ICARDA Annual Report 1991

International Center for Agricultural Research in the Dry Areas

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 17 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 CGIAR seeks to enhance and sustain food production and, at the same time, improve socioeconomic conditions of people, through strengthening national research systems in developing countries.

ICARDA focuses its research efforts on areas with a dry summer and where precipitation in winter ranges from 200 to 600 mm. The Center has a world responsibility for the improvement of barley, lentil, and faba bean, and a regional responsibility—in West Asia and North Africa—for the improvement of wheat, chickpea, and pasture and forage crops and the associated farming systems.

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.

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 are offered extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and by specialized information services.

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Cover

ICARDA takes to the air to record the changing distribution of rangeland vegetation. In a cooperative project with the Tropical Agricultural Research Center of Japan, a camera equipped with a wide-angle lens mounted beside a video monitoring camera takes photographs from a balloon 200 m above the ground. Vegetation maps, made from photographs and verified against LANDSAT Satellite images, indicate detailed species distribution and will provide evidence of changes caused by overgrazing. (Photo credit: Shiguru Takahata)

Foreword

A large expanse of the WANA region, about 375 million hectares or 22% of the total area, is steppe. This zone, where annual rainfall is less than 200 mm, has traditionally been used for communal grazing of small ruminants and only rarely supports livestock throughout the year. There is evidence of severe degradation of the steppe. Originally occupied by shrubs and scattered woodland, it is now characterized by sparse, ephemeral vegetation of low productivity. The trend is accentuated by recent developments associated with changing settlement and utilization patterns. Traditional transhumance and nomadism are rapidly disappearing with the decline in the number of wholly nomadic families. Villages are being founded either within the expanding frontier of cultivation or within the steppe while, concurrently, flock sizes have increased. This transformation has been aided by the spread of mechanical transportation—pick-up trucks and water tankers—to move flocks and convey their needs to grazing over large distances. A new type of user has entered the scene: the commercial entrepreneur who has no stake in conserving resources of common interest, creating a situation of disruptive competition.

These developments are exposing the steppe to increasing hazards. On the wetter margins, the settled nomads and other farmers are growing crops on soils too fragile for cultivation and prone to severe soil erosion. On the drier margins, overgrazing is setting in motion a process of desertification not unlike that seen in the Sahel of North Africa.

These trends and their long-term impact are not yet fully understood; thus, there is a need for careful monitoring and diagnosis of events and an understanding of the operative processes and user perceptions. ICARDA has begun a major effort to define and quantify this evolving situation and develop appropriate ecologically sound technologies that both serve the needs of the steppe inhabitants and conserve the resource base that sustains them. Among the approaches being pursued is work conducted in Syria in cooperation with the Tropical Research Center of Japan, in which the changing distribution patterns in the steppe are monitored from an aerial observatory (see cover). This work, which combines new and traditional mapping practices, promises to give insight into processes that threaten the sustainability of the steppe, and, through this better understanding, suggest remedial measures.

Nasrat R Fadda
Director General

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Chairman
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PART ONE

Major Developments in 1991

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Major Developments in 1991

At ICARDA, 1991 was a busy and intellectually stimulating year. The Center continued to provide ideas and information to TAC (Technical Advisory Committee) for the development of a draft paper on the CGIAR (Consultative Group on International Agricultural Research) priorities. Discussions on intellectual property rights and biosafety gained further momentum in response to the CG efforts to develop a system-wide policy.

The Center underwent a Mid-Term Management Review in 1991. The Review, suggested by the CGIAR Chairman, was a sequel to the second EMR (External Management Review) of ICARDA in 1988. Its objective was to monitor progress of implementation of the EMR recommendations. The Mid-Term Review panel's report was very encouraging:

"The progress detailed by ICARDA in its 6-monthly reports, monitoring progress of the implementation of the 1988 EMR recommendations, is a reality."

"We are fully satisfied that, from a management perspective, ICARDA has achieved a remarkable turnaround in the past few years. We highly commend the Board and Management for their success, and are confident that the few residual problems can be satisfactorily overcome."

The Board, Management, and staff of ICARDA, while pleased with the findings of the report, cannot afford to feel complacent, knowing that there are more important tasks that remain to be accomplished—not only those highlighted by the panel, but also those emerging at the international level. New priority setting to address the emerging global environmental concerns within the framework of sustainable food production is at the forefront of the Center's efforts to refine its future strategy. Specialized staff committees are defining new priorities for the Center's next Medium-Term Plan in the context of current and expected funding. The Center is sensitive to the international, regional and local conditions in which it operates, and of the changes in the international political structures that dictate adjustments.

A three-member Gender Issue Committee, appointed by the Secretariat, visited ICARDA in 1991. The Committee commented positively on the Center's approach to the various aspects of the gender issue. ICARDA subsequently established an in-house committee to monitor developments and to evolve new approaches.

Governance and Management

The Board of Trustees of ICARDA continued their activities on behalf of the Center, having earlier reviewed all aspects of its work, including the updating of staff policies, production of a Board Handbook, audit plans and procedures, and Board self-evaluation essential for the smooth and efficient running of a healthy Center. As part of the 1991 annual meeting of the Board, a seminar on "Complementarities between National Research Systems and International Agricultural Research Centers" was organized.

Two new members, Mr George Some from Syria and Dr Mervat El-Badawy from AFESD (Arab Fund for Economic and Social Development), Kuwait, joined the Board in 1991.

Senior Staff Changes

The Center was active during 1991 in its search for competent staff members to fill the vacant senior positions. Four new senior scientists arrived, and one from ICARDA's program in Morocco returned to headquarters in Aleppo. In addition, several visiting scientists and post-doctoral fellows joined the Center during the year. Two senior staff members retired and another two proceeded on sabbatic leave.

Staff Benefits

Staff salary scales were reviewed during the year, but their revision did not seem justified. Nevertheless, certain benefits accruing to the regional staff were revised upwards. The Center is currently conducting a job equivalence study. The first phase—an analysis of organization, staff grading, and position titles, and the compilation of updated job descriptions—has been completed. Preliminary findings indicate that the Center already has clear reporting lines and that programs and departments are structured to make efficient use of resources. The second phase of the study will group support staff by functions and define equivalence between them.

Financial Matters

In spite of a tight funding situation, ICARDA ended 1991 with a balanced budget. The stricter budgetary control measures introduced during the past 2 years clearly paid off: ICARDA was saved from making any unusual budgetary adjustments in terms of reducing staff or activities.

Three additional events helped the Center to cope with the budget shortfall. First, Japan generously contributed USD 300 000 to ICARDA's core funding. Second, the AFESD affirmed that it would maintain its support to the Center. Third, the Syrian government introduced a more favorable exchange rate in August 1991, which helped to reduce local costs.

Research and Training Highlights

Following two dry cropping seasons in Syria, the total seasonal rainfall in 1990/91 was 290 mm, slightly less than the long-term average of 328 mm. The early part of the season was fairly dry; most of the rain fell in the spring. Crop yields were generally higher than in the 2 previous years because the distribution and amount of rainfall were more favorable. In the barley-growing areas, low rainfall until the end of December delayed emergence of barley until the first week of January, when the crops emerged and grew rapidly.

In the drier areas of the wheat-growing zone of Syria, rainfall in late October and early November provided enough moisture for emergence of some early planted wheat crops, but sparse rainfall in December caused severe moisture stress which led to reduced yields. Plentiful rainfall started only at the beginning of January. In the wetter wheat-growing areas, however, rainfall was heavy during October and sufficient to sustain growth during November and December. The growing season began 10 weeks earlier than at other sites in the region.

Except in May, thermal conditions during the growing season were close to the long-term average, with fewer than normal cold spells. The 35 frost-days recorded at Tel Hadya represent the average for the site. The -0.1°C at Bouider on 10 May was the first subzero temperature ever recorded in Syria in that month. A hailstorm on 21 May at Tel Hadya damaged cereal crops.

The weather was remarkably similar across WANA (West Asia and North Africa). A dry, warm autumn was followed by ample rain from January to March, extending into May at some locations. Yields in general were greater than for last season, with Morocco and Tunisia harvesting record crops. However, in parts of Libya, Jordan, and Syria the early season drought was not compensated for in time, so yields were low. Eastern Turkey, Iran, and Afghanistan had well-distributed rains and good crops. In the south of WANA, rains in Yemen, Ethiopia, and the Sudan were abundant during the main cropping season, which assured a good harvest.

Agroecological Characterization

A new look at climatic data together with crop production statistics is prompting a reappraisal of ICARDA's perception of crop zones in Syria. The scheme of 'stability zones' currently used for agriculture across the country is based solely on annual precipitation means and frequencies. However, within these zones, other aspects of the climate may vary and this has implications for crop, landrace or cultivar adaptation to different areas.

Long-term meteorological data for Syria were analyzed for climatic differences, within and across stability zones. Compared with the north, the same stability zone in the south has less frost, a warmer growing season, and an earlier end to the wet season (usually March). In the northeast, significant rainfall typically continues into May, making terminal stress less likely.

An important finding was the low frost frequency and higher heat unit accumulation in the wetter areas than in the drier areas of northern Syria. This linkage between winter temperature and precipitation helps explain the observed crop distribution: wheat in wetter (warmer) areas and barley in drier (cooler) areas.

Results also showed that chickpea distribution is not satisfactorily explained by average precipitation.

This work represents a new approach to agroclimatic characterization at ICARDA. Its utility for guiding future activities, particularly in germplasm targeting, will be assessed.

Germplasm Conservation

ICARDA continued to contribute to the CGIAR effort to collect, evaluate, conserve, and distribute germplasm of its mandated crops. Over 2100 accessions were collected in West and Central Asia and North Africa, and about 5000 new accessions were received from other institutions, bringing the total holding to 88 806 accessions.

An extensive collection mission for wild wheat relatives was carried out in the republics of Turkmenia, Uzbekistan, and Tajikistan in Central Asia. Several populations of the rare *Aegilops juvenalis* were collected, as well as *Aegilops* × *Aegilops* hybrids, and natural *Aegilops* × *Triticum* hybrids. Local herbarium studies revealed a new species, *Aegilops kotschyi*, from Turkmenia. As a result of the collecting activities in Central Asia, Libya, and Syria and of donations received from collaborating institutes, ICARDA now has one of the world's largest (2166 accessions) and best documented *Aegilops* collections.

Vacuum-packed seeds being prepared for long-term storage at -22°C. More than 88 000 accessions are now held in the ICARDA germplasm collections.

Collection trips to Jordan and the Sweida region in Syria provided 114 new accessions of wild barley, *Hordeum spontaneum*. In the latter mission, four wild wheat populations of *Triticum urartu* and 22 of *T. dicoccoides* also were collected. Extensive morphological variation and high genetic diversity in loci coding for storage proteins were found in both species. Two sites were identified as suitable for *in situ* conservation research.

Pasture and forage legumes were collected at 108 sites in Algeria. *Medicago*, *Vicia*, *Trifolium* and *Astragalus* were the most prevalent genera of 1421 accessions collected. During the year, 25 wild *Lens* and 3 wild *Cicer* populations were collected in Syria, and 87 faba bean landraces and 88 accessions of pasture and forage legumes were collected from Portugal.

Considerable effort was devoted to the characterization and evaluation of 5300 germplasm entries. Barley accessions with desirable traits were identified in collections from Afghanistan, Algeria, China, Pakistan (Balochistan region), and the republics of Uzbekistan and Turkmenia. Sources for pod indehiscence and low pod drop were identified in lentil germplasm from Iran. Significant variation for frost tolerance and early vigor was found in Jordanian medics evaluated jointly with the national program of Jordan.

Safety duplication of unique cereal germplasm was accomplished and 15 090 accessions were dispatched to CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo), Mexico; 600 duplicate faba bean accessions were shipped to the Federal Institute of Agrobiology, Linz, Austria.

Testing ICARDA gene-bank accessions for seed-borne viruses continued during 1991; about 1800 accessions of barley, lentil, and faba bean were identified as virus-free. Around 340 lentil accessions were freed from seed-borne infection during multiplication in the field.

The germplasm collection is used by NARS (National Agricultural Research Systems) and ICARDA scientists. During the year, 24 000 seed samples were dispatched on request to users in West Asia and North Africa, at ICARDA and other institutions. This represents a 107% increase over last year's requests for material from ICARDA's gene bank.

Germplasm Enhancement

Cereal Crops

ICARDA's stress tolerance breeding strategy for spring barley produced promising results on farmers' fields. Rihane-03 performed well in Morocco, Tunisia, and Algeria in a year with above-average rainfall. It was released in Spain as Resana. Arta, a pure-line selection from the Syrian local landrace, Arabi Abiad, ranked first for the third consecutive year in the on-farm verification trials in Syria. It outyielded the two local barley landraces by an average of 11% over 3 years and the most recently released variety in Syria, Furat, by about 12%.

As part of the activities of the Mashreq project, supported by the UNDP (United Nations Development Programme), the performance of Tadmor and WI 2291 was evaluated with and without fertilizer application in Syria. On average, both lines outyielded Arabi Aswad, the local landrace, by 15 and 20% without fertilizer and by 28 and 36% with fertilizer, respectively. Arabi Abiad and Arta also have adapted well in the highlands of Balochistan (Pakistan).

Arta, Harmal, and one pure-line selection from a Jordanian landrace (JLB 6-38) performed well as dual-purpose barleys in Jordan over two cropping seasons. The Ethiopian scientists in collaboration with ICARDA identified one line (accession 3357-10) that outyielded the local checks in two consecutive cropping seasons at three locations with low input levels.

In WANA, barley is grown on approximately 6 million hectares in high-altitude areas where yields average less than 1000 kg/ha. Breeding barley for high-elevation areas was initiated only 3 years ago; as a first step, over 500 entries from WANA and the former USSR were evaluated. The germplasm showed a gradation in growth habit from spring to pure winter types and a wide range of maturity types.

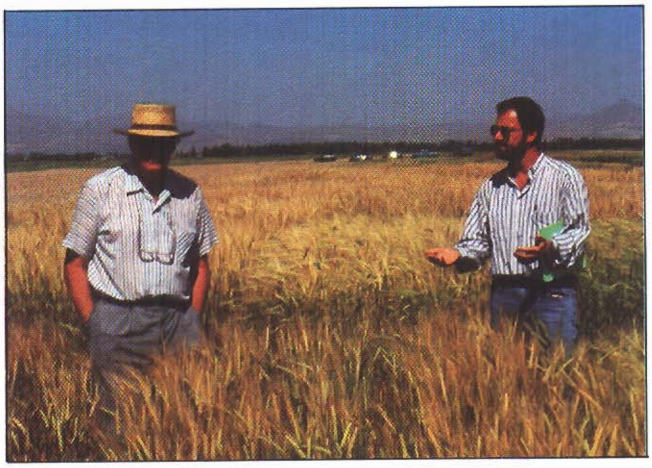
Germplasm was evaluated for cold tolerance in the field in Ankara and Syria, and under controlled conditions (freezing chambers) in Krasnodar-USSR. Cold damage was less in Syria than in Ankara. Of 1891 lines, about 50% (winter types) were selected for cold tolerance and overall performance. Cold tolerance also was found in spring types.

Cropping in high-elevation areas extends the agriculturally profitable regions of various countries; in the Atlas Mountains of Morocco, terracing improves the efficiency of land use.

Progress in breeding for cold tolerance was evident from the high-elevation nursery. Top lines in Algeria outyielded the national check variety Tichedrett by as much as 1000 kg/ha.

Durum wheat breeding at ICARDA emphasizes drought, cold, and heat resistance. The cultivar Lahn was developed for cold continental areas. It has a high yield potential in combination with resistance to cold, high grain quality, and resistance to *Septoria tritici*, yellow rust and common bunt. In Syria, Lahn yielded more than 10 000 kg/ha in areas with cold stress but with high-input conditions. The cultivar is adapted to the irrigated areas of Syria, where it occupies more than 15 000 ha, and has proved promising in Lebanon and Turkey.

Drought tolerance is the most important varietal requirement for WANA. A collection of eight pairs of isogenic lines, differing in the wax layer, was planted at Tel Hadya and Breda to determine the role of waxy stems and leaves in drought tolerance. At Tel Hadya the glaucous lines yielded 30% more grain and had 11% higher biomass than the non-glaucous lines. Four of the top five dry-matter-producing genotypes were glaucous. Similarly, four of the five top grain yielders were glaucous lines. Contrary to expectations, yields of the glaucous and non-glaucous lines were similar under severe moisture stress at Breda. This difference in the effect of the wax layer under different stress severity will be investigated further.



Drs John Hamblin (ICARDA) and Hans Braun (CIMMYT) select winter wheat at the International Winter Cereals Research Institute in Konya, Turkey.

During 1991, the Syrian national program released two bread wheat varieties: Bohouth 6 and Cham 6. Bohouth 6 was released for the high-rainfall and irrigated areas of the country, and Cham 6 for the low-rainfall zones (200-350 mm rainfall). Cham 6 yielded 26% more than Mexipak in large-scale testing.

In farmer verification trials carried out in the low-rainfall (< 400 mm) areas of western Algeria, three CIMMYT/ICARDA bread wheat varieties (Cham 4, Zidane 89, and Cham 6) yielded more than the local check, Mahon Demias. These highly promising varieties are currently being multiplied by the Algerian national program.

In wheat, of 349 accessions of *Aegilops* spp., *Triticum monococcum*, *T. dicoccoides*, and *T. boeoticum*, 34 were identified as resistant or tolerant to barley yellow dwarf virus.

Cultivated forms also were resistant to diseases. Three lines of durum wheat showed resistance to all three cereal rusts, 13 had combined resistance to yellow rust and common bunt, and 8 to septoria and barley yellow dwarf. Brachoua, one of the most promising lines in farmer verification trials, was resistant to both septoria blotch and barley yellow dwarf.

Multiple disease resistance was identified in bread wheat germplasm: 18 lines showed resistance to all three cereal rusts, 6 lines showed combined resistance to yellow rust and common bunt, and 2 lines to septoria and barley yellow dwarf. One line was resistant to all six diseases. Such germplasm is extremely important as parental material.

Screening for greenbug (*Schizaphis graminum*) in the collaborative aphid resistance screening project is conducted by ARC (Agricultural Research Center) scientists in Giza, Egypt. Arabi Aswad and Golan were used as susceptible barley and wheat checks, respectively. In 1989/90, barleys from the Indian national program were significantly more resistant than both checks and other lines tested. This was especially apparent late in the testing cycle when these lines successfully headed and produced seed while the other lines were killed. This, combined with rapid crop development, large kernel size, and adequate disease resistance, led to the inclusion of these lines in barley crossing and testing programs in Egypt and Sudan against laboratory and field aphid populations.

The winter barley nurseries were upgraded in response to the increased emphasis being placed on winter barley improvement. Three nurseries were distributed for the first time: a Winter and Facultative Crossing Block and two barley germplasm pools, one for naked barley and the other for barley yellow dwarf virus resistance. Naked barley is potentially important for human food.

The CIMMYT/ICARDA agreement on spring wheat nursery preparation and distribution was implemented. About half of the regular durum and bread wheat observation nurseries were lines received from the base program of CIMMYT in Mexico; their seed was multiplied at Tel Hadya. Distribution of observation nurseries was restricted to the WANA region, and duplication in the distribution of international nurseries to national programs was carefully eliminated.

Food Legume Crops

The national programs, participating in the International Testing Network, made excellent progress during 1990/91 by identifying and releasing for their farmers 18 improved legume cultivars in Algeria, Argentina, Egypt, Iraq, Morocco, Sudan, Syria, Tunisia, Turkey, and the USA. Several lines were identified for multilocation testing, on-farm trials or pre-release multiplication, and as sources of resistance to various stress factors. Participants received from ICARDA over 950 sets of 35 different nurseries of legumes (including vetches and lathyrus for the first time) for their 1991/92 season crop improvement work. These included segregating populations and breeding lines.

Transfer of crop improvement research to the national programs continued from the Douyet Research Station of INRA (Institut National de la Recherche Agronomique), Morocco. The major faba bean producing countries (China, Ethiopia, Egypt, Morocco, Sudan, Syria, and Tunisia) have developed the necessary leadership to pursue a vigorous program, with regional and international networking, facilitated through the ICARDA/INRA base. Faba bean scientists from the Nile Valley and North Africa Regional Programs held a "Specialized Travelling Workshop" in Morocco. The Regional Faba Bean Large- and Small-seeded Yield Trials and *Orobanche* Screening Nursery were initiated and distributed from Douyet Research Station to all North African national programs and some Nile Valley scientists.

One significant achievement at Douyet was the confirmation of *Orobanche* resistance and high yield potential of three faba bean lines (Sel 88 Lat. 18009, 18035 and 18105) in five verification trials in farmers' fields heavily infested with *Orobanche* in the Fes region of Morocco. The resistant lines were 46% higher yielding and had 64% less *Orobanche* infestation than the local commercial variety Aquadulce. Because of high farmer demand for these lines, seed multiplication was done during the main season at Douyet and in the summer at Annaceur sites of INRA.

Systematic evaluation of wild lentil germplasm was initiated for key stress traits, such as resistance to major fungal diseases, vascular wilt and ascochyta blight, and tolerance to drought. Biotechnological techniques are being employed to introgress the desirable traits from wild lentils. A total of 221 accessions of wild lentil from nine countries were tested for their reaction to vascular wilt at the seedling stage. The 41 most resistant wild accessions were rescreened for their reaction at the adult stage. Of these, only a few accessions of *Lens nigricans* sspp. *orientalis*, *nigricans*, and *ervoides* retained their resistant reaction from the seedling to adult stages. The reactions of 245 accessions of wild lentils and three lines of *Vicia montbrettii* to ascochyta blight ranged from highly resistant to susceptible.

Greenhouse screening, using a nitrogen-free hydroponic system, allows evaluation of rhizobial strains for various characteristics including effectiveness and competitiveness with indigenous populations.

Field evaluation of four strains of lentil rhizobia, which were selected after large-scale greenhouse screening of 250 different isolates, revealed that strain 739 from Syria and 760 from Portugal produced significant yield responses of about 20 and 40%, respectively, across four different lentil cultivars in the presence of native lentil rhizobia at Tel Hadya. These results indicate a potentially important role for inoculation of lentil with selected *Rhizobium* strains.

The advantage of winter over spring sowing was assessed using the yield performance data of 72 to 486 breeding lines tested at three ICARDA research sites (Jindiress, Tel Hadya, and Terbol) from 1983 to 1991. The average yield of winter-sown trials was 71% greater than that of spring-sown trials. A similar advantage has been obtained in several other WANA countries, where NARSs have released more than 30 chickpea cultivars for winter sowing. This cultural practice has been spreading in the Mediterranean region; the current area under winter sowing is nearly 20 000 ha.

From 1981 to 1990, nearly 1595 breeding lines of chickpea were developed that were resistant to at least one of the pathotypes of *Ascochyta rabiei.* These lines were reevaluated in 1990/91 using diseased debris and a mixed inoculum of six pathotypes of the fungus. Three lines (FLIP 84-79C, FLIP 85-86C, and FLIP 90-103C) showed resistance and should prove extremely useful in breeding chickpea for durable resistance. DNA markers closely linked to loci associated with ascochyta blight resistance are being developed.

Ghab 3 is the latest cultivar of winter chickpea released by the Syrian National Program because of its superior yield performance and seed quality.

Crossing between common vetch (*Vicia sativa*) and subterranean vetch (*Vicia amphicarpa*) is being done to improve the drought tolerance of the former and herbage and seed yield of the latter.

Sources of multiple resistance were identified from 200 accessions of annual wild *Cicer* species evaluated for six biotic and abiotic stress factors. Accession ILWC 62 of *Cicer bijugum* was resistant to ascochyta blight, fusarium wilt, bruchids, cyst nematode, and cold. Similarly, accession ILWC 39 of *Cicer echinospermum* was resistant to fusarium wilt, leaf miner, bruchids, and cold. These sources are being used to improve the cultigen through inter-specific hybridization. DNA-fingerprinting is being used to verify the crosses between *Cicer arietinum* and *C. echinospermum*.

Forage Legume Crops

Annual forage legumes are an alternative to fallow in cereal-based rotations in the dry areas of WANA. The two genera of feed legumes being intensively evaluated at ICARDA are vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.). The most promising species are narbon vetch (*Vicia narbonensis*), common chickling (*Lathyrus sativus*) and dwarf chickling (*Lathyrus cicera*) because of their potential in the dry areas, and wooly-pod vetch (*Vicia villosa* ssp. *dasycarpa*) for its potential in the high-elevation areas. In Balochistan wooly-pod vetch showed negligible cold damage and produced larger herbage and straw yield than other legumes. It is also resistant to *Orobanche crenata* and can therefore be grown in *Orobanche*-infested fields.

Subterranean vetch (*Vicia sativa* ssp. *amphicarpa*) is a potentially important species because 56% of the seeds produced underground are hard; this is an important requirement for persistence in any pasture species. Work with this subspecies indicated that barley grown after vetch (a nitrogen-fixing species) produced significantly higher yields than barley after barley. The underground podding of this vetch increases its persistence under heavy grazing. However, its vegetative growth is slow and the aboveground pods tend to shatter. In contrast, common vetch (*Vicia sativa* ssp. *sativa*) grows well under favorable conditions and lines with nonshattering pods exist, but it is not cold- or drought-tolerant. To increase the productivity of underground vetch and to improve the drought and cold tolerance of common vetch, a crossing program was started in 1989/90. High vigor was clearly observed in the F_1 plants carrying few underground pods. Selection will be carried out from F_2 onwards for two types of plants: underground vetch with vigorous aboveground growth and common vetch with cold and drought tolerance.

The high cost of traditional hand harvesting of forage legumes is a severe limitation on their acceptability in rotations, even though rotations alternating them with barley produce more animal feed than continuous barley, commonly practised by farmers. Unfortunately, the first trials of mechanized harvesting have led to large losses in yield. Losses were attributed to the poor growth of the vetch in a dry year, which reduced plant height. Rolling the land at sowing increased the mechanically harvested yield of grain by 17% and of straw by 36%. In spite of the losses due to mechanized harvesting, farmers are still interested in continuing the experiments because of the high cost and unavailability of labor in the area.

ICARDA has established a Dryland Pasture and Forage Legume Network of scientists in WANA to improve communication of research on pasture and forage legumes, especially those adapted to livestock-feeding systems. The network uses an informal quarterly newsletter developed jointly with IBPGR (International Board for Plant Genetic Resources) to promote communication among scientists. National Steering Committees were formed to overcome the institutional separation of team members who can contribute to the network.

Seed Production

The Seed Unit strengthens seed programs through: (a) training, (b) building up a seed production infrastructure, (c) making available limited quantities of high-quality seed, (d) disseminating information, and (e) carrying out seed technology research. The Unit is funded by the Governments of the Netherlands and Germany, and seeks to work in close cooperation with other organizations with similar goals. During 1991, cooperation with the University of Jordan and the IAC (International Agricultural Center) in Wageningen, the Netherlands became intensive. The University of Jordan is now sharing the training activities with the Unit; two regional courses and one in-country course were conducted in the Seed Technology Laboratory of the University. Curricula have been developed for a number of IAC/ICARDA international courses.

To reduce the number of training instructors without reducing the number of people who are annually trained, the Unit initiated a Train the Trainer course in 1990 and trained seven national staff members in field-inspection methodology. They in turn organized and conducted two courses in 1991 and will continue to train more people in their countries in 1992.

Jointly with the GOSM (General Organization for Seed Multiplication) in Syria, a system of pre-release seed multiplication was initiated. Quality seed of three varieties (Nesser, bread wheat; Lahn, durum wheat; Rihane 03, barley) was produced. Nesser was released in Syria. The consequence of the pre-release multiplication was that seed of the new variety was available to farmers at the time of its release.

Resource Management and Conservation

Wheat Production Technology in Syria

In partnership with the socioeconomic section of the Directorate of Scientific Agricultural Research, social scientists of ICARDA initiated a long-term study on the Adoption and Impact of Modern Wheat Production Technology in Syria. The 1991 objectives were to develop baseline measures of use and adoption of technology by wheat producers in Syria and to describe present levels of adoption in terms of environmental and farm system characteristics. The specific technologies covered were mechanization, irrigation, varieties, chemical fertilizers, herbicides, and insecticides.

Syrian wheat production is more than 90% mechanized, and 35% of the wheat area surveyed was under either supplemental or full irrigation. Modern HYVs (high-yielding varieties) are grown on 87% of the area planted, by 86% of the farmers surveyed. Durum wheat HYVs are significantly more important than bread wheat; the ratio is 70:30. The most important HYV durum variety is Cham 1 (released in 1983) followed by Haurani, a local variety. Mexipak (released 1971) covers 54% of the HYV bread wheat area. Chemical fertilizers, herbicides, and insecticides were used by 95, 54, and 13% of wheat producers surveyed, respectively.

Adoption patterns reflect the success of government policy to introduce modern technology in wheat production. The uptake curve of HYVs among farmers coincides closely with the release of new varieties and the varieties grown are chiefly those selected in government targeting. From an initial 5% in the early 1970s, the proportion of farmers growing HYVs more than doubled in each succeeding 5-year interval.

Constraints to Increased Production in Turkey

In 1991, the Turkish Central Research Institute for Field Crops and ICARDA began a 3-year collaborative project in the highland areas of Kayseri and Sivas provinces in Central Anatolia, Turkey. The initial research activity was a rapid rural appraisal by a multidisciplinary team of scientists in collaboration with village extension workers, local agricultural officials, and farmers in 32 villages.

Initial survey results confirmed the low levels of productivity and the gap between yields obtained by farmers and researchers in the area. In general, farmers have low incomes and are dependent on small holdings, 40% of which are either rented or sharecropped. Half the farmers own tractors, which are not always effective on small, steeply sloping fields. Wheat, barley, and chickpea are the dominant crops. Almost half the arable land is fallowed each year.

The potential benefits of fertilizer are well known, but its use is little understood and consequently varies widely. Farmers are aware of new high-yielding varieties, but availability of certified seed is a problem.

Animals are a key component in the farming system because their products constitute a major source of cash income. However, the size of flocks has been diminishing because of reduced feed supplies. In particular, natural pastures on the upper slopes that previously provided grazing for 8 to 9 months of the year have been heavily degraded by erosion, and have lost most of the natural plant cover.

Wind Erosion

Serendipity provided an excellent test site at Tel Hadya for a new wind-erosion project. Vacuum seed harvesting of a *Medicago* field altered the soil structure and thereby simulated the conditions that arise frequently in barley fields when stubble-grazing animals trample the field, usually from May to September. Before the soil was tilled to restore its resistance to wind, three dust samplers were placed 100 m apart in the field along the line of the predominant wind direction to monitor erosion. The dust samplers were constructed at ICARDA according to a design obtained from Texas.

Wind generally needs a run of 200 m over a specific surface to achieve about 90% of its bearing capacity. Thus the third sampler, 200 m downwind, provided a good measure of total soil loss due to wind during one week in September: about 2000 kg over a field width of 100 m. Dust data were not available for the windiest time of the season, from June to August at

In a wind erosion project at Tel Hadya, the weight of dust collected in samplers was used to calculate the amount of material moved across a field.

ICARDA sites in northwest Syria, but September wind speeds were known. From the time of medic seed harvest, 11 July, until September, extrapolations were possible. The soil surface remained unchanged during this time (no tillage, no rain), so that wind speed was the only major factor involved. The minimum amount of material moved off the 100-m width of the field during this time was calculated to be 60 000 kg, which represents a loss of approximately 3 mm over a 2-ha surface.

Ley Farming

In 1991 a cooperative project with TARC (Tropical Agricultural Research Center) of Japan introduced and tested a remote sensing system to monitor rangeland vegetation.

The system used small-scale images from the LANDSAT 5 TM Satellite to locate rangeland. The exact position of the area being studied was determined using a Sony PYXIS Global Positioning System. Photographs were taken from a balloon at a height of 200 m. Vegetation distribution was derived from the red band of the photographs, using an edge enhancement technique to improve the definition of the borders of vegetation areas, and then converted to black and white imagery. Vegetation maps were made from these images after verification with detailed species mapping along 70-m transects.

Shifts in vegetation cover over years will give evidence of desertification from overgrazing. The system has been tested at Maragha, southwest of Aleppo, on unimproved rangeland and areas improved by planting *Atriplex halimus* and *Salsola vermiculata*.

Stubble Grazing

For 4-5 months after harvest in late May or June, cereal stubble is the main source of feed for flocks in the WANA region. Although mating of the ewes occurs during this period and prolificacy may be reduced by poor nutrition, very few studies have been made of the nutrition of grazing ewes.

At Tel Hadya, accurate measurements of the amounts of each straw fraction at intervals of a few days over three periods in a month were achieved by careful sampling across the full width of the combine harvester cut, using a quadrat placed at right angles to the path of the harvester. The patterns of removal of heads, leaves, and stems from grazed barley stubble varied at different stocking rates. Barley heads were removed in small quantities by the grazing sheep in the first 5 days. Leaves were removed at a steadily declining rate throughout the month. Stems were initially removed slowly, then more rapidly as the availability of leaves decreased. Eventually, at the highest stocking rate, even the rate of removal of stems decreased as the supply of straw became exhausted, and sheep lost 100 g/day body weight from inadequate nutrition.

Barley stubble is a major source of nutrients for ewes during the mating season in the WANA region.

Outreach Activities

The six Regional Programs developed to conduct the outreach activities of ICARDA continue to be responsive to the changes occurring both within the WANA region itself and in the stakeholder community. However, as in any family where the relationships between individual members change over time, relationships have been changing within the six Programs. This is particularly noticeable as several of the stronger NARSs of the region proudly acquire the status of true partners in research and training efforts. The level of development and the nature of cooperation between ICARDA and the countries of WANA vary considerably, but all strive to maintain an effective two-way research and training continuum for promoting agriculture in WANA.

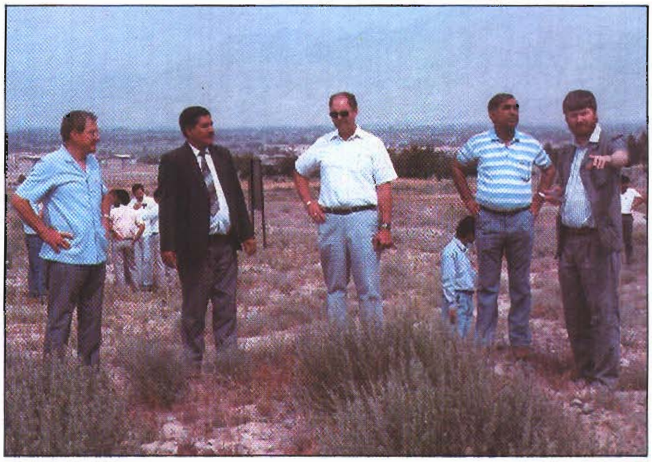
Highland Regional Program

The Highland Regional Program, with financial support from the Governments of Italy and Iran and USAID (United States Agency for International Development), is responsible for developing collaborative research with those WANA countries where cold stress limits crop growth in winter (usually above 750 m altitude).

In Turkey, a series of small interconnected projects has been initiated in collaboration with the Ministry of Agriculture and Rural Affairs, Cukurova University, and Ankara University. These projects examine the constraints to sustained improvements of productivity in such areas as Anatolia and the Taurus mountains, where severe environmental and physiogeographic factors are major influences in determining the livelihood of farming communities.

ICARDA will soon base its first resident scientist in Tehran, Iran to facilitate the development of the large Iran/ICARDA collaborative project designed to enhance research output for the drylands of northwest Iran. The Iranian Government has recently procured 500 ha of land at Akce Kohl, near the city of Marageh in Tabriz province, where the joint Iran/ICARDA research team will establish a major research institute. Exploratory germplasm evaluation trials already have been established in three key locations.

In Pakistan, ICARDA continued to assist AZRI (Arid Zone Research Institute) in Quetta with funding from USAID through PARC (Pakistan Agricultural Research Council). ICARDA, PARC, and USAID completed negotiations to continue support of AZRI until 1994. AZRI is expected to become an active partner in the network of institutions in the Highland Regional Program.



The Director of AZRI and participants from USAID, Winrock, and ICARDA attend the annual AZRI Research Coordination Meeting in Quetta, Pakistan.

Particular research emphasis has been given to a drought-tolerant forage shrub called fourwing saltbush, marketing of meat of small ruminants, and selection of cereal (particularly for yellow rust resistance), lentil, and forage germplasm adapted to dry and cold environments. A study was made of the agribusiness sector in Balochistan with the aim of strengthening linkages between agribusiness, AZRI, farmers, and NARSs.

Arabian Peninsula Regional Program

The Regional Program for the Arabian Peninsula, with generous support from the AFESD, continued its research and training activities, despite political unrest in the region. These activities focused on (a) germplasm exchange, evaluation and improvement, (b) training and human resource development, and (c) visits and consultancies by ICARDA and other national scientists. The program operates from Aleppo, but negotiations are underway to base it in the United Arab Emirates.

A total of 69 cereal and 22 food legume trials were conducted to evaluate local adaptation and drought, heat, and salinity tolerance. Varietal descriptions and evaluations of the common and improved wheat and barley cultivars from Saudi Arabia and Yemen commenced. The F_1s of the Regional Crossing Blocks for the Arabian Peninsula, recently initiated at ICARDA, are being grown to produce segregating populations.

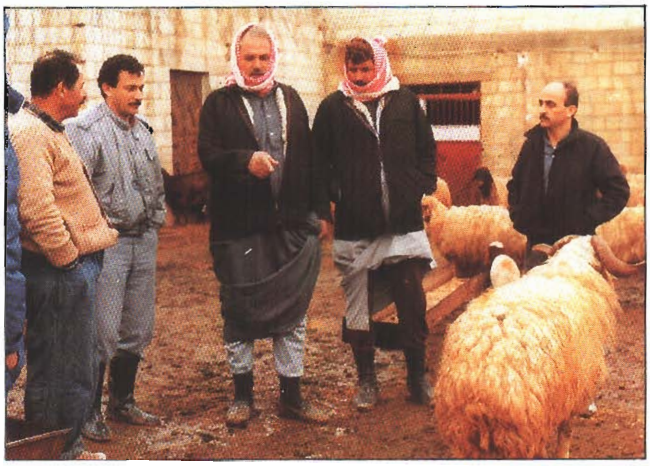
Drs Nasrat Fadda, Director General of ICARDA (*center*), and Samir Achmed, Regional Coordinator of the Arabian Peninsula (*extreme left*), examine forage crops in the United Arab Emirates with the Director of the Eastern Region, Mr Abdullah Khalfan Al-Sharaiki, and other Emirate scientists.

West Asia Regional Program

Work in the Mashreq Project, supported by UNDP and AFESD, continued in the three countries (Syria, Jordan, Iran). Activities focused on farm demonstrations with farmer participation. National program scientists are taking the lead in these activities.

The 1991 results confirmed that barley fertilization and improved practices for cultivating barley are superior to farmer practices. In Syria, fertilizer application on barley resulted in average yield increases of 13-23%. The promising new barley lines Tadmor and WI 2291 outyielded the local cultivar in the drier areas of northern Syria by up to 55%.

Application of the recommended production package for barley in Jordan resulted in an average grain yield increase of 100%. In Iraq, the average yield increase for barley was 131% with applied fertilizer and 59% with 6-row Gezira, the improved cultivar.



