consumption. Commercial producers gave plant height second highest priority because they wanted to reduce production costs through mechanical harvesting. In contrast, on-farm feed producers were more concerned with high fodder yields and the softness of straw because of the importance of these traits for their animals. Commercial producers were also concerned with grain size and kernel weight because these qualities influence the market price.

Adoption of Winter Chickpea in Syria

A study conducted in 1990 showed that about 47% of Syrian farmers growing Ghab 1 and Ghab 2 chickpea cultivars adopted the practice of winter sowing; but a serious attack of ascochyta blight in some areas in the 1995/96 season prompted a new survey, by Syrian national program and ICARDA researchers, to reassess the performance of winter-sown chickpea and to identify problems faced by farmers growing this crop.

The unusually wet weather of 1995/96 had caused ascochyta blight to occur widely on farmers' fields, but with variable severity. An overall yield decline of 30 to 40% relative to last year was anticipated. However, the newly released cultivar Ghab 3 showed greater tolerance than Ghab 1 or 2. Blight severity was much greater where the seed used had come from farmer's stock or the local market rather than government seed sources.

In a formal survey, 46% of the 104 farmers contacted reported they had blight on their fields. However, although significant differences in the yields of both winter- and spring-planted crops occurred between regions and between zones, the average yields of winter chickpea were higher everywhere, with an average difference of 28% (1.09 *vs* 0.85 t/ha); and Ghab 3 significantly outyielded Ghab 2 and Ghab 1.

Of the sampled farmers, 84% said that they would continue to grow winter chickpea next year because of the greater anticipated yield and profitability.

Tarhin: Another Rehabilitation Success

Farmers in another village in the El-Bab area (70 km north of Aleppo, Syria) have reported benefits from

Marginal land used by a village community in the El-Bab area, near Aleppo, Syria after its improvement by seeding native legumes and applying phosphate fertilizer.

ICARDA's pasture technology. Marginal land development in collaboration with farmers goes back to 1994, when ICARDA identified four villages in the El-Bab area. Each of these villages has marginal lands totaling 30 to 100 ha, traditionally used for grazing by sheep and goats in winter and spring. All marginal lands in those villages had one thing in common: they were all degraded.

The technology consisted of seeding with legumes collected from native pastures in Syria and Lebanon, and fertilization with phosphate. The most important condition, however, was the agreement the scientists made with farmers: not to graze their animals on the improved pasture during late March to April, which is the time for flowering and seed-set for the pasture legumes. Now, after three years of improvement of the pasture by the ICARDA team, and full adherence by the farmers to the agreed pasture management, the farmers have started to reap the benefits of this cooperation. Last year farmers at Batajek, one of the four villages, started to use their improved pasture during October to December, a period known for feed shortage by flock owners.

This year another village, Tarhin, started to use its deferred pasture beginning early October. A farmer at Tarhin, Mr Amin Yagan, said that using the pasture at that time of the year was fully supporting his flock of 400 sheep for at least two months. Previously, he said, he would have been hand-feeding his animals (300 g/sheep per day barley grain and 600 g/sheep per day barley straw) at that time of the year.

Outreach Activities

ICARDA's six regional programs continued to enhance collaborative relationships among NARS and between NARS and ICARDA to ensure the continuum of strategic, applied and adaptive research, as well as transfer of technology to farmers. The major developments in 1996 included the establishment of a Regional Office for the Arabian Peninsula Regional Program in the United Arab Emirates; a Country Liaison Office in Iran; a three-member ICARDA Team in Yemen; and strengthening of collaboration with the Newly Independent Republics of Central Asia.

North Africa Regional Program

The North Africa Regional Program (NARP) focuses on research, training and farmer participation in technology development in Algeria, Libya, Morocco, and Tunisia. Studies initiated last year on the optimum use of available and "harvested" water are providing additional and sustainable options to the Maghreb dry areas. For the first time in nearly two decades, the Maghreb countries achieved a record harvest of wheat, barley, and legume crops.

Intra-Regional Cooperation: There was increased interaction between the North African and West Asian NARS. Cooperation in the Mashreq and Maghreb (M&M) Project and the Mediterranean Highlands Project – funded, respectively, by IFAD/AFESD and EC – was further boosted by the Durum Network for the dry areas of WANA, supported by IFAD, and the ICARDA faba bean breeding efforts.

Regional Traveling Workshops: NARP brought together Aleppo-based and NARP scientists and farmers in several regional events. The M&M Project field days for farmers were combined with both the Cereals Traveling Workshop and the Agronomy Traveling Workshop. Farmers participated in the assessment of barley technology in central Tunisia, western Libya, and the Khouribga, El Brouj, and South Meknes provinces of Morocco. Farmers and extension workers were also involved in the development of research plans at both national and regional coordination meetings.

Regional Training Workshop: The Native and Exotic Fodder Shrubs Training Workshop in Central Tunisia brought together over 100 scientists and sheep owners from WANA, the Newly Independent Republics of Central Asia, Australia, South Africa, Chile, and southern Europe. For the second year of operation of the Mediterranean Highlands Project, researchers from Turkey and North Africa held a Traveling Workshop in the Middle and High Atlas Mountain areas of Morocco.

A sheep owner from Central Tunisia explains to farmers and scientists from different parts of the world, his evaluation of exotic and native fodder shrubs in feeding his herd.

Survey of Biotic Stresses: Disease and insect surveys in Libya, carried out by ICARDA, and the completion of earlier surveys by Tunisian and Moroccan pathologists and entomologists provided a full picture of disease and insect distribution in the Maghreb.

Inter-Center Cooperation: ICARDA, in cooperation with CLIMA and IPGRI, assisted the Moroccan and Tunisian forage programs in assembling, characterizing, and preserving collections of native forage species, while ICARDA/IFPRI cooperation assisted North African NARS in identifying policy and property rights constraints to livestock production in the rangelands and their integration with sustainable crop/forage production systems.

Nile Valley and Red Sea Regional Program

The Nile Valley and Red Sea Regional Program (NVRSRP) is based on tripartite cooperation among the NARS of Egypt, Eritrea, Ethiopia, Sudan and Yemen; ICARDA; and donors. In addition to the three major bilaterally-funded projects on cereals, food legumes and resource management, two new projects were initiated: the Research Component of the Agricultural Sector Management and Support Project (ASMSP) in Yemen and the Matrouh Resource Management Project in the rainfed Northwestern Coast of Egypt. Both these Projects are supported by the World Bank.

External Review of Barley Improvement Project in Ethiopia: The Barley Improvement Project was evaluated in October 1996 by a Review Team appointed by the Netherlands donor. The Evaluation Report, which recommended that "Phase II is perfectly justified," commended the "leadership and direction that the Project has provided, most significantly in building multidisciplinary teams, giving transparent research management, emphasizing the use of national genetic resources and developing targeted production packages." The Report also stated that "the Project has made a substantial contribution to the sustainable development of the Barley Program in Ethiopia."

External review of barley improvement project in Ethiopia: Leader of the Review Team (second from left) interviews a farmer.

On-Farm Monitoring of Resource Management in Egypt: The long-term trials on strategic research in resource management in Egypt were well established in the 1995/96 season in selected locations representing the old irrigated lands, the newly reclaimed lands, and the rainfed areas of North Sinai. Different rotations were implemented along with monitoring of the sustainability of natural resources under different levels of management. Preliminary results of this work were presented at the National Coordination Meeting held in Cairo on 15 to 19 September.

Agricultural Sector Management Support Project (ASMSP) in Yemen: In May/June 1996, a team of three ICARDA scientists was posted at the Agricultural Research and Extension Authority (AREA) in Dhamar, Yemen. The major objectives of this new World Bank supported collaborative program are to introduce effective research management principles and procedures; develop and introduce efficient research priority setting, program planning, implementation and evaluation procedures; and strengthen agricultural research and thereby accelerate the development, transfer and adoption of appropriate technologies with emphasis on rainfed agriculture. A major National Research Review Workshop was held from 8 to 12 September. A comprehensive evaluation of agricultural research in Yemen was done through collaboration between ICARDA and AREA, while the development of a National Research Strategy and Medium-term Plan was initiated in cooperation with ISNAR.

Matrouh Resource Management Project (MRMP) in Egypt: In July 1996, ICARDA signed a contract for the Adaptive Research and Technical Assistance Agreement of the MRMP, financed by the World Bank/International Development Association (IDA). The project is designed to assist the population of the Northwestern Coastal Zone of Egypt in making the best use of available natural resources. The main components of the Project include water-harvesting and watershed management, rangeland and grazing management, adaptive research in rainfed and dryland farming systems, extension and training, and monitoring and evaluation. The Project implementation started in November 1996.

Complementary Research in Regional Networks: The problem-solving Regional Networks Project, supported by the Netherlands Government, includes networks on Wheat Rusts, Wilt and Root-Rots of Food Legumes, Aphids and Viruses, Thermotolerance in Wheat, Drought in Barley and Water-Use Efficiency in Wheat, and Socioeconomics. These networks achieved considerable progress in dealing with common problems facing the production of cool-season food legumes and cereals in Egypt, Ethiopia, Sudan, and Yemen. The season's results were reported at the Regional Coordination Meeting in Yemen, held from 29 September to 2 October.

Human Resources Development: Over 453 Egyptian and 192 Ethiopian researchers received training and participated in workshops and meetings. Another 145 Egyptian, Ethiopian, Sudanese, and Yemeni scientists working within the Networks Project received individual training or attended short courses, conducted field surveys in Sudan and Yemen, and participated in workshops and conferences. Seventeen Yemeni scientists were enrolled in universities (14 in overseas universities and 3 in Sana'a University) under long-term graduate training programs.

West Asia Regional Program

The West Asia Regional Program (WARP), operating from Amman, Jordan, promotes regional cooperation in research, training and information dissemination in Jordan, Cyprus, Syria, Lebanon, south Turkey, and Iraq. The major emphasis in this region is on the improvement of farming systems in the 200–450 mm rainfall zone. Major support for cooperation is provided through the Mashreq and Maghreb Project (M&M), funded by the Arab Fund for Economic and Social Development (AFESD) and the International Fund for Agricultural Development (IFAD). The Project focuses on the development of integrated crop/livestock production in low-rainfall areas of the Mashreq and Maghreb regions.

Intra- and Inter-Regional Collaboration: Collaboration between countries in the region included exchange of germplasm and participation in workshops and technical meetings. Inter-regional collaboration was also strengthened in WANA. Three coordination meetings were organized with Jordan, Iraq, and Syria. To review the M&M Project results and develop workplans, coordination meetings were organized in Iraq, Jordan, Lebanon, and Syria. Several farmers participated in these meetings.

For the first time in the Mashreq region, a Traveling Workshop for farmers was organized by the M&M Project. Fifteen farmers/sheep owners attended this one-week workshop in Jordan in April 1996. In addition, five other workshops were organized by WARP in 1996: a Traveling Workshop in

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Human Resources Development: A regional training course on statistical analysis of livestock experimental data was held in Aleppo in July 1996, while several courses were conducted in each participating country. About 20 students from West Asia are working for their Masters and Doctoral degrees under the joint supervision of ICARDA and NARS scientists.

Arabian Peninsula Regional Program

An ICARDA Regional Office for the Arabian Peninsula Regional Program (APRP) was established in the United Arab Emirates (UAE). The Office is hosted by the UAE Ministry of Agriculture in Dubai. A scientist from headquarters was posted as Regional Coordinator to the Office in November. Recruitment is already under way for two ICARDA scientists in water management and protected agriculture. The implementation of the collaborative Phase II of the Project on "Strengthening Agricultural Research and Human Resource Development in the Arabian Peninsula" is now in operation. Phase II, which is co-financed by the Arab Fund for Economic and Social Development (AFESD) and the International Fund for Agricultural Development (IFAD), involves Bahrain, Kuwait, Qatar, Saudi Arabia, Oman, the UAE, and Yemen. It is a continuation of Phase I of the Project which was operated from ICARDA headquarters from 1988 to 1995. Phase II aims at increasing food security in the Arabian Peninsula through increased productivity of field crops and livestock, based on optimization of water-use efficiency, improvement of stress tolerance, prevention of soil degradation and desertification, and strengthened co-operation among participating countries with regional and international organizations. In a Regional Steering Committee Meeting, held at ICARDA headquarters on 25 to 26 September, and in which representatives from the member countries participated, it was agreed that the Project will emphasize regional cooperation in on-farm water use, abiotic stresses (drought, moisture deficit, heat, salinity), rangelands and forages, and protected agriculture.

Highland Regional Program

The Highland Regional Program (HRP), with its regional base in Ankara, Turkey, coordinates training and research activities for the highland areas (over 700 m asl) of the WANA region. During the year, activities were extended to the Newly Independent Republics of Kazakhstan, Kyrghyzistan, Tajikistan, Turkmenistan, Uzbekistan, Armenia, Azerbaijan, and Georgia, which have agroecologies similar to those of the highland areas in West Asia.

Iran: A one-week visit by ICARDA's Director General, Prof. Dr Adel El-Beltagy, promoted further cooperation with Iran – he visited various research institutes and met the Minister of Agriculture and a large number of high-ranking officials. As a result of this visit, an ICARDA Office was established in Tehran in October 1996, and an ICARDA/Iran Project Coordinator was posted there. Major emphasis is on germplasm enhancement to develop high-yielding, stress-tolerant bread and durum wheat and barley cultivars for different agroecological regions of the country. Another major component of the pro-

ICARDA's linkages with Central Asian Republics grow stronger. Seen in Samarkand, from left to right, are Bakhtier Kholmanov, Department of Foreign Relations of the Academy of Agricultural Sciences; Gus Gintzburger, ICARDA; Tagir Gilmanov, Utah State University; Inkilob Atakurbanov, Experiment Farm Consultant; Uktam Aripov, Director General of the Karakul Sheep Institute, Samarkand; Vladimir Karimov, Samarkand reporter; Nemat Tulaev, State Farm Agronomist; and Aeshmirza Choriev, Deputy Director General, Karakul Sheep Institute. The group met to discuss ways to rehabilitate degraded rangelands.

ject in Iran is the transfer of technology to farmers. A visit of 56 Iranian farmers to ICARDA headquarters was organized to acquaint them with the latest techniques and technology for sustainable agricultural production in dry areas.

Two in-country training courses were organized for Iranian researchers in Seed Production Technology and Data Analysis and Interpretation of Diagnostic Farm Surveys. Twenty-four participants from the Dryland Agricultural Research Institute and Extension Organization were also trained at Kermanshah in June and July.

Turkey: Thirteen collaborative research activities were carried out during the year by Turkish scientists in close collaboration with ICARDA. These included two new activities: socioeconomic surveys on the status of supplemental irrigation in the Central Anatolian Plateau, and crop modeling in cereals and food legumes.

Mediterranean Highlands: Good progress was made during the second year of the EC/ICARDA Mediterranean Highlands Project operating in Algeria, Morocco, Tunisia, and Turkey. As mentioned under NARP, a Traveling Workshop was organized in Morocco in May and was attended by project scientists from the four participating countries and ICARDA.

Newly Independent Republics of Central and

Mexican scientists screen barley lines for head-scab resistance at Toluca research station, Mexico.

West Asia: As a follow up of the ICARDA/GTZ/Uzbekistan workshop in Tashkent in December 1995, a multi-CG Center project proposal for increasing sustainable agricultural production in the Central Asian Republics was submitted to BMZ by ICARDA.

A workshop on the assessment of livestock production in Central Asia was jointly organized by SR-CRSP of the USAID and ICARDA in Tashkent, 27 February to 1 March. As a result ICARDA is a partner with the University of California at Davis in a project development grant received from the SR-CRSP for 1997 for Central Asia. Also, ICARDA actively participated in and supported the activities of the CGIAR Task Force Committee on Central-Eastern European States (CEES) and the Former Soviet Union (FSU-NIS).

ICARDA was the liaison CG Center to organize the CGIAR Central Asia NARS Meeting in Tashkent, 5 to 6 September, and actively assisted the CGIAR Secretariat in the preparation of the CG Task Force Report on CEES and FSU-NIS. Several scientists from the region were provided opportunities to attend the International Wheat Conference in Ankara, the International Conference on *in-situ* Conservation of Germplasm in Antalya, Turkey, and the Shrubs Workshop in Tunis, Tunisia. Two senior scientists from Uzbekistan visited ICARDA to discuss further opportunities for collaboration.

Latin America Regional Program

The Latin America Regional Program (LARP), based at CIMMYT in Mexico, directs a major part of its resources to breeding barley germplasm to be used by NARS in the region. For several years, the emphasis has been on the incorporation of disease resistance into otherwise high-yielding barley cultivars in an effort to protect the disease-prone areas of Latin America from the threat of fusarium head-scab epidemics.

Existing linkages with advanced institutions, Oregon and North Dakota State Universities and the barley breeding programs in Alberta and Saskatchewan, are reinforcing some research aspects of LARP.

Germplasm of hull-less barley, a crop essentially rediscovered by Canadian farmers in recent years, has been developed by the ICARDA/CIMMYT Program and has been adopted by Canadian breeders, and five of the national programs in Latin America have also released hull-less cultivars for food and feed.

As a result of ICARDA Director General Prof. Adel El-Beltagy's visit to Mexico in September, new linkages and contacts were established with several Mexican institutions interested in working on combating desertification. As a first step, ICARDA will provide full information to these institutes about its work on arresting desertification; thereafter, areas of mutual interest will be identified for collaboratrive work.

Collaboration with Ecuador, Peru, Bolivia, Chile, Brazil, and Uruguay was further strengthened through joint research activities, workshops and meetings, and LARP's involvement in graduate studies programs of national researchers.

Training

In 1996, ICARDA offered training to 659 individuals. Training participants came from 42 countries comprising 19 WANA countries, 1 Latin American country, 8 African countries (excluding North Africa), 5 Asia and Pacific region countries (excluding West Asia), and 9 European countries. Of these, about 45% persons were trained in courses at ICARDA headquarters in Aleppo, while the remaining attended in-country, sub-regional and regional training courses. About 15% of the trainees were women.

ICARDA continued its strategy to gradually decentralize its training activities by offering more non-headquarters training courses. In 1996, ICARDA offered 11 headquarters courses and 19 in-country, regional and sub-regional courses.

The *Manual of Training Procedures* was revised and implemented during the 1996 training season, and the Training Policy on *Graduate Research Training* was also revised and implemented.

Several contacts were made with sister IARCs, regional and international research and training organizations such as CIHEAM, ACSAD, AOAD, API, CIMMYT, IPGRI, ICRISAT, FAO, and UNDP for conducting joint training activities in areas of mutual interest. Three joint group courses were conducted in collaboration with CIHEAM and one each with GTZ, IPGRI, FAO, IDRC, and SDC in 1996.

For the UNDP-assisted project entitled *Technical Assistance to Agricultural Investment in the Southern Region-Phase II*, Syria, for which ICARDA is the implementing agent for the human resource development component, ICARDA managed to facilitate the conduct of 10 short-term specialized training courses in collaboration with the Egyptian International Center for Agriculture (EICA) in Cairo, Egypt; the International Program for Agricultural Knowledge Systems (INTERPAKS) at Urbana-Champaign, Illinois, USA; the Arab Planning Institute (API), Kuwait; and the national program in Settat, Morocco. One hundred and thirty-five senior training participants from the Southern Regional Agricultural Development Project (SRADP), Syria, participated in these courses.

Information Dissemination

In collaboration with the CGIAR Secretariat, a comprehensive version of ICARDA's homepage was mounted on the Internet. Three issues of *Caravan*, a new general-audience newsletter launched in 1995, were produced. These developments brought ICARDA in touch with a wider cross-section of its audiences throughout the world.

To reinforce the growing awareness and appreciation of ICARDA's work, a number of other public awareness items were produced and distributed widely. These included press releases, posters, information leaflets and booklets, video films, and a desk calendar. The Dubai Space Channel featured ICARDA's Presentation Day in its program on agriculture. Several journalists representing national, regional and international media visited the Center and published articles about its work in their newspapers and magazines.

A BARLEY database, containing over 40,000 references, was created. Collaboration was established with CLIMA to jointly publish a world bibliography on *Lathyrus* in both CD-ROM and hard-

PART TWO

Research and Training Overview

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Research and Training Overview

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 West Asia and North Africa (WANA) region, ICARDA is responsible for the improvement of durum and bread wheats, chickpea, 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 close collaboration with National Agricultural Research Systems (NARS). For certain specialized areas of research, the Center has established strong linkages with several advanced institutions in industrialized countries (see Appendix 7). The research program follows a three-dimensional approach to bring out the interlinkages between the various facets of its work: (i) the agroecological dimension which defines the broad setting in which the Center's work is conducted, (ii) the commodity dimension which responds to the requirements of enhancing the germplasm and improving the production and management of the mandated commodities, and (iii) the activity dimension which introduces a matrix/project-based approach that cuts across the boundaries between other aspects of the Center's research.

The Center has identified seven integrative activities central to its current research program. These are: agroecological characterization, germplasm conservation, germplasm enhancement, farm-resource management, 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.

At its headquarters at Tel Hadya, about 35 km southwest of Aleppo, Syria, ICARDA conducts research on a 948-ha farm. The Center operates four additional sites in Syria and two in Lebanon (see Table 19). The report that follows represents only a selection of important results achieved in collaboration with NARS during the 1995/96 cropping season. Progress in transfer of technology and strengthening partnerships with NARS is summarized under "Outreach Activities." A full report of each major program/unit (see Appendix 2) is available on request.

The Weather in WANA, 1995/96

In general the weather in the WANA region in 1995/96 was favorable for crop production. In North Africa rainfall was generally above normal, particularly in Tunisia and the northeast of Algeria. This resulted in increased area, yield and production of

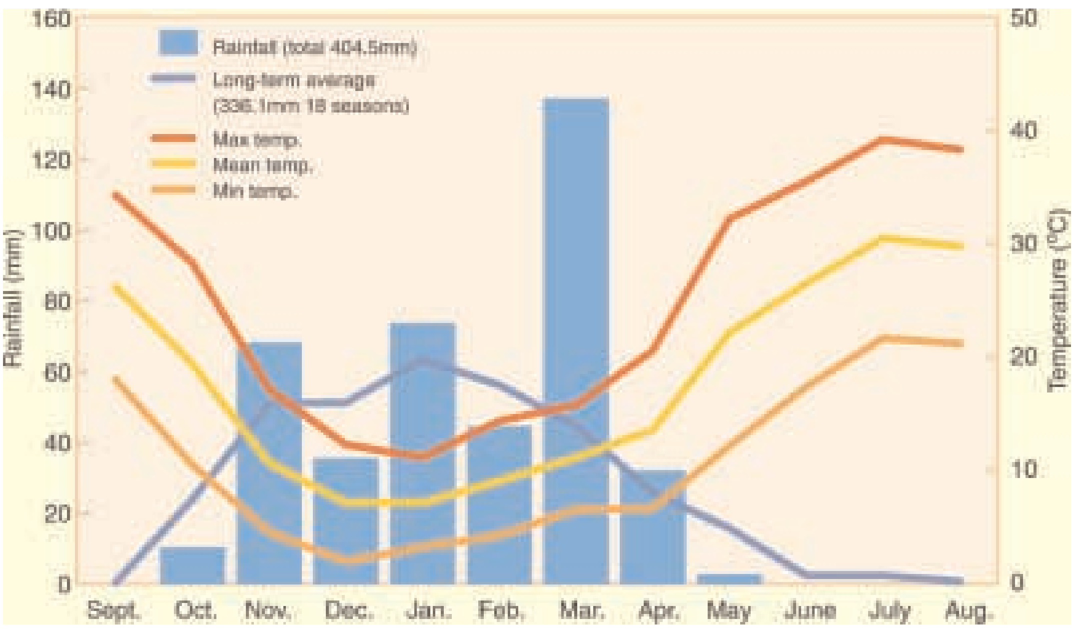


Fig. 1. The weather in 1995/96 at Tel Hadya, ICARDA's main research station near Aleppo, Syria

wheat and barley. Barley cultivation expanded in the marginal areas, resulting in a more than six-fold production increase over the 1994/95 season in Morocco, and more than ten fold in Tunisia. In Egypt, where cereals are mostly grown under irrigation, wheat output remained stable, notwithstanding a slight reduction in the rainfed northern areas which received somewhat below-average rainfall.

In Ethiopia, Somalia, and Sudan, rainfall was generally adequate resulting in satisfactory harvests of the secondary, short-growing-season crops and adequate soil moisture for a succesful start to the main growing season. In Sudan, wheat production for 1996 was below average but better than the 1994/95 season.

In West Asia, early rains were somewhat below average and irregular but this was compensated by above-average rainfall later in the season. Rainfall between March and May 1996 was within the wettest 10% on record in southeastern Turkey, Lebanon and the agricultural areas of Syria and Jordan. Nevertheless, because of the erratic early rains, the area sown to cereals was reduced, which affected production to a varying extent, as compared with the previous year. In Jordan the aggregate cereal output in 1996 was about 20% below the previous year, and that in Lebanon was also somewhat below normal. In Syria, a slight increase in barley area compensated for the wheat shortfall. The weather at ICARDA's main station at Tel Hadya, near Aleppo, Syria is shown in Figure 1. In Iraq the impact of below-average rainfall early in the season was aggravated by shortages of agricultural inputs. In Turkey, wheat production increased by 5% as compared with the 1995 below-average crop, whereas barley production was at the level of the 1995 above-average production.

In Iran, rainfall and snowfall were above average in the cereal-production areas, resulting in some localized but severe flooding, and wheat production was 6% higher than the average of the previous five years. In Pakistan, the monsoon rains were heavy which benefited the wheat crop and contributed to a 6% yield increase over the previous year.

In the Arabian Peninsula, heavy rains in Yemen in June 1996 caused damaging floods across the country. Early-season rainfall (November 1995 to January 1996) in northern Oman was far above average.

Germplasm Conservation

ICARDA continues to contribute to global efforts to save and utilize plant biodiversity. Joint collecting missions during 1996 with NARS yielded 440 new accessions; another 165 were received from collaborating institutes. By the end of 1996, the Center's gene bank was holding 111,740 germplasm accessions.

A total of 19,804 accessions of cereals, food legumes, and forage legumes were distributed to users throughout the world. In addition, to fulfil safety duplication requirements, 2025 accessions of vetch, 2000 of medics, and 1000 of faba bean were dispatched to the Federal Institute of Agrobotany, Linz, Austria; and 1270 of *Lathyrus* spp. were sent to the Station Fédéral Agronomique de Changins, Nyon, Switzerland.

ICARDA holds its germplasm collection in trust under the auspices of FAO.

Diversity in Barley Germplasm Collection

Since its establishment, ICARDA has focused on germplasm indigenous to the West Asia and North Africa region, and landraces from other parts of the world. This is because indigenous germplasm, such as the barley wild progenitor, *Hordeum vulgare* L. subsp. *spontaneum* (C. Koch) Thell., and cultivated barley landraces, are valuable sources of genes for stress tolerance in breeding crops for the semi-arid regions, but they are under threat of genetic erosion. With 24,500 accessions, ICARDA currently holds the third largest barley collection in the world. Of these, 14,489 accessions were received from the USDA Small Grain Collection; 2049 from the Germplasm Resources Institute, Chinese Academy of Agricultural Sciences, China; and 1068 from the Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany. Twenty other donor institutions contributed to the collection. The Cereal Improvement Program (now merged in the Germplasm Program) at ICARDA contributed 2336 accessions, mostly breeding lines and named cultivars. Accessions collected by ICARDA in collaboration with national programs are listed in Table 1.

Table. 1. Barley germplasm collected by ICARDA.

Country	No. of accessions Cultivated barley (ssp. *vulgare*)	Wild barley (ssp. *spontaneum*)
Morocco	459	-
Syria	220	113
Egypt	151	1
Jordan	107	139
Pakistan	102	2
Algeria	95	-
Ecuador	56	-
Iran	46	8
Lebanon	12	25
Turkmenistan	5	8
Tajikistan	5	1
Tunisia	3	-
Uzbekistan	1	2
Turkey	-	36
Iraq	-	8
Libya	-	7
Cyprus	-	3
Russia	-	2
Total	1264	355

Table 2. Frequency distribution of categories in 16 characters for barley germplasm accessions.

Category	Code	No. acces.	Description
Growth class	GCL	4,141	winter
		5,607	facultative
		11,270	spring
No. kernel rows	RNO	14,545	six
		6,312	two
Kernel cover	KCV	2,274	naked
		17,978	covered (hulled)
Awn texture	ARG	1,180	smooth
		19,468	rough
Spike density	SDE	2,074	lax (rachis internode >4 mm)
		16,964	intermediate
		1,918	dense
Growth habit	GHA	2,548	erect
		11,235	intermediate
		5,333	prostrate
Hoodedness/ awnedness	H_A	168	sessile hoods
		213	elevated hoods
		129	awnless or awnleted (<2 cm)
		20,366	awned, on all six rows for six-rowed forms
		147	awned on central rows for six-rowed forms only
Lemma color	LCO	14,343	white/brown
		3,257	purple or black
		1,931	other
Awn color	ACO	4,390	white
		8,371	yellow
		2,904	brown
		738	reddish/brown
		465	black
Glume color	GCO	3,531	white
		6,175	yellow
		1,165	brown
		1,061	black
		794	other
Grain color (pericarp)	KCO	1,491	white
		3,149	blue
		1,030	black
		6,949	other
Rachilla hair length	RHL	7,181	short
		5,731	long
Stem color	SCO	607	green
		187	purple
		12,156	other
Frost damage	FRD	675	1 damaged completely (1-9 scale)
		399	3 very poor
		1,292	5 fair
		3,070	7 good
		173	9 no damage
Resistance to lodging	LOD	1,920	1 excellent (1-9 scale)
		11,454	3 good
		2,125	5 fair
		1,775	7 poor
		1,151	9 very poor
Powdery mildew	PM	14	1 resistant (1-9 scale)
		1,862	3 moderately resistant
		2,030	5 moderately
		1,003	7 moderately susceptible
		174	9 very susceptible

The collection missions were undertaken to fill the gaps not only in the barley germplasm collection but also in other crop collections. Gaps were filled with germplasm received from IBPGR/IPGRI-supported missions to Bhutan, Libya, Morocco, Oman, Saudi Arabia and Yemen (399 accessions), and from the national programs of Tunisia (490 accessions), Nepal (317), Morocco (258), Syria (209), Iraq (108), and Iran (100).

Cultivated barley germplasm held at ICARDA was characterized and evaluated for a number of descriptors. The characterization and evaluation data for more than 12,000 accessions were published in two catalogs (ICARDA 1986, 1988). The third catalog with data on more than 9000 accessions is under preparation for publication. Summary data for 16 characters are shown in Table 2.

The major part of the barley collections at the ICARDA genebank is of spring barley (11,270 accessions), followed by facultative types (5607), and winter barley (4141). There are 14,545 accessions of six-rowed barley, and 6312 of two-rowed barley (including the types with rudimentary sterile florets). Barley collection with covered (hulled) kernels accounts for 17, 978 accessions; and naked (hull-less) barley for 2274 accessions.

The characterization data were used for estimating phenotypic diversity of individual characters in 21 countries well represented in the ICARDA barley germplasm collection (Table 3). The relative Shannon–Weaver information index (H_{SR}), standardized according to Adrivon and de Vallavieille-Pope, was used. The overall country diversity H_{SR} was calculated as the arithmetic mean of the character H_{SR}

Table 3. Estimates of relative Shannon-Weaver information index (H_{SR}) of barley accessions for 21 countries and 12 characters and mean diversity H_{SR} over all characters.

