ICARDA Annual Report 1990

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 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

The 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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International Center for Agricultural Research in the Dry Areas

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Cover

Conservation of biodiversity is a prerequisite for sustainable agriculture. As part of the CGIAR global effort, ICARDA is actively involved in the collection, conservation, and characterization of the landraces and wild relatives of its mandated crops. In 1990, for the first time in the last about 50 years, an international team of germplasm scientists explored parts of central Tibet, China, to collect wheat and barley landraces.

Left to right: Mr Brad Fraleigh, Plant Gene Resources, Ottawa, Canada; Dr Bryan Harvey, University of Saskatchewan, Saskatoon, Canada; Dr Bent Skovmand, CIMMYT, Mexico; Interpreter; Dr Jan Valkoun, ICARDA, Aleppo, Syria; Mr Dong Ke-yi, Zetang Agricultural Research Institute (ZARI), Zetang, Tibet, China; Secretary; and Dr Li, ZARI, Zetang, Tibet, China.

Foreword

A major service performed by International Centers associated with the Consultative Group on International Agricultural Research is the collection, conservation and evaluation of germplasm. ICARDA's role is particularly important since its region of West Asia and North Africa is the center of origin and diversity of all the Center's mandated crops--wheat, barley, chickpea, lentil and faba bean--as well as a wide range of pasture and forage crops.

The Center's germplasm conservation work, however, is not confined to its immediate region. In 1990 ICARDA scientists participated in collection missions to Algeria, Bulgaria, China, Japan, Libya, Morocco, Tunisia and the USSR, acquiring 6000 new accessions to bring the Center's total collection to over 90,000 accessions. Two of these missions deserve special mention. For the first time in more than 50 years, an international mission, including ICARDA scientists, ventured into the highlands of Tibet (see cover), where unique, highly stress-resistant barley landraces were collected. Closer to home, ICARDA staff joined Soviet and Syrian colleagues in a collection mission that retraced the steps of the Russian pioneer plant geneticist, Nicolai I. Vavilov. Sadly, the mission confirmed that severe genetic erosion has taken place in recent decades, lending yet further evidence in support of the ongoing global effort to conserve our precious genetic patrimony for future generations.

Nasrat Fadda

Nasrat R Fadda
Director General

E Porceddu

Enrico Porceddu
Chairman
Board of Trustees

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PART ONE

Major Developments in 1990

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Major Developments in 1990

The year 1990 saw the start of the implementation of ICARDA's Strategy and Medium-term Plan. These documents define the vision, orientation, and specific actions of the Center for the immediate future and look beyond it into the twenty-first century. ICARDA has made a good start in this direction, although it had to make radical adjustments dictated by funding shortfalls that affected it as well as every other center in the CGIAR (Consultative Group on International Agricultural Research) System.

Other influences on ICARDA have derived from the current active rethinking on the CGIAR priorities, goals, and structure. A new priorities document is under preparation which already indicates that the System will move from a mandate confined to food commodities towards the wider concept of self-reliance that also encompasses non-food commodities, the production and export of which enhances the ability to procure food and attain a higher degree of food security. There is also a move to develop multicommodity, multidisciplinary centers which would focus on the ecological foundations of production systems as well as commodity improvement in collaboration with the global commodity activities and national partners. Such trends, still in the formative stage, will, in due course, shape our future mandates and the orientation of our work.

Governance and Management

For the Board of Trustees of ICARDA, 1990 was a highly productive year. A Board Handbook was developed and issued; it serves as a concise source of information on the composition and operation of the Board and its Committees, as well as of the CGIAR and ICARDA. The Board, through its Audit Committee, formalized the internal audit function and approved the first ever audit plan for implementation in 1991.

Dr Mouin Hamze, President, Board of Directors, Agricultural Research Institute, Beirut, Lebanon, joined ICARDA's Board of Trustees during the year as representative of Lebanon. Dr Hasan Seoud, representative of Syria, left the Board to join as the Assistant Director General (Government Liaison) of ICARDA.

Senior Staff Changes

During the year 13 senior staff members left the Center, and 11 new senior staff members were recruited. Thus, though ICARDA lost valuable expertise with the outgoing staff, the new staff members reinvigorated the Center with their expertise in the changing research thrusts.

Research and Training Highlights

For the second year in succession, the 1989/90 season was one of low rainfall, particularly in Syria where most of ICARDA's research sites are located. At Tel Hadya, for example, the total precipitation received was about 230 mm, a mere 67% of the long-term average. The rainfall distribution was uneven, with the bulk in the first 10 weeks of the cropping season, while the rest of the season was characterized by prolonged periods of drought with intermittent and inadequate rainfall. The latter period also had below-average temperatures with a markedly above-average number of 50 days of frost. This combination of adverse climatic conditions resulted in low yields. The pattern, with variations, prevailed in most of the West Asia and North Africa (WANA) lowlands. Morocco and Tunisia, as well as the highlands

Effects of drought during the 1989/90 season were aggravated by late frost. A barley plot photographed in March 1990 at Tel Hadya, Syria.

of Turkey and Iran, received adequate late rains which saved their season; but Algeria, Sudan, Ethiopia, Jordan, and Cyprus suffered the adverse effects of a dry to very dry season.

Agroecological Characterization

Spatial Weather Generator

Analyses of the combined effects of weather variables were carried out using data generated for rainfall, daily maximum and minimum temperatures, and solar radiation. Results indicated that favorable temperatures in the seedling stage tended to be associated with adequate rainfall, while cold weather, especially in the drier part of the barley growing area, tended to be associated with below-average rainfall. Therefore, periods of drought tended to be less hazardous than might be expected. Such weather models can be linked with crop growth models to provide probabilities for a given yield level, including that for crop failure. Such data are calibrated or compared with yields from on-farm trials.

Germplasm Conservation

ICARDA continued to participate in the CGIAR's effort to collect, evaluate, conserve, and distribute germplasm. The year saw increased genetic resources activities, through the support of visiting scientists from IBPGR (International Board for Plant Genetic Resources), the USSR, and elsewhere. Over 6000 new accessions were added, mainly from North Africa, West Asia, the USSR, and China, raising the total collection held at ICARDA to over 91 000. Valuable germplasm was obtained from the USSR, including natural *Aegilops-Triticum* hybrids and rare *Aegilops* species. In a major collection mission in Tibet, the first in 50 years to be conducted by an international team, unique barley germplasm was collected from isolated areas. In Syria, a joint USSR-ICARDA collection expedition traced the historic Vavilov route. The expedition expressed concern over the incidence of severe genetic erosion.

Pasture legume populations were sampled at 161 sites in Morocco. Both the abundance and frequency were measured for each species, and their distributions related to soil and climate. *Scorpiurus muricatus* was the most frequent species (138 sites) and also the most abundant (mean pod yield of 23 kg/ha). Clovers (*Trifolium* spp.) were found at 73 sites, mainly with high rainfall (>500 mm). *T. scabrum* was the most frequent clover (53 sites), followed by *T. campestre* (41), and *T. angustifolium* (40). For some species, over 200 kg pods/ha were found at certain sites.

Over 78 000 accessions have been transferred to the new storage facilities which became operational in 1989, and 6132 are being held in the long-term base collection at -22°C. Systematic duplication of accessions at appropriate locations was actively pursued, and 6200 additional durum wheat accessions were despatched to CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico). Over 11 500 accessions were provided to scientists in 29 countries, as well as those at ICARDA.

Characterization of germplasm, held in ICARDA's collections, received increased attention in 1990. Several promising accessions resistant/tolerant to biotic and abiotic stresses were identified for utilization in breeding for crop improvement.

Considerable attention was paid to germplasm characterization. Durum wheat, bread wheat, and barley collections from China, Algeria, Egypt, Syria, and the USSR were evaluated; highly drought-tolerant germplasm was identified from the USSR material, which included emmer accessions.

Management of germplasm evaluation data was further refined. With the assistance of two IBPGR scientists, two world-wide ecogeographical databases were established for wild wheat (17 000 accessions) and annual forage and pasture legumes (33 000 accessions). These databases will greatly facilitate germplasm exchange, including identification of duplicates.

Germplasm Enhancement

One of the main objectives of germplasm enhancement is the development of high-yielding stable cultivars. Stability is being sought through the development of tolerance or resistance to biotic and abiotic stresses. The gene pool of cultivated species has been enlarged through the exploitation of landraces and exotic material, and appropriate genes have been incorporated into cultivated forms. ICARDA's work continues to provide evidence in support of the theory that selection is more efficient where it is carried out in environments for which the material is intended.

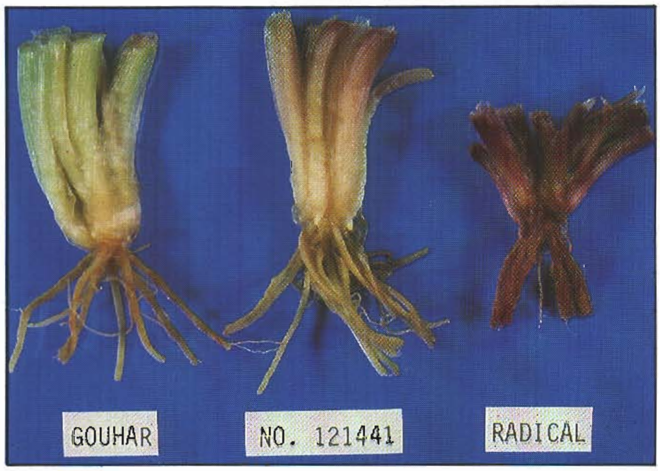
In 1989/90, national programs within WANA and beyond released 22 cereal and 10 food legume varieties. ICARDA is proud to have been associated with those national programs in the development and release of new varieties.

Cereal Crops

Barley genetic improvement continued to rely on the use of landraces, in spite of their narrow adaptation range. To deal with this limitation, a decentralized breeding approach was followed and some broadly adapted lines were identified.

Over 2000 landraces and varieties collected from high-altitude areas were tested for cold and drought tolerance and yield in Turkey, Syria, Pakistan, and Morocco. The best 150 of these lines were further tested in the laboratory for cold tolerance using the crown freezing test at -10°C, and their tolerance to cold was confirmed. Two of them were identified as outstanding: Radical (from the USSR) and Star (from Iran), and are now used as checks. About 250 crosses were made specially for ICARDA's highland work. The material was advanced during the season by three cycles using greenhouses. The F4s will enter multilocation testing in 1990/91.

Barley is still considered an important food crop in some regions, including parts of WANA. Hull-less (naked), large-seed varieties are easier to thresh and are preferred by the consumer. About 100 naked barley lines, developed in the Center's CIMMYT-based program for Latin America, were further tested in WANA in 1989/90. These lines have a 1000-kernel weight of 50-60 g, as compared to 30-40 g for barley for feed. Another important outreach activity is the Center's cooperative research in North Africa on barley yellow dwarf virus. Over 2000 cereal lines were evaluated and six barley and 10 wheat lines were found tolerant to the virus.



Crown freezing followed by TTC (triphenyl tetrazolium chloride) treatment was used to identify cold tolerance in barley lines (if the tissue is living, it turns red in TTC solution). Left to right: susceptible, intermediate, and resistant barley lines.

The new ICARDA/CIMMYT agreement continued to guide the active cooperation between the two centers. Several ICARDA staff members visited CIMMYT during the year. The fruitfulness of cooperation was highlighted by the number of genetic lines exchanged: 5000 lines of bread wheat were received from, and 1672 sent to, CIMMYT. For durum wheat, these numbers were 2810 and 1177 lines, respectively. A large number of crosses with wild relatives (108 for durum wheat) were made during the year to incorporate new variability into the gene pool of these two crops.