The Mashreq Project focuses on farmer cooperation. The project team in Syria visited one of the sheep owners who is participating in project activities.

On-farm trials to validate improved cultivars and production technology of lentil and chickpea in the Delta area of Egypt are being conducted by the Nile Valley Regional Program.

Nile Valley Regional Program

The Nile Valley Regional Program provides research, transfer of technology, and training to improve the production of cool-season food legumes (faba bean, chickpea, and lentil) and cereals (wheat in cooperation with CIMMYT in Egypt and Sudan; barley in Egypt). The strategy involves a multidisciplinary, multi-institutional and problem-oriented approach that makes full use of the expertise, human resources, and infrastructures available in the participating countries. The program emphasizes an on-farm approach to develop technology suitable for local conditions.

Funding continued from the Commission of the European Communities for Egypt, the Government of the Netherlands for the Sudan, and SAREC of Sweden for Ethiopia.

On-farm demonstrations of improved wheat production packages, including new varieties from the joint CIMMYT/ICARDA program, resulted in yield increases of 21 to 67% in Egypt and 2 to 117% in Sudan. Economic studies showed high marginal rates of return (over 500%), which confirmed the profitability of the demonstrated packages, including those with variable costs.

Government support and the attractiveness of wheat production packages have increased the level of self-sufficiency in the Sudan from 29% in 1987/88 to 65% in 1990/91, during which period wheat production increased three-fold from 1.7 to 5.2 million tons.

Improved barley production packages, which included the newly released cultivars Giza 127 and Giza 124, outyielded traditional practices by 20-30% in Egypt.

Extensive on-farm trials and demonstrations of a range of packages for the production of food legumes were conducted in all three countries. The benefits of integrated control of *Orobanche*, including the use of resistant cultivar Giza 402 and glyphosate, were repeatedly demonstrated in Egypt. Significant improvements in the production of lentil were demonstrated in all countries and three cultivars adapted to different agroecological zones (FLIP 84-782, 86-122, and 86-16L) are being recommended for release in Ethiopia. Cultivar-verification trials across four chickpea-growing Governorates in Egypt confirmed that two lines, L 70 and FLIP 14-80, outyielded farmers' cultivars by more than 35% and that all cultivars responded to *Rhizobium* inoculation with yield increases of over 15%.

North Africa Regional Program

The North Africa Regional Program coordinates and executes ICARDA's core and special-funded collaborative projects in Algeria, Libya, Morocco, and

Tunisia. The cereal studies are jointly sponsored by ICARDA, CIMMYT, and the Rockefeller Foundation, and the food legume impact study is sponsored by ICARDA and the World Bank.

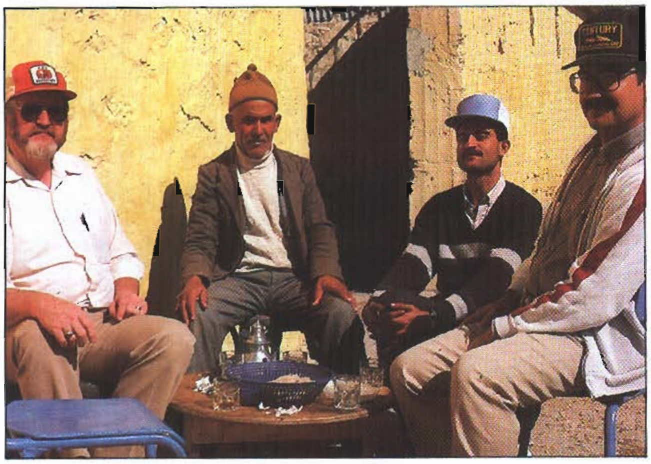
The faba bean program was phased out and these activities were temporarily assigned to ICARDA's Regional Food Legume Scientist in Morocco until the bilateral GTZ/INRA (Morocco) project for Strengthening Sector on Food Legume Research in INRA is funded and qualified staff are recruited. A regional faba bean project proposal for funding was developed and submitted to the BMZ (Federal Ministry of Technical Cooperation) of Germany with the endorsement of the four national programs of North Africa. The Project aims to ensure that the genetic material and techniques developed by ICARDA in the last 10 years are fully exploited to meet the needs of the North Africa region as a whole.

ICARDA's long and close association with NARSs in North Africa has permitted the IFAD (International Fund for Agricultural Development) special-funded project on Technology Transfer to make a good start despite the financial difficulties encountered. The project, designed to increase barley, food legumes, and livestock production in North Africa, has achieved many promising results in 2 years. Multidisciplinary groups of national staff from several institutions were integrated into the work, and the technologies requiring transfer to farmers were identified. This included high-yielding varieties of barley, chickpea, and lentil and their associated production packages.

At the agroecological level, ICARDA strengthened its collaboration with Libya and Tunisia for research in drier areas through the initiation of case studies within the special-funded project on Dry Land Resource Management and the Improvement of Rainfed Agriculture in the Drier Areas of West Asia and North Africa.

Latin America Regional Program

The ICARDA/CIMMYT Barley Project focuses on developing improved barley germplasm with high yield potential and multiple disease resistance in high-rainfall environments, primarily in countries of the Andean Region of South America where the crop occupies 1.1 million hectares. The Program results are applicable to barley areas in the Far East, particularly China, where barley is grown on 4.6 million hectares and early maturing lines may fit particularly well in intensive cropping systems.



INRA-MIAC staff visit a farmer from an area near El Brouj in Morocco.

Because most available resistance sources are only useful against a single disease and often occur in poor agronomic backgrounds, a step-wise approach to incorporate combinations of genetic resistance to major diseases in the Andean Region has been adopted. Combinations of two or more disease resistances are being incorporated into adapted advanced lines. Subsequent crossing and selection combine desirable traits. Lines are available with combinations of resistance to stripe rust, leaf rust, scald, barley yellow dwarf virus, and net blotch in high-yielding, well-adapted germplasm.

Superior barley varieties have been released in Chile (including Centauro, a hull-less variety for human food), Peru, Ecuador, Brazil, the USA, Australia, Vietnam, and China.

Training

Applied training is increasingly achieved through in-country courses, whereas at Tel Hadya emphasis is on advanced training. Training in cooperation with other centers such as CIHEAM (Centre International de Hautes Etudes Agronomique Méditeranéennes) and INRA (France) provides combined expertise, to the advantage of the trainees.

Trainees in a cereal disease methodologies short course learn to screen for disease resistance.

During 1991, ICARDA offered training to 738 persons from 17 WANA and 23 other countries. Twelve percent of the trainees were women. Twenty-three of the 41 courses were conducted at headquarters. Training courses reflected ICARDA's agroecological focus: pasture and range management, farm survey methods, supplemental irrigation technology, and agroclimatic analyses. Computer training was provided to both ICARDA and NARS staff.

The results of the training follow-up study were published and are being used for the development of a 5-year training plan. The manual of training procedures was tested throughout the year and improved where necessary. The final version will be developed in the near future. Production of training materials was given high priority, and manuals for Biological Nitrogen Fixation and Insect Pests of Wheat and Barley were completed. Six audio-visual training modules also were completed.

Information Dissemination

The Center made full use of the emerging advances in information technology to improve the speed, relevance, and effectiveness of its information dissemination activities. Emphasis was on (a) sharing management initiatives and progress in research with donors, national policy makers, and scientists, (b) strengthening national program capacities through training and networking, and (c) providing increased support to ICARDA scientists at headquarters and in the outreach programs.

Off-line interaction with the major international databases was further strengthened by enlarging the CD-ROM library, which now covers biology and agriculture, women, weather, water resources, and technology. In-house development of two new, specialized databases on barley and steppe received increased attention. The databases are being generated by extracting bibliographic references from the international database pool and, in the case of barley, in cooperation with CIMMYT.

The activities of the WANA information network, initiated in 1990, gained further momentum. Through increased personal contacts and correspondence, new exchange agreements were established with several libraries.

Training courses were organized for in-house staff and three WANA participants on the use and application of CSD/ISIS in information management and retrieval.

The production of publications was consolidated to make the best use of resources. Much of the backlog of the Center's commodity-based newsletters was cleared, well-defined audience-specific categories were established for publications, and print runs were reduced where necessary. During the year, the Center produced over 80 publications, which included the Annual Report, program reports, specialized research reports, conference proceedings, and training manuals. In addition, 57 research articles were submitted to international journals, of which 52 had been published by the end of the year. To improve the output and quality of editing, two English-language editors were added to the information team.

Public awareness activities were intensified through an increased number of news releases and donor-specific brochures. Contacts with the local, regional, and international media were further strengthened.

The Arabic unit produced two training manuals by sharing resources with the National Agricultural Research Project, Egypt. A questionnaire was sent out to identify additional national programs in WANA with whom resources could be shared to increase information dissemination in Arabic. Arabic translation services were extended to TAC and ICRISAT. A modest increase was made in the Center's effort to produce a French version of its key publications.

PART TWO

Research and Training Overview

Contents

Research and Training Overview

As emphasis on the sustainability of agricultural resources increases, the goals of research programs are adapted to reflect the greater demand for higher productivity within a restricted resource base. ICARDA's research programs focus on the Center's overall goal of increasing crop and livestock productivity in the West Asia and North Africa (WANA) region. Multidisciplinary links integrate the seven activities of the Center: agroecological characterization, germplasm conservation, germplasm enhancement, farm resource management, training, information dissemination and impact assessment and enhancement. An overview of research activities during the past year is presented in the following pages.

The Weather in 1990/91

Northern Syria

The season started out exceptionally dry in autumn 1990. The first substantial rains did not occur until early December and rainfall until the middle of March was 36% less than the long-term average. Total rainfall during the 1990/91 growing season was 290 mm. Although it was about 12% less than the long-term average, its distribution was good for crop growth. Winter temperatures were mild, but wide fluctuations in temperature occurred in March.

In the barley-growing areas, represented by Bouider, Ghrerife and Breda, rainfall until the end of December was insufficient to allow emergence of barley. However, when the rains began in January, the crops emerged quickly.

In the wheat-growing areas, represented at the dry end of the range by Tel Hadya and at the wet end by Jindiress, the picture was more complex. In the drier areas, rainfall in late October and early November provided enough moisture to enable some of the early planted wheat crops to emerge, but December rainfall was sparse. As a result, these early crops suffered from severe moisture stress, which reduced their yield potential unless they were irrigated. As in the barley area, at Tel Hadya plentiful rainfall started only at the beginning of January.

In the wetter wheat-growing areas, however, rainfall was heavy during the last week of October and sufficient to sustain growth during November and December. The growing season at Jindiress started 10 weeks earlier than at the other sites.

January rainfall was ample, but rainfall in February was below the long-term average, especially in the barley-growing areas. Sufficient soil moisture prevented undue stress to crops. From March until May, rainfall was above average, although the May rainfall was of little benefit to crops. By mid-May, high day temperatures (30+°C), open-pan evaporation and strong winds forced crops to mature over a relatively short period of time.

Seedbed preparation occurred under dry conditions at Tel Hadya in November. Soils remained dry until the rains began in January.

WANA region

During the 1990/91 season, the general weather pattern was remarkably similar all around the Mediterranean from Morocco to Egypt and Turkey: the mostly dry and unusually warm autumn of 1990 was followed by a period with ample precipitation from January to March or into May, with May bringing exceptionally cool weather everywhere. Since most of the rain fell during the second half of the season, when crops made better use of it than if it had fallen earlier, yields in general were better than in the previous season.

Regional and local exceptions and variations to the general picture occurred. In Tunisia, eastern Algeria and western Libya, November brought some heavy rainfall, while January was very dry in much of this area and also in Morocco.

Further east, in eastern Libya, Egypt, Jordan, southern Syria and Cyprus, the autumn of 1990 was exceptionally dry. The late March rainfall was insufficent to make up the moisture deficit, arriving too late to compensate for the stress that crops had already suffered. Therefore most yields in this area were lower than average.

In the region from eastern Turkey across Iran and Afghanistan to western Pakistan, the season brought ample, well-distributed precipitation and generally very good conditions for crop growth. Dry spells in February and April did not detract from the overall favorable picture, nor did floods in parts of Afghanistan caused by heavy rains and snowmelt in March.

Further south, in eastern Africa and the southern Arabian peninsula, similar favorable conditions prevailed. The small rains in spring 1991 in Ethiopia were good and yields were only slightly less than those of the previous year's good crop. More important, the big rains, during which the main single crop is grown in Sudan, Ethiopia and Yemen, were plentiful in 1991, although there were some areas in Sudan and Ethiopia where their onset was delayed and yields did not reach the high levels achieved elsewhere. In Somalia, both the small rains in the autumn of 1990 and the main rains during the spring of 1991 were ample and created the potential for a good harvest.

Agroecological Characterization

Preliminary Climatic Analysis for Syria

The predominant ecological classification scheme for Syria is based on precipitation. The ecological zones are distinguished on the basis of long-term average precipitation, with an allowance for years in which precipitation exceeds the maximum for that zone. This scheme is clearly useful in explaining the distribution of natural vegetation, and for targeting crop species.

Perhaps because of the obvious importance of precipitation, the agroecological relevance of other factors has not been widely considered. These include: precipitation distribution over the cropping season; the temperature regime; the timing of moisture supply in relation to evaporative demand; photoperiod; regimes of humidity, solar radiation and wind; soil properties; government policy, and availability of supplemental irrigation and labor.

The effect of these other factors can be determined by observation, but this is costly if it involves multi-year, multi-site field trials. In addition, the climatic factors listed above show variability from year to year, so there is no guarantee that results recorded in a short time span will be representative of the long-term climate. A study using simple climatic analyses was undertaken to illustrate the possibilities of using such information for enhancing efficient agricultural technology in the WANA region.

The analyses were conducted for Syria, where data for a number of weather stations were available from 1960 to 1987. The stations used are shown in Figure 1, along with the Syrian agricultural stability (ecological) zones.

Precipitation

When precipitation data for October to May were analyzed, the zonal classifications of the nine stations did not always agree with the expected classification. On the basis of precipitation, Idleb, Marret, and Qamishli would be zone 1b, Sweida and Hama zone 1b or 2,

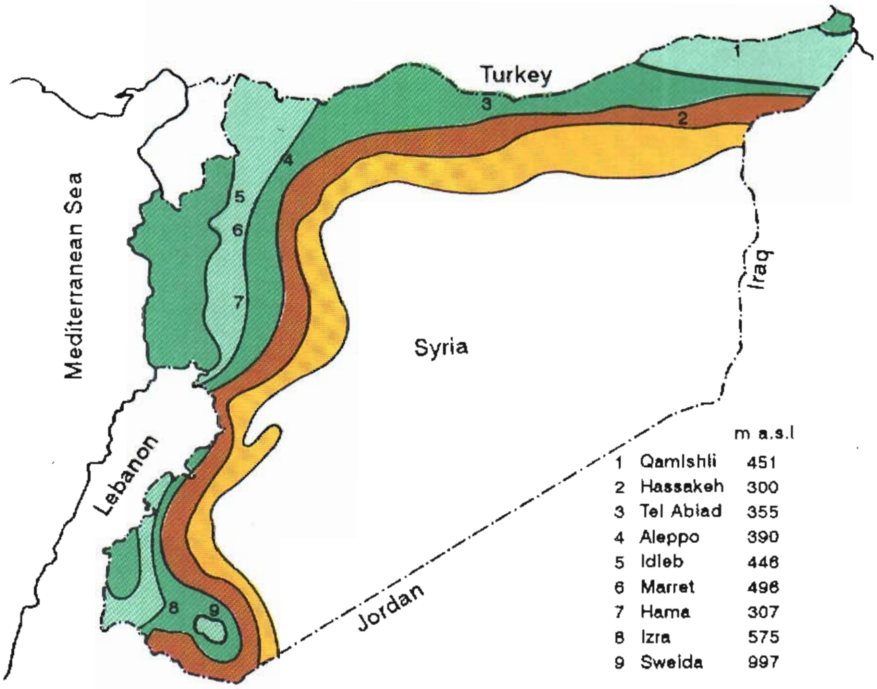


Fig. 1. Agricultural stability zones in Syria (1a to 5) and location of Syrian weather stations.

Aleppo zone 2, and Hassakeh, Tel Abiad and Izra zones 2 or 3. This raises questions about the stability of the boundaries that separate zones.

The pattern of precipitation distribution over the crop season is important in determining crop yields. Distribution within and among sites could be characterized in many ways. Two approaches are used here. The first is to consider the fraction of seasonal precipitation received before (or after) a certain date or growth stage. This analysis is based on that fraction of Oct-May precipitation received on or before Jan 31. Results are shown in Table 1.

The range in distribution is large. In the extreme case (Hassakeh), as little as 18% or as much as 87% of the Oct-May precipitation has been received by Jan 31. Conversely, at Idleb, not less than 34% and not more than 73% of Oct-May precipitation has been received by Jan 31. The median precipitation received by Jan 31 is close to 50% of seasonal rainfall for all sites. However, northeastern sites are all just under 50%, and northwestern sites just above, with no clear trend for the southwest. The northeast appears to be the most variable, the northwest the least, and the southwest intermediate.

Table 1. Precipitation received by January 31 at Syrian weather stations.

Station	Precipitation (% of Oct-May total) Low	Median	High
Qamishli	25	47	73
Hassakeh	18	48	87
Tel Abiad	16	49	78
Aleppo	37	56	80
Idleb	34	56	73
Maaret	33	55	79
Hama	39	54	82
Izra	18	53	78
Sweida	23	48	73

The second approach used to examine precipitation distribution is a tabulation of the month-by-month frequency of rainfall above a certain threshold. In the example shown in Table 2, a monthly threshold of 25 mm was used.

Table 2. Probability (%) of exceeding 25 mm monthly precipitation at selected sites in Syria.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Qamishli	93	83	86	86	38	0	0	0	0	21	67	82
Hassakeh	81	65	77	65	30	0	0	0	4	13	43	70
Tel Abiad	86	68	75	43	22	0	0	0	0	22	35	69
Aleppo	87	85	76	47	25	0	0	0	0	32	61	93
Idleb	100	93	97	69	23	3	0	0	3	0	70	97
Maaret	92	79	79	52	20	4	0	0	4	28	62	85
Hama	100	79	79	59	7	0	0	0	4	29	63	81
Izra	88	84	76	30	0	0	0	0	0	4	35	71
Sweida	96	89	89	39	8	0	0	0	0	27	59	73

The probability of receiving significant rainfall in northeastern and north-central Syria is high in April and May. At both Qamishli and Hassakeh the probability of significant rain is as high in April as in February. This is not the case at other stations. In effect, for a given seasonal rainfall total, the month-by-month distribution in the northeast will be 'flatter' (less varied) than elsewhere. Thus, the risk for terminal drought will be somewhat lower in the northeast, but the midseason drought risk will be higher.

At Tel Abiad the distribution is not as 'flat' as in the northeast, but given that this is the driest of the nine sites, it still exhibits surprisingly high probabilities of significant rain late in the season.

The southwest, unlike the northeast, has virtually no prospect of significant rain in May, and much lower prospects in April than in February and March. This might in turn imply greater susceptibility to terminal drought than in the north.

Thermal time

The ability of crops to efficiently exploit the winter peak in precipitation is influenced by the growth of the crop canopy. Winter crop growth is constrained by phenological development, which is highly sensitive to temperature. An integrative measure of the thermal regime is a growing degree-day (GDD) sum above a base temperature. In the example shown here (Table 3) GDDs are accumulated above a base temperature of 0°C for the period Dec 1 to March 31.

The variability in thermal time accumulation within sites is clearly substantial, implying wide year-to-year variability in rates of crop development. For example, these figures suggest a range of up to one month in heading date. Among sites, variability is greatest in the northeast and least in the southwest.

The thermal time sum for Izra suggests substantially faster crop development there than at other sites. This is not surprising given the lower latitude. The other southern station, Sweida, has an elevation 400-700 m greater than the other sites and has GDD sums similar to those further north.

Table 3. Growing degree-day sums, December-March, at sites in Syria.

Station	10% chance of lower GDD sum	Median GDD sum	10% chance of higher GDD sum
Qamishli	877	1053	1211
Hassakeh	798	952	1164
Tel Abiad	749	949	1095
Aleppo	813	964	1131
Idleb	836	1037	1192
Maaret	726	849	1043
Hama	889	1084	1277
Izra	1016	1157	1305
Sweida	856	1007	1188

Frost events

Cold tolerance is an important aspect of crop adaptation to some Mediterranean environments. Measures that relate to the required cold tolerance include growth stage during frost, and frequency and severity of frosts. Two measures (number of frost-days and date of last frost) indicate a high degree of year-to-year variability within sites, distinct regional tendencies, and considerable site-to-site variability within a region.

The number of frost-days at a site can vary from zero in some years to 50 or more at some northern sites. Tel Abiad has recorded as few as 9 and as many as 84 frost-days in a season. The southwest has lower frost probabilities than elsewhere, whereas the dry stations in the northeast have the greatest frost probabilities.

Despite its elevation of 997 m, Sweida has frost probabilities similar to those at Izra (575 m) in the same region. On the other hand, Qamishli in the far northeast has much lower probabilities than Hassakeh and Tel Abiad. The lower incidence of frost-days in the extreme northeast of the country (corresponding to zone 1 in Figure 1) than in regions to the immediate south is supported by results presented in the Climatic Atlas of Syria.

At first glance these data imply substantially greater frost risk in (most of) the northeast than in the northwest. However, seasonal frost frequencies for Tel Hadya and Breda were mostly greater than those for Aleppo for the period of overlapping record (1979/80 to 1986/87). Tel Hadya and Breda in fact have frost frequencies closer to those of Hassakeh and Tel Abiad.

Probabilities for late frosts (Table 4) follow a similar pattern to number of frost-days. Those stations having high frost frequencies also tend to have later frosts. An exception is Sweida which, despite its relatively low frost frequency, still records late frosts. April frosts at Tel Abiad and Hassakeh can be expected at least once in 10 years, but April frost is a very low probability event at the other locations considered here.

Table 4. Probability of frost at Syrian weather stations.

Station	Chance of frost later than date 50%	Chance of frost later than date 10%	Latest frost on record
Qamishli	Feb 27	Mar 28	Apr 18
Hassakeh	Mar 11	Apr 2	Apr 18
Tel Abiad	Mar 15	Apr 9	Apr 27
Aleppo	Mar 6	Mar 28	Apr 6
Idleb	Feb 1	Mar 10	Mar 26
Maaret	Mar 12	Mar 29	Apr 14
Hama	Feb 25	Mar 21	Mar 29
Izra	Jan 28	Mar 8	Mar 27
Sweida	Mar 2	Mar 27	Apr 26

Relation between frost and precipitation

Weather variables are not mutually independent. As indicated above, the geographical distribution for frost frequency might be related to the geographical distribution of precipitation if a single relationship holds across the entire geographical area of interest. We used data for northern Syria, from Hama north to Qamishli, including ICARDA data for Breda, Tel Hadya, and Jindiress. Results for the wettest and coldest month (January) are shown in Figure 2.

There clearly is a negative correlation between frost-days and precipitation, which is unaffected by latitude or by elevation differences among the stations. This close correlation potentially confounds the attribution of crop distribution (i.e., crop zones) to a single variable: precipitation.

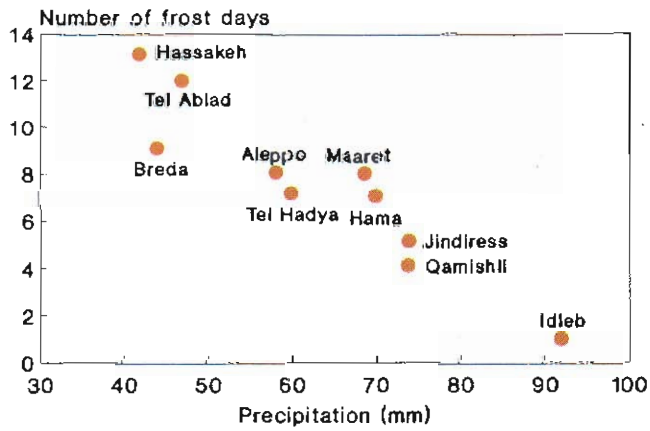


Fig. 2. Mean number of January frost-days and January precipitation at weather stations in northern Syria.

Conclusions

Although data are sparse from Syrian weather stations having similar growing season precipitation, it is still possible to draw conclusions about the climatic differences that exist between geographically distinct regions classified in the same agricultural stability zone.

There are clear differences between north and south. Crop areas in the south (represented by Izra) have relatively warm winters, earlier crops (heading 10—15 days earlier) and less frost risk. The south also has a somewhat compressed wet season, with a sharply decreased probability of significant rain in April. However, in terms of matching crop evaporative demand to water availability, earlier crop development may partially or completely compensate for the shorter wet season. Even in relatively wet years, terminal drought is the norm in this region.

Across the north, as Figure 2 shows, frost risk increases with dryness. Thus, from northwest to northeast, large differences in frost regime are not evident at similar precipitation levels. Differences in crop performance, or landrace distribution, occurring within a stability zone, but in geographically separate areas of the north, are therefore unlikely to be related to frost.

Stations with higher frost frequencies not surprisingly have slower accumulations of thermal time over the period when frost occurs (Dec-Mar) (Figure 3, Table 4). Thus, the apparent adaptation of barley to relatively dry, and wheat to relatively wet, environments may be partly a consequence of the warmer winter conditions in wetter areas. Wheat, a relatively long-season crop, develops faster in the wetter than in the drier environments of northern Syria.

The precipitation regimes of northeast and northwest Syria are subtly different. The probability of significant late season (April-May) precipitation is substantially higher in the northeast (with correspondingly lower probabilities in midseason). The fact that the northeast is the principal area for wheat production in Syria may be related to the crop's ability to make the best use of late rainfall. Dryland wheat production in Hassakeh province (northeast) far exceeds that of barley, whereas in Aleppo province (northwest) there is more barley than dryland wheat.

Winter temperatures may account for the distribution of food legumes in Syria. Chickpea is usually considered to be a crop adapted to the wetter areas of the wheat-based farming systems of WANA, i.e., the wetter end of stability zone 1b. Lentil in this

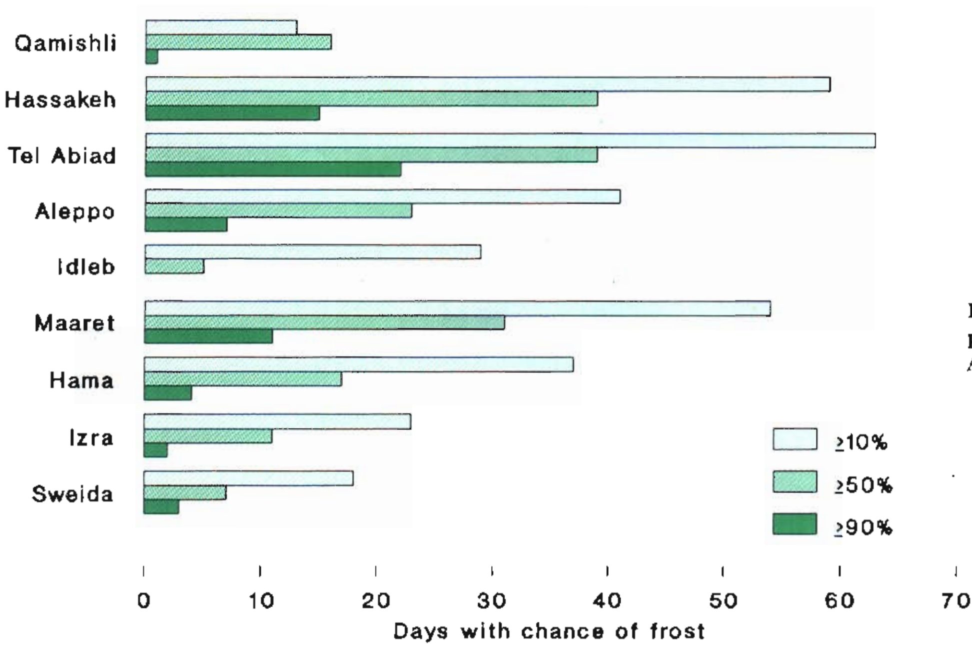


Fig. 3. Number of days with probability of frost during November-April at Syrian weather stations.

system is considered to be the predominant food legume at the drier end of zone 1b. This rainfall-based zonation concept for food legumes in Syria does not accord with the concentration of the chickpea-growing area in the south, a low-rainfall environment. For example, in 50% of years, the southern provinces of Daraa and Sweida contain at least 60% of the national chickpea area, mostly in areas classified as stability zone 2 (250-350 mm mean precipitation).

Despite the relatively low precipitation in southern Syria (compared with the northwest) lentil is clearly not the preferred food legume in the south. In 50% of years, Daraa and Sweida contribute less than 10% of the national lentil area and the lentil area is much smaller than that of chickpea in these provinces. Whether for climatic or other reasons, the stability zone system does not explain lentil distribution in southern Syria.

To reconcile this information in climatic terms, it is evident that the distribution of chickpea in Syria corresponds to those areas where the risk of cold damage is relatively low and heat unit accumulations are relatively high. That includes the south, and the wetter (i.e., low frost risk, higher winter GDD sum) areas of the north. Preference of chickpea over lentil in the south, and chickpea's southern predominance in stability zone 2, are probably connected to the later planting that is possible with chickpea. Planting lentil is risky because this crop is seeded early in the wet season. Planting chickpea (usually about 2 months after lentil) entails less risk because farmers adjust to dry conditions simply by not seeding.

Germplasm Conservation

ITGC/ICARDA Germplasm Collection Mission in Algeria

A forage and pasture legume germplasm collection in Algeria was carried out by a team from the Institut Techniques des Grandes Cultures (ITGC), Algeria and ICARDA from June to July. The mission was initiated to ensure that ICARDA's germplasm collection contains representative accessions of Algeria's native legumes. The team covered 6000 km, traversing central, west-southwest and east Algeria. These areas normally receive more than 350 mm annual precipitation and altitudes range from 25 to 1750 m a.s.l. Most material was collected in the western and eastern areas; collection in the central section was limited because high rainfall delayed maturation of plants.

The collected material was brought to ICARDA for multiplication, taxonomic verification, characterization and preservation. One-half of accessions with sufficient quantities of seed was left at ITGC. The accessions not held by ITGC will be sent to Algeria after seed multiplication in the ICARDA greenhouse in 1991/92. Data were stored in the Mediterranean Forage Legume Database. Collection data will be analyzed to relate the distribution of species and their genetic characteristics to soil, climate and natural vegetation.

Accessions from 21 genera (Table 5) were collected from 108 sites. The 248 accessions of *Vicia* greatly increased the representation of this genus in the ICARDA collection.

Table 5. Genera collected in Algeria, 1991.

Genus	No. accessions
Medicago	384
Trifolium	280
Vicia	248
Astragalus	114
Scorpiurus	69
Trigonella	49
Lathyrus	45
Melilotus	44
Hippocrepis	43
Coronilla	41
Lotus	28
Aegilops	14
Onobrychis	14
Anthyllis	11
Ononis	10
Hedysarum	9
Ornithopus	7
Pisum	4
Potereum	4
Tetragonolobus	2
Hordeum	1
Total	1421

Collection and Survey of Legumes in Syria

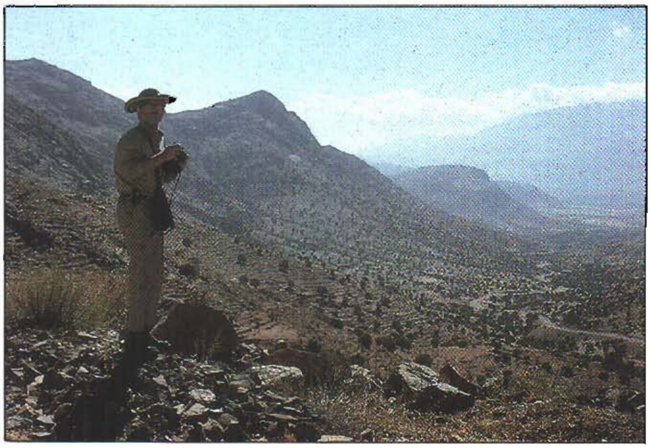
More than half of Syria is rangeland that receives less than 250 mm annual rainfall. It is intensively grazed by sheep and goats, and normally suffers from severe overgrazing and soil erosion. Legumes, which are well adapted to dry conditions, can still be found growing in this area. A study in collaboration with the Justus-von Liebig University, Giessen, Germany was initiated to collect these legumes and evaluate them in relation to their environment to enable selection of germplasm suitable for rehabilitation of degraded steppe.

Legume seeds were collected in the drier areas of the steppe, from the north through central Syria, including the Palmyrite mountains. Soil samples were collected from all sites for chemical and physical analysis.

All but three sites were heavily grazed and yielded few seeds. Of the 219 accessions collected (Table 6), *Astragalus* represented 42% of the total, *Trigonella* 24%, and *Medicago* 14%. Seeds will be multiplied at ICARDA and used for further agronomic and utilization studies.

Table 6. Legumes collected in the Syrian steppe, 1991.

Genus	Species	Accessions
Astragalus	9	91
Hippocrepis	1	8
Hymenocarpis	1	4
Lathyrus	1	1
Lotus	1	2
Medicago	6	30
Melilotus	1	3
Ononis	1	1
Onobrychis	1	12
Scorpiurus	1	1
Trifolium	6	11
Trigonella	7	53
Vicia	1	2
Total	37	219



USDA plant collector surveys a valley in Morocco.

Collection of Rhizobia for Pasture and Feed Legumes

We plan to establish an international collection of *Rhizobium meliloti* for annual *Medicago*, *R. trifolii* for clovers, and *R. leguminosarum* for feed legumes (*Lathyrus*, *Vicia*, *Astragalus*) and other indigenous legume species. The collection is intended to provide a bank of effective strains suitable for legumes with economic potential for the region, to promote and encourage research in strain selection in WANA, and to preserve the microbial resources in the region.

Most strains are collected from nodules and soils of the region during winter or spring. Dilutions from a particular soil sample collected from a specific area are used to inoculate legume seedlings. Rhizobia are then isolated from the nodules and preserved in a lyophilized (freeze-dried) state to minimize genetic variation and prolong storage life. Purified strains of rhizobia for pasture and feed legumes are available upon request to scientists of national programs and elsewhere.

The rhizobial collection now consists of 685 purified strains of effective rhizobia for pasture and feed legumes. Most are *R. meliloti*, with strains for annual medics, medics adapted to acid soils (most from Morocco) and medic strains obtained from foreign collections. A second group includes strains of clover rhizobia (*R. trifolii*) collected in the region. The rhizobial collection for feed legumes contains strains for *Lathyrus, Vicia, Pisum, Astragalus, Hymenocarpus* and *Scorpiurus*.

Cultures of spontaneous antibiotic-resistant mutants of 35 strains of medic rhizobia also are included in the collection. The collection is continually expanding with the assistance of cooperators from national institutions, IBPGR, and Microbial Resources Centres.

The ICARDA microbiology laboratory also produces peat-based inoculants utilizing gamma-irradiated peat. Inoculant quality is monitored by counting the number of rhizobia in the culture to ensure that it meets the standard of 10^9 rhizobia per gram of peat. In 1990/91 the laboratory distributed a record number of bags to cooperators throughout the region, mostly countries of the Mediterranean basin (Table 7).

Table 7. International requests for peat-based inoculants for pasture and feed legumes, 1990/91.

Legume	Amount of seed inoculated (kg)	No. of bags†	Country‡
Medics	298	85	Algeria
Medics	2488	711	Jordan
Medics	31	9	Iraq
Medics	17	5	Iran
Vetches	300	10	Jordan
Medics	882	252	Syria
Medics	56	16	Turkey
Medics	80	23	Morocco

† Each bag weighs 90 g and inoculates approximately 3.5 kg of medic seed or 3.0 kg of vetch seed.
‡ Includes cooperative projects between ICARDA and Ministries of Agriculture.

Documentation of Genetic Resources

Documentation of collections is an important genebank function with direct relevance to all other activities, from acquisition of new germplasm to provision of samples to users. Deficiencies in the germplasm documentation system, either in completeness and accuracy of information on accessions or in level of efficiency of data handling and data analysis, can negatively affect work of the entire gene bank. Thus, the Genetic Resources Unit at ICARDA critically examined in 1991 its documentation system, which had been in operation for a number of years on VAX computers. This assessment led to the decision to modify the current system and to implement a new system using Personal Computers.

Modifications to the documentation system concerned the descriptor scheme in use, composition and structure of database files for crops; and software for data handling. Crop databases are gradually being expanded to include the quantity and quality of seeds in base and active collections (stock control descriptors). Passport descriptors are being modified to remove ambiguity, which will simplify recording and interpreting information.

Efficiency of data handling largely depends on the structure of the database. The system has been trimmed to reduce the fields, resulting in fewer, but more closely related, descriptors. The structure of a typical crop database in the new format is shown in Figure 4. Database performance tests indicate that the changes in design of the database have increased the speed of data retrieval and reduced disk memory requirements. A menu-driven program to handle databases in the new structure has been developed using the CLIPPER development system. The databases also can be accessed through dBASE III+ or dBASE IV.

During transfer of the passport data files for all crops from the VAX computer to PCs, the data records were closely examined to verify the accuracy and consistency of information. In addition to a review of the passport data files for individual crops or genera, crop databases were crosschecked to ensure consistency

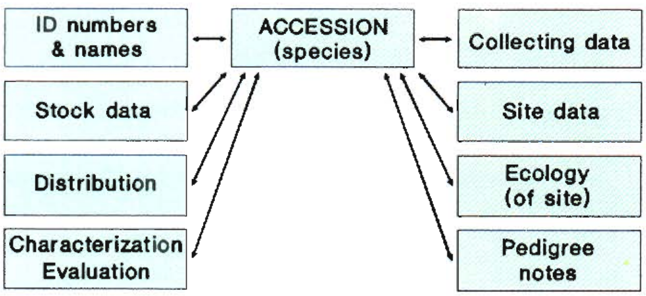


Fig. 4. New format depicting structure of a typical crop database. Descriptors with only one possible value are on the right, those with many possible values are on the left. The new format permits greater speed of data retrieval.

of data formats and locate gaps in information, particularly for germplasm collected during multi-crop missions. The data for germplasm collected by ICARDA (17 800 accessions, or 20% of the total holdings) were verified, discrepancies removed and gaps in the data filled according to the original collectors' records.

The importance of this work can be illustrated with the following. The GRU is proceeding with safety duplication of its collections, whereby ICARDA's chickpea collection will be duplicated at ICRISAT. In the past there has been substantial chickpea germplasm exchange between the two centers, and ICRISAT has received many accessions from the same donors. It was agreed to duplicate only that part of ICARDA's collection which does not overlap ICRISAT's.

Two catalogues published in 1991 (kabuli chickpea and durum wheat germplasm) were developed in cooperation with the Legume and Cereal Improvement Programs, respectively. These publications contain passport information and evaluation data on agronomic traits. Unlike catalogues of other crops published earlier by ICARDA, the chickpea catalogue uses scores for all quantitative traits.

Evaluation of Accessions

Barley germplasm

In a study to identify germplasm accessions having potential for highland areas in WANA, 159 accessions originating from the (former) USSR, Pakistan, Afghanistan and Iran were planted at Tel Hadya with five checks (Tadmor, Radical, Roho, Arar, Rihane-03).