Origin	N‡(MAX)	Character† ACO	ARG	GCL	GCO	GHA	H/A	KCO	KCV	LCO	RHL	RNO	SCO	Mean
United States	2,168	0.66	0.73	0.93	0.71	0.88	0.30	0.83	0.23	0.17	0.92	0.50	0.06	**0.58**
Turkey	1,373	0.67	0.47	0.99	0.63	0.92	0.02	0.74	0.03	0.64	1.00	0.63	0.07	**0.57**
Syria	285	0.70	0.99	0.41	0.70	0.59	0.01	0.87	0.06	0.58	0.56	0.38	0.89	**0.56**
Ethiopia	2,640	0.92	0.05	0.48	0.88	0.80	0.00	0.84	0.29	0.56	0.84	0.85	0.10	**0.55**
Iran	425	0.57	0.29	0.83	0.61	0.93	0.00	0.79	0.26	0.97	0.77	0.62	0.00	**0.55**
Afghanistan	279	0.65	0.23	0.84	0.61	0.96	0.03	0.66	0.43	0.71	0.97	0.42	0.03	**0.55**
China	2,892	0.35	0.10	0.72	0.67	0.68	0.14	0.64	0.94	0.86	1.00	0.35	0.11	**0.55**
Japan	258	0.71	0.04	0.98	0.71	0.95	0.11	0.70	0.87	0.47	0.71	0.38	0.00	**0.55**
Russia	277	0.77	0.21	0.88	0.69	0.80	0.06	0.81	0.14	0.43	1.00	0.54	0.04	**0.53**
India	424	0.60	0.13	0.59	0.68	0.95	0.14	0.68	0.73	0.66	0.85	0.21	0.09	**0.53**
Germany	486	0.66	0.30	0.87	0.57	0.65	0.04	0.63	0.21	0.55	0.95	0.62	0.16	**0.52**
Morocco	643	0.69	0.10	0.58	0.54	0.63	0.30	0.53	0.13	0.33	0.94	0.53	0.75	**0.50**
France	70	0.69	0.26	0.94	0.55	0.86	0.00	0.62	0.19	0.00	0.97	0.62	0.07	**0.48**
Yugoslavia	423	0.68	0.15	0.81	0.63	0.83	0.00	0.69	0.02	0.60	0.79	0.50	0.04	**0.48**
Hungary	62	0.60	0.12	0.97	0.55	0.66	0.00	0.68	0.00	0.61	0.97	0.59	0.00	**0.48**
Jordan	128	0.59	0.20	0.29	0.76	0.42	0.00	0.65	0.00	0.62	0.84	0.53	0.52	**0.45**
Spain	229	0.38	0.28	0.84	0.51	0.53	0.00	0.76	0.00	0.49	0.84	0.41	0.00	**0.42**
Greece	339	0.50	0.11	0.89	0.42	0.80	0.00	0.53	0.05	0.81	0.55	0.26	0.03	**0.41**
Pakistan	238	0.40	0.00	0.56	0.18	0.83	0.00	0.37	0.91	0.16	0.70	0.04	0.58	**0.40**
Switzerland	669	0.67	0.04	0.62	0.42	0.69	0.03	0.36	0.25	0.02	0.96	0.37	0.04	**0.37**
Tunisia	591	0.39	0.10	0.69	0.39	0.45	0.00	0.32	0.00	0.44	0.50	0.12	0.65	**0.34**
World	**18,995**	**0.77**	**0.30**	**0.92**	**0.81**	**0.87**	**0.17**	**0.82**	**0.49**	**0.73**	**1.00**	**0.65**	**0.26**	**0.65**

† For character codes (see Table 2).
‡ Maximum number of accessions evaluated.

values. World collection diversity was estimated from pooling over countries. The diversity estimates by character and country and the mean country diversity are shown in Table 3. The highest diversity in the world estimates was for rachilla hair (1.00), growth class (0.92) and growth habit (0.87), while the lowest diversity was in hoodedness/awnedness (0.17) and stem color (0.26). The mean diversity in the ICARDA world collection (0.65) was higher than in any individual country, and that in the USDA barley collection (0.57). The diversity estimates from ICARDA characterization data were substantially higher than the estimates for USDA barley collection for all developing countries, except Pakistan: for example, Turkey (0.57 vs 0.43), Syria (0.56 vs 0.43), Ethiopia (0.55 vs 0.48), Iran (0.55 vs 0.46), Afghanistan (0.55 vs 0.46), China (0.55 vs 0.36), India (0.53 vs 0.43), Morocco (0.50 vs 0.28), Jordan (0.45 vs 0.31) and Tunisia (0.34 vs 0.13). ICARDA data indicate that barley germplasm from countries of the primary and secondary centers of diversity such as Turkey, Syria, Iran, Afghanistan, Ethiopia, China, India, and Morocco possesses high phenotypic diversity, as does that from developed countries which introduced exotic germplasm and utilized it extensively in their breeding programs (USA, Japan, Russia, and Germany).

Genetic Resources Documentation on the Internet

ICARDA is a partner in the development of the CGIAR System-wide Information Network for Genetic Resources (SINGER). The main objective of SINGER is to integrate CGIAR genetic resources databases, to strengthen standardization of data and facilitate access to information, and thus to the genetic resources conserved in genebanks of the CGIAR centers. The CGIAR collectively maintains over 600,000 accessions of landraces, wild species and improved varieties; ICARDA genebank accounts for about 20% of these genetic resources. SINGER is a distributed database utilizing CGIAR's Integrated Voice and Data Network (IVDN) and it is accessible via the Internet's World Wide Web. A CD-ROM version of the database is also envisaged to serve those who do not yet have access to the Internet. SINGER will also offer other opportunities to users: participation in the Clearing-House Mechanism of the Convention on Biological Diversity, facilitation of the System-wide collaborative activities such as management of safety duplication, planning of joint collecting missions, and analysis of genetic diversity.

During 1996, SINGER implementation work at ICARDA ranged from installation of necessary hardware and software which handles data transfer between ICARDA and SINGER Network Operation Center (and databases in other Centers) to a major restructuring of the ICARDA germplasm database in order to reach, and to sustain, agreed SINGER data standards. By the end of 1996 the passport data, collecting missions details, characterization information, and the data related to transfer of ICARDA-held germplasm to users were all transferred to SINGER. A CD-ROM is expected to be produced by mid-1997.

Germplasm Enhancement

Barley Mixtures to Increase Stability of Production

Landraces are still widely used in subsistence agriculture where maximizing stability of performance is more important than maximizing yield. ICARDA's cooperative research with national partners has provided evidence that landraces are natural mixtures of different genotypes. Pure-line selection within Syrian barley landraces has produced lines with superior performance for the dry areas of the country, but pure lines may not be the most suitable cultivars to stabilize yield in adverse and variable conditions. It is reasonable to speculate that heterogeneity within landraces is a buffer against environmental fluctuations and that it may enhance stability even at levels lower than in the original landrace. The use of mixtures as opposed to homogeneous varieties has often been suggested as a means of promoting stability. Improved stability and decreased disease severity are common features of mixtures relative to their components in monoculture. A recent report in the literature indicated that, although the yield advantage of mixtures is generally small, their use is a viable strategy for sustainable productivity in subsistence agriculture.

The role of different levels of heterogeneity in stabilizing barley yields in stress environments in West Asia was evaluated. Two barley landraces, Arabi Abiad (white seeded) and Arabi Aswad (black seeded), which constitute the bulk of barley production in Syria, were used. The first is common in slightly better environments (between 250 and 400 mm annual rainfall) and the second in harsher environments (less than 250 mm annual rainfall).

Starting with 72 lines extracted from a black-seeded population and 75 from a white-seeded population, selection for grain yield under stress conditions was conducted over three consecutive cropping seasons from 1987/88 to 1989/90. At the end of each season the best lines were promoted to the following year's testing. With these lines mixtures at different levels of heterogeneity were developed, and a trial was started in 1990/91. Two groups of mixtures were included in the trial, one black-seeded and the other white-seeded. For each group the mixtures were constituted with lines extracted from the same population. The black-seeded group had mixtures of 72, 34, 17, and 5 components, and the white-seeded group had 75, 34, 15, and 5 components. The mixtures at the second-highest levels (34 lines, in both groups) comprised the lines selected over one cycle. In the mixtures with 17 and 15 components, the lines selected over two cycles were used, while the mixtures with the lowest number of components contained the lines selected over three cycles. The experiment comprised 8 mixtures, 10 pure lines (the best 5 black-seeded and the best 5 white-seeded), and 6 checks. The trial was conducted for five cropping seasons from 1990/91 to 1994/95 in three to six locations per year (total of 26 year–location combinations) in northern Syria and Lebanon. In all locations the trials were grown under rainfed conditions.

Mean yields ranged from 614 to 4385 kg/ha. Black-seeded material tended to have lower average grain yield and lower response to improved environments than white-seeded material. Intercepts were always positive in the black-seeded material. In both groups the mixtures with five components had an advantage over the more complex mixtures. In the black-seeded group (Table 4), the mixture of five lines had both average grain yield and regression coefficient significantly higher than Arabi Aswad with a slightly larger intercept (Fig. 2), but it did not have a clear advantage over pure lines. In particular, SLB 5-31 had a high average grain yield, combined with a good response to environment and positive

Table 4. Grain yield (kg/ha), regression coefficient (b), and intercept (a) of four black-seeded mixtures, five lines, and three checks of barley.

Material	Grain yield	b	a
Mixtures			
MIXB 72	2017	0.88	147.4
MIXB 34	2060	0.96	10.2
MIXB 17	2076	0.97	11.8
MIXB 5	2131	0.93	150.1
Pure lines			
SLB 5-96	2164	0.97	99.9
SLB 5-07	2179	0.98	97.6
SLB 5-86	1950	0.84	167.0
SLB 5-31	2266	1.05	35.7
SLB 5-30	1982	0.86	144.2
Checks			
Arabi Aswad	1896	0.83	116.7
Tadmor	1971	0.86	140.0
Zanbaka	1946	0.84	154.9
LSD (0.05)	164		

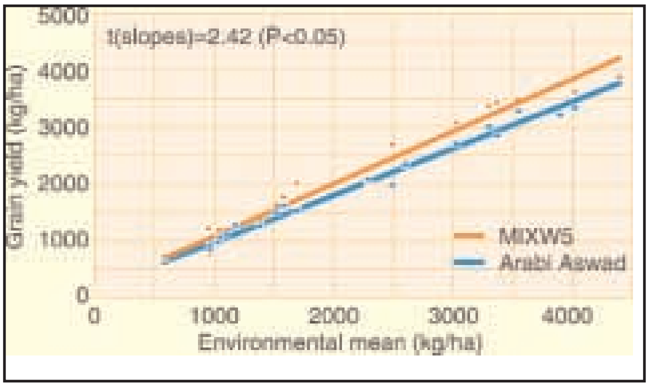


Fig. 2. Linear regression over environmental means of the black-seeded mixture with five components and parental landrace Arabi Aswad.

intercept.

In the white-seeded group (Table 5), the mixture of five components had an advantage over the single lines, combining high average grain yield (2263 kg/ha) with good response (b=1.05) and positive intercept (a=32.9). However, it was better than the landrace Arabi Abiad only for the intercept (Fig. 3). The only pure line with a positive intercept, SLB 9-98, had a very low average grain yield (1833 kg/ha) and low response (b=0.79).

Table 5. Grain yield (kg/ha), regression coefficient (b), and intercept (a) of four white-seeded mixtures, five lines, and three checks of barley.

Material	Grain yield	b	a
Mixtures			
MIXW 75	2237	1.15	-226.7
MIXW 34	2209	1.17	-277.1
MIXW 15	2174	1.08	-139.1
MIXW 5	2263	1.05	32.9
Pure lines			
SLB 9-63	2288	1.14	-144.4
SLB 9-71	2302	1.15	-152.3
SLB 9-76	2388	1.24	-248.5
SLB 9-09	2328	1.13	-86.8
SLB 9-98	1833	0.79	146.1
Checks			
Arabi Abiad	2202	1.14	-222.9
Arta	2414	1.19	-117.9
Harmal	2204	1.15	-248.8
LSD (0.05)	164		

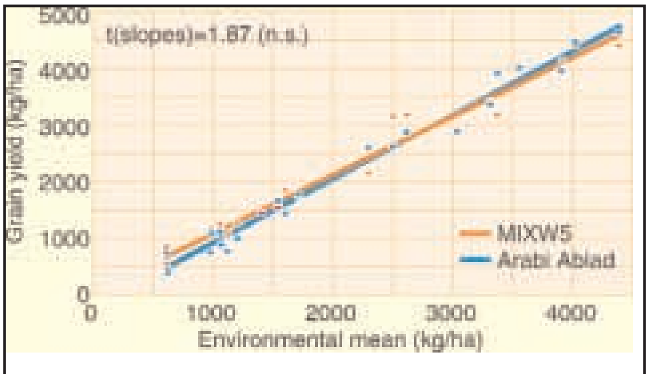


Fig. 3. Linear regression over environmental means of the white-seeded mixture with five components and parental landrace Arabi Abiad.

The results indicate the possibility that the two Syrian barley landraces possess different buffering mechanisms. The advantage of both five-component mixtures over the more heterogenous mixtures suggests that a high level of heterogeneity of landraces may not be needed to maintain yield stability.

Response of Barley Lines to Selection

Barley lines were selected for high yield under stress (YS), high yield under non-stress (YNS), or average performance (AP) during three breeding cycles (cohorts) of three years each. The lines were then tested in a total of 21 year–location combinations (from 1991 to 1994). The average grain yields in these combinations ranged from 0.35 t/ha to 4.86 t/ha. Some preliminary data were reported in ICARDA Annual Report for 1994.

The yield under stress of the YS lines was between 27 and 56% higher than that of the YNS lines, with the top YS lines yielding between 16 and 30% more than the top YNS lines under stress (Table 6).

Realized heritability was between 0.35 and 0.67 when selection was under stress and was significant in all three cohorts. On the contrary, selection under non-stress for grain yield was significant in only one cohort, and its efficiency in improving yield under stress was significantly lower than selection under stress. The best YNS line ranked only 19th for yield under stress. The two highest-yielding lines under stress were not only selected under stress, but were also landraces collected in very dry areas. This confirms earlier findings and suggests that the most effective way to improve productivity of crops grown in less-favored conditions is to use locally adapted germplasm and to select in the target environment(s).

Gains from direct selection under stress may be even higher than shown by the results above. The fact that in genetic terms there was always a positive response to selection, but that in breeding terms the superiority of the best lines over the check appeared in the second cohort and increased in the third, would suggest that, with progressive cycles of selection and

Table 6. Mean and range of grain yield (t/ha) of barley lines under stress of the selection groups and the checks, yield advantage of YS lines over YNS lines, yield advantage of the best YS line over the best YNS line, and yield advantage of the best line in each group over the best check.

Entries	Grain yield: Mean ± SE	Grain yield: Range	Top YS/ Top YNS	Top line/ Best check
YS88	0.63±0.02	0.51–0.67	1.16	0.84
YNS88	0.41±0.05	0.16–0.58		0.73
AP88	0.56±0.03	0.38–0.66		0.82
YS89	0.73±0.05	0.50–0.84	1.30	1.05
YNS89	0.52±0.04	0.41–0.65		0.81
AP89	0.67±0.06	0.56–0.82		1.02
YS90	0.80±0.03	0.73–0.92	1.28	1.14
YNS90	0.63±0.02	0.54–0.72		0.90
Checks				
Rihane-03	0.54			
Mari/Aths*2	0.65			
ER/Apm	0.72			
Harmal	0.77			
A. Abiad	0.75			
A. Aswad	0.80			

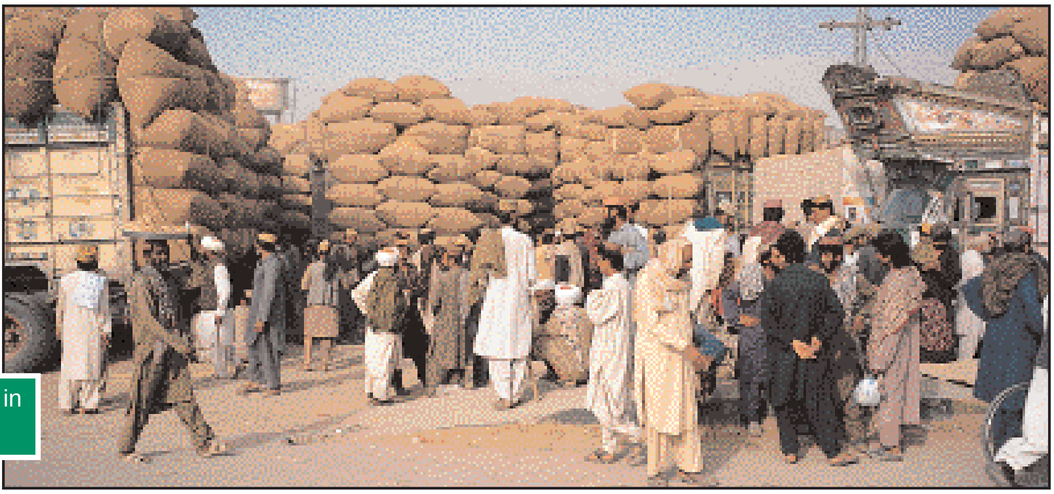
of recombination of the best lines, more substantial gains are possible. Recent data on the performance of lines selected under stress and tested in 1993, 1994, and 1995 indicate up to 30% gains compared with the local cultivars at yield levels below 1.5 t/ha.

These results may explain why several breeding programs based on selection under high-yielding conditions have not been successful in improving crops grown in marginal environments and/or with no inputs. However, direct selection in the target environment can sometimes be difficult to implement if the target environments are remote, in areas with poor infrastructure, or even inaccessible. The most effective way to reach such areas is through participatory breeding, an approach which brings to the farmers a large amount of genetic variability. This will not only bring formal plant breeding closer to the poorest farmers, but will by-pass the problems associated with transfer of technology. Since the technology will be essentially developed on-farm, the only transfer which is needed is from farmer to farmer—usually less problematic than transfer of technology from scientists to farmers.

Barley Straw Quality Improvement

In years when growing conditions for barley are good, the yield of straw is high but its nutritive value may be poor. Nutritive value determines whether the straw is worth storing. Farmers are aware of this, and suggest that new varieties of barley be screened for straw quality.

Analysis of published ICARDA data showed that small-ruminant body weight gain could be predicted from the voluntary intake of straw (r=0.92), whether or not supplements were fed. This means that voluntary intake can be used as a benchmark for the nutritive value of straw. A set of 45 straw samples grown in 8 years was used, of which the voluntary intake



A barley straw market in Balochistan, Pakistan.

had previously been measured.

Using these samples, a range of laboratory or animal-based tests were evaluated to help breeders identify genotypes having straws with a high voluntary intake. Repeatability of the tests, their heritability and their relevance were taken into account. From genotypes that were agronomically suitable, several tests permitted increases in intake of 6–10% per generation; these included Near-Infrared Reflectance methods, measurements of digestion of straw in synthetic fabric bags in the rumen, gas production when straw was incubated with rumen fluid, the preference of sheep for the straw, or its acid detergent fiber content. The work also showed that some traits (including protein or cell wall content) had low heritability and therefore should not be used for selecting barley varieties for straw quality.

Improving Barley for Food

Barley is well known as a crop used for animal feeding and by the brewing industry. What is less known is that it was probably the first cereal crop to have been cultivated for human consumption thousands of years ago, in particular in the Fertile Crescent. Barley is mainly used as a source of carbohydrate, though protein content is also important. As food, it is used in many different ways such as soup, porridge, bread (using composite flour), and also several different types of beverages.

In Europe, particularly in the Mediterranean region, barley has always enjoyed a "healthy-food image" since it has been the basis of numerous herbal remedies. For instance, barley grain and palm oil are the richest natural source of vitamin E, and there is a lower tendency to develop arthrosclerosis among people whose diet is rich in cereal grains.

Recently, it has been discovered that the presence of mixed, linked (1-3) (1-4) —D-glucans in barley can lower blood-serum cholesterol levels in humans. This component is present in the endosperm and is defined as non-starch polysaccharides.

Beta-glucan in different types of barley varies between 2 and 9%. Barley with higher beta-glucan level can be used in special diets, while barley with lower beta-glucan content is more desirable for malting.

In response to requests from several national programs, ICARDA started working for the improvement and utilization of barley as food. Germplasm screening was carried out for different characters associated with quality of the grain as food. Traits such as protein content, thousand kernel weight, hardness, and lysine and beta-glucan content were analyzed.

Despite the development in recent years of chemical methods to estimate beta-glucan content, there is no generally acceptable, speedy and simple screening procedure which can be used in a breeding program. ICARDA developed several calibrations to predict beta-glucan content using an advanced near-infrared analyzer "NIRSystem 5000." The best equation provided a multiple correlation coefficient (r^2) of 0.72, and a standard error of prediction of 0.33. The preliminary results with normal barley are very close to the world level accuracy, and calibration will be further improved.

Hardness is another important character for food barley. ICARDA is able to predict this trait using Near-Infrared Reflectance Spectroscopy; and its calibration is under way. Preliminary results are encouraging.

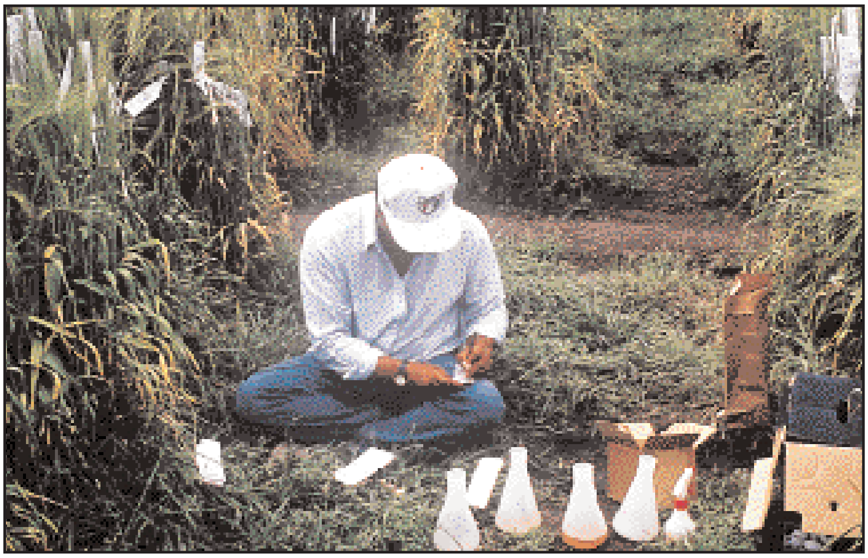
Fighting Fusarium Scab in Barley

In the northern part of the Western Hemisphere, fusarium head scab causes severe economic losses to many barley producers. The worst affected area is the Upper Midwest of the United States, where the losses in wheat and barley were estimated at one billion dollars for 1993 and half-a-billion for 1994. The ICARDA/CIMMYT Barley Project is making a major effort to protect the barley areas prone to this disease in Latin America.

New cultivars have been identified which showed a good level of resistance to artificial head-scab epidemics in screening trials at Toluca, Mexico. These cultivars include Shyri and Atahualpa, both of which originated in Ecuador. The Ecuadorean national program is promoting their use by providing seed, fertilizer, and herbicides to farmers. The Bolivian cultivar San Lorenzo has not yet been tested at Toluca but, since it comes from the same cross as

Atahualpa, it is expected to be resistant to head scab.

In cooperation with Oregon State University, the search for head-scab resistance has been pursued by crossing malting barley with the scab-resistant cultivar Gobernadora and then using the *bulbosum* method of doubled-haploid (DH) production to speed the development of some 98 homogeneous lines. These lines have been screened in Mexico, and in China where the Shanghai Academy of Sciences helped conduct a series of trials in 1995/96. The DH lines that showed most promise in both Mexico and China are being offered as parental material to the national programs of Latin America's Southern Cone.



Fusarium head scab screening at Toluca, Mexico.

Genetic Mapping of the Barley Cross Tadmor x WI2291

An integrated genetic map of barley crosses Tadmor x WI2291 and Igri x Franka, consisting of 160 marker loci, has been constructed using the computer package JoinMap Version 1.4 (Fig. 4). While the segregation data set of Igri x Franka was downloaded from the publicly available GrainGenes database, mapping of the cross Tadmor x WI2291 was performed at the Technical University of Munich and ICARDA. Segregation data of 48 RFLP and 31 RAPD markers were obtained for the 260 individuals of the cross. Common markers between populations are a prerequisite for an integrated map. To find out whether markers with the same core name were targeting the same locus, a pre-integrated map was calculated. Markers mapping within a 5 cM of each other were considered to represent only one locus and their names were adjusted accordingly.

Having standardized the different marker symbols, 26 markers were found to be common to the two populations (Table 7). These markers were evenly distributed in the linkage groups, hence allowing unambiguous integration of the two data sets. Marker orders on the integrated map were identical to the orders of the two component maps. Except for chromosomes 4H and 7H,
all other chromosomes were well populated with molecular markers, comprising in total 58 intervals

Table 7. The number of markers shared by Tadmor x W12291 and Igri x Franka crosses.

Mapping				Chromosome				
Populations	1H	2H	3H	4H	5H	6H	7H	Total
T/WI and I/F	MWG 837 2077 c649b 912	MWG c682 878 858 950 949	MWG 584 571a 971	MWG 2033 880	MWG 502 522 533 602 891	MWG 916 951 934 514 2053 10c	MWG 832 836	
Total	4	5	3	2	5	6	2	27

T/WI and I/F represent Tadmor H WI2291 and Igri H Franka, the prefix c indicates cDNA-clones.

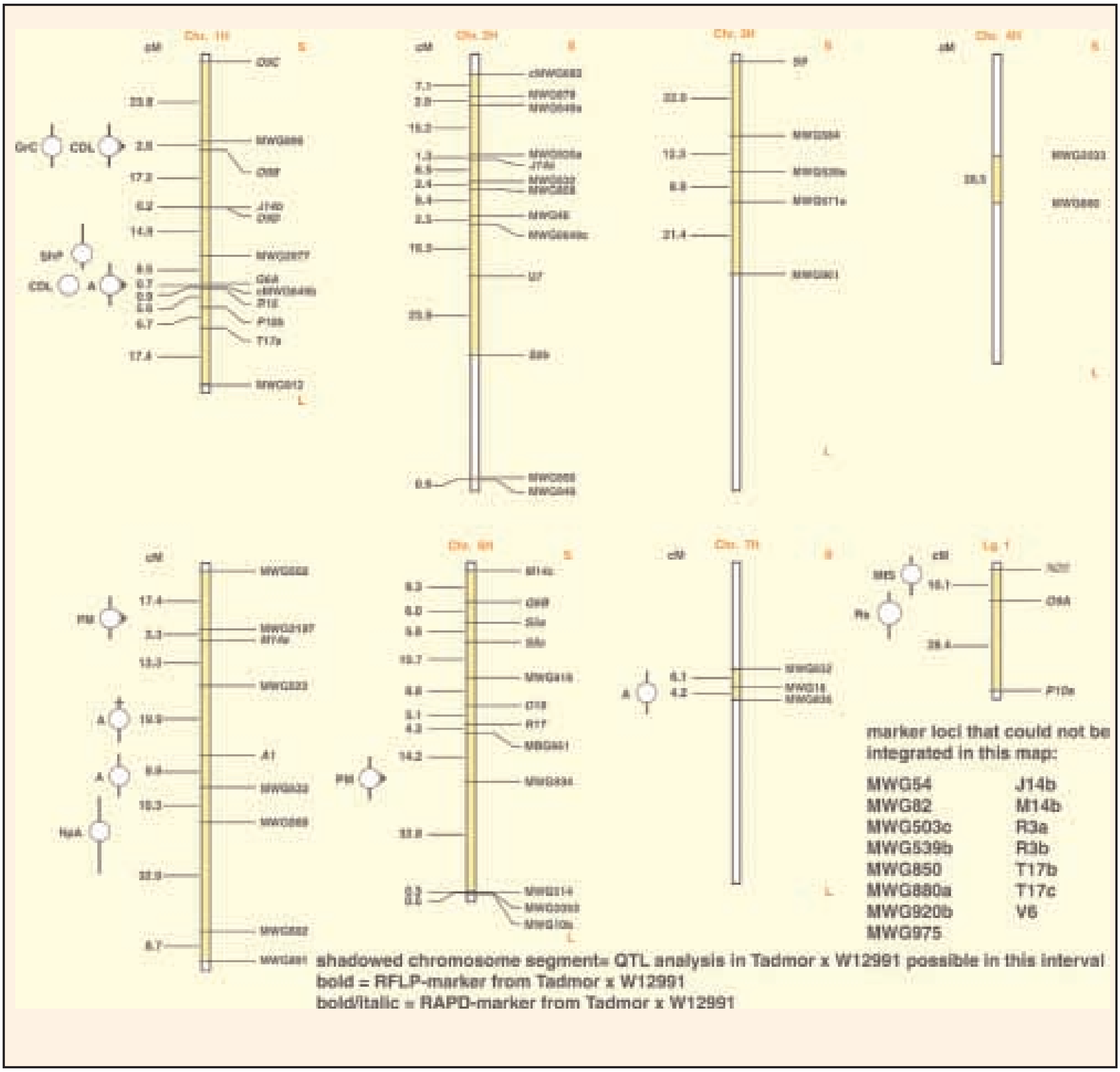


Fig. 4. Genetic linkage map from Tadmor x WI2991 (260 RiL-lines) joined with Igri x Franka (70 DH-lines).

in which a Quantitative Trait Loci (QTL) analysis in the cross Tadmor x WI2291 is feasible.

Traits were evaluated in Syria during seed increase in double-row plots in 1995 at Tel Hadya, and in 1996 in replicated field trials at Tel Hadya and Breda. Marker data and field data were analyzed with PLABQTL for QTLs. The analysis revealed a QTL explaining around 15% of the variation for powdery mildew. This indicates a possible quantitative inheritance of powdery mildew resistance. The QTL has been located on chromosome 5S near marker M2197. The QTL was expressed in Tel Hadya in 1994 and 1995; the mean of the powdery mildew evaluation also showed the QTL which explained the same amount of variation. Further genome intervals contributed only little to the powdery mildew resistance. For *Rynchosporium secalis*, a QTL has been identified linked to the additional linkage group link 1. This QTL explained between 25 and 31% of the variation between the two different field evaluations. With a high LOD score of 30 and 34, respectively, it can be concluded that a major gene is involved in the resistance at this locus. Further additional markers are necessary to integrate the additional linkage group link 1 with the available 7 linkage groups. However, linkage groups for chromosomes 1, 5, and 6 can be considered complete (Fig. 4), 2 and 3 around 75% complete, and 4 and 7 only scarcely covered with markers.

For other agronomic traits, QTLs could be determined with a high significance (high LOD score). However, in most cases these QTLs explain only a small proportion of the variation. For several physiological traits co-factors could be identified, which explain some of the variation of the trait.

The cross was originally intended to combine resistance to powdery mildew and scald. Lines with combined resistance have been identified. For both traits, molecular markers have been identified which can explain some of the variation of the trait.

Combining Productivity and Yield Stability in Durum for Mediterranean Dry Areas

The durum crop in the WANA region is grown mainly in dry areas characterized by drought, cold, terminal stress, and soil and nutrient problems (alkalinity, boron toxicity and micronutrient deficiencies). In addition, almost all diseases, insects, and viruses that can attack durum are widespread in this region. The main objective of the joint CIMMYT/ICARDA durum project is to assist the WANA countries to enhance durum production in the dry areas.