A third CIMMYT wheat breeder stationed at ICARDA supports the highland wheat program with a multilocation varietal development scheme: crossing and testing for drought and disease tolerance in Aleppo, and for cold tolerance and local adaptation in Turkey. This work will soon be extended to the highlands of Iran and Pakistan.

The CIMMYT/ICARDA project also identified lines of barley--Gloria/Come and Ase/2cM//B7688--resistant to Russian wheat aphid. In a cooperative project with USDA scientists, the effectiveness of the

CIMMYT scientist, stationed at ICARDA, evaluating CIMMYT/ICARDA winter and facultative wheat advanced lines at Tel Hadya, Syria.

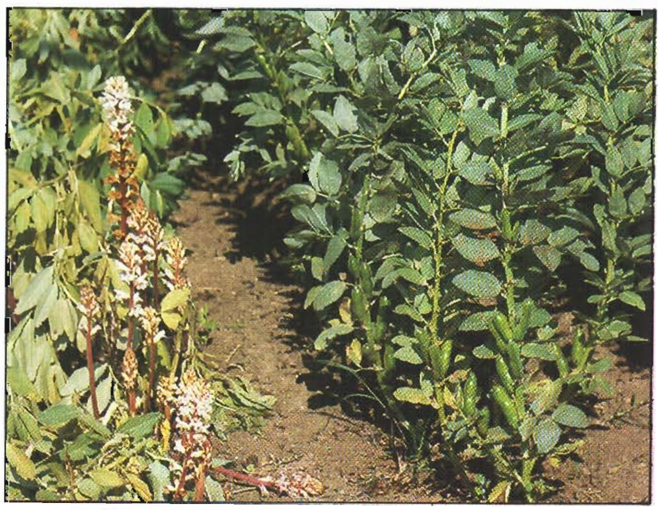
biological control of this serious insect pest through the use of parasites was established. Several Russian wheat aphid parasites were provided by ICARDA to the USA for possible release.

Biotechnology tools were increasingly used in the cereal breeding activities. Over 700 dihaploid lines of bread wheat and barley were developed from crosses, and 200 lines were obtained from Oregon State University. These are being field tested. A precise genetic analysis of these lines is possible due to their absolute homozygosis. Work on RFLP (Restriction Fragment Length Polymorphism) and PCR (Polymerase Chain Reaction) revealed a high degree of polymorphism among ICARDA genotypes, leading to further studies on DNA-marker-assisted selection for adaptation to Mediterranean environments.

Food Legume Crops

In line with ICARDA's objectives to stabilize food legume production as a means to sustain productivity of cereal-dominated cropping systems, greater attention was paid to generating food legume germplasm resistant to biotic and abiotic stresses. The dry and cold 1989/90 season provided ideal conditions for germplasm screening.

Faba bean research, fully transferred to Morocco in 1990, made significant progress. Three selections resistant to the parasitic weed *Orobanche*, which is the principal production constraint in North Africa, yielded twice that of the traditional cultivar Aquadulce in *Orobanche*-infested fields. Drought tolerance was identified by Tunisian scientists in lines 80S80028, S82113-8, and S82033-2.



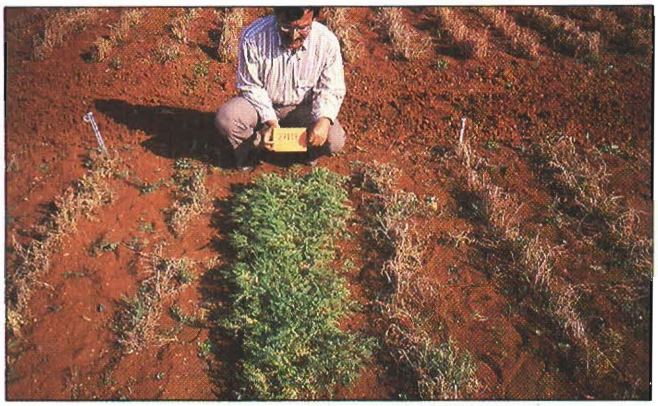
A resistant faba bean selection (right), jointly identified by the Moroccan and ICARDA scientists, survived a heavy natural infestation of *Orobanche* at Douyet station in Morocco.

Only a small number of international faba bean nurseries were sent out from Morocco for use in the local improvement programs; the nurseries contained lines with specific disease resistance or determinate growth habit.

Active cooperation continued with ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) in kabuli chickpea improvement. To screen chickpea lines for major production constraints at the same location, four planting dates provided the answer: October (cold tolerance), December (winter planting, *Ascochyta* resistance), January (spring planting), and March (drought tolerance).

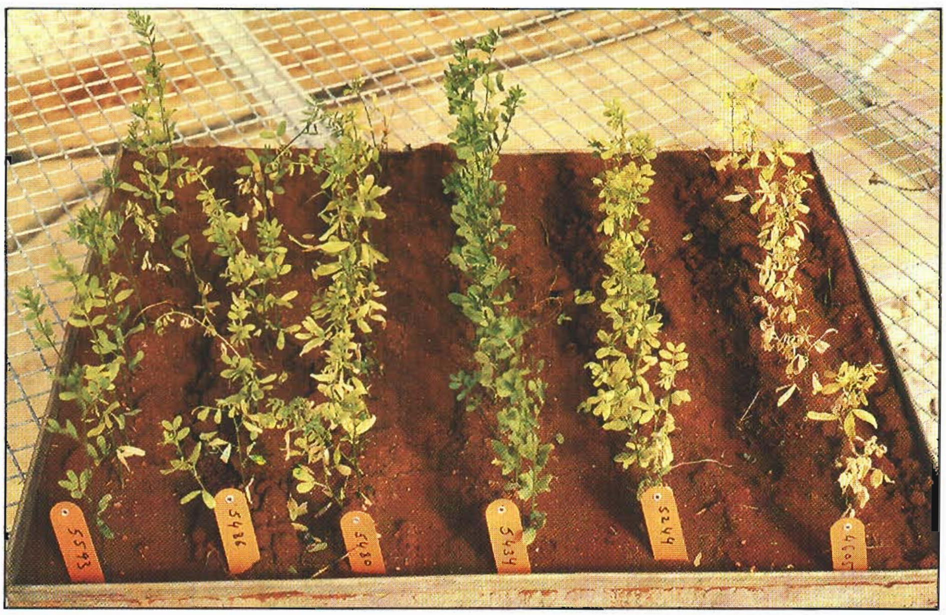
Trials over the last seven years, including the 1989/90 season, consistently showed that winter sowing increased yields on average by 67% over spring sowing. Some excellent cold-tolerant lines were identified, including a mutant of ILC 482. Results indicated that selection for inheritance of cold tolerance was more reliable in later segregating generations than in early ones.

In cooperative studies with the University of Frankfurt, DNA "fingerprinting" techniques were developed to help identify isolates of the *Ascochyta* blight fungus, as well as characterize chickpea germplasm lines. Biological nitrogen fixation in chickpea increased with increasing moisture supply. Resistance to leaf miner was confirmed and studies on the mechanism of resistance continued during the year.



A mutant line No. 27118 of ILC 482 kabuli chickpea survived the severe cold spell during March 1990 at Tel Hadya, Syria.

In lentils, the increased abiotic stress tolerance of breeding lines over landraces was confirmed. Disease-resistant lines were also identified: ILL 298 and 6435 for wilt, and ILL 5588 for combined wilt and *Ascochyta* resistance. Additional resistance was identified in wild lentils. Lentil lines were identified with tolerance to drought but responding to additional moisture with greatly increased yield and biological nitrogen fixation. Promet was confirmed to be an economically viable and effective seed treatment insecticide to control *Sitona* larval damage to lentil root nodules.



Lentil lines were screened in a greenhouse under standard growth conditions and an artificial epiphytotic of *Fusarium* wilt at Tel Hadya, Syria. Several promising lines were identified.

Pasture Legumes

An evolutionary method was developed to breed pasture legumes. A mixture of 84 accessions of 15 medic species was used to select varieties adapted to the ley farming system (cereal/self-regenerating pasture). The mixture was part of a long-term rotation experiment with plots large enough to permit long periods of grazing. *M. rotata*, a local cultivar, was most promising; none of the imported medic cultivars were successful, confirming the importance of using native material.

The more promising genotypes had long peduncles and hard seeds, and small plants (small leaves, short internodes, short petioles, and small seeds) were more successful than large ones. There was a weak negative correlation between flower abortion and prominence.

Subterranean vetch (*Vicia sativa* subsp. *amphicarpa*) is a potentially important pasture species that produces some of its seeds below the ground. During the drought of 1990, it produced nearly 1400 kg/ha of underground seed in the absence of grazing. Even where sheep heavily grazed the plots, the plants produced more than 200 kg/ha of seed, and herbage yield was as good as for most other pasture legumes. Some of the seed (56%) remained hard (dormant) at the end of autumn, suggesting that subterranean vetch has potential both in ley farming and continuous pasture systems.

Resource Management and Conservation

Experience has proved that in the lower rainfall areas, such as those in WANA, production increases must be sought through the management of farm resources and their conservation, as much as from genetic improvement. ICARDA's farm resource management research encompasses all the principal components of the natural resource base, especially soil and water.

Soil Cultivation

Mechanized tillage has become common in WANA only relatively recently, and the techniques and implements farmers use often appear ill-matched to the agricultural needs. Deep tillage, which has a high fuel cost, may be unnecessary, even detrimental; and research at Tel Hadya has shown that it does not improve water infiltration or crop yield over shallower tillage. Some yield reduction has been experienced using a zero-tillage, direct-drill planter, but this is because of a limitation on the machine's row-spacing adjustment. The technique itself shows great promise for local conditions.

Zero tillage with direct drilling into stubble shows great promise.

Elsewhere, deep tillage tended to reduce weed incidence in chickpeas, but narrower spacing achieved the same result. Alternatively, wider row spacing permitted interrow cultivation and did not reduce yield. However, those results are based on data from one season only.

Supplemental Irrigation

Supplemental irrigation can alleviate the risk of yield loss in seasons with inadequate rainfall. As irrigation water is limited, however, it should be applied to maximize yield and economic returns, which depends on management skills and crop species and variety used. In one trial, 232 mm supplemental irrigation increased barley yield from 400 kg/ha to 3370 kg/ha; or about 13 kg for every millimeter of supplemental irrigation. Varieties adapted to higher rainfall areas, such as Rihane (barley) and Cham 4 (wheat)--both released in several countries recently--responded better to additional water. Rapeseed and sunflower, both important sources of vegetable oil in WANA, also responded well to supplemental irrigation and, as in the case of barley and wheat, their response depended on the cultivar used.

On-farm Fertilization of Wheat

Seventy researcher-managed, wheat fertilizer trials were conducted on farmers' fields in northern Syria. Sites were chosen to represent different soils and rotations, and analyses showed that soil contents of available N and P were below the critical levels (10 and 5 ppm, respectively) in about half the fields used. Highest yields were obtained after watermelons, especially under low rainfall. N response increased with increasing rainfall, and P response was less pronounced than that of N. It appears that wheat is less responsive than barley to added P. Regression equations were developed to describe wheat yield, in terms of fertilizer rate and rainfall, for three different rotations and four different initial soil values of mineral N and available P. A partial budget analysis showed that all the fertilizer treatments were profitable, but the optimum rate was 120 kg N/ha without any phosphate where wheat followed lentil or chickpea, and with the addition of 40 kg P_2O_5/ha where wheat followed watermelon.

Phosphate Studies

The deficiency in available P common to most WANA soils can be alleviated by fertilizer; but the interactions of crop growth and variable soil-moisture conditions on P-uptake, superimposed on the complexities of the chemical processes of phosphate in the soil, make it difficult to define an optimum, efficient P-fertilizer strategy. Several lines of work are in progress. A relationship between P sorption and iron oxide content, found in a study of 21 soils, suggests that analysis for iron oxide might provide a quick index of a soil's ability to immobilize added P. In the field, results from Breda, Tel Hadya, and Jindiress reveal a wide range, 0 to 45 kg P_2O_5/ha, in the fertilizer maintenance rate--that is, the lowest rate of annual application sufficient to maintain P-availability in the soil at a level necessary for optimal crop growth.