Frost tolerance was a key character under evaluation. Extensive variation in this character, mostly based on lateness, exists among the tested germplasm. Accessions equal to the check Radical in frost tolerance originated from republics and regions of the former USSR (Uzbekistan, Turkmenia, the Caucasus region and Crimea), Iran and Afghanistan. Good cold tolerance, similar to that of the check Tadmor, was found in some accessions from the Baluchistan province of Pakistan, as well as in material from the USSR, Afghanistan and Iran. Most cold-susceptible germplasm originated from two provinces in Pakistan.

Generally, the tested germplasm headed later than the checks, especially material from north of the Caucasus. Accessions from Pakistan and some of the material from Iran headed relatively early. Mean grain yield of the tested germplasm was mostly below the local check level. Nevertheless, about 50% of accessions originating from Afghanistan and the Baluchistan province of Pakistan yielded more than the local check Tadmor, as well as some accessions from republics of Uzbekistan, Turkmenia, Azerbaijan and the Dagestan region of Russia. Iranian germplasm varied extensively in grain yield.

Although some barley germplasm from arid environments of central Asia and the Caucasus region demonstrated good yield performance and frost tolerance in this experiment, their potential for the highlands of WANA must be evaluated in an additional trial in a highland environment.

Iranian lentil landraces

A joint trial to evaluate the ICARDA lentil germplasm accessions of Iranian origin was conducted at Tel Hadya, Syria with the Seed and Plant Improvement Institute (SPII) of Iran. During this trial, an Iranian scientist was trained in lentil germplasm evaluation.

Seventeen characters were measured in 861 lentil accessions grown in an unreplicated trial with systematic checks (ILL 4400, ILL 4401, Precoz and Idleb). The largest variation for quantitatively scored descriptors was for the yield descriptors (seed yield, straw yield, harvest index). The taller accessions had higher seed and straw yields and also larger seed size. Higher straw yields were accompanied by higher seed yields. Other descriptors with large coefficients of variation were seeds per pod, height to first pod and plant height. Iranian accessions were more than 20 days later than checks in flowering. The 100-seed weight was significantly lower for the Iranian accessions than for the checks. Seed and straw yields also were lower than in the checks, a consequence of the late flowering of these accessions at the evaluation site.

The Iranian lentil accessions had mostly indehiscent pods and low pod drop, both important traits for modern lentil production. However, most accessions had medium to high lodging, which would interfere with mechanical harvest.

Seed Health

The Seed Health Laboratory plays an important role in ensuring safe reciprocal seed exchange between ICARDA and cooperators of national and international institutions. It is active in training national cooperators on detection techniques for seed-borne pathogens/pests.

In the past year, 98 consignments from cooperators in 35 countries were received after passing Syrian Quarantine Authorities. A routine procedure at ICARDA is to fumigate or freeze all incoming seeds to destroy insect pests, then inspect seeds for symptoms of infection, soil particles, weed seeds, bunt balls and nematode galls. In 1991, 55% more lines were tested than in 1990. Before planting, seeds that were not treated by the sender were treated with Vitavax 200 (for cereals) and thiabendazole or benomyl with tridemorph + Maneb (for legumes). In 1991, two quarantine pathogens that do not occur in Syria were detected (*Tilletia indica* and *T. contraversa*) in some consignments of wheat, which were subsequently destroyed.

Imported seeds free of quarantine pathogens were planted in the isolation area (approximately 19 ha) for one cycle as a precaution against inadvertent introduction of pathogens and pests. Careful field inspection in all plots revealed only one exotic pathogen.

During 1991, consignments of regular nurseries and specific trait germplasm of cereal and food and forage legumes were distributed from Aleppo to 72 countries. This represented a 13% increase in seed dispatch over the previous season. After testing, all exported seeds were provided with phytosanitary certificates issued by the Syrian authorities.

Seed health testing was conducted on seed samples from plots where disease symptoms were observed on plants. Compared with the previous year, the total number of lines tested increased by 105%. Seed samples of all bread wheat plots were tested and those contaminated by *Urocystis agropyri* (flag smut) were eliminated. Unless specific requests were made by the recipient for untreated seed, all dispatched seeds were treated with fungicides. Legume seeds also were routinely fumigated.

The increased demand for cereal nurseries from European countries reflects their growing interest in winter nurseries, but West Asia continues to receive the greatest number from ICARDA.

Field inspection received greater emphasis in 1991. The seed increase plots of crops destined for international distribution as well as seed multiplication fields of cereals and food and forage legumes were carefully inspected at appropriate growth stages. Particular attention was paid to wheat flag smut and barley stripe mosaic virus. Infected or even suspected plants were rogued and burned. Plots showing symptoms of flag smut were not harvested.

Virology

The activities of the Virology Laboratory focused on the following: (a) survey of viruses of faba bean and lentils in a number of WANA countries, (b) survey of seed-borne viruses of barley, faba bean and lentil in Syria, (c) evaluation of cereal breeding lines and wild relatives for barley yellow dwarf virus resistance, and (d) evaluation of faba bean lines for bean yellow mosaic virus resistance. Activities also included regular testing for seed-borne viruses in seeds dispatched in international nurseries and testing gene bank accessions to free them from seed-borne infections. The virology lab continued to provide ELISA kits for virus testing to a number of NARS laboratories upon request.

Legume viruses

Lentil and faba bean samples from plants showing virus infection symptoms, and collected from Algeria, Egypt, Jordan, Libya, Syria and Tunisia, were tested for virus identification. In faba bean, bean yellow mosaic virus was most common. The newly described faba bean necrotic yellows virus (FBNYV) was detected in faba bean samples from Jordan and Syria. In lentil, luteoviruses, FBNYV and other viruses were detected frequently. FBNYV was found to be naturally occurring in chickpea and a number of forage legumes (*Medicago*, *Melilotus*, *Trifolium* and *Vicia*).

A survey was conducted in Syria to assess the rate of seed-borne virus infections in faba bean, lentil and barley. Seeds collected directly from farmers at planting time were given serological tests. The infection rate of barley stripe mosaic virus (BSMV) in barley seed ranged from 0.0 to 25.9%; broad bean stain virus (BBSV), bean yellow mosaic virus (BYMV) or pea seed-borne mosaic virus (PSbMV) in lentil seed ranged from 0.0 to 2.8%; and BBSV, BYMV or PSbMV infection rate in faba bean seed ranged from 0.0 to 0.5%.

Food (chickpea, faba bean, lentil and pea) and forage legume crops were evaluated for their reaction to infection with pea seed-borne mosaic virus, a virus often detected in lentil and pea in Syria. Yield loss in response to infection varied from 41 to 66% in food legume crops, and from 12 to 36% in forage legume crops. Natural infection of chickpea is rare, and the high losses encountered with this crop in the experiment are unlikely to occur, whereas for the other crops evaluated, yield loss values obtained represented potential damage to the crops if prevailing conditions lead to high disease incidence.

Cereal viruses

A number of quantitative traits were evaluated as potential indicators of yield loss induced by barley yellow dwarf virus (BYDV) infection. In barley and durum wheat the correlation between yield loss and grain weight or harvest index was highly significant. In bread wheat, correlations were highly significant for biomass and grain weight. In all cases, it was evident that disease index was not a good indicator for yield loss, even in barley, where symptoms are thought to be useful in screening for BYDV resistance. One barley line (JLB7-17) produced very mild BYDV symptoms, but suffered a yield loss of 40% in response to BYDV infection.

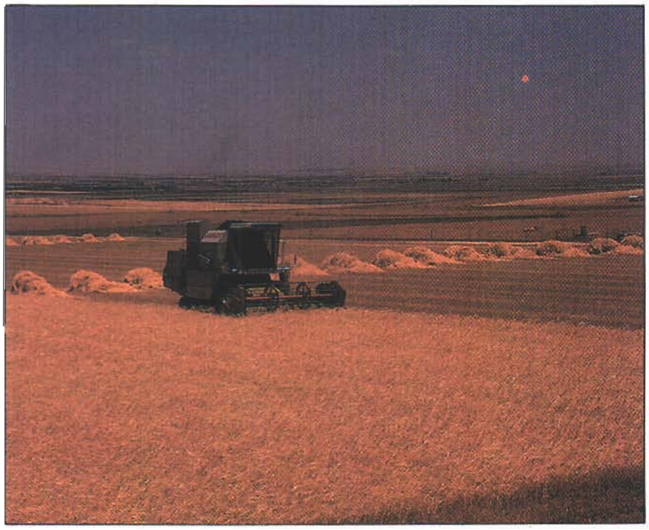
Germplasm Enhancement

Barley

Spring barley

In recent years, one of the most important activities of spring barley breeding at ICARDA has been the comparison of newly developed germplasm in contrasting environments, using experimental sites in northern Syria, Lebanon and Cyprus. This has addressed the question of whether selection for unfavorable conditions should be conducted in favorable or unfavorable conditions. The results indicate that to increase grain yield of barley in unfavorable conditions, selection must be conducted in those conditions. Selection can be improved further by using locally adapted germplasm.

A special nursery consisting of 360 six-row barley lines (F4 and F5) was distributed to Morocco, Algeria, Tunisia and Libya. These lines were not selected for yield in Syria and will be used to begin a specific selection program in north African countries. This work



Barley cover crop being harvested by a combine fitted with a straw collector. Straw and stubble are used for digestibility trials.

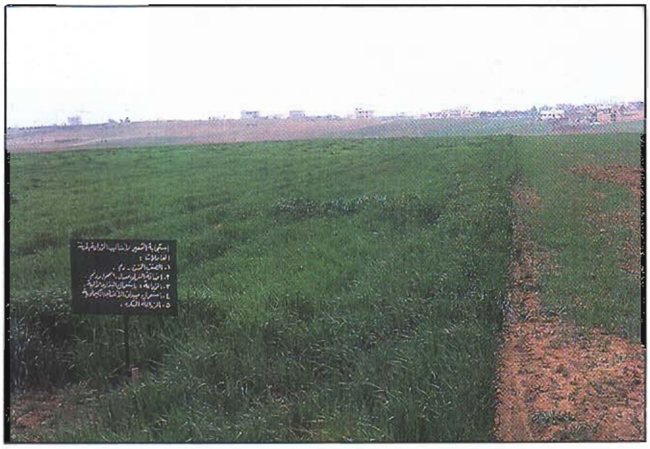
will be supported through a special project funded in 1991 by OPEC Funds for International Development.

Barley is one of the most reliable cereal crops in rain-fed agriculture. On-farm verification trials conducted in zone B in Syria (with 320 mm average rainfall) include barley, durum wheat and bread wheat: checks, cultivars currently grown by farmers, and new lines which are tested for 1 to 3 years. The trials provide information on the relative performance of the three cereals when grown side by side, planted on the same day, and receiving the same agronomic practices. Barley outyielded both durum wheat and bread wheat in all cropping seasons, except in years with severe frost and exceptional rainfall. The data confirm the yield advantage of barley over wheat in areas where abiotic stresses are less severe as well as in areas where barley is the officially recommended crop.

Use of genetic resources. Results of the last five cropping seasons showed that adaptation plays an important role in stress conditions and a breeding program is more efficient if adapted germplasm instead of exotic germplasm is used. Therefore we encouraged barley breeders in countries where landraces are still widely grown to use the variability presumably present in their local germplasm. The success of this methodology transfer has been variable. In some countries (Iraq and Tunisia) locally adapted germplasm is already used by some breeders. In others, like Iran, local landraces have been collected but not used. In three countries (Syria, Ethiopia and Nepal) barley breeders have begun this type of work in collaboration with ICARDA.

A new collection of individual heads from Nepalese barley landraces was made in 1989. The objective was to start a program of evaluation and selection similar to that in Ethiopia. Nepalese scientists collected and evaluated 313 local landraces (single heads and populations). Some were found to have partial resistance to yellow rust, one of the main yield-limiting factors in that country.

During 1990 and 1991, 313 head-row progenies and populations were evaluated by Nepalese scientists using the cultivar Bonus (a two-row recommended variety) as a systematic check. The material was evaluated for several traits including maturity, 1000-kernel weight and reaction to yellow rust and powdery mildew. There was



Demonstration plots illustrate the advantages of improved production packages over traditional methods.

wide variability in both phenology and kernel size but of more immediate interest was the variability in reaction to powdery mildew and yellow rust.

Adaptation strategies associated with terminal drought stress. Two adaptation strategies to terminal drought stress in Mediterranean environments have been observed. The first, represented by early entries, is based upon avoidance of terminal drought stress. In this case early heading is combined with good early growth vigor, and an ability to recover from cold damage.

The second strategy, represented by landraces from east and northeast Syria, includes tolerance to low winter temperatures and terminal drought, by combining medium early heading with slow early development. This implies a prostrate winter growth habit and poor early vigor. Because differences in early development are due to a difference in vernalization requirement, the success of each adaptation strategy depends upon the temperature regime in the target environment.

Under stress the landraces show lower year-to-year yield fluctuations than the early entries. In four environments with a similar yield level (130-150 g/m^2), but having a range in number of frost-days (14 to 44), four of the five early entries with a high yield potential had a standard deviation which exceeded that of all the landraces. Low winter temperatures have an impact upon the yield stability of the crop. Yield stability is important, especially in lower yielding environments, so the probability of occurrence of low winter temperatures in the target environment is an important factor in determining the optimum development strategy. The adaptation strategy of barley breeding material forms the basis of some of our future research.

ICARDA/CIMMYT barley project

High-yielding barley germplasm with multiple disease resistance. The objective of the project is to provide barley varieties, through national programs, to farmers in the Andean Region. These varieties must be resistant to rust (leaf, stripe, and stem), scald, net blotch and barley yellow dwarf virus, to reduce the risk of crop losses.

New varieties released in the Andean Region are superior in yield and have good resistance to prevalent diseases; however, diseases such as loose smut, which are easily controlled by seed treatment, could become a problem for farmers who retain seed for the following year's planting. Incorporation of genetic resistance through backcrossing to commercial varieties is in progress.

Early maturing barley with disease resistance. Early maturity is an important trait. Its incorporation into the ICARDA/CIMMYT germplasm provides national programs with an opportunity to select varieties for specific circumstances, such as a cash crop in a rotation that involves several crops per year, or for its utilization in a short-season growing period.

Seed of a hooded early maturing barley was increased to permit large-scale testing. The line will be grown as a companion crop with ryegrass for grazing experiments to be conducted in the Yaqui Valley in Mexico in a farmer's field.

The farmers of the Yangtze Basin in China require barley varieties with resistance to both scab and bean yellow mosaic virus (BYMV). Some crosses were made with Zhedar 1 and Zhedar 2, sources of scab resistance, and Zhedar 4 and Zhedar 5, sources of BYMV resistance. These varieties were provided by the Zheijiang Academy of Agricultural Sciences. New crosses were made with winter cultivars that have resistance to BYMV in Europe; among them Franka, Birgit, Ogra, Melusine and Torrent. The Bulk Method is used for generation advancement; fungicide is used to protect the lines against rust. In F5 populations, five individual plants per line were advanced for selection, based on agronomic merit and a range of maturities from very early types to those with maturity similar to the variety Gobernadora.

The variety Gobernadora continues to expand in nine Chinese provinces: Zheijian, Jiangzu, Anhui, Hebei, Hubei, Hunan, Fujian, Guandong and Shanghai. The total area under cultivation is not known, but in Shanghai Province Gobernadora is grown on 20 000 ha. In Shanghai, a new line similar in maturity and yield but shorter than Gobernadora could be released soon. In Sichuan Province, the area planted with V-24 is 40 000 ha; yields are 20 to 30% higher than commercial varieties.

Medic/barley rotations. Barley monoculture, as practised in the Upper Plateau of Mexico, has resulted in low yields and great foliar disease pressure. The rotation of a legume with barley is expected to break the life cycle of scald and net botch. Furthermore, the legume could fix N and improve the soil. Ley farming is being presented as a solution to the problem.

Winter and Facultative Barley

Winter and facultative barley is grown in areas with continental climates. In WANA region it covers approximately 6 million hectares in high-altitude areas where several biotic and abiotic stresses limit average yields to less than 1 t/ha. The objective of this project, in collaboration with NARS, is to increase facultative and winter barley production of WANA countries by minimizing the effects of stresses, increasing yield potential and strengthening the technical manpower of the national programs.

The strategy adopted is to analyze the germplasm, especially of WANA countries, for various traits. Crosses involve the use of locally adapted germplasm and use winter × winter, winter × spring, and facultative × facultative hybridization. The F2 is evaluated at a number of locations in WANA to target germplasm for the different environments. The success of a breeding program depends on the available genetic variability. New variability is obtained from many sources, particularly from environments with similar problems.

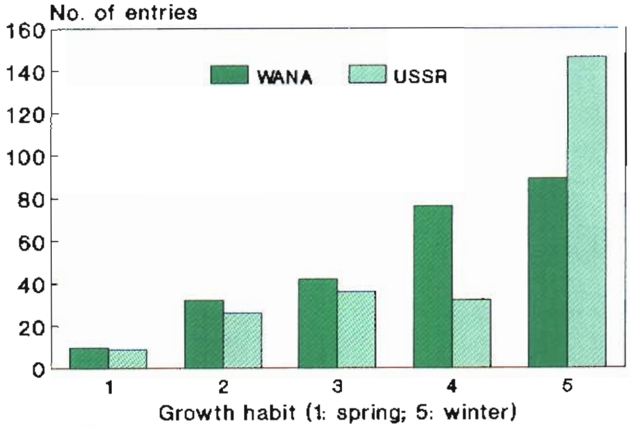


Fig. 5. Variation in growth habit of winter and facultative barley germplasm.

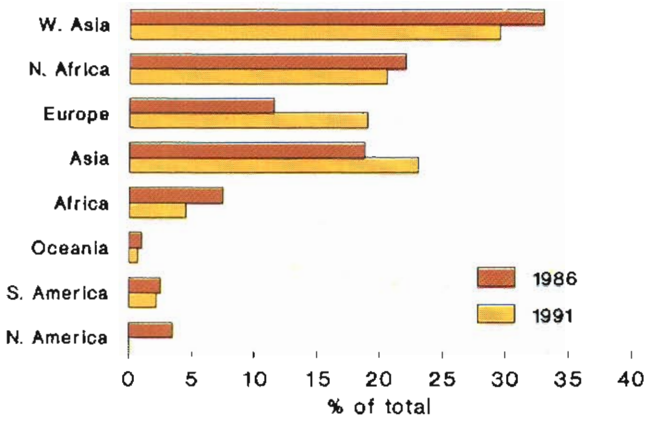


Fig. 6. Distribution of barley nursery sets in 1986 and 1991. (Asia excludes West Asia and Africa excludes North Africa.)

Two hundred and fifty-two entries of barley from WANA (Nepal, Pakistan, Afghanistan, Turkey, Morocco, Algeria, Ethiopia) and 252 from the (former) USSR were evaluated for agronomic score, growth habit, maturity, disease tolerance, and lodging resistance in the 1990/91 season. Variability for growth habit and maturity was large. The germplasm from WANA showed a gradation in growth habit from spring to pure winter types and a wide range of maturity types (Fig. 5). More than 80% of the barley germplasm from WANA and USSR was of the winter or facultative type.

The genetic variation for plant height was greatest in germplasm from WANA. In low-rainfall areas, tall and stable plant height is a desirable trait associated with yield stability. On the basis of disease tolerance, agronomic score and lodging resistance, 170 lines were selected for further evaluation.

Distribution of Nurseries

The distribution of barley nursery sets for 1986 and 1991 is compared in Figure 6. Requests for international nurseries were received from cereal scientists worldwide. In both periods West Asia received the largest share (30-33%), followed by North Africa and Asia; Australia, North America and South America received the least number of sets. In 1991, relative to 1986, a larger percentage (19%) of nurseries was sent to Europe, reflecting an increase in requests for winter nurseries.

Barley Pathology

Barley pathology research focuses on the control of barley diseases for present and improved farming systems in countries of the WANA region. Rapidly changing agricultural practices in the region will have a large effect on several barley diseases. Resistance remains the most sustainable method of disease control and the testing of material generated by breeding projects at ICARDA and NARS uses most of the barley pathology resources. Presently germplasm is screened in the field for four diseases: scald (*Rhynchosporium secalis*), powdery mildew (*Erysiphe graminis*), covered smut (*Ustilago hordei*) and common root rot (*Cochliobolus sativus*). Seedling tests are carried out for barley leaf stripe (*Pyrenophora teres*) and netblotch (*Pyrenophora graminea*). In the 1991/92 season, field screening for leaf stripe and netblotch as well as for loose smut (*Ustilago segetum*) will be improved.

Rather than selecting for high levels of disease resistance, we aim to eliminate susceptible lines because the environments in which barley is normally cultivated in WANA do not encourage the development of most leaf diseases. However, highly susceptible lines will suffer losses, as can be seen with scald in Syria. Determining the level of resistance needed and developing methods to measure this quantitatively are a high priority.

Six years ago a screening program for resistance to covered smut was started. Breeding material is rated after seed inoculation with a mixture of Syrian pathogen strains. Inoculation methods were modified to cope with the large number of entries. During the first two seasons, trials were sown at a high seed density and the percentage of smutted heads was noted at the end of the season. Since then, trials have been space planted to enable the evaluation of individual plants.

Avoiding susceptible parents would improve the level of smut resistance. However, even within crosses involving susceptible parents there is variability among sister lines, which allows negative selection against susceptibility. In the advanced yield trials, crosses were made with three or more sister lines, of which at least one line showed more than 15% smutted plants. In 11 out of 13 crosses, significant differences among sister lines were present.

Durum Wheat

The release and cultivation of high-yielding and stress-tolerant durum wheat cultivars has increased in the WANA region. High durum wheat yields were achieved largely with stress-tolerant and stable varieties, in both dryland and irrigated areas. Varieties such as Cham 1, Waha, Petra, Cham 3, Sebou and Omrabi are grown over large areas of the region. Six years after release, Cham 1 is grown on more than 0.5 million hectares in Syria; similar results have occurred in other countries of the WANA region. In addition, the area sown to Cham 3, a drought-tolerant cultivar adapted to the Middle East, increased greatly because of its good grain quality and high yield performance under drought. In 1990/91, 62 000 t of certified seed of Cham 3 was produced in Syria. In North Africa, Omrabi and Brachoua show high and stable performance. Omrabi lines have been released in Tunisia, Algeria and Morocco, and Brachoua is under increase in Libya.

The facultative durum wheat breeding activities of the last decade emphasized the development and distribution of germplasm adapted to high-altitude areas. Resistance breeding will continue to focus on cold, yellow rust and common bunt. In addition, training will be targeted to national programs with major durum-growing areas in high-altitude regions. One hundred crosses between germplasm carrying winter growth habit and cold tolerance and germplasm adapted to high-altitude areas were made. Parental material was selected for yellow rust resistance, and 14 populations were selected for further screening. From the advanced lines, 38% were selected for regional testing.

Threshing percentage

Moisture stress reduces sink development and terminal stress limits yield by reducing the grain-filling period and/or the grain-filling ability of a genotype. Threshing percentage is a measure of the percent grain weight of total head weight and expresses the ability of a genotype to fill the potential sink sites in the spike.

There was great variability in grain filling between the various genotypes in Syria, especially at the driest site, Breda. The trait showed highly significant positive correlation with yield at both moisture environments, Tel Hadya and Breda. Figure 7 shows the relation of threshing percentage and grain yield in Breda for the 1990/91 season.

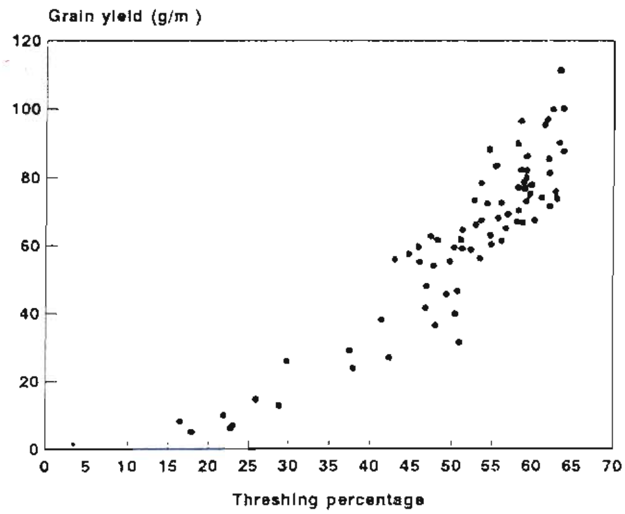


Fig. 7. Relation between grain yield and threshing percentage in 81 durum wheat genotypes.

In an analysis combining three years of data, the trait correlated highly with grain yield at both sites. This trait will now be included in our routine screening; it may have practical application for genotype assessment in severely moisture-stressed environments.

Spring Wheat

Spring bread wheat breeding

During 1991, the CIMMYT/ICARDA spring bread wheat breeding project emphasized the development of improved, adapted germplasm for the variable and unpredictable environments of West Asia and North Africa, with special attention to rain-fed areas, particularly those receiving less than 400 mm annual rainfall.

The emphasis is on crosses for low-rainfall areas where abiotic stresses are most important. Biotic stresses are important in the moderate to high-rainfall areas of WANA where they reduce yields. About one-third of our crossing program is aimed at abiotic stresses. About 20% of the crosses involve unconventional material such as landraces, extracted from collections made in the region. They were evaluated for two to three consecutive years under drought, cold and disease pressure before being promoted to crossing blocks.

Several promising bread wheat lines were identified with higher yields than local and improved checks. Table 8 presents the number and percentage of lines yielding more than the checks.

Close integration between ICARDA scientists and key national program staff in WANA has resulted in the identification of a number of improved genetic stocks. These stocks are assembled as parental material having desirable traits and are distributed yearly, upon request, to NARS for use in their breeding programs (Table 9). During the last 5 years, 840 accessions have been distributed.

Table 9. Number of bread wheat lines with desirable genetic traits distributed to national programs as genetic stocks.

Characteristics	1987-90	1991	Total
High yield and stability	144	36	180
Abiotic stress resistance			
Terminal drought	99	23	122
Cold	46	13	59
Terminal heat	54	13	67
Biotic stress resistance			
Yellow rust	56	17	73
Leaf rust	36	9	45
Stem rust	16	3	19
Septoria leaf blotch	53	9	62
Common bunt	36	13	49
Wheat stem sawfly	61	17	78
Hessian fly	3	4	7
Selected landraces	24	12	36
Breadmaking quality	33	10	43
Total	661	179	840

Over two years the average yield superiority of a promising bread wheat line (Gomam) over the national check was 9% more than the improved check in farmers' fields of Syria. This line also performed better than the checks in 34 rain-fed locations of WANA during 1989. Gomam was grown in verification trials and will be considered for possible release next year.

Table 8. Bread wheat lines yielding more than local and improved checks in different environments.

	Mexipak		Cham 4		Cham 6		All 3 checks	
Environment	No.	%	No.	%	No.	%	No.	%
Terminal drought	122	46	130	49	30	11	15	6
Cold (early planting)	229	87	94	36	65	25	54	20
Terminal heat (late planting)	208	79	195	74	61	23	50	19
High input	93	35	97	37	159	60	58	22

Seed of this cultivar is under multiplication by ICARDA's seed unit.

Bread wheat pathology

The 1990/91 season was favorable for screening for resistance to yellow rust (*Puccinia striifornis*), leaf rust (*P. recondita*), stem rust (*P. graminis*), septoria tritici blotch (*Mycosphaerella graminicola*) and common bunt (*Tilletia foetida* and *T. caries*) at Tel Hadya and Lattakia (Syria) and Terbol (Lebanon). During the off-season in Terbol, the summer planting developed leaf rust and stem rust well and yellow rust was present on a few susceptible lines. The main season was characterized by the occurrence of a severe leaf rust epidemic in Syria and Lebanon, which mainly affected the durum wheat cultivars in Syria but allowed us to identify susceptible material in the bread wheat nurseries.

International Nurseries

Resistance screening to wheat diseases from the past five seasons has produced four germplasm pools with sources of resistance to yellow rust, leaf rust, septoria tritici blotch and common bunt. Sets of these pools were dispatched to collaborators in WANA and beyond. The pools contain good sources of resistance that could be used in crossing programs.

In wheat leaf rust and wheat yellow rust nurseries, 86 and 93% of the entries respectively were resistant; in the wheat preliminary disease nursery, 53% of the entries were resistant to stem rust, whereas for septoria 50% were resistant. For common bunt, 35% were resistant.

Regional durum wheat nurseries were assembled by the joint CIMMYT/ICARDA durum wheat project at ICARDA in 1991. The number of spring-type regular nurseries was unchanged. The two germplasm pools for disease resistance, which had been made available for the last two consecutive seasons, were withdrawn as planned. New germplasm pools will be made available next season. The nursery containing winter-type segregating populations was discontinued.

Requests for the regional nurseries were received from cereal scientists worldwide, except Oceania. In 1986 countries in West Asia received the largest share (39%) followed by North Africa, but in 1991 North Africa received the largest share (35%) followed by West Asia. In 1991, 67% of total nursery sets were sent to WANA (excluding Ethiopia, Sudan and Pakistan) compared with 60% in 1986. This trend is expected to continue following the CIMMYT and ICARDA agreement on nursery distribution. Figure 8 summarizes the strategy, devised in consultation with national programs of the region. Improved material developed at CIMMYT in Mexico and by the CIMMYT/ICARDA project in Aleppo is included in the nurseries.

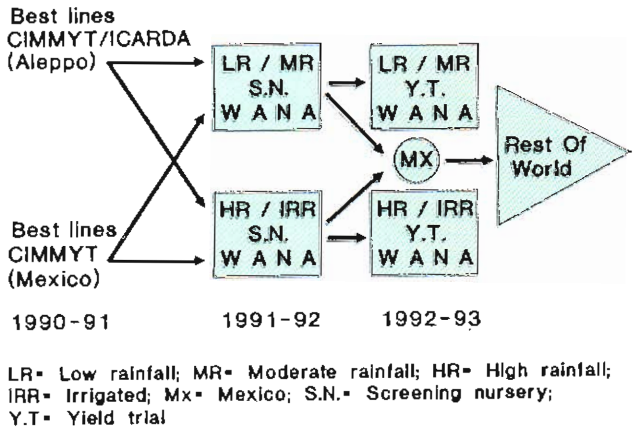


Fig. 8. Joint CIMMYT/ICARDA scheme for nursery distribution.

Legumes

The Legume Program encourages and supports the national efforts in West Asia and North Africa (WANA) and other developing countries to improve the productivity and yield stability of cool-season food legumes (lentil, chickpea, faba bean, dry pea) and annual feed legumes (mainly vetches and chicklings). It also aims to enhance their role in increasing the sustainable productivity of cereal-based, rain-fed farming systems.

The process of devolution to national programs of the responsibility for the improvement of faba bean continued to phase out the research at ICARDA. The ICARDA faba bean breeder and pathologist, who transferred faba bean research to the scientists of INRA, Morocco, at Douyet Research Station near Fes, left Morocco in September 1991. The final phase of the transfer is being handled by the ICARDA legume scientist posted at Fes.

Consistent with ICARDA's focus on the dry areas, research efforts on legumes adapted to dry environments were increased. Researchers from the legume and other ICARDA programs worked on specific research projects in multidisciplinary teams, often with national program scientists. Research on kabuli chickpea was conducted jointly with the International Crop Research Institute for Semi-Arid Tropics (ICRISAT). We continued collaboration with institutions in the industrialized countries on basic research, particularly in the application of biotechnological tools in crop improvement.

Although the improvement research on lentil, kabuli chickpea, dry pea and forage legumes was centered at Tel Hadya, several ICARDA testing sites in Syria and in the Beka'a valley of Lebanon also were used. Breeding material was advanced through an additional generation during summer at Terbol research station for kabuli chickpea and lentil and at Annaceur (Atlas mountains, Morocco) for faba bean. Several national program research sites were jointly used for strategic research on the development of breeding material with specific resistance to some key biotic and abiotic stresses because of the presence of ideal screening conditions there.

Kabuli chickpea

Yields of chickpea are low and unstable in WANA, but improvement is possible through the adoption of winter sowing in low-altitude regions. Trials at three ICARDA sites (Tel Hadya, Jinderess and Terbol) for 8 years (1983/84 to 1990/91) with more than 100 newly bred lines per year have shown that winter-sown chickpea produces 71% or 659 kg/ha higher yield than spring-sown chickpea. The yield increase from winter sowing rises to 133% with the 10% top-yielding genotypes. Winter sowing is expanding in WANA with the area estimated at 30 000 ha for 1990/91 (Fig. 9). Adoption studies in Syria and Morocco showed that farmers realize the advantage of winter sowing.

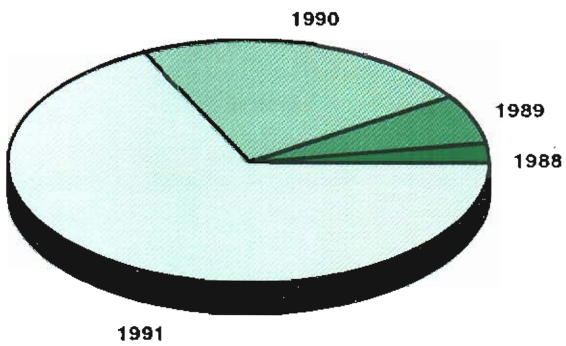


Fig. 9. Estimated adoption of winter chickpea in the Mediterranean environment.

Winter-sown chickpea consistently outyields the spring-sown crop in low-altitude areas in the Mediterranean environment.

National programs have made good use of ICARDA's enhanced germplasm. Eight cultivars including two in Algeria (FLIP 84-79C and FLIP 84-92C), two in Iraq (ILC 482 and ILC 3279), one in Syria (Ghab 3 = FLIP 82-150C), two in Tunisia (FLIP 84-79C and FLIP 84-22C) and one in Turkey (Akcin = 87AK 17775) were released in 1991. Thirteen NARS have selected 47 lines for pre-release multiplication and/or on-farm trials.

Resistance breeding. To stabilize chickpea production, efforts continued in breeding for stress resistance. Evaluation of 20 000 germplasm accessions for ascochyta blight resistance during the past decade has resulted in the identification of resistance sources (Table 10). Resistance of a few kabuli accessions to fusarium wilt was confirmed, as was resistance of ILC 5901 to leaf miner. Three kabuli accessions were identified as drought resistant. Two lines were confirmed as the best sources of tolerance to cold out of 10 000 accessions evaluated so far.

Table 10. Sources of resistance to biotic and abiotic stresses in kabuli chickpea identified between 1978 and 1991.

Stress	Source of resistance
Ascochyta blight	ILC 72, ILC 182, ILC 187, ILC 200, ILC 2380, ILC 2506, ILC 2956, ILC 3279, ILC 3856, ILC 4421, ILC 5586, ILC 5902, ILC 5921, ILC 6043, ILC 6090, ILC 6188
Fusarium wilt	ILC 54, ILC 240, ILC 256, ILC 336, ILC 487
Leaf miner	ILC 316, ILC 992, ILC 1003, ILC 1009, ILC 1216, ILC 2622, ILC 5594, ILC 5901
Cold	ILC 794, ILC 1071, ILC 1251, ILC 1256, ILC 1444, ILC 1455, ILC 1464, ILC 1875, ILC 3465, ILC 3470, ILC 3598, ILC 3746, ILC 3747, ILC 3791, ILC 3857, ILC 3861, mutant of ILC 482
Drought	FLIP 87-59C, ILC 6104, ILC 6118

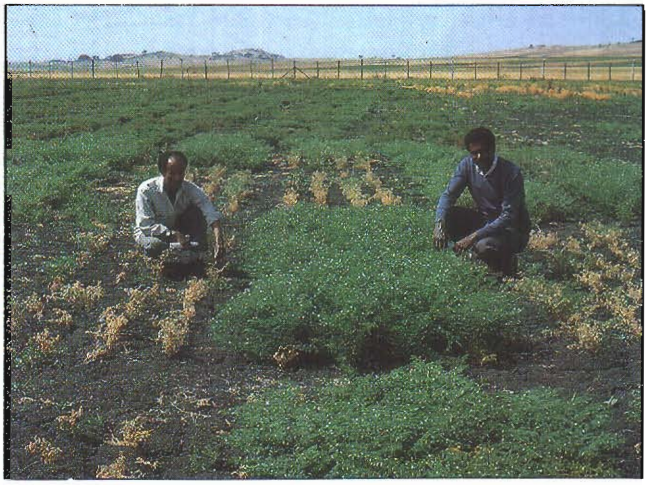
Evaluation of over 1300 ICARDA breeding lines using six races of *Ascochyta rabiei*, the causal agent of ascochyta blight disease, revealed that three lines (FLIP 84-79C, FLIP 85-86C and FLIP 90-103C) had a highly resistant reaction (rating 2 on a 1 to 9 scale).

Accessions of annual wild *Cicer* species have been found to possess resistance to multiple stresses. Three separate interspecific crossing programs were initiated to transfer genes for cold tolerance, cyst nematode resistance and seed yield. The first backcrosses have been made for all three traits.

A karyotype analysis of eight annual *Cicer* species revealed two groups: (a) *C. arietinum*, *C. reticulatum* and *C. echinospermum*, and (b) *C. bijugum*, *C. cuneatum*, *C. judaicum*, *C. pinnatifidum* and *C. yamashitae*. Within each group, it is possible to obtain fertile hybrids through crossing. Molecular markers derived by DNA fingerprinting were used to follow the interspecific crosses. Attempts are being made to identify markers that may be linked with the genes that contribute to ascochyta blight resistance. In collaboration with the University of Frankfurt, the application of Polymerase Chain Reaction technology is being studied and DNA fingerprinting is being used to study variability in *Ascochyta rabiei* to facilitate disease resistance breeding.

Studies were initiated using host pathogen/race combinations on the components of resistance to ascochyta blight as this information will help in developing partial resistance. Disease severity rating was negatively related with the latent period (LP) for infection and positively with lesion size and lesion growth rate (LGR). High disease severity ratings were always accompanied by a simultaneous occurrence of high LGR, high pycnidia number (PN) produced per lesion, short LP and high sporulation (SPO). Low severity ratings were associated with low LGR, low PN, long LP and very low SPO.

Insect control. Leafminer (*Liriomyza cicerí*) and podborer (*Helicoverpa armigera*) damage was reduced by spray of neem seed extract. However, the protective effect lasted for only 7—10 days. Studies on chickpea/leafminer interaction revealed that leaf exudates were among the factors imparting host resistance. Control of the seed bruchid *Callosobruchus chinensis* in storage could be achieved up to 6 months



In Ethiopia, chickpea lines are screened for resistance to root and wilt rots.

by use of such insecticides as Actellic or K-othrin (at 0.5 g/kg seed). Use of 3 ml neem seed oil with 20 g salt per kg seed also provided acceptable seed protection.