The performance of stable-yielding durum genotypes combining yield potential with abiotic and biotic stress resistance is shown in Table 8. The mean for stable productivity of newly developed CIMMYT/ICARDA durum genotypes was 34.1% better than that for Cham 1, the standard check.

Table 7. Durum genotypes with stable productivity for the Mediterranean continental areas.

Entry No.	Name	Mean grain yield (kg/ha)	Stability		
			MDMYL	RS (%)	Rank
8	Omrabi 5	3053	0.122	188	2
11	Massara1	3000	0.120	192	1
4	Genil 3	2956	0.146	157	3
10	Omrabi 3	2925	0.158	146	4
2	Omruf 2	2824	0.212	108	5
	Cham 1	2803	0.230	100	7
	LSD (0.05)	334			

MDMYL = Mean of difference from maximum highest yielder at each location divided by location mean. RS = Relative stability (%) = (MDMYL of check /MDMYL of test entry) x 100.

Syria, Tunisia, and Turkey have released Omrabi 3; and Iran and Iraq have released Omrabi 5 for commercial production. These varieties are derived from a cross between Haurani and Jori C69 which was subjected to the selection strategy developed by the joint CIMMYT/ICARDA durum breeding program. Later they were also tested through international nurseries in the WANA region. Omrabi 3 and Omrabi 5 combine high productivity with resistance to drought and cold. They also possess good quality traits for making burghul and pasta.

Synthetic Hexaploid Wheat

In a pre-breeding project, which started in the 1994/95 season, a number of triploid hybrids between durum wheat cultivars Haurani and Cham 5 and wild *Triticum* spp., as well as *Aegilops speltoides* and *Ae. tauschii*, were produced. Seventy-eight seeds were obtained in Haurani x *Ae. tauschii* hybrids after colchicine treatment and chromosome doubling, and 12 seeds were produced in two untreated hybrid plants. The well-developed, fully viable seeds gave rise to vigorous plants, which should have the same genomic constitution (AABBDD) as bread wheat. The A- and B-genome chromosomes of the synthetic hexaploid wheats originate from durum wheat Haurani, well adapted to semi-arid regions of Syria, whereas the D-genome chromosomes were obtained from *Ae. tauschii* parents, which were collected from heat-affected and low-rainfall sites (150–250 mm/ year) in northern and central Syria. As the synthetic hexaploid wheats can be crossed easily with bread wheat and their chromosomes are fully homologous, they may be a valuable source of heat-and drought-tolerance genes in bread wheat breeding for rainfed semi-arid regions of West Asia, North Africa, and other parts of the world.

Screening Durum Wheat for Pasta Quality

Gliadin and glutenin are the major groups of protein in the durum seed. Their presence is associated with pasta quality. Gliadin 45 is associated with glutenin low molecular weight 2 and gliadin 42 is associated with glutenin low molecular weight 1. To select for pasta quality, PCR amplification by using specific primers is adopted as new tools in selection.

The advance durum yield trials (ADYT) 94, 95 and 96 were analyzed with PCR primers. Screening of 380 lines from ADYT 94 and 240 lines from ADYT 95 showed that more than 89% of lines had gliadin 45 (Fig. 5), less than 10% had gliadin 42, and 2.5% had heterozygoses. For glutenins, screening of the same lines showed the same percentages (Fig. 6)

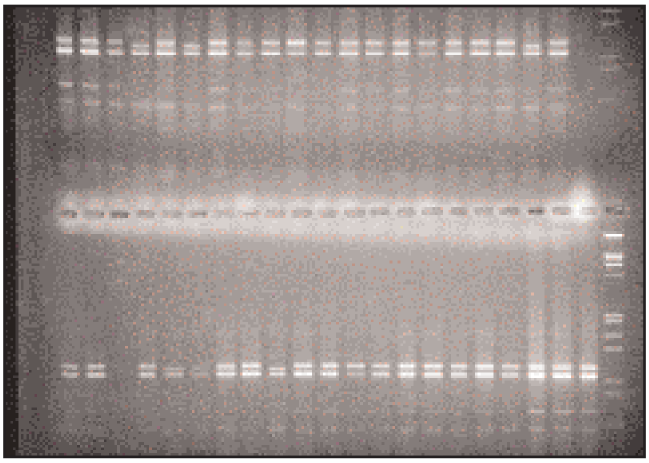


Fig. 5. PCR screening for quality in ADYT96 durum wheat genotypes. Primers for gliadin are used. Second highest band is gliadin 45 or gliadin 42. Gliadin 45 is higher than gliadin 42 by 50bp.

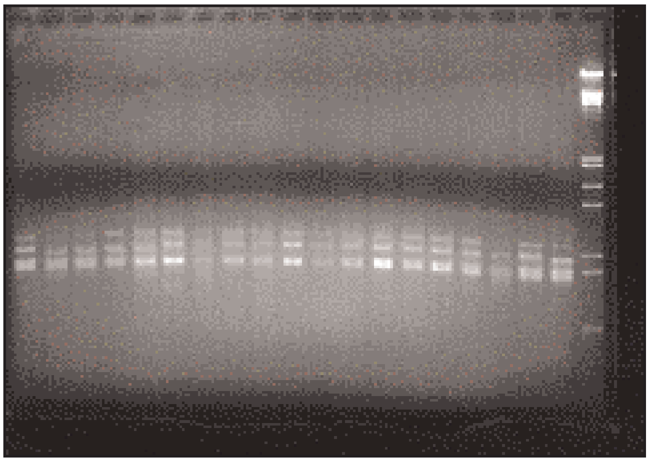


Fig. 6. PCR screening for quality in durum wheat ADYT genotypes. Primer 2 for LMW glutenin are used. Highest band is glutenin LMW 2 or 1. Glutenin LMW 2 is higher than glutenin LMW 1 by 50bp. In heterozygotus lines the two bands for glutenin LMW2 and LMW1 are present.

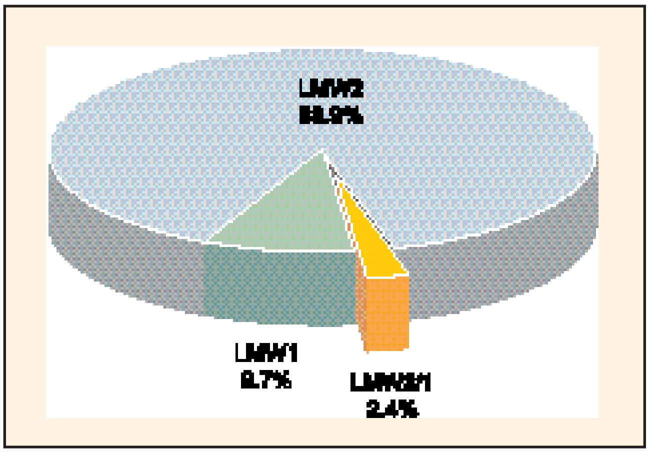


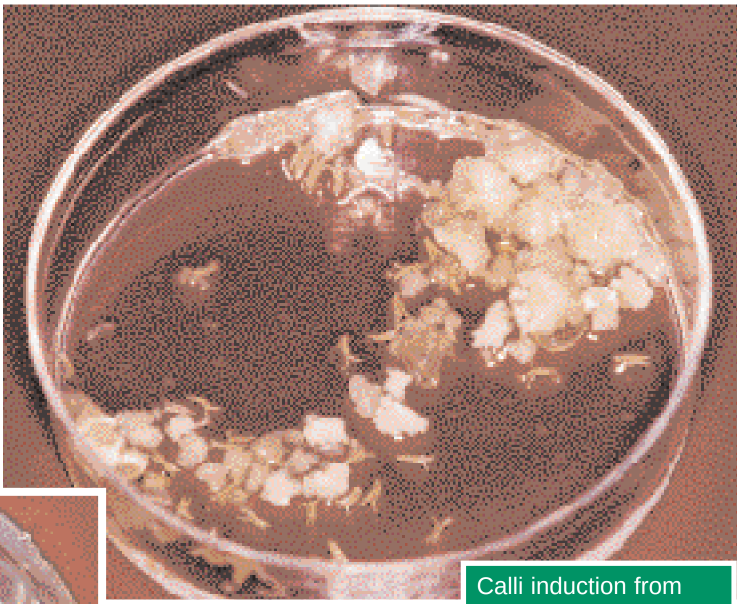
Fig. 7. Glutenin in ADYT96.

as for gliadin. Screening of ADYT 96 (Fig. 7) showed similar results as ADYT 94 and ADYT 95: 88.9% of lines had genotypes with good quality and less than 8.7% with poor quality and 2.4% were heterozygotes. These results show that more than 90% of lines cultivated in the WANA region have genotypes with low molecular weight glutenin 2 and gliadin 45. Screening of the ADYT for glutenins and gliadins has not yet identified true recombinants.

It may thus be concluded that the screening for gliadin is not necessary if only pasta quality is considered.

Double Haploid (DH) Production in Spring Bread Wheat

Spring wheat germplasm was screened in 1996 to assess its androgenesis capacity. The F_1 material used for DH production combined yellow rust resistance with good agronomic performance. The F_1 of 22 spring wheat crosses was analyzed for green plantlet regeneration capacity under the same experimental conditions (growing conditions of donor plants: 15ºC day, 10ºC night, 16 h day length, 8 h night in growth chambers, using the same induction media, BAD1 and regeneration media R9). The crosses with a high number of induced calli and, even more importantly, with a high conversion rate of calli into green plants, yielded an acceptable number of green plants per 100 cultured anthers.



Calli induction from anther culture in liquid induction medium.

Green plantlet regeneration from calli.

Analysis of variance showed significant differences for genotype and temperature. In general, it seems to be most important to collect induced calli in time (6 weeks after plating anthers) and subject calli to light on regeneration media. If this can be done, a high rate of conversion of calli into green plants can be achieved. This will be attempted in 1997.

New Sources of Resistance to Russian Wheat Aphid in Winter Cereals

Screening for resistance to Russian wheat aphid (RWA) was carried out in the field and plastic houses at Tel Hadya. A total of 2518 lines of barley, 181 of winter bread wheat and 231 of spring bread wheat were screened in the field; 29 barley lines were selected from the field and were tested in the plastic house to confirm their reaction. Other special nurseries were also tested in the plastic house: 5 winter bread wheats from Colorado State University (USA), and 17 accessions of wild species from INRA, France.

Of the 29 barley lines, 11 showed a very good level of resistance to RWA (score <3 in the Toit scale of 1–6). Six of these lines are crosses with *Hordeum vulgare* subsp. *spontaneum*. Two of the five winter wheat lines from Colorado were also highly resistant. The wild species from INRA, France were all highly resistant to RWA (score of 2); of these, 13 are

Triticum monococcum subsp. *monococcum* and three are *T. monococcum* subsp. *aegilopoides* (syn. *T. baeoticum*). These should be good sources to use in breeding durum wheat in which no lines with resistance to RWA have yet been identified.

Detection of Biotypic Variation in Russian Wheat Aphid Populations

The fact that only two of the five bread wheat lines from Colorado (USA) are resistant to Russian wheat aphid in Syria, indicates the existence of biotypic variation in RWA populations (Table 9). This was also supported by differential reactions to RWA in barley. Evaluation of 34 barley lines from the Aphid Laboratory, Stillwater, Oklahoma (USDA-ARS, USA) exhibited differential reactions to RWA in Morocco and in Syria. The existence of this biotypic variation in RWA populations requires testing of the germplasm in targeted environments before crosses are made.

Table 9. Biotypic variation in Russian wheat aphid populations (using bread wheat differential lines), Tel Hadya, 1996.

Line	RWA (North America)	RWA (West Asia)
F96PYN3-1838	R	S
F96PYN3-1828	R	R
F96AYN2-321-DN5	R	S
F96AYN2-315-DN6	R	R
Halt-DN4	R	S

R = Resistant; S = Susceptible.

Survey of Cereal Insect Pests in Libya

A survey of insect pests was carried out in Libya from 13 to 17 April, covering coastal areas from Sabrata to Masrata. A total of 62 fields (11 of bread wheat, 9 of durum wheat, and 35 of barley) were surveyed. Seven oat fields were also surveyed in the eastern area from Tripoli to Sabrata.

Shoot fly was causing heavy damage to barley; most of the farmers interviewed said they had to replant their fields. This fly is popularly known there as “sowing fly” (Diptera: Anthomyiidae, *Delia platura* (Meigen). This species is synonymous to *Hylemia cilicrura* Rond, and is probably the same that occurs in Ethiopia.

The barley stem gall midge, *Mayetiola hordei* (Keiffer), seemed to be the second most damaging insect along the costal central areas of Libya. Across all barley fields, the average infestation was 70%.

The most interesting finding was that Hessian fly, *Mayetiola destructor* (Say), was not found in the survey. This insect occurs in all the Mediterranean countries, including Morocco, Algeria, Tunisia, Spain and Portugal. Another survey, covering the coastal area from east to west, is necessary to confirm this finding.

Seed Treatment for Control of Common Bunt in Wheat

In an attempt to replace chemical seed-treatment of common bunt by organic nutrients, the use of skimmed milk powder was investigated at Tel Hadya in the 1994/95 season. The results were promising. Two common bunt susceptible cultivars, Sebou (durum wheat) and Bau (bread wheat) showed 86 and 87% head infection, respectively, when inoculated with the two common-bunt pathogens (*Tilletia tritici* and *T. laevis*) mixed in the ratio of 1:1. Seed-treatment with Vitavax-200 (carboxin + thiram)

Table 10. Effect of organic seed-treatment (skimmed milk) on the control of common bunt of wheat, *Tilletia tritici* and *T. laevis*, as compared with chemical seed-treatment (Vitavax-200).

Treatment	% head infection 1994/95 Sebou	Bau	1995/96 Sebou	Bau
T. tritici & *T. laevis* (check)	86	87	55	83
T. tritici & *T. laevis* + Vitavax-200	1	2	3	9
T. tritici & *T. laevis* + skimmed milk	7	10	3	2
T. tritici (check)	-	-	69	60
T. tritici + Vitavax-200	0	1	4	1
T. tritici + skimmed milk	6	8	5	1
T. laevis (check)	-	-	43	67
T. laevis + Vitavax-200	0	1	2	0
T. laevis + skimmed milk	3	1	2	2

reduced the common-bunt infection to 1 and 2% on Sebou and Bau, respectively, whereas the skimmed-milk treatment reduced it to 7 and 10%. The results obtained in 1995/96 confirmed this (Table 10).

Highland Winter Lentils

Lentil is currently sown in spring in Iran and Turkey at elevations above 850 m on about 400,000 ha. Research in Turkey has indicated that yields may be increased by up to 50 % by early sowing in late autumn using winter-hardy cultivars. However, the use of such cultivars is not yet widespread in Turkey, because the level of winter hardiness in the current cultivars is inadequate to survive cold winters.

A major program to recombine yield with the necessary winter hardiness is underway at the Central Research Institute for Field Crops, Ankara, Turkey. Two complementary approaches are being followed. In the first approach, winter-type germplasm collected from southeast Anatolia is being selected (Table 11). In the second approach, crosses with winter-hardy germplasm sources and early-generation material are produced at ICARDA's main research station at Tel Hadya in Syria and segregating populations are then selected under severe winter conditions in highland Turkey.

In the 1995/96 winter season, 172 red-cotyledon lines selected from germplasm were tested at Haymana, Konya, Sivas and Yozgat, in Turkey.

Lentil breeding team at Haymana, Turkey, with ICARDA/Turkey, Coordinator, assesses variation for winter hardiness in lentil.

Table 11. Program of selection of Turkish lentil germplasm for winter-hardiness (WH) at Central Research Institute for Field Crops, Haymana, Turkey from 1990–1997.

Year	Activity
1990/91	Collection of 152 landrace populations from southeast Anatolia
1991/92	5604 single plant selections made - selection for WH
1992/93	880 progeny rows - selection for WH
1993/94	340 preliminary yield trials, 1 location - selection for WH
1994/95	325 yield trials, 1 location - selection for WH
1995/96	172 yield trials, 4 locations - selection for WH
1996/67	45 yield trials, 4 locations

Screening for winter-hardiness was only possible at Haymana, where the absolute minimum temperature dropped to -16ºC. At other sites the susceptible control was undamaged in the relatively mild winter. The mean yields of the winter yield trials varied from 2977 kg/ha at Yozgat to 721 kg/ha at Haymana. Next season a selected set of 45 lines will be sown at the same sites. These lines will form the germplasm base of highland winter lentil technology. Research on the agronomy of these new winter-hardy lines is also underway particularly on the key issue of weed control.

In Iran, screening for winter-hardiness has been undertaken at Gazvin by the Seed and Plant Improvement Institute. The best large-seeded selections are ILL 590 and 857. On-farm trials of winter sowing are in progress in the area surrounding Gazvin.

In addition, as an aid to the field-based selection for winter-hardiness, the use of marker-assisted selection is being explored. A total of 1084 recombinant inbred lines (RIL), at the F_6 generation, have been prepared at USDA-ARS, Washington State University for 10 crosses segregating for winter-hardiness. These will be used for a quantitative trait locus analysis of winter-hardiness in collaboration with the Turkish program. In a related activity at Tel Hadya, the parents and 87 F_8 RILs derived by single seed descent from a single cross (L92-17-2 (P_1) H L692-16-1(S)(P_2)) were planted in December 1995. In January 1996, following a period of relatively warm winter (daily max. and min. temp. 14 and

3.7ºC), the temperature dropped at night to an absolute minimum of -6.6ºC, 34 days after sowing. There were clear differences between the parents in susceptibility to cold. The parents and RILs were scored for severity of damage on a 1–9 scale with 1 = no damage, and 9 = plants killed. The parents were scored as $P_1 = 1$ and $P_2 = 5$. The RIL population showed a discontinuous segregation pattern of 46 resistant and 41 susceptible lines, $\chi^2 = 0.184$ ($P < 0.05$), for a single-gene segregation (Fig. 9). Initial analysis for linked DNA-markers at a stringent LOD score and recombination frequency showed linkage between a RAPD marker (OPS16b) and cold tolerance at 9.1 cM in a data set of 127 segregating loci. Quantitative trait locus analysis for the trait will be undertaken and the population will be retested

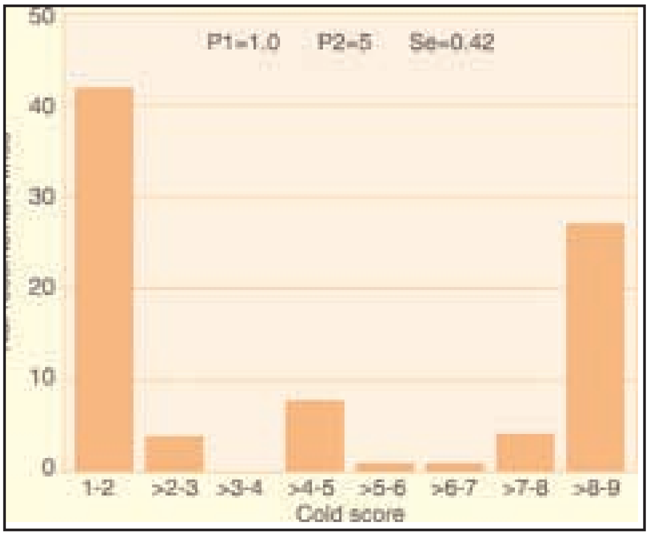


Fig. 9. Response of recombinant lentil lines to cold.

against winter cold. But it is clear from this preliminary research that markers for cold-related traits can be found in lentil.

Introgression of Genes for Nematode Resistance from Wild to Cultivated Chickpea

Heterodera ciceri is an important nematode causing severe damage to chickpea in Jordan, Lebanon, Syria, and Turkey. Screening of 9000 chickpea germplasm accessions maintained at ICARDA revealed that all were susceptible, but several accessions of wild species revealed the presence of variability for resistance. A resistant accession of *Cicer reticulatum* (ILWC 119) was crossed with two high-yielding cultivars (ILC 482 and FLIP 87-69C) during 1989/90 at Tel Hadya, Syria. The F_1 progenies were grown in the summer nursery at Terbol in the Beqa'a Valley of Lebanon to produce F_2 seeds. These F_2 seeds were grown at Tel Hadya in the plastic house at 20 ± 2ºC to evaluate their reaction to a Syrian population of the cyst nematode using an inoculum level of 20 eggs per gram of soil. Single seeds were first sown in small jiffy pots containing inoculum-free soil. Three such pots were then sunk in a larger plastic pot containing nematode-infested soil. Plants were allowed to reach flowering to early podding stage when they were uprooted to examine the nematode infestation on roots growing out of the jiffy pots in the infested soil. Root infestation was recorded on a 0–5 scale (where 0=free of nematodes, and 5=more than 50 females/plant). Plants with a score of 0–2 were considered resistant. Such plants, with their major root system intact in the jiffy pot, were transplanted to larger pots containing nematode-free soil for seed increase. The generation of the selected lines was advanced by using the summer nursery in Terbol and the next generation again evaluated for reaction to nematode infestation in a plastic house at Tel Hadya. Using this technique, 16 F_9 progenies have been developed showing uniformity in resistance to the nematode and good agronomic characters. Their seeds are now being mul-

ICARDA has successfully transfered genes for resistance to nematodes from wild to cultivated chickpea.

tiplied for yield evaluation. This is the first example of successful transfer of nematode resistance from wild to culti-vated chickpea.

Chickpea Transformation

***Agrobacterium*-mediated transformation.** Two strategies can lead to transgenic plants following *Agrobacterium* inoculation: (i) *de novo* regeneration from selected callus tissue, and (ii) rapid shoot-proliferation from already existing meristems. In the collaborative work carried out at the University of Hannover, the general culture conditions were optimized, suitable explants selected, and optimum coculture conditions determined.

Genotype-dependent susceptibilities for *Agrobacterium*-mediated gene transfer. By using the reporter genes, a-glucuronidase (gus) and the green fluorescent protein (gfp), different chickpea seedling-explants were analyzed for their susceptibility to *Agrobacterium tumefaciens*. As in other grain legumes, a large number of transformation events were detected in the rapidly proliferating cambial tissue. Only limited expression was found in shoot-proliferating tissue. From the transient expression assays it was concluded that the transformation process itself is not a limiting step. The experiments did not show significant difference in the number of transformation events between the three lines (ILC 482, ILC 1929, ILC 3279).

Regeneration capacity. Since general culture conditions, susceptibility for *Agrobacterium*-mediated transformation and vector construction do not represent unsurmountable problems, the induction of multiple shoots on meristems appeared to be the most important constraint. If *de novo* regeneration is not achieved, inoculation and transformation of pre-existing meristems followed by rapid multiplication is the only way to regenerate transgenic plants. The application of cytokinins like BAP or TDZ at fairly high concentrations leads to necrosis in shoot tips, while this necrosis is more pronounced in kabuli-type than desi-type chickpea. Although shoot tip necrosis could not be inhibited, multiple shoot or shoot bud formation was observed on more than 50% of the treated explants (apical thin layers). In addition, prolonged incubation with small amounts of cytokinin resulted in the production of proliferating clones. However, when using TDZ after 2–3 months in culture, more callus formation was observed.

Vector construction. The Bayer company provided the Stilbene-Synthase gene (*Vst-1*) from *Vitis* sp. for direct DNA-transfer in a high-copy pUC19 plasmid and a binary plasmid for use in *Agrobacterium*-mediated transformation. Both plasmids have been successfully transferred into *Escherichia coli* strain NM522 and the binary plasmid was introduced into hyper-virulent strain EHA105.

Protoplast culture. A standardized protoplast isolation and callus regeneration protocol for chickpea has been worked out. Routinely, a high yield of viable protoplasts (5–8 H 10^6 from 50 explants) can be obtained, which will allow transformation of calli via PEG-mediated DNA transfer.

Protoplast transformation and selection. For the first transformation experiments, constructs harboring the *pat* gene were used, which allowed to use phosphinotricin to select the positive clones during the cultivation in suspension culture in light at 22^{o}C. Due to the herbicide action, non-transformed calli turned brown after one week. The transformed calli were placed on B5 solid medium with 10 µM/L TDZ and 10 mg/L phosphinotricin.

How *Ascochyta rabiei* Creates its Enormous Genetic Variability: the Deciphering of the Molecular Mechanism

There is great genetic variability in the chickpea pathogen *Ascochyta rabiei* not only between different countries, but also within a country between different locations or even within the same field. This was revealed in a cooperative survey conducted by ICARDA, INAT (Tunisia), NIAB (Pakistan), and the University of Frankfurt (Germany).

The molecular mechanism of the genetic variability was for the first time shown in a segregating population of a cross between the Syrian isolate AA6 and the US isolate MatI. An allele variant was found that was present in neither parent. By applying locus-unspecific microsatellite-derived RFLP probes and locus-specific primers (so-called sequence-tagged microsatellite site or STMS primers), the presence of this new length allele (Fig. 10) was confirmed. This mutated F_1 allele was sequenced, and it contained a hypervariable compound microsatellite composed of several pentameric and decameric repeat units. It is now clear that (i) the mutated allele was donated by the US parent, and (ii) mutation was a consequence of an expansion of a TATTT repeat: a $(TATTT)_{53}$ repeat mutated to a $(TATTT)_{65}$ repeat during sexual ascospore production (Fig. 11, upper panel). This is an excellent example of the molecular mechanism leading to hypervariability in micro-satellite loci of the *A. rabiei* genome.

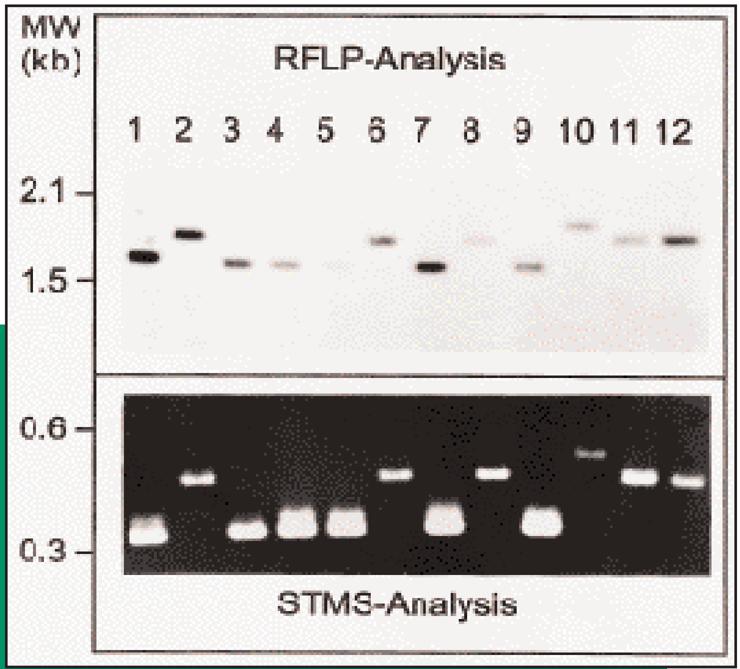


Fig. 10. RFLP and STMS analysis of a hypervariable microsatellite locus in a segregating F_1 population of *A. rabiei* (lanes 3–12), and the individual parents (lane 1 and 2). For RFLP analysis, the cloned PCR fragment was used as a probe on a southern blot containing *A. rabiei* DNA. For STMS analysis, the locus was amplified with the flanking primers indicated in Fig. 11. Both STMS and RFLP analysis allow one to trace the F_1 bands back to the parents, and detect the increased allele size in one of the F_1 progeny (lane 10).

Sequencing of the same locus from a series of isolates originating from different geographical locations (Pakistan, Tunisia) confirms the hypervariability and uniqueness of this locus. Another type of mutation was discovered in isolate TAr328, where a duplication of two pentameric units created a new decamere repeat (Fig. 11, lower panel).

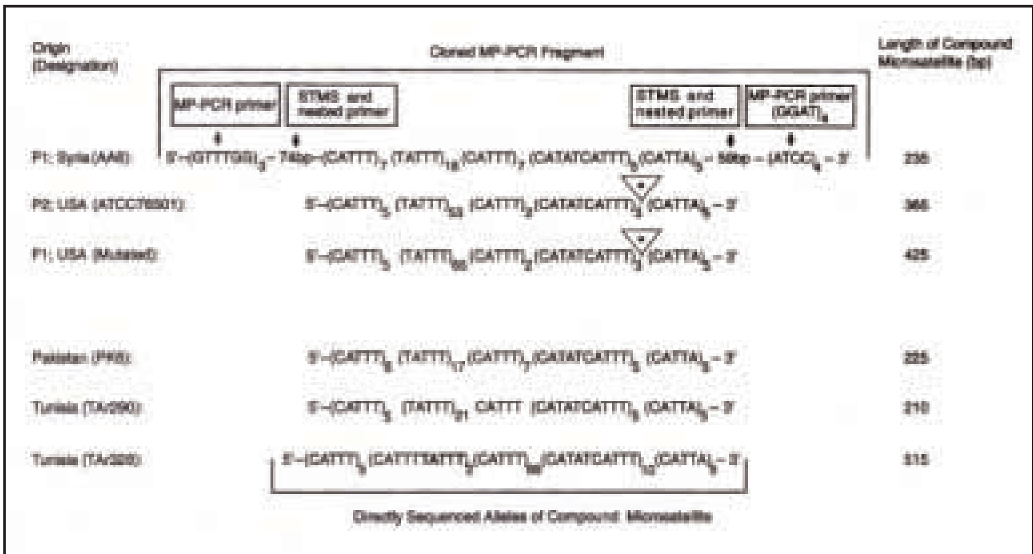


Fig. 11. Allelic variation at a compound microsatellite locus of *A. rabiei*. The uppermost sequence (AA6) represents the originally cloned allele and includes the microsatellite and its flanking regions. The upper three sequences were derived from the parents of a cross and one F_1 mycelium. The F_1 allele is identical to the P2 allele except for an increased number of TATTT-repeats. The lower three sequences were derived from three randomly chosen *A. rabiei* isolates from Tunisia and Pakistan. Binding sites for PCR, STMS and nested sequencing primers are indicated on top.

This is the first proof that the genetic diversity in *A. rabiei* is brought about by the combined action of point mutations, duplications and excisions, giving rise to new genetic variants. Some of these new variants might also be new and more aggressive pathotypes.

Survey of Virus Diseases of Faba Bean in Yemen

This survey, conducted in 1996, was a collaborative effort between ICARDA scientists and NARS colleagues from Yemen, Egypt, Sudan, and Ethiopia. The survey was an activity of the "Network on integrated control of aphids and major virus diseases in cool-season food legumes and cereals" supported by the Netherlands. Faba bean fields visited were in the governorates of Sana'a, Hajjah, Al-Mahweet, Dhamar, Al-Beida, and Ibb.

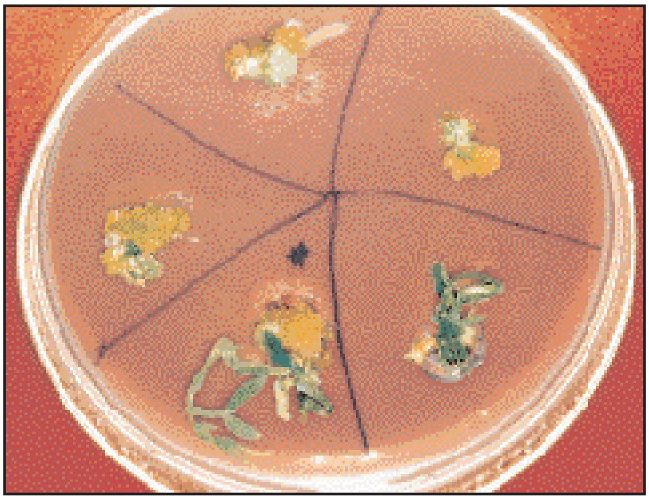
Disease-symptom data were recorded for each field, and diseased samples were collected for diagnosis. Nearly 15% of the fields visited had a virus-disease incidence of 10% or higher. Laboratory tests were conducted at the ELISA laboratory of the Yemeni–German Plant Protection Project at Sana'a using the recently developed tissue-blot immunoassay technique. The most common virus disease on faba bean in Yemen was bean yellow mosaic potyvirus, followed by alfalfa mosaic alfamovirus. A few samples were found to be infected with the leafhopper-transmitted chickpea chlorotic dwarf geminivirus (CCDV). This was the first time this virus was detected on a legume crop in the Arabian Peninsula. The results will help in targeting faba bean improvement efforts against these virus diseases.