Soil Nitrogen Dynamics

Soil nitrogen dynamics, particularly as affected by crop rotation, may influence straw quality and grain protein content of cereals. It appeared that rainfall and N availability influenced straw and seed quality more than plant genotype. Dry matter response to increased water supply was generally greater than N uptake, thus reducing the concentration of N in grain and straw. For example, supplemental irrigation reduced the nitrogen content of wheat grain from 2.86 to 1.92%, as compared to the control in a dry year, but N fertilizer reduced this effect. It also means that straw quality is better in a dry year, compensating to some extent for reduced quantity.

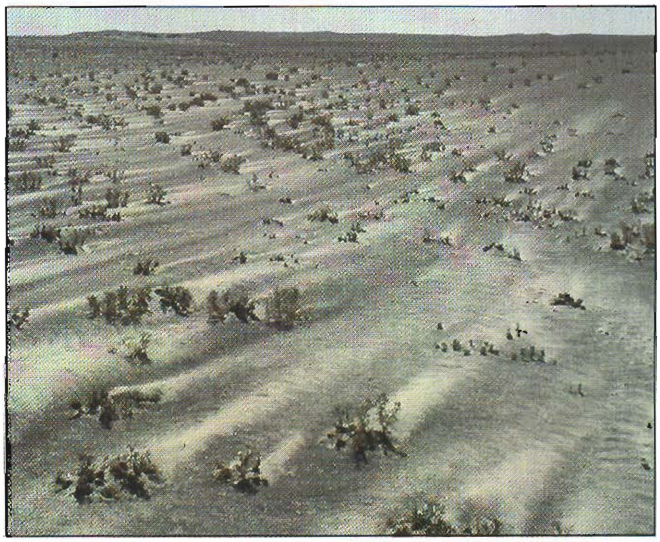
Sustainability of Ley Farming

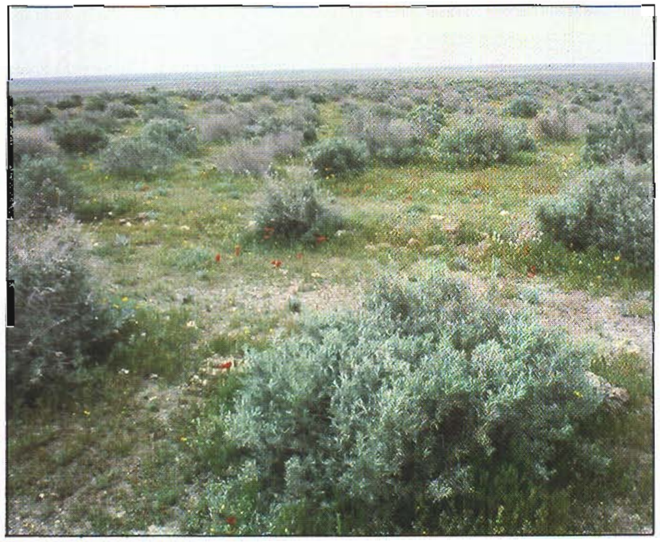
Changes in the seed bank size of medic pasture were used to determine the sustainability of ley farming (cereal/self-regenerating pasture). Of the six species compared, *M. noeana* lived longest-- 49% of seed surviving for four years--compared with *M. polymorpha*, of which only 19% seed survived. *M. noeana* germinated poorly in the year after seed set (the cereal year), which makes it especially suitable for ley farming.

Besides seed longevity, the medics have two other attributes that contribute to sustainability. These are their ability to defer germination for up to two months, and the ability of seedlings to survive prolonged drought. In the autumn of 1990, heavy rain fell at Tel Hadya in November, followed by two months of below-average rain. The mortality of *M. noeana* seedlings was 94%, but that of *M. polymorpha* only 6%. More than 90% of *M. noeana* seedlings germinated after the November rains, compared with only 50% of *M. rotata*. *M. rotata* reestablished after the rains in January. *M. noeana* would have produced good pasture if the year had been normal, but in the difficult weather conditions of 1990 it produced virtually nothing. A mixture of species should ensure productivity in all circumstances.

Seed Coat Thickness

Seed coat thickness in six pasture legumes provided an indication of hardseededness, an important indicator of adaptation to permanent pasture in Mediterranean environments. When the testa thickness is more than 8% of the seed radius, more than 20% of the seeds will germinate. If this relationship holds true for other pasture legumes, plant breeders will have a quick and reliable method to screen legumes for hardseededness.





Degraded marginal land at Maragha in northern Syria (left) and adjacent land improved by planting two indigenous shrubs, *Atriplex holimus* and *Salsola vermiculata* (right).

Reversing the Degradation of Marginal Lands

One method of improving degraded marginal and rangelands is to sow or plant edible shrubs. ICARDA, in collaboration with the Government of Syria and ACSAD (Arab Center for Studies of the Arid Zones and Dry Lands), is measuring the productivity of shrub vegetation at three levels of stocking intensity. An important measure of land degradation is the size of the seed bank of annual and ephemeral species which, even in the improved shrub land, provide much of the feed for livestock.

The seed bank of the improved pasture was reduced by the process of establishing the shrubs. When the experiment started the seed bank of unimproved pasture was 37 kg/ha, compared with only 11 kg/ha in the improved pasture. After just one summer the seed banks were nearly equal: 10 and 9 kg/ha, respectively. Herbage production (including shrubs) of improved pasture was more than double that of unimproved pasture. The improved pasture supported the sheep for several months longer than the unimproved one.

Improved Grasslands for Sheep Grazing

Over a period of four years, grasslands topdressed with superphosphate at 60 kg/ha/year produced 300% more herbage than nonfertilized land. The extra herbage reduced the need for barley supplement to feed Awassi sheep by about 50%. The fourth year was the driest and the amount of feed saved (180 kg/ha at the highest

Legumes in natural grasslands after three years of application of 60 kg P/ha/year.

stocking rate) was the greatest, demonstrating the value of this technology to farmers where the risk of drought is high.

At low phosphate the seed bank remained at about 2000 legume seeds per square meter, while at high phosphate it rose to 8800 seeds. Sustainability of the technology is therefore expressed by the reduced demand for supplementary feeding, improvement of the vegetation cover, seed bank increase, and improved capacity to fix nitrogen.

Feed Legumes on Farmers' Fields

Vetch (*Vicia sativa*) and chickling (*Lathyrus sativus*) were sown in rotation with barley on eight farms. Barley yields were higher after both legumes than after barley (900 kg/ha compared with 800 kg/ha), and barley/legume rotations produced much more grain and straw than barley/fallow. Both legumes were valuable in dry areas (<300 mm rainfall), and vetch appeared to have an advantage over chickling in areas prone to frost. Another vetch--*Vicia narbonensis*, and a chickling--*Lathyrus cicera*, appeared even better adapted to such areas.

Seed Production

The Seed Unit continued its active assistance to NARSs (National Agricultural Research Systems) in WANA in strengthening their seed programs to realize full benefits of improved technologies. The Unit also provided valuable service to ICARDA's commodity programs by cleaning, treating, and quality testing their seed. The seed cleaning laboratory of the Unit became operative in 1990 and was extensively used.

In addition to its regular activities during 1990 (training, strengthening of infrastructure in NARSs, dissemination of information, etc.), the Unit increased its emphasis on seed health and morphological varietal description. Cooperation with the seed programs of Ethiopia, Jordan, Sudan, and Yemen was considerably strengthened.

The Unit also refined its work plan for future activities. Increased attention will be paid to the seed production aspects of food and feed legumes, and to region-related seed technology research. Alternative seed production systems will be explored, and greater cooperation with the private seed production sector will be sought.

Trials on fattening lambs on forage legumes under farm conditions.

Impact Assessment and Enhancement

Monitoring Chickpea Adoption in Morocco

Studies in Morocco with 150 farmer-managed trials over a three-year period revealed that 61% of surveyed farmers in areas with low *Ascochyta* incidence had adopted winter sowing of chickpea. The rate of adoption was roughly one-third of this value in areas with high *Ascochyta* pressure, and the overall rate of adoption was 43%. The 1989/90 season saw a heavy disease outbreak which caused a setback to adoption, but seed size is also an important criterion in farmer evaluations of winter-sown varieties. The national program is now releasing new varieties with larger seed and higher levels of disease resistance. Their adoption rate will be monitored.

Adoption studies in Morocco confirmed that cold-tolerant, winter-sown chickpea varieties outyielded the spring-sown ones (foreground).

Winter Sowing of Chickpea in Syria

Parallel observations in Syria on the adoption of the cold-tolerant chickpea varieties Ghab 1 and Ghab 2, which were released in 1986, indicated that about 47% of the farmers who had grown the material adopted the practice of winter sowing. Here, yield, rather than seed size or the incidence of diseases and weeds, played the major role in adoption.

Outreach Activities

ICARDA's outreach activities continued to be conducted during 1990 through six regional programs: the Highland Regional Program, the Arabian Peninsula Regional Program, the West Asia Regional Program, the Nile Valley Regional Program, the North Africa Regional Program, and the Latin America Regional Program. In most cases, the research and training activities of these programs are supported by a combination of core and special project funding. All outreach activities are conducted in partnership with NARSs. In addition to the specific research results and human resource development emanating from these joint collaborative efforts, one of the main impacts of their activities has been the considerably increased collaboration and cooperation between research and training scientists both within and between countries of the WANA region, reflected in an increasing number of commodity and discipline-oriented networks. ICARDA continues to support and encourage such national, subregional, and regional networks while simultaneously placing emphasis on greater interdisciplinary client participation in solving complex, and frequently location-specific, problems.

Highland Regional Program

The Highland Regional Program (HRP) was formally established in July 1990 at the joint CIMMYT/ICARDA office in Ankara, Turkey, with financial support from the Government of Italy. The Program is responsible for cooperative work in areas at elevations above 1000 m, mainly in Turkey, Iran, and Pakistan where winter wheat and barley are the dominant crops.

The first full-scale national coordination and planning meeting between ICARDA, CIMMYT, and the Turkish Ministry of Agriculture, Forestry and Rural Affairs was held in October at the Ministry's Central Research Institute for Field Crops.

With the establishment of the Highland Program, ICARDA's oldest highlands outreach project, MART/AZR, funded by USAID and based at Arid Zone Research Institute (AZRI), Quetta, Pakistan, found a place for itself in the Center's regular administrative regional program structure. A reshuffling of ICARDA personnel at AZRI took place to match the Program's new thrusts which are linked with local agribusiness and include research on (a) sustainable range and small ruminant management strategies, (b) improved water-harvesting systems, (c) germplasm evaluation, and (d) the economic evaluation of new technologies.

The research at AZRI has demonstrated the benefits of improved feeding during pregnancy and lactation on ewe fertility and lamb growth rates. Fourwing saltbush has been found to be a valuable winter feed to supplement the sparse range vegetation usually insufficient to meet the energy, protein and phosphorus needs of animals. Catchment basin water harvesting has continued to provide modest increases in yields of cereal and forage crops but, in some cases, has resulted in waterlogging and reduced yields. A yellow rust epidemic on wheat reconfirmed the importance of identifying and releasing adapted lines resistant to this fungal disease. A preliminary survey of livestock marketing suggests that, contrary to common assumptions, intermediaries may not be taking an unfair share of the retail price.

A Letter of Understanding between the Agricultural Research Organization of the Ministry of Agriculture of the Islamic Republic of Iran and ICARDA was signed for initiating a large-scale outreach project in 1991. This five-year project will help strengthen the research capabilities in the highland and rainfed areas of northwest Iran through breeding and agronomy work on cereals and food and forage legume crops. The project funding will be provided by the Islamic Republic of Iran.