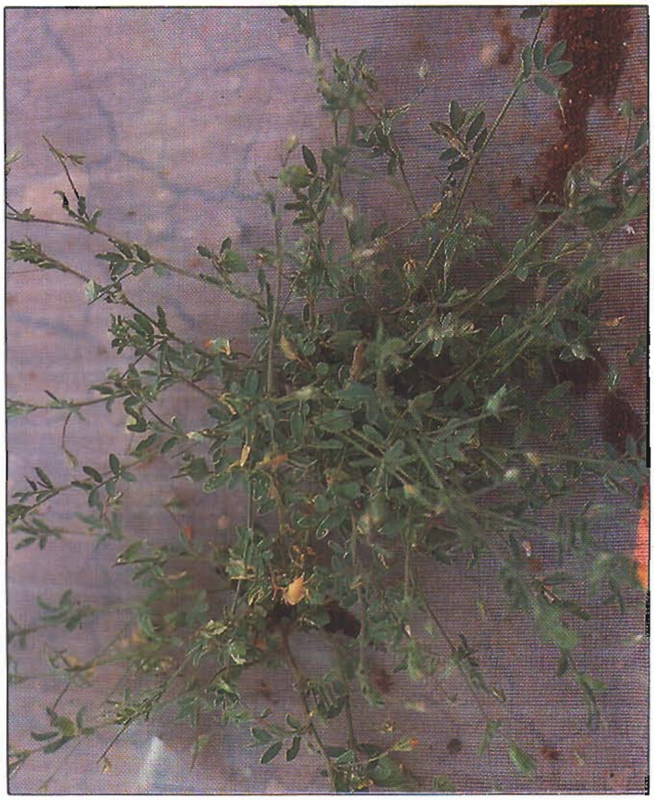
Nitrogen fixation. In studies of the need for inoculation with *Rhizobium* spp. to improve N_2 fixation, the symbiotic effectiveness of resident rhizobial populations at 38 chickpea-growing sites in Syria was evaluated using a hydroponic N-free system and two chickpea cultivars (ILC 195 and ILC 482). The ability to fix N in an N-free system (where plant N = fixed N), compared with uninoculated plants fed adequate combined N for maximum growth, gave the test of symbiotic efficiency. Soils of more than half the tested sites contained a native population with low symbiotic efficiency, where inoculation with selected superior strains was consistently positive.

Our chickpea rhizobia collection (100 strains) was characterized by collecting data on symbiotic effectiveness with a range of improved cultivars, salt and heat tolerance and intrinsic antibiotic resistance (IAR). IAR characterization separated the collection into four distinct regional groups. Polyclonal antisera for highly effective strains from each group are under preparation for strain identification using ELISA technique.

Lentil

Progress in the use of ICARDA's enhanced germplasm occurred in all the three contrasting agroecological regions (the lowland Mediterranean region, the highlands and the southern latitude region) on which our breeding efforts are targeted. With the release of three cultivars (Arbolito in Argentina, Sazak-91 in Turkey and Crimson in USA) during 1991, the total number of cultivars released so far has reached 25 in a total of 18 countries. In addition, 16 lines are in pre-release multiplication or on-farm testing by NARS in the Mediterranean region, four in the highlands, nine in the southern latitude region in Asia and Africa, four in Argentina and one in China.

Nearly 250 crosses were made and handled in a bulk-pedigree method using off-season generation advancement. The international breeding nurseries have evolved and diversified from the stage of provision of yield trials to supply of an additional wide range of crossing blocks/resistance sources and segregating populations for each of the three major target agroecological regions. There was an increase in the number of entries provided by NARS in the international trials.



Screening of cultivated and wild lentils (shown here) has identified sources of resistance to fusarium wilt and ascochyta blight.

Faba bean lines are screened for resistance to *Orobanche* at Douyet Research Station in Morocco.

Over 120 accessions of wild relatives of lentil were evaluated for various agronomic characters. Valuable variation for earliness was observed, which can be used in lentil improvement. Screening of these accessions for drought and increased moisture supply using a line-source sprinkler at Breda showed interesting variability, which could be useful in our breeding program.

DNA fingerprinting, using digoxigenin-labeled oligonucleotides as probes, was tested to detect genetic variability within and between the subspecies of *Lens*. More enzyme/probe combinations have to be tested to obtain useful banding patterns.

Disease resistance. Screening of lentil lines for vascular wilt at seedling as well as adult stage revealed that three lines (ILL 6434, -6991 and -6995) were most promising and these will be shared with NARS in the form of Lentil International Fusarium Wilt Nursery. Re-screening for wilt resistance at adult stage of 41 wild accessions, which were resistant to wilt in seedling stage, revealed that eight accessions were highly resistant. Some of these also showed resistance to ascochyta blight. Of the four wild lentil species/subspecies, *L. nigricans* subsp. *ervoides* had the highest proportion of accessions showing resistance to ascochyta blight.

Harvest mechanization. Lentil harvest mechanization was promoted in Northern Syria in cooperation with the General Organization of Agricultural Mechanization. An impact of these efforts was evident from the increase in the area harvested by swathe-mower in Kameshly.

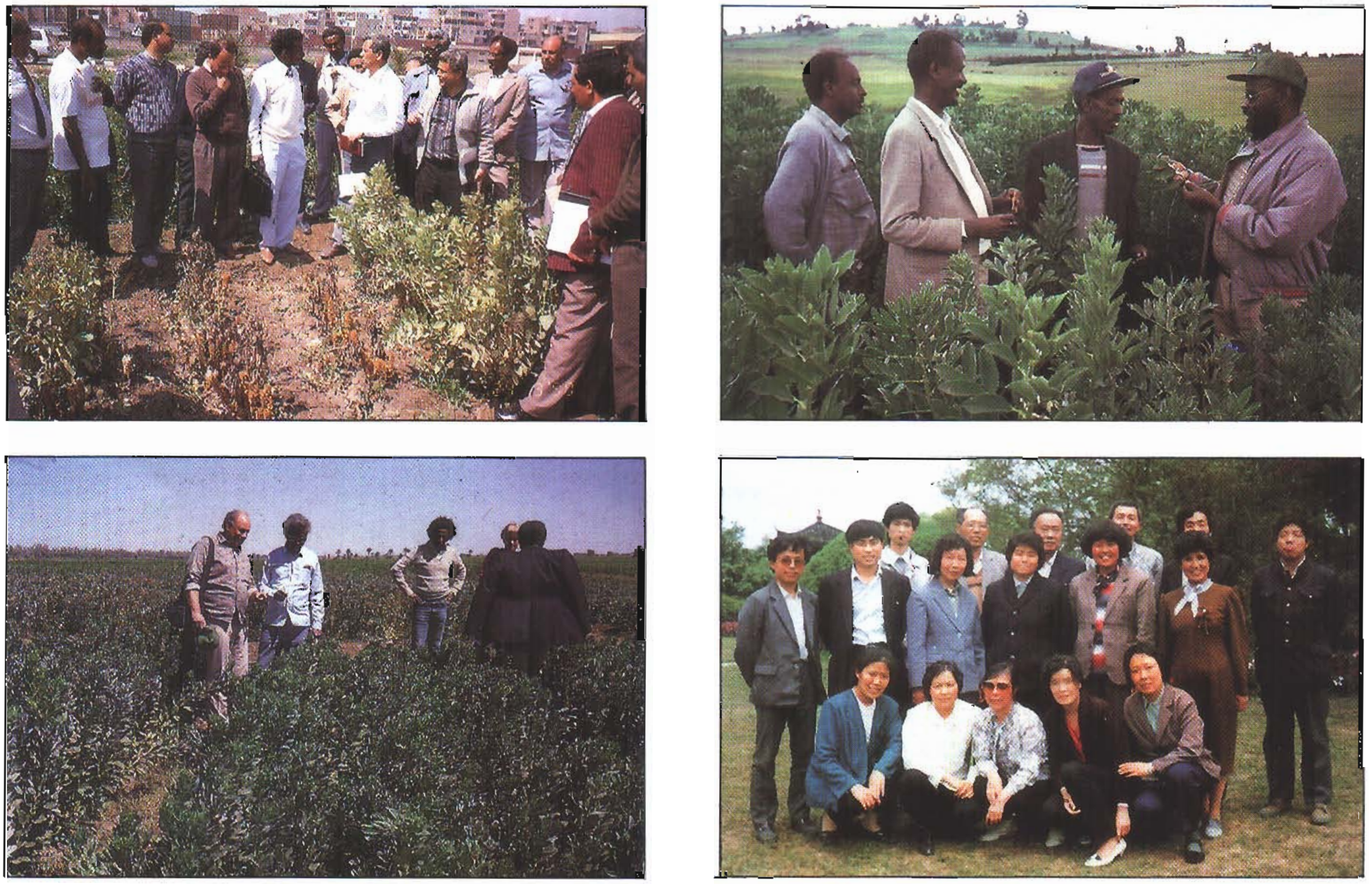
Biological nitrogen fixation. In a field evaluation of four strains of lentil rhizobia, selected after large-scale greenhouse screening of 250 different isolates, strains 739 from Syria and 760 from Portugal produced significant yield responses of ca. 20 and 40%, respectively, across four different lentil cultivars in the presence of native lentil rhizobia at Tel Hadya. These results indicate a potentially important role for lentil inoculation with selected *Rhizobium* strains.

Insect control. The effect on yield and the nitrogen status of plants of the feeding of *Sitona crinitus* larvae on lentil nodules was studied at four locations in northern Syria using a soil application of Carbofuran or seed treatment with Promet insecticide. The insecticides reduced nodule damage and increased the nitrogen status of plants at flowering. The adverse effect of *Sitona* damage on nitrogen nutrition of lentil was particularly conspicuous at Alkamiye, where untreated plots showed typical symptoms of nitrogen deficiency, emphasizing the importance of *Sitona* control for the dryland agriculture. Studies on control of the seed bruchid *Callosobruchus chinensis* in storage showed that although insecticides Actelic and K-othrin were the most effective agents, satisfactory control also could be obtained by treating the produce with olive oil + salt.

Faba Bean

The ICARDA faba bean research team at Douyet research station took appropriate steps to transfer the improvement research to Moroccan scientists and established close links between this group and the other

Faba bean research has been devolved to national programs. The Douyet Research Station of INRA will serve as a base for North African research.



Strong faba bean improvement teams are in place in (clockwise from upper left) Egypt, Ethiopia, China and Sudan.

NARS in North Africa. Offices, pathology laboratory, seed preparation laboratory, screenhouse facilities for pure line breeding and field facilities for disease screening research were established. Improved faba bean germplasm, including inbred and advanced lines with disease resistance, closed flowers, determinate growth habit and Independent Vascular Supply (IVS) trait, were transferred. North African Regional Yield Trials and *Orobanche* nurseries were initiated. Verification trials to transfer *Orobanche* resistant lines to Moroccan farmers were initiated.

The NARS continued to make good use of enhanced germplasm from ICARDA and expanded their own varietal improvement programs. In Syria, Hama 15 (a selection from ILB 1270) was released. In Egypt, Giza 461 and Reina Blanca were released because of their superior yield and resistance to foliar diseases. In Sudan, Shambat 75 and Shambat 104 have been released for non-traditional faba bean growing areas.

Determinate lines are in on-farm trials in China and Syria. In Tunisia, three lines have been selected for pre-release multiplication because of their superior yield in drought conditions during the last three years. In Algeria, 14 lines are in multilocation tests. Line ILB 1814 is in pre-release multiplication in Iraq and Chile. In Ethiopia, a cross bulk has been purified and is now in pre-release multiplication.

Major progress during the 1990/91 season was made in developing *Orobanche*-resistant faba bean. Three selections (18009, 18035 and 18105), previously rated as *Orobanche* resistant, were verified in naturally infested fields of farmers, where they gave significantly higher yields, and much less *Orobanche* infestation than Aquadulce, the check. Seeds of these lines are being multiplied. An integrated system for the control of *Orobanche* was tested at Douyet, which could further improve the performance of *Orobanche*-tolerant cultivars.

Studies on the control of *Bruchus dentipes* on farmers' field in Syria showed that two applications of such insecticides as Metyphon, Fastac and Dimethoate at early podsetting and 2 weeks later resulted in significant reduction of insect infestation in faba bean.

Forage Legumes

In spite of the diversity of feed legume species in the Mediterranean region, few have been used specifically as feed crops, and little effort has been given to improving them. Our goal therefore has been to develop improved cultivars of species currently in use by farmers and to examine the potential of alternative wild species found in areas receiving 250-500 mm rainfall. The two genera intensively evaluated are vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.)

Evaluation of improved lines of common vetch (*V. sativa*) in Morocco resulted in identification for release of IFLVS 1812/2083, which shows good resistance to *Orobanche*. Studies at Quetta showed that *Vicia villosa* ssp. *dasycarpa* was well adapted to the cold and harsh environments of highland regions.

Pod shattering is a serious problem in common vetch. Crosses between nonshattering lines and dehiscent high-yielding types were made. Superior families with complete indehiscence were selected and distributed to NARS in WANA.

Subterranean vetch (*Vicia sativa* ssp. *amphicarpa*) was identified as a potentially important species for developing ley farming because of the hardness of the seeds produced underground. Barley grown after underground vetch produced significantly higher grain and forage yield than barley after barley.

The seasonal evapotranspiration of various feed legumes in this drought year was similar to that of food legumes but feed legumes were superior in water-use efficiency. *Vicia narbonensis* and *Lathyrus sativus* had the highest water-use efficiency for total biological yield and *Vicia narbonensis* for seed yield.

Evaluation of legume seeds for anti-nutritional factors. Although members of the Leguminosae enjoy widespread use as protein sources in both human and animal feeding, it has long been recognized that their nutritive value and protein digestibility are poor, and they may be toxic unless subjected to heat treatment. The anti-nutritive effects have been ascribed to a number of inherent constituents of most legumes. Before a legume is used for human and/or animal feed, evaluatory tests are necessary to establish if the full nutritional potential is to be realized.

In Syria, *Vicia* and *Lathyrus* are used as supplements to cereal straw and grains in dry season sheep feeding, or as partial replacement for soya bean in poultry diets. For example, *V. narbonensis* has considerable promise in the 250-300 mm rainfall zone with some lines having seed yield in excess of 3.0 t/ha and a harvest index of 40%. Its nutritional value is reduced because of the presence of tannins. Genetic variability in the tannin content is therefore being studied.

Similarly, *Lathyrus* species have tremendous potential and could be important grain legumes for animals and humans in some parts of the WANA region. The major drawback to their full utilization is the presence of a potent, low molecular weight neurotoxin: BOAA or diaminopropionic acid (ODAP). This non-protein amino acid has been implicated in the development of an irreversible neurodegenerative condition (lathyrism) in subjects consuming the seeds. Quite often, lathyrism manifests itself as an irreversible spastic paralysis of the legs and in extreme cases death can result.

A crossing program was initiated to reduce the neurotoxin (BOAA) content of high-yielding and well-adapted genotypes of *Lathyrus sativus* using a parent with low BOAA content. The analysis for BOAA content is intended to establish the relationships between the concentrations of anti-quality components and certain agronomic and morphological characteristics.

Dry pea. Evaluation of dry pea cultivars introduced from other institutions for adaptation to dry areas of WANA was continued. Of 72 new accessions received, 10 high-yielding selections were retained for evaluation of their performance at ICARDA sites in Syria and Lebanon prior to incorporating them in the Pea International Adaptation Trial.

The optimum plant density for conventional leaf-type pea was 36 plants/m^2 and 80 plants/m^2 for the leafless types, under both rain-fed and assured moisture conditions.

International Nurseries

For the 1991/92 season, 956 sets of 35 different nurseries of chickpea, lentil, chicklings, vetches and pea were distributed to more than 135 cooperators in 55 countries. Stability analysis of various lentil and chickpea international yield trials permitted identification of genotypes with wide adaptation.

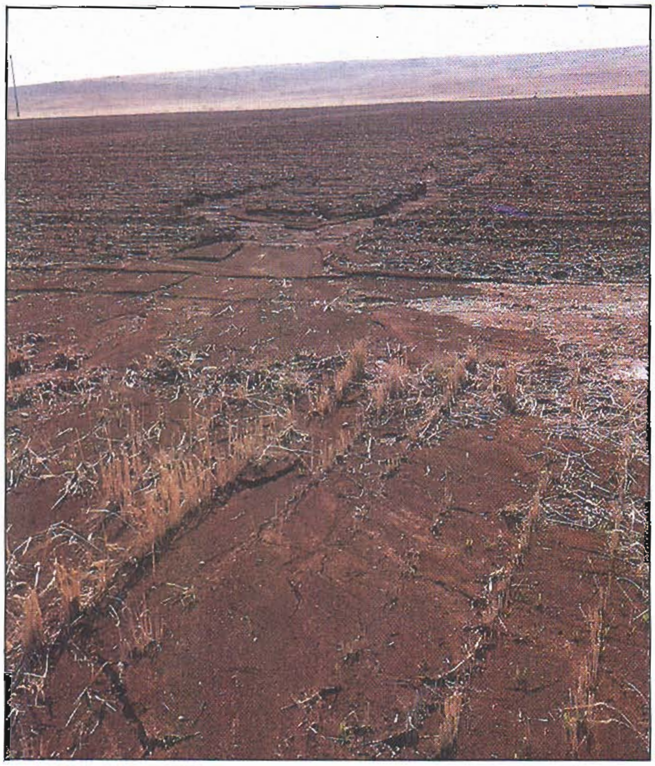
Resource Management and Conservation

Soil Erosion

Information about the magnitude of erosion losses and the relative importance of contributing factors is necessary to develop strategies to prevent or reduce soil loss. In northwest Syria, erosive winds occur mainly during June, July and August when the soil is dry and the surface cover very sparse. After harvest, sheep graze cereal stubble, leaving large areas almost entirely bare. Soil management is a critical factor in preventing erosion.

In a study to examine erosion losses by wind, samplers were placed at eight sites in four locations along a rainfall gradient: Tel Hadya, Breda, Ghrerife and Maragha (annual means: 327, 262, 244 and <200 mm, respectively) to collect air-borne dust. Although the recording period was short and only at the end of the wind erosion season in 1991, the collected data are of considerable interest and, significantly for the future of this work, the methodology employed performed well. In particular, the data show that, in a highly erodible field, the lateral build-up of local wind erosion can be studied. When wind speed, wind direction, and the lateral and vertical distribution of the collected material are known, the origin of the collected material can be determined.

Erosion was highest in a seed medic field at Tel Hadya, which was harvested by a method that pulverized the soil. Tel Hadya soils normally are not susceptible to wind erosion because their high clay and calcium carbonate content results in stable aggregates that are sufficiently irregular to protect loose, erodible soil from all but the strongest winds. Had it been cultivated after harvest, the seed medic field would have been less susceptible to erosion.



Wind erosion of topsoil can be severe in Aleppo province after harvest and stubble grazing.

The low values recorded for soil erosion at the other sites (Breda and Ghrerife) probably reflect the timing of the measurements (after the period of strongest winds) and the relatively low erodibility of the fields. As the Tel Hadya field shows, surface condition is the major factor on open land. Serious wind erosion can occur almost anywhere when the surface aggregates are pulverized, and this happens every year on farmers' stubble and fallow fields (and on grazing land) through the agency of small ruminant hooves. Such situations need to be included in future wind erosion studies, and simple preventive measures such as strip tillage evaluated.

Erosion control with *Atriplex* hedges

As mechanized tillage extends further into the flatter areas of dry rangeland and marginal arable lands, the danger of serious wind erosion intensifies. Appreciable wind erosion was observed in grazed fields of barley stubble in the Ghrerife area (mean annual rainfall, 250 mm) in 1990 and 1991. One potential solution to the problem is to plant windbreaks.

Atriplex **hedges, intercropped with barley, provide forage and protection against erosive winds.**

Atriplex spp. are drought-resistant fodder shrubs planted to improve degraded dry rangeland. Stands of these shrubs can control wind erosion, but stands may be less attractive to land users in steppe areas than the quick returns obtained from plowing and planting to barley. One compromise applicable to both steppe and barley-zone conditions is to grow the barley in arable strips between shrub hedges. The hedges, planted transversely to the prevailing wind, would provide erosion control as well as a grazing resource, while the greater part of the land surface could still produce barley and other feed crops.

Two activities were initiated in the 1990/91 season: at existing atriplex plantations at Maragha (Aleppo province, about 30 km east of Khanasser), and at ICARDA's site at Ghrerife, where a new trial was initiated early in 1991. The studies are intended to provide experience in establishing and managing atriplex hedges, to investigate how well crops grow between those hedges, and to provide data of total productivity (crops and atriplex forage) on land under mixed cropping. These studies are necessary before establishing demonstrations of wind erosion control by hedges, which would be a large-scale operation.

The Steppe and Range Directorate of the Syrian MAAR maintains a large station in the steppe at Maragha, which has been planted to *Atriplex* spp. Some of the mature atriplex is in double rows with 10—12 m wide plowed alleyways in between. With the cooperation of the Steppe and Range Directorate staff, short lengths of six of these alleyways were sown to barley in December 1990.

The first observation was that the atriplex bushes grew much more rapidly where a little phosphate fertilizer was supplied at planting time. Grain yields were 0.69 t/ha with fertilizer, 0.48 t/ha without; total dry matter was 1.93 t/ha with fertilizer and 1.26 t/ha without.

Access to additional land at Ghrerife made possible the planting of a new long-term trial (approximately 4 ha) specifically to look at atriplex intercropping. In January and February 1991, about 10 000 young atriplex shrubs (*Atriplex halimus*) were planted in rows, each about 60 m long, to comprise four hedge designs and three widths of arable alleyway. Half of each 60-m length of hedge was planted with phosphate fertilizer (about 5 g P, as single superphosphate, per shrub), half without. All bushes were watered at the time of planting and once subsequently. Two crop rotations will be followed on the arable areas, barley/barley and barley/vetch. In the first year, sowing was unavoidably very late; only barley was sown and the vetch plots were left fallow. The full rotations will be established in the 1991/92 season.

At least another year must elapse before this work begins to yield hard data, but two observations were recorded:

No interaction between mature atriplex shrubs and barley was evident at Maragha; growth and height of barley were uniform across the width of the arable strip from one hedge to the other.

Phosphate fertilizer strongly promoted the growth rate of young atriplex shrubs at Ghrerife. Growth was very weak in the absence of fertilizer, particularly on those parts of the site that had not previously been cropped.

Tillage and barley residue management

The increasing intensity of cropping and tillage across open tracts of arable land in dry areas is increasing the risk of wind erosion. These areas support large populations of small ruminants who graze intensively most stubble and crop residues. Particularly after a poor rainfall season, flocks are herded across the same field several times during the long hot summer, until very little plant material remains and the soil surface has been broken down. Given the value of animals and animal feed, this practice will not be changed, but it is important to quantify what is happening and to establish the value (and costs) of alternative, more conservative practices such as stubble retention.

In some environments, the retention of cereal stubble after harvest reduces evaporative loss from the soil and contributes to a better water balance for the succeeding crop. Retention of crop residues on the soil surface may in time improve the surface structure and the rate of water infiltration into the capping silty soil. Since small quantities of additional stored water can have a significant effect on crop production, efficiency of infiltration is important.

To determine the effectiveness of stubble retention in the dry barley areas of Syria, a tillage and barley residue management trial was established on a 2.5-ha field at the Breda station. The five main treatments examine tillage vs. no tillage, time of tillage, straw retention, and stubble retention.

The first crops were planted in this trial in 1989/90. The yield data for 1990/91 were considered in three rotation groups: barley in barley/barley, barley in barley/vetch, and vetch in barley/vetch. The results of one year are preliminary. However, the main focus of the trial is on the barley residue and tillage management treatments, and it is interesting that significant differences already have emerged between these treatments. June tillage resulted in slightly higher yields of barley and vetch than October tillage. Between tillage (at either time) and no-till, differences were significant for barley straw consistently across both rotations. Barley crops in no-till treatments produced less dry matter but equalled (or exceeded) the grain yields of the tilled treatments through a larger harvest index. For the vetch crop, the pattern of dry matter production was reversed: one (but only one) no-till treatment significantly outyielded the rest.

Availability of Phosphate to WANA Soils

Surface adsorption and precipitation processes reduce the availability of fertilizer phosphate applied to soils. In calcareous soils, abundant in arid and semi-arid areas, precipitation of highly insoluble calcium phosphates is assumed to be a major factor in the loss of P availability, but the possible influence of iron oxides on the availability of P applied to calcareous soils also merits attention. These minerals appear to be the most active P sorbents in the calcareous soils of the Mediterranean region.

A study was begun to investigate how P availability was related to soil composition, time after P application and P application rate for a group of calcareous WANA soils collected from the surface (0—20 cm) horizons in Jordan, Syria, Tunis and Pakistan. Soils ranged widely in their calcium carbonate and iron oxide contents, and in other soil components believed to influence the availability of phophorus.

In three experiments, monocalcuim phosphate (MCP) was added to soils at various rates. Following cropping with wheat, soils were air-dried and analyzed for Olsen P and P content. The ratio between the increase in Olsen P and the P applied to the soil as MCP was chosen as the availability index, AI (Fig. 10). The rationale for this choice is that Olsen P correlates well with the amount of soil P available to plants, and soil test calibration for WANA is based on this soil test.

The soil properties influencing AI differed between high and low rates of P addition. At low addition rates, AI was a negative function of the amount of iron

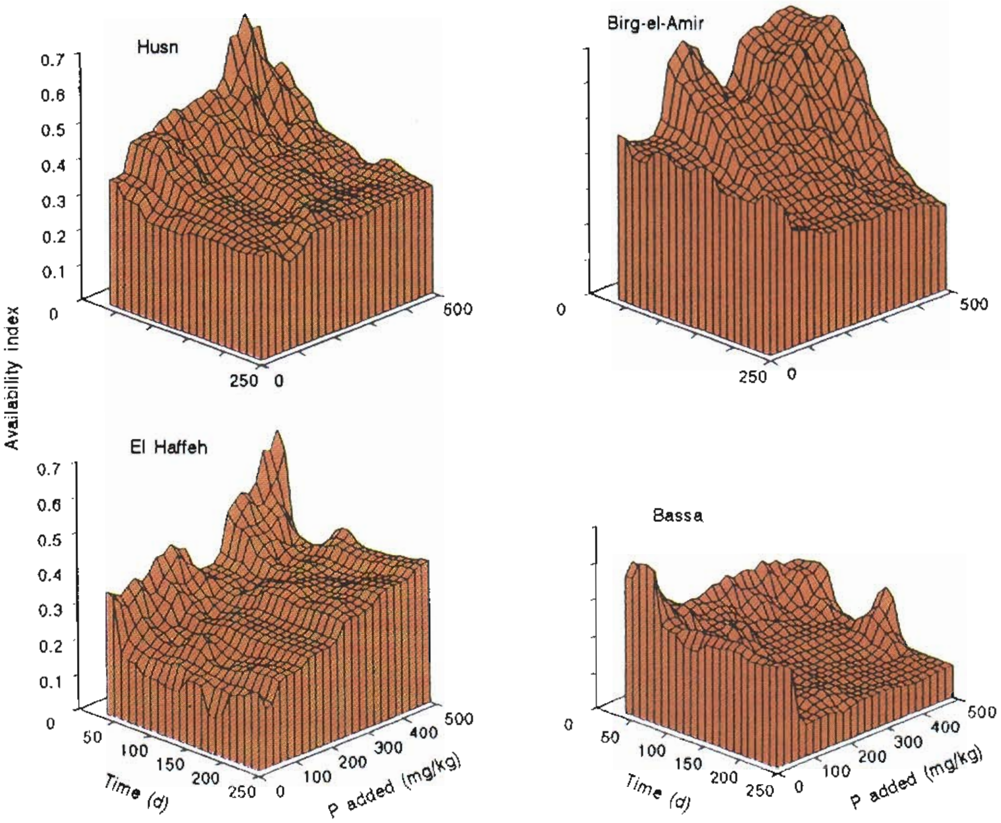


Fig. 10. Smoothed block diagrams showing the availability index in four soils as a function of amount of P applied and time after P application.

oxides. These, according to the P sorption curves, seem to dominate sorption at low (<100 μM) concentrations of P in the soil solution. Compared with other soil components such as calcium carbonate, iron oxides and clay minerals (edge surfaces) have high-affinity P-adsorption sites from which phosphate is less easily removed by the bicarbonate ions of the Olsen extractant.

At high rates of P addition, the soil solution becomes much more highly supersaturated with respect to insoluble calcium phosphates, and so precipitation can take place more easily than at low rates of addition. Since precipitation of calcium phosphates in calcareous systems seems to proceed from the initial phosphate adsorption and crystal nucleation on the calcium carbonate surfaces, the amount and reactivity of the calcium carbonate in the system must influence the availability of the applied P. This explains the negative correlation between AI and CCE (calcium carbonate equivalent).

The results contradict several field and laboratory studies in which linear relationships were reported between extractable P and amount of P added (i.e., AI was similar at different P addition levels). However, experimental conditions in the laboratory incubation experiments affect results. One would expect incubation data for high P application levels to match field conditions, since high phosphate concentrations occur in the vicinity of granules, powder or droplets of liquid fertilizer. This conclusion may not be true if high phosphate concentrations near the point of P application do not result in rapid precipitation of calcium phosphate, and phosphate can diffuse to high-affinity adsorption sites within a relatively large soil volume. Then, the AI would be better predicted by an incubation at low P addition level. In long-term field studies in the Breda, Tel Hadya and Jindiress soils, the AI appeared to increase in the order Jindiress < Tel Hadya < Breda. This matches better the relative order of the AI values at low addition levels than at high levels.

The lack of correlation between AI and iron oxides at high P addition rates does not necessarily imply that iron oxides are not active in retaining the adsorbed P against bicarbonate extraction. It may simply result from the "dilution" of true adsorption by the quantitatively more important precipitation processes. Consequently, one would expect AI to be correlated to iron only for populations of calcareous soils with high iron/CCE ratios.

This study stresses the difficulties involved in predicting the availability of fertilizer P applied to calcareous soils. The loss of availability is related to the nature of the processes of adsorption and precipitation, but the relative importance of these processes appears to be a complex function of the soil composition (in particular of the amount and reactivity of calcium carbonate and iron oxides), P addition level and time after P addition.

Rotations

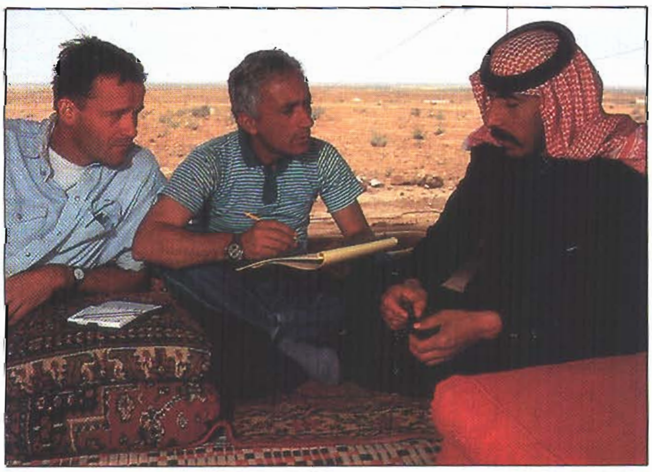
Annual pasture, forage and food legumes with cereals

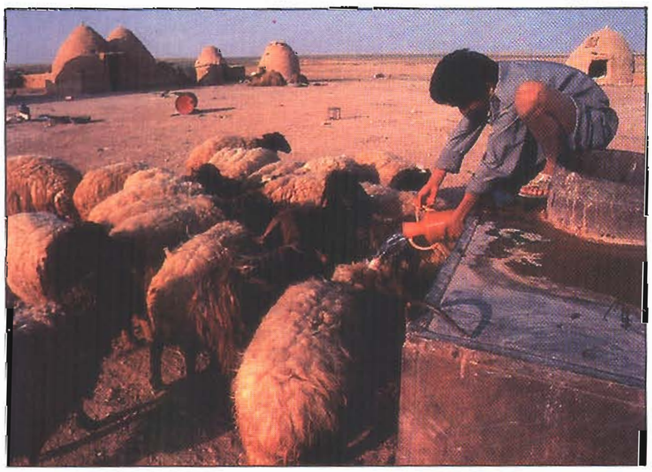
Pasture, feed and food legume species can help to stabilize Mediterranean dryland farming systems in 250-350 mm rainfall zones. Farmers are using less fallow, plowing more marginal land and growing fewer legumes than in the past. Researchers wish to replace the fallow by encouraging reintroduction of pasture, and feed and food legumes primarily in 300-350 mm rainfall zones, where in most years they can demonstrate the benefits of cereal/legume rotations.

The objective of long-term trials has been to establish baseline production data for comparison of alternative cropping systems under Syrian conditions. Data are accumulating from two-course rotation experiments which permit examination of long-term treatment effects.

Each year nitrogen fertilizer is applied to half of each wheat plot. It stimulates both wheat straw and grain yields in wet years but has little advantage when the weather is dry, particularly for grain yields because drought conditions can severely impair the reproductive phase of growth. Wheat grain and straw on plots following fallow, lentil and vetch responded to nitrogen in much the same way in all years except in the second of two dry seasons (233 and 234 mm rainfall).

It is possible that stored water available in fallow treatments allowed more efficient use of fertilizer. It is also possible, under the conditions of this experiment, that lentil shows a greater response to N fertilizer than vetch. Lentil returns less N to the soil because the entire plant is removed during hand-harvesting. Although vetch is similarly harvested, it has a more branched root system and more of the root remains in the soil after harvest. Total soil N increased by 15% during the 6 years in soils where vetch was rotated with wheat, while soil N concentrations remained the same in soils where a lentil/wheat rotation was practised. Thus, wheat after lentil could be more responsive to fertilizer N than wheat after vetch.





A project funded by BMZ of the German Government supports a survey of Bedouin households in the steppe area of Syria. Researchers interview sheep owners to assess their production practices and response to changing conditions. Truck transport has had a significant impact on livestock owners. Water is now brought to camps, permitting longer occupations of sites and intensifying grazing pressure on the steppe.

When the vetch and lentil portions of the rotation are compared, a trend of higher production from lentil is clear but in most cases the differences were not statistically significant.

Barley trials

Barley rotation trials at Tel Hadya and Breda have now completed nine cropping years. Trials consist of six 2-year rotations of barley/fallow, barley/barley, or barley with a legume forage [*Vicia sativa* (vetch) and *Lathyrus sativus* (lathyrus)]. Comparisons are being made between productivity (grain, total dry matter, total crop N) among rotations, forages and fertilizer regimes.

The crops were harvested at the hay stage originally, but since the 1985/86 season they have been allowed to grow to maturity, with earlier cutting of small sample areas to assess hay-stage productivity. However, because mature mixtures of cereal and legume are not practical, either experimentally or agriculturally, they were replaced with another forage legume, *Vicia narbonensis*, to be harvested mature, and more *V. sativa*, to be harvested green to simulate a green-grazing utilization. This latter treatment is intended to provide a comparison with the vetch harvested at maturity, to determine the availability of soil moisture and mineral N to the succeeding barley crop. Fertilizer treatments (N and P) were changed so that all the phosphate was applied to the barley crop and a comparison of N rates was determined for the barley.

It will not be possible to see the full impact of the rotations introduced in 1990 until the first 2-year rotational cycle is complete, but it is interesting to compare the performance of the newly introduced *V. narbonensis* with the two other forage legumes grown to maturity (Table 11). Narbon vetch produced 20—25% more dry matter at maturity than common vetch and lathyrus (and crop N output was comparable or higher), and differences at the hay-stage sampling were even greater. This result agrees with previous comparisons of forage legumes, but relative effects on subsequent crops have not previously been looked at in a rotation context. Improved legume performance, without detriment to the subsequent barley, is essential if barley/forage rotations are to become sufficiently attractive for widespread adoption by barley-zone farmers.

Table 11. Yields of three pure legumes in barley/legume rotations, 1990/91.

Site/Crop	Mature crop (t/ha)				Hay crop TDM (t/ha)
	Grain	Straw	TDM†	Total N	
Tel Hadya	***	***	***	*	***
Vetch	0.68	1.43	2.11	48.2	2.09
Lathyrus	0.72	1.41	2.13	54.4	1.80
Narbon vetch	0.93	1.67	2.60	52.8	2.73
Breda	***	***	***	***	***
Vetch	0.50	0.88	1.38	34.1	1.25
Lathyrus	0.75	0.81	1.55	41.5	0.96
Narbon vetch	0.77	1.08	1.85	45.7	1.72

† TDM = total dry matter.

Rhizobium Research

Symbiotic response of annual medics to strains of *Rhizobium meliloti*

Past research has concentrated on investigating the response of a selected number of species of annual medics to strains of *Rhizobium meliloti*. These medics (*M. noeana*, *M. orbicularis*, *M. polymorpha*, *M. rigidula*, *M. rotata* and *M. truncatula*) are potentially important species for ley farming systems in the Mediterranean region. Elite strains of rhizobia have been identified, tested and recommended as effective inoculants for these particular legumes. In view of the marked strain by host interaction usually present in our studies, it was necessary to expand research efforts to other species of annual medics occurring naturally in the region.

The *Medicago* species examined were: *aculeata*, *blancheana*, *coronata*, *intertexta*, *minima*, *orbicularis*, *polymorpha*, *radiata*, *rigidula*, *scutellata* and *truncatula*. The inoculum consisted of eight ICARDA *R. meliloti* strains. Uninoculated controls with and without nitrogen were included. The experiment was conducted in a plastic house using modified Gibson tubes. The sterile *in vitro* system contained vermiculite and a mineral solution lacking N. Seedlings were raised from disinfected seed, transferred aseptically to the tubes, then inoculated with 1 ml of bacterial suspension.

The *in vitro* system allowed us to detect differences among strains in their ability to nodulate medic species. The inclusion of the uninoculated control containing 70 ppm of N verified that plants responded normally to all the physiological and environmental factors to which they were exposed during the growth period. In contrast, plants of the uninoculated controls with no mineral N showed typical symptoms of N deficiency: stunted with yellowish foliage and purple stems. No nodulation occurred on the roots of the uninoculated control plants.

Plant response to rhizobial strains was consistent. There were strong associations between medic species in response to inoculation: the symbiotic behavior of *M. polymorpha* with either *M. intertexta*, *M. blancheana* or *M. aculeata* was very similar and showed no evidence of strain-specific associations. The pairs *M. rigidula/M. coronata* and *M. orbicularis/M. minima* exhibited the same consistency of symbiotic response.

In general, N_2 fixation and nodulation of most of the species differed among the rhizobial strains. Medics display a high specificity for their rhizobia. Their symbiotic habit ranges from promiscuous to highly specific, depending on the type of indigenous soil rhizobia. Table 12 shows the effect of rhizobial strain on the herbage biomass with strong strain-specific interactions between rhizobial strains and some medics. For *M. truncatula*, *M. rigidula* and *M. polymorpha*, the results confirmed previous findings, which showed their requirement for highly specific strains. We have identified superior strains for these particular species.

Results strongly indicate that there is potential to select better strains of rhizobia for all medics. In most cases, herbage yields of uninoculated plants were not significantly different from those of the inoculated treatments. Superior strains were detected, however, which resulted in plant growth 4- to 5-fold that of the uninoculated control plants. Strains M15, M53 and M194 produced good quality nodulation and N_2 fixation in *M. scutellata*. In addition, strain M53 had a broader spectrum of promiscuity than other strains, fixing nitrogen in association with *M. intertexta* and was effective with *M. aculeata*, *M. blancheana* and *M. polymorpha*.

All species responded to inoculation with at least one of the strains, with the exception of *radiata*, *orbicularis*, *truncatula* and *rigidula*. These investigations revealed that most of the medic species tested in the region need specific rhizobia to fix nitrogen. Once

Table 12. Effect on foliage dry weight (mg/plant) of inoculating 11 species of annual medics with 8 strains of *Rhizobium meliloti*.