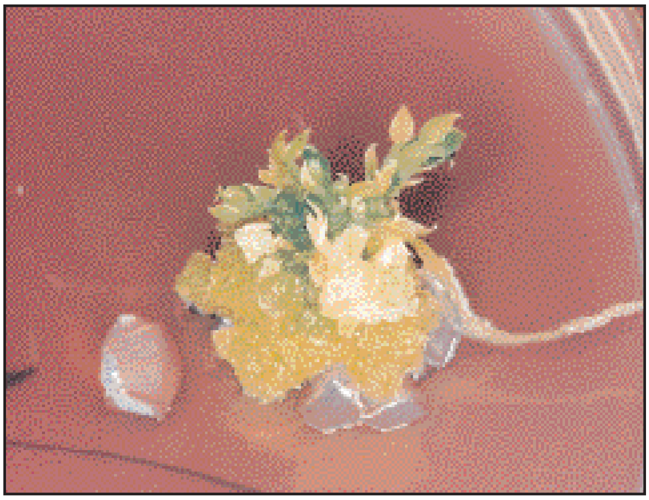
Tissue Culture in *Lathyrus sativus*

Consumption of *Lathyrus sativus* seeds is restricted as they contain high concentration of the neurotoxin ODAP (ß-N-oxalyl-L-, ß-diaminopropionic acid) which causes paralysis in humans. Protocols have recently been developed to obtain plants with a low concentration of ODAP. Different explants are cultured on medium where they produce calli. From these calli, plants are regenerated. Due to somaclonal

Table 12. Regeneration of calli from *Lathyrus sativus* explants.

Explant source	Variety	No. explants	No. callogenic explants	No. undeveloped explants	Calli with roots	Calli with shoots	Calli with roots and shoots
Root	Sel 558 (P21)	33	28	3	13	0	0
	Fam 85	15	4	11	1	0	0
	Sel 520	33	28	2	13	0	0
	Sel 482	22	20	2	11	0	0
Internode	Sel 558	41	36	2	15	0	0
	Fam 85	6	5	1	0	0	0
	Sel 520	35	32	1	15	0	0
	Sel 482	26	22	2	9	1	0
Shoot	Sel 558	26	19	7	2	13	2
	Fam 85	4	4	0	0	1	0
	Sel 520	33	30	3	3	11	6
	Sel 482	27	20	7	2	17	1
Leave	Sel 558	22	19	0	4	0	0
	Fam 85	3	3	0	0	0	0
	Sel 520	39	36	1	2	0	0
	Sel 482	57	52	3	11	0	0
Total		422	358	45	101	43	9





Root and shoot formation on explants of *Lathyrus sativus*.

variation, a number of these plants have a considerably lower concentration of ODAP than the original seed/variety.

This technique was tested at ICARDA with four local varieties. Seed color of the seedlings relates to the amount of toxin in the seed. Of 422 explants cultured, 85% dedifferentiated into calli (Table 12). Of these calli, 43% regenerated either roots, shoots or both on the first medium they were cultured on. Some of the calli have been transferred to a regeneration medium. After two months of culturing, nine explants developed both roots and shoots. Differences in calli formation between the varieties are low. To enhance the somaclonal variation, it is important to have a good callogenic phase before the regeneration is induced. Culture medium B5L gives a high number of calli which show just rooting; an adjustment in the hormones will be tried to induce shoot development. The calli with differentiation of roots or shoots will be transferred to regeneration media to induce the development of roots or shoots.

Seed Health Laboratory

The Seed Health Laboratory (SHL) tests all incoming and outgoing seed, conducts field inspection and rouging of diseased plants, develops control measures for seed-borne diseases, and facilitates the issue of phytosanitary certificates and certificates of origin.

The number of seed samples tested during the last five years (1992–1996) has been increasing (Table 13). The percentage of samples found infected with seed-borne pathogens was low in 1996 compared with 1992–1995. Teliospores of one or more of the following quarantine pathogens were found contaminating cereal seed samples: *Urocystis agropyri*, *Tilletia indica*, and *T. controversa*. These had a high frequency of occurrence in 1992, but it was much less during 1993–1996. Such samples are destroyed.

In each season, plants grown in more than 150 ha in the postquarantine isolation area, plots for inter-

Table 13. Number of seed samples of cereal and food and forage legumes tested at ICARDA for seed health and percentage of samples found infected during 1992–96.

Season	Incoming		Outgoing		Total	
	Tested samples (%)	Infected samples (%)	Tested samples (%)	Infected samples (%)	Tested samples (%)	Infected samples (%)
1996	10,189	1.8	5,498	21.6	15,687	8.7
1995	4,754	12.1	6,481	23.4	11,235	18.6
1994	8,021	20.5	2,460	22.6	10,482	21.0
1993	8,153	7.6	2,652	45.7	10,805	17.4
1992	11,868	42.3	3,319	38.9	15,187	41.6

national nurseries, accessions regeneration, and seed multiplication fields are periodically inspected and infected plants are rouged and burned.

Seeds with satisfactory health status were treated and dispatched to cooperators in about 75 countries, along with phytosanitary certificate and certificate of origin.

During the year, the SHL provided individual training to scientists from national programs, and conducted several in-country/regional courses in seed health testing for quarantine, seed production and seed certification, and seed conservation. These courses were organized in Syria, Jordan, Egypt, Yemen, Turkey, Pakistan, and Iran.

Resource Management and Conservation

Management of Rangelands in the Syrian Steppe

Rangeland is a vital resource for livestock-based systems of pastoral communities of West Asia and North Africa. Increasing human and livestock populations have led to overgrazing and increasing degradation of rangelands in the arid and semi-arid areas.

To manage the natural vegetation and plan the rehabilitation of degraded areas efficiently, ICARDA has started a project for rangeland type-inventory, survey, and mapping. The first phase is to map the native vegetation and the government fodder-shrub reserves of the Maragha region (Aleppo province, northwest Syria) using LANDSAT satellite imagery at different dates. Satellite-image interpretation and ground-truthing is carried out on a test area of some 65,000 ha. ICARDA will further enrich the thematic maps with biomass availability at different seasons, villages and pastoral camp sites, tracks and water points on a GIS database so that adequate management and restoration can be applied in collaboration with the government authorities and the concerned pastoral communities through a participatory approach, as described on page 14 of this Annual Report.

An example of a first attempt to map the range type and fodder-shrub reserves of the Maragha steppe is presented in Figure 12.

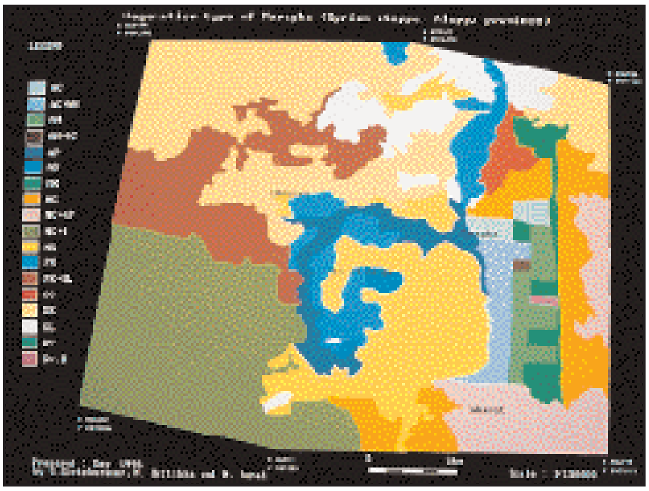


Fig. 12. Range type and fodder-shrub resources of the Maragha steppe, Syria.

Relationships between Poverty and Land Availability and Productivity in WANA

The relationships between poverty and the land resource base are usually unclear and often contradictory. The current mainstream view is that the occurrence of poverty is unrelated to the quality of the land resource base. To confirm whether this view is also applicable to WANA, country-level indicators of land-resource endowment were developed and compared with a country-level indicator of rural poverty. The countries incorporated in the analysis cover the geographical domain of the dry areas and the ICARDA mandate region, with a cropping season of less than 180 days.

The rural poverty indicator, developed at ICARDA, is based on mean incomes and purchasing power parity, adjusted for societal equity in incomes. On the basis of data obtained from the CD-ROM "Digital Soil Map of the World and Derived Soil Properties," produced by FAO, land in each category was subdivided into three quality classes: suitable land, land without major physical constraints; conditionally suitable land, land with some physical constraints that can be corrected by appropriate management; and unsuitable land with major physical constraints that cannot be economically corrected by management.

Using these classes and data from the FAO agricultural statistics database AGROSTAT, two quality-land availability indicators were defined, which assess at country-level the per-capita land availability in the categories "suitable land" and "suitable + conditionally suitable land." For each country a land productivity indicator was also derived from AGROSTAT data. The combination of the two quality-land availability indicators and the land productivity indicator yielded two land-resource endowment indicators (LRE1 and LRE2).

A significant relationship appears to exist between the rural poverty indicator and the two land-resource endowment indicators, which integrate quality-land availability and productivity (Fig. 13a and b). This relationship holds for the availability of suitable land (Fig. 13a), and the total of suitable and conditionally suitable land (Fig. 13b).

However, when comparing the poverty indicator with either the indicators of quality-land availability or of land productivity, no significant relationship could be established.

Notwithstanding the highly aggregated nature of the data used, these findings indicate that in the WANA mandate area poverty is linked to the combined effects of scarcity of quality land (or prevalence of marginal lands) and the productivity of the land. The implication is that since the land-resource base for agriculture is limited and likely to be further reduced by population pressure and its associated competing uses, the enhancement of agricultural productivity is the appropriate pathway for poverty alleviation in WANA.

The dataset used in this analysis was restricted to 37 countries and will need to be expanded to a much larger number of countries to confirm this linkage between poverty, quality-land availability, and productivity.

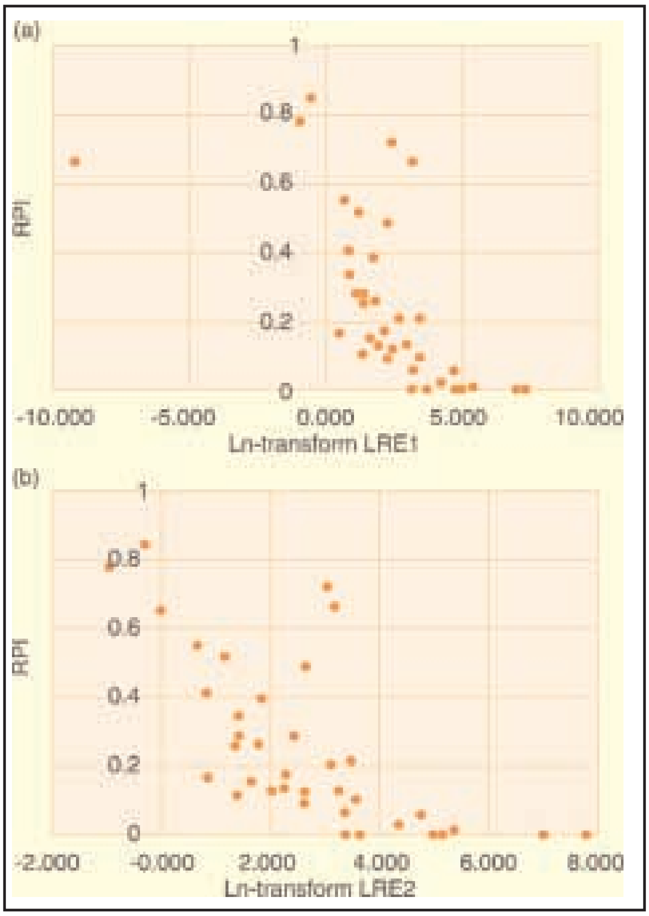


Fig. 13. Rural poverty *vis-a-vis* land availability/productivity.

Farm-level Studies in Lebanon

The need to rebuild Lebanon's infrastructure is closely paralleled by that for agricultural renewal. Recent farm-level surveys, conducted jointly with colleagues from Lebanese institutions and ICARDA's Terbol station (Lebanon) staff have (i) evaluated crop performance and farmer perspectives of on-farm demonstrations of new, promising varieties of cereals and legumes, and (ii) analyzed the nature and needs of legume production systems.

A major observation from the surveys is the wide variety of farm environments and farm-level objectives that must be considered in planning research and extension. While all the demonstrated cereal and legume varieties performed well, it was found that yield superiority was not the only determinant of acceptance and adoption. Other criteria, such as seed and straw quality, price, demand and marketability, and suitability for domestic requirements, may also be equally important. Defining the major characteristics of a farming system helps to identify critical criteria for the adoption of new crop varieties and technology.

The observations from the diagnostic survey of legume production were very similar: great diversity of crops, cropping systems and, not least, farm sophistication and yield levels. Legume crops (mainly chickpea, lentil, and faba bean) are basic components of cropping systems in many parts of Lebanon and contribute significantly to rural incomes; but yields are low and highly variable, and the potential for doubling, even trebling, them exists in many places. Constraints to achieving this include: high input costs and low market prices for outputs (due to competition from imported products); the absence of well-established mechanisms for improved seed multiplication and distribution; and inadequate technology transfer. The conclusion drawn was that Lebanese farmers are good adopters of improved technology. They need well-targeted support from the agricultural services.

Farm-level surveys were conducted in Lebanon in 1996 to understand the needs for future agricultural research.

Pasture and Forage Legumes Increase Soil Nitrogen, Organic Matter, and Barley Yields

Long-term rotation trials are being conducted by ICARDA to generate information for the improvement of the existing farming systems in WANA. They aim at quantifying the effect of replacing cereal/fallow and continuous cereal rotations with cereal/pasture and forage legume rotations. Pasture and forage legumes tested include medics (*Medicago* spp.), chicklings (*Lathyrus* spp.), and vetch (*Vicia* spp.). Experiments are conducted both on station and on farm.

In an on-station long-term experiment at Tel Hadya, the use of medic and vetch in rotations provided a significant accumulation of total nitrogen and organic matter in the soil (Table 14). After 10 years, the organic matter increased by 32% in rotations including legumes, while in the cereal/fallow and the cereal/cereal rotations, it decreased by 2 and 4%, respectively.

On-farm trials were conducted for seven cropping seasons in northwest Syria where annual rainfall is about 270 mm and barley is the most common

Table 14. Effect of rotations on organic matter (%) and total soil nitrogen content (ppm) at Tel Hadya, Syria.

Rotation	Organic matter		Total soil nitrogen	
	1985	1995	1985	1995
Cereal/legume	1.01	1.34	632	903
Cereal/fallow	1.10	1.08	637	738
Cereal/cereal	0.99	0.95	596	650

Table 15. Effect of rotations on dry matter (t/ha), metabolizable energy (ME, Megajoules x 1000/ha), and crude protein (CP, kg/ha) at El-Bab, Syria.

Response	Rotation treatment			
	Barley/ vetch	Barley/ chikling	Barley/ barley	Barley/ fallow
DM	5.32	5.02	4.82	2.91
CP	202.4	197.5	139.4	84.5
ME	21.22	20.63	19.65	11.97

crop. The trials compared fallow or barley with common vetch (*Vicia sativa*) or chickling (*Lathyrus sativus*) in rotations with barley. Yield of feed from both phases of the rotation was greatest from the barley/vetch and barley/chickling rotations (Table 15). Total outputs of crude protein were twice as high for the rotations including legumes compared for the average output of barley/fallow and barley/barley. The barley/vetch rotation gave the highest output of metabolizable energy.

For the promotion of these forage and pasture legumes, ICARDA is developing an informal farmer-to-farmer seed distribution program. This should ultimately lead to increased demand for seed that will attract commercial seed producers. Small seed processing units have been developed that will allow farmers to produce their own pasture seed outside the formal seed sector. On-farm testing of machinery for seed production of pasture and forage legumes is currently underway in several WANA countries including Syria, Morocco, and Lebanon.

Fodder Shrubs and Milk Quality

In the spring of 1995 and 1996, flock owners in the steppe area of Aleppo province rented blocked areas of fodder shrubs from the Syrian Ministry of Agriculture and Agrarian Reform. The saltbushes (mainly *Atriplex* species) and understorey of grasses on these blocks enabled owners to reduce concentrate supplementation of sheep and control the grazing pressure on the surrounding overgrazed steppe. However, in 1995 people reported that the quality of yoghurt and cheese made from the milk of ewes grazing the shrubs was reduced. A study was therefore conducted with food-science specialists at the University of Aleppo to investigate in what ways the quality of the milk was changed by the presence of saltbush in the diet of sheep in the long-term trial at Maragha.

It was found that milk from ewes having access to saltbush contained marginally more minerals and less fat and protein than milk from ewes grazing native pastures. The difference in the mineral content was reflected in both the freezing point and the electrical conductivity of the milk. Although the yield of milk was not significantly affected, the dry matter content of the milk was reduced. Yields of cheese solids and of total solids in yoghurt were also somewhat lower when ewes grazed saltbush. Subjective scores for the taste and appearance of yoghurt were reduced. When fat was analyzed, the average number of carbon atoms in the fatty acids was increased, likely to make the fat harder. These results indicate that the quality of the cheese and yoghurt made from milk of ewes grazing saltbush may be somewhat lower than the same products made from milk of ewes grazing native pastures. This will be further confirmed and its economic significance will be assessed. Also, ways to reduce this negative effect will be studied.

Training

ICARDA places emphasis on training as an essential component of its program to generate, promote, and disseminate research results. In 1996, training opportunities were offered to 659 individuals. Training participants came from 42 countries: 19 WANA countries, 1 Latin American country, 8 African (excluding North Africa) countries, 5 Asia and Pacific region countries, and 9 European countries. Of these about 45% were trained at ICARDA headquarters in Aleppo, while the remaining attended in-country, sub-regional and regional training courses elsewhere. About 15% of the trainees were women.

ICARDA continued its strategy of gradually decentralizing its training activities by offering more non-headquarters courses. In 1996, ICARDA offered 11 headquarters courses and 19 in-country, regional and sub-regional courses.

The training offered reflected ICARDA's agro-ecological thrust. Besides topics in commodity programs, courses were also offered in biometrical methods in agricultural research; agronomy of production systems; morphological variety description; statistical analysis of livestock experimental data; data analysis and interpretation of results from farm surveys; DNA molecular marker techniques; economics of seed production; experimental station management; agro-ecological characterization; legume field inspection methodology; scientific writing and data presentation; cropping systems simulation model (CropSyst) in agricultural research; native and exotic fodder shrubs in arid and semi-arid zones.

Several contacts were made with other IARCs, regional and international research and training organizations such as CIHEAM, ACSAD, AOAD, API, CIMMYT, IPGRI, ICRISAT, FAO, and UNDP for conducting joint training activities in areas of mutual interest. Three joint group courses were conducted in collaboration with CIHEAM and one each with GTZ, IPGRI, FAO, IDRC, and SDC in 1996.

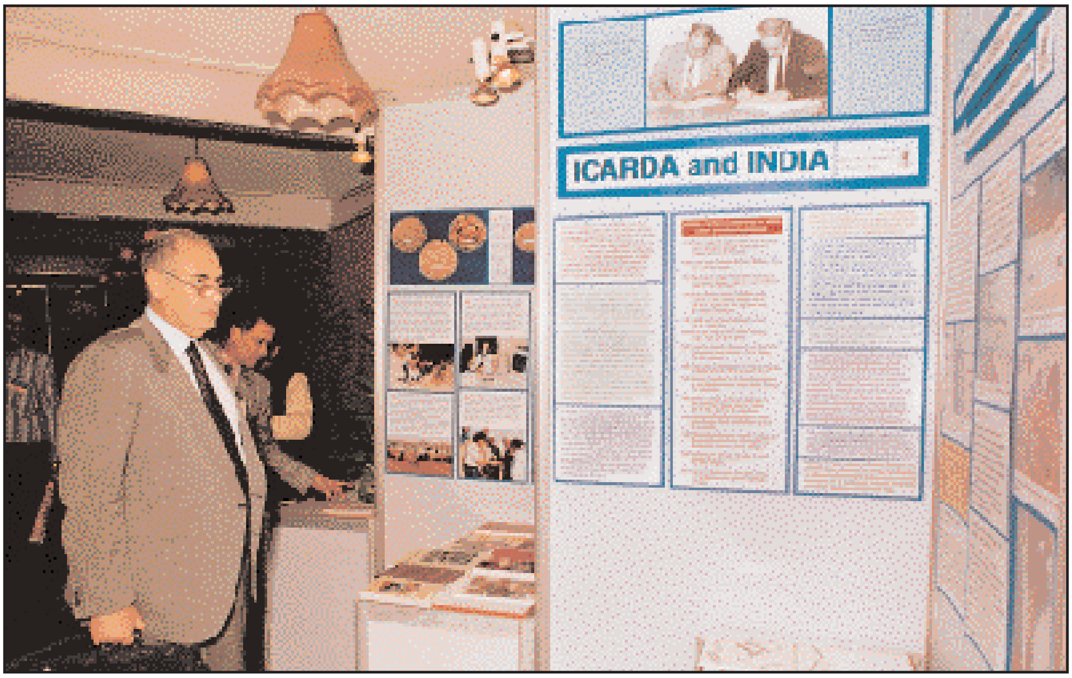
For the UNDP-assisted project entitled "Technical Assistance to Agricultural Investment in the Southern Region—Phase II," Syria—for which ICARDA is the implementing agent for the human resource development component—the Center facilitated 10 short specialized training courses in collaboration with the Egyptian International Center for Agriculture, in Cairo, Egypt; the International Program for Agricultural Knowledge Systems (INTERPAKS) at Urbana-Champaign, Illinois, USA; the Arab Planning Institute, Kuwait; and the national program in Settat, Morocco. The courses included the following topics: (i) extension programs for field crops and horticulture, (ii) advanced methods in bee breeding, (iii) advanced extension methods, transfer of technology and land reclamation, (iv) operation and management of agricultural machinery and heavy equipment, (v) utilization of TV and video in the production of extension programs, (vi) methods in management of livestock feeding and milking, (vii) rural women development, (viii) extension programs for integrated pest management, (ix) planning and evaluation of agricultural projects, and (x) study tour to the IFAD-funded project in Al-Menia province, Egypt. One hundred and thirty-five officials from the project, including the directors of agriculture in the provinces of Rural Damascus and Dara'a, participated in these training courses. These new training activities proved effective in linking national programs in the region with each other and with other regional and international organizations.

The *Manual of Training Procedures* was revised and implemented. This manual defines categories of ICARDA training, establishes procedures for selection of training participants, and details the support provisions offered to training participants who receive ICARDA training awards. The Center continued to collect feedback from the concerned programs/units and NARS on this working document to update it for guiding the 1997 training activities. The policy on the ICARDA Graduate Research Training Program (GRTP) was also revised and implemented in 1996. This policy covers not only NARS scientists for conducting their graduate studies in collaboration with ICARDA, but also ICARDA regional staff members for improving their qualifications.

Information Dissemination

During 1996, emphasis continued to be placed on public awareness and on upgrading technology. Over 15 press releases were produced in English and Arabic. The subjects covered ranged from a workshop on shrubs in Tunisia to involving women in barley products development in Ecuador. Several of these were published in Arabic, English, Italian, Greek and Russian-language newspapers. Using new desktop publishing technology, pictures were incorporated into the press releases. The Center attracted visits from several media representatives, including staff from *Al-Ahram*, *Financial Times Television*, the German Development and Cooperation magazine *D+C*, *Frankfurter Allgemeine*, Canadian Broadcasting Corporation, and *the Philadelphia Enquirer*; contacts were strengthened particularly with Arabic media, including Syrian television. As a result, ICARDA featured on the TV channels in the region more than ever before. Three videos on crop rotation work in Syria were produced in-house and distributed.

With technical support from the CGIAR Secretariat, a comprehensive version of ICARDA's homepage was made available on the World Wide Web. The general-audience magazine, *ICARDA Caravan*, launched at the end of 1995, continued to appear and was well received. Articles during 1996 covered a wide range of ICARDA's work, from the use of satellite imagery to examining water-harvesting potential to the environmental threat posed by rangeland degradation. Positive feedback came from all over the world and resulted in the initiation of new contacts, not only with media, but with potential collaborating scientists. Reaction to *Caravan* has been so positive that the original mailing list—about 1200—had more than tripled by the end of the year. *The Week at ICARDA* continued to be published as



Prof. Dr Adel El-Beltagy, Director General of ICARDA, reviews the Center's display at the International Crop Science Congress, held in New Delhi.

the in-house newsletter for the ICARDA family.

Other public-awareness publishing included a wide variety of leaflets, flyers and booklets on ICARDA's work, with emphasis on natural-resource management. This included a number of publications on biodiversity conservation and use, printed to coincide with the Leipzig biodiversity conference in the summer of 1996. Display material was developed for international meetings including the International Centers Week, held in Washington DC, and the International Crop Science Congress, held in New Delhi.

To ensure quick, high-quality and economic production of this growing output, investments were made in acquiring modern desktop publishing (DTP) technology. QuarkXpress was adopted as the standard DTP software package. This permits greater speed and flexibility in the production of publications. Using this facility, the Major Developments section of this 1996 Annual Report was published in four languages for the first time: English, German, French, and Arabic. A number of Pentium PCs were installed to speed up graphics and other prepress outputs. Two scanners were added to the DTP facility, to produce publication files complete with photographs for output to black-and-white or four-color lithographic film. An Agfa imagesetter was also acquired; the printing facilities were upgraded with the addition of a Heidelberg press.

Despite the growing emphasis on public awareness, scientific publications were not neglected. A total of 39 journal articles and 66 conference papers were edited for publication or presentation, and several workshop proceedings were produced. To strengthen the capabilities of national programs in publishing of research results, a science writing and editing course was again offered, this time in Ankara, Turkey. The in-house scientific journals *FABIS*, *RACHIS* and *LENS* continued to be published. Arabic versions of key documents, including the Annual Report for 1995, were produced.

The library made more on-line information available to ICARDA staff through the installation of three CD-ROM towers holding 21 CDs. Collaboration was established with the Centre for Legumes in Mediterranean Agriculture (CLIMA) in Australia to produce a comprerhensive bibliography on *Lathyrus* in print and CD-ROM formats. Another joint project on the production of a bibliography on Central Asian rangelands was completed in collaboration with the Small Ruminant CRSP Group, Department of Rangeland Resources, Utah State University, USA. Collaboration with CIMMYT continued in producing the *Literature Update on Wheat, Barley and Triticale.*

A BARLEY database containing about 40,000 bibliographic references covering the years 1970 to 1995 was developed. Besides developing these facilities, the Center responded to over 5000 requests for information services during the year.

The data collected in a joint traveling workshop with the Syrian national program in 1995 was analyzed. A directory of information and documentation resources in Syria will be published soon.

Impact Assessment and Enhancement

Farmer Participation in Tunisia

One of the special nurseries distributed to Tunisia as part of the decentralized barley breeding was planted near Tejerouine, a village in southern Tunisia close to the border with Algeria. The nursery included 207 barley lines, mostly early segregating populations, together with check varieties. These were both the landraces grown in North Africa, such as Martin from Tunisia, Saida and Tichedrette from Algeria, Arig 8 from Morocco, and California Mariout and Athenais from Libya, some improved varieties (Rihane-03, released in Morocco, Tunisia and Algeria, and ER/Apm released in Morocco), and one promising Tunisian variety, Manal 92. A check variety was planted every 10 entries, so each check variety was present more than once.

Visual selection was conducted by the barley breeder at l'Ecole Supérieure d'Agriculture de Kef, and by the host farmer and his wife with the results indicated in Table 16.

The data suggest that farmers could be more selective than breeders. This is expected since breeders usually select not only lines that could become varieties, but also those with some useful specific traits, while farmers are presumably only interested in lines which could become cultivars.

Table 16. Number and percent of lines selected by a breeder, a farmer and the farmer's wife, from a nursery of 207 bar-ley breeding lines (Tejerouine, Tunisia, 1996).

Selected by	No. (%)	In common with:	
		farmer	farmer's wife
breeder	40 (19.3)	2	3
farmer	13 (6.3)	-	0
farmer's wife	14 (6.8)	-	-

The type of material selected was of interest. Martin, the local landrace, was present once among the 40 lines selected by the breeder, twice among the 13 lines selected by the farmer, and was never selected by the farmer's wife. She was the only one to select twice, one of the two Algerian landraces, Tichedrette and once the other Algerian landrace, Saida. The farmer also selected Saida twice, but from the two plots not selected from by his wife (Saida was present three times in the nursery). Therefore, although chosen from different plots, the farmer and his wife eventually agreed on at least one cultivar. The reasons for these differences in selection will be further investigated to help the development of barley varieties with greater farmer acceptance.

Assessment of Fertilizer Use on Rainfed Barley in Syria

Earlier studies indicated that fertilizer use on rainfed barley was new to barley producers in Syria. Barley grain and straw yields showed significant increases with the application of nitrogen and phosphate fertilizers. Economic analysis shows that fertilizer use on rainfed barley is profitable at the farm level with positive impact at the national level in terms of net benefits and benefit–cost ratios, and there are certain fertilizer options which have no risk.

Fertilizer use has now become common among barley farmers in Syria, especially in Zone 2*, but there remain two questions to be answered: what is the current situation of barley production in Syria? and how much increase in barley production at the national level has been due to fertilizer use?

Official statistics on national trends indicate that, between 1981 and 1995, there was a clear increase in both barley area and barley production in Syria. The total area cultivated with barley increased by 46%, from 1,346,000 ha in 1981 to 1,963,000 ha in 1995. A major issue is the large year-to-year fluctuation in the total barley production, the consequence of more than 95% of the barley area being rainfed. Despite this fluctuation, growth of production and yield has occurred since 1990, with total barley production increasing from 846,000 tonnes in 1990 to 1,722,000

Table 17. Average area, production, and yield of barley for five-year periods in Syria.

Years	Area (x000 ha)	Production (x000 tonnes)	Yield (kg/ha)
Syria total			
1981–85	1425	831	583
1985–90	2116	1129	534
1991–95	2108	1371	650
Zone 2			
1981–85	374	286	765
1985–90	620	480	774
1991–95	720	747	1064
Zone 3			
1981–85	304	153	503
1985–90	451	211	468
1991–95	502	235	468

tonnes in 1995, and barley yield up from 448 kg/ha in 1990 to 877 kg/ha in 1995.

However, for a better understanding of barley production trends at the national level, and to avoid the influence of year-to-year fluctuation, average annual area, production, and yield of barley were calculated for five-year periods (Table 17). Between 1981–85 and 1991–95 the average annual area of barley increased by 48% and total production by 67%. Yield per unit area increased by 11%. The difference between the zones is instructive. Over this period, the proportion of total Syrian national barley production from Zone 2 increased from 34 to 54%, and area productivity from 750 to 1064 kg/ha (38%). In contrast, there was no yield increase in Zone 3**. This is because the majority of Zone 3 barley farmers have practised continuous barley cropping over the last 10 years. However, fertilizer use was diffused in this zone and some farmers adopted it, but its effectiveness was limited to stopping the decline in barley yield due to cultivating the land every year.