H.E. Dr H. Toufighi, Deputy Minister for Agriculture, Islamic Republic of Iran (right) and ICARDA's Director General Dr Nasrat Fadda sign a Letter of Understanding for a five-year project on cereals and food and forage legumes to start in 1991 in Iran.

Arabian Peninsula Regional Program

With continued support from the Arab Fund for Economic and Social Development (AFESD), the Arabian Peninsula Regional Program (APRP) in 1989/90 focused on (a) germplasm exchange, evaluation, enhancement and promotion, (b) human resource development, and (c) consultancy visits by ICARDA and other scientists. The Program continues to operate from Aleppo, but negotiations are under way to base it in the United Arab Emirates.

A total of 63 cereal, 50 food legume, and 2 forage trials were conducted for local adaptation, drought, and salinity tolerance. Varietal description and evaluation for the common and improved wheat and barley cultivars grown in Yemen and Saudi Arabia commenced.

The strong demand for ICARDA's assistance in human resource development continued. Fifty-eight trainees from the Arabian Peninsula participated in the Center's training courses during 1989/90. Three in-country courses were jointly held in Yemen, Qatar, and Oman, and a traveling workshop on food legume and cereal crops was held in Oman.

West Asia Regional Program

As part of its activities, the West Asia Regional Program (WARP) continued the execution of the Mashreq Project supported by the United Nations Development Programme (UNDP) and AFESD. The activities focused on increased productivity of barley, pasture, and sheep in the critical rainfall zones of Syria, Jordan, and Iraq, with emphasis on the transfer of available technology to farmers.

On-farm trails on barley fertilization in low-rainfall areas of Syria and Jordan resulted in grain yield increases ranging from 5 to 100%. The straw yield increase was about double that achieved for grain. Economic analyses showed that farmers' net return could be increased by 50%.

A recommended package of practices for barley production was demonstrated in 17 farmer-managed trials in Jordan. The average increase in grain yield ranged from 40 to 70% over that of farmers using standard practices.

Scientists from west Asian countries reviewing the food legume national program in Jordan during the West Asia Regional Workshop in April 1990.

Several demonstrations on sheep improvement were initiated with farmers and sheep owners in north and northeast Syria. These included: increasing birth rate by synchronization, distribution of improved rams for boosting sheep production, and demonstrating the effect of flushing ewes before birth on increasing lamb weights.

In Iraq, WARP assisted the national program in the establishment of a sheep breeding station at Al-Radwanieh, near Baghdad. A total of 70 improved rams and ewes were purchased from Turkey; the national program provided other breeds.

In Jordan, one lentil and two chickpea cultivars were released. One wheat and two barley lines are now in the final evaluation stage before release to farmers. Two dual-purpose barley lines are in prerelease seed multiplication in central Iraq.

Human resource development through training courses and workshops continued to receive high priority. Four training courses on forage production and technology transfer were conducted. WARP also assisted in three regional courses in lentil harvest mechanization, genetic resources, and seed testing. A food legumes traveling workshop was hosted in Jordan.

Nile Valley Regional Program

The Nile Valley Regional Program (NVRP) covers research, transfer of technology, and training to improve the production of cool-season food legumes and cereals in Egypt, Ethiopia, and Sudan. The cereal component is a joint responsibility with CIMMYT.

ICARDA collaborates with the three countries in developing annual work plans; providing germplasm and technical, logistic and management support, as well as training opportunities; and contributing to the coordination of activities at national and regional levels. Emphasis is on an on-farm research approach to develop technology suitable for farm conditions.

Funding continued from the EC (The Commission of European Community) for Egypt, from the Government of the Netherlands for the Sudan, and from SAREC (Swedish Agency for Research Cooperation with Developing Countries) for Ethiopia (cereals not included in funding for Ethiopia). Regional initiatives are shared: Egypt takes the lead in screening for aphid resistance, Sudan is responsible for research on heat stress in wheat, and work on drought and salinity tolerance is jointly coordinated between Egypt and Sudan.

A SAREC Review Mission visited Ethiopia to evaluate the performance of NVRP.

North Africa Regional Program

The North Africa Regional Program (NARP) covers Algeria, Libya, Morocco, and Tunisia. During 1990, five senior scientists were based in Morocco and Tunisia. Three of them are supported by the Government of Italy/IFAD (International Fund for Agricultural Development) and UNDP through special-project funding; and two faba bean scientists at Douyet, Morocco, are supported by ICARDA on an interim basis. The Program is coordinated from Tunis.

The Italy/IFAD project aims at increasing barley, food legume, and livestock production; and the UNDP-supported Maghreb Project is directed at monitoring diseases and enhancing cereal and food legume germplasm.

Collaboration with Libya, initiated in 1989, was considerably strengthened in 1990. ICARDA provided substantially increased training opportunities to Libyan researchers at headquarters and in courses organized in North Africa.

Regional and international activities of NARP included in-country training courses, traveling workshops, meetings, seminars, and conferences. Efforts continued on developing the capability of the Moroccan national program to fully take over the faba bean research. A formal request for bilateral assistance from the Federal Republic of Germany (BMZ) to Morocco is being processed.

Latin America Regional Program

Activities of this Program during 1990 continued to be largely confined to the ICARDA-CIMMYT Barley Project. This collaborative inter-center activity has concentrated on the (a) incorporation of multiple disease resistance into barley germplasm adapted to Latin American conditions, (b) improvement of hull-less barley genotypes suitable as human food in the Andean Region, (c) exploitation of early-maturing barley genotypes, (d) resistance to the Russian wheat aphid and other pests as well as diseases, and (e) an examination of the potential of medic-barley rotations in the region. The national programs of Peru, Brazil, Chile, China, and Australia have recently released barley varieties originating from ICARDA-CIMMYT germplasm.

Training

The emerging pattern in training emphasizes advanced training at Tel Hadya and applied training in in-country or regional courses. A total of 714 persons from 22 WANA countries, 13 other developing countries, and 6 industrialized countries were trained in 1989/90. Of these, 52% received training at headquarters and 48% in in-country courses. The percentage of women trainees continues to grow and, in 1990, it reached 13.6. Twenty-one courses were given at headquarters, and 20 in-country or regional courses in collaboration with NARSs.

Training in genetic resources and information management and retrieval received particular attention during the year. A total of 40 persons were trained in genetic resources activities: 17 at headquarters, 13 in in-country courses conducted in cooperation with IBPGR, 5 in individual non-degree and another 5 in individual degree programs. Three Syrian librarians received training in information management and retrieval.

The visiting scientist program included 19 WANA and 2 Chinese scientists. A total of 21 MSc and 19 PhD students completed their research requirements at ICARDA.

A training follow-up study report was published. The major conclusions of the report are under consideration. A Training Procedures Manual was also published to streamline the training activities of the Center.

Information Dissemination

ICARDA's efforts to gain increased accessibility to the mainstream of intellectual information continued in 1989/90. Five CD-ROM databases were acquired/ordered during the year: Food, Agriculture and Science, covering 6000 publications from 20 international centers; AGRIS, providing international literature in agricultural science and technology from over 135 countries; CAB Abstracts, providing 750 000 bibliographic references; AGRICOLA, covering 2.5 million documents; and SESAME, containing 50 000 citations in French.

By extracting bibliographic references from AGRIS, the Center developed specialized databases on faba bean (FABIS) and lentil (LENS). An ILDOC database containing references to books, reports, and technical publications in the ICARDA library was established. The library also installed SRLS, a database of the Union Catalog of Serials developed by ICRISAT in cooperation with 14 IARCs (International Agricultural Research Centers) including ICARDA. SRLS provides access to 5400 journals and monographic serials available in cooperating centers.

As a first step towards establishing an information network in WANA, the Center hosted a meeting of Syrian librarians. The meeting was useful in developing new contacts for information exchange, and providing guidelines for future collaboration.

Through the courtesy of the Atomic Energy Commission, Damascus, the Center has gained on-line access to INIS (International Nuclear Information System database), Vienna; and ACSAD has offered to share its databanks.

Sixty-three research articles were published or submitted to international journals in 1990, the highest number ever in any one year since the establishment of ICARDA. Thirty-seven publications were produced in-house, in addition to others produced for the Center by external publishers.

CD-ROM databases acquired during 1990 were extensively used by ICARDA scientists and trainees.

A manual of Publication Policy and Procedures was developed to provide guidelines for producing information materials to meet specific needs of the various audiences of ICARDA.

Efforts to strengthen the public awareness activities continued. News releases on important events were distributed to both regional and international media. Efforts to establish a media network within WANA were intensified, and contacts with both the regional and international media widened.

A desk-top publishing facility in Arabic was acquired, and Arabic versions of key documents were produced. A revised draft of ICARDA Style Guide for Science Writing in Arabic was developed.

PART TWO

Research and Training Review

Contents

Research and Training Overview

ICARDA's research follows a three-dimensional approach (Fig. 1) to bring out the interlinkages between the various facets of its work: (i) the agroecological dimension which defines the broad setting in which the Center's work is conducted, (ii) the commodity dimension which responds to the requirements of enhancing the germplasm and improving the management of the mandated commodities, and (iii) the activity dimension which introduces a matrix/project-based approach that cuts across the boundaries between other aspects of the Center's research.

The Center has identified seven integrative activities central to its current and future research program. These are: agroecological characterization, germplasm enhancement, farm resource management, training and networking, information dissemination, and impact assessment and enhancement. Each activity is a multidisciplinary research effort with a well-defined set of objectives and program of work, designed to contribute to the Center's overall goal of achieving sustainable increases in crop and livestock productivity.

The advantages of introducing the seven activity packages were discussed in the Center's Annual Reports for 1988 and 1989, but are restated here for quick reference. Introduction of these packages has enhanced interaction between programs at ICARDA's main research station as well as between main station and outreach programs. It has also helped in achieving greater coherence of activities and a more efficient use of resources across the Center, and has allowed a clearer perception of the balance between and among activities for human and financial resources allocation. The Center is now able to efficiently measure the appropriateness and effectiveness of its research programs.

ICARDA introduced reporting its work by activity for the first time in its Annual Report for 1988, and has since continued to follow the same structure of reporting.

The Weather in 1989/90

In much of West Asia and North Africa (WANA), the 1989/90 cropping season was one of low rainfall, particularly so in Syria where most of ICARDA's sites are located. For example, at the Center's principal

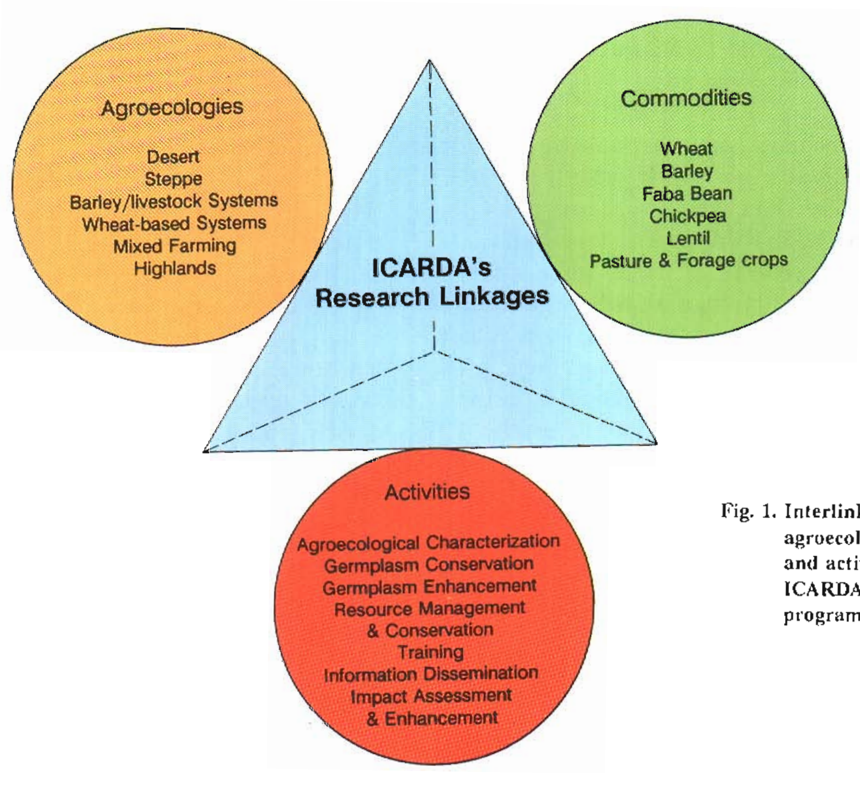


Fig. 1. Interlinkages between agroecological, commodity, and activity thrusts of ICARDA's overall research program.

station at Tel Hadya the total rainfall received was about 230 mm, a mere 67% of the long-term average. The rainfall distribution was uneven, with the bulk in the first 10 weeks of the season, while the rest of the season was characterized by prolonged periods of drought with intermittent and inadequate rainfall. The later part of the season also faced below-average temperatures and a markedly above-average number of 50 frost days. This combination of adverse conditions resulted in low yields.