Strain	acu†	bla	cor	int	min	orb	pol	rad	rig	scu	tru
M15	23	20	24	29	5	10	11	9	10	173	10
M29	21	16	23	41	6	10	17	9	11	63	16
M53	57	55	22	118	5	11	42	7	10	106	13
M194	16	29	24	40	6	15	15	7	7	17	14
M197	26	27	55	42	6	12	16	14	15	40	11
M235	14	21	26	46	10	20	15	7	12	96	15
M276	22	18	26	38	8	12	17	7	10	42	13
M277	8	28	32	36	4	13	14	17	12	48	13
Nil + N	-	125	98	133	26	35	70	55	50	112	85
Nil	7	14	12	24	5	11	14	10	9	37	10
LSD‡	10.7	13.9	10.2	16.6	3.8	6.9	9.6	5.4	7.7	87.9	8.7

† acu = *M. aculeata*, bla = *M. blancheana*, cor = *M. coronata*, int = *M. intertexta*, min = *M. minima*, orb = *M. orbicularis*, pol = *M. polymorpha*, rad = *M. radiata*, rig = *M. rigidula*, scu = *M. scutellata*, tru = *M. truncatula*.

‡ LSD values only for corresponding column at P ≥0.05.

effective rhizobia are identified and prove satisfactory under field conditions, they would be suitable inoculants for their respective hosts in situations where inoculation is deemed necessary. More studies will be conducted in the coming season with additional accessions and species of annual medics.

Symbiotic performance of lyophilized rhizobia

Lyophilization (freeze-drying) of rhizobial cells ensures long viability and lack of genetic variation during long-term storage. Joint research with cooperators at the Boyce Thompson Institute at Cornell University has indicated that lyophilized rhizobia, reconstituted and suspended in vegetable oil, are able to survive on seeds under adverse environmental conditions. Oil-based inoculants with lyophilized rhizobia can be applied at higher rates (cells per seed) than peat-based inoculants. This is especially important for small-seeded legumes and where populations of ineffective rhizobia are large. Mortality of rhizobia by desiccation is common with the small seeds of *Medicago*, which must be sown at a shallow depth. Alternative inoculation techniques are currently being explored to solve the problem of the rapid decline in the population of rhizobia applied on seeds.

Oil-based and peat-based inoculation were compared on seed of *M. rotata* sel 2123, *M. rigidula* sel 716, *M. polymorpha* sel 1035 and *M. truncatula* cv. Jemalong using the ICARDA M15, M29 and M53 strains of *R. meliloti*.

Statistical analysis indicated some significant differences in herbage yields; all medics tested had nodules from peat and lyophilization treatments, except *M. rigidula* (Table 13).

The effect on herbage yield of the lyophilized rhizobial inoculant was significant in *M. truncatula* and *M. polymorpha* compared with yields from peat-based inoculation treatments. Inoculation of *M. truncatula* with lyophilized strains M29 and M53 increased herbage yields by 260 and 210% respectively, compared with peat inoculation. Similarly, *M. polymorpha* inoculated with lyophilized M53 resulted in a yield increase of 170% compared with peat inoculation. Inoculation method had no effect on the yields of *M. rigidula* and *M. rotata*. The question of comparing, and improving, the oil-based (lyophilized rhizobia) method with normal peat-based inoculation technique merits further research, which should include closer examination of the fate of seed-applied rhizobia.

Table 13. Herbage yields of medics as affected by methods of seed inoculation (peat-based or lyophilized).

Treatment	Herbage yields (t/ha)			
	M. rigidula	*M. rotata*	*M. truncatula*	*M. polymorpha*
M15/Peat	2.02	2.75	1.64	1.68
M15/Lyo	1.95	1.71	1.15	2.24
M29/Peat	1.78	1.48	0.61	0.88
M29/Lyo	1.62	2.17	1.69	1.28
M53/Peat	1.95	1.71	0.64	1.14
M53/Lyo	2.15	2.21	1.34	1.91
Control +N	3.11	3.15	1.96	2.21
Control -N	2.40	2.27	0.93	1.08

Rhizobial requirement of clovers in marginal lands

Past investigations using indigenous species of *Trifolium* have shown variation in nitrogen fixation and nodulation response. Parasitic or ineffective nodulation was accompanied by low herbage yield and plants showed

Wild *Trifolium* spp. collected in Syria are multiplied in the greenhouse for future field trials.

the typical symptoms of nitrogen deficiency. Clovers are important pasture legumes in marginal lands in the WANA region. We have initiated further research to elucidate whether the main species of clovers found in the region require inoculation, and if so, to select the appropriate rhizobia for use in peat-based inoculants.

An experiment was carried out to evaluate the indigenous populations of *Rhizobium trifolii* and determine the degree of symbiotic association with various *Trifolium* species. Soil samples were collected at Tel Hadya from areas receiving nil, low and medium levels of phosphorus fertilizer. Soil sampling was done at random at depths ranging between 10 and 20 cm. The samples were sieved carefully and sieves disinfected between samples to prevent cross-contamination by indigenous rhizobia.

Results indicated considerable variation in response to inoculation, independent of phosphorus amendments. The significant responses in shoot yield due to inoculation were a function of the type of symbiotic association. Plant growth was, in general, much greater in response to mineral nitrogen than in response to the inoculations with the four soils and the two rhizobia (Table 14). This highlights the need to select superior strains of *R. trifolii* able to match the responses of mineral nitrogen.

Table 14. Shoot biomass production (mg/plant) of seven indigenous clover species in response to inoculation with four sources of *Rhizobium trifolii*.

	Species†						
Treatment‡	pur	res	lap	spe	cam	ste	tom
Soil 1	11.0	9.3	6.1	4.2	4.0	8.6	8.2
Soil 2	6.4	7.7	6.4	6.3	3.8	7.7	9.7
Soil 3	4.1	4.3	4.1	3.8	3.0	9.0	3.9
Soil 4	4.1	3.6	4.6	3.3	3.6	7.2	3.6
Strain T5	9.4	3.3	4.2	2.7	3.2	9.5	5.2
Strain T49	6.1	1.6	3.9	3.3	2.9	8.1	3.3
Control +N	17.8	15.5	10.5	6.3	5.3	17.5	16.4
Control−N	5.0	3.8	4.1	2.6	2.6	8.1	3.7
SEM	1.9	1.0	0.8	0.6	0.6	1.4	1.2

† pur = *T. purpureum*, res = *T. resupinatum*, lap = *T. lappaceum*, spe = *T. speciosum*, cam = *T. campestre*, ste = *T. stellatum*, tom = *T. tomentosum*.

‡ Fertilizer (P_2O_5/year)— Soil 1: 0 kg/ha; Soil 2: 25 kg/ha; Soils 3, 4: 40 kg/ha.

The indigenous rhizobial population of the low-fertilization soils nodulated five *Trifolium* spp. Although nodulation was functional and the plants fixed nitrogen, shoot biomass was lower than that produced when the plants were treated with mineral nitrogen. This again clearly indicates the need to search for superior strains of *R. trifolii*.

Dryland Resource Management Project

In the past, the agricultural systems that evolved in the dry areas of WANA were of low intensity and low productivity but were well adapted to an environment characterized by a fragile and limited natural resource base and uncertain and fluctuating meteorological conditions. However, the increasing pressures on soil, water and natural vegetation in these areas seriously threaten their potential for future productive utilization.

The problems and potential of the existing systems are poorly understood. The people, institutions and policies interact with the physical limitations of the environment to determine how drylands are utilized. Degradation results from decisions made by individual land users in response to a range of perceived constraints and incentives. The search for solutions can only begin when the rationale behind such decisions is known. The individual's knowledge, of both the local environment and the factors controlling how it is utilized, is crucial in this process. The people concerned must participate actively in all stages of the research and development process if practical and acceptable improvements are to be instituted. To achieve this, a flexible, interdisciplinary approach is needed.

The Dryland Resource Management Project aims to help develop the capacity of small multidisciplinary teams of national scientists to work together to diagnose, analyze and solve agricultural and environmental problems in the dry areas of WANA. Case studies in six countries are intended to describe and analyze current resource management practices and indigenous perceptions of options for sustainable improvements, and to initiate within the national program interdisciplinary activities that address the problems of farmers and herders in dry areas. National teams of scientists will conduct the case studies and report their findings at a workshop scheduled for March 1993.

The Dryland Pasture and Forage Legume Network was established in 1991 at a workshop held at ICARDA, Tel Hadya. The Network aims to improve communication among WANA scientists conducting pasture and forage research.

Self-reseeding Species in Forage Chains

Thirty-six ecotypes and varieties of perennial and annual self-reseeding species, mainly originating from Central Italy, were evaluated for forage production and seed bank yields in 1990/91 at Perugia, Italy. The objective was to identify forages with patterns of production that can be utilized in sequence to extend the grazing season of either mixed or single-species pastures.

Dry matter yield was measured monthly from plots. The first cut was 4 April; the last on 17 September. Cuts were made at flowering for perennials and monthly thereafter if the herbage was higher than 10 cm. Annuals were managed as pasture, with monthly cuts when the herbage was higher than 10 cm. The seed bank of the annual legumes was monitored in summer by collecting soil samples to 5-cm depth in each plot. Soil was sieved and seed was hand-sorted from debris.

Medicago sativa cv. Casalina had the highest dry matter production of the alfalfas; *Lotus corniculatus* cv. Polcanto the highest yield for birdsfoot trefoil. A Persian clover, *Trifolium resupinatum* cv. Guadamello, was the highest-producing annual. The highest yields of seed were from *T. subterraneum* cv. Manciano and *M. arabica* cv. Trasimeno.

Livestock Nutrition/Management

Forage legume straw as a supplement for cereal straw

Cereal straw is an abundant by-product fed to ruminants the world over. The low rumen-degradable nitrogen content of straw can limit its value by restricting microbial activity in the rumen. Ruminants sometimes require more protein than can be synthesized by rumen microbes. In such cases, supplements containing undegradable nitrogen such as oilseeds (but not urea) can improve straw intake. Legume hays or straws can be valuable supplements containing both kinds of protein, and feeding them with cereal straw could dilute and minimize the effects of any antinutritional factors that they may contain.

An intake and digestibility trial compared diets containing pea straw or vetch straw with barley straw. A control diet of barley straw alone and a standard diet containing cotton seed cake with barley straw in the ratio 15:85 also were fed. Diets were mixed before feeding, and contained 10 g/day of a vitamin and mineral supplement.

The chemical composition of the dietary ingredients is shown in Table 15. The nitrogen content of barley straw was 3.5 g/kg dry matter (DM), but diets supplemented with cotton seed cake, 66% pea or 66% vetch all contained about 10 g/kg DM.

Table 15. Chemical composition (g/kg dry matter) of dietary ingredients or standard ration.

	Organic matter	ADF	NDF	Nitrogen
Barley straw	924	502	889	3.5
Straw + 15% CSC†	928	475	825	10.3
Pea straw	902	479	693	12.6
Vetch straw	911	487	722	12.5

† CSC = cotton seed cake.

The unsupplemented straw had an extremely low N concentration (equivalent to 20 g crude protein/kg as fed), and sheep consumed significantly less of it than of any other diet. Increasing the proportion of legume straw in the diet linearly increased DM intake. The intakes of diets containing vetch straw were greater than of diets containing similar levels of pea, despite the vetch having a similar N content and organic matter digestibility. Cotton seed cake as a supplement was of intermediate effectiveness, between 66 and 100% vetch and 66% pea. Dry matter digestibility increased with inclusion of legume straw.

Sheep receiving 33% or less legume straw had a negative N balance, implying loss of body protein. Nitrogen retention increased linearly with legume straw inclusion level. The increases in intake and N retention with vetch and pea straw compare well with other legume straws and the pattern of response to legume levels parallels that seen with *Trifolium* hay. There was little difference in N balance between pea and vetch straws at each level of inclusion despite differences in digestible OM intake. The small output of urinary N in all treatments except 100% vetch suggests that N balance was limited by digested N rather than by energy intake.

Research is continuing on the diets with 66% legume straw inclusion to observe whether metabolic parameters, rumen microbial activity and rumen fill can explain the differences in voluntary intake and nitrogen retention.

Nutritive value of pea and vetch forage

In previous grazing trials in which sheep were allowed to choose between plots containing pea varieties and others containing vetch species, animals refused to eat pea forage. Smell apparently was the aversive stimulus. In another trial, sheep ate hay more rapidly than fresh forage, although the hay was cut at a more mature stage than the fresh forage; the difference was greater with peas than with vetch. The volatile compounds of pea forage have a different gas chromatograph pattern from those of vetch. We studied differences in digestive physiology between pea and vetch fodder in the fresh and dried state that were not caused by differences in plant maturity or food intake.

Pea crops are cut for hay in April at Tel Hadya.

The digestibilities of dried and fresh forage of both Syrian local pea and common vetch were measured with ruminally cannulated sheep on each forage. Dry matter intake was restricted to 20 g/kg bodyweight. Rates of passage of digesta fluid and stained particle fractions, rates of degradation of leaf and stem in the rumen, rumen pH, rumen ammonia and blood urea also were measured.

Both the pea and vetch crops received a total of 350-400 mm of water, including supplementary irrigation. Crops were harvested daily from the vegetative to late flowering/early podding stages. Half of the daily harvest was fed fresh to sheep and the remainder bagged in cotton sacks and sun-dried for feeding to the same sheep in May.

Drying the forage significantly reduced the digestibility of certain fractions and reduced total water intake. Sheep fed vetch forage consumed and retained much more N than those fed pea (fresh or dry), and drying increased N retention by about 3 g/day. Urinary or fecal N excretion did not differ between the forages.

Nitrogen removal from pasture and stubble by sheep

In grazing systems, a complicating factor in the N cycle is the return or removal of N in the urine and feces of sheep. This is particularly pertinent under the management regimes in WANA where sheep are very mobile, moving on and off fields frequently.

To quantify these flows, an experiment was conducted during the 1990/91 season at Tel Hadya. Six plots (7500 m^2 each) were fenced. Three were sown to barley and three were established in an area of self-regenerating medic pasture. Six sheep per plot grazed the area during the day but were removed at night and housed. The aim of the experiment was to determine the total removal of N through urine and feces deposition off the field and through milk off-take, and to determine the amount of N returned to the fields, its form (urine or feces) and how the partitioning of N in urine and feces changes with the quantity or quality of the pasture consumed.

Fecal collection bags were fitted to the animals to collect the total urine and feces produced (slops). The bags were changed when the animals left the field each evening and again when they were put out to graze in the morning. In addition, a sample of feces was taken directly from the rectum of the animal (grab sample) each time the bags were changed. The total N content of the slops was partitioned between the contribution from urine and feces. Each collection period lasted 1 week and occurred once monthly. The experiment, with five collection periods, began in early April, at the start of grazing, and progressed to the end of August, at which time all plant material in the medic plots was grazed. During July and August, grazing was supplemented with barley grain (on medic pasture) or cotton seed cake (on barley stubble) fed to the animals indoors to ensure adequate energy and N intake.

Approximately 50% of the output of N from animals in the form of urine and feces was deposited off the field (Fig. 11). When the off-take of N in the milk was

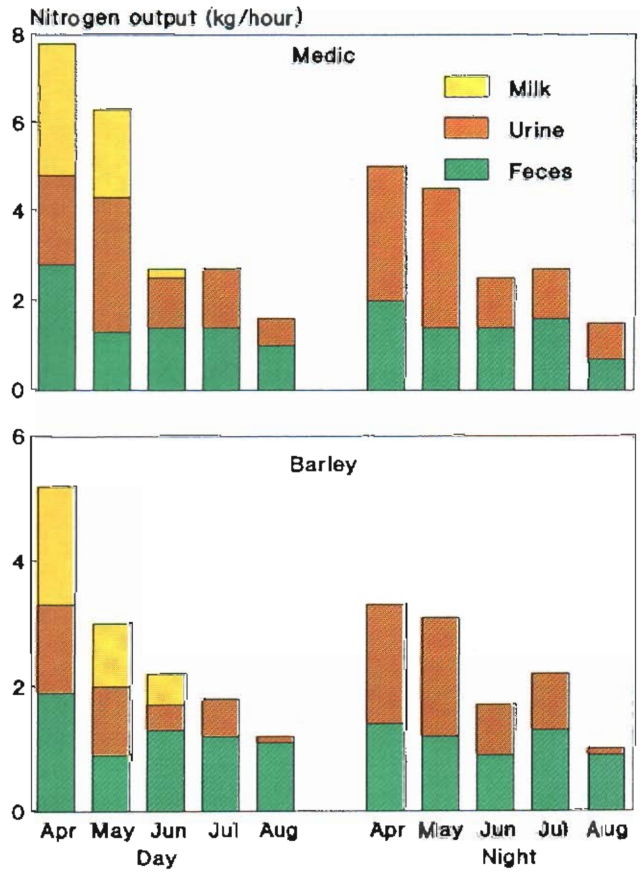


Fig. 11. The amount of N produced during the day or night and present in feces, urine, or milk of animals grazing medic-based pasture or barley.

included, the total amount removed by animals was greater than that recycled to the pasture. The largest removal of N from the field occurred early in the season when feed had a higher N content and herbage intakes by the animals were high. The proportion of total N contained in the feces or urine changed during the growing season. Nitrogen in the urine represented only a small part of the total in late August when animals were grazing barley stubble with a very low N content.

The amount of N in the urine and feces originating from the supplementary feed was only a small portion of the total N excreted by the animal. As the proportion of supplementary feed increases in the animal's diet, however, supplementary feeding may represent a transfer of N back onto the field.

Training

ICARDA emphasizes training as an essential thrust to generate, promote and disseminate research results. In 1991, ICARDA trained 738 people, representing 40 countries (Table 16). Half the participants were trained at ICARDA headquarters in Aleppo; the other 50% attended in-country, subregional and regional courses elsewhere. About 12% of the total trainees were women and 33% of trainees in degree courses were women. ICARDA continued its strategy to gradually decentralize its training activities by offering more in-country courses.

The training offered reflected ICARDA's interest in agroecology. Courses were offered in commodity improvement, pasture and range management, supplemental irrigation technology, experimental design, agroclimatic analysis, farm survey methods, agroecological characterization and winter chickpea technology transfer. Emphasis was given to new technology in a course on molecular marker techniques of crop improvement and a course on new biometrical tools for plant variety evaluation, the latter was conducted in Spain in collaboration with CIHEAM and CIMMYT.

The final report of the training follow-up study was published and distributed. The report highlights data obtained from surveys with 231 former training participants from nine WANA countries. The study examined how ICARDA training has helped its alumni, the amount of follow-up trainees have received, the trainees' evaluation of ICARDA training and other issues. The data from the study are helping to guide ICARDA trainers in developing new courses and training policies.

At ICARDA, trainees learn to screen for disease resistance in cereals.

A working document of the Manual of Training Procedures was published and implemented for this season's training activities. Work began on a medium-term plan that will define the direction ICARDA training will take in the next 5 years. The plan outlines a training system that has strong components of needs assessment, follow-up communication and training material development. The plan will be developed into a special project proposal that will be submitted to a donor agency for funding.

The production of training materials received high priority during 1991. Six audiovisual training modules were completed and work began on three multi-media training kits. An autotutorial room was developed at headquarters to enable training participants to use the audiovisual training modules.

Table 16. Participants in ICARDA training courses (1986-1991).

	1986	1987	1988	1989	1990	1991	Total
Africa							
Ethiopia	27	38	67	28	15	45	220
Ghana	-	-	-	-	-	1	1
Kenya	-	-	-	-	-	1	1
Nigeria	-	-	1	-	-	-	1
Somalia	1	-	1	2	1	-	5
Uganda	-	-	-	-	1	1	2
Zimbabwe	-	-	1	-	-	-	1
	28	38	70	30	17	48	231
Asia and the Pacific							
Afghanistan	-	-	-	-	4	6	11
Bangladesh	1	-	1	-	2	-	4
Bulgaria	-	-	-	-	1	1	2
China	4	3	6	3	4	2	22
India	1	3	3	-	-	1	8
Malaysia	-	-	1	-	-	-	1
Nepal	-	1	1	23	-	1	26
Pakistan	7	4	6	24	11	3	55
S. Korea	-	-	-	-	1	-	1
Thailand	-	-	-	-	-	1	1
USSR	-	-	-	-	-	2	2
Yugoslavia	-	-	-	-	-	1	1
	14	11	18	50	23	18	134
Latin America							
Argentina	-	-	-	-	-	1	1
Bolivia	-	-	4	-	2	-	6
Chile	-	-	-	-	2	-	2
Colombia	-	1	6	-	4	1	12
Ecuador	-	1	5	-	15	-	21
Guatemala	-	-	-	-	-	1	1
Mexico	-	-	2	-	1	-	3
Peru	-	-	3	2	8	-	13
Uruguay	-	-	-	-	-	1	1
Venezuela	-	-	2	-	-	-	2
	-	2	22	2	32	4	62
West Asia & North Africa							
Algeria	45	63	16	34	33	30	221
Cyprus	1	-	-	3	5	3	12
Egypt	33	13	85	58	45	73	307
Iran	10	2	5	58	42	19	136
Iraq	7	1	-	-	14	9	31
Jordan	14	16	20	9	40	77	176
Kuwait	-	1	1	1	2	-	5
Lebanon	4	1	-	10	10	15	40
Libya	3	-	-	1	30	59	93
Morocco	36	12	82	58	81	42	311
Oman	-	1	2	-	16	22	41
Qatar	-	-	-	-	9	-	9
Sudan	29	25	15	25	20	17	131

Table 16. (Cont.)

	1986	1987	1988	1989	1990	1991	Total
Saudi Arabia	1	-	46	-	1	1	49
Syria	55	72	67	110	134	178	616
Tunisia	37	20	39	30	50	29	205
Turkey	57	11	36	10	40	69	223
United Arab Emirates	-	1	-	-	2	2	5
Yemen Republic	14	9	47	22	30	9	131
	346	248	461	429	604	654	2742
Developed Countries							
Belgium	-	-	-	-	3	-	3
France	-	-	-	-	1	-	1
Germany	5	8	12	9	7	5	46
Greece	-	1	-	-	-	-	1
Italy	-	-	-	-	-	2	2
Netherlands	2	2	2	3	4	2	15
Spain	2	2	2	1	1	11	19
United Kingdom	-	1	3	1	1	2	8
United States	-	-	-	-	-	1	1
	9	14	19	14	17	23	96
Total	397	313	590	525	693	747	3265

Information Dissemination

In the Communication, Documentation and Information Services department of ICARDA, two areas are emphasized: collection of research information and the publication and dissemination of research results. Databases on barley, lentil and faba bean have been created by extraction of information from international databases, and are maintained in CD-ROM format in the ICARDA library. The increase in requests from researchers at headquarters, the WANA region and beyond reflects the growing interest in specific crops and all aspects of agricultural production in the area served by ICARDA.

Publication of research results remains a high priority, as the Center produces three crop newsletters, annual research and training reports, and proceedings of international workshops and conferences. In 1991, the Center printed a catalogue of publications produced by ICARDA from 1977 to 1990; this catalogue will be updated periodically and made available to researchers to assist in the dissemination of information produced by the Center.

Public awareness activities continued to inform the media and others of the research results achieved at the Center and in its Outreach regions. Release of the information in English and Arabic versions ensures that the material reaches the intended audiences. Translation of key publications into French is a continuing process, intended to increase the dissemination of knowledge.

Impact Assessment and Enhancement

Supplemental Irrigation in Syria

ICARDA has been conducting technical research on supplemental irrigation (SI) in rain-fed farming systems for about 5 years in Syria. On-station trials and demonstration trials are conducted on farmers' fields. Parallel with this work has been a continuing study of the social and economic dimensions of SI: what the farmers are doing, how their systems are evolving and why, the implications for production levels, the stability of production and sustainability.

Data from farm and village surveys in northeast and northwest Syria, experimental results from trials and demonstrations and secondary data have been used to quantify crop production in situations with and without SI. Whole-farm budget models have been used to process values of physical productivity into estimates of economic productivity and thereby to compare four levels, or development stages, of SI enterprises. The stages, which tend to be sequential in any one enterprise, are marked by an increasing intensity of cropping. Cropping intensity, determined by the nature of the water resource and the available managerial skills, is seen as the principal factor influencing the productivity and efficiency of the SI system.

The main focus is on wheat, but other crops must be considered when evaluating the whole-farm situation. The cropping pattern changes as the cropping intensity increases: barley and legumes are replaced by higher-value summer crops and vegetables, although the proportion under wheat tends to remain static.

The quantitative effect of SI on wheat yields, and its margin of advantage over rain-fed cropping in both physical and economic terms, vary greatly from year to year according to rainfall. However, the approximate degree of difference is indicated in Table 17.

Table 17. Effect of water source on wheat yield range.

Rain-fed		Supplemental irrigation	
Yield (t/ha)	% of farmers	Yield (t/ha)	% of farmers
1.0–1.5	52	< 3.0	20
1.6–2.0	36	1.0–4.0	68
2.1–2.5	12	> 4.0	12

Supplemental irrigation appears to increase the net revenue from wheat, relative to rain-fed cropping, by 30% in a wet season and 58% in an average season, and is the break-even factor in a dry season.

The effect of SI on yield stability is no less important. One conclusion from this work is that, while SI cannot eliminate all influence of weather on wheat yields, it can reduce spatial and temporal variability to a minimum. The farm survey data showed a reduction in the coefficient of variation of wheat yields from 86% for rain-fed crops to 41% for SI crops.

In general, a farming system is more or less sustainable according to its reliance on internal vs. external resources. For systems based on supplemental irrigation, much depends on the source of water. Water pumped from an underlying aquifer may be considered an internal resource, but if the level of that aquifer is falling, there may be no long-term sustainability.

Economic Analysis of Syrian Chickpea Production

Chickpea is the second most important legume crop in Syria. Data on winter chickpea production were collected in a recent study that compared the actual on-farm costs and gross margins for winter and spring chickpea in Aleppo and Hassakeh provinces. Unlike previous studies of a few farmers selected to participate in on-farm trials, this analysis was based on a large sample of ordinary farmers growing winter and spring chickpea under commercial conditions. This study verified findings of the earlier on-farm research.

Survey results indicated that (a) farmers applied higher rates of phosphate and nitrate fertilizer on winter chickpea than on spring chickpea, (b) weeding is important for reducing yield losses in winter chickpea, and (c) the average cost of combine harvesting was lower than that of hand harvesting.

Average yields of winter chickpea were 78 and 64% higher than those of spring chickpea in Hassakeh and Aleppo, respectively. In Aleppo province the cost of grain production was 24.9 SL/kg for spring chickpea and 18.6 SL/kg for winter chickpea, while in Hassakeh it was 15.8 SL/kg and 13.5 SL/g, respectively. Gross margins for winter chickpea were 102 and 23% higher than those for spring chickpea in Hassakeh and Aleppo provinces, respectively.

This research shows that the yields and gross margins of winter chickpea are higher than those of spring chickpea in both provinces. However, most farmers are not aware of this. Increased extension work is necessary to inform farmers of the greater economic returns possible with winter chickpea. Government support in the form of providing winter chickpea seeds, herbicides and a more efficient marketing organization would also benefit farmers in northern Syria.

Adoption of New Wheat Technologies in Syria

Wheat is the most important food commodity in Syria. As wheat area expanded, Syria was a net exporter until the 1950s. Since then, however, the domestic demand has increased but the area planted to wheat has not. Moreover, vegetable, fruit and industrial crop production has increased and impinged on wheat land. Consequently, Syria no longer produces a surplus of wheat, and wheat grain and flour have become the most important agricultural imports.

Wheat has been a consistent focus of attention for the government of Syria. In 1991, the Socioeconomic Section of the Directorate of Agricultural Research joined ICARDA's Farm Resource Management Program in a multi-year study of the adoption and impact of improved wheat production technology. The objectives were to determine the levels of adoption of wheat technology and identify factors contributing to yield gaps between technology performance on farms vs. research trials.

In the first year, a primary data set was collected through a formal survey covering nine provinces representing 91% of the national wheat area. The results of this first year are presented here. The survey sampled districts selected according to stability zone and contribution to national production. The districts were grouped into five regions: Al-Jazirah, West, Al-Ghab, Hauran and Al-Furat (Fig. 12).

The most noticeable features in the national trends of annual wheat area and production (Figs. 13 and 14) are a general decline in total area, increased use of high-yielding varieties (HYVs) instead of local varieties, increase in irrigated area and large year-to-year fluctuations in total production. Whereas irrigated yields show overall improvement, rain-fed yields are less easily interpreted. Nonetheless, HYV yields are almost invariably higher than local variety yields under both rain-fed and irrigated conditions.

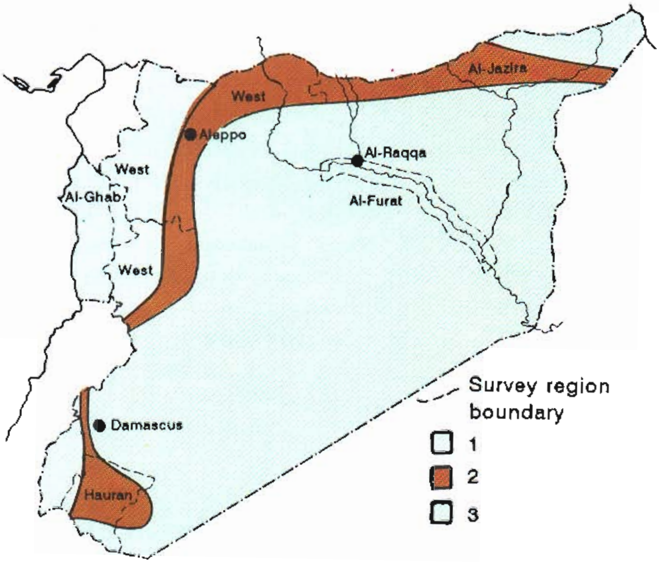


Fig. 12. Stability zones and survey regions of Syria.

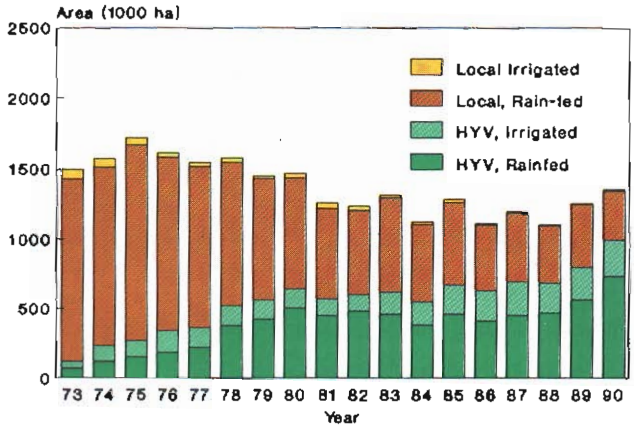


Fig. 13. Trend of areas sown to wheat in Syria, 1973-90.

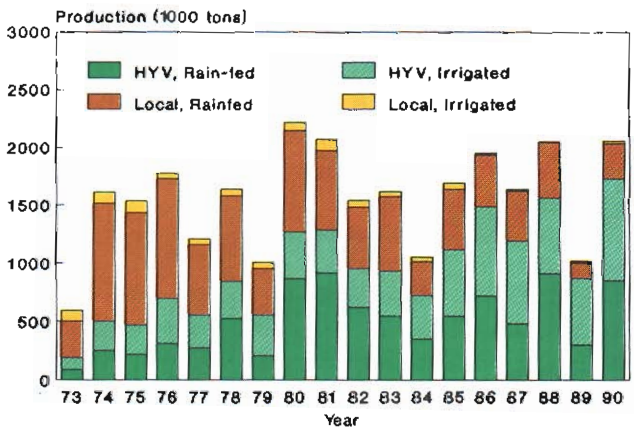


Fig. 14. Trend of wheat grain production in Syria, 1973-90.

Total wheat area

The reduction in total area may be due to changes in the geographic distribution of wheat. It appears that rain-fed wheat is being replaced in the wetter areas by other, more valuable crops, while in the drier areas more HYV wheat is being grown. Although HYV wheat demonstrates a definite advantage over local wheat in rain-fed areas, the largest contributor to increased productivity is the combination of irrigation and HYVs. The significance of irrigation alone is indicated by the higher yields obtained from irrigated local wheat than with rain-fed HYV wheat during the past decade.

The survey indicated important changes in western Syria and Al-Jazirah (north), with increases of 33 and 32% in the proportion of area grown in HYVs. The apparent recent shift in Al-Jazirah is crucial at the national level because of the vast wheat areas in that region. Recent growth in area under supplemental irrigation explains much of the rapid expansion of HYV area in both regions.

Varieties

The first improved wheat varieties in Syria were Florence Aurore (a bread wheat) and Senator Capelli (a durum wheat), followed by Jouri 69 (durum) and Mexipak (bread), both released before 1973. At that time, HYVs occupied about 15% of the total wheat area. Florence Aurore and Senator Capelli have since been officially reclassified as local varieties, but between 1973 and 1987 six durum and three bread wheats were released, all targeted to different environments. Associated technology, such as fertilizer recommendations, is based on zones rather than on varieties.

Varietal adoption shows a complex pattern. The total area sown to improved varieties during the past 20 years has increased dramatically, and the 1991 survey broadly confirmed the trends in HYV adoption presented by the official statistics (Table 18). Overall adoption increased from 66 to 87% of the total area between the 1987 and 1991 harvests, but differed with water regimes and locations. Increases in HYV adoption over the past 4 years were most significant among producers and farmers in the West region and Al-Jazirah. Hauran still has not seen the introduction of new varieties, and irrigated areas, like Al-Ghab and Al-Furat regions, were already almost entirely under HYV wheat.

Table 18. Percentage of farmers adopting new varieties in Syria.

Year of adoption	Regions					
	West	Al-Ghab	Al-Jazirah	Al-Furat	Hauran	Total
Before 1976	1	15	3	20	-	5
1976-80	5	30	9	45	-	12
1981-85	33	45	13	30	-	23
1986-90	47	10	75	5	-	47
Non-adopters	14	-	-	-	100	13
Total	100	100	100	100	100	100

Of the wheat varieties grown (durum and bread wheat, high yielding and local varieties), producers of only HYV durum constitute 51% of the sample, whereas HYV bread wheat only covers 11%. Farmers growing a mix of HYV bread and durum or HYV and local wheat are more diversified and grow more than twice as many varieties per farm. The most specialized are producers growing only one local variety.

Specialization, producing either HYV durum or HYV bread wheat (but not both), tends to come early in the adoption process. Farmers appear to make an initial choice about which type of HYV wheat to grow and then continue with that variety. Few farmers grow local varieties once they have adopted HYVs. Only 10% of Syrian farmers continue to grow a small field of local wheat for household consumption while using HYVs as a cash crop.

Surprisingly, there are more HYV bread-wheat specialists in rain-fed zone 2 than HYV durum specialists (Table 19). Less surprisingly, 77% of rain-fed zone 2 farmers are growing local varieties only. The relationship between irrigation and HYVs is clear: farmers able to irrigate their entire crop tend to specialize in either HYV durum or HYV bread wheat.

The percentage of new adopters has roughly doubled every 5 years until virtually the maximum has been

Table 19. Percentage of farmers using different variety mixes within water regimes.

Variety	Rain-fed		Irrigated		
	Zone 1	Zone 2	Supple-mental	Full	Mixed regime
HYV durum only	48	4	77	60	31
HYV bread only	7	15	8	20	6
HYV durum + HYV bread	19	-	9	20	28
HYV + local variety	12	4	5	-	28
Local variety only	14	77	1	-	7
Total	100	100	100	100	100

reached in all regions except Hauran. Hauran is a special case, and the absence of HYVs in this region is probably due to external factors rather than to producer choices. The correlation between early adoption and irrigation is strong. The rapid growth of HYVs in the West and Al-Jazirah regions reflects the spread of supplemental irrigation there over the last 10 years.

Adoption of improved varieties is a response to higher yields and higher net returns. Within the range of choice of new varieties, farmers will select and specialize in those varieties that give them the best return under prevailing economic conditions. Syrian wheat producers do not recognize a great deal of difference among the HYVs, except for the basic distinction between durum wheat and bread wheat. When they make a change, it is to add a new variety to the existing mix rather than to replace older with newer HYVs.

This finding is of fundamental importance in determining the impact of new varieties on the farming system and especially on the nature of linkages to external institutions such as markets and government agricultural organizations. Syrian wheat producers are now very much oriented toward external linkages. Seed source and harvest sale are two excellent indicators of linkages with wider systems. The government seed organization is the sole source of supply for 77% of HYV and local variety producers, the remainder coming from on-farm and market sources. On average, producers sell 88% of their harvest to the government marketing organization.

Irrigation

The growth of irrigation in Syria has been remarkable, more than doubling since 1973. Fully irrigated wheat area has expanded in a similar fashion, from 9% of total wheat area in 1973 to 20% at the end of the 1980s. Irrigated HYVs now provide nearly half of the national production.

Of the total wheat area covered by the survey, 35% was irrigated: 20% under supplemental irrigation and 15% with full irrigation. About 8% of farmers with access to irrigation water did not irrigate their wheat crop, preferring to use their pump wells for higher value crops, especially cotton and summer vegetables. Thousands of new pump systems have been installed in Al-Jazirah since 1987, increasing the irrigated area in this region from 13% in 1987 to 30% in 1991. Irrigated wheat in the West region shows a similar increase, although smaller areas are involved.

The survey has been important in establishing three points about recent wheat irrigation trends in Syria. First, the irrigated area has continued to increase despite a general decrease in total wheat area over the past 5 years. Second, supplemental irrigation of wheat is more widespread than full irrigation, and this situation is particularly marked in the West and Al-Jazirah regions. Third, farmers do not appear to select varieties for irrigation on the basis of response to extra water.

The evidence is clear that, given the opportunity and wherewithal, farmers will adopt irrigation technology. The benefits of irrigation in terms of higher yields are obvious. Moreover, the vast majority of wheat producers with access to irrigation apply at least some of their water to wheat; 92% of surveyed wheat producers with access to water irrigated all or part of their wheat crop. About 44% of them used only supplemental irrigation, 34% used full irrigation, and 22% followed a mixed strategy.

Production technology

New production technology has been widely adopted by farmers. Mechanical tillage, mechanized planting and harvesting, high-yielding varieties, fertilizers and chemical weed and pest control are common.

Of the farmers surveyed, 99% used a tractor for preseeding tillage, 69% used a machine for seeding, the rest relying on hand broadcasting, and over 90% harvested by machine. Half of the crop was hand-harvested in the Hauran and Al-Furat regions. In the latter, many plots are small and separated by bunds for basin irrigation, which makes mechanization of harvest difficult with existing equipment.

Only 5% of farmers did not use nitrogen fertilizer in 1991. Those who did applied fertilizer at planting, seeding, or later, or combined applications during the growing season. Those not using N fertilizer tended to rely on rainfall alone, although most rain-fed wheat farmers did apply N fertilizer. Phosphate fertilizer was applied by 87% of the farmers surveyed. Regional distribution of non-phosphate users was fairly even, except in Al-Ghab where only 50% of the farmers used phosphate fertilizer in 1991.

Herbicide has the lowest adoption rate of the major external inputs. Only half of surveyed farmers applied herbicide to at least one of their wheat fields. Most of the nonusers were in Al-Jazirah, Al-Furat and Hauran regions. Herbicides were most popular in Al-Ghab and the West. In total, the West accounted for 44% of herbicide use in the sample, and Al-Jazirah accounted for 63% of nonusers.