Based on the data collected from the survey on adoption of fertilizer, the fertilizer response functions and yield gap analysis, and the official statistics for barley, a preliminary estimate of the average annual impact of fertilizer use on barley in Zone 2 and Zone 3 was calculated. Fertilizer application to rainfed barley increased yield to 261,000 tonnes, which translates to an increase in the national income by about 873 million Syrian Pounds (SYP) annually (equivalent to US$ 20.8 million at 42 SYP=1 US$ exchange rate). About 81% of this increase came from Zone 2 and the remainder from Zone 3.

* Zone 2: 250–350 mm mean annual rainfall with ≥ 250 mm in two-thirds of years.

** Zone 3: > 250 mm mean annual rainfall with ≥ 250 mm in half of years.

Performance of Improved Barley Lines in Farmers' Fields in Lebanon

Six barley lines—three improved lines (HDS, Mary Athenaise and Faiz), two released cultivars (Rihane 03 and Litani) and the local cultivar—were evaluated in farmers' fields at four locations in the rainfed areas in Lebanon, with and without fertilizer. The trials were in two replicates and each experimental plot was about 0.1 hectare. Results of grain yield over locations and fertilizer treatments showed that Mary Athenaise gave 31% more grain yield than the released cultivars. This line was also preferred by farmers when they visited the fields before crop harvest. As for straw yield, Mary Athenaise and HDS gave greater straw yield than the two released and the local cultivars. Fertilizer application resulted in an average increase of 50% in grain yield and 41% in straw yield. Fertilizer effect varied among locations and varieties.

Forage Legumes On-Farm Evaluation and Demonstration

Syria, Lebanon, Iraq, and Jordan, in their collaborative research with ICARDA, have an extensive component on demonstration in farmers' fields of the potential of forage legumes as the best alternative in the barley-based rotations.

During the 1995/96 growing season, three species of legumes were evaluated in farmers' fields at three sites in Lebanon (Table 18). Kasr is the driest location which received only 252 mm rainfall. It was observed that *Lathyrus cicera* was more adapted to the drier areas than the other two species. Also, *L. cicera* responded well when moisture conditions improved.

In Jordan, several on-farm evaluation trials were conducted in which vetch (*Vicia sativa*) line 715 gave the highest dry-matter yield compared with other *Vicia* species. In the demonstration of vetch grazing on six farmers' fields, ewes and lambs started grazing the vetch during March and April, and their daily weight gain ranged from 135 to 289 g/head per day. Sheep owners were very pleased with this system and ready to adopt it.

In Syria, 12 demonstration trials of vetch were planted for direct grazing in four Governorates in Zone 2. The crop performance was good with an estimated dry-matter yield ranging from 1.4 to 3.3 t/ha. Sheep grazed during March–early May. Some farmers left part of the field for seed and straw production. Sheep weight gain ranged from 88 to 269 g/head per day for the 12 locations.

Table 18. Dry-matter, grain and straw yield (kg/ha) of three forage-legume species grown in three sites in Lebanon during the 1995/96 season.

	Saaydeh			Ain Esaoudah			Kasr		
Species/line	Dry matter	Grain	Straw	Dry matter	Grain	Straw	Dry matter	Grain	Straw
Vicia sativa 715/2556	3246	2238	5403	2727	970	2528	439	49	218
Vicia sativa 3030/2520	3115	1253	2517	3142	2691	3979	1703	335	826
Lathyrus cicera 127/492	3183	2326	3812	3265	2004	5334	2386	682	1873

Farmers who participated in the project are convinced of the value of vetch/barley rotation. They are able to produce high-quality feed for their animals, as well as improve their soils. Farmers who planted vetch in rotation with barley instead of the continuous barley, reported a significant decrease of infection with the cereal mealy bug. A study of the inci-

Outreach Activities

ICARDA continued its support to strengthening national agricultural research systems (NARS) through its six outreach programs which ensure the research continuum between the Center's headquarters and NARS. Much of ICARDA's outreach program activities are supported through bilateral and multilateral projects involving tripartite cooperation between NARS, ICARDA, and donors. Successful models for a multi-disciplinary and multi-institutional research approach have been established at both national and regional levels. Such a collaborative approach avoids duplication of research, enhances the efficiency of the research management system, and makes the best use of resources.

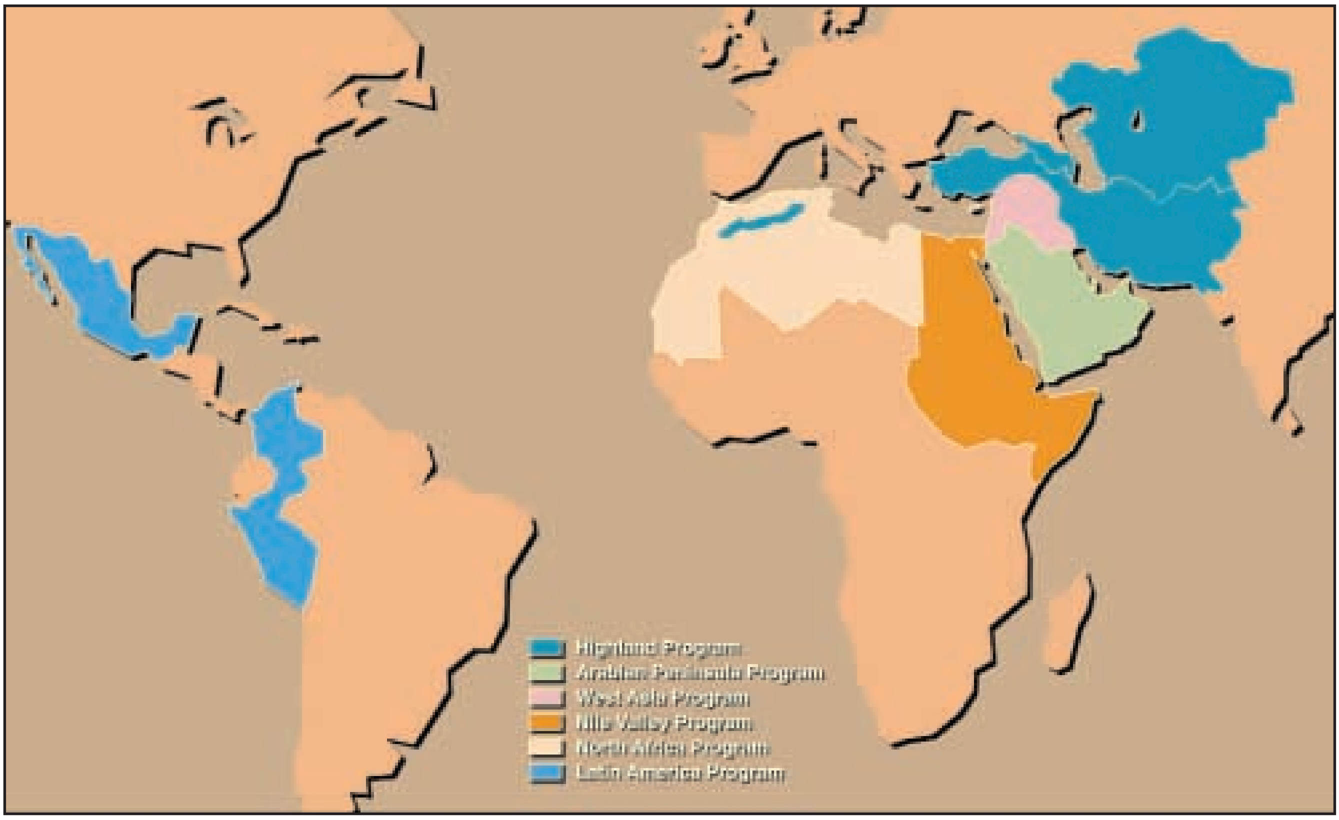
The six outreach programs are: the North Africa Regional Program (NARP), the Nile Valley and Red Sea Regional Program (NVRSRP), the West Asia Regional Program (WARP), the Arabian Peninsula Regional Program (APRP), the Highland Regional Program (HRP), and the Latin America Regional Program (LARP).

North Africa Regional Program

The North Africa Regional Program (NARP) serves the all low lands, particularly drier areas, of the Maghreb region (Algeria, Morocco, Tunisia, and Libya) and seeks to extend to the whole region the benefits of collaboration between ICARDA and NARS.

Mashreq/Maghreb Project

The Regional Program for the Development of Integrated Crop/Livestock Production in the Low Rainfall Areas of WANA, popularly known as the Mashreq/Maghreb Project, jointly funded by the Arab Fund for Economic and Social Development (AFESD) and the International Fund for Agricultural Development (IFAD), has consolidated mutual support between the Mashreq and Maghreb regions of



ICARDA's regional programs. The Central Asian Republics are served by the Highland Regional Program.

WANA. During 1996, Maghreb scientists reviewed research in the Mashreq and made recommendations on the use of olive trees and agroindustrial by-products in animal feeding, use of medics in rotations, techniques of forage-mixture production, and integration of socio-economic research with crop improvement work. The expertise of the Mashreq programs in producing feed blocks and techniques for increasing sheep fertility was extended to the Maghreb region. More details on the Mashreq/ Maghreb Project are presented under the West Asia Regional Program.

Farmers use plastic sheets, or a mixture of straw and mud—a long-time tradition in North Africa—to store urea-treated straw for animal feeding.

Integration of Activities for Better Farmer Involvement

NARP, in collaboration with Agricultural Research Center, Libya, organized a one-week event combining the Mashreq/Maghreb field days for farmers and the Cereals and Agronomy Traveling Workshops for evaluation of production techniques and selection of germplasm. A large number of Libyan farmers joined scientists from

A Tunisian extension agent from the Range, Pasture, and Livestock Bureau explains the technique of acacia planting for livestock grazing, to sheep owners from WANA, Australia, France, and South Africa.

Algeria, Morocco, Tunisia, Libya, and ICARDA in study tours. Merits and economic performance of technological innovations were assessed at the farm level. The concept of an integrated and multidisciplinary approach to analyze the problems faced by farmers was put to the test. Farmers' attitudes towards technology and constraints to adoption were considered, and the study will continue in 1997.

Native and Exotic Fodder Shrubs Seminar

Sheep owners from Australia, Jordan, Morocco, Syria, South Africa and Tunisia, and around 100 scientists from all over the world, including the newly independent republics of Kazakhstan and Uzbekistan, attended a seminar on the use of native and exotic fodder shrubs in animal feeding, organized by ICARDA in cooperation with the Tunisian national program and CIHEAM. Sheep owners provided detailed explanations of their experiences with shrubs at the local level, while field visits in central Tunisia showed the host country's experience in feeding its livestock in very dry years on *Acacia* spp., spineless cactus, and *Atriplex* spp.

Human Resource Development

In addition to the Cereals and Agronomy Traveling Workshops, four courses were conducted in the Maghreb countries covering agroecological characterization of environments, on-farm methodologies, use of agroindustrial by-products in animal feeding, field plot techniques and data collection. Tunisian and Moroccan scientists carried out surveys of diseases and insects in Libya.

Scientists from the Maghreb region presented papers on their collaborative research at the International Barley Genetics Symposium, Saskatoon, Canada; at the 2nd International Crop Science Congress, New Delhi, India; and at several WANA regional conferences. Junior staff received training and attended 11 different courses at ICARDA headquarters in Aleppo, while several North African scientists participated as lecturers in ICARDA-offered courses.

Nile Valley and Red Sea Regional Program

NVRSRP, which is based on tripartite cooperation among the NARS of Egypt, Eritrea, Ethiopia, Sudan and Yemen; ICARDA; and donors continues to employ coordination and networking at national and regional levels, technology generation and transfer, and human resource development as tools to enhance sustainable productivity of a wide range of major food crops covering cool-season food legumes and cereals (wheat, in cooperation with CIMMYT, and barley). Resource management is an important component of the collaborative Egyptian program. ICARDA collaborates with the countries of the region as a partner in the development of annual work plans, exchange of germplasm, provision of technical backstopping and training opportunities, and research coordination at national and regional levels.

The region has diverse environments ranging from dry desert lands to wet tropical highlands. Food deficits and subsistence farming characterize all the countries of the region.

Barley Improvement Program in Ethiopia

The Barley Improvement Program, supported by the Netherlands, was evaluated by a Review Mission according to the policy of the donor. The Review Team, led by a consultant to the DGIS of the Netherlands, with an Ethiopian expert and ICARDA researchers, joined the NVRSRP Regional Barley Traveling Workshop, held in Ethiopia from 14 to 19 October 1996. The Team visited some of the major barley-producing regions in Ethiopia, studied project documentation, and held discussions with farmers, scientists, Institute of Agricultural Research management staff, and government authorities to assess the achievements made, identify shortcomings, and make recommendations for the future. Based on achievements made, the Review Mission Report strongly recommended a second phase of the project, to be started in June 1997.

The External Review Team members joined the Barley Traveling Workshop in Ethiopia to obtain first-hand information on the progress of the barley project.

Regional Networks

The problem-solving Regional Networks Project continued to be supported by the Netherlands Government to strengthen basic and applied research on common problems facing the production of cool-season food legumes and cereals in Egypt, Ethiopia, Sudan, and Yemen. These networks include rusts of wheat, wilt/root rots of food legumes, aphids/viruses of cereals and legume, thermo-tolerance in wheat, drought and water-use efficiency and socioeconomic studies. During the year, trials and surveys for data collection within the different networks were conducted in different locations of the participating countries and an exchange of training programs for scientists was organized. Achievements in these networks were presented and discussed in the Regional Coordination Meeting held in Sana'a, Yemen, 1-4 October 1996. In November 1996, an Ethiopian scientist joined NVRSRP/ICARDA as a Visiting Scientist for a two-year term, in the position of Coordinator for the Regional Networks Project. The Visiting Scientist from Sudan completed his two-year assignment in November.

Regional Wheat Traveling Workshop in Sudan. Participants came from Egypt, Ethiopia, Sudan and Yemen, and from ICARDA and CIMMYT.

Regional Food Legume Traveling Workshop in Egypt.

Resource Management in Egypt

For the second year, the long-term trials were conducted in the five selected locations representing the old irrigated lands, the newly reclaimed lands, and the rainfed areas of North Sinai. Different rotations were implemented. Soil, plant, and water samples were collected during the last growing season, and the preliminary results were presented at the National Coordination Meeting held in Cairo in September 1996. At the same meeting, planning for the implementation of next season's trials was discussed. A workshop was held in Cairo in May 1996 to plan the different long-term monitoring activities (biophysical measurements and socioeconomic data collection). These activities started with 85 farmers in 17 villages representing the areas where the long-term trials are located.

Matrouh Resource Management Project in Egypt

In July 1996, ICARDA signed the contract for the Adaptive Research and Technical Assistance Agreement of the Matrouh Resource Management Project (MRMP), financed by the World Bank/ International Development Association (IDA). The Project is designed to assist the population of the Northwestern Coastal Zone of Egypt in making the best use of limited natural resources to improve their socioeconomic status. The main components of the Project include water-harvesting and watershed management, rangeland and grazing management, adaptive research in the fields of rainfed and dryland farming systems, extension and training, and monitoring and evaluation. The Project implementation started in November 1996.

Agricultural Sector Management Support Project in Yemen

In the Republic of Yemen, ICARDA started the implementation of the World Bank-supported Agricultural Sector Management Support Project (ASMSP). In May/June 1996, a team of three scientists was placed with the Agricultural Research and Extension Authority (AREA) in Dhamar. The major objectives of this new collaborative program are to introduce effective research management principles and procedures; develop and introduce efficient research priority setting, program planning, implementation and evaluation procedures; and strengthen agricultural research and thereby accelerate the development and adoption of appropriate technologies with emphasis on rainfed agriculture. The long-term technical assistance will focus on rainfed crop production, livestock (small ruminant) improvement, and management of natural resources within a farming systems approach.

After establishing an office at AREA's headquarters in Dhamar, the team organized a series of workshops and visited all of AREA's regional research stations. A major National Research Review Workshop was held from 8 to 12 September 1996, sponsored by AREA, ICARDA and the World Bank, in which representatives from IDAS/GTZ, ERARLUP/FAO, and ETC/Netherlands Government participated. The Workshop reviewed the achievements in agricultural research and extension in Yemen during the last decade and identified future research needs and priorities. It laid the foundation for developing a medium-term strategy for agricultural research in Yemen. A report on the Assessment of Agricultural Research was prepared to serve as a basis for preparing the strategy and program plans. An orientation workshop on research strategy, program planning and priority setting was organized to build a consensus among scientists towards developing a research strategy. An inventory of available technologies for on-farm testing is being prepared and diagnostic surveys are being designed for determining research priorities with emphasis on rainfed areas with mixed crop/livestock production systems.

Staff Education, Training, and Professional Visits

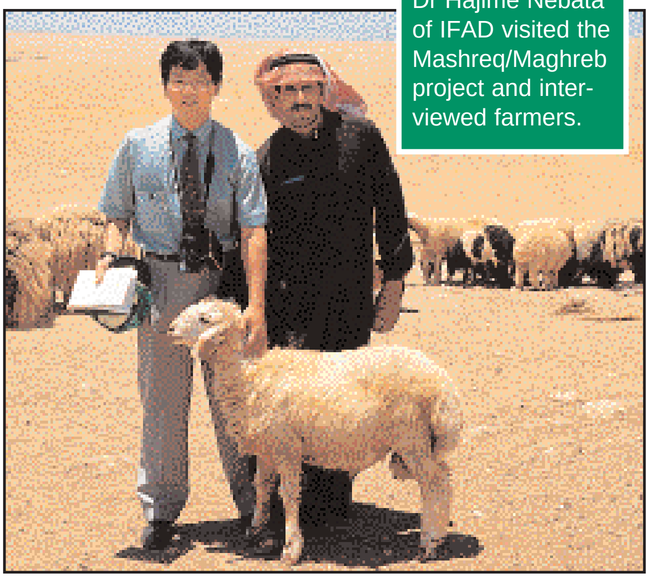
Within the ASMSP, 17 Yemeni scientists were enrolled in universities (14 in overseas universities and three in Sana'a University) under long-term graduate MSc and PhD degree programs. Seventeen administrative and financial personnel also underwent short-term non-degree training in Cairo and Aleppo. The total number of Egyptian, Ethiopian, Sudanese and Yemeni scientists trained within NVRSRP was as follows: in-country training, 88 persons; individual/short courses, 115; scientific visits, 28; workshops, 212; coordination meetings and conferences, 349.

West Asia Regional Program

The West Asia Regional Program (WARP), operating from Amman, Jordan promotes regional cooperation in research, training and information dissemination in Jordan, Cyprus, Syria, Lebanon, south Turkey, and Iraq, which have a typical Mediterranean climate, characterized by cold winters and a hot and dry grain-filling period. Rainfall is highly erratic both in time and space. The region is characterized by a limited agricultural resource base, shortage of water, high population growth and a widening food and feed gap. The major emphasis in this region is on the improvement of farming systems in the 200–450 mm rainfall zone.

Mashreq/Maghreb Project

The major project implemented by WARP is the Regional Program for the Development of Integrated Crop/Livestock Production in the Low Rainfall Areas of WANA (the Mashreq/Maghreb Project), funded by AFESD and IFAD. The project, which covers the Mashreq and Maghreb countries, has a significant socioeconomic component embracing both rangeland and arable land, and considers linkages between crop and livestock across ecological zones. A major focus is on policies and property rights and how they affect technology transfer and adoption and rangeland degradation.



Dr Hajime Nebata of IFAD visited the Mashreq/Maghreb project and interviewed farmers.

Coordination Meetings

Annual coordination meetings were organized in Iraq, Jordan, Lebanon, and Syria. The meetings provided good opportunities for close interaction between NARS and ICARDA researchers, and also for within-country cooperation. Work plans were discussed and developed for the Mashreq/Maghreb Project. The meetings were attended by the Project team, ICARDA scientists, and farmers and sheep owners who are cooperating with the Project. Farmer's involvement in the planning and workplan development was very useful since they enriched the discussion with their practical experience. This approach will be strengthened in the future.

Farmer Traveling Workshop in Jordan

For the first time in the Mashreq region, a traveling workshop for farmers was organized by the Mashreq/ Maghreb Project. Fifteen farmers/sheep owners from Iraq, Syria, Palestine, Lebanon, and Jordan attended the week-long workshop in Jordan in April 1996. Farmers discussed field and crop management practices used in Jordan, their production strategy, and the constraints that limit productivity increases, and suggested new approaches. Active discussion among farmers on animal production also took place, and they were receptive to new ideas.

Traveling Workshop in Lebanon

A traveling workshop in Lebanon was organized in May with participation of 40 researchers from Algeria, Libya, Morocco, Tunisia, Iraq, Jordan, Lebanon and Syria, in addition to several researchers from ICARDA, and Lebanese institutions. Scientists visited demonstration sites, met with farmers, discussed with them their activities and noted the impact of the Mashreq/Maghreb Project during its first year. The group also visited research stations and had meetings with officials.

Workshop on Rangeland Research and Development in Jordan

WARP, in cooperation with GTZ and the Ministry of Agriculture in Jordan, organized a workshop in May on rangeland research and development in Jordan. The workshop reviewed the work in rangelands by different projects and institutions and arrived at practical recommendations that will enhance and strengthen the cooperation and complementarities between these institutions.

Seminar on Forage Legumes in Iraq

A one-day seminar was organized by the Mashreq/ Maghreb Project in Iraq in April to review forage-legume activities in Iraq and their future directions. The seminar was attended by 35 scientists from Iraq in addition to 5 farmers and 4 scientists from Morocco, Jordan, and ICARDA.

Traveling workshop in Lebanon.

Farmer Consultations and Planning Meetings

Several one-day consultation meetings were organized with farmers to discuss the Project work plan and to obtain their views on the activities. In Iraq, a meeting was organized in Mosul in January with participation of 22 farmers/sheep owners. In Lebanon, the consultation meeting was held in Tel Amara in February with participation of 67 farmers from the project areas, in addition to 25 researchers and representatives of 10 development projects working in Lebanon. In Jordan, three meetings were held in March: one included 28 farmers from north Jordan, the second included 27 farmers from central Jordan, and the third included 33 farmers from south Jordan. In Syria, meetings with farmers were organized in Hama (10 farmers), Raqqa (7), Hassakeh (10), and Dara'a (7) governorates in May. Farmers expressed concern about a number of technical and policy issues, which will be considered in future project activities.

Regional Training

In an advanced training course on statistical analysis of livestock experimental data, organized in Aleppo in cooperation with CIHEAM in July, several case studies were examined. The case studies were on small-ruminant nutrition and feeding trials using crop residues, agroindustrial by-products and concentrates fed alone or in various combinations. Statistical designs considered in the course were randomized complete and incomplete blocks, lattice, factorial layouts, and cross-over designs. Simple and multiple covariance to adjust treatment effects was also considered.

Collaboration among West Asian Countries

Collaboration was strengthened in the exchange of germplasm of cereal and legume landraces and improved cultivars. Promising barley lines from Cyprus were distributed to participating countries; wheat and barley cultivars from Iraq were sent to Syria, Jordan and Lebanon; and those from Syria were evaluated in Jordan and Iraq. Several scientific visits and training opportunities were exchanged between countries; training in the production of by-product feed blocks was offered in Iraq to technicians from Jordan and Lebanon. Training in sheep management and reproductive physiology was offered by Jordan to technicians from Lebanon. Training in computer use for livestock trials was offered by Jordan to Syrian scientists. Iraqi scientists visited Jordan to gain experience in conducting on-farm and demonstration trials.

Inter-Regional Collaboration

Collaboration between scientists from West Asia and North Africa was strengthened through the Mashreq/Maghreb Project. Scientists from Iraq visited North Africa and exchanged experience with Tunisian and Moroccan scientists in by-product feed-block production and utilization and sheep production. Similarly, scientists from North Africa visited West Asia and exchanged experience in the utilization of olive by-products and socioeconomic studies (Syria and Jordan) and in forage-legume production and utilization (Iraq). Several scientists from the four North African countries participated in a traveling workshop in Lebanon, attended by scientists from West Asia and ICARDA, where they had a unique opportunity to discuss their work, and exchange experience and information.

Mashreq Country Socioeconomic Group

The Mashreq Country Socioeconomic Group was established in WARP following the appointment of a socioeconomist in the Amman office with support from the OPEC Fund. The group, which consists of socioeconomists working in Iraq, Syria, Jordan, Lebanon and ICARDA, met twice in 1996 to discuss socioeconomic studies conducted in these countries in the adoption and impact of barley production technology, sheep fertility, and adoption and impact of livestock technology. The group also developed a proposal for a socioeconomic network for West Asian countries.

Collaboration with Other Organizations

Collaboration with the International Food Policy Research Institute (IFPRI) continued through the Mashreq/Maghreb Project. Several workshops and meetings were jointly organized in the area of policy and property rights. Close cooperation with GTZ was also maintained. During 1996, two workshops were jointly organized by WARP and GTZ.

Human Resource Development

Several in-country training courses were conducted in Jordan, Iraq, Lebanon, and Syria, some for technicians and others for farmers. The total number of training events was 19, with about 250 participants. Twenty students are working for their MSc and PhD degrees under the joint supervision of ICARDA and NARS scientists from these countries.

Arabian Peninsula Regional Program

An ICARDA team, headed by the Director for International Cooperation, visited the United Arab Emirates (UAE) in November to initiate the establishment of an ICARDA Regional Office for the Arabian Peninsula Regional Program (APRP). The team met the Minister of Agriculture and Fisheries in the UAE, who welcomed hosting the Regional Office at the Ministry in Dubai. An ICARDA-appointed Coordinator has assumed his responsibilities in the new office. The formal opening of the new Regional Office of the ICARDA Arabian Peninsula Program will take place in January 1997.

The Regional Office is responsible for the implementation of the collaborative second Phase of the Project on “Strengthening Agricultural Research and Human Resource Development in the Arabian Peninsula” which is now in operation. The Project involves all seven countries of the Arabian Peninsula: Bahrain, Kuwait, Qatar, Saudi Arabia, the Sultanate of Oman, the UAE, and the Republic of Yemen. It is a continuation of APRP Phase I, which was operated from ICARDA headquarters from 1988 to 1995, and financed by the Arab Fund for Economic and Social Development (AFESD).

Phase II, cofinanced by AFESD and the International Fund for Agricultural Development (IFAD), aims at increasing food security in the Arabian Peninsula through increased productivity of field crops and livestock, based on optimization of water-use efficiency, conservation of native plant species, prevention of soil degradation and desertification, and strengthened cooperation among participating countries with regional and international organizations. Thus, Phase II has strong natural-resource management and technology transfer components, in contrast to Phase I which had greater emphasis on germplasm enhancement. In a Regional Steering Committee Meeting held at ICARDA headquarters in September 1996, involving the member countries, it was agreed to give priority to the following areas for regional cooperation: on-farm water use, abiotic stresses (drought, moisture deficit, heat, salinity), rangelands and forages, and protected agriculture.

Highland Regional Program

The Highland Regional Program (HRP), with its regional base in Ankara, Turkey, coordinates training and research activities for the highland areas (>700 m asl) of the WANA region. During the year, activities were extended to the newly independent republics of Central Asia (Kazakhstan, Kyrghyistan, Tajikistan, Turkmenistan and Uzbekistan) and West Asia (Armenia, Azerbaijan and Georgia) which have agroecologies similar to those of the highland areas in West Asia.

Mediterranean Highlands

Good progress was made during the second year of the EC/ICARDA Mediterranean Highlands Project that operates in Algeria, Morocco, Tunisia, and Turkey. The project is catalyzing exchange of germplasm and information between the Turkish Anatolian highlands and the High Plateau and Atlas mountain areas of North Africa. Germplasm exchanged between the two regions is being widely tested. A traveling workshop was organized in

Morocco in May and was attended by Project scientists from the four participating countries and ICARDA.

Participants of the CGIAR/Central Asia NARS Consultation Meeting in Tashkent, 5–6 September 1996. ICARDA assisted the CGIAR in organizing this meeting.

Newly Independent Republics of Central and West Asia

During the year, efforts to initiate activities in the Newly Independent Republics were intensified. A multi-CG Center project proposal for increasing sustainable agricultural production in the Central Asian Republics was submitted to BMZ by ICARDA. A workshop on livestock production in Central Asia was jointly organized by the USAID's Small Ruminant Collaborative Research Support Program (SR-CRSP) and ICARDA in Tashkent in March. Also, ICARDA assisted the CGIAR in conducting the CGIAR/Central Asia NARS Meeting in Tashkent in September. In addition, through ICARDA's support, several scientists from the region attended the 5th International Wheat Conference held in Ankara, and the International Conference on *In Situ* Conservation of Germplasm held in Antalya, Turkey.

Iran

Major emphasis of the Iran/ICARDA bilateral project is on germplasm enhancement to develop high-yielding, stress-tolerant bread and durum wheat and barley cultivars for release to farmers in different agroecological regions of Iran. To overcome the spread of diseases such as yellow rust, which cause significant fluctuation in production, research efforts during the last three years were intensified and a strategy to release a large number of cultivars with different genetic makeup was developed to check the spread of diseases on a large scale, averting the potential danger of epidemics. Three bread wheat varieties (Nek Najad, Gahar, and Zagroos), one durum wheat variety (Seymareh) and two barley varieties (Izch and Sahand) were released during 1996.

During the year, 56 Iranian farmers visited ICARDA to acquaint themselves with the Center's work.

Another major component of the project is transfer of technology to farmers. A visit of 56 Iranian farmers to ICARDA headquarters was organized to acquaint them with the latest techniques and technology for sustainable agricultural production in dryland areas, and to familiarize them with the farmers' participatory approach, especially in germplasm improvement for the harsh dry-area environment, where stability in production is of paramount importance.

A large number of Iranian scientists were trained at ICARDA headquarters in a variety of disciplines. In addition, two in-country training courses were organized for local researchers: Seed Production Technology, and Data Analysis and Interpretation of Diagnostic Farm Surveys. Twenty-four participants from the Dryland Agricultural Research Institute and Extension Organization were also trained at Kermanshah in June and July.

To promote cooperation further, ICARDA's Director General visited various research institutes in Iran and met a large number of high-ranking officials headed by the Minister of Agriculture of the Islamic Republic of Iran. As a result of this visit, a decision was made in consultation with the Iranian colleagues to post an Iran/ICARDA Project Coordinator in Iran and establish an ICARDA Liaison Office in Tehran starting in October 1996.

Pakistan

Good progress was made during the second year of the collaborative project on range management and small ruminant improvement between the Arid Zone Research Institute (AZRI) and ICARDA.

Late in 1996, AZRI announced that the Balochistan Seed Council had approved the release of the following varieties: AZRI-96 bread wheat, Sanober-96 barley, Shiraz-96 lentil, and Kuhak-96 vetch. These lines had been identified when ICARDA had scientists based in Quetta implementing the USAID-supported project on institutional strengthening, which ended in 1994.

Turkey

Thirteen collaborative research activities were carried out during the year by the Turkish scientists in close collaboration with ICARDA. This reflected two new activities compared with 1995: one on socioeconomic surveys on the status of supplemental irrigation in the Central Anatolian Plateau and the second on crop modeling in cereals and food legumes. The Turkey/ICARDA Highland Project continued to lay more emphasis on the transfer of improved technologies to farmers.