In North Africa (Morocco, eastern Algeria, and Tunisia), the season started early, in mid-October, and was followed by good rains up to January. Only in central and western Algeria were the early rains less plentiful, so planting had to be delayed until December. The period from February to mid-March was dry and relatively warm across the whole region. Good rains in April and May benefitted the crops, and even caused some flooding in south-western Algeria. For such crops as barley, however, these rains were too late. On aggregate, cereal production was above average in Tunisia and Morocco, but considerably below average in Algeria.

For Sudan, 1989/90 was the second bad season in a row. The rains came late and were below average throughout the country, leading to a poor harvest. The western provinces were the worst affected.

In Ethiopia, the small rains started early and the total rainfall was about average. Crops yields were, however, reduced to less than average because of an early end of the rains in early May. The main rainy season started timely in central, southern, and eastern Ethiopia, but was delayed until mid-July in the west and north. While the rains were plentiful in the west, center and most of the south, they were insufficient and short in the north and erratic in the east. Crop yields in the west and center were good, in contrast to extremely poor yields and widespread crop failure in northern Ethiopia for the second year in succession.

In Yemen, growing conditions during the season were generally favorable in spite of a late start, leading to an average crop.

In Jordan and Cyprus, the season started late and rainfall remained below average throughout. Worst affected was southern Jordan, where seasonal rainfall was only a third of the long-term average. Rain in April saved the crops, but cereal yields in both countries were the lowest in the past four years.

In spite of good early rains in Syria and Iraq, rainfall remained below average throughout the remainder of the season. It was, however, relatively well distributed and good rains in February made an average wheat harvest possible. In the drier part of Syria, however, barley yields were very low, though better than in 1988/89, and the crop failed in many areas.

In Lebanon, too, rains were not plentiful, but well distributed, resulting in an average cereal crop.

In Turkey and Iran, a good start of the season was followed by below-average rainfall during the first quarter of 1990; but ample rains in April led to an above-average cereal harvest. In northern Turkey, heavy rains in June caused flooding and damage.

In Pakistan, the season started late in November but rainfall was abundant, as also in Afghanistan, especially during February and March. A record wheat crop was harvested for the second year in succession in Pakistan.

Agroecological Characterization

Agroecological characterization is the systematic description of specified geographical areas in terms of their physical environments (climatic parameters and their variability, and soils), the prevailing agricultural systems, and the linkages between environment and agriculture. It may be applied variously to improve the understanding of existing systems, their dynamics, constraints, and untapped potential; to generalize site-specific research results; to identify suitable environments for the extension of new technology; and to facilitate the transfer of technology successful in one area to similar environments elsewhere.

ICARDA's activities in this sphere are of two types: the development and testing of tools for agroecological characterization (methodologies, software, interlinked models) for regional scientists to adopt and adapt; and the characterization of specific environments and farming systems through surveys, data collection, and simple diagnostic trials. Examples of both types are presented here.

The Spatial Weather Generator

The spatial weather generator (SWG), described in previous ICARDA Annual Reports, has now been linked to a process-oriented wheat model to generate long time-spans of wheat crop data for the case-study area in Northwest Syria. The SIMTAG model, which simulates wheat growth and development on a daily time step, was originally developed by M. Stapper at ICARDA about 10 years ago. The version used for this study has been modified to allow its direct linkage to the SWG. A summary flowchart of the modified model is given in Fig. 2.

The study area comprises the surroundings of Aleppo in northwestern Syria (Fig. 3). It extends from 35°30'N to 36°30'N and from 36°30'E to 38°00'E. The western rim of the area is dominated by ranges of hills stretching in a north-south direction, while most of the remainder of the area has a flat to undulating topography, broken by a hilly plateau in the center, southeast of Aleppo. This plateau is framed by two closed drainage basins on its south-western and northeastern sides. Tel Hadya is situated close to the center of the southwestern basin. Rainfall is highest in the western hills and decreases rapidly toward the east and, to a lesser extent, toward the south (Fig. 4). This pattern is disturbed only by the effect of the plateau in the center.

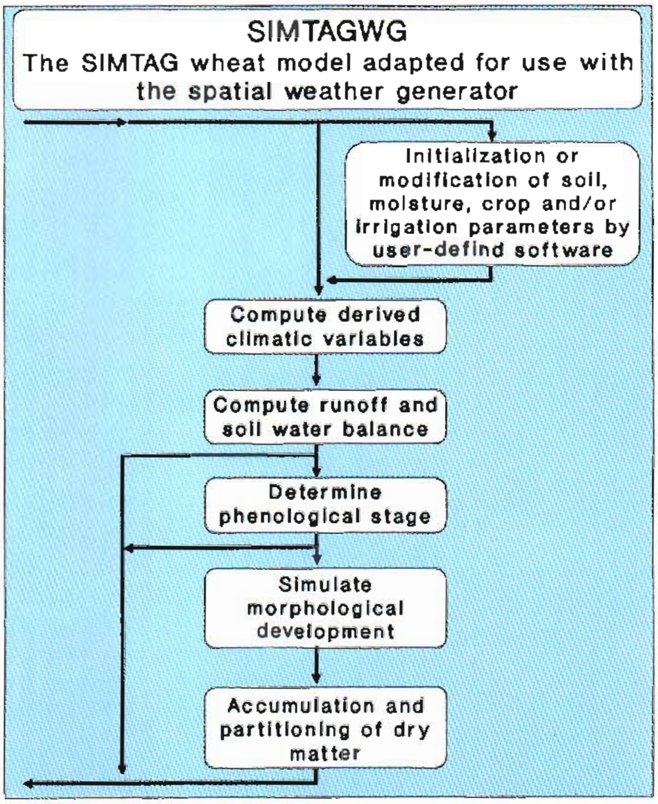


Fig. 2. Generalized flowchart of the SIMTAG wheat model modified for integration with the Spatial Weather Generator.

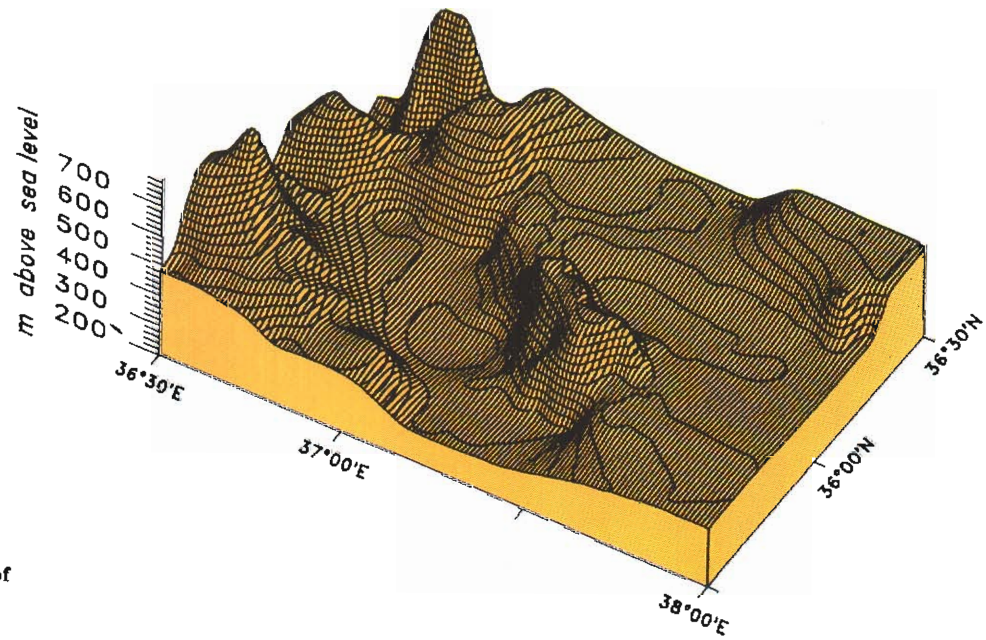


Fig. 3. Major topographic features of the study area in Northwest Syria.

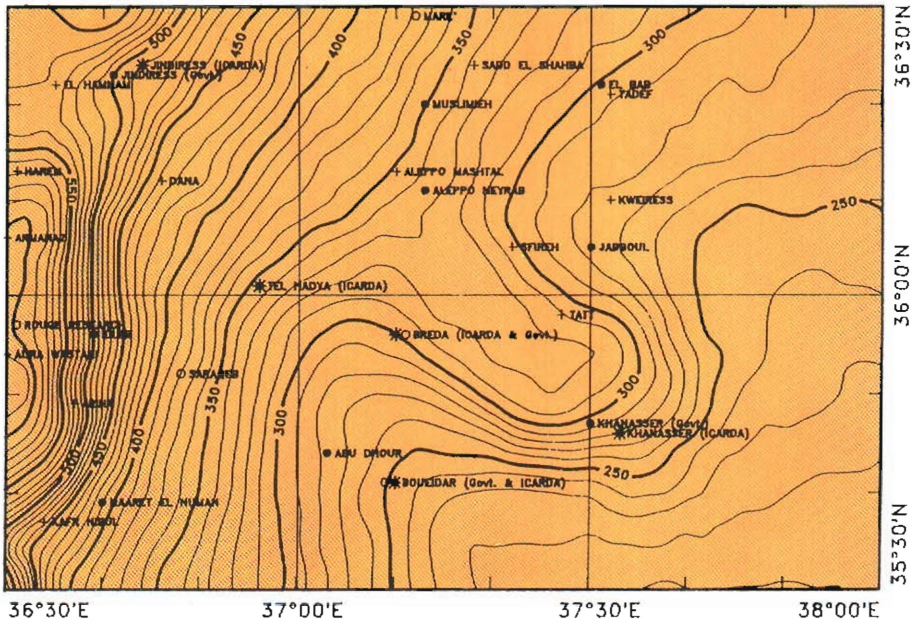


Fig. 4. Location of, and mean annual rainfall at the meteorological stations whose data were used in this study (* daily precipitation, air temperature and solar radiation; • daily precipitation and air temperature; o daily precipitation; + monthly precipitation).

Climatic data from the 19 meteorological and precipitation stations (Fig. 4) were used. Temperature data were available from 14 of them, and solar radiation data from five. These data were supplemented with data from a number of stations outside the area, to improve interpolation near the boundaries, and by monthly data from a large number of precipitation stations.*

Results

Based on the real data, 500 years of daily rainfall, maximum and minimum temperature and solar radiation values were generated for a 4 by 4 minute-wide grid across the study area. One hundred of these years were used to simulate the growth of 99 crops of Cham 1 wheat in each grid cell.