Summary

There is little evidence that any process of specialization and commercialization has occurred among the surveyed farmers. On average, HYV producers sell about 88% of their harvest, mostly to the government marketing organization. Producers of both improved and unimproved wheat sell between 75 and 100% of their harvest each year. Those who grow only HYV durum are no more market-oriented than those diversified farmers who grow HYV durum, HYV bread and local wheat on the same farm.

These findings underline the success of the Syrian government program in introducing modern technology into national wheat production. Moreover, they demonstrate that external resources and commercial considerations are important for all wheat producers, including those who continue to grow only local varieties.

Outreach Activities

ICARDA's six Regional Programs continued to be responsive to the changing needs of the region and of the stakeholder community. Although the level and nature of cooperation between these Programs and the WANA countries has varied to match the increasing research and training capacity of NARS, together they strive to maintain an effective partnership with the common objective of achieving sustainable increases in agricultural productivity.

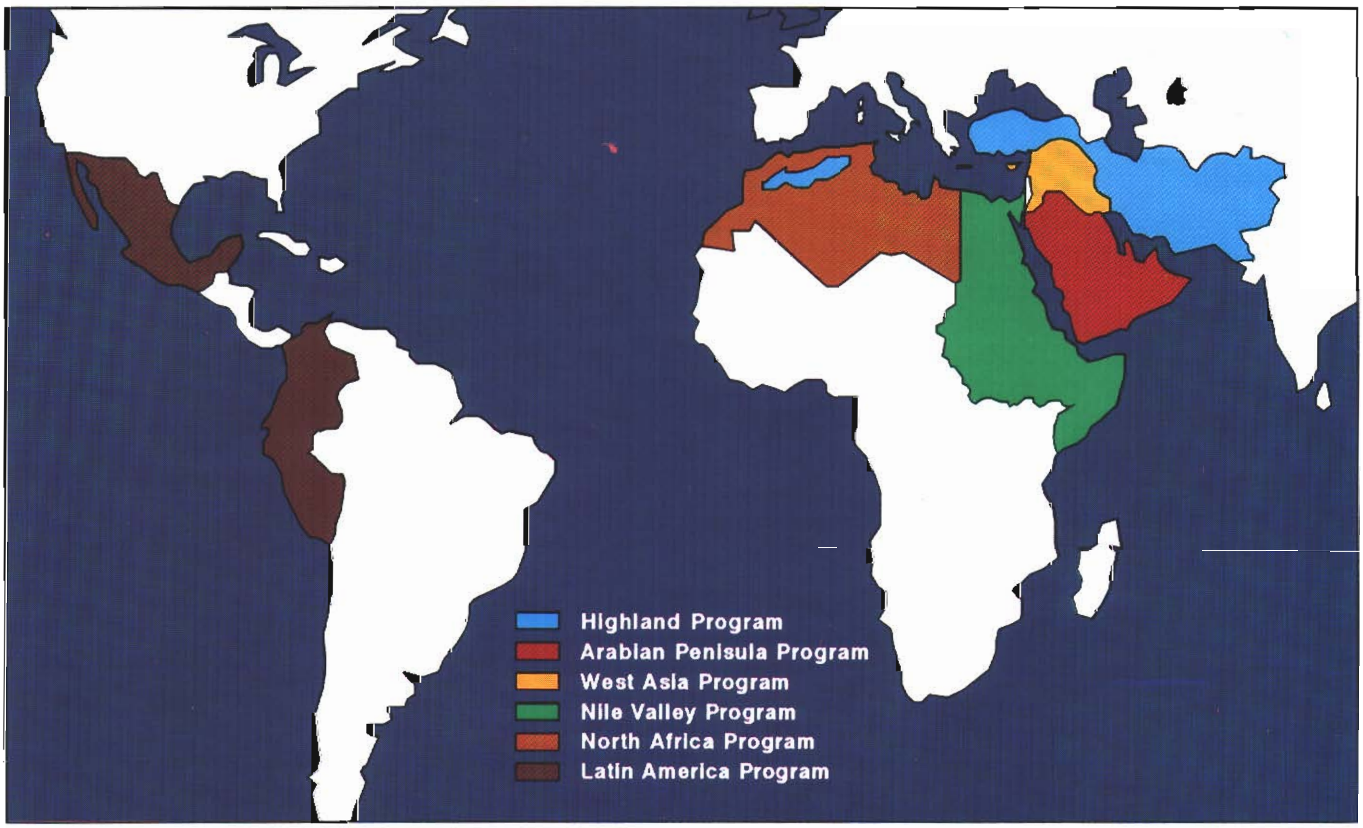
The region faced the Gulf crisis in early 1991, but disturbances to ICARDA's outreach activities were only minor and short-lived.

Highland Regional Program

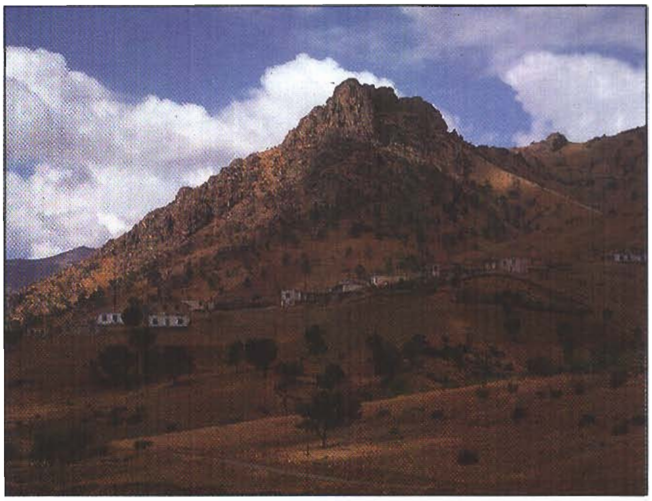
With financial support from the Governments of Italy and Iran, and from USAID, this Program focuses on highlands in WANA, an agroecological zone which remains largely unexploited by research and development programs. If sustainable agricultural systems can be devised that are in harmony with the severe environmental conditions experienced in highland areas, it is likely that agricultural productivity and the economic welfare of their inhabitants will be greatly enhanced.

Highland areas in WANA represent approximately 40% of the total agricultural land and are found principally in Turkey, Iran, Pakistan, Afghanistan and the Atlas mountain region of Morocco and Algeria. ICARDA's initial thrust in highland research has been in West Asia; a mature program now operates in Pakistan and similar programs are being developed in Turkey and Iran.

In Turkey, after a year of research carried out jointly by Cukurova University and ICARDA in the Taurus mountain villages in Adana province, it became evident that the communities there are extremely disadvantaged



Each region of ICARDA's six Outreach programs has specific needs and constraints to production.



Steep slopes in the Taurus Mountains limit arable land; this area is the target of the Cukurova University/ICARDA research project.

compared with those in other areas of the country. In eight villages selected at random from four counties in Adana province, an average family of 6.6 persons worked just over 4 ha of land, which is 2.5 ha less than the Turkish average. Of this land, 3.7 ha was used for the production of field crops, mostly wheat, barley, chickpea and oats, and 23% of the cropping land was fallowed each year. As this area receives 700 mm of annual precipitation, opportunities exist for intensification of cropping activities by fallow replacement. Most farmers practise mixed crop/livestock husbandry. Some villages are more specialized and carry large goat flocks which rely on rough forest grazing from the mountain tracts as their principal source of nutrition.

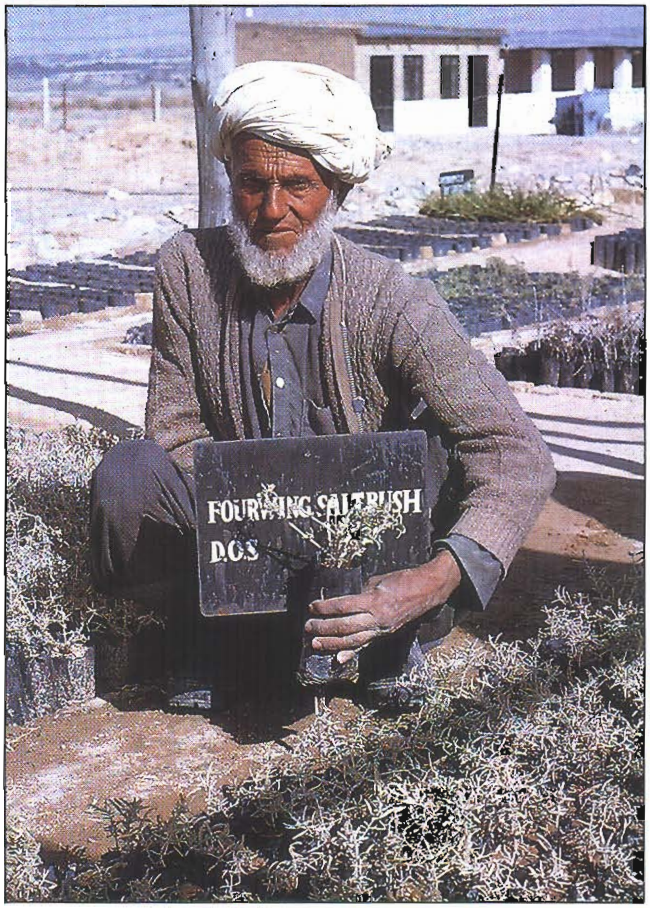
An analysis of yearly sources and supply of labor for the household revealed the following statistics: from a potential annual total of 1142 labor force days per family unit, only 327 days were used on the farm, 23 days in off-farm employment, and the remaining days were unused. This implies a potential for much greater production in such villages if other problems such as poor infrastructure, lack of education, inadequate husbandry techniques and difficulty in acquiring appropriate collateral to raise credit can be overcome. The Taurus Mountains Project will seek ways to overcome these constraints.

The climatic conditions and severe degradation of rangelands in highland Balochistan result in shortages of feed for small ruminants at most times of the year. One solution to this feed shortage is to establish fodder banks from the drought-tolerant shrub called fourwing saltbush (*Atriplex canescens*). AZRI has now extended its research on fourwing saltbush (FWSB) to unfenced farmers' fields. In some of these studies, FWSB is intercropped with wheat, giving farmers the option to use their land for wheat production during the establishment years of the FWSB. This also helps reduce wind erosion. FWSB plants are spaced 1 m apart with 3 m between rows. In time, the plants will form a fodder hedge that will trap soil particles. Small ruminants can browse the FWSB after the wheat harvest as a protein-rich supplement to the wheat stubble. Other studies are investigating the revegetation of heavily degraded rangelands with FWSB and ways to increase the germination rate of seeds. Studies have already started to define the browsing level of FWSB for sustained production of the species.

A Regional Bread Wheat Trial was repeated at Quetta using material that was received from ICARDA in 1989; 14 of the 23 genotypes yielded more grain than the local check. No yellow rust (*Puccinia striiformis*) was observed on any of the 23 lines, nor were they affected by the extremely low temperatures recorded in late December 1990. The material will be advanced to multilocation testing.

One of the main purposes of the USAID-funded project at AZRI is to "foster a collaborative relationship whereby (public sector) research institutes serve private agribusiness and farmers and use the private sector to disseminate marketable, improved technologies." The three ICARDA scientists based in Quetta have helped AZRI respond to this project purpose, initially by studying the agribusiness sector in Balochistan, and secondly by starting studies on the marketing of meat of small ruminants.

The agribusiness sector in Balochistan is very small and the potential for development to serve the extensive range-based small production systems and rain-fed agriculture is low. However, certain technologies developed at AZRI during the last 6 years could be of potential interest to agribusiness but may need further on-farm testing for their acceptability to farmers. These include the production of seedlings of FWSB in private nurseries, fabrication of an improved camel-drawn seed drill, and multiplication and sale of improved varieties of wheat, barley, lentil and forage crops to farmers.



Fourwing saltbush is grown from seed at the AZRI nursery in Pakistan and planted out when the bushes are about 6 months old.

Seasonal changes in the prices of sheep and goats at the producer and wholesale level were monitored at Quetta livestock market once a month. The prices that producers expected to receive varied far more than the price the wholesaler received. These large variations are related to the seasonal migration of animals and to religious festivals.

Arabian Peninsula Regional Program

With support from the Arab Fund for Economic and Social Development, the Regional Program for the Arabian Peninsula aims to strengthen research and training cooperation among the participating countries and with other regional and international organizations operating in the Peninsula. The countries participating in this program are: the United Arab Emirates (UAE), Bahrain, Qatar, Kuwait, Saudi Arabia, the Sultanate of Oman and the Republic of Yemen. The third Annual Coordination Meeting of this Program, scheduled to be held in the UAE, was postponed because of the unexpected political developments in the region. A draft agreement for locating the office of this Program in the UAE was submitted for approval to the Government of the UAE.

The major objectives of this Program are to enhance research on the improvement of barley, bread wheat, durum wheat, food and feed legumes, pasture, forage and livestock production and the related farming systems. The major constraints to agricultural production in the Arabian Peninsula are drought, heat, salinity, diseases and pests, weeds, inadequate seed industry and lack of trained personnel.

Several promising nurseries of barley, wheat and food and feed legumes were provided to the UAE, Qatar, Saudi Arabia, the Sultanate of Oman and the Republic of Yemen. Varietal description and evaluation for the common and improved wheat and barley cultivars grown in the Arabian Peninsula were initiated in cooperation with ICARDA's Seed and Genetic Resources units. A varietal description booklet will be produced in 1992.

Wheat and Barley Regional Crossing Blocks for the Arabian Peninsula, initiated at ICARDA headquarters in 1989/90 in cooperation with the Cereal Improvement Program, were continued. Results of the 1990/91 season were very encouraging; the segregating populations from these crosses will be evaluated in 1991/92 at ICARDA and in participating countries.

West Asia Regional Program

The West Asia Regional Program serves the research and training needs of Syria, Jordan, Iraq, Cyprus, Lebanon and the lowlands of Turkey. It also operates a Mashreq Project, supported by UNDP, for increasing the productivity of barley, pastures and sheep in critical rainfall zones of Syria, Jordan and Iraq, and for the transfer of technology to farmers.

Fertilizer application to barley in Syria increased average yields by 13–23%. The promising new barley lines Tadmor and WI 2291 outyielded the local cultivar

Syrian and Jordanian colleagues discuss Mashreq Project activities during a study tour.

in the dry areas of Syria by up to 55%. In Jordan, a 100% increase in barley yield was achieved with the use of the recommended production package. In Iraq, the improved six-row barley Gezira produced 59% higher yields than the local check; fertilization application boosted the yield to 131%.

Planting *Vicia sativa* after barley in the barley/fallow or barley/barley rotation showed that yield of barley after fallow was higher than barley yield after *V. sativa*. Demonstrations of *V. sativa* planting for grazing on farmers' fields were started in Jordan.

Work on the improvement of straw quality by urea treatment started in Syria, and demonstrations were conducted on farmers' fields. In Jordan, demonstrations to farmers were conducted on station and will be extended to farmers' fields next season.

Two chickpea lines (ILC 3279 and ILC 482) and one lentil line (78 S 26002) were identified by Iraq for release to farmers. In Jordan, two chickpea lines (FLIP 84-15C and FLIP 85-5C) and two lentil lines (87-5L and FLIP 84-147L) were identified for pre-release testing on farmers' fields. In Lebanon, lentil lines FLIP 86-22L and FLIP 87-15L, chickpea line FLIP 85-15C and faba bean line FLIP 85-98F were identified for on-farm testing.

Estrus synchronization of ewes resulted in 95% success in Iraq. Work on sheep breeding continued at Al-Radwanieh Station in central Iraq; 1754 matings were recorded between the different breeds available at the station for producing new hybrids or to maintain pure strains.

Surveys of farmers (98 in Syria and 45 in Jordan) were conducted to determine the impact of new technologies introduced through the Mashreq Project during the past 2 years. The data are being analyzed.

The annual coordination meeting with Lebanon was held at ICARDA headquarters in Aleppo, with Jordan in Amman, and with Syria in Aleppo. Research and training plans for the 1991/92 season were developed for all three countries.

Nile Valley Regional Program

The Nile Valley Regional Program (NVRP), started in 1988/89, covers research, transfer of technology and training to improve the production of cool-season food legumes (faba bean, chickpea, lentil and pea) and cereals (wheat in cooperation with CIMMYT in Egypt and Sudan, and barley in Egypt). A Regional Research Coordinator was appointed in October 1991 and based in Cairo; he is responsible for coordinating the NVRP activities at the national and regional levels, as well as for the administration of the Project. The administrative responsibilities were previously carried out by a Director of Administration who retired in September 1991.

Funding for NVRP continued from the ECC for Egypt, the Government of the Netherlands for the Sudan and SAREC of Sweden for Ethiopia.

Faba bean

In Egypt, in pilot production plots/demonstrations of an improved faba bean production package in Minia and Fayoum Governorates, seed and straw yields increased by about 480 kg/ha (26%) and 330 kg/ha (12%), respectively, over farmers' practices. Economic analysis indicated that farmers adopting the recommended package increased their net revenues by 44 to 56%. Similarly, integrated control of *Orobanche* using a resistant cultivar (Giza 402) and glyphosate increased yield by 13 to 110% and the average net benefit by about 50%.

In demonstrations in Minia, intercropping faba bean with autumn-planted sugarcane increased faba bean plant populations and seed and straw yields by 8 plants/m^2 (42%), 320 kg/ha (25%) and 1820 kg/ha (74%), respectively, compared with farmers' plots. In Beheira and Kafr-El-Sheikh Governorates, the newly released variety Giza 461 outyielded the old variety Giza 3 by about 570 kg/ha (43%) and 80 kg/ha (11%) for seed and straw yields, respectively.

Eighteen promising faba bean lines resistant to *Orobanche* and 27 resistant to aphids were selected at Giza. One hundred tonnes of high quality seed of Giza 461 and 45 tonnes of Reina Blanca were processed for the next season's planting.

In Ethiopia, pilot production-cum-demonstrations of faba bean at 38 locations in the provinces of Shewa (central zone), Arsi (northeast) and Gojam (northwest) showed considerable yield advantages with the recommended production package. At Arsi, the package produced yields between 2400 and 4160 kg/ha, compared with 1200—3330 kg/ha on farmers' fields. The average economic benefit from adopting the new technology was 43% with a marginal rate of return (MRR) to investment of 535%. In the central zone of Shewa, faba bean yields were increased by 41 to 208% as a result of package adoption, with 393% MRR. In Gojam, yield advantages averaged 112% with an increase of 130% in net benefit and 307% MRR. In verification trials, the recommended one hand-weeding (25-30 days after emergence) increased faba bean yield by 23% at Wolmera and 17% at Debre Zeit.

In Sudan, pilot production/demonstrations of improved packages conducted in the Nile Province, the Northern Province, Gezira, New Halfa and Rahad Schemes indicated that farmers adopting the recommended package had 20 to 82% higher yields and an additional net profit ranging between 25 and 88%, compared with their neighbors. The Variety Release Committee approved the release of two superior lines adapted to the nontraditional faba bean areas: Shambat 104 and Shambat 75 for the central areas.

Lentil

In Egypt, pilot production plots/demonstration in Sharkia, Kafr-El-Sheikh and Beheira Governorates indicated that the average increases in seed yield from the improved package adoption were 9, 13 and 48% in demonstration plots in Sharkia, Dakahlia and Kafr-El-Sheikh, respectively. The new cultivar, Precoz, outyielded Giza 370 by 26%.

In Ethiopia, the improved lentil production package was demonstrated to farmers at 16 sites in the Shewa Region. On average, the adoption of the package increased yield by 67% and net benefit 11-fold compared with traditional methods. Improved lentil cultivars were developed for different agroclimatic areas and three lines, FLIP 84-78L, FLIP 86-12L and FLIP 86-16L, were recommended for release.

In Sudan, the improved production package in demonstration plots at Rubatab increased yield by 28.4%, compared with traditional practices, and increased net revenue by 32%. In Wad Hamid, where lentil was newly introduced, the improved package yielded 1610 kg/ha.

Chickpea

In Egypt, chickpea seed yield with the recommended production package in demonstration plots in Beheira Governorate was 39% more than with traditional practices. Results of the on-farm verification trials across Assiut, Ismailia, Beheira and Quena Governorates revealed two promising breeding lines, L 70 and FLIP 14-80, which outyielded the local cultivar by 37 and 36%, respectively. In *Rhizobium* inoculation studies, the seed yield of inoculation treatment exceeded the uninoculated and the N fertilization treatments by 28.8 and 15.5%, respectively.

In Ethiopia, transfer of the improved chickpea production package to farmers started in 1990/91 in the Shewa Region. Yield obtained with the improved package at 16 sites was higher by 8% across locations compared with traditional practices.

In Sudan, chickpea yields from pilot production/demonstration plots at Rubatab and Wad Hamid areas were higher by 56 and 168%, respectively, than with the traditional practices. In researcher-managed on-farm trials, ridge planting gave higher seed yield than flat planting.

Field pea

Improved production package components for field pea are being developed for the 1992 on-farm demonstrations in Ethiopia. Five improved field pea cultivars were recommended for release. Aphids, cutworms and leaf miner were identified as common insect pests. In disease studies, promising lines resistant to *Septoria* and *Ascochyta* spp. were identified.

Wheat

In Egypt, on-farm pilot production/demonstration plots of an improved wheat production package gave 21 to 67% higher yields and 12 to 73% higher profitability than traditional practices in Fayoum, Upper Egypt and New Valley. The high marginal rate of return (557-650%) indicated the stable high profitability of the improved package even when the variable cost increased. In on-farm verification trials the cultivars Giza 164 (bread wheat) and Sohag 3 (durum wheat) proved promising in Upper Egypt: Giza 163 and 164, Bani Sweif 1 and Sohag 3 outyielded all tested entries, and semi-dwarf wheat gave yield advantages only at high density. Effective irrigation management was identified for high grain yield.

In central and eastern Sudan, in on-farm pilot production/demonstrations involving 756 farmers, yield advantages from the package adoption ranged between 44 and 117% and from 2 to 49% in northern areas. Yields up to 6000 kg/ha were achieved by some farmers. Economic studies showed that the profitability of the improved packages was confirmed by high levels of marginal rates of returns exceeding 500%, with a record of 1788% in Gezira. Encouraged by the high and profitable yields obtained in the NVRP pilot production/demonstration plots, the Government of Sudan continued to expand wheat production. Wheat self-sufficiency increased from 29% in 1987/88 to 65% in 1990/91.

Barley

In Egypt, on-farm demonstrations of the improved barley production packages including the two newly released cultivars, Giza 123 and Giza 124, produced 20 and 30% higher yields, respectively, than the traditional practices with CC 89, a previously recommended cultivar, and the local cultivar. Eight barley genotypes gave both high and stable yields over different environments. Several barley genotypes were identified with both multiple disease resistance and high yield.

Cereal travelling workshops, such as this one in Egypt, provide an overview of research and production constraints in the region.

Ahmed Omri of INRA in Rabat, Morocco discusses barley research with the director, Hoceine Faraj, a member of ICARDA's Board of Trustees.

Regional Cooperation

Regional cooperation among the three participating countries involved exchange of germplasm, technical information and improved technology, in addition to participation in regional travelling workshops and national coordination meetings. To complement back-up research at the regional level, Egypt is taking the lead in screening for aphid resistance in various crops, and Sudan in biological control of aphids. Work on heat stress in wheat is conducted in Sudan while work on drought and salinity tolerance is coordinated between Egypt and Sudan. Ethiopia will be taking the lead in breeding chickpea for resistance to wilt and root rot diseases.

North Africa Regional Program

The North Africa Regional Program (NARP) covers Algeria, Libya, Morocco and Tunisia. Its objectives are to coordinate and execute ICARDA core and special-funded collaborative projects in the region. Three senior scientists are posted in Morocco and Tunisia, and two post-doctoral fellows were recently appointed in Tunisia to support NARS in adoption and impact studies of cereals and food legumes. The cereal studies are jointly sponsored by ICARDA, CIMMYT and the Rockefeller Foundation, and the food legume impact study is sponsored by ICARDA and the World Bank.

A regional project proposal for Strengthening Faba Bean Research Network in North Africa has been developed for submission to the Federal Ministry of Technical Cooperation (BMZ) of the Republic of Germany for funding. The proposal was submitted with the endorsement of Algeria, Libya, Morocco and Tunisia for a first phase of 3 years (1992-1995). The project aims to ensure that the genetic material and techniques developed by ICARDA in the last 10 years are fully exploited for the benefit of farmers.

The IFAD special-funded project on Technology Transfer in barley, food legumes and livestock production in Algeria, Libya, Morocco and Tunisia made good progress. Multidisciplinary groups of research, teaching and extension personnel were integrated into the project activities on transfer of technology and production packages for high-yielding varieties of barley, chickpea and lentil.

The 1990/91 crop season's climatic conditions in North Africa were most favorable for crop production. An all-time record crop of cereals was harvested in Morocco (8.5 million tonnes) and Tunisia (2.55 million tonnes). Cereal production also was high in Algeria, exceeding 3.5 million tonnes despite the losses from diseases.

Through ICARDA's collaborative activities with NARS in this region, several varieties of wheat, barley, chickpea, lentil and faba bean were released or are at the pre-release multiplication stage in various countries. The production packages for these varieties were developed for many agroecological zones.

Faba bean research, now based in Morocco, made significant progress and many selections were identified with good resistance to the parasitic weed *Orobanche*, the most serious constraint to production. These selections gave much higher yields than the local varieties in infested areas. In Tunisia, faba bean lines S82 113-8, 80S 800-82 and others showed good tolerance to drought. Moreover, 14 faba bean lines from ICARDA showed resistance to the aggressive type, red-flowered *Orobanche foetida*. This represents the first record of resistance to *O. foetida*. Out of these, lines 18035 and 18054 were resistant also to *Orobanche crenata*, the dominant *Orobanche* type in the region.

The pasture, forage and livestock program began to play an important role in support of NARS in North

Africa. A viable network of dryland pasture and forage legume researchers has been established and project proposals for special funding are being developed to strengthen these commodities in the region.

ICARDA strengthened its collaboration with Libya and Tunisia for research through the initiation of case studies within the special-funded project on Dryland Resource Management and Improvement of Rain-fed Agriculture in the Drier Areas of West Asia and North Africa. These case studies are the first phase in a collaborative process of developing sustainable agricultural production in marginal areas.

ICARDA agreements with the governments of Algeria and Libya were drafted for approval. Collaboration with Libya in research and training was further strengthened. ICARDA organized in-country training courses for cereal improvement and on-farm survey methods in Libya. The number of Libyan trainees and participants in ICARDA's training courses and professional meetings has increased substantially.

Following many years of organizing individual country/ICARDA coordination meetings, ICARDA organized for the first time the North Africa/ICARDA Regional Coordination Meeting in Tunis, 8-12 October 1991. The meeting was attended by about 100 participants from Algeria, Libya, Morocco, Tunisia, IFAD, MIAC and ICARDA, who discussed the 1990/91 results of collaborative research and developed work plans for the 1991/92 season. It is expected that, in future, NARS will organize their individual coordination meetings prior to the single Regional Coordination Meeting.

Latin America Regional Program

The ICARDA/CIMMYT Barley Project focuses on developing improved barley germplasm with high yield potential and multiple disease resistance in high-rainfall environments, primarily in countries of the Andean Region of South America where the crop occupies 1.1 million hectares. The Program results are applicable to barley areas in the Far East, particularly China, where barley is grown on 4.6 million hectares and early maturing lines may fit particularly well in intensive cropping systems. Lines are now available with combinations of resistance to stripe rust, leaf rust, scald, barley yellow dwarf virus and net blotch in high-yielding, well-adapted germplasm.

Superior barley varieties have been released in Chile (including Centauro, a hull-less variety for human food), Peru, Ecuador, Brazil, the USA, Australia, Vietnam and China.

Resources for Research and Training

Finance

ICARDA's programs are funded by its generous donors. In 1991 the Center received donor funding of 19.477 million USD. These funds, combined with the income of 2.737 million USD from other sources (Table 20), provided the Center with a total of 22.214 million USD to operate its programs in 1991. This was a slight increase over ICARDA's income in 1990: 21.841 million USD excluding in-trust projects. The in-trust projects utilize ICARDA's capacities and accumulated experience, but do not represent a commitment beyond the duration of funding (see Appendix 6). ICARDA's 1991 in-trust project funding totalled 3.4 million USD, which include the first-year pledge of 1.7 million USD for the 5-year cooperative agreement with Iran for 8.3 million USD.

Table 20. Sources of funds for ICARDA's programs and capital requirement (× 1000 USD), 1991 and 1990.

	1991	1990		1991	1990
ANERA	10	-	Japan	300	-
Arab Fund	622	635a	Mexico	10	-
Australia	155	320	Near East Foundation	-	16a
Austria	175	175	Netherlands	969	909a
Canada	844	871	Norway	457	457
China	30	30	OPEC	50	-5a
Denmark	410	396	Rockefeller Foundation	-	32a
FAO	23	18a	Spain	125	125
Finland	278	251	Sweden	697	638
Ford Foundation	313	288a	UNDP	200	129a
France	377	438a	United Kingdom	1,189	983a
Germany	2,330	2,310a	USAID	4,576	4,416a
IBRD (World Bank)	4,000	4,300	Exchange gain (net)	1,387	1,189
IDRC	114	227a	Earned income	1,350	1,766b
IFAR	3	-	Other	-	-514c
India	25	25			
Iran	-	16a			
Italy	1,195	1,400a	Total	22,214	21,841

a Part or all of these amounts were provided for specified activities ("restricted core" and "special projects").

b Investment income, sale of crops, and overhead recovery.

c Provision for doubtful accounts.

Staff

The following staff joined ICARDA during 1991: Dr V. Aletor, Post-doctoral Fellow, Animal Nutrition; Mr T. Duplock, Director of Administration; Mr E. Estoque, Finance Officer; Dr T. Goodchild, Ruminant Nutritionist; Dr J. Hamblin, Cereal Program Leader; Dr A. Hamdi, Post-doctoral Fellow, Lentil Breeding; Mr J. Konopka, Documentation Officer; Ms M. Leybourne, Visiting Research Associate; Dr T. Oweis, Water Management Specialist; Dr L.D. Robertson, Legume Germplasm Curator; Dr N.P. Saxena, Visiting Scientist/ICRISAT, Legume Physiology; Ms L. Sears, Editor; Ms E. Talmage, Science Editor and Dr G. Walker, Agroclimatologist. Dr M. Jones, on staff as Agronomist, was appointed FRMP Leader.

Two senior staff members proceeded on sabbatical leave: Dr A. Abdel Moneim, Forage Legume Breeder and Dr L. Materon, Microbiologist.

During 1991 the following staff members left ICARDA: Dr B.D. Bhardwaj, NVRP Director of Administration; Dr P. Cocks, PFLP Leader; Dr B. Curtis, CIMMYT Liaison Officer; Dr M. Diekmann, Visiting Scientist; Mr K. El-Bizri, Head, Computer Services; Mr A. Elings, Associate Expert; Dr Munir El-Turk, Research Associate; Dr S. Hanounik, Faba Bean Pathologist; Dr P. Jegatheeswaran, Mechanical Workshop Engineer; Dr P. Lashermes, Biotechnologist and Dr K.H. Linke, *Orobanche* Control Specialist.

A list of senior staff as of 31 December 1991 is given in Appendix 14.

Farms

ICARDA operates five sites in Syria and two in Lebanon (Table 21). These sites represent a variety of agroclimatic conditions, typical of those prevailing in West Asia and North Africa.

At Tel Hadya most crops germinated in January or February, as precipitation until the end of December totalled 50 mm compared with an average of 135 mm. Following a 50-mm rain in late March, approximately 6 weeks were left until maturity of most crops. A hailstorm in May 21 destroyed several trials. As a result, the yield in many fields was substantially reduced. Hay crops (vetches or peas) were not affected by hail and gave good yields when cut green in April.

Table 21. 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	944	284	350
Bouider	35°41'N	37°10'E	35	268	210
Ghrerife	35°50'N	37°15'E	2	320	280
Breda	35°56'N	37°10'E	76	300	280
Jindiress	30°24'N	36°44'E	10	210	470
LEBANON					
Terbol	33°49'N	35°59'E	39	890	600
Kfardane	34°01'N	36°03'E	50	1080	430

The fall of the water table in the area increased to an average of 2 m per year during the last 3 years. Over the last 8 seasons it dropped by approximately 11 m (Fig. 15). This development increases the need for research into rain-fed agriculture and improvement of supplemental irrigation.

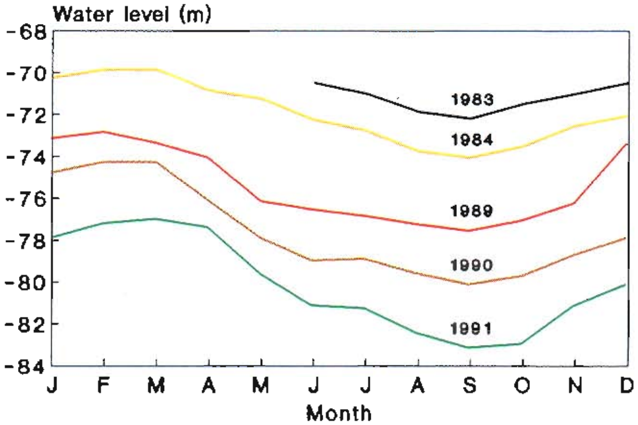


Fig. 15. Water table at Tel Hadya, Syria.

Small Ruminants Unit

ICARDA maintains a flock of 700 Awassi sheep and a small flock of goats for research studies. Ruminant research includes animal husbandry and reproduction, large-scale grazing trials and assessment of the nutritive value of feeds. During 1991 a small flock of Awassi sheep from Turkey was brought to Tel Hadya. They will be compared with Syrian Awassi to assess the relative contributions of genetics and nutrition to high performance.

Computer Services

The Computer Services Unit of ICARDA provides support services to programs and units of the Center for the storage and retrieval of their data, and assists in scientific and management information processing. It renders biometrics support to the research programs and provides support on all software in use at the Center. It has a major responsibility for training NARS personnel in the areas of statistical computing and the application of computers in research and biometrics.

The enhancement and upgrading of the information-processing resources gained further momentum in 1991 as the number of personal computers increased. They were complemented by additional software, including SAS and ORACLE, bringing the total software library to 83 PC packages, used throughout the Center.

Further progress was achieved in modernizing the central computing environment. The Center is in the process of acquiring a dual-host VAX 4000 computer and an integrated network linking the VAX with terminals and PCs. A suitable database management system, together with proper financial and administrative software, will be phased in with the installation of the new machines.

Applied statistics and biometrics

Statistical computing needs at the Center were met through the in-house package CRISP and a number of standard commercial statistical software such as SPSS, GENSTAT, SAS and BMDP.

In collaboration with the Farming Resources Management Program, the study of relative contribution of residual phosphate vs. applied phosphate on phosphate nutrition of lentil crop during the growing season at three experimental sites was completed using Non-Linear Regression procedures in BMDP software.

CSU also collaborated with the Legume Program in data management and analysis for Chickpea Consumer Survey data using three different questionnaires to assess the uses of chickpea in different kinds of diets, seed quality needed for each preparation and the rate of consumption of the foods by inhabitants of cities and villages.

In collaboration with the Cereal Program, an examination of the data collected under the study on assay of variation in virulence among isolates of *Mycosphaerella graminicola* was conducted on wheat cultivars for disease development. A second study involved detection of outliers in data on heat tolerance of wheat. Studentized residuals were used for detection of statistical outliers in the data on heat damage collected from a completely randomized design. The effect of removing the outliers on estimate of genotype effect and on precision was assessed. Estimate of the error variance was considerably reduced when outliers were excluded from the analysis. An application of errors-in-variable model was made on the heat tolerance data. Percentage damage in wheat genotypes was computed using two new methods and an original method. To examine the efficacy of new methods, an error-in-variable approach in linear functional relationship was considered. The suitability of the two new methods in comparison with the original method for measuring heat tolerance was assessed.

The COVRBD analysis of covariance for RBD design module was modified to add the following statistics: Genotypic Correlation, Phenotypic Correlation, Environmental Correlation and Heritabilities. The computation for standard errors as well as probabilities of significance for the above correlations were also added.

Estimation of heritability of a plant trait, from data collected on several pure breeding lines evaluated at a single location and at multiple locations, was formulated. Heritability estimates were obtained from analysis of variance estimates of variance components. Evaluation of standard error using the Taylor series expansion of heritability in terms of mean squares due to genotypes and error was completed.

Management information systems

ICARDA's information systems were formerly based on an in-house Management and Accounting System (MAS), which no longer met all the needs of financial management. ICARDA management enlisted the services of two consultants to study the existing systems and ICARDA's future needs. Several software options are being considered. In the interim, the existing MAS has been modified and expanded to meet current needs of monthly reporting. The Fixed Assets and Inventory Management systems also were altered to improve costing by project and accuracy of stores control, respectively.

Training

CSU contributed to the human resource development programs of the Center and the NARS by providing training in statistics, database management, spreadsheet and word processing software, biometrics, system operation and hardware maintenance. A Training and Computing Laboratory was established for the use of Center staff and NARS trainees. Two visitors from Iran were trained in the use and application of statistical software. Training of the unit's personnel is ongoing; during 1991, two staff participated in a course on Crop Growth Simulation Model held at Cukurova University, Adana, Turkey.