Latin America Regional Program

The Latin American Regional Program (LARP), based at CIMMYT in Mexico, directs a major part of its resources to breeding barley germplasm to be used by NARS in the region. For several years, the emphasis has been on the incorporation of disease resistance into otherwise high-yielding barley cultivars in an effort to protect the disease-prone areas of Latin America from the threat of fusarium head scab epidemic. In the northern part of the Western Hemisphere, fusarium head scab causes severe economic losses to many barley producers.

Existing linkages with advanced institutions—Oregon and North Dakota State Universities and the barley breeding programs in Alberta and Saskatchewan—are reinforcing some research aspects of LARP.

Germplasm of hull-less barley, a crop essentially rediscovered by Canadian farmers in recent years, has been developed by the ICARDA/CIMMYT Barley Program and has been adopted by Canadian breeders; five of the national programs in Latin America have now also released hull-less cultivars for food and feed.

Mexico

New linkages were established during the visit of ICARDA's Director General to Mexico in September 1996, especially with Mexican institutions working on problems of desertification, such as government agencies, universities and NGOs. As a start, a regular flow of information of ICARDA's research is to be established, and thereafter, common interests will be identified for collaborative work.

Ecuador

One scientist completed his doctoral degree at North Dakota State University on finding new resistance genes to leaf rust. New sources of resistance are necessary to solve the rust problem in Ecuador, where the pathogen's virulence overcame all the major genes present in the variety differential set. The scientist was appointed leader of the Cereal Program at INIAP, the national research institute.

The area under cultivation with the barley cultivars Shyri, Calicuchima, and Atahualpa is being expanded in Ecuador. However, the seed production facility is relatively small to produce enough seed to cover national needs. One INIAP scientist from Chuquipata Experiment Station started barley seed production with 13 small farmers in the Loja province. Farmers were provided at the farm gate with certified seed, fertilizer and herbicide as a loan to grow barley. These farmers had grain yields ranging from 2.1 to 4.5 t/ha, a three- to six-fold increase over the national average. Twelve of the 13 cooperators repaid the loan after harvest, and will be part of a much larger number of participants in 1997.

Ecuadorean farmers review the performance of Atahualpa barley with a national researcher.

Barley is the staple food in the Andean Region. A group of 25 women attended a workshop organized by INIAP under GTZ sponsorship to develop new recipes using barley as the main ingredient. One thousand booklets with recipes adapted to local taste were printed in cooperation with private industries and will be sold at a modest price. Barley as a food is not restricted to the Andean Region. Therefore, research findings showing a significant reduction in cholesterol level in humans could have a positive effect on barley incorporation in the North American diet.

The incorporation of durable disease resistance in barley was set as a priority in a workshop organized by the Netherlands Government in Quito in 1994. Funds for the next three years were approved in 1996 and will be made available to NARS in the region to finance research in this area. The work was initiated with the development of four populations from crosses made to improve the level of partial resistance against leaf rust in Ecuadorean varieties. In the crosses, the best partial resistance source was provided by a scientist from the Netherlands; F_2 populations were sent to Ecuador for planting in 1997.

Peru

The Visiting Scientist Program addressed the need of NARS scientists to make short visits to select barley germplasm in Mexican nurseries. This resulted in the release of two barley cultivars by the National Agrarian University La Molina in Peru. The cultivars UNA-94 and UNA-96 were selected and introduced to Peru by university staff in early segregating populations (F_2). Both cultivars carry multiple disease resistance to diseases prevalent in the country and have good yield potential. The 11 t/ha yield obtained with UNA-94 in a seed-increase trial was the highest yield recorded in the country.

Hull-less barley has shown good adaptation in Peru. The hull-less cultivar UNA-95 was developed by gamma radiation from the commercial cultivar Bellavista at La Molina University. The Peruvian Government proposes to devote a larger area to the cultivar in the highlands, where the price for hull-less barley is higher than that for hulled barley.

Bolivia

The hull-less cultivar San Lorenzo has attractive large white grains that fit the Bolivian consumer demands. In Bolivia, there are three main uses of barley grain: barley flour, barley rice and barley flakes. In the last decade, Bolivia has had lower rainfall than normal during the growing cycle. As a result, plant height of commercial cultivars was reduced. A crossing program to address this problem was formulated by crossing the tallest germplasm with cultivars adapted to Bolivian conditions. Early segregating populations (F_2) were sent for screening at Cochabamba, Bolivia, late in 1996.

A Bolivian researcher conducts field screening of barley for BYD resistance.

Chile

The Chilean barley program is one of the most advanced in the region. Almost all barley production in the country is for the local malting industry. Chilean breeders have drawn from Mexican sources of resistance to scald, stripe rust, leaf rust, net blotch, and Russian wheat aphid. Two years ago, tolerance to acid soil was identified in ICARDA/CIMMYT germplasm when tested on Chilean acid soils.

Promoting hull-less barley as a coffee substitute was one of the objectives of the Chilean program. The cultivar Centauro was released to farmers for this purpose, but its adoption lagged behind expectations because the market for the crop has not yet developed.

The 2nd International Conference of Malting Barley, sponsored by FAO, was held in Temuco, Chile, in December 1996. A large number of breeders and pathologists from the region participated to discuss common problems and encourage collaboration.

Brazil

In southern Brazil, hull-less barley was promoted as a feed crop with good acceptance by milk and meat producers. However, its cultivation came to an abrupt halt after the cultivar Acumai, grown on 1000 ha, became susceptible to leaf rust and was not replaced. Plans to reactivate the program were formulated when an EMBRAPA breeder, located at Ponta Grossa Experimental Station, visited Mexico in 1996. Selected barley lines will be screened for their adaptation to Brazilian conditions.

Uruguay

A double-haploid (DH) population was developed by crossing Gobernadora, a scab-resistant cultivar, with a line with good malting quality. Both parents and 98 DH lines, produced at Oregon State University, were field-tested against *Fusarium graminearum* at Toluca, Mexico, in 1995 and 1996. The same DH set was tested at Shanghai, China, in 1996. Ten scab-resistant DH lines, as determined in both locations, were sent to Uruguay for head-scab screening in 1997. The network established for head-scab screening in various countries might help in rapid identification of suitable types to be used as commercial cultivars or parents in breeding programs. In addition to field screening against the fungus, the toxin analysis on deoxynavelenol (DON) content will be made at the technology laboratory in Uruguay (LATU). The information obtained in Uruguay will add to data already available on the line’s DON content determined at North Dakota State University laboratories.

Resources for Research and Training

Finance

ICARDA's programs are funded by its generous donors (see Appendix 11). In 1996, the Center's grant funding was USD 20.857 million. Combined with other income of USD 1.555 million, the total revenue for the year was USD 22.412 million. The operating expenses for 1996 were USD 23.416 million, resulting in a deficit of USD 1.004 million. The deficit was a result of the reevaluation of the local currency during the year.

During 1996 the Government of Japan, through its Japan International Cooperation Agency (JICA), provided in-kind contribution of equipment and staff support, estimated at USD 0.4 million, to ICARDA.

Staff

During 1996, the following internationally-hired staff members joined ICARDA: Dr Samuel Bockari-Kugbei, Seed Economist; Dr Chrysantus Akem, Legume Pathologist; Dr S.V.R. Shetty, Team Leader (Yemen); Dr Leonard Reynolds, Livestock Specialist (Yemen); Dr Mohamed Zainul Abedin, Farming Systems Specialist (Yemen); Dr Michael Zöbisch, Soil Conservation and Land Management Specialist; Dr Eddy De Pauw, Agroclimatologist; Mr David Martone, Personnel Officer; Mr Alain Mayoux, System Programmer/Network Administrator; and Mr Issam Abdalla Saleh A. El-Nagga, Accountant.

The following Post-Doctoral Fellows joined ICARDA during 1996: Dr Hala Toubia Rahme, Dr Seid Ahmed Kemal, Dr Ashutosh Sarker, and Dr Wafa Chouman in the Germplasm Program; Dr Tidiane Ngaido and Dr Mustafa Bounejmate in the Pasture, Forage and Livestock Program; Dr Heping Zhang in the Farm Resource Management Program; and Dr Kamel Chabane in the Genetic Resources Unit. Two Visiting Scientists also arrived during the year: Dr Hailu Gebre in ICARDA Cairo Office, and Dr Phil Eberbach in the Farm Resource Management Program.

The following staff members left ICARDA during 1996: Dr Robert H. Booth, Assistant Director General (International Cooperation); Dr A.J.G. van Gastel, Head of Seed Unit; Dr Michael Norveille, International Facilitator, Management Project (Cairo Office); Dr Omar Mamluk, Plant Pathologist; Ir Joop van Leur, Barley Breeder/Pathologist; Ms Souad Hamzaoui, Center Librarian; Mr Faik Bahhady, Assistant Livestock Scientist; Mr Bassam Hinnawi, Travel Officer; Mr Ahmed Mousa El-Ali, Public Relations Officer; and Ms Morag Ferguson, Visiting Research Fellow.

Computing and Biometrics

General and Technical Support

The year marked the beginning of another transition in the computing environment of ICARDA. The first Windows-NT server, dedicated for the SINGER project, was installed in the Genetic Resources Unit. The external e-mail facility became available in February. Migration from Windows 3.1 to Windows 95 operating system was set in motion. Preparations for connecting to the CGIAR Integrated Voice and Data network continued. Over 628 written user-requests, in addition to hundreds by phone or e-mail, were fulfilled for the installation and maintenance of software, hardware, and network connections. The local-area computer network was extended to the new IPGRI WANA building. More than 60 new personal computers were purchased and installed.

Scientific Computing

The Trials Management System (TMS) was completed with all modules and utilities required for automation of the legume international nursery trials. The completed multi-user system not only manages the multi-locational and multi-year trials, but also performs statistical analyses, stores the derived statistics, and produces reports and results from queries. Seven reports in addition to queries and graphical presentations of varietal performance were developed in a client/server environment using Oracle 7 tools in which the database resides on VAX/VMS and the user produces the results on a PC under Windows. Using TMS, the users can now produce reports for location by entry, means with ranks and pedigrees for complete and incomplete block designs, location-wise agronomy details, top five entries across all locations, and performance comparison for common entries over two years. The user can also query performance and associated statistics of all entries in a trial for all attributes for a specific year and location.

A feature to query the performance of a specific entry or an attribute over a range of trials over locations and years is also added to the TMS. The output may be produced as graphics.

A sub-system for seed despatch to cooperators was included in TMS. The despatch sub-system consists of data entry and query forms for cooperators' details, and requested and despatched sets of trials by cooperators. Additionally, it produces reports for notification letters, list of available trials and details of each nursery, request forms for seeds, despatch table, address labels of cooperators, phytosanitary certificate requests to the Seed Health Laboratory, letters to the Purchasing Unit for details of shipment, proforma invoice for shipment, and details of shipment to cooperators as letter and fax.

Testing and implementation of TMS for legume nursery trials of 1994 was initiated. The data for field observations from the CRISP file was loaded into TMS using the Pro*C program in addition to data for sites, pedigrees and location-wise agronomy and use of chemicals.

The Meteorological Database (METDB) application was further enhanced with an efficient data-loading utility written in Delphi, which converts data from different input format into the METDB database. Daily climatic data from ICARDA's research stations in Syria (Tel Hadya, Breda, Bouider, Jindiress and Ghrerife) was entered into the database. Two new data entry forms were added to the METDB system. The client/server METDB system will have a distinct advantage in printer and font selection for reports under Windows environment. The Data Query utility available in Oracle 2000 will provide much flexibility in generating reports based on some pre-defined formats.

The topographic maps in 1:1,000,000 scale for all the WANA countries were generated from the digital chart of the world using ARC/INFO-PC and dBASE. The layers for hypsography, drainage, roads, and populated places for all WANA countries are now available. The users can now query and analyze the themes, as well as overlay the different thematic layers for a specific WANA country. Also, a utility tool was developed using ARC Avenue to visualize and obtain the statistical parameters from the climatic data pertaining to any weather station within a country selected by a hot link. The software tool Map Objects from ESRI has been studied and in conjunction with Delphi was found suitable for future development of ICARDA's GIS applications.

Support was provided on the operation of Erdas Imagine on an Alpha workstation as well as on a Windows NT server. Three digital scales were installed for automatic capturing of data into PC. Support was also provided for the installation of the DNA Sequencer and Fragment Analysis System in the Biotechnology Laboratory.

SAS for Windows software was upgraded from 6.10 to 6.11 that now includes SAS/ASSIST and SAS/Access to PC File Formats. SPSS was upgraded from the DOS to Windows version, while version 6.0 of Systat for Windows and StatExact for Windows were procured. A set of GENSTAT programs for various specialized requirements was made available.

Biometrics

Biometric support was provided for the planning of experiments, analysis of data, and interpretation and presentation of results. The number of interactive sessions with individual researchers exceeded 100. Statistical reviews were conducted on a number of research manuscripts.

Specifically, assistance was provided to scientists in: (i) designing experiments for mixtures of barley genotypes; evaluation of grazing methods on forage growth; straw management in crop rotation; evaluation of wheat genotypes with a re-enforced check cultivar in incomplete blocks; screening chocolate spot and orobanche tolerant faba bean material; predicting response of supplemental irrigation; modeling grazing effect, and (ii) analyzing yield data combined over four years to model the effects of delay in planting, amount of supplemental irrigation and nitrogen on bread wheat and durum wheat varieties; barley yields over multi-environments, and of barley mixtures; fitting genetic model for distribution of days to flowering; crop loss assessment; wheat rotations at

Kamishly, modeling in terms of time-trends; prevalence of medic and legumes; probit analysis on insect responses; and on-farm trials data on barley yield.

Discussions with scientists helped to develop the following biometric techniques:

Accounting covariances between plot errors over years in long-term rotational trials: In long-term rotation trials, the observations from the same plot over years are correlated; ignoring such correlations may affect the precision of the estimates of rotation effects. Five covariance structures between the plot errors over time were examined to assess the effect of correlations on the standard errors of rotation means and rotation x cycle combination (interaction) means on wheat yields using eight years of data from six two-phase rotations with wheat. Based on wheat yield data from the four cycles of the rotations considered, the compound symmetry covariance structure (constant correlation) between plot errors arising over alternate years gave more efficient estimates of rotation means compared with the other four covariance structures.

Estimation of genotypic correlation using data from incomplete blocks: Precise assessment of association among traits of a crop plant is helpful in developing crop improvement strategies and in genetic studies. Genotypic and phenotypic correlations are often employed by crop improvement scientists for indirect selection consideration. Plant breeders often evaluate their material in incomplete block design. An estimate of correlation is required along with a measure of precision in terms of standard error. Methods for evaluation of standard errors of genotypic and phenotypic correlations are not available in literature for trials conducted in incomplete blocks. An algebraic evaluation of such correlation is cumbersome. Three methods—simulation, jackknife, and bootstrap—were used to evaluate bias and standard errors of genotypic and phenotypic correlations. These were illustrated with data on grain yield, days to heading, and plant height in barley genotypes evaluated in triple lattices.

Correlation among stability indices under a phenotypic data model: Using three models to generate G x E data, correlations were simulated among the six stability statistics: across-environment-variance, CV, Yau's statistic, Ecovalence, slope, and deviation mean square. The simulated data on correlations are now available for several combinations of the values of the parameters of the models, numbers of genotypes, and environments.

Management Information Systems

With the phasing out of the Management and Accounting System (MAS) effective 1 January 1996, the parallel run of MAS together with Oracle General Ledger and Accounts Payable was discontinued. For a smooth transition, many new software procedures were developed, new reports were inducted, and existing ones were modified. Finance staff were trained in the use of On-Line Transaction Processing.

The Oracle Personnel, Purchasing and Inventory Systems were maintained. Several new reports were added and some of the software procedures were fine-tuned and new programs were developed to meet the new requirements. The database of four years operational data was reorganized periodically to avoid downtime and ensure reasonable response from the VAX cluster. The medical bills processing system was upgraded preparing the ground for migration to the next generation of 'client/server' paradigm.

Staff members attended workshops and training sessions on the Intranet technology. Structures were created and tested for housing information within the programs and units for ICARDA-wide sharing on the Local Area Network.

Training was given to 124 ICARDA staff members on data analysis using SAS, MS-DOS Ver. 6.2, Microsoft Windows, QuattroPro for Windows, Harvard Graphics 3.0 under Windows, WordPerfect 6.1 under Windows, Lotus 123 for Windows, dBase V, Oracle Purchasing System, Inventory Control System, and General Ledger & Account Payable. A total of 61 participants from the NARS were given training in the following areas: Biometrical Methods in Agricultural Research (Tel Hadya); and Design and Statistical Analysis of Experiments (Amman, Jordan). In conjunction with other programs, training was provided in Scientific Writing & Data Presentation (Ankara, Turkey); Statistical Methods in Livestock Experiments (Tel Hadya); Variety

Description and Maintenance; and Data Analysis Using MSTAT-C. Individual training was provided to visiting scientists from Iran, Jordan and Pakistan, and from ICRISAT.

Farms

ICARDA operates five sites in Syria (including its main research station at Tel Hadya, near Aleppo) and two in Lebanon (Table 19). These sites represent a variety of agroclimatic conditions, typical of those prevailing in the WANA region.

At the Tel Hadya site of ICARDA, yields for the 1995/96 season were in many cases below expectations, although rainfall was above average (405 mm) and the crops were not damaged by frost.

Table 19. ICARDA sites in Syria and Lebanon.

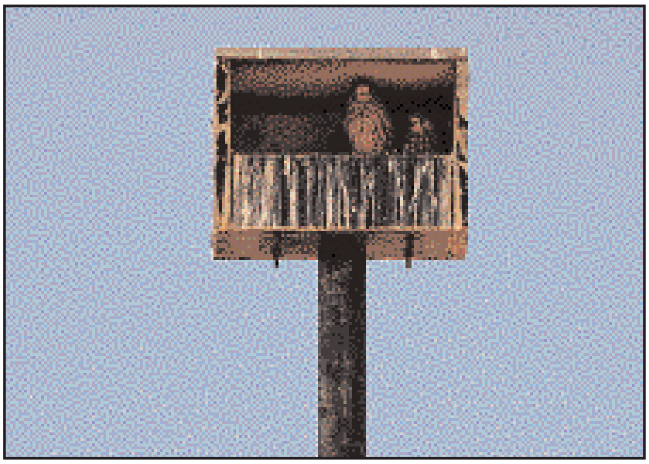
Site	Location		Area (ha)	Approximate elevation (m)	Average precipitation (mm)
SYRIA					
Tel Hadya	36°01'N	36°56'E	948	284	336
Bouider	35°41'N	37°10'E	35	268	220
Ghrerife	35°50'N	37°15'E	2	320	258
Breda	35°56'N	37°10'E	76	300	267
Jindiress	30°24'N	36°44'E	10	210	474
LEBANON					
Terbol	33°49'N	35°59'E	39	890	569
Kfardane	34°01'N	36°03'E	50	1080	430

The main reason for this could be high temperatures in early May—32 to 35°C from 2 to 10 May, which may have affected all crops, except early-planted lentils. In addition, humidity and moderate temperatures in March/April favored the spread of *Ascochyta rabiei* on chickpeas.

Orobanche crenata and *O. aegyptiaca* unfortunately hampered the cultivation of rape seed (mainly varieties of *Brassica napus* and *B. campestris*), as well as safflower (*Carthamus tinctorius*) in rotation with cereals and legumes. Therefore, another crop is being considered: cumin (*Cuminum cyminum*, Arabic: *Kamun*). Its production at present is limited due to its hand-harvesting requirement. ICARDA will test the combine harvesting technique, developed for lentil, on cumin, which grows only about 20 cm tall.

The common kestrels (*Falco tinnunculus*) continued to use the nesting boxes, which were put up for them at the Tel Hadya farm for the second year. ICARDA's interest in kestrels lies in their appetite for rodents. Kestrels can help bring down the number of voles, a widespread pest in the area.

The most successful nesting-box for kestrels in the field was located between rangeland and a sloping field growing durum wheat.



Fledgling common kestrels ready to leave nesting-box—their two siblings flew a couple of days earlier.

Appendixes

Contents

Appendix 1

Precipitation (mm) in 1995/96

	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	TOTAL
SYRIA													
Tel Hadya													
1995/96 season	0.0	10.3	68.3	35.5	73.7	44.6	137.0	32.2	2.9	0.0	0.0	0.0	404.5
Long-term average (18 seasons)	0.5	24.0	51.0	51.3	63.4	56.2	44.7	25.9	15.8	2.5	0.0	0.8	336.1
% of long-term average	0	43	134	69	116	79	306	124	18	0	-	0	120
Breda													
1995/96 season	0.0	9.8	50.4	35.6	71.6	48.4	95.6	23.4	25.0	0.0	0.0	0.0	359.8
Long-term average (39 seasons)	1.6	14.3	30.5	49.6	49.4	41.6	33.9	28.4	16.5	1.4	0.0	0.0	267.2
% of long-term average	0	69	165	72	145	116	282	82	152	0	-	-	134.6
Bouider													
1995/96 season	0.0	7.0	30.2	27.4	73.8	41.2	83.0	29.8	23.6	0.0	0.0	0.0	316.0
Long-term average (23 seasons)	0.5	17.3	27.9	35.1	43.7	39.1	28.6	17.2	10.2	1.1	0.1	0.0	220.8
% of long-term average	0	40	108	78	168	105	290	173	231	0	0	-	143
Ghrerife													
1995/96 season	0.0	9.0	37.6	27.0	76.6	41.8	89.6	22.4	30.0	0.0	0.0	0.0	334.0
Long-term average (11 seasons)	0.5	24.3	30.6	36.4	49.2	48.1	36.6	12.4	17.7	2.7	0.0	0.0	258.5
% of long-term average	0	37	123	74	156	87	245	181	169				
Jindiress													
1995/96 season	2.0	9.2	146.9	72.3	98.2	42.4	170.6	48.9	2.0	0.0	11.1	0.0	603.6
Long-term average (36 seasons)	1.5	29.0	59.8	90.8	85.4	74.6	64.4	41.4	21.9	3.9	0.4	1.3	474.4
% of long-term average	133	32	246	80	115	57	264	118	9	0	2775	0	127
LEBANON													
Terbol													
1995/96 season	0.0	4.4	130.2	25.2	88.9	93.4	205.4	28.0	3.0	0.0	0.0	0.0	578.5
Long-term average (16 seasons)	0.4	22.1	78.4	94.4	121.8	108.8	100.1	24.2	16.2	2.5	0.2	0.0	569.7
% of long-term average	0	20	166	27	73	86	205	116	19	0	0	-	102
Kfardan													
1995/96 season	0	4.2	96	14.5	144.7	147.2	97.3	18	3	0	0	0	524.9

Note: For location, area, and elevation of these sites, see Table 19 on page 71.

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
1993	Kaputor, Namoi
Bolivia	
1991	Kantuta
1993	Kolla
Brazil	
1989	Acumai
Canada	
1992	Seebe
1993	Falcon
1994	Tukwa
1995	Kasota
Chile	
1989	Leo/Inia/Ccu, Centauro
China	
1986	Gobernadora
1988	Zhenmai 1
1989	V-24 Api/CM67//B1 CT-16
Cyprus	
1980	Kantara
1989	(Mari/Aths*)
1994	Mia Milia, Achera
1995	Lefkonoiko, Sanokrithi-79, Lysi
Ecuador	
1989	Shyri
1992	Calicuchima-92, Atahualpa-92
Egypt	
1992	Giza 125
1993	Giza 126
Ethiopia	
1981	BSH 15
1984	BSH 42
1985	Ardu
Country/year	Variety
Barley (contd.)	
Iran	
1986	Aras
1990	Kavir, Star (Makui)
Iraq	
1994	Rihane-03, IPA 7 IPA 9, IPA 265
Italy	
1992	Salus, Digersano (naked)
Jordan	
1984	Rum (6-row)
Kenya	
1984	Bima
1993	Ngao
Lebanon	
1989	Rihane-03
Libya	
1992	Wadi Kuf Wadi Gattara
Mexico	
1986	Mona/Mzq/DL71
Morocco	
1984	Asni, Tamellat, Tissa
1988	Tessaout, Aglou, Rihane, Tiddas
Nepal	
1987	Bonus
Pakistan	
1985	Jau-83
1987	Jau-87, Frontier 87
1993	Jau-93
Peru	
1987	Una 87, Nana 87
1989	Bellavista
1994	Una 94
Portugal	
1982	Sereia
1983	CE 8302
1991	Ancora
Qatar	
1982	Gulf
1983	Harma
Country/year	Variety
Barley (contd.)	
Saudi Arabia	
1985	Gusto
Spain	
1987	Resana (Rihane-03)
Syria	
1987	Furat 1113
1991	Furat 2
1994	Improved Arabi Abiad (Arta)
Tanzania	
1991	Kibo
Thailand	
1987	Semang 1 IBON 48 Semang 2 IBON 42 BRB-8
Tunisia	
1985	Taj, Faiz, Roho
1987	Rihane"S"
1992	Manel 92
Turkey	
1993	Tarm-92, Yesevi 93
1995	Orza
Vietnam	
1989	Api/CM67//B1
Yemen	
1986	Arafat, Beecher
Durum Wheat	
Algeria	
1982	ZB S FG'S'/LUKS GO
1984	Timgad
1986	Sahl, Waha
1991	Korifla
1992	Om Rabi 6
1993	Haidar, Belikh 2, Om Rabi 9, Kabir 1
Cyprus	
1982	Mesoaria
1984	Karpasia
1994	Macedonia
Egypt	
1979	Sohag I
Country/year	Variety

Country/year	Variety
Durum Wheat (contd.)	
1988	Sohag II, Beni Suef
1990	Sohag III, Beni Suef I
Greece	
1982	Selas
1983	Sapfo
1984	Skiti
1985	Samos, Syros
Iraq	'Waha Iraq'
Jordan	
1988	Korifla = Petra Cham 1 = Maru N-432 = Amra Stork = ACSAD 75
Lebanon	
1987	Belikh 2
1989	Sebou
1994	Waha = Cham 1
Libya	
1985	Marjawi, Ghuodwa, Zorda, Baraka, Qara, Fazan
1991	Zahra 1
1992	Khiar 92
1993	Zahra 5 = Korifla Zahra 3
1995	Zahra 7, Zahra 9
Morocco	
1984	Marzak
1989	Sebou, Om Rabi
1991	Tensif
1992	Brachoua, Om Rabi 5
1994	Anouar, Jawhar
1995	Om Rabi 6
Pakistan	
1985	Wadhanak
Portugal	
1983	Celta, Timpanas
1984	Castico
1985	Heluio
Saudi Arabia	
1987	Cham 1
Spain	
1983	Mexa
1985	Nuna
1989	Jabato
1991	Anton, Roqueno

Country/year	Variety
Durum Wheat (contd.)	
Syria	
1984	Cham 1
1987	Cham 3, Bohouth 5
1993	Om Rabi 3
1994	Cham 5
Tunisia	
1987	Razzak
1993	Khiar, Om Rabi 3
Turkey	
1984	Susf bird
1985	Balcili
1988	EGE 88
1990	Cham 1 = Sam 1
1991	Kiziltan
1994	Om Rabi = Aydin 93 Firat 93
1995	Haran = Om Rabi 5
Iran	
1994	Haran 94
1995	Om Rabi 5
Bread Wheat	
Algeria	
1982	Setif 82, HD 1220
1989	Zidane 89
1992	Zidane, Nesser, ACSAD 59 = 40DNA, Cham 4 = Sidi Okba, Siete Cerros = Rhumel, Alondra = 21AD, DouggaXBJ = Soummam
1994	Mimouni, Ain Abid
China	
1995	Mayon-1 = (Dongfeng 1)
Egypt	
1982	Giza 160
1988	Sakha 92, Giza 162, Giza 163, Giza 164
1991	Gammeiza 1, Giza 165
1993	Sahel 1
1994	Giza 166, Giza 167, Sids 1, Sids 2, Sids 3, Benesuef-3
1995	Giza 167, Sids 4, Sids 5, Sids 6, Sids 7, Sids 8
Ethiopia	
1984	Dashen, Batu, Gara

Country/year	Variety
Bread Wheat (contd.)	
Greece	
1983	Louros, Pinios, Arachthos
Iraq	
1989	Es14
1994	Adnanya, Hamra, Abu Ghraib
Iran	
1986	Golestan, Azadi
1988	Sabalan, Darab, Quds
1990	Falat
1995	Tajan, Nicknejad Mahdabi, Darab 2
Jordan	
1988	Nasma = Jubeiha, L88 = Rabba
1990	Nesser
Lebanon	
1990	Seri
1991	Nesser = Cham 6
1995	Roomy
Libya	
1985	Zellaf, Sheba, Germa
Morocco	
1984	Jouda, Merchouche
1986	Saada
1989	Saba, Kanz
Oman	
1987	Wadi Quriyat 151, Wadi Quriyat 160
Pakistan	
1986	Sutlej 86
Portugal	
1986	LIZ 1, LIZ 2
Qatar	
1988	Doha 88
Sudan	
1985	Debeira
1987	Wadi El Neel
1991	Neelain
1992	Sasarieb
Syria	
1984	Cham 2, Bohouth 2
1986	Cham 4

Bread Wheat (contd.)

Country/year	Variety
1987	Bohouth 4
1991	Cham 6, Bohouth 6
Tanzania	
1983	T-VIRI-Veery ‘S’ 69/BD
Tunisia	
1983	T-DUMA-D6811-Inrat 69/BD Tunisian release
1987	Byrsa, Salambo
1992	Vaga 92
Turkey	
1986	Dogankent-1 (Cham 4)
1988	Kaklic 88, Kop Dogu 88
1989	Es14
1990	Yuregir, Karasu 90 Katia 1
1994	Sultan 94
1995	F//68.44/NZT/3/ CUC’5', Kasifbey 95 Basribey 95
UAE	
1995	Cham 2, Seyhan 95, Kirgiz 95
Yemen	
1983	Marib 1, Ahgaf
1988	Mukhtar, Aziz, Dhumran, SW/83/2
1995	Radfan, SW/88/7, SW/88/6, SW/88/8, SW/89/3, SW/89/7

Kabuli Chickpea

Country/year	Variety
Algeria	
1988	ILC 482, ILC 3279
1991	FLIP 84-79C
	FLIP 84-92C
China	
1988	ILC 202, ILC 411
1993	FLIP 81-40W
	FLIP 81-71C
Cyprus	
1984	Yialousa (ILC 3279)
1987	Kyrenia (ILC 464)
Egypt	
1993	ILC 195

Kabuli Chickpea (contd.)

Country/year	Variety
France	
1988	TS 1009 (ILC 482)
	TS 1502 (FLIP 81-293C)
1992	Roye Rene (FLIP 84-188C)
Iran	
1995	ILC 482, ILC 3279
	FLIP 84-48C
Iraq	
1991	Rafidain (ILC 482)
	Dijla (ILC 3279)
Italy	
1987	Califfo (ILC 72)
	Sultano (ILC 3279)
1995	Pascia (FLIP 86-5C)
	Otello (ICC 6306/ NEC 206)
Jordan	
1990	Jubeiha-2 (ILC 482)
	Jubeiha-3 (ILC 3279)
Lebanon	
1989	Janta 2 (ILC 482)
1993	Baleela (FLIP 85-5C)
Libya	
1993	ILC 484
Morocco	
1987	ILC 195, ILC 482
1992	Rizki (FLIP 83-48C)
	Douyet (FLIP 84-92C)
1995	Farihane (FLIP 84 79C),
	Moubarak (FLIP 84-145C)
	Zahor (FLIP 84-182C)
Oman	
1988	ILC 237
1995	FLIP 87-45C
	FLIP 89-130C
Pakistan	
1992	Noor 91 (FLIP 81-293C)
Portugal	
1989	Elmo (ILC 5566)
	Elvar (FLIP 85-17C)
Spain	
1985	Fardan (ILC 72)
	Zegri (ILC 200)

Kabuli Chickpea (contd.)