The 99 growth seasons were divided into two groups: those with favorable moisture conditions for early growth, ≥ 30 mm of rainfall during the 30 days after germinating rains and those with unfavorable moisture conditions (<30 mm). Germinating rains were defined as the first 3-day period starting between 1 November and 1 January with 20 mm or more of rainfall.

In general, early germinating rains are more likely to be followed by drought at the seedling stage ("dry starts") than are late germinating rains; that is, continuing ample rainfall after germination is more probable in seasons with late germinating rains. By then, the mean temperature has dropped so that, on average, "wet" starts of the growing season are cooler than "dry" starts (Figs. 5 and 6). However, the general steep decrease of temperature during the period from November to January conceals the fact that, at the same time of the year, "dry" starts of season are frequently colder than "wet" starts, which are characterized by moist, mild weather.

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* ICARDA is indebted to the Syrian Meteorological Department which generously made data available for this study.

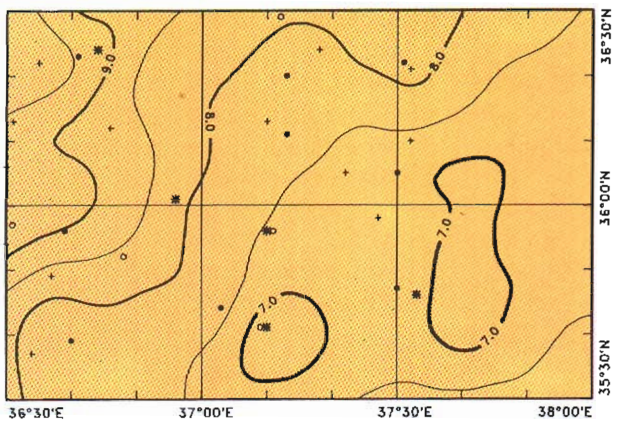

Fig. 5. Average temperature (°C) during "wet" start of seasons. "Wet" start is defined as germinating rains of ≥ 20 mm in 3 days, followed by a period of 30 days with ≥ 30 mm rainfall. (For explanation of symbols, see Fig. 4.)

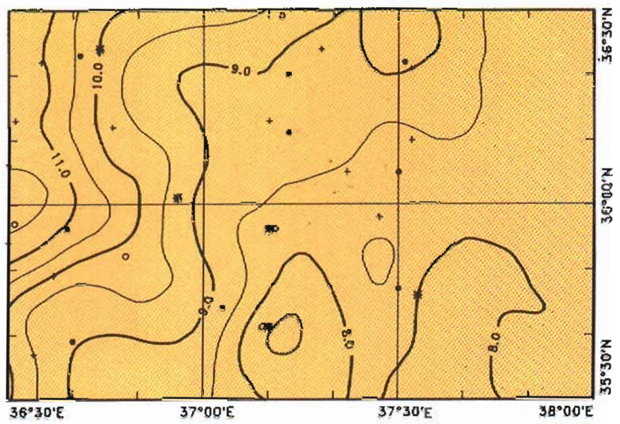

Fig. 6. Average temperature (°C) during "dry" start of seasons. "Dry" start is defined as germinating rains of ≥20 mm in 3 days, followed by a period of 30 days with <30 mm rainfall. (For explanation of symbols, see Fig. 4.)

The number of favorable seasons with ample moisture supply at the beginning combined with temperatures permitting vigorous early growth decreases from the humid western hills toward the dry southeast, where the germinating rains tend to occur late and where, in those cases when they happen early, the risk is high that they are followed by a dry spell (Figs. 7 and 8).

Simulation of wheat growth assumed a uniform soil type across the whole area, an absence of nutrient stress, and a standardized soil moisture content on a uniform planting date of 15 November. One focus of investigation was the temperature conditions during the sensitive period from heading to the start of linear grain filling. Risk of frost during this period is very low (less than 2%) in the wet, hilly areas in the west and also in the extreme east, but it rises to 5-10% in the closed drainage basin that includes Tel Hadya and Breda (Fig. 9). Risk of excessively high temperature during this period is also quite low. Across the whole area, the values stay well below the critical temperature level of 30 to 33°C, indicating that damage due to excessive heat around anthesis time will be a rare exception (Fig. 10).

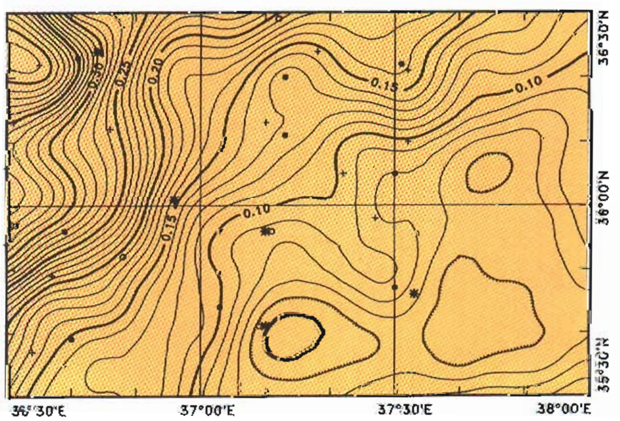

Fig. 7. Probability of "wet" start of season with a mean air temperature of ≥ 10 °C. (For further explanations, see Figs. 4 and 5.)

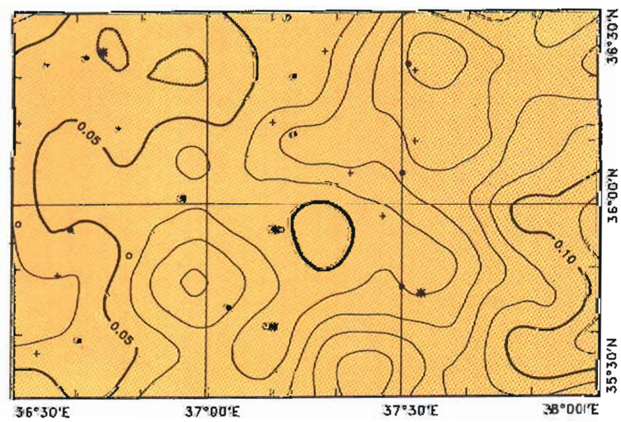

Fig. 8. Probability of "dry" start of season with a mean air temperature of ≥ 10 °C. (For further explanations, see Figs. 4 and 6.)

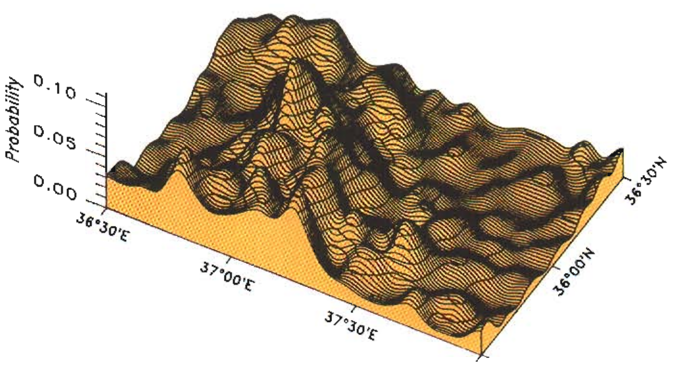

Fig. 9. Probability of frost during the period from heading through anthesis until the start of linear grain filling for Cham 1 wheat planted on 15 November 1990.

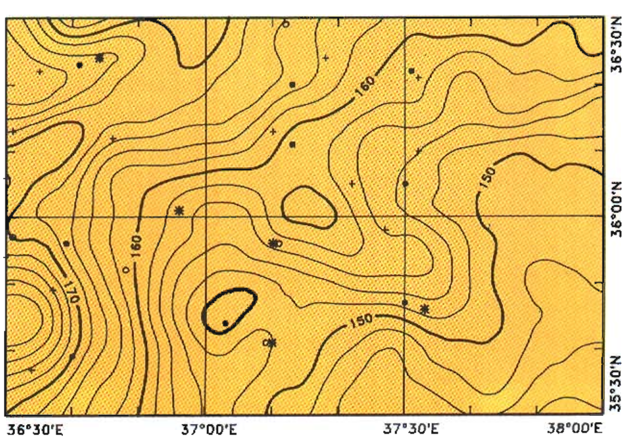

Fig. 10. Mean maximum temperature (°C) exceeded in 1 year out of 5 during the period between heading and start of linear grain filling for Cham 1 wheat planted on 15 November 1990.

Taken with the pattern of frost risk, this illustrates how well adapted the crop is to the area. Its development rate is regulated so that it evades both types of temperature stress optimally: anthesis is late enough to reduce frost risk and at the same time early enough to avoid heat damage.

Predictions of grain yield and total dry-matter production from the SIMTAG model have been compared with those from multiple regression models based on the results of on-farm agronomy trials in 70 locations over 4 years. The predictions from the regression models were based on simulated rainfall data for the same 99 years as were used in running the SIMTAG model. The mapped means of predicted dry-matter production for this period are quite similar for the two models (Figs. 11 and 12). They are also similar to the isohyets of annual rainfall (Fig. 4), reflecting the overriding importance of moisture availability for crop growth in this area.

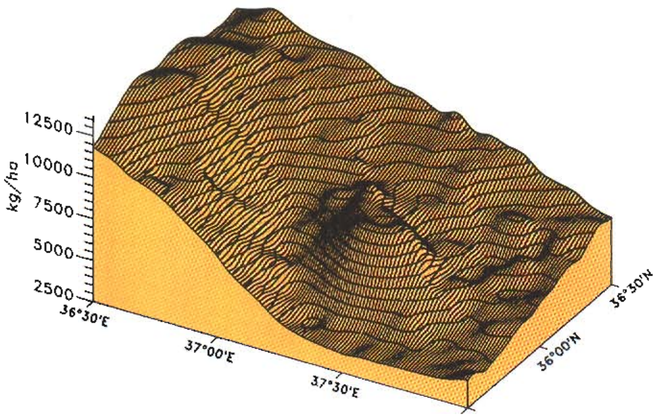

Fig. 11. Average total above-ground dry matter (kg/ha) of Cham 1 wheat planted on 15 November as predicted by simulations with SIMTAG, assuming a uniform calcic rhodoxeralf type of soil. The plant density after emergence was assumed to be 300 plants/m².

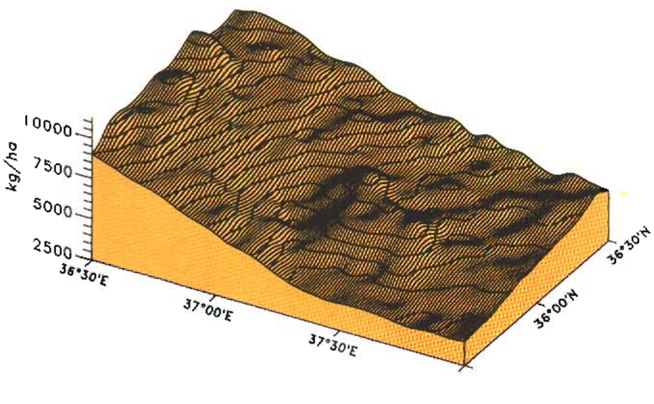

Fig. 12. Average total above-ground dry matter (kg/ha) of Cham 1 wheat planted on 15 November and fertilized with 120 kg/ha N and 80 kg/ha P_2O_5, as predicted by regression.