Appendices

Contents

Appendix 1

Precipitation (mm) in 1990/91

	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	TOTAL
SYRIA													
Tel Hadya													
1990/91 season	1.6	7.8	19.0	21.7	71.9	35.0	73.3	38.7	21.1	0.0	0.0	0.0	290.1
Long-term average (13 seasons)	0.5	24.5	48.5	53.8	61.0	50.2	43.8	28.4	14.2	3.0	0.0	0.1	328.0
% of long-term average	320	32	39	40	118	70	167	136	149	0	0	0	88
Breda													
1990/91 season	0.0	4.4	26.2	12.4	50.9	20.6	60.0	35.2	31.6	0.0	0.0	0.0	241.3
Long-term average (33 seasons)	1.2	16.9	30.8	53.3	48.7	38.3	34.4	31.4	16.1	1.5	0.1	0.0	272.7
% of long-term average	0	26	85	23	105	54	174	112	196	0	0	0	88
Boueider													
1990/91 season	0.0	4.4	15.8	21.4	52.0	18.8	61.8	22.6	16.6	0.0	0.0	0.0	213.4
Long-tem average (18 seasons)	0.1	14.7	23.0	35.0	37.6	33.9	29.6	17.5	9.4	0.7	0.1	0.0	201.6
% of long-term average	0	30	69	61	138	55	209	129	177	0	0	0	106
Ghrerife													
1990/91 season	0.0	4.2	22.8	18.8	57.8	16.4	68.4	23.2	20.2	0.0	0.0	0.0	231.8
Long-term average (6 seasons)	0.0	38.6	23.8	38.5	44.0	35.4	38.0	13.3	12.1	0.6	0.0	0.0	244.3
% of long-term average	0	11	96	49	131	46	180	174	167	0	0	0	95
Jindiress													
1990/91 season	3.2	61.0	38.4	32.9	70.3	50.5	70.6	82.7	28.4	0.0	0.0	0.0	438.0
Long-term average (31 seasons)	1.4	31.4	55.1	92.0	84.1	73.9	65.9	43.7	19.3	2.3	0.3	0.8	470.2
% of long-term average	228	194	70	36	84	68	107	189	147	0	0	0	93
LEBANON													
Terbol													
1990/91 season	0.0	8.0	47.8	42.6	128.8	80.8	121.8	44.6	57.8	0.0	0.0	0.0	531.4
Long-term average (10 seasons)	0.0	23.9	62.4	77.9	91.2	97.4	95.6	26.2	13.4	0.6	0.3	0.0	488.9
% of long-term average	0	33	77	55	141	82	127	170	431	0	0	0	109

Appendix 2

Cereal and Legume Varieties Released by National Programs

Country	Year of release	Variety
Barley		
Algeria	1987	Harmal
Australia	1989	Yagan
	1991	High
Brazil	1989	Acumai
Chile	1989	Leo/Inia/Ccu
		Centauro
China	1986	Gobernadora
	1989	V-24
Cyprus	1980	Kantara
	1989	(Mari/Aths*)
Ecuador	1989	Shyri
Ethiopia	1981	BSH 15
	1984	BSH 42
	1985	Ardu
Iran	1986	Aras
	1990	Kavir, Star
Jordan	1984	Rum (6-row)
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
Peru	1987	Una 87, Nana 87
	1989	Bellavista
Portugal	1982	Sereia
	1983	CE 8302
	1991	Ancora
Qatar	1982	Gulf
	1983	Harma
Saudi Arabia	1985	Gusto
Spain	1987	Rihane
Syria	1987	Furat 1113
Thailand	1987	Semang 1 IBON 48
		Semang 2 IBON 42
Tunisia	1985	Taj, Faiz, Roho
	1987	Rihane''S''
Vietnam	1989	Api/CM67//B1
Yemen AR	1986	Arafat, Beecher
Durum Wheat		
Algeria	1982	ZB S FG'S'/LUKS GO
	1984	Timgad
	1986	Sahl, Waha
Cyprus	1982	Mesoaria
	1984	Karpasia
Egypt	1979	Sohag I
	1988	Sohag II, Beni Suef
Greece	1982	Selas
	1983	Sapfo
	1984	Skiti
	1985	Samos, Syros
Jordan	1988	Korifla = Petra
		Cham 1 = Muru
		N-432 = Amra
		Stork = ACSAD 75
Lebanon	1987	Belikh 2
	1989	Sebou
Libya	1985	Marjawi, Ghuodwa, Zorda, Baraka, Qara, Fazan
Morocco	1984	Marzak
	1989	Sebou, Oum Rabia
Pakistan	1985	Wadhanak
Portugal	1983	Celta, Timpanas
	1984	Castico
	1985	Heluio
Saudi Arabia	1987	Cham 1
Spain	1983	Mexa
	1985	Nuna
Syria	1984	Cham 1
	1987	Cham 3, Bohouth 5
Tunisia	1987	Razzak
Turkey	1984	Susf bird
	1985	Balcili
	1988	EGE 88

Country	Year of release	Variety
Bread Wheat		
Algeria	1982	Setif 82, HD 1220
	1989	Zidane 89
Egypt	1982	Giza 160
	1988	Sakha 92, Giza 162
		Giza 163, Giza 164
	1991	Gammeiza 1
Ethiopia	1984	Dashen, Batu, Gara
Greece	1983	Louros, Pinios, Arachthos
Iran	1986	Golestan, Azadi
	1988	Sabalan, Darab, Quds
	1990	Falat
Jordan	1988	Nasma = Jubeiha
		L88 =Rabba
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
Syria	1984	Cham 2
	1986	Cham 4
	1987	Bohouth 4
	1991	Cham 6, Bohouth 6
Tanzania	1983	T-VIRI-Veery 'S'
		T-DUMA-D6811-Inrat
		69/BD Tunisian release
Tunisia	1987	Byrsa
Turkey	1988	Kaklic 88, Kop, Dogu 88
	1989	Es14
	1990	Yuregir, Karasu 90, Katia 1
Yemen AR	1983	Marib 1
	1988	Mukhtar, Aziz, Dhumran
Yemen PDR	1983	Ahgaf
	1988	SW/83/2

Country	Year of release	Variety
Kabuli Chickpea		
Algeria	1988	ILC 482, ILC 3279
	1991	FLIP 84-79C
		FLIP 84-92C
China	1988	ILC 102, ILC 411
Cyprus	1984	Yialousa (ILC 3279)
	1987	Kyrenia (ILC 464)
France	1988	TS 1009 (ILC 482)
		TS 1502 (FLIP 81-293C)
Iraq	1991	ILC 482, ILC 3279
Italy	1987	Califfo (ILC 72)
		Sultano (ILC 3279)
Jordan	1990	Jubeiha-2 (ILC 482)
		Jubeiha-3 (ILC 3279)
Lebanon	1989	Janta 2 (ILC 482)
Morocco	1987	ILC 195, ILC 482
Oman	1988	ILC 237
Portugal	1989	Elmo (ILC 5566)
		Elvar (FLIP 85-17C)
Spain	1985	Fardan (ILC 72)
		Zegri (ILC 200)
		Almena (ILC 2548)
		Alcazaba (ILC 2555)
		Atalaya (ILC 200)
Sudan	1987	Shendi (ILC 1335)
Syria	1982/86	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)
	1990	Damla 89 (FLIP 85-7C)
		Tasova 89 (FLIP 85-135C)
	1991	Akcin (87AK 11115)
Lentil		
Argentina	1991	Arbolito (ILL 4650x-4349)
Australia	1989	ILL 5750
Algeria	1987	Syrie 229
	1988	Balkan 755, ILL 4400

Country	Year of release	Variety
Lentil (cont.)		
Canada	1989	Indian Head (ILL 481)
Chile	1989	Centinela (74TA 470)
China	1988	FLIP87-53L (ILL 6242)
Egypt	1990	Precoz (ILL 4605)
Ecuador	1980	R 186
	1987	INIAP-406 (FLIP 84-94L)
Ethiopia	1984	ILL 358
Jordan	1990	Jordan 3 (78S 26002)
Lebanon	1988	Talya 2 (78S 26013)
Morocco	1990	Precoz (ILL 4605)
Nepal	1989	Sikhar (ILL 4402)
Pakistan	1990	Manserha 89 (ILL 4605)
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)
USA	1991	Crimson (ILL 784)
Faba bean		
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
Syria	1991	Hama 1 (Selection from Aquadulce)
Sudan	1989	Karima-1
Forage Legumes		
Morocco	1990	*Vicia sativa* (ILF-V-1812)

Appendix 3

Publications

Articles in scientific journals, 1991

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Media Coverage

'The fingerprint of chickpea,' Al-Liqa (Germany), March 1991. (Article on scientific cooperation between German institutions and ICARDA)

'Signing of cooperation agreement between the Ministry of Agriculture and the International Center for Agricultural Research in the Dry Areas, ICARDA,' Ad-Diyar (Lebanon), April 1991

'Agreement signed for cooperation between the Ministry of Agriculture and ICARDA,' An-Nahar (Lebanon), April 1991

'Lebanese Minister of Agriculture Dalloul and ICARDA Director General: Signing of cooperation agreement in the field of agricultural research,' As-Safir (Lebanon), April 1991

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'The Advisory Committee on Agricultural Research Has Begun Meeting,' Ar-Rai (Jordan), 5 June 1991

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'ICARDA to Host Talks on Environmental Management,' Turkish Daily News, 12 Dec 1991

Contributions to Conferences 1991

February

London GB. Linnean Society of London: Grasses of Arid and Semi Arid Regions

De-Wet, J.M.J., F.R. Bidinger and J.M. Peacock. Pearl millet (*Pennisetum glaucum*) - A cereal of the Sahel.

March

New Delhi IN. International Golden Jubilee Symposium on Genetic Research and Education: Current Trends and the Next Fifty Years

Malhotra, R.S., W. Erskine and M.C. Saxena. Adaptation of improved lentil genotypes to diverse environments.

Singh, K.B. The role of wild species in improvement of cool season food legumes.

Raleigh US. Symposium on Plant Breeding in the 1990s

Singh, K.B., R.S. Malhotra and M.C. Saxena. Breeding for cold tolerance in chickpea.

Rome IT. Expert Consultation on the Role of Agricultural Universities in National Agricultural Research Systems

El-Sebae Ahmed, Samir and Robert H. Booth. Current and potential role of agricultural universities in strengthening national agricultural research systems in West Asia and North Africa.

Sidi Bel Abbes DZ. Research Achievement of Cereals, Food Legumes and Forages in Sidi Bel Abbes and Saida Provinces

Beniwal, S.P.S. ICARDA's food legume activities in North Africa with special reference to Algeria.

April

Aleppo SY. UNDP/ICARDA/FRANCE Workshop on Biotechnologies for the Improvement of Cereal and Legume Crops in West Asia and North Africa: Present Status and Future Perspectives

Beck, D. Biotechnology for rhizobia: present and future trends.

Lashermes, P. Biotechnology research activities for cereal improvement at ICARDA.

Makkouk, K.M. Diagnostics available at ICARDA for the detection of cereal and legume viruses in seeds, leaves and aphid vectors.

Materon, L. Present and future trends of biotechnology for rhizobia.

Weigand, F. RFLP-fingerprinting in legume improvement.

Montpellier FR. IV International Rangeland Congress

Osman, A.E., P.S. Cocks, M. Shorbagy and S. Ismail. Seeding of native shrubs improves degraded marginal lands in Mediterranean environment.

Paris FR. Colloque International Devenir des Steppes D'Arabie et du Bilad Ach Cham

Treacher, T. Linkages between steppe and cultivated areas through livestock systems - Implications for research and development to establish more productive and stable systems.

June

Gainesville US. International Symposium on Physiology and Determination of Crop Yield

Saxena, N.P., M.C. Saxena and K.B. Singh.

Functional ideotype to increase and stabilize yield of rainfed winter and spring chickpea in West Asia and North Africa.

Nairobi KE. Fifth Symposium on Parasitic Weeds

van Hezewijk, M.J., K.-H. Linke, A. Pieterse and J.A.C. Verkleij. The effect of ammonium fertilizer in combination with nitrification inhibitors on *Orobanche crenata* infestation in faba bean.

Linke, K.-H., H. Schnell and M.C. Saxena. Factors affecting the seed bank of *Orobanche crenata* in fields under lentil based cropping system in northern Syria.

July

Brno CZ. Eighth Meeting of the EUCARPIA Section: Biometrics on Plant Breeding

Yau, S.K. Variance of relative yield as an agronomic type of stability measure.

Helsingborg SE. Sixth International Barley Genetics Symposium

Ceccarelli, S., J.A.G. van Leur and S. Grando. Barley breeding for sustainable agricultural development in WANA.

Damania, A.B. and S.K. Yau. Biodiversity for useful traits in a genetic resources collection of barley.

Grando, S. and S. Ceccarelli. Use of *Hordeum vulgare* ssp. *spontaneum* in barley breeding for stress conditions.

Grillo, A. and R. Petti. Comparison among barley genotypes at different levels of water supply, using a rain-shelter facility.

Inagaki, M.N. and M. Tahir. Haploid production of wheat and barley through interspecific crosses.

August

Orlando US. International Symposium on Soil Testing and Plant Analysis

Matar, A. Soil testing as a guide to fertilization in West Asia and North Africa (WANA) region.

St. Louis US. American Phytopathological Society Meeting

Khoury, W. Components of resistance to *Ascochyta rabiei* in chickpea.

September

Mar del Plata AR. National Horticultural Meeting

Gray, L.N., C. Pastrana, N.G. de Delgado and W. Erskine. Un nuevo cultivar de lenteja (*Lens culinaris* Medik.)

Pisa IT. XXXV Convegno della Societai Italiana di Genetica Agraria

Petti, R. and A. Grillo. Accrescimento a basse temperature di genotipi di orzo adattati ad ambienti siccitosi.

D'Ovidio, R., E. Iacono and O.A. Tanzarella. Restriction Fragment Length Polymorphism analysis in durum wheat.

Ercoli, L. Transfer of storage proteins genes from *Triticum aestivum* to *Triticum durum* through chromosome engineering.

Wye GB. British Society of Animal Production, Occasional Meeting: Animal Production in Developing Countries, Resolving Technical and Socio-economic Constraints

Ceccarelli, S. Plant breeding technologies relevant to developing countries.

Nersoyan, N.K., P.E. White and S. Christiansen. Nitrogen build-up in medic pasture-wheat in comparison to other rotations in dry Mediterranean zones.

Rihawi, S. and T. Treacher. Influence of variety and season on the yield and nutritional quality of barley and wheat stubble in north west Syria.

November

Aleppo SY. Workshop on Quarantine for Seeds

Bos, L. and K.M. Makkouk. Plant viruses as pests of quarantine significance to seed.

Makkouk, K.M. and L. Bos. Detection of seed-borne viruses in seeds.

December

Cairo EG. 4th Arab Congress of Plant Protection

Bayaa, B., W. Erskine and A. Hamdi. Screening wild lentil for resistance to vascular wilt and Ascochyta blight diseases.

El Naimi, M. and O.F. Mamluk. Pathogenicity of *Septoria tritici* blotch, *Mycosphaerella graminicola*, with inoculum of different origin on wheat species.

Makkouk, K.M. and W. Ghulam. Screening cereals for barley yellow dwarf virus resistance.

Makkouk, K.M., L. Katul, R. Casper and S.G. Kumari. Faba bean necrotic yellows (FBNYV): a possibly new virus disease of faba bean (*Vicia faba*) and lentil (*Lens esculenta*) in West Asia and North Africa.

Makkouk, K.M. and S.G. Kumari. Pea seed-borne mosaic virus: host range, purification, serology, transmission characteristics and occurrence in West Asia and North Africa.

Makkouk, K.M., W. Radwan and A.H. Kassem. Survey of seed-borne viruses in barley, lentil, and faba bean in Syria.

Saskatoon CA. International Workshop on Common Root Rot

van Leur, J.A.G. Testing barley for resistance to *Cochliobolus sativus* at ICARDA, Syria.

Publications produced at ICARDA

Scientific Reports 1991

Strengthening agricultural research for dryland farming in the highlands of Iran. Joint Iran/ICARDA collaborative project. 61 p. ICARDA-195.

Seed unit, annual report 1990. 20 p. ICARDA-196.

Cereal improvement program, annual report 1990. 210 p. ICARDA-198.

Genetic resources unit, annual report 1990. 120 p. ICARDA-199.

Smith, A. and L. Robertson (editors). Legume genetic resources for semi-arid temperate environments: proceedings of an international workshop on genetic resources of cool-season pasture, forage, and food legumes for semi-arid temperate environments, Cairo, Egypt, 19-24 June 1987. 511 p. ICARDA-201.

Food legume improvement program, annual report 1990. 333 p. ICARDA-202.

Highland regional program: the MART/AZR project, annual report 1990. 101 p. ICARDA-219.

Farm resource management program, annual report 1990. 268 p. ICARDA-221.

Meteorological reports for ICARDA experiment stations in Syria and Lebanon: 1989/90. 323 p. ICARDA-223.

Singh, K.B., L. Holly and G. Beijiga. A catalog of kabuli chickpea germplasm. 398 p. ICARDA-225.

Carter, E.D. Legumes in farming systems of the Near East and North African region. 118 p. Reprinted ICARDA-227.

Jones, M. Agricultural sustainability research at ICARDA. A presentation at Centers Week 1991, Washington DC, USA. 20 p. ICARDA-230.

Damania, A.B., J. Valkoun, B. Humeid, L. Pecetti, J.P.

Srivastava and E. Porceddu. Durum wheat germplasm catalog. 563 p. ICARDA-234.

ICARDA annual report 1990. 133 p. ICARDA-238.

Rana, M.S.K. and B.A. Malik. Food legume breeding strategies: proceedings of a workshop held at National Agricultural Research Center, Pakistan Agricultural Research Council, Islamabad, Pakistan, 22 Mar 1989. 90 p. ICARDA-242.

Harris, C.H., P.J.M. Cooper and M. Pala. Soil and crop management for improved water use efficiency in rainfed areas: proceedings of an international workshop held in Ankara, Turkey, 15-19 May 1989. 352 p. ICARDA-247.

Draft report. Workshop on quarantine for seed in the Near East region, 2-9 Nov 1991, Aleppo, Syria. 39 p. ICARDA-253.

Periodicals

ICARDA Quarterly Progress Report. Winter 1990/Spring 1991, 11 p.; Summer 1991, 9 p.

Faba Bean in AGRIS. Vol 6, 1990 (Cumulation), 45 p. ICARDA-239.

FABIS Newsletter. No. 26, 52 p.; No. 27, 44 p. ICARDA-240.

LENS Newsletter. Vol 17, No. 1, 42 p.; No. 2, 46 p. ICARDA-224.

Pasture and Forage Legume Network News. No. 1, 7 p.; No. 2, 10 p.; No. 3, 12 p.

RACHIS Newsletter. Vol 9, No. 1, Ar, 46 p.; Vol 9, No. 2, En, 50 p., Ar, 48 p.; Vol 10, No. 1, En/Ar, 40 p. ICARDA-251.

Seed Info. No. 1, 9 p.; No. 2, 12 p.

The MART/AZR Project Publications

Ahmad, Sarfraz, A. Rodriguez, G. Farid Sabir, B. Roidar Khan and M. Panah. Economic losses of wheat crops infested with yellow rust in highland Balochistan: survey results. 15 p. Research report No. 67.

Ahmad, Sarfraz, B. Roidar Khan, Asghar Ali, J.D.H. Keatinge and Irshad Begum. Selection of bread wheat genotypes for spring sowing in the arid highlands of Balochistan. 12 p. Research report No. 69.

Ahmad, Sarfraz, Irshad Begum, S.A. Jaleel, M.Anwar Khan, B. Roidar Khan and A.Y. Allan. Germplasm evaluation in the arid highlands of Balochistan: Annual report of the AZRI germplasm research group. 29 p. Research report No. 73.

Ali, Asgar, Sarfraz Ahmad, Bakhut Roidar Khan and J.D.H. Keatinge. Selection of vetch genotypes under rainfed conditions in highland Balochistan. 12 p. Research report No. 68.

Chaudhry, Maqsood Ahmed. Strengthening linkages between research, agribusiness and farmers. 41 p. Research report No. 72.

Khan, B. Roidar, E.F. Thomson, A.Y. Allan and A.L. Rodriguez. AZRI research plans for 1991/92. 58 p. Research report No. 70.

Mahmood, K. and A. Rodriguez. Marketing and processing of small ruminants in highland Balochistan. 14 p. Research report No. 71.

Sabir, G. Farid, A. Afzal, N.A. Shah, J.G. Nagy, J.D.H. Keatinge and A. Rodriguez. Camel survey results in highland Balochistan. 29 p. Research report No. 66.

Nile Valley Regional Program (NVRP) Publications

Nile Valley regional program on cool-season food legumes and barley, annual report 1989/90, Ethiopia. 102 p. ICARDA/NVRP-DOC-011. ICARDA-220.

Nile Valley regional program on cool-season food legumes and wheat, annual report 1989/90, Sudan. 193 p. ICARDA/NVRP-DOC-012. ICARDA-232.

Nile Valley regional program on cool-season food legumes and cereals, annual report 1989/90, Egypt. 138 p. ICARDA/NVRP-DOC-013. ICARDA-248.

North Africa Regional Program Publication

North Africa/ICARDA regional coordination meeting, research highlights and workplans 1990/1991 in collaboration with the Algerian, Libyan, Moroccan and Tunisian agricultural research programs. 156 p.

West Asia Regional Program Publications

Increased productivity of barley, pasture and sheep (Mashreq Project RAB/89/026). 117 p. Mash/Doc/004.

The second technical annual report of Mashreq Project for barley, forages, and sheep, 1990/1991 season. 111 p. (RAB/89/026).

Increased productivity of barley, pasture and sheep. Workplan for Syria 1991/92. (Mashreq Project RAB/89/026). 85 p. (English, Arabic). Mash/Doc/005.

Increased productivity of barley, pasture and sheep. Workplan for Jordan 1991/92. (Mashreq Project RAB/89/026). 102 p. (English, Arabic). Mash/Doc/006.

Increased productivity of barley, pasture and sheep. Workplan for Iraq 1991/92. (Mashreq Project RAB/89/026). 105 p. (English, Arabic). Mash/Doc/007.

An introduction to Mashreq Project, objectives and activities. 8 p. ICARDA-Mashreq-Doc-008. (RAB/89/062)

Latin America Regional Program Publications

Annual report for CIMMYT/ICARDA regional durum wheat nurseries 1989/90. 229 p. ICARDA-249.

Annual report for CIMMYT/ICARDA regional bread wheat nurseries 1989/90. 229 p. ICARDA-252.

Belaid, Abderrezak and Michael L. Morris. Wheat and barley production in rainfed marginal environments of West Asia and North Africa: problems and prospects. CIMMYT Economics Working Paper 91/02. 76 p. (ISSN 0258-8587)(Prepared in collaboration with ICARDA). CIMMYT, Mexico.

Syria/ICARDA Collaborative Program Publications

ICARDA-Syria collaborative research and training program: fertilizer use on wheat in Northern Syria. 1989/90 annual report. 64 p. ICARDA-215.

ICARDA-Syria collaborative research and training program. 1990/91 workplan. 42 p. ICARDA-216.

ICARDA-Syria collaborative research and training program: Annual report 1989/90. 242 p. ICARDA-235.

Books, Reports and Journals Published Outside ICARDA

Acevedo, E., A.P. Conesa, P. Monneveux and J.P. Srivastava (editors). Physiology-breeding of winter cereals for stressed Mediterranean environments: Proceedings of a Physiology/Breeding Symposium for Stressed Mediterranean Environments [Montpellier FR 3-6 July 1989], Les Colloques no. 55, 490 p. (ISSN 0293-1915). (Paris FR: Institut National de la Recherche Agronomique, ISBN 2-7380-0306-0).

Amine, M. (editor). Ley farming: Proceedings of a Seminaire National Ley Farming [Rabat MA 1990-02-01 to 02], 178 p. (Rabat MA: Actes Editions, Institut Agronomique et Veterinaire Hassan II).

Cubero, J.I. and M.C. Saxena (editors). Present status and future prospects of faba bean production and improvement in the Mediterranean countries: Proceedings of the Zaragoza/Spain Seminar. [Zaragoza ES 27-29 June 1989], Options Méditerranéennes, Serie A: Seminaires Méditerranéens, No. 10, 186 p. (ISSN 1016-121X) (Paris FR: Centre International de Hautes Etudes Agronomique Méditerranéennes).

Gregg, Bill, A.J.G. van Gastel, B. Homeyer, K. Holm, A.S.A. Gomaa, and M. Salah Wanis. Roguing seed production fields. NARP Publication No. 40, 20 p. (Giza EG: National Agricultural Research Center).

Gregg, Bill, A.J.G. van Gastel, B. Homeyer, K. Holm, A.S.A. Gomaa, Salah Wanis, Eniat H. Ghanem, A. Abdel Monem, A. Gouda and O. Shehata. Procedures for inspecting wheat seed fields. NARP Publication No. 39, 31 p. (Giza EG: National Agricultural Research Center).

Perrier, E.R. and A.B. Salkini (editors). Supplemental irrigation in the Near East and North Africa: Proceedings of a Workshop on Regional Consultation on Supplementary Irrigation [Rabat MA 7-9 December 1987], 611 p. (Dordrecht NL: Kluwer Academic Publishers, ISBN 0-7923-1007-3).

Wheat and barley production in rainfed marginal environments of the developing world: 1990-91 CIMMYT world wheat facts and trends. 50 p.

Journals

Faba bean abstracts 1(1981-1991) (Wallingford GB: CAB International, ISSN 0260-8456).

Lentils (1991-) (Wallingford GB: CAB International, ISSN 0961-5336). Formerly **Lentil Abstracts (1981-1991)**, ISSN 0260-8464.

Other Publications

Orobanche field guide. 42 p.

Manual of training procedures: working document. 23 p. ICARDA-194

Testing seed for fungal pathogens. 40 p. ICARDA-197.

ICARDA's seed unit. 8 p. ICARDA-200.

International cereal nurseries. List of cooperators and nursery distribution 1990/91. 32 p. ICARDA-203.

Procedures for inspecting wheat seed fields. 43 p. ICARDA-204.

Roguing seed production fields. 26 p. ICARDA-205.

Hybridization techniques in barley. 16 p. ICARDA-206.

Hybridization techniques in chickpea. 16 p. ICARDA-207.

Hybridization techniques in faba bean. 15 p. ICARDA-208.

Hybridization techniques in lentil. 16 p. ICARDA-209.

Introduction to biological nitrogen fixation. 12 p. ICARDA-210.

Sarraj, W. Science writing in Arabic. 191 p. ICARDA-211.

Proceedings of the twenty-fourth meeting of the Board of Trustees, 30-31 May 1990. 148 p. ICARDA-212.

Farm resource management program: research and training plans 1990/91 season. 61 p. ICARDA-213.

Cereal improvement program: research and training plans 1990/91. 158 p. ICARDA-214.

ICARDA in the news 1989. 56 p. ICARDA-217.

Kearl, Bryant. Training follow-up study. Final report. 47 p. ICARDA-218.

Fadda, N. An introduction to ICARDA. A presentation at Centers Week 1991, Washington DC, USA. 27 p. ICARDA-222.

Training at ICARDA. 20 p. ICARDA-226.

International School of Aleppo. Faculty handbook 1991/92. 106 p. ICARDA-228.

International School of Aleppo. Student handbook 1991/92. 43 p. ICARDA-229.

International School of Aleppo. Year book 1990/91. Eagles flight around the world. 90 p. ICARDA-231.

ICARDA's interim external management review, 2-12 September 1991. Center's report to the panel. 102 p. ICARDA-233.

ICARDA program of work and budget. 47 p. ICARDA-236.

Progress report on the recommendations of the 1991

external management review: external program and Management reviews 1988. 44 p. ICARDA-237.

ICARDA in the news 1990. 40 p. ICARDA-241.

A review of CGIAR priorities, part II. Essence paper. 25 p. ICARDA-243.

Annual report for the international barley nurseries 1989/90. 207 p. ICARDA-244.

Porceddu, E. and A.B. Damania. Sampling strategies for conserving variability of genetic resources in seed crops. Technical Manual No. 17. 28 p. ICARDA-245.

International nursery report No. 13. Food legume nurseries 1988/89. 442 p. ICARDA-246.

Plant variety testing: description, performance and release. 2 p. ICARDA-250.

Cereal improvement program: research and training plans 1991/92. 35 p. ICARDA-254.

Miller, R. Insect pests of wheat and barley in West Asia and North Africa. 136 p. Technical Manual No. 9 (Rev. 2). ICARDA-255.

Law and legislation of agricultural quarantine in the Syrian Arab Republic. 49 p. ICARDA-257.

Appendix 4

Graduate Theses Produced with ICARDA's Assistance

Master's

DE[*] Justus-Liebig-Universitaet Giessen

Stefan Schlingloff (DE). Einfluss der Unkrautbekaempfung auf den Ertag und Wasserverbrauch von Kornerebsen im semi-ariden Regenfeldbau Syriens. (The effect of weed control on yield and water use of dry peas in the semi-arid rainfed agriculture in Syria.) 112 p. (In German, English summary).

JO University of Jordan, Amman

Jehad Zaki Abd Al-Raheem Yasin (JO). Weed control in chickpea (*Cicer arietinum* L.). 98 p.

Salam Abd-Alrahman al Thahabi (JO). Weed control in lentils. 100 p. (Arabic summary). 100 p.

LE Lebanese University

Jihad Alamee (LE). Use of *Hordeum spontaneum* in barley breeding under stress conditions. 73 p.

NL Wageningen Agricultural University

Negussie Tadesse (ET). Expansion of rust focus in faba beans (*Vicia faba* L.). 46 p.

SY University of Aleppo

Fatima Jasem El Mahmoud (SY). Effect of change in soil moisture content on the phosphate fertilizer use and its relation to lentil crop productivity. 244 p.

TR University of Cukurova, Adana

Mustafa Darwich (SY). Economics of winter and spring chickpea production in Aleppo and El Hassakeh provinces of Syria: a comparative study. 63 p.

Doctoral

GB University of Reading

Mario A. Pagnotta (IT). The ecology and ecological genetics of pasture legumes in Syria. 252 p.

US Michigan State University

Maurice Emile Saade (SY). An economic analysis of fertilizer allocation and import policies in Syria. 332 p.

US Stanford University

Meri Lynn Whitaker (US). Optimizing input use in highly variable environments: nitrogen fertilizer use on rainfed wheat in Northwest Syria. 262 p.

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[*] See Appendix 15 for country code

Appendix 5

ICARDA Calendar 1991

January

15 - 24 *Adana*. Course on Crop Growth Modelling

February

9 - 11 *New Delhi*. Satellite Symposium on Genetics of Grain Legumes
10 - 11 *Aleppo*. 2nd Coordination Meeting on International Cooperation
10 - 11 *Aleppo*. Short Course on Design of Livestock Research Program
10 - 21 *Aleppo*. Short Course on Soil and Plant Analysis
11 - 21 *Aleppo*. Short Course on Survey and Data Collection
12 - 15 *New Delhi*. Golden Jubilee Symposium
17 - 25 *Amman*. In-country Course on Experimental Design and Computer Application
25 - 10 Mar. *Libya*. In-country Course on Techniques of Germplasm Evaluation

March

1 - 14 *Aleppo*. Short Course on Pasture and Range Management
3 - 7 *Amman*. FAO's 4th Session of N.E. Regional Commission on Agriculture
3 - 14 *Aleppo*. Short Course on Biological Nitrogen Fixation
3 - 30 June *Aleppo*. Long-term Course on Cereal Improvement
3 - 30 June *Aleppo*. Long-term Course on Seed Production
5 - 6 *Cairo*. Islamic Development Bank Meeting
8 - 9 *Tunis*. Steering Committee of UNDP Pathology Project RAB/89/009
8 - 14 *Egypt*. NVRP Travelling Workshop
9 - 17 *The Hague*. 54th TAC Meeting
10 - 21 *Aleppo*. Short Course on Introduction to Computing: Biometry in Agricultural Research
11 - 15 *New Delhi*. ICARDA/ICAR Seminar on Lentil in S. Asia
15 - 14 Apr. Ramadan Fast
19 - 22 *Rome*. Expert Consultation on Role of Universities in NARS of Developing Countries
19 - 4 Apr. *Aleppo*. Short Course on Cereal Disease Methodologies
20 - 27 *Aleppo*. Short Course on Forage Quality Assessment
27 - 28 *Aleppo*. Short Course on Seed Health Testing
28 - 04 Apr. *Ethiopia*. Computer Application and Statistical Analysis

April

7 - 10 *Aleppo*. Workshop on Biotechnologies for Improvement of Cereal and Legume Crops in WANA
6 - 11 *Egypt*. In-country Course on Wheat Field Inspection Methodology
7 - 11 *Amman*. In-country Course on Legume Hybridization Techniques
10 - 13 *Paris*. International Conference on "The Future of Steppe Areas in the Arabic Peninsula and Bilad Ech Cham"
20 - 21 *Aleppo*. 19th Program Committee Meeting
21 - 21 May *Aleppo*. Pasture and Forage Legume Germplasm Evaluation
21 *Aleppo*. Nomination and Audit Committees Meetings
22 *Aleppo*. 24th Executive Committee Meeting
23 *Aleppo*. 25th BOT Meeting (Closed)
24 - 25 *Aleppo*. 25th BOT Meeting (Open)
24 - 25 *Aleppo*. BOT Seminar on "Complementarities Between National Research Systems and International Agricultural Research Centers"
21 - 2 May *Aleppo*. Short Course on Insect Control in Legumes and Cereals
21 - 2 May *Morocco*. Course on Faba Bean Improvement
22 - 2 May *Aleppo*. Short Course on Biology and Control of *Orobanche*
22 - 26 *Montpellier*. IVth International Rangeland Congress
28 - 2 May *Aleppo*. Ley Farming Network Meeting
28 - 7 May *Amman*. In-country Course on Legume Seed Production
28 - 7 May *Amman*. In-country Course on Regional Seed Certification
29 - 1 May *Syria*. West Asian Travelling Workshop

May

14 - 17 *Tunisia*. In-country Course on Winter Chickpea

2 - 4 *Tunis*. Meeting on Possibility of Establishing a Regional Network for Research on Wheat and Barley in the Rain-fed Areas of WANA
4 - 6 *Aleppo*. School Accreditation Visit
5 - 11 *Agadir*. Workshop on Fertilizer Use Efficiency in WANA

5 - 16 *Aleppo*. Short Course on Breeding Methodology in Food and Feed Legumes
5 - 12 *Morocco*. N. Africa Legume Traveling Workshop
6 *Aleppo*. Presentation Day for Tishrin University (Lattakia)
6 - 9 *Syria*. Travelling Workshop in Ley Farming in Syria
6 - 10 *Tunisia*. N. Africa Cereal Travelling Workshop
6 - 17 *France*. In-country Course on Breeding Strategies for Cereal Improvement
8 *Aleppo*. Presentation Day for Aleppo University
8 - 9 *Frankfurt*. Benefits Committee Meeting
9 *Aleppo*. Presentation Day for Syndicate of Agricultural Engineers
12 - 23 *Aleppo*. Course on Mechanical Harvesting of Food and Feed Legumes
15 *Quetta*. AZRI Annual Planning Seminar
19 - 30 *Aleppo*. Short Course on Computer Use for Statistical Analysis of Agricultural Experiments
21 - 24 *Paris*. CGIAR Mid-term Meeting
23 - 25 *Turkey*. In-country Course on Winter Chickpea
26 - 30 *Aleppo*. Short Course on Design of Grazing Management Experiments
26 - 30 *Aleppo*. In-country Course on Operation Maintenance of Harvesters
27 - 21 Jun *Morocco*. In-country Course on Agroecological Characterization

June

1 - 11 *Libya*. Sub-regional course on Farm Survey Methods
3 *Amman*. Seminar with Jordanian Scientists
4 - 6 *Amman*. Steering Committee for Mashreq Project
13 - 19 *Turkey*. CIMMYT/ICARDA/MAFRA Turkey Winter Cereals Travelling Workshop
16 - 28 *Aleppo*. In-house Planning Meetings
23 - 25 Eid Al-Adha Holiday
19 - 2 Jul. *Aleppo*. Short Course on Seed Processing and Storage
23 - 25 *Rome*. Center Directors Meeting
24 - 30 *Rome*. 55th TAC Meeting

July

14 - 16 *Damascus*. Mashreq Project Planning Meeting for Syria
14 - 2 Aug. *Wageningen*. Course on Plant Variety Research
15 - 19 *Tunis*. Third Regional Coordination Meeting for UNDP/ICARDA Project on Disease Surveillance and Germplasm Enhancement for Cereals and Food Legumes
22 - 27 *Helsinborg (Sweden)*. International Barley Genetics Symposium
24 - 31 *Aleppo*. NVRP Steering Committee

August

12 - 14 *Ethiopia*. National Workshop on Dryland Farming Research
19 - 21 *Amman*. Mashreq Project Planning Meeting for Jordan
19 - 23 *Aleppo*. Short Course on Satellite Imagery for Interpreting Rainfall Data
24 - 29 *Baghdad*. Mashreq Project Planning Meeting for Iraq
22 - 25 *Hyderabad*. ICRISAT/ICARDA Planning Meeting
26 - 30 *Geneva*. In-country Course on Satellite Imagery: Interception for Rainfall Mapping
29 - 6 Sep. *Ethiopia*. In-country Course on Seed Certification

September

2 - 3 *Adana*. Cukurova University/ICARDA Planning Meeting
2 - 11 *Aleppo*. Interim EMR Review
4 - 5 *Aleppo*. Lebanon Coordination Meeting
14 - 16 *Amman*. Mashreq/UNDP Project Regional Technical Committee Meeting
15 - 23 *Cairo*. NVRP Regional Coordination Meeting
16 - 18 *Algiers*. Individual National Coordination Meetings - N. Africa
16 - 27 *Spain*. Course on New Biometrical Tools for Plant Variety Evaluation
22 - 3 Oct. *Aleppo*. DNA Molecular Marker Techniques for Germplasm Evaluation and Crop Improvement
23 - 25 *Amman*. Jordan Coordination Meeting
23 - 27 *Feldafing (Germany)*. Seminar on "Agricultural Sustainability Growth and Poverty Alleviation: Issues and Policies"
26 - 30 *Tunis*, *Tripoli*. Individual National Coordination Meetings - N. Africa
29 - 10 Oct. *Aleppo*. Short Course on Supplemental Irrigation Technology and Scheduling
29 - 24 Oct. *Aleppo*. Course on Experimental Station Operations Management

October

1 - 2 *Rabat*. Individual National Coordination Meetings - N. Africa
5 - 7 *Aleppo*. 10th Annual Coordination Meeting, Syrian National Program/ICARDA
6 - 17 *Aleppo*. Training Workshop on Agroclimatic Analysis in Semi-arid Areas
8 - 12 *Tunis*. N. Africa Regional Coordination Meeting
13 - 23 *Amman*. In-country Course on Dryland Agriculture
18 - 24 *Ethiopia*. NVRP Travelling Workshop
20 - 31 *Jordan*. Course on Seed Testing
21 - 27 *Washington*. 56th TAC Meeting
26 - 7 Nov. *Amman*. In-country Course on Sheep Nutrition and Management
28 - 1 Nov. *Washington*. International Centers Week
28 - 1 Nov. *Morocco*. In-country Course on Agroecological Characterization

November

2 - 9 *Aleppo*. Workshop on Quarantine for Seed in the N.E. Region
2 - 14 *Oman*. In-country Course on Statistics and Experimental Design, Analysis and Reporting
3 - 8 *Lattakia*. 31st Science Week in Syria
4 *Casablanca*. IDRC/ICARDA Agroecological Characterization Project Planning Meeting for Morocco
4 - 5 *The Hague*. 25th Executive Committee Meeting
7 *Ankara*. IDRC/ICARDA Agroecological Characterization Project Planning Meeting for Turkey
9 - 24 *Egypt*. In-country Course on Maintenance of Seed Processing Plants
10 - 14 *Amman*. First Workshop for Dryland Resources Management Project
18 - 23 *Aleppo*. NVRP Steering Committee Meeting
18 - 29 *Montpellier*. In-country Course on Breeding Strategies for Cereal Improvement
25 *Aleppo*. Informal Review Meeting ICARDA/TARC on the Development of Sustainable Native Pasture Project

December

10 *Ankara*. Turkey/ICARDA Planning Meeting
15 - 19 *Aleppo*. Workshop on Study of Marginal Lands in WANA

Appendix 6

Special Projects

During 1991, the following activities (special projects and projects 'in-trust' for national programs) were operational utilizing funds provided separately from ICARDA's core budget. 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 and are not repeated here.