Country/year	Variety
	Almena (ILC 2548)
	Alcazaba (ILC 2555)
	Atalaya (ILC 200)
1995	Bagda (ILC 72 x CA2156)
	Kairo (ILC 72 x CA2156)
	Athenas (ILC 72 x CA2156)
Sudan	
1987	Shendi (ILC 1335)
1994	Jebel Mara 1 (ILC 915)
Syria	
1986	Ghab 1 (ILC 482)
1986	Ghab 2 (ILC 3279)
1991	Ghab 3 (FLIP82-150C)
Tunisia	
1986	Chetoui (ILC 3279)
	Kassab (FLIP 83-46C)
	Amdoun 1 (Be-sel-81-48)
1991	FLIP 84-79C
	FLIP 84-92C
Turkey	
1986	ILC 195, Guney Sarisi 482 (ILC 482)
1991	Akcin (87AK 11115)
1992	Aydin 92 (FLIP 82-259C)
	Menemin 92 (FLIP 85-14C)
	Izmir 92 (FLIP 85-60C)
1994	Aziziye (FLIP 84-15C)
	Damla (FLIP 85-7C)
USA	
1994	Sanford (Surrotato x FLIP85-58C)
	Dwelley (Surrotato x FLIP85-58C)

Lentil

Country/year	Variety
Algeria	
1987	Syrie 229
1988	Balkan 755, ILL 4400
Argentina	
1991	Arbolito (ILL 4650x-4349)

Lentil (contd.)

Country/year	Variety
Australia	
1989	ILL 5750
	Aldinga (FLIP 84-80L)
1993	Digger (FLIP84-51L)
	Cobber (FLIP84-58L)
	Matilda (FLIP84-154L)
1995	Northfield (ILL 5588)
Bangladesh	
1993	Bari Masur-2 (Sel. from ILL 4353 x ILL 353)
1995	Bari Masur-4 (Sel. from L5 x FLIP84-112L)
Canada	
1989	Indian Head (ILL 481)
1994	CDC Redwing (Eston x ILL 5588)
	CDC Matador (Indian Head (ILL 481) x (Eston x PI179310)
Chile	
1989	Centinela (74TA 470)
China	
1988	FLIP87-53L (ILL 6242)
Ecuador	
1987	INIAP-406 (FLIP 84-94L)
Egypt	
1990	Precoz (ILL 4605)
1996	Sinai 1 (sel ILL 4605)
	Giza 51 (FLIP84-51L)
Ethiopia	
1980	R 186
1984	Chalew ILL 358
1993	NEL 2705, FLIP84-7L
1994	NEL 2704
1995	Gudo (FLIP84-78L), Ada'a (FLIP86-41L)
Iraq	
1992	Baraka (ILL 5582)
Jordan	
1990	Jordan 3 (78S 26002)
Lebanon	
1988	Talya 2 (78S 26013)
1995	Toula (FLIP 86-2L)

Lentil (contd.)

Country/year	Variety
Libya	
1993	El Safsaf 3 (78S 26002)
Morocco	
1990	Precoz (ILL 4605)
Nepal	
1989	Sikhar (ILL 4402)
N. Zealand	
1992	Rajah (ILL 6243)
Pakistan	
1990	Manserha 89 (ILL 4605)
1995	Masur-95 (18-12 x ILL 4400)
1996	Shiraz-96 (ILL 5865)
Sudan	
1993	Rubatab 1 (ILL 813)
	Aribo 1 (ILL 818)
Syria	
1987	Idleb 1 (78S 26002)
Tunisia	
1986	Neir (ILL 4400)
	Nefza (ILL 4606)
Turkey	
1987	Firat '87 (75kf 36062)
1990	Erzurum '89 (ILL 942)
	Malazgirt '89 (ILL 1384)
1991	Sazak '91 (ILL 854)
1996	Sayran 96 (ILL 784)
USA	
1991	Crimson (ILL 784)

Faba Bean

Country/year	Variety
Egypt	
1991	Reina Blanca, Giza 461
Iran	
1986	Barkat (ILB 1269)
Portugal	
1989	Favel (80S 43977)
Sudan	
1990	Sellaim-ML
1991	Shambat 75
	Shambat 104

Faba Bean (contd.)

Country/year	Variety
1993	Shambat 616 (00616)
	Basabeer (BB 7)
	Hudeiba 93 (Bulk 1/3)
Syria	
1991	Hama 1 (Selection from Aquadulce)

Peas

Country/year	Variety
Cyprus	
1994	Kontemenos (PS210713)
Ethiopia	
1994	061K-2P-2192
Oman	
1995	Collegian, MG102703, A0149, Syrian Local Dry Pea
Sudan	
1989	Karima-1
1994	Ballet

Forage Legumes

Country/year	Variety
Jordan	
1994	*Vicia villosa* subsp. *dasycarpa* (IFLVD 683)
	Vicia sativa (IFLVS 715)
	Lathyrus ochrus (IFLLO 101/185)
Morocco	
1990	*Vicia sativa* (ILF-V-1812)
1992	*Vicia villosa* ssp *dasycarpa* (IFLVV 2053)
1994	*Vicia narbonensis* (IVLVN 2387)
	Vicia narbonensis (IVLVN 2391)
	Vicia sativa (IVLVS 709)
Pakistan	
1996	*V. Villosa* ssp. *dasycarpa* Kukak-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, and publications produced at ICARDA as well as for ICARDA by other publishers. Some of the titles published in 1994 and 1995 but not captured for reporting in the Center's Annual Reports for those years are also included. A complete list of publications is published separately and is available on request.

Journal Articles

1994

Annicchiarico, P. and L. Pecetti. 1994. Morpho-physiological traits as descriptors for discrimination of durum wheat germplasm. Genetic Resources and Crop Evolution 41: 47-54.

Annicchiarico, P. and M. Perenzin. 1994. Adaptation patterns and definition of macro-environments for selection and recommendation of common-wheat genotypes in Italy. Plant Breeding 113: 197-205.

Pecetti, L., G. Boggini and J. Gorham. 1994. Performance of durum wheat landraces in a Mediterranean environment (eastern Sicily). Euphytica 80(3): 191-199.

Scholz, H. and M.W. van Slageren. 1994. Proposal to conserve *Aegilops caudata* (Gramineae) with a conserved type. Taxon 43(2): 293-296.

1995

Annicchiarico, P. and L. Pecetti. 1995. Morpho-physiological traits to complement grain yield selection under semi-arid Mediterranean conditions in each of the durum wheat types *Mediterraneum typicum* and *syriacum*. Euphytica 86: 191-198.

Franz, A., K.M. Makkouk and H.J. Vetten. 1995. Faba bean necrotic yellows virus naturally infects *Phaseolus* bean and cowpea in the coastal area of Syria. Journal of Phytopathology 143: 319-320.

Horn, N.M., K.M. Makkouk, S.G. Kumari, J.F.J.M. Van den Heuvel and D.V.R. Reddy. 1995. Survey of chickpea (*Cicer arietinum* L.) for chickpea stunt disease and associated viruses in Syria, Turkey and Lebanon. Phytopathologia Mediterranea 34: 192-198.

Katul, L., H.J. Vetten, D.-E. Lesemann, E. Maiss and K.M. Makkouk.1995. Diagnostic methods for the detection of faba bean necrotic yellows virus, a circular ssDNA virus. EPPO Bulletin 25: 329-336.

Kumari, S.G. and K.M. Makkouk. 1995. Variability among twenty lentil genotypes in seed transmission rates and yield loss induced by pea seed-borne mosaic potyvirus infection. Phytopathologia Mediterranea 34: 129-132.

Mahalakshmi, V., S.K. Yau, J. Ryan and J.M. Peacock. 1995. Boron toxicity in barley (*Hordeum vulgare* L.) seedlings in relation to soil temperature. Plant and Soil 177: 151-156.

Makkouk, K.M., G. Dafalla, M. Hussein and S.G. Kumari. 1995. The natural occurrence of chickpea chlorotic dwarf geminivirus in chickpea and faba bean in the Sudan. Journal of Phytopathology 143: 465-466.

Makkouk, K.M. and S.G. Kumari. 1995. Transmission of broad bean stain comovirus and broad bean mottle bromovirus by weevils in Syria. Journal of Plant Diseases and Protection 102(2): 136-139.

Makkouk, K.M. and S.G. Kumari. 1995. Screening and selection of faba bean (*Vicia faba* L.) germplasm for resistance to bean yellow mosaic potyvirus. Journal of Plant Diseases and Protection 102(5): 461-466.

Pecetti, L. and P. Annicchiarico. 1995. Efficacy of a visual assessment for drought tolerance in durum wheat improvement under dryland conditions. Cereal Research Communications 23(1-2): 95-101.

Pecetti, L., P. Annicchiarico and J. Gorham. 1995. Field heterogeneity of the stress affects genotypic response to salinity in durum wheat. Cereal Research Communications 23(1-2): 173-177.

Van Slageren, M. W. 1995. Genepools of Mediterranean wild wheat relatives advance knowledge of crop. Diversity 11(1-2): 121.

1996

Abdel-Monem, M.A.S. 1996. Nitrogen utilization by spring wheat *Triticum aestivum*, L. as estimated by 15N technique under irrigation in Egypt. Journal of Agricultural Sciences, Mansoura University 21(7): 2455-2461.

Abou-Zeid, S.T., M. Abdel Monem and Y.A. Abd El-Aal. 1996. Interaction between Azolla and N fertilizers under the flooded system: greenhouse study. Journal of Agricultural Sciences, Mansoura University 21(3): 1203-1209.

Al Yasin, F. and S. Filo. 1996. Effects of stocking rate on pastoral production and productivity of ewes. Bassel Al-Assad Journal for the Sciences of Agricultural Engineering (1): 63-82. (In Arabic.)

Annicchiarico, P. and G. Mariani. 1996. Prediction of adaptability and yield stability of durum wheat genotypes from yield response in normal and artificially drought-stressed conditions. Field Crops Research 46: 71-80.

Attene, G., S. Ceccarelli and R. Papa. 1996. The barley (*Hordeum vulgare* L.) of Sardinia, Italy. Genetic Resources and Crop Evolution 43: 385-393.

Bejiga, G., K.B. Singh and M.C. Saxena. 1996. Evaluation of world collection of kabuli chickpea for resistance to iron-deficiency chlorosis. Genetic Resources and Crop Evolution 43: 257-259.

Bejiga, G., S. Tsegaye, A. Tullu and W. Erskine. 1996. Quantitave evaluation of Ethiopian landraces of lentil (*Lens culinaris*). Genetic Resources and Crop Evolution 43: 293-301.

Ceccarelli, S. 1996. Adaptation to low/high input cultivation. Euphytica 92: 203-214.

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Christiansen, S., A. M. Abd El Moneim, P. S. Cocks and M. Singh. 1996. Seed yield and hardseededness of two amphicarpic pasture legumes (*Vicia sativa* ssp. *amphicarpa* and *Lathyrus ciliolatus*) and two annual medics (*Medicago rigidula* and *M. noeana*). Journal of Agricultural Science, (Cambridge) 126(4): 421-427.

Cocks, P.S. and A.E. Osman. 1996. Productivity and botanical composition of communally-owned Mediterranean grasslands in the marginal farming areas of north Syria. Journal of Arid Environments 33(3): 389-398.

Damania, A. B., L. Pecetti, C. O. Qualset and B. O. Humeid. 1996. Diversity and geographic distribution of adaptive traits in *Triticum turgidum* L. (durum group) wheat landraces from Turkey. Genetic Resources and Crop Evolution 43: 409-422.

Di Vito, M., K. B. Singh, N. Greco and M. C. Saxena. 1996. Sources of resistance to cyst nematode in cultivated and wild *Cicer* species. Genetic Resources and Crop Evolution 43: 103-107.

El-Ghandour, I. A., M. Abdel Monem and R. A. K. Mostafa. 1996. Nitrogen fixation and nutrient uptake by two chickpea genotypes cultivated in sandy soils of Egypt. Folia Microbiologica 41(3): 267-271.

El Ahmed, A., H. Ghazal, J. van Leur and S. Asaad. 1996. Effect of environment on seed infection with barley stripe (*Pyrenophora graminea*). Bassel Al-Assad Journal for the Sciences of Agricultural Engineering (1): 15-30. (In Arabic.)

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Erskine, W. 1996. Seed-size effects on lentil (*Lens culinaris*) yield potential and adaptation to temperature and rainfall in West Asia. Journal of Agricultural Science, (Cambridge) 126: 335-341.

Erskine, W. and B. Bayaa. 1996. Yield loss, incidence and inoculum density associated with vascular wilt of lentil. Phytopathologia Mediterranea 35: 24-32.

Erskine, W., B. Bayaa and M. C. Saxena. 1996. Registration of ILL 5588 lentil germplasm resistant to vascular wilt and ascochyta blight. Crop Science 36: 1080.

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Erskine, W., S. Chandra, M. Chaudhry, I. A. Malik, A. Sarker, B. Sharma, M. Tufail and M.C. Tyagi. 1996. A bottleneck in lentil: widening the genetic base in South Asia. Diversity 12(3): 64.

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Hamdi, A., I. Kusmenoglu and W. Erskine. 1996. Sources of winter hardiness in wild lentil. Genetic Resources and Crop Evolution 43: 63-67.

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Robertson, L. D., K. B. Singh, W. Erskine and A. M. Abd El Moneim. 1996. Useful genetic diversity in germplasm collections of food and forage legumes from West Asia and North Africa. Genetic Resources and Crop Evolution 43: 447-460.

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Focus on Seed Programs. 1996, No. 6: the Yemen seed industry, En, 6 pp.

Focus on Seed Programs. 1996, No. 7: the Turkish seed industry, En, 10 pp.

ICARDA *Caravan:* Review of Dryland Agriculture. 1996, No. 2 Winter 1995/96, En, 20 pp., No. 3 Spring/Summer 1996, En, 24 pp., No. 4 Autumn/Winter 1996, En. 24 pp.

LENS Newsletter. 1995, Vol. 22, No. 1/2, En/Ar, 56 pp.

Literature Update on Wheat, Barley, and Triticale. Vol 2, No. 1, 92 pp., No. 2, 122 pp., No. 3, 125 pp., No. 4, 113 pp., No. 5, 120 pp. En. CIMMYT/ICARDA; CIMMYT, Mexico City, Mexico. *(Restricted distribution from CIMMYT.)*

RACHIS. 1994, Vol. 13, No. 1/2, En/Ar, 60 pp.

Seed Info. 1996, No. 11, En, 19 pp.

Other Publications

Biodiversity: a key to food security. 18 pp. ISBN: 92-9127-041-5.

Communication, documentation and information services (Leaflet). 8 pp.

ICARDA in the news 1995 (a compilation of media stories on ICARDA). Ar/En. 96 pp.

ICARDA publications price list. 18 pp.

ICARDA publications catalog, 1994-1995 supplement. 71 pp. ISBN: 92-9127-045-8.

Landraces in crop breeding (Leaflet). 8 pp.

WANA catalogue of weed seed. WANA Seed Network Publication No. 13/96. 44 pp. Seed Production Center, Nicosia, Cyprus; ICARDA, Aleppo, Syria.

WANA catalogue of cultivated crops. WANA Seed Network Publication No. 14/1996. 48 pp. Seed Production Center, Nicosia, Cyprus. ICARDA, Aleppo, Syria.

WANA catalogue of varieties. WANA Seed Network Publication No. 15/1996. 50 pp. Seed Production Center, Nicosia, Cyprus. ICARDA, Aleppo, Syria.

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Linke, K. H., J. Sauerborn, M. C. Saxena and A. A. El-Mnoufi. 1996. *Orobanche* Field Guide. 44 pp. University of Hohenheim/ICARDA/University of Alexandria.

Makkar, H. P. S. and A. V. Goodchild. 1996. Quantification of tannins: a laboratory manual. 25 pp. ISBN: 92-9127-038-5. ICARDA, Aleppo, Syria.

Ryan, J., S. Garabet, K. Harmsen and A. Rashid. 1996. A soil and plant analysis manual adapted for the West Asia and North Africa region. En. 140 pp. ICARDA, Aleppo, Syria. ISBN: 92-9127-044-X.

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Regional Program Publications

North Africa Regional Program

(Available from: ICARDA, Immeuble STB Dalia 6, 1st Floor, Apt. 1, Tunis, Tunisia.)

North Africa/ICARDA regional coordination meeting: research highlights and workplans 1994/1995 in collaboration with the Algerian, Libyan, Moroccan and Tunisian agricultural research programs. 95 pp.

Nile Valley Regional Program

(Available from: ICARDA, 15 G. Radwan Ibn El-Tabib Giza, 11th Floor, P. O. Box 2416, Cairo, Egypt.)

Nile Valley Regional Program on Cool-season Food Legumes and Wheat: annual report 1993/94, Sudan. 186 pp.

Nile Valley Regional Program on Cool-season Food Legumes and Cereals: annual report 1993/94, Egypt. 185 pp.

Nile Valley and Red Sea Regional Program on Cool-season Food Legumes, Cereals, and Resource Management, workplan and budget, 1995/96, Egypt. 117 pp.

Nile Valley and Red Sea Regional Program on Cool-season Food Legumes and Cereals, Regional Networks, workplan and budget, 1995/96. 88 pp.

Nile Valley and Red Sea Regional Program on Cool-season Food Legumes and Wheat, workplan, 1995/96, Sudan. 63 pp.

Solh, M. B. 1996. The Nile Valley Regional Program (NVRP): a model for technology transfer. 36 pp.

West Asia Regional Program

(Available from: ICARDA, P. O. Box 950764, Amman 11195, Jordan.)

The development of integrated crop/livestock production in the low rainfall areas of West Asia and North Africa (Mashreq/Maghreb Project): annual report 1994/1995 season. ICARDA/IFAD/IFPRI/AFESD. 182 pp.

Driouchi, A. and M. Boulif. 1996. Increased productivity of barley, pasture and sheep in the critical rainfall zones: consultancy report on economic assessment of Mashreq Project Technology Transfer (1989-1992). 44 pp.

Gursoy, O. 1996. Increased productivity of barley, pasture and sheep in the critical rainfall zones: consultancy report on animal production. 35 pp.

Haddad, N. 1996. The development of integrated crop/livestock production in the low rainfall areas of West Asia and North Africa (Mashreq/Maghreb Project). Annual report. 1994/1995 season. ICARDA/IFPRI/AFESD/IFAD. 182 pp.

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Hadjichristodoulou, A. 1996. Increased productivity of barley, pasture and sheep in the critical rainfall zones: consultancy report on barley and self-regeneration barley. En. 21 pp.

Hadjipanayioutou, M. 1996. Increased productivity of barley, pasture and sheep in the critical rainfall zones: consultancy report on utilization of by-product and urea-treated straw in small ruminant feeding. 36 pp.

Hadjipanayioutou, M. 1996. Increased productivity of barley, pasture and sheep in the critical rainfall zones: consultancy report on production and utilization of agricultural by-product block for sheep feeding. 13 pp.

Mashreq Project Newsletter. 1996, No. 8, Ar/En, 40 pp., No. 9, Ar/En, 36 pp.

Highland Regional Program (Turkey)

(Available from: ICARDA, P. O. Box 39, EMEK, Ankara, Turkey.)

Highland Regional Program, sixth annual coordination meeting of the Turkey/ICARDA Highland Project: a brief report and work plan for 1996/97 season, Cukurova University/ICARDA, 14-17 Oct 1996, Adana, Turkey. 27 pp.

Highland Regional Program, EC/ICARDA Mediterranean Highlands Project (MES/94/B7-4080/3939): enhancing productivity and sustainability of crop production in the Mediterranean highlands, research results 1995/96 and work plan 1996/97. EC/IRESA/INRA/ITGC/TARM/ICARDA. 41 pp.

Appendix 4

Graduate Theses Produced with ICARDA's Assistance

Master's

1995

SD* University of Khartoum

Mohamed M. Ali Makkawi (SD). Evaluation of seed vigor and its relationship to field performance in lentil (*Lens culinaris* Medik.). 180 pp.

1996

JO University of Jordan, Amman

El-Tahir Ahmed Abdel Aleem (JO). Differential reaction of wheat cultivars to hot environments. 87 pp.

Mohamed Ibrahim Ismail (SD). Study of drought tolerance in several durum wheat genotypes subjected to water stress at various growth stages. 108 pp. (Arabic summary)

Raed Badwan (SD). Economics of wheat seed production in Jordan. 188 pp. (Arabic summary)

LB American University of Beirut

Adel Abdel Rahim (SD). Genotype x environment interactions studies in field peas (*Pisum sativum* L). 214 pp.

Abdel Magid Adlan Hamed (SD). Ecological studies on faba bean necrotic yellows virus: virus-vector relationship and yield loss assessment. 70 pp.

Doctoral

1996

DE Universitaet Hohenheim

Rolf Wachholtz (DE). Socio-economics of Bedouin farming systems in dry areas of northern Syria. (German summary). 270 pp.

ES University of Cordoba

Alfredo Impiglia (IT). Seed storage proteins genetic variability in durum wheat landraces.151 pp. (Spanish summary)

GB University of Reading

Safouh Rihawi (SY). Grazing of barley stubble in Syria: effects of stocking rate and supplementation on intake of stubble fractions. 694 pp.

RU Kuban State Agrarian University

Zouheir Masri (SY). [The changes of soil structure and properties of red-brown earth with different farming under Mediterranean type conditions]. 325 pp. (In Russian.)

* Country codes:
DE, Federal Republic of Germany; ES, Spain; IT, Italy; JO, Jordan; LB, Lebanon; RU, Russia; SD, Sudan.

Appendix 5

Agreements

Agreements of Cooperation with Governments and Institutions in 1996

IRAN

10 April 1996. Interim Memorandum of Understanding between the Government of the Islamic Republic of Iran and ICARDA (En, Pe).

Islamic Development Bank

7 November 1996. Information Systems Network Project (OICIS-NET). Memorandum of Understanding between the Islamic Development Bank and ICARDA.

Agreements of Cooperation with other Countries, Institutes and International Organizations

CANADA

16 June 1996. Memorandum of Understanding between ICARDA and the University of Guelph, Canada, to establish a program of scientific and technical cooperation.

CIMMYT

18 September 1996. Collaborative Agreement between the International Maize and Wheat Improvement Center (CIMMYT) and ICARDA for Wheat Improvement in West Asia and North Africa (WANA).

COMMISSION OF THE EUROPEAN COMMUNITIES

16 September 1996. Cooperation Agreement No. 12161-96-08 SOED ISP SYR between Commission of the European Communities Joint Research Centre (JRC), Space Applications Institute (SAI), Italy, and ICARDA, for research on crop state monitoring and yield forecasting.

FRANCE

9 July 1996. Agreement of Cooperation between Maison de l'Orient Méditerranéen, Université Lyon (CNRS), Institut Universitaire d'Études du Développement (IUED), Geneva, and ICARDA.

INDIA

20 November 1996. Workplan for Scientific and Technical Cooperation between the Indian Council for Agricultural Research (ICAR) and ICARDA, 1996-1998.

ITALY

23 June 1996. Letter of Agreement between ICARDA and the Universita Degli Studi della Tuscia.

23 June 1996. Letter of Agreement between ICARDA and the Universita Degli Studi di Napoli "Frederico II".

13 November 1996. Memorandum of Understanding between ICARDA, the Centre for Computer Science Application in Agriculture (CeSIA), Italy, and the Applied Meteorology Foundation (FMA), Italy.

SWITZERLAND

12 May 1996. Memorandum of Understanding for Duplicating *Lathyrus* Genetic Resources and Data between Station Fédérale de Recherches Agronomiques de Changins (RAC), Switzerland, and ICARDA.

26 July 1996. Agreement of Cooperation between Maison de l'Orient Méditerranéen, Université Lyon (CNRS), Institut Universitaire d'Études du Développement (IUED), Geneva, and ICARDA.

Appendix 6

Special Projects

During 1996, the following Special Projects were operational. Special Projects include all activities supported by funds provided separately from ICARDA's unrestricted core budget, i.e., supported by Restricted Core, Complementary and In-Trust funding. 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.

AUSTRALIA

ACIAR (Australian Centre for International Agricultural Research)

Development and Conservation of Plant Genetic Resources from the Western Mediterranean Region.

Improvement of Drought and Disease Resistance in Lentils in Nepal, Pakistan and Australia.

Improvement of Faba Beans in China and Australia through Germplasm Evaluation, Exchange and Utilization.

GRDC (Grains Research and Development Corporation)

Improved ICARDA Germplasm for Australia through Regional Adaptation Analysis.

Coordinated Improvement Program for Australian Lentils

Faba Bean Germplasm Multiplication.

International Durum Wheat Improvement Cooperation.

AFESD (Arab Fund for Economic and Social Development)

Technical Assistance to ICARDA's Activities in Arab Countries (Postgraduate Research Training and Visiting Scientist Program).

Regional Adaptive Research Programme for the Development of Integrated Crop/Livestock Production in West Asia and North Africa.

Arabian Peninsula Regional Program - Phase II.

CANADA

IDRC (International Development Research Centre)

Scientific Support to Dryland Resource Management Research in the Highlands of Yemen.

Water Harvesting (Jordan).

Integrated Watershed Development (Syria).

Farmer Participation in Barley Breeding.

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.

Enhancing Productivity and Sustainability of Crop Production in the Mediterranean Highlands.

FAO (Food and Agriculture Organization of the United Nations)

Analytical Review of NARS in West Asia and North Africa.

FAO/RNE (Regional Office for the Near East)

Upgrading Laboratory Analytical Procedures.

Second International Conference on Soil Solarization and Integrated Management of Soil-Borne Pathogens and Pests.

FORD FOUNDATION

Dryland Resource Management and the Improvement of Rainfed Agriculture in Drier Areas of WANA.

Support to Gender Analysis in the Agricultural Systems of WANA.

FRANCE

Amélioration de l'intégration de l'elevage ovin dans les systémes céréaliers et pâtures de l'Afrique du Nord (Improved integration of sheep, cereal and pasture in rainfed farming systems of North Africa).

GERMANY

BMZ (Federal Ministry for Economic Cooperation) / GTZ (German Agency for Technical Cooperation)

DNA-Marker Assisted Breeding and Genetic Engineering of ICARDA-Mandated Crops.

Use of DNA-Markers in Selection for Disease Resistance Genes in Barley.

Resource Management for Sustainable Agricultural Production in WANA.

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.

GTZ (German Agency for Technical Cooperation)

Development of National Seed Production Organizations in WANA.

Workshop on the Privatization of the Seed Industry in the WANA Region.

Workshop on the Assessment of Research and Seed Pro-duction Needs in Dryland Agriculture in the West and Central Asian Republics.

Workshop on Local Seed Supply Systems: Status, Constraints and Prospects.

IDA (International Development Agency)/World Bank

Agriculture Sector Management Support Project (ASMSP), Yemen.

Matrouh Resource Management Project.

IFAD (International Fund for Agricultural Development)

Regional Adaptive Research Programme for the Development of Integrated Crop/Livestock Production in West Asia and North Africa.

West Asia and North Africa Dryland Durum Wheat Improvement Network.

Arabian Peninsula Regional Program - Phase II.

IRAN

ICARDA/Iran - Scientific and Technical Cooperation.

NETHERLANDS

Strengthening Research and Transfer of Technology for Sustained Barley Production in Ethiopia.

Problem-Solving Regional Networks Involving Cool Season Food Legumes and Cereals in the Nile Valley Countries and Yemen.

Training in Seed Technology.

OPEC Fund for International Development

Barley Development Program: Devolution of Barley Breeding to Maghreb.

Adoption and Impact of ICARDA/NARS Technologies in West Asia.

SPAIN

Incorporating Resistance to Drought and Upgrading the Grain Quality in Durum Wheat for Ibero-Maghreb Region.

Race Identification of *Fusarium oxysporum* f. sp. *ciceri* in Chickpea in the Mediterranean Region.

Exchange of Fodder, Pasture and Range Plant Germplasm.

Reclamation of Marginal Soils.

SWITZERLAND

Maghreb and Mashreq Seminar on Fodder Shrubs in the Mediterranean Arid and Semi-Arid Zones - Desertification Control.

UNDP (United Nations Development Programme)

Use of Biotechnology for the Improvement of ICARDA-Mandated Crops.

Technical Assistance to Agricultural Investment in the Southern Region - Phase II.

UNITED KINGDOM

ODA (Overseas Development Administration)

Measurement of Biodiversity within the Genus *Lens.*

Fixation and Cycling of Nitrogen in a Dryland Legume/Cereal Production System.

UNITED STATES OF AMERICA

NCISE (National Committee for International Science and Education)

NCISE-IARC Pilot Linkage Program Research Fellowship: Cooperative Development of Statistical Methods Useful for Agricultural Research in Dry Areas.

USAID (United States Agency for International Development)

ICARDA/CIMMYT/Ministry of Agriculture and Land Reclamation, Egypt, Collaborative Project: Improvement of Maize and Wheat in Egypt.

SR-CRSP (Small Ruminant Collaborative Research Support Program) Assessment Team: GIS Modelling Tools to Predict Regional Trends of Rangeland Production in Central Asia.

USDA/FAS/OICD (United States Department of Agriculture. Foreign Agricultural Service. Office of International Cooperation and Development)

Strengthening Seed Availability for Disaster Stricken Areas in West Asia and North Africa.

Appendix 7

Collaboration in Advanced Research

ICARDA's collaborative activities with advanced institutions in industrialized countries, regardless of funding source:

International Centers and Agencies

ACSAD (The Arab Center for the Studies of Arid Zones and Dry Lands)
- Joint workshops, conferences and training
- Exchange of germplasm.
- ICARDA provides ACSAD with plant pathology back-stopping.
- ACSAD is participating in the ICARDA/CIMMYT Durum Wheat Network for WANA, supported by IFAD.

CIAT (Centro Internacional de Agricultura Tropical)
- ICARDA is participating in the systemwide Soil Water and Nutrient Management Initiative and in the Systemwide Initiative on Participatory Research and Gender Analysis for Technology Development, both coordinated by CIAT.

CIHEAM (International Center for Advanced Mediterranean Agronomic Studies)
- Joint training courses and information exchange.
- Collaboration in an analytical review of NARS in WANA.

CIMMYT (International Center for the Improvement of Maize and Wheat)
- CIMMYT has seconded two wheat breeders to ICARDA, and 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.

CIP (International Potato Center)
- CIP and ICARDA share offices in Tunisia.

FAO (Food and Agriculture Organization of the United Nations)
- ICARDA participates in the Inter-Agency Task Force convened by the FAO-RNEA (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.

EC (Commission of the European Community)
Joint Research Centre, Space Applications Institute, Italy
- Agrometeorological research on land use and crop monitoring and yield forecasting.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)
- Chickpea improvement: ICRISAT has seconded a chickpea breeder to ICARDA.
- ICARDA and ICRISAT maintain the Global Grain Legume Drought Research Network.
- ICARDA and ICRISAT are co-convenors of the theme *Optimizing Soil Water Use* within the systemwide Soil Water and Nutrient Management Initiative.
- ICARDA is collaborating with ICRISAT on insect pests of grain legumes within the Systemwide Initiative on Integrated Pest Management.