Yet there are significant differences, particularly if one compares the minimum anticipated grain yields in 4 years out of 5 (Figs. 13 and 14). Those predicted by the simulation model for the western hill areas are more than 40% greater than those predicted by the regression model, although there is close agreement in the dry southeast. The differences may be traced, at least in part, to the different initial assumptions of the two models and the extent to which the regression model is extrapolated beyond the conditions from which it was derived. In general, the simulation model is more sensitive to growth conditions. Nevertheless, field data from experiment stations representing the wetter parts of the study area accord better with the predictions of the regression models than with those of SIMTAG. It is suspected that SIMTAG overestimates the green area of Cham 1 at the humid end of the spectrum, thereby accumulating more dry matter, which in turn leads to an overestimation of grain yield. Whether this is due to a problem in the model or difficulties in estimating the genetic parameters for Cham 1 correctly is not clear and deserves further attention. On the other hand, SIMTAG seems to perform as well as or better than the regression models in that part of the area having 350 mm or less annual rainfall.

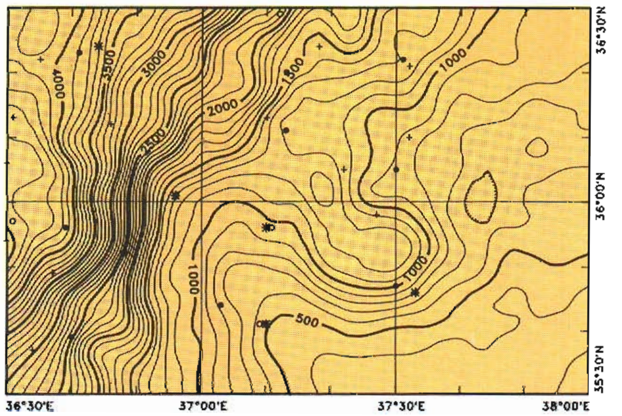

Fig. 13. Grain yield (kg/ha) exceeded in 4 years out of 5 by Cham 1 wheat as predicted by simulations with SIMTAG. (For further explanations, see Fig. 11.)

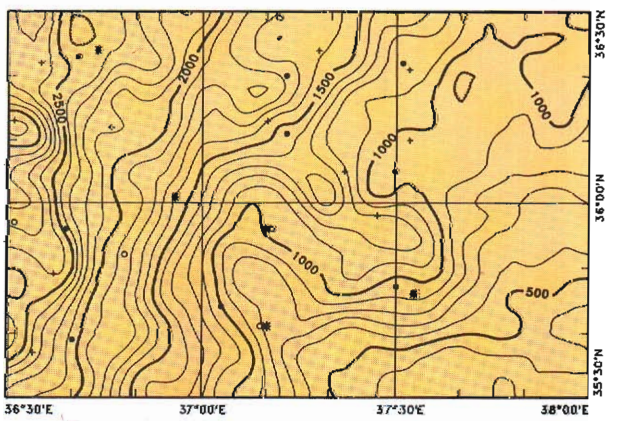

Fig. 14. Grain yield (kg/ha) exceeded in 4 years out of 5 by Cham 1 wheat as predicted by regression (For further explanations, see Fig. 12.)

Dryland Farming Systems of Northern Jordan

The first objective of this multidisciplinary program begun by the Jordan University of Science and Technology (JUST) and ICARDA in 1988 was to characterize the agricultural production systems of the "marginal zone" of rainfed agriculture (200-300 mm mean annual rainfall) in Jordan. The Mafraq area was selected as being representative. It lies between the Syrian border to the north, the Zarqa valley to the south, and the Hejaz railway and the Ramtha-Jerash road to the east and west, respectively, an area of about 1000 km^2.

The ICARDA Annual Report for 1989 outlined the geography of the area and the history of its agricultural settlement, and summarized the analyses of two years' farm survey work. It was concluded that the livestock-crop interface was the key on-farm element to focus upon. Almost all farmers with livestock identified feed supply as their principal problem. They wished to increase the productivity of their arable land specifically to lessen their dependence on external feed sources.

Concurrently with the farm survey work, a series of agronomy trials was started. Described as diagnostic, the trials were intended to (i) complement the survey work by exploring possible options for improved productivity of arable land for feed supply, and (ii) examine the potential of various fodder legumes and of an improved barley cultivar and improved inputs and management practices for barley under farmers' field conditions. Results are now available for the first two seasons.

Results

First, it is clear that forage legumes can be productive in this environment. Both seasons were very dry, but there were no crop failures. A mean grazing-stage dry-matter yield from the six lowest rainfall sites (mean, 153 mm) of 1.63 ± 0.19 t/ha is remarkably good and shows remarkably low variation. *Vicia narbonensis* and *V. ervillia* appeared to be the most promising of the cultivars tested, particularly for grain production; but *V. dasycarpa* is also a good cultivar for grazing-stage utilization. *V. narbonensis* and, in 1989/90 the two *Lathyrus sativus* cultivars, all produced as much straw as did the barley.

The barley trials demonstrated the major importance of fertilizer in this area. Fertilizer increased grain yield by more than 20% at six sites out of eight, and total dry matter at seven sites (Table 1). JUST, where little fertilizer response was observed, was the only site not located on a farmer's field and may well be atypical. Over the eight sites together, mean increases were approximately 33% for both grain and total dry matter.

None of the other three factors tested had any significant effect. The improved cultivar, WI 2269, failed to outyield the local landrace, Arabi Abiad, and there was no yield increase from the use of a herbicide. These results may be attributed to the dryness of the two seasons during which these experiments were conducted, but in the Mafraq area dry seasons are quite common. Drilling the seed gave no advantage over broadcast seeding. Nevertheless, the success of a broadcast crop depends a great deal on the quality of the seedbed and the method of covering. If these are satisfactory, there is no reason for any relative yield loss. However, one sees many poorly broadcast crops in Jordan, over which the seed drill would almost certainly bring an improvement.

It is intended to continue these diagnostic trials for one more season. However, the results to date of the barley trials have amply demonstrated the importance of testing each factor of improved management separately in the agroecological zone concerned. Among the three 1988/89 sites, for instance, the full package of four improved practices (cultivar, fertilizer, herbicide, and seed drilling) gave yields much higher than those of control at one site and moderately higher at another, but at both sites approximately similar increases could have been obtained from the fertilizer component alone. The testing and demonstration of recommended packages, thus, can sometimes lead to unnecessarily complex and expensive combinations of inputs.

Table 1. Barley response to fertilizer (100 kg DAP/ha) at eight sites: mean total dry-matter and grain yields (kg/ha) of two genotypes in Jordan.

		TDM		Grain	
	Site	-F	+F	-F	+F
1988/89	JUST	4500	4730	890	960
	Balama	1970	3320	540	930
	Rihab	2370	3130	650	820
1989/90	Ramtha	6820	8990	2500	3230
	Balama	4010	5010	2080	2500
	Deir Waraq	1760	2790	710	1250
	Faa	1620	2110	670	750
	Noeimeh	1630	2870	630	1100
	Mean	3090	4120	1080	1440

JUST = Jordan University of Science and Technology.

Germplasm Conservation

As part of the global CGIAR effort, exploration, collection, evaluation, utilization, and conservation of germplasm of both cultivated and wild species of crops, for which ICARDA has either a regional or global mandate, are important components of the Center's core research programs. These activities are carried out in close collaboration with NARSs (National Agricultural Research Systems) and IBPGR (International Board for Plant Genetic Resources). Genetic resources originating from the region are of considerable importance for developing improved varieties adapted to local farming systems, as well as for basic research.

During 1990, the Center collected 1620 new entries of germplasm and received 4387 through other examine the potential of various fodder legumes and of an improved barley cultivar and improved inputs and management practices for barley under farmers' field conditions. Results are now available for the first two seasons.

Results

First, it is clear that forage legumes can be productive in this environment. Both seasons were very dry, but there were no crop failures. A mean grazing-stage dry-matter yield from the six lowest rainfall sites (mean, 153 mm) of 1.63 ± 0.19 t/ha is remarkably good and shows remarkably low variation. *Vicia narbonensis* and *V. ervillia* appeared to be the most promising of the cultivars tested, particularly for grain production; but *V. dasycarpa* is also a good cultivar for grazing-stage utilization. *V. narbonensis* and, in 1989/90 the two *Lathyrus sativus* cultivars, all produced as much straw as did the barley.

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Evaluation of six-row barleys from the People's Republic of China. Several accessions were found to be tolerant to cold.

Wild six-row barley, sometimes referred to as *Hordeum agriocrithon*, was collected from the border of a cultivated barley field in central Tibet.

institutions as donations or in exchange, bringing the total number of accessions preserved at its gene bank to 90 895. Over 11 600 samples were provided in response to requests from ICARDA breeders, NARS scientists, and other bonafide users throughout the world. Reports were produced listing a manageable number of samples possessing desirable traits for the stressed environments to encourage greater utilization of the germplasm stored in the Center's gene bank.

The transfer of all active collections from the old to the new medium-term store operating at 0°C was completed in 1990. In addition, 18 396 seed samples were dried, sealed under vacuum, and stored in the new long-term cold room operating at -22°C.

Two ecogeographical databases, one on wild wheat and the other on Mediterranean annual forage and pasture legumes, were developed jointly with IBPGR. These databases are being constantly updated. Training of national program staff in genetic resources conservation through individual and group courses in collaboration with IBPGR/FAO (Food and Agriculture Organisation of the United Nations) was an important activity during 1989/90.

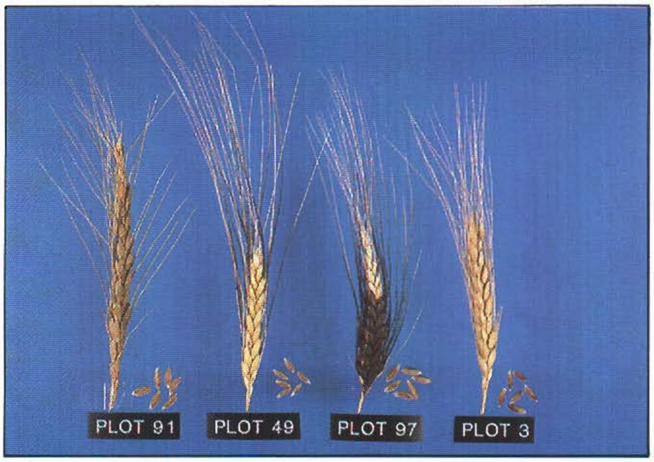
Collection of Genetic Resources

In a race against time the Center undertakes exploration and collection missions each year to preserve landraces and wild relatives of crops threatened by genetic erosion. Missions to Algeria, Bulgaria, China, Japan, Libya, Morocco, Syria, Tunisia, and the USSR were carried out in close collaboration with the national genetic conservation program.

Two missions were particularly significant in adding rare germplasm to the Center's gene bank: a joint mission with the USSR to the northeast and western parts of Syria, and another with China, the University of Saskatchewan, and CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo) to central Tibet. While the former mission, whose team members included two scientists from the Vavilov Institute of Plant Industry, attempted to retrace the route taken by Prof. N.I. Vavilov during his explorations in Syria in the 1930s, the latter mission collected valuable barley and wheat samples from high-altitude areas in Tibet. The team also found a rare, six-row, wild form of barley with shattering rachis, which has sometimes been referred to as *Hordeum agriocrithon*.

Evaluation of Variability in Wild and Primitive Wheat

Wild emmer, *Triticum dicoccoides*, is considered to be the immediate progenitor of cultivated wheat. Its main attributes are its tolerance to various biotic and abiotic stresses and a high protein content in the kernels.



Variability in spike form in populations of *Triticum dicoccum*, a primitive emmer wheat which was the forerunner of the modern wheat.

Multiplication and characterization of forage germplasm at Tel Hadya, Aleppo, Syria.