AFESD (Arab Fund for Economic and Social Development)

Arabian Peninsula Regional Program

ANERA (American Near East Refugee Aid)

Seed Production Cooperative Project in Lebanon

EEC/SAREC/Netherlands

Combined Support to Nile Valley Regional Program (EEC-Egypt, SAREC-Ethiopia, Netherlands-Sudan)

FAO (Food and Agriculture Organisation of the United Nations)

Jointly sponsored with ICARDA courses/workshops on 'Seed Quarantine' and 'Consultation meeting on Wheat and Barley Research and Production in Rain-fed Areas'

Ford Foundation

Graduate and Post-doctoral Fellowships
Research on Environmental and Agricultural Problems of Dry, Marginal Lands

France

Capital equipment in support of ICARDA project on 'Use of Biotechnology for the Improvement of ICARDA Mandated Crops'

Support of an associate expert on biotechnology research

GTZ (German Agency for Technical Cooperation, Federal Republic of Germany)

Seed Production

Land Use Management for Marginal Lands in the Barley/Livestock Zones of Jordan and Syria

IDRC (International Development Research Centre, Canada)

Yellow Dwarf Virus

IFAD/Italy (International Fund for Agricultural Development and the Government of Italy)

Maghreb Project - research and technology transfer program to increase barley, food legumes, and livestock production in North Africa, Algeria, Morocco, Tunisia, and Libya.

IFAR

Meeting on 'Barley Genome Mapping'

IMPHOS (Institut Mondial de Phosphate)

Study of Soil Test Calibration in Limited Rainfall Areas

Iran

Scientific and Technical Cooperation - ICARDA/Iran

Italy

Chickpea Germplasm Development

Enhancing Wheat Productivity in Stress Environments Utilizing Wild Progenitors

Support to Activities in Mountainous Areas - Highlands Regional Program

IUED (Institut Universitaire d'Etudes du Développement)

Social and economic analysis of agro-pastoral systems in the dry areas of Syria

Netherlands (Directorate General for International Cooperation)

Collection and Characterization of Wild Relatives of Wheat

Seed Production

Utrecht University - Collaborative Project

OPEC (Organization of Petroleum-Exporting Countries) Fund for International Development

Barley Development Program

Improvement of Rainfed Agriculture in the Drier Areas of West Asia and North Africa

UNDP (United Nations Development Programme)

Use of Biotechnology for the Improvement of ICARDA Mandated Crops

Soil Test Calibration for Fertilizer Recommendation

UNDP/AFESD

Surveillance of Diseases and Germplasm Enhancement for Cereals and Legumes (Maghreb Countries) - Preparatory Assistance Phase

Mashreq Project - Increased Productivity of Barley, Pasture, and Sheep in the Critical Rainfall Zones

USAID (United States Agency for International Development, Washington, USA)

C13 Discrimination for Barley in Dry Environments

MART/AZR Project - Arid Zone Research Institute, Quetta, Balochistan

ICARDA/CIMMYT/Ministry of Agriculture and Land Reclamation, Egypt

Appendix 7

Research Networks Coordinated by ICARDA

Title	Coordinator	Donor	Subject/objectives	Countries
Inoculation of pasture and forage legumes	L. Materon	Core funds	1. Identify need for inoculation of pasture and forage legumes. 2. Evaluate response to inoculation with introduced and native strains of *Rhizobium* spp. 3. Biological nitrogen fixation studies. 4. Training of national program scientists in WANA.	11, in WANA 5, outside WANA
Barley pathology	J. van Leur	USAID	Research on the epidemiology, virulence and resistance of pathogens of importance to barley cultivation in the ICARDA region.	7, in WANA
Durum germplasm evaluation	A.B. Damania and L. Pecetti	Italy	Following a Durum Germplasm Consultation meeting at Viterbo, Italy, a set of 200 selected accessions from the genetic resources collection was sent to national programs in 11 countries. The evaluators will score economically important agronomic and disease resistance characters at ecologically different locations in their own countries and report back to ICARDA. The pooled information will be provided to interested scientists and the germplasm recommended to breeders for use in their crossing programs. Very useful data have already been received from Ethiopia, Pakistan, Tunisia, and Canada.	6, in WANA 5, outside WANA
Barley, durum wheat, and bread wheat international nursery system	S.K. Yau	Core funds	Evaluation of the barley, durum wheat, and bread wheat advanced lines, parental lines and segregating populations developed by ICARDA and CIMMYT, and by national programs themselves.	50, worldwide
Screening wheat and barley for resistance to aphids	R. Miller	Egypt, EEC, Sudan, Ethiopia, SAREC	Wheat and barley seedlings are screened against *Rhopalosiphum padi* and *Schizaphis graminum* in a laboratory in Egypt. Promising lines are then retested against natural populations of aphids in Upper Egypt and in the Sudan. Resistant germplasm is recommended to breeders in Egypt, Sudan, Ethiopia, and ICARDA.	Egypt Sudan Ethiopia

Title	Coordinator	Donor	Subject/objectives	Countries
Screening wheat and barley for resistance to Hessian fly	R. Miller and M. Mekni	ICARDA/ MIAC	Differential nurseries containing the known resistance genes for Hessian fly are planted in six countries. Annual surveys are performed in the Maghreb countries. A training workshop, sponsored by ICARDA, MIAC, INRA, and INRAT, will be held in Morocco for trainees from North Africa. Germplasm is being exchanged.	Morocco Algeria Tunisia
Biological nitrogen fixation in food legumes	D. Beck	IDRC (Chickpea only)	1) Evaluate the necessity for inoculation in chickpea, lentil, and faba bean. 2) Evaluate response to rhizobial inoculation with network strains 3) Quantification of N fixed using ^{15}N to evaluate legume N input into farming systems.	9, in WANA
Nile Valley Faba Bean Aphid Screening	S. Weigand	SAREC, EEC, DGIS	A joint screening program for host plant resistance to aphids in faba bean with the aphid screening laboratory at Giza Research Station, Egypt, serving as a center for screening faba bean lines from the three countries and ICARDA. Promising material based on its origin is field-tested by the respective national programs and a "regional aphid screening" nursery has been established and tested in the three countries.	Egypt Sudan Ethiopia
International Food Legume Testing Network	R.S. Malhotra	Core funds	The network provides for dissemination of genetic material and improved production and plant protection practices to the national program scientists for evaluation and use under their own agroecological conditions. It also permits multilocation testing of material developed by the national programs and assists in developing better understanding of genotype and environmental interaction as well as agroecological characterization of major food legume production areas.	25, worldwide
Soil Test Calibration	A. Matar	Core funds, UNDP, IMPHOS	To standardize the methods of soil and plant analysis used in the WANA region and promote training and soil sample exchange.	12, in WANA

Title	Coordinator	Donor	Subject/objectives	Countries
			To evaluate the relationships between laboratory determination of soil fertility status and crop responses to the major plant nutrients, nitrogen and phosphorus. To establish procedures to integrate soil, climate and management to optimize fertilizer recommendations.	
Dryland Pasture and Forage Legume Network	S. Christiansen	Core funds, IBPGR	To build communication linkages among pasture forage and livestock scientists in WANA.	7, in WANA
Network of stem and leaf rusts of wheat in Nile Valley countries	O. Mamlouk	NVRP, core funds	To identify sources of primary inoculum of stem and leaf rusts of wheat, their pathways and sources of resistance in the Nile Valley countries.	Egypt Sudan Ethiopia

Appendix 8

Agreements

The following is a list of important agreements* relating to the establishment of ICARDA, its cooperation with national governments, universities, regional and international organizations, and others.

Agreements for the establishment of ICARDA

These agreements were negotiated and signed by the International Development Research Centre (IDRC) of Canada acting as Executing Agency on behalf of the Consultative Group on International Agricultural Research.

17 Nov 1975 CHARTER of the International Center for Agricultural Research in the Dry Areas (En, Fr). Signed for IBRD, FAO, UNDP, and IDRC. And 1976-06-08 Amendment to the CHARTER (En, Fr).

16 Dec 1976 General by-laws of the International Center for Agricultural Research in the Dry Areas (En).

Sept 1990 Second Amendment to the CHARTER (En).

Agreements for cooperation with Governments in West Asia and North Africa (not including agreements for specific work plans).

Normally, these agreements set the modalities for cooperation in individual countries, identify the kind of facilities that each party will make available to the other, and give ICARDA's staff privileges equivalent to those accorded to the staff of the United Nations.

ALGERIA

Country

16 Sept 1981 avec le Ministere de l'Agriculture et de la Revolution Agraire de le REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE (Fr).

8 Oct 1986 avec la REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE (Fr).

CYPRUS

Country

5 Feb 1979 with the Government of CYPRUS (En).

Other

7 Feb 1982 with the Agricultural Research Institute, ARI CYPRUS (En).

6 July 1987 with the Agricultural Research Institute, ARI, CYPRUS (En).

29 May 1990 with the Agricultural Research Institute, ARI, CYPRUS (En).

EGYPT

Country

29 Mar 1978 with the Government of EGYPT (En).

31 May 1980 with the Government of EGYPT (Ar, En).

26 May 1987 with the Ministry of Agriculture and Land Reclamation of the Arab Republic of EGYPT (En).

Other

19 Sept 1987 with the University of Alexandria, EGYPT (En).

ETHIOPIA

26 June 1989 with Alemaya University of Agriculture, ETHIOPIA (En).

IRAN

20 July 1976 Agreement with the Imperial Government of IRAN to establish a Principal Station on Iranian territory (En, Fa).

* When the different parties to an agreement signed on different dates, the date of the agreement is given as that of the last signature.

10 Oct 1984 with the Government of the Islamic Republic of IRAN (En).

1 Sept 1987 with the Government of the Islamic Republic of IRAN (En).

22 Nov 1990 with the Government of the Islamic Republic of IRAN (En).

IRAQ

6 Sept 1986 with the Government of IRAQ (Ar, En).

JORDAN

Country

27 Oct 1977 with the Government of JORDAN (En).

Other

21 Mar 1988 with the Jordan University of Science and Technology, JORDAN (En).

LEBANON

Country

6 July 1977 Agreement with the Government of the LEBANON (Ar, En) to permit operations on Lebanese territory.

Other

25 Mar 1978 with the Agricultural Research Institute, ARI, LEBANON (En) for the provision of lands.

11 Apr 1991 Explanatory Memorandum between Agricultural Research Institute, ARI, LEBANON and ICARDA to the agreement signed on 25 Mar 1978 (Ar, En).

12 Apr 1991 with the American University of Beirut, LEBANON (En).

MOROCCO

18 Jan 1985 with the Kingdom of MOROCCO (Ar).

26 June 1986 with the Ministry of Agriculture and Agrarian Reform of the Government of the Kingdom of MOROCCO for the posting of ICARDA scientists in Morocco (Ar).

PAKISTAN

19 Mar 1980 with the PAKISTAN Agricultural Research Council (En).

30 Nov 1989 with the Pakistan Agricultural Research Council, PAKISTAN (En).

SUDAN

Country

21 Oct 1978 with the Government of the Democratic Republic of the SUDAN (Ar, En)

Other

15 Sept 1985 with the University of Gizira, SUDAN (En).

28 Jan 1987 with the University of Khartoum, SUDAN (En).

SYRIA

Country

28 June 1976 Agreement with the Government of the SYRIAN ARAB REPUBLIC (Ar, En, Fr) for the establishment of the International Center for Agricultural Research in the Dry Areas (ICARDA) on the Syrian territory.

28 June 1976 Agreement with the Government of the SYRIAN ARAB REPUBLIC (Ar, En, Fr) for the establishment of the International Center for Agricultural Research in the Dry Areas (ICARDA) on the Syrian territory. Reprinted in 1991. Incorporates ratification dates.

28 June 1987 of the original agreement and the amended articles dated 1 June 1985 of the By-law No. (22) dated 2 April 1977 of the endorsed agreement.

14 July 1977 Agreement with the Government in the SYRIAN ARAB REPUBLIC (Ar, En) for the provision of lands.

8 Oct 1989 with the Meteorological Department of the SYRIAN ARAB REPUBLIC (Ar, En).

Other

30 May 1977 with University of Aleppo SYRIA (Ar, En).

21 Nov 1985 with Tishreen University, SYRIA (Ar).

22 Apr 1989 with University of Aleppo, SYRIA (Ar, En).

TUNISIA

11 Mar 1980 with the Government of TUNISIA (Ar).

20 Nov 1989 with the Government of the Republic of TUNISIA (Ar, En).

TURKEY

Country

29 Sept 1985 with the Ministry of Agriculture, Forestry and Rural Affairs of TURKEY (En).

6 Mar 1990 with the Ministry of Agriculture, Forestry, and Rural Affairs of TURKEY (En).

Other

9 July 1990 with Cukurova University, TURKEY (En, Tr).

3 Dec 1990 with Ankara University, TURKEY (En, Tr).

YEMEN ARAB REPUBLIC

9 Dec 1987 with the Government of the YEMEN ARAB REPUBLIC (Ar, En).

Agreements for cooperation with other countries (not including agreements for specific work plans).

BULGARIA

28 Feb 1988 with the Institute of Plant Introduction and Genetic Resources, IPIGR, Sadovo, BULGARIA (En).

CANADA

18 Oct 1989 with the University of Saskatchewan, CANADA (En).

CHINA

20 Aug 1987 with the Chinese Academy of Agricultural Sciences, CAAS, CHINA (Ch, En).

FRANCE

30 Oct 1981 avec l'Office de la Recherche Scientifique et Technique Outre-Mer ORSTOM-FRANCE (Fr).

13 May 1986 avec l'Institut National de la Recherche Agronomique INRA. Centre de Cooperation International pour le Developpement CIRAD, et l'Institut Francais de Recherche Scientifique pour le Developpement en Cooperation, ORSTOM, FRANCE (En, Fr).

INDIA

15 Dec 1986 with the Indian Council of Agricultural Research, ICAR, INDIA, (En, Hi).

ITALY

16 June 1982 with the Consiglio Nazionale delle Richerche, CNR, ITALY (En, It).

28 Nov 1985 with the University of Tuscia, ITALY (En).

JAPAN

29 Sept 1987 with the Tropical Agricultural Research Center, TARC, JAPAN (En).

6 Apr 1989 with the Tropical Agricultural Research Center, TARC, JAPAN (En).

NEPAL

30 Aug 1988 with the National Agricultrual Research Coordination Committee, NARCC, NEPAL (En).

USA

14 Apr 1987 with North Carolina State University, USA (En).

USSR

2 Aug 1988 with V.I. Lenin All-Union Academy of Agricultural Sciences-VASKhNIL, Moscow, USSR (En, Ru).

19 May 1989 with V.I. Lenin All-Union Academy of Agricultural Sciences-VASKhNIL, Moscow, USSR (En, Ru).

Agreements with international and regional organizations (not including agreements for specific work plans)

ACSAD

12 Dec 1982 with the Arab Center for Studies of the Arid Zones and Dry Lands, ACSAD (Ar).

AOAD

5 Apr 1982 with the Arab Organization for Agricultural Development, AOAD (Ar).

IBPGR

14 Mar 1990 with the International Board for Plant Genetic Resources, IBPGR (En).

CIHEAM

21 Feb 1989 with the International Center for Advanced Mediterranean Agronomic Studies, CIHEAM (En, Fr).

CIMMYT

15 Sept 1987 with the Centro Internacional de Mejoramiento de Maize y Trigo, CIMMYT (En).

ICRISAT

1978 with the International Crops Research Institute for the Semi-Arid Tropics, ICRISAT, on chickpea research (En).

IFDC

5 Apr 1980 with the International Fertilizer Development Center, IFDC (En).

IMPHOS

29 Nov 1988 with the World Phosphate Institute, IMPHOS (En).

IRRI

24 June 1991 with the International Rice Research Institute, IRRI (En).

WINROCK

5 May 1987 with Winrock International Institute for Agricultural Development (En).

Appendix 9

The International School of Aleppo

The year 1991 was an important one in the development of the International School of Aleppo (ISA).

The graduating class of 1991 was the first 12th grade in the history of ISA. The seven graduates were admitted to universities throughout the world, with Clemson University, McGill University, and Sofia University (Bulgaria) heading the list of quality institutions accepting ISA graduates. Their acceptance confirms the quality of instruction and overall positive climate that is found at ISA.

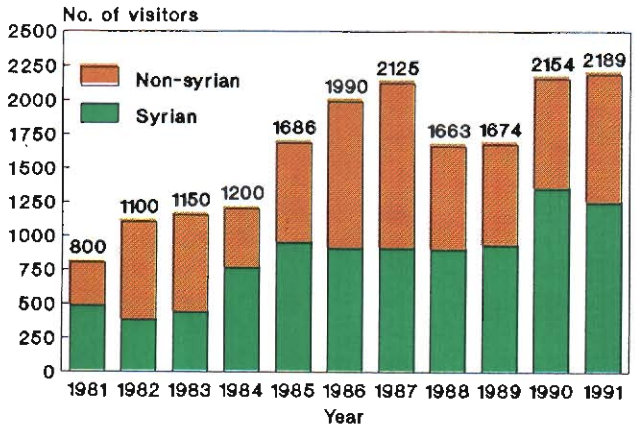
Two ongoing program developments were completed by the end of 1991: accreditation of the school and implementation of an International Baccalaureate Program. Besides giving stature to the school, the realization of both of these programs has provided an opportunity for the school to acquire additional funding from its non-ICARDA constituents. Enrollment has levelled off at around 275 students, the maximum the school can handle. The revised fee structure enables the school to operate with only a nominal subsidy from ICARDA. Providing quality education to the 275 students will continue to be the means by which the school supports the expatriate ICARDA family.

Appendix 10

Visitors to ICARDA

During 1991, ICARDA received 2189 visitors, a moderate increase over 1990. This reflects the growing interest in the Center both at national and international levels.

The visitors included scientists, consultants, members of the CGIAR System, diplomats, senior government officials, Board of Trustees members, conference and training participants, outreach staff, auditors, farmers, students, job interviewees, and others from all over the world representing 150 universities and national, international, and private organizations.



Visitors to ICARDA, 1981-1991.

Appendix 11

Statement of Activity
For the Year Ended 31 December 1991
(× 1000 USD)

	1991	1990
REVENUE		
Grants	19,477	18,886
Exchange gains	1,387	1,189
Interest income	881	989
Other income	469	777
Total revenue	22,214	21,841
EXPENSES		
Research		
Farm resource management	2,146	2,015
Cereal improvement	2,893	2,729
Food legume improvement	2,593	2,523
Pasture, forage, and livestock	1,879	1,898
Total research	9,511	9,165
Research support	4,784	4,383
Cooperative programs	1,201	1,831
Training	770	1,057
Information	945	960
General administration	3,136	3,196
General operations	1,649	1,678
Subtotal	12,485	13,105
Total operating expenses	21,996	22,270
EXCESS OF EXPENSES OVER REVENUE	218	(429)
ALLOCATED TO		
Operating fund	218	(1,244)
Locally generated fund	-	815
Deficit	218	(429)

Appendix 11 (Cont.)

Statement of Grant Revenue
For the Year Ended 31 December 1991
(× 1000 USD)

	Current year grants	Funds received	Receivable 31 Dec 1991	(Advance) 31 Dec 1991
CORE UNRESTRICTED				
Australia	155	(155)	-	-
Austria	175	(175)	-	-
Canada	844	(844)	-	-
China	30	(30)	-	-
Denmark	410	(410)	-	-
Finland	278	(278)	-	-
Ford Foundation	150	(150)	-	-
Germany	1,008	(1,008)	-	-
India	25	(18)	8	-
International Bank for Reconstruction and Development (World Bank)	4,000	(4,300)	-	-
Italy	159	(159)	-	-
Japan	300	(300)	-	-
Mexico	10	(10)	-	-
Netherlands	671	(841)	-	-
Norway	457	(457)	-	-
Spain	125	(125)	-	-
Sweden	697	(697)	-	-
United Kingdom	1,108	(1,108)	-	-
United States Agency for International Development	4,450	(4,450)	-	-
	15,052	(15,515)	8	-
CORE RESTRICTED				
Arab Fund	528	(172)	528	(172)
France	295	(502)	-	(359)
Germany	1,211	(1,076)	-	(658)
International Development Research Centre	113	(52)	41	(11)
Italy	478	(498)	-	(553)
Overseas Development Administration	81	-	81	-
United States Agency for International Development	107	-	-	(2)
Closed projects	-	(847)	253	-
	2,813	(3,147)	903	(1,755)

Appendix 11 (Cont.)

	Current year grants	Funds received	Receivable 31 Dec 1991	(Advance) 31 Dec 1991
SPECIAL PROJECTS				
ANERA	10	(10)	-	-
Arab Fund	94	(172)	-	(182)
Food and Agriculture Organization	24	(12)	-	-
Ford Foundation	163	(150)	-	(106)
France	82	(60)	-	(215)
German Agency for Technical Cooperation	111	(135)	63	(30)
International Fund for Agricultural Research	3	-	-	-
Italy	558	(560)	-	(1,342)
Netherlands	298	(827)	66	(262)
The OPEC Fund for International Development	(50)	(41)	9	-
United Nations Development Programme	200	(95)	22	(75)
United States Agency for International Development	19	(66)	-	(38)
Closed projects	-	(77)	8	-
Future projects	-	-	-	(13)
	1,612	(2,205)	168	(2,263)
	19,477	(20,867)	1,079	(4,013)
Less: provision for doubtful accounts	-	-	(786)	-
GRAND TOTAL	19,477	20,867	296	(4,013)

Appendix 12

Collaboration in Advanced Research

ICARDA received Special Project funding for some of its collaborative activities with advanced institutions in industrialized countries. Such items are detailed in Appendix 6. ICARDA's participation in the following activities was, however, financed out of core or restricted-core funds.

International Centers and Agencies

International Center for the Improvement of Maize and Wheat, Mexico

- Wheat and barley improvement: CIMMYT has seconded three wheat breeders to ICARDA, and ICARDA has seconded a barley breeder to CIMMYT

International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India

- Chickpea improvement: ICRISAT has seconded a chickpea breeder to ICARDA and provided consultancy in chickpea pathology

Canada

Agriculture Canada and Laval University, Sainte Foy, Quebec

- Screening advanced ICARDA wheat and barley lines for resistance to barley yellow dwarf virus (BYDV)

Canadian Grain Commission, Winnipeg

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

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

France

Institut National de la Recherche Agronomique (INRA) and Ecole Nationale Superieure d'Agronomie, Montpellier

- Study of biological nitrogen fixation and nitrogen assimilation in food legumes as a function of genotype
- Study of chickpea rhizobia and drought and cold tolerance
- Inoculation of medics in southern France

University of Lyon, Laboratoire d'Ecologie Microbiènne

- Genetic diversity of *Rhizobium* spp. for chickpea

University of Paris South

- Haploid breeding and anther culture for cereal improvement

Federal Republic of Germany

University of Bonn

- Taxonomic classification of genus *Lens* and genetic variability within subspecies based on DNA fingerprint analysis

University of Giessen

- Weed control and water-use efficiency in peas
- Ecogeographic survey of legumes in the Syrian steppe

University of Hohenheim

- Economics of irrigated food-legumes production by small-holders in Sudan
- Physiological factors as determinants of yield in durum wheat
- Influence of VA-Mycorrhiza on growth, nutrient and water relations in chickpea
- Integrated control of *Orobanche* spp. in food legumes
- Crossing faba-bean genotypes from Europe and West Asia to obtain wider adaptability
- Genetics of phosphate uptake in chickpea
- Influence of heterozygosity and heterogeneity on yield performance and stability of barley in dry areas
- Economics of Bedouin production systems in Syria
- Better straw quality: breeding and evaluation methods

Max-Planck Institute for Biochemistry, Munich

- Resistance mechanisms in chickpea to leafminer

University of Frankfurt

- DNA fingerprinting in chickpea and *Ascochyta rabiei*

University of Frankfurt and Max-Planck Institute of Psychiatry, Munich
- RFLP analysis in chickpea and lentil

Italy

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

University of Napoli; ENEA, Rome; Ministry of Agriculture, Sicily; Department of Pathology, Ministry of Agriculture, Rome
- Development of chickpea germplasm with combined resistance to *Ascochyta* blight and *Fusarium* wilt using wild and cultivated species

University of Perugia
- Inoculation of annual medics with *Rhizobium* spp.
- Increasing the productivity of marginal lands in western Syria

University of Perugia and Ministry of Agriculture, Catania
- Improving yield and yield stability of barley in stress environments

University of Tuscia, Viterbo
- Enhancing wheat productivity in stress environments utilizing wild progenitors primitive forms

University of Tuscia, Viterbo; Germplasm Institute, Bari; and ENEA, Rome
- Evaluation and documentation of durum wheat germplasm

Japan

Japanese International Cooperation Agency (JICA)
- Intestinal, lung and blood parasites in small ruminants in Syria

Tropical Agriculture Research Center, Tskuba, Ibaraki
- Analysis of rangeland vegetation using remote sensing

Netherlands

DGIS: The Directorate General for International Cooperation
- Agronomic characterization of germplasm collections on the basis of information on the environment in the regions of collection, and evaluation of data
- Virulence analysis of yellow rust of wheat in some countries of WANA

Royal Tropical Institute, Amsterdam
- *Orobanche* control

University of Utrecht
- Water-use efficiency of bread wheat

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 conditions

Spain

Polytechnical University, Madrid
- Improvement of the energy efficiency of medic rhizobia

University of Cordoba
- Effect of environmental stresses on nitrogen fixation
- Developing *Orobanche* resistance in faba bean
- Developing wilt resistance in chickpea
- Soil phosphate studies

University of Cordoba and INIA
- Barley stress physiology

University of Granada
- Isolation of VA-Mycorrhiza from forage legumes

United Kingdom

Institute for Grassland and Environmental Research, Aberystwyth
- Fermentation kinetics and gas production of tropical feeds

Overseas Development Natural Resources Institute, London
- Evaluating the nutritive value of straws for small ruminants

Plant Breeding Institute, Cambridge
- Characterization of barley genotypes
- Study of resistance of faba bean to *Botrytis fabae*

Royal Veterinary College, London
- Factors that cause peas to be unpalatable to sheep

University College, London
- Development of metabolic index for drought stress in barley and durum wheat

University of Nottingham
- Factors influencing adoption of new agricultural technology in dry areas of Syria

University of Reading
- Root studies of barley and wheat
- Investigation of seed dormancy in plant populations on grazed marginal land
- Impact assessment of supplemental irrigation on rain-fed wheat-based farming systems
- Investigation of N-cycling in crop rotations using ^{15}N

United States of America

Montana State University, Bozeman
- Research and training on barley diseases and associated breeding methodologies

Oregon State University, Corvallis; Montana State University, Bozeman; and Kansas State University, Manhattan
- Interdisciplinary research and training to enhance germplasm of selected cereals for less favorable environments

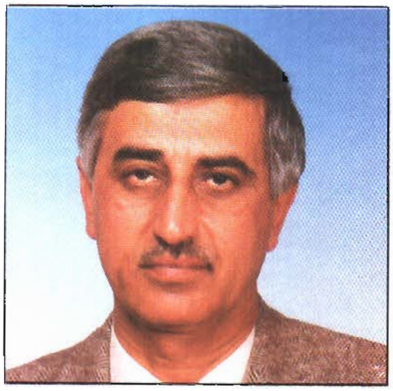
University of Pennsylvania
- Phylogenetic studies of *Rhizobium meliloti*

Washington State University, Pullman
- Transfer of *Bacillus thuringiensis* gene to *Rhizobium* for the control of *Sitona* larvae in lentil and peas

Appendix 13

Board of Trustees

Dr El-Badawy



Dr Some

During 1991, the Board of Trustees acquired two new members to replace Mr. Hasan Nabulsi and Dr. Alfred P. Conesa, whose terms had expired.

Dr George Some of Syria is widely recognized as one of the leading authorities on irrigation in the Middle East, and is intimately familiar with the challenges to agricultural development in Syria and West Asia and North Africa in general.

Prior to earning his PhD in technical sciences at the Moscow Institute for Irrigation and Land Amelioration in 1975, Dr Some gained considerable first-hand experience as an agricultural engineer in Syria's eastern Deir Ezzor Province. He later became Deputy Chief of the irrigation section in the Syrian Ministry of Agriculture and Agrarian Reform and currently serves as Head of the Directorate of Irrigation and Water Use.

Dr Some is National Director of the UNDP-FAO Project for Improved Water Resources Management for Agricultural Use, and National Coordinator of the Supplementary Irrigation Project under Rain-fed Agriculture and Improved Irrigation Management at the Farm Level.

Dr Some's talent and insight were key contributors to the success of the ICARDA-Syria Joint Cooperation Program on Supplementary Irrigation, for which he served as national coordinator from 1987 to 1990.

Dr Mervat El Badawy is possibly one of the most educated women in the Arab world, possessing many advanced degrees in the fields of economics, computing and engineering.

Dr El Badawy holds two doctorates from the University of Paris, one in Economics and the other in Engineering. She also earned two MScs, one in Computer Sciences and one in Mathematical Economics and Econometrics. Dr Badawy distinguished herself as an academic of the first rank at the University of Paris - Sorbonne. She rose from lecturer in 1971 to full professor by 1976, teaching at the graduate and undergraduate level. She was awarded the Prix de l'Etat en Sciences Economiques in 1986.

Dr El Badawy currently holds the position of Chief Economist for Economic and Social Development with the Kuwait-based Arab Fund for Economic and Social Development (AFESD). Prior to that she served as Senior Economist (1977-1981) and Deputy Director (1981-1989) of AFESD's Research and Studies Department.

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The Board held the following meetings during 1991:

20-21 April	19th meeting of the Program Committee, Aleppo
22, 24-25 April	25th meeting of the Board of Trustees, Aleppo
23 April	24th meeting of the Executive Committe, Aleppo
5-6 November	25th meeting of the Executive Committee, The Hague.

Appendix 14

Senior Staff
(as of 31 December 1991)

Syria

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Director General's Office

Dr Nasrat R. Fadda, Director General
Dr Aart van Schoonhoven, Deputy Director General (Research)
Mr James T. McMahon, Deputy Director General (Operations)
Dr Robert Booth, Assistant Director General (International Cooperation)
Mr Terence N. Duplock, Director of Admistration
Mr V.J. Sridharan, Internal Auditor
Ms Afaf Rashed, Administrative Assistant to the Board of Trustees

Government Liaison and Public Relations

Dr Hassan Seoud, Assistant Director General (Government Liaison)
Mr Ahmed Mousa El Ali, Public Relations Officer

International Cooperation

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Dr A.J.G. van Gastel, Seed Production Specialist
Dr Zewdie Bishaw, Assistant Seed Production Specialist

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Mr John E. Noisette, Director of Finance
Mr Suresh Sitaraman, Finance Officer, Financial Operations
Mr Mohamed K. Barmada, Finance Officer, Outreach
Mr Suleiman Is-hak, Finance Officer, Cash Management
Mr Edwardo Estoque, Finance Officer, Financial Reporting
Mr Mohamed Samman, Pre-Audit and Control

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Dr Murari Singh, Senior Biometrician/Acting Head
Mr Bijan Chakraborty, Senior Programmer-Project Leader
Mr Michael Sarkissian, Systems Engineer
Mr C.K. Rao, Senior Programmer
Mr Awad Awad, Senior Programmer

Personnel

Ms Leila Rashed, Personnel Officer

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Dr Hazel Harris, Soil Water Conservation Scientist
Dr Mustafa Pala, Wheat-Based Systems Agronomist
Dr Mohamed Bakheit Said, Senior Training Scientist
Dr Richard Tutwiler, Socioeconomist
Dr Theib Oweis, Water Harvesting/Supplemental Irrigation Specialist
Dr Graham Walker, Agroclimatologist
Dr Elizabeth Bailey, Agricultural Economist/Visiting Scientist
Mr Wolfgang Goebel, Post-Doctoral Fellow/Agro-climatologist
Dr Karel Timmerman, Post-Doctoral Fellow
Mr Ahmed Mazid, Agricultural Economist
Mr Abdul Bari Salkini, Agricultural Economist
Mr Sobhi Dozom, Research Associate
Mr Mahmoud Oglah, Research Associate
Mr Massimo Giangasspero, Associate Expert (seconded from FAO)
Ms Marina Leybourne, Visiting Research Associate

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Dr John Hamblin, Program Leader/Breeder
Dr John Peacock, Cereal Physiologist
Dr Habib Ketata, Senior Training Scientist
Dr Salvatore Ceccarelli, Barley Breeder
Dr Guillermo Ortiz Ferrara, Bread-Wheat Breeder (seconded from CIMMYT)
Dr Omar Mamlouk, Plant Pathologist
Dr Ross Miller, Cereal Entomologist
Dr Miloudi Nachit, Durum-Wheat Breeder (seconded from CIMMYT)
Dr Muhammed Tahir, Plant Breeder
Mr Joop van Leur, Barley Pathologist
Dr Tom S. Payne, Winter Wheat Breader (seconded from CIMMYT)

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Dr Stefania Grando, Research Scientist
Dr Sui K. Yau, International Nurseries Scientist
Mr Moamed Asaad Mousa, Research Associate
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Dr Douglas Beck, Food Legume Microbiologist
Dr William Erskine, Lentil Breeder
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Dr K.B. Singh, Chickpea Breeder (seconded from ICRISAT)
Dr Ali Abdul Moneim Ali, Forage Legume Breeder
Dr Susan Gerlach, Entomologist
Dr R. S. Malhotra, International Trials Scientist
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Dr Mark Ratinam, Post-Doctoral Fellow
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Dr Mamdouh Omar, Visiting Scientist
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Appendix 15

Acronyms and Abbreviations

AFESD	Arab Fund for Economic and Social Development (Kuwait)
AGRIS	International Information System for Agricultural Science and Technology (FAO, Italy)
ANERA	American Near East Refugee Aid
ARC	Agricultural Research Center
AZRI	Arid Zone Research Institute (Pakistan)
BOT	Board of Trustees (ICARDA)
CG	Consultative Group
CGIAR	Consultative Group on International Agricultural Research (USA)
CIHEAM	Centre International de Hautes Etudes Agronomique Mediterranéennes (France)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico)
DGIS	Directorate Central for International Cooperation (the Netherlands)
EEC	European Economic Community
ENEA	Ente Nazionale per l'Energia Alternativa
EMR	External Management Review
FABIS	Faba Bean Information Service (managed by ICARDA)
FAO	Food and Agriculture Organisation of the United Nations (Italy)
GOSM	Central Organization for Seed Multiplication (Syria)
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit (German Agency for Technical Cooperation, West Germany)
IBPGR	International Board for Plant Genetic Resources (FAO, Italy)
IBRD	International Bank for Reconstruction and Development (World Bank, USA)
ICAR	Indian Council of Agricultural Research (India)
ICARDA	International Center for Agricultural Research in the Dry Areas (Syria)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
IDRC	International Development Research Centre (Canada)
IFAD	International Fund for Agricultural Development (Italy)
IFAR	International Fund for Agricultural Research (USA)
IMPHOS	Institut Mondial de Phosphate
INIA	Instituto Nacional de Investigaciones Agricolas (Mexico)
INRA	Institut National de la Recherche Agronomique (France, Morocco)
IUED	Institut Universitaire d'Etudes du Developpement (Switzerland)
JICA	Japanese International Cooperative Agency
LENS	Lentil News Service (managed jointly by ICARDA and the University of Saskatchewan)
MAAR	Ministry of Agriculture and Agrarian Reform (Syria)
MAFRA	Ministry of Agriculture, Forestry, and Rural Affairs (Turkey)
MART/AZR	Management of Agricultural Research and Technology/Arid-Zone Research project

MIAC	Midamerica International Agricultural Consortium
NARS	National Agricultural Research System(s)
OPEC	Organization of Petroleum-Exporting Countries (Austria)
PARC	Pakistan Agricultural Research Council
SAREC	Swedish Agency for Research Cooperation with Developing Countries (Sweden)
TAC	Technical Advisory Committee (FAO, Italy)
TARC	Tropical Agricultural Research Center (Japan)
UNDP	United Nations Development Programme (USA)
USAID	United States Agency for International Development
WANA	West Asia and North Africa

Units of measurement

°C	degrees Celsius
cm	centimeter
hr	hour
ha	hectare
g	gram
kg	kilogram
km	kilometer
m	meter
mm	millimeter
t	tonne (1000 kg)

Countries

AR	Argentina
CA	Canada
CZ	Czechoslouvakia
DE	Federal Republic of Germany
DZ	Algeria
EG	Egypt
ES	Spain
ET	Ethiopia
FR	France
GB	United Kingdom
IN	India
IT	Italy
JO	Jordan
KE	Kenya
LE	Lebanon
MA	Morocco
NL	Netherlands
SE	Sweden
SY	Syria
TR	Turkey
US	United States

Appendix 16

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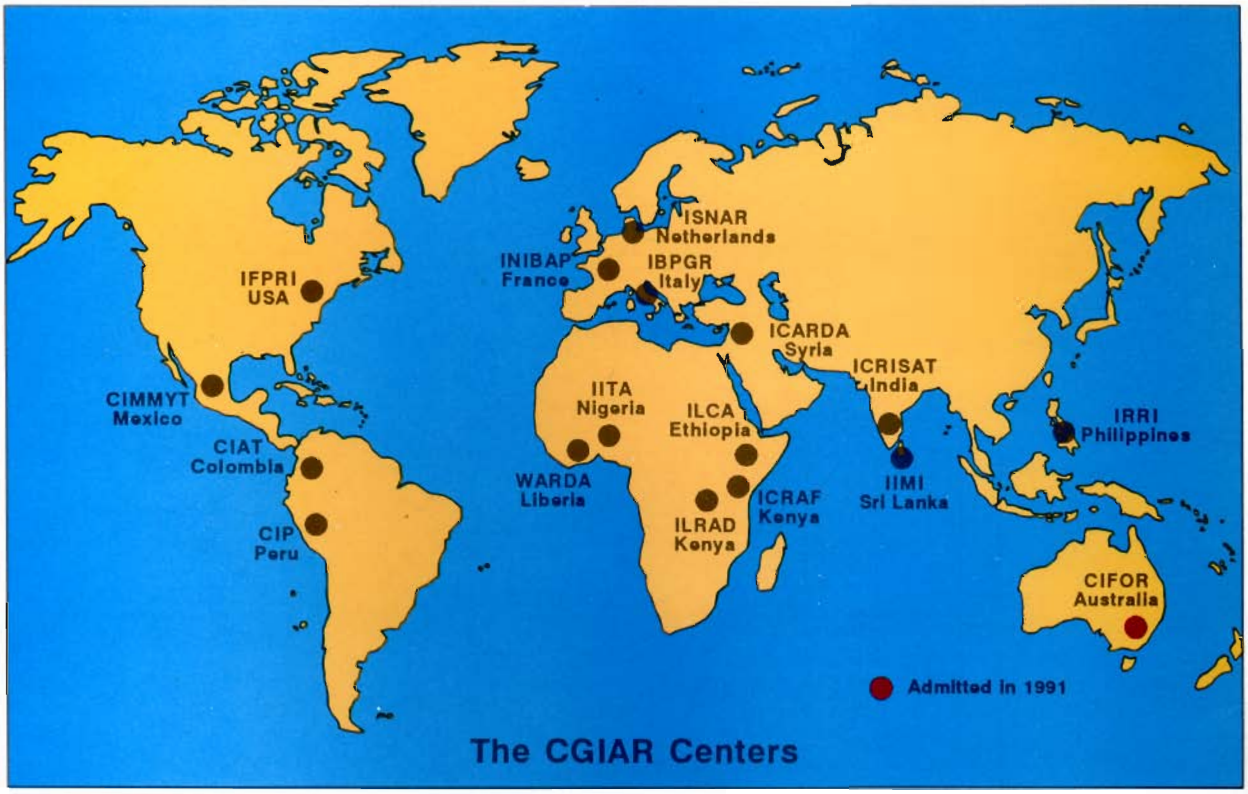

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