IFPRI (International Food Policy Research Institute)
- ICARDA collaborates with IFPRI in the Inter-Center Initiative on Property Rights and Collective Action.
- Collaboration in policy and property rights research in WANA: ICARDA hosts two joint ICARDA/IFPRI appointed Post-doctoral Fellows.

IIMI (International Irrigation Management Institute)
- ICARDA and IIMI share offices in Cairo.
- ICARDA is the convening center for a project on *Efficient Use of Water in Agriculture* within the Systemwide Water Resources Management Programme coordinated by IIMI.

IITA (International Institute of Tropical Agriculture)
- ICARDA is collaborating with IITA on parasitic weeds within the Systemwide Initiative on Integrated Pest Management.

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 Initiative on Feed Resources Production and Utilization coordinated by ILRI.

IPGRI (International Plant Genetic Resources Institute)
- ICARDA hosts and services the IPGRI Office for West Asia and North Africa.
- ICARDA participates with other CG Centers in the System-wide Genetic Resources Program, coordinated by IPGRI.

Islamic Development Bank
- ICARDA provides support to the implementation of OICIS-NET (Information Systems Network for Member Countries of the Organization of Islamic Conference).

ISNAR (International Service for National Agricultural Research)
- ICARDA and ISNAR cooperate in research management for NARS in WANA.
- ICARDA is currently hosting a senior scientist from ISNAR.

AUSTRALIA

NSW Agriculture, Agricultural Research Centre
- Durum Wheat Improvement.
- Improvement of Faba Beans in China.

CLIMA (Centre for Legumes in Mediterranean Agriculture)
- Conservation of plant genetic resources from the western Mediterranean region.
- Lentil improvement.
- Faba bean germplasm multiplication.
- Germplasm testing and assessment of anti-nutritional factors: *Lathyrus* spp. and *Vicia* ssp.

Victorian Institute for Dryland Agriculture
- Lentil improvement.

University of Sydney, I.A. Watson Wheat Research Centre
- Wheat improvement through regional adaptation analysis.

University of Western Australia
- Whole-farm modelling of pasture, cereals and livestock (with CLIMA).
- Collection, evaluation and ecology of subterranean vetch (*Vicia amphicarpa*).

Plant Breeding Institute, Cobbity, NSW
- Yellow rust virulence and resistance.

AUSTRIA

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

CANADA

Agriculture Canada, Quebec
- Screening for barley yellow dwarf virus resistance in cereals.

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.

Laval University, Quebec
- Screening for barley yellow dwarf virus resistance in cereals.

University of Guelph
- Agrometeorology and crop modelling.

University of Saskatchewan, Saskatoon
- Collection, evaluation and conservation of barley, durum wheat, and their wild relatives.
- Information services on lentil, including publication of the *LENS Newsletter*.
- Evaluation of chickpea germplasm and their wild relatives.

DENMARK

Danish Centre for Tropical Agriculture and Environment, Royal Veterinary and Agricultural University, Copenhagen
- Barley improvement.

FRANCE

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 Ecole Nationale Supérieure d'Agronomie (ENSA), Montpellier and ENSA-INRA, Le Rheu).
- Monitoring and on-farm data analysis of parasitic diseases of small ruminants.
- Water balance studies in cereal-legume rotations in semi-arid Mediterranean zone (with Bioclimatology Research Unit of INRA, Thiverval-Grignon).

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.

Réseau Céréales Méditerranéen (RCM), Paris
- Collaboration on cereal improvement in the Mediterranean region.

Université Paris-Sud, Labo Morphogénése Végétale Expérimentale
- Production of double haploids in durum wheat.

GERMANY

BBA (Institute for Biochemistry and Plant Virology), Braunshweig, Germany
- Control of Faba Bean Necrotic Yellows Virus.

University of Bonn
- Ecology and biology of cereal cyst nematodes.

University of Kiel
- Assessment of information needs for development of water management models.

University of Frankfurt am Main
- Development and use of DNA molecular markers for indirect selection in chickpea.

- Characterization of *Ascochyta rabiei* and mapping of geographical distribution in WANA.

University of Göttingen
- Development of wheat germplasm with multiple disease resistance.

University of Hannover
- Development of transformation protocols for chickpea.

University of Hohenheim
- Barley market studies and economic assessment of grain and straw quality and morphological traits.
- Effect of heterozygosity and heterogeneity on yield stability of barley.
- Straw quality: breeding and evaluation methods (near-infrared reflectance and histochemistry).
- Stability of crop/range/livestock systems in the Al Bab area in northern Syria.

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

Technical University, Munich
- Use of DNA markers in selection for disease resistance genes in barley.

ITALY

Applied Meteorology Foundation, Florence; Centre for Computer Application in Agriculture (CeSIA)
- Agroecological characterization: generation of weather data.

Institute of Nematology, Bari
- Studies of parasitic nematodes in food legumes.

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

University of Naples; ENEA, Rome; Stazione Sperimentale di Granicoltura per la Sicilia, Caltagerone; Instituto Sperimentale per la Patalogia Vegetale, Rome
- Development of chickpea germplasm with combined resistance to *Ascochyta* blight and *Fusarium* wilt using wild and cultivated species .

University of Tuscia, Viterbo
- Enhancing wheat productivity in stress environments utilizing wild progenitors and primitive forms.
- 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)
- Animal health: surveys and monitoring of parasitic and viral diseases.

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.

NETHERLANDS

International Agricultural Centre, Wageningen
- Contribution by ICARDA to international seed technology training.

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

Royal Tropical Institute, Amsterdam
- *Orobanche* control.

PORTUGAL

Estacao National de Melhoramento de Plantas, Elvas
- Screening cereals for resistance to yellow rust, scald, *Septoria*, and powdery mildew.
- Developing lentil, faba bean, chickpea, and forage legumes adapted to Portugal's conditions.

RUSSIA

Krasnador Agricultural Research Institute
- Wheat and barley breeding.

Scientific Research Institute for South East, Saratov
- Durum wheat quality.
- Cold and drought tolerance in durum and bread wheat.

SPAIN

INIA (Instituto Nacional de Investigacion y Tecnologia Agraria y Alimentaria)
- Barley stress physiology (with University of Cordoba).
- Improvement of drought tolerance and semolina and pasta quality of durum wheat (with University of Cordoba; 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 Cordoba).

- Exchange of Fodder, Pasture and Range Plant Germplasm.
- Reclamation of Marginal Soils.

SWITZERLAND

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
- Measurement of biodiversity within the genus *Lens*.
- Botanical surveys and assessment of communal pastures in Turkey.

Institute for Grassland and Environmental Research (IGER), Aberystwyth
- Evaluation of cereal straw quality.

University of Reading
- Nitrogen cycling in dryland legume/cereal rotations.
- Gender analysis in the agricultural systems of WANA.
- Adaptation of lentils.
- Utilization of cereal straws and stubble.

Scottish Agricultural College, Edinburgh
- Isozyme variability in barley landraces.

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
- SR-CRSP (Small Ruminant Collaborative Research Program) Assessment Team on GIS modelling tools for predicting trends in rangeland production in Central Asia.
- Developing chickpea cultivars with resistance to *Ascochyta* blight.

Cornell University, Ithaca
- Use of molecular markers for genome mapping and marker-assisted selection for stress resistance in durum wheat.

University of Nebraska-Lincoln, Department of Biometry
- Cooperative development of statistical methods useful for agricultural research in dry areas.

North Dakota University
- Grain quality and PCR-primers for durum wheat.

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.

Oregon State University; Kansas State University; Texas A&M
- Collaborative interdisciplinary research in winter and facultative wheat and barley.

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 Forage and Range Research Laboratory, Logan, Utah
- SR-CRSP (Small Ruminant Collaborative Research Program) Assessment Team on GIS modelling tools for predicting trends in rangeland production in Central Asia.

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.

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

Utah State University
- SR-CRSP (Small Ruminant Collaborative Research Program) Assessment Team on GIS modelling tools for predicting trends in rangeland production in Central Asia.

Washington State University, Pullman, Washington
- Mapping economic genes of lentil.
- Adaptation of peas for Mediterranean environments.
- *Ascochyta* blight resistance in chickpea.

Appendix 8

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions involved	Donor Support
International & Regional Networks				
Cereal International Nursery	Disseminates barley, durum wheat and bread wheat advanced lines, parental lines and segregating populations developed by ICARDA, CIMMYT and by national programs themselves. Feedback from NARSs assists in developing adapted germplasm for national programs and provides a better understanding of genotype x environment interaction and of the agro-ecological characteristics of major cereal production areas.	Germplasm Program	50 countries worldwide; CIMMYT	ICARDA Core funds
International Legume Testing Network (ILTN)	Dissemination of genetic material to NARSs for evaluation and use under their own conditions. Permits multilocation testing of material developed by NARSs and ICARDA and helps in developing better understanding of genotype x environment interaction as well as agro-ecological characterization of legume production areas. Includes lentil, chickpea, dry pea, vetches and chickling.	Germplasm Program	52 countries worldwide; ICRISAT	ICARDA Core funds
SEWANA Durum Wheat Research 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
Soil Test Calibration Network	To standardize methods of soil and plant analyses used in the WANA region and promote training and soil sample exchange. Evaluate relationships between laboratory determination of soil fertility status and crop response to nitrogen and phosphate. Establish procedures to integrate soil, climate and management to optimize fertilizer recommendations.	Farm Resource Management Program	Algeria, Libya, Morocco, Tunisia, Syria, Jordan, Iraq, Cyprus, Turkey, Pakistan, Yemen	ICARDA UNDP IMPHOS
Dryland Pasture and Forage Legume Network	Communication linkages among pasture forage and livestock scientists in WANA.	Pasture, Forage and Livestock	WANA; Europe; USA; Australia	ICARDA FAO-RNEA

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions involved	Donor Support
WANA Plant Genetic Resources Network (WANANET)	Working groups will specify priorities in plant genetic resources; identify and implement collaborative projects; implement regional activities.	IPGRI Regional Office for WANA; ICARDA Genetic Resources Unit	WANA countries; IPGRI; FAO; ACSAD	IPGRI ICARDA FAO
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 lentils 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
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 GTZ DGIS
Agricultural Information Network for WANA (AINWANA)	Improve national and regional capacities in information management, preservation and dissemination.	Communication, Documentation and Information Services	WANA countries; CIHEAM; ISNAR	ICARDA
Dryland Resource Management Research Network	Promotes and supports interaction between countries conducting case studies of dryland resource management under the auspices of the Dryland Resource Management Project.	Farm Resource Management Program, ICARDA	Egypt, Lebanon, Libya, Jordan, Pakistan, Syria, Tunisia, Yemen	Ford Foundation IDRC ICARDA

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions involved	Donor Support
Global Grain Legume Drought Research Network (GGLDRN)	Establish integrated global efforts on enhancing and stabilizing grain legume production in drought-affected environments through provision of information. Characterize and map types of drought using GIS. Quantify yield losses using existing data or through experimentation. Identify priority areas for research. Extend available technologies to target regions.	ICRISAT/ ICARDA	Worldwide; ICRISAT FAO	ICARDA; ICRISAT FAO
Sub-Regional Networks				
Networks operating under the North Africa Regional Program (NARP):				
North African Sub-Regional Collaborative Research Network	Multinational, multidisciplinary cooperation between national programs in North Africa. Lead countries are identified for specific activities to serve as the liaison country between specialists in the identified area.	NARP, ICARDA	Algeria, Libya, Morocco, Tunisia	AFESD; IFAD
North African Faba Bean Research Network	Network provides for continued availability of ICARDA enhanced faba bean germplasm and runs regional trials and nurseries including Orobanche resistance nursery, joint evaluation visits, regional training courses.	GTZ INRA, Morocco	Algeria, Libya, Morocco, Tunisia	GTZ
Networks operating under the West Asian Regional Program (WARP):				
West Asian Sub-Regional Collaborative Research Network	Multinational, multidisciplinary cooperation between national programs in West Asia. Lead countries are identified for specific activities to serve as the liaison country between specialists in the identified area.	WARP, ICARDA	Cyprus, Iraq, Jordan, Lebanon, Syria	AFESD; IFAD
Networks operating under the Highland Regional Program (HRP):				
Highland Sub-Regional Collaborative Research Network	Multinational, multidisciplinary cooperation between national programs in West Asia. Lead countries are identified for specific activities to serve as the liaison country between specialists in the identified area.	HRP, ICARDA	Iran, Pakistan, Turkey; Central Asian Republics; Trancaucasian Republics	ICARDA & CIMMYT

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions involved	Donor Support
Enhancing Productivity and Sustainability of Crop Production in the Mediterranean Highlands	Improvement of crop production in the highland areas of the Mediterranean region through the use of improved, disease resistant and drought and cold tolerant varieties in appropriate crop sequences, through enhanced collaboration between countries of the Mediterranean region with large highland areas of similar ecological conditions.	HRP, ICARDA	Algeria, Morocco, Tunisia, Turkey	EEC
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	DGIS, Netherlands
Management of Wilt and Root Rot Diseases of Cool Season Food Legumes	Identify sources of resistance to wilt and root-rots. Incorporate resistance into germplasm with suitable characteristics. Provide segregating populations to NARS to select under their own conditions. Develop strategy for multiple disease resistance. Identify races in Fusarium wilt pathogens. Studies on other components of integrated disease management.	AUA, Ethiopia	Egypt, Ethiopia, Sudan, ICARDA, ICRISAT	DGIS, Netherlands
Integrated Control of Aphids and Major Virus Diseases in Cool Season Food Legumes and Cereals	Assess the potential for and implement biological control of aphids. Identify and incorporate sources of resistance to, and improve chemical control of aphids. Develop improved diagnostic methods to identify virus diseases, and assess their spread and relative importance. Identify germplasm for virus resistance. Develop integrated pest management program.	ARC, Egypt ARC, Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA	DGIS, Netherlands
Thermotolerance in Wheat and Maintenance of Yield Stability in Hot Environments	Identify physiological and morphological traits for improving wheat adaptation to heat; verify these traits in collaboration with breeders. Identify improved management strategies through a better understanding of development and growth. Describe the physical environment and characterize promising genotypes for development of computer simulations of crop growth. Characterize photothermal and vernalization responses of selected commercial lines.	ARC, Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA, CIMMYT	DGIS, Netherlands

Research Networks Coordinated by ICARDA

Title	Objectives/Activities	Coordinator	Countries/ Institutions involved	Donor Support
Water Use Efficiency in Wheat	Develop and identify wheat cultivars requiring less water and tolerant to moisture stress. Identify irrigation regimes that meet crop-water requirements. Improve soil management practices for soil moisture conservation. Develop improved production packages. Calibrate crop modelling systems.	ARC, Egypt	Egypt, Ethiopia, Sudan, Yemen, ICARDA	DGIS, Netherlands
Socio-Economic Studies on Adoption and Impact of Improved Technologies	Monitoring and evaluation of technology transfer to farmers with respect to adoption levels and identification of factors influencing adoption; impact of improved technology on farm income levels and production; effect of policy and institutional factors on technology transfer and adoption.	ARC, Sudan	Egypt, Ethiopia, Sudan, Yemen, ICARDA	DGIS, Netherlands
Barley Networks operating under the Latin American Regional Program (LARP)				
Development of Stripe Rust Resistant Barley	To produce barley resistant to stripe rust using double haploid method (DH). DH lines produced by Oregon State University, field tested in Mexico, and superior cultivars distributed to NARS.	LARP Regional Coordinator	Oregon State Univ. Latin American NARS; CIMMYT	ICARDA & CIMMYT Core Funds
Development of Hull-less Barleys	Develop high yielding hull-less cultivars and improve their nutritional value, producing cultivars with high energy and low fibre.	LARP Regional Coordinator	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.	LARP Regional Coordinator	CIMMYT; Chile; Ecuador; Kenya	ICARDA & CIMMYT Core Funds
Development of Germplasm Resistant to Scab and Barley Yellow Mosaic Virus (BYM)	Development of scab resistant barley with tolerance to BYM for China.	LARP Regional Coordinator	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.	LARP Regional Coordinator	CIMMYT; Vietnam; Uganda; Thailand	ICARDA & CIMMYT Core Funds
Development of Leaf Rust Resistant Barleys	Network of researchers investigating leaf rust resistance.	LARP Regional Coordinator	Virginia Tech.; North Dakota State; CIMMYT; Latin American NARS	ICARDA & CIMMYT Core Funds

Appendix 9

ICARDA International School

Enrollment at ICARDA International School stood at 284 students in 1996. Thirty-two countries were represented in the student body during the 1996/97 school year. The certification program was completed for all full-time contract teachers to be appropriately trained.

Accreditation preparation continued. The Accreditation Team will visit in early 1997 when the School is expected to be accredited for K-12.The visit will be from the Middle States Association of Schools and Colleges.

The International Baccalaureate (I.B.) academic program continued in grades 11 and 12, as did the International General Certificate of Secondary Education (IGCSE) in grades 9 and 10.

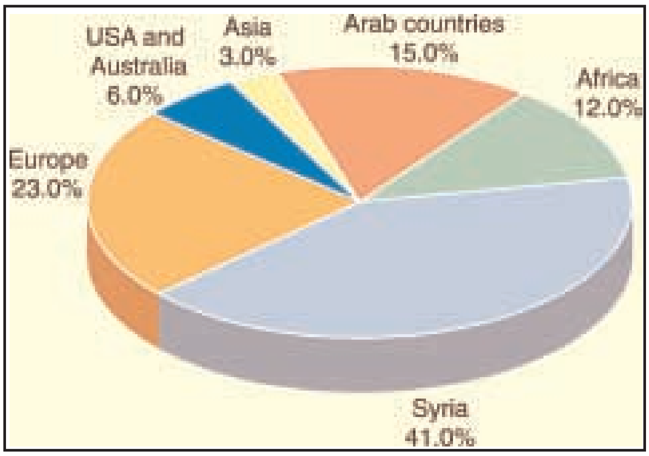
Curriculum development for the elementary school continued to draw upon the curricula from many countries; 17 students graduated in 1996. The School graduates continue to be accepted at major universities around the world.

Appendix 10

Visitors to ICARDA

During 1996 ICARDA received 1977 visitors. These included scientists, training participants, conference participants, members of diplomatic corps, members of parliaments, government officials, consultants, university students, farmers, and others from over 68 countries. Of these, 41% came from the host country, Syria, 15% from other Arab countries, 3% from other countries in Asia, 23% from Europe, 6% from the USA and Australia, and 12% from Africa.

Among the distinguished visitors, ICARDA was honored by the visit of H.E. Dr Abdul Jawad Al-Saleh, the Minister of Agriculture, Palestinian Authority; H.E. Mr Xavier Marchal, Counsellor of European Union in Syria; H.E. Dr Heinz Reiners, Ambassador of the Federal Republic of Germany in Syria: H.E. Ambassador Robert O. Blake, Chairman, Committee on Agricultural Sustainability for Developing Countries; Prof. Dr Mahmoud Mahfouz, Chairman of Education and Scientific Research Committee of Egyptian Parliament; Mr Robert Havener, Chairman, CIAT Board of Trustees; Dr Christian Bonte-Freidheim, Director General of ISNAR; Prof. Dr Ibrahim Hamidah, Director General, Desert Research Institute, Cairo, Egypt; and Dr Shawki Barghouti, Chief, Agricultural and Water Operations Division, South Asia Region, the World Bank.



Visitors to ICARDA headquarters, Aleppo, Syria.

Appendix 11

Statement of Activity

For the Year Ended 31 December 1996 (x 1000 USD)

	1996	1995
REVENUE		
Grants	20,857	19,319
Exchange gains - net	588	1,939
Interest income	718	1,013
Other income	249	808
	22,412	23,079
EXPENSES		
Research	16,919	16,042
Training	1,522	1,272
Information services	847	819
General administration	2,707	2,748
General operations	1,421	1,702
	23,416	22,583
(DEFICIT)/EXCESS OF REVENUE OVER EXPENSES	(1,004)	496
ALLOCATED AS FOLLOWS:		
Capital invested in property, plant and equipment	160	211
Capital fund	100	40
Operating fund	(1,264)	245
(Deficit)/Surplus	(1,004)	496

Statement of Grant Revenue

For the Year Ended 31 December 1996 (x 1000 USD)

Donors	Amount	Donors	Amount	Donors	Amount
Arab Fund	1,339	India	38	Spain	118
Australia	377	International Bank for Reconstruction and Dev. (World Bank)	3,300	Sweden	522
Austria	80	IDRC	70	Switzerland	55
Canada	437	IFAD	742	United Kingdom	718
China	20	Iran	1,093	UNDP	591
CGIAR	150	Italy	1,163	USDA	11
Denmark	339	Japan	566	USAID	1,250
EEC	3,017	The Netherlands	1,951	Total	20,857
Egypt	150	Norway	309	Exchange gains - net	588
FAO	12	ODA	27	Interest income	718
Ford Foundation	90	OPEC	82	Other income	249
France	324				22,412
GTZ	1,916				

Appendix 12

Board of Trustees

Prof. Tomio Yoshida completed his term on the Board in 1996. At a brief farewell ceremony, organized in Aleppo, Board and Management of ICARDA, as well as senior staff, thanked Prof. Yoshida for his valuable contributions to the growth and development of ICARDA. Prof. Yoshida, in turn, said he found his term on the Board of Trustees truly rewarding, and he would continue to be a strong supporter of ICARDA. He wished ICARDA greater success.

Prof. Iwao Kobori was elected to join the Board starting the February 1997 meeting.

Prof. Iwao Kobori

Born in 1924 in Yokohama, Japan, Prof. Iwao Kobori graduated from the Department of Geography, Tokyo Imperial University in 1946. From 1949 to 1985, he held senior faculty positions at the University of Tokyo. He served as a Professor in the Faculty of Humanities and Social Science, Mie University from 1985 to 1987; and then in the School of Political Science and Economics, Meiji University from 1987 to 1995. In 1995 he joined the Academic Division of the United Nations University as Professor.

Prof. Kobori's international activities have included his role as Visiting Professor, University of Michigan; Director, Maison du Japon; Member, IGU Commission, Desertification in and around Arid Lands; Member, Governing Board, ICRISAT; Advisor, Natural Resources Program, the United Nations University; Expert, Preparatory Workshop on Desertification, UNEP; Advisor, Arabia Plan, UNESCO; Council Member, International Desert Development Commission; and Expert, Space Archaeology, UNESCO.

The Government of France recognized Prof. Kobori for his outstanding work by conferring on him the Légion d'Honneur (Chevalier) in 1979, and the Palme Académiques in 1986.

Prof. Kobori was President of the Japanese Association for Arid Land Studies from 1990 to 1998. He was also President of the Société Franco-Japonaise de Géographie from 1975 to 1995, and continues to be Honorary President of this important Society. He is a Member, Société de Géographie de Paris; Honorary Member, Societa di Geografia Italiana; and Honorary Advisor, Xinjiang Karez Research Association.

Prof. Kobori has published over 45 scholarly articles in learned journals, written six books, edited nine publications, and translated seven titles.

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Board Meetings, 1996

The Board held the following meetings during 1996:

24 Jan, Cairo	Executive Committee Meeting
26-27 Jan, Cairo	Program Committee Meeting
29 Jan, Cairo	BoT Meeting
15 July, Aleppo	Extra-ordinary BoT Meeting
12-14 July, Aleppo	Program Committee Meeting
4-5 Nov, USA	Executive Committee Meeting, Cornell University, Ithaca, NY

Appendix 13

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(as of 31 December 1996)

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Dr M.C. Saxena, Research Coordinator
Dr Elizabeth Bailey, Project Officer
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Mr Suresh Sitaraman, Finance Officer, Financial Operations
Mr Edwardo Estoque, Finance Officer, Financial Reporting
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Dr Mustafa Pala, Wheat-based Systems Agronomist
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Dr Richard Tutwiler, Socioeconomist
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Dr Michael Zöbisch, Soil Conservation & Land Management Specialist
Dr Eddy De Pauw, Agroclimatologist
Mr Wolfgang Göbel, Agroclimatologist
Dr Ahmed Mazid, Agricultural Economist
Dr Abdul Bari Salkini, Agricultural Economist
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Dr Philip Eberbach, Visiting Scientist
Mr Sobhi Dozom, Research Associate
Mr Ahmed Chbinou, Research Fellow

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Dr Habib Ketata, Senior Training Scientist
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Dr Omar Mamluk, Plant Pathologist
Dr Miloudi Nachit, Durum Wheat Breeder (seconded from CIMMYT)
Dr Franz Weigand, Biotechnologist
Dr Khaled Makkouk, Plant Virologist
Dr William Erskine, Lentil Breeder
Dr Ali M. Abd El Moneim, Forage Legume Breeder
Dr Michael Baum, Biotechnologist
Dr Chrysantus Akem, Legume Pathologist
Mr Issam Naji, Agronomist
Dr Stefania Grando, Research Scientist
Dr R.S. Malhotra, International Trials Scientist
Dr Sui K. Yau, International Nurseries Scientist
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Dr S.M. Udupa, Post-Doctoral Fellow
Dr Hala Toubia Rahme, Post-Doctoral Fellow
Dr Ashutosh Sarker, Post-Doctoral Fellow Lentil Breeding
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Appendix 14

Acronyms

ACSAD	Arab Center for Studies of the Arid Zones and Dry Lands (Syria)
AFESD	Arab Fund for Economic and Social Development (Kuwait)
AOAD	Arab Organization for Agricultural Development (Sudan)
API	Arab Planning Institute
APRP	Arabian Peninsula Regional Program for Economic and Social Development (Kuwait)
AREA	Agricultural Research and Extension Authority (Yemen)
ASMSP	Agricultural Sector Management Support Project
AZRI	Arid Zone Research Institute (Pakistan)
BMZ	German Ministry for Technical Cooperation
CD-ROM	Compact-Disc, Read Only Memory
CIAT	Centro Internacional de Agricultura Tropical (Colombia)
CIHEAM	Centre International de Hautes Etudes Agronomiques Mediterraneennes (France)-International Centre for Advanced Mediterranean Agronomic Studies
CGIAR	Consultative Group on International Agricultural Research (USA)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico)
CLIMA	Center for Legumes in Mediterranean Agriculture (Australia)
EC	European Community
FAO	Food and Agriculture Organization of the United Nations (Italy)
GRTC	Graduate Research Training Program
GTZ	German Technical Assistance Agency (Germany)
HRP	Highland Regional Program
IARCs	International Agricultural Research Centers
IBPGR	International Board for Plant Genetic Resources (Italy)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
IDA	International Development Association
IDRC	International Development Research Center (Canada)
IFAD	International Fund for Agricultural Development (Italy)
IFPRI	International Food Policy Research Institute (USA)
IPGRI	International Plant Genetic Resources Institute (Italy)
INAT	Institut National Agronomique de Tunisie (Tunisia)
INIAP	Instituto Nacional de Investigaciones Agropecuarias (Ecuador)
INRA	Institut National de la Recherche Agronomique (France)
INTERPAKS	International Program for Agricultural Knowledge Systems (USA)
ISNAR	International Service for National Agricultural Research (The Netherlands)
IVDN	Integrated Voice and Data Network
LARP	Latin America Regional Program (CIMMYT, Mexico)
MRMP	Matrouh Resource Management Project
NARP	North Africa Regional Program
NARS	National Agricultural Research Systems
NIAB	Nuclear Institute for Agriculture and Biology (Pakistan)
NGOs	Non-Governmental Organizations
NVRSR	Nile Valley and Red Sea Regional Program
OPEC	Organization of Petroleum Exporting Countries (Austria)
SDC	Swiss Development Cooperation
SINGER	System-wide Information Network for Genetic Resources
TKW	Thousand Kernel Weight
UNDP	United Nations Development Programme
USDA	United States Development Agency
WANA	West Asia and North Africa
WARP	West Asia Regional Program

Appendix 15

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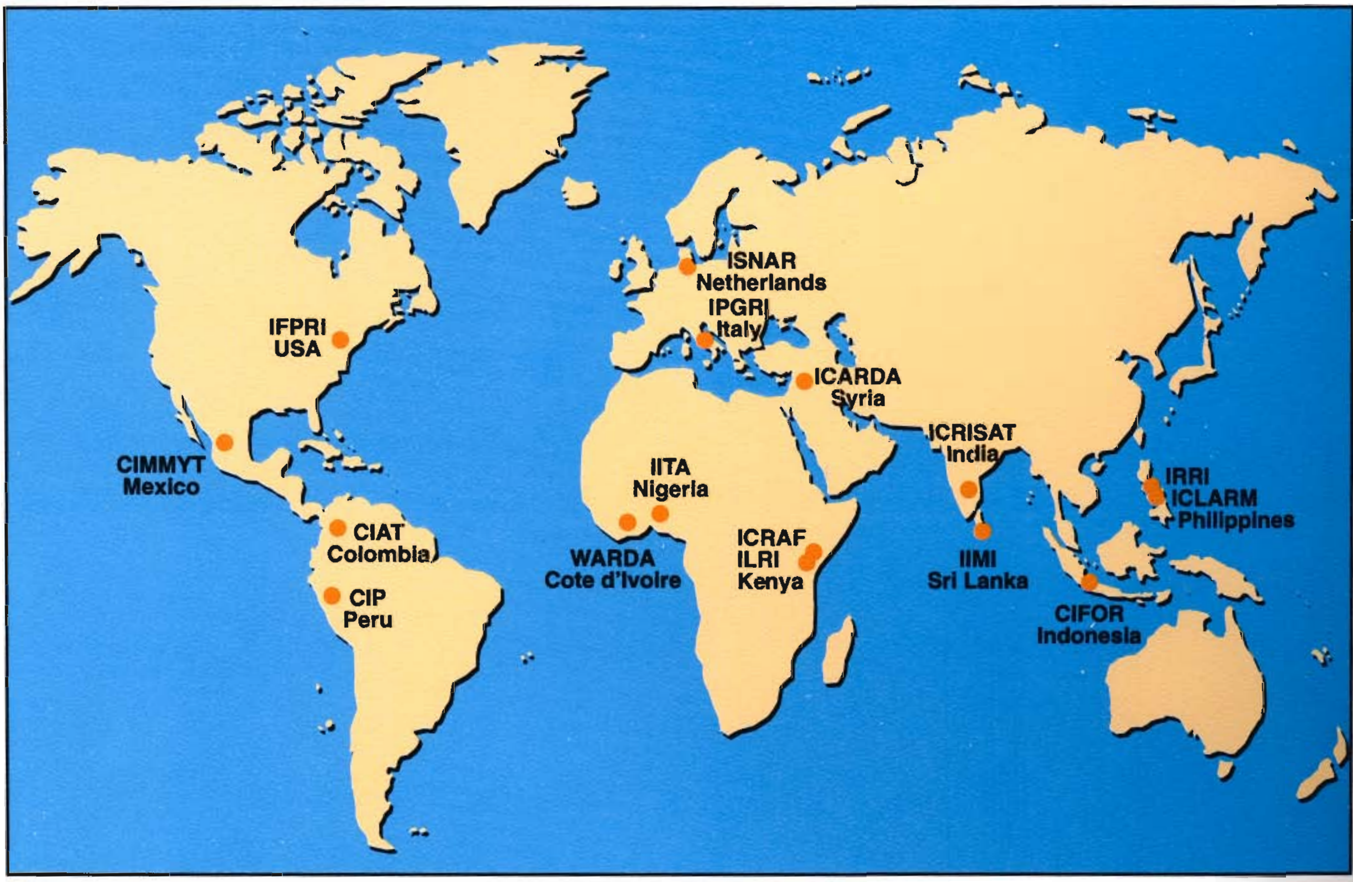

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