Since it crosses readily with durum wheat, emphasis is being placed on isolating the best lines from populations for utilization in wheat improvement. A joint project with the University of Tuscia, Viterbo, Italy, evaluated 344 accessions of *T. dicoccoides* and identified several lines more tolerant to abiotic stresses at Breda and biotic stresses at Tel Hadya than the local checks. In another study under the same project, *T. boeoticum*, the wild progenitor of the earliest cultivated wheat, *T. monococcum* (einkorn), was evaluated for tolerance to frost. Of 194 accessions evaluated, 166 were found frost-tolerant at Breda. It was interesting to find the earliest known carbonized grains of this brittle diploid wild progenitor in a prehistoric settlement of Tel Mureybit in northern Syria dating from the eighth millennium B.C. Since there is no evidence of a systematic cultivation at this archeological site, it is presumed that this species was gathered from the wild by early settlers.

Triticum dicoccum or emmer wheat is the most ancient of all domesticated cereals known to have been cultivated in the fertile crescent as far back as 7500 B.C. It is still grown on a limited scale in Czechoslovakia, Ethiopia, Iran, eastern Turkey, the Balkans, and central Italy. In a joint project with the Tishreen University, Lattakia, Syria, population samples of *T. dicoccum* were evaluated for biotic and abiotic stresses at Tel Hadya and Breda. Twelve samples were found to be immune to common bunt at Tel Hadya and these are being utilized by breeders to improve resistance and create a broader genetic base in durum wheat. Significant variability within populations for all agromorphological characters was also noted, which can be exploited for crop improvement.

Multiplication and Characterization of Food Legume and Forage Germplasm

A total of 2136 germplasm accessions of lentil, chickpea, and faba bean were tested in the field. Wild species were planted in a greenhouse for seed increases. Preliminary evaluation indicated that wild forms of *Lens* and *Cicer* may be potential donors of useful genes. Although only a few of these forms readily cross with cultivated species, future advances in biotechnology may solve the problems of incompatibility of chromosome pairing and undesirable linkages during crossing-over.

ICARDA's collection of chickpea germplasm, as well as the 4150 samples received from ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) during 1990, were sown in the isolation area following the quarantine rules. Nearly half of this collection originated from Iran, and the rest from India, Spain, Turkey, and the USSR. Forage legumes, especially *Medicago* species, were received from the University of Southampton, and from collections conducted in Jordan and Syria by the Center's staff.

Duplication of Base Collection of Wheat

One of the serious concerns of gene conservationists is that many of the precious germplasm collections have not been duplicated to ensure against loss due to manmade or natural causes. ICARDA has taken the lead in exchanging cereal germplasm accessions with CIMMYT. In 1989/90, the Center shipped 6246 durum wheat accessions to CIMMYT for storage as a duplicate base collection. A duplicate base collection of 1290 durum wheat accessions was received from CIMMYT for storage at ICARDA. This activity will continue until the entire germplasm collection at ICARDA is duplicated and stored at CIMMYT.

***Scorpiurus* sp., frequently found in Morocco, holds promise for pasture legume development in the Mediterranean region.**

Distribution of Pasture Legumes in Morocco

Part of the breeding strategy for improving pasture legumes is to understand their natural distribution and to identify the species with the characteristics necessary for developing improved pasture crops. ICARDA is attempting this approach in Syria, and is applying it in other countries in cooperation with the appropriate national authority. A report from Jordan was presented in the last year's Annual Report. This year we report work from Morocco, where INRA (Institut National de la Recherche Agronomique) and ICARDA have examined the distribution of pasture legumes. Because of the extensive nature of the work, only a report on clovers is presented here, although similar reports are available for medics and 15 other genera.

A total of 161 sites were sampled covering six regions of Morocco: Oudja, Marrakech, Beni-Mellal, Settat, Tangiers, and the Middle Atlas. The sites were sampled at random, and the species present and their seed yields were recorded. Soils were analyzed and climate assessed. The seeds were multiplied in nursery rows to establish the identification of species.

Clovers were found at 73 of the 161 sites. Sixteen species were identified, of which *Trifolium scabrum* was the most widespread (53 sites), followed by *T. campestre*, (45), *T. glomeratum* (41), and *T. angustifolium* (40). The most abundant clover (highest mean seed yield) was *T. angustifolium*, which had a pod yield of 265 kg/ha at one site. The next most abundant clovers were *T. glomeratum* (3.5 kg/ha), *T. squarrosum* (1.8 kg/ha), and *T. lappaceum* (1.7 kg/ha).

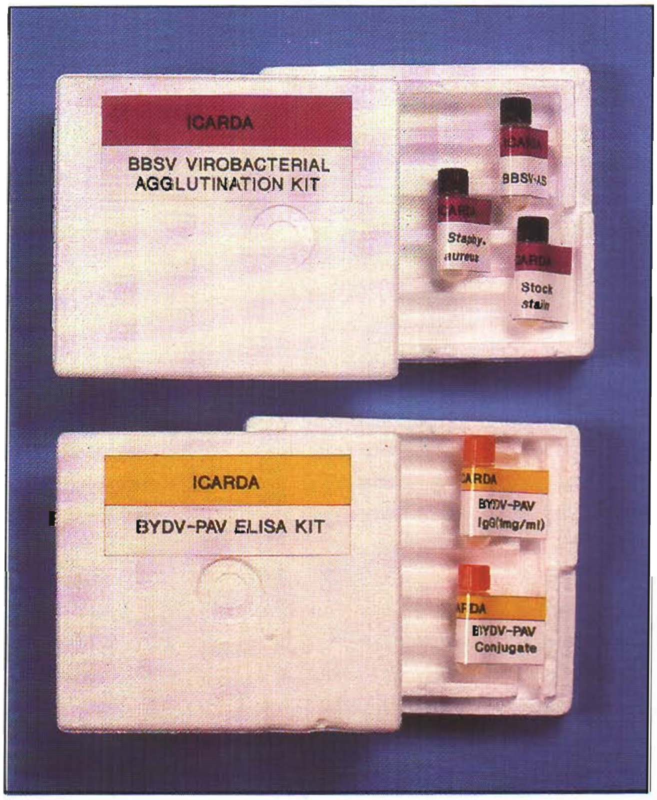
Of the other legumes, *Scorpiurus sulcata* occurred at 138 sites with a mean pod yield of 23 kg/ha; *Astragalus hamosus* at 52 sites (1.5 kg/ha); and *Hedysarum coronarium* at only 3 three sites, but its mean seed yield was 224 kg/ha. In addition, *Medicago polymorpha* was recorded from 98 sites, *M. laciniata* from 55, and *M. aculeata* from 50.

The clovers were most frequent in the-high rainfall area northwest of Morocco, but rare in the dry area near Marrakech. They inhabited almost all sites (91%) that receive more than 500 mm rainfall, and only 15% of the sites receiving less than 400 mm. *T. cherleri* was the most frequent clover in dry areas. The clovers preferred sites with low temperatures, and were therefore frequent in the mountains. Nearly all clovers preferred acid to neutral soils, though *T. lappaceum* and *T. angustifolium* also grew widely on alkaline soils. *Ornithopus compressus* was the most soil-specific species, growing only in sandy soils, low in pH, lime, and potash. Most other genera, with few exceptions, occurred at both low- and high-rainfall sites.

Thus, Morocco seems to possess a natural store of genetic resources that can provide adapted legumes for nearly all situations. Moreover, the knowledge that natural populations are widespread opens the possibility for their improvement through better management and fertilizer use. The results show that the grasslands of Morocco are similar to those of Syria and Jordan. There is a strong implication that all the grasslands of the Mediterranean basin have widespread and genetically diverse legume populations.

Virology Laboratory

Facilities at the Virology and the Seed Health Laboratories, attached to the Genetic Resources Unit, were considerably strengthened during 1989/90. The Virology Laboratory continued testing germplasm accessions for seedborne virus infections. Kits for the diagnoses of barley yellow dwarf, broad bean stain, broad bean mottle, and broad bean wilt viruses were developed. These kits provide reagents enough for testing at least 2000 samples, and are available to national programs on request.



Diagnostic kits for viruses: Barley Yellow Dwarf Virus Enzyme-linked Immunosorbent Assay (ELISA) kit for cereals, and Virobacterial Agglutination kit for legumes.

Germplasm Enhancement

Cereal Crops

Increasing Barley Yields Under Stress

The WANA countries grow approximately 11 million hectares of barley. The crop is largely grown by subsistence farmers who use it (both grain and straw) as animal feed for small ruminants, but also as human food. The yield of barley has remained unchanged over the last few decades except for fluctuations associated with seasons. A large proportion of the crop is grown in marginal areas (where it is often the only possible crop) which are frequently ecologically fragile and where climatic conditions are unpredictable. The high risk of crop failure makes farmers reluctant to use inputs such as fertilizers, pesticides and herbicides, although the beneficial effect of these inputs in the short term has been demonstrated repeatedly.

The introduction of barley germplasm developed for high-input agricultural systems has been unsuccessful in marginal areas in WANA. This has often led to some skepticism about the role of breeding in the agricultural development of these areas. The key question for both policy makers and plant breeders is whether breeding has failed to produce an impact because it is not possible to breed for these extremely variable and unpredictable conditions, or because breeding for these conditions needs a different approach. The evaluation and selection of barley breeding material in contrasting environments and for a number of cropping seasons has provided some answers to this question.

Two groups of 332 and 234 barley lines were evaluated for 3 years in 10 and 9 environments, respectively. The first group was grown during 1986-88 and the second during 1987-89. The environments were diverse as shown by the average grain yield of the lines (Fig. 15), which ranged from almost a crop failure in 1987 at Bouider to nearly 6000 kg/ha in 1989 at Athalassa in Cyprus. For each line, yield under stress was estimated from its average grain yield at the low-yielding sites, and yield potential was estimated from its grain yield at the high-yielding sites (Fig. 15).

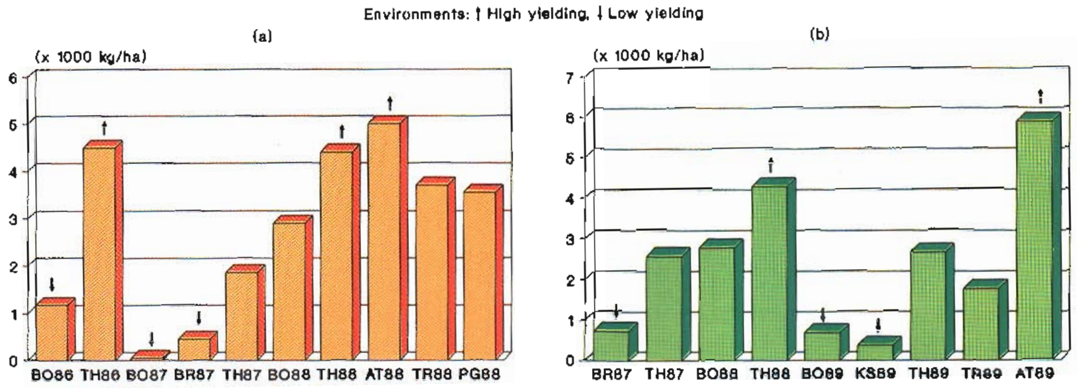


Fig. 15. (a). Average grain yields of 332 barley lines evaluated during 1986-88 in 10 environments, and (b) of 234 barley lines evaluated during 1987-89 in nine environments. BO, Bouider; TH, Tel Hadya; BR, Breda; AT, Athalassa; TR, Terbol; PG, Perugia; KS, Ksabiya.

The lines with the highest yield under stress (indicated as LY) outyielded the best check (Arabi Aswad), yielding between 1060 kg/ha (LY8) and 1446 kg/ha (LY1). However, their yield potential was lower than the best check (Rihane-03) under high-yielding conditions (Fig. 16a, b). By contrast the lines with the highest yield potential (indicated as HY in Fig. 16d) outyielded Rihane-03, with yields between 6333 (HY4) and 6962 kg/ha (HY5). Under stress, these lines (Fig. 16c) yielded lower than Arabi Aswad, and considerably lower than the LY lines (Fig. 16a). These data suggest that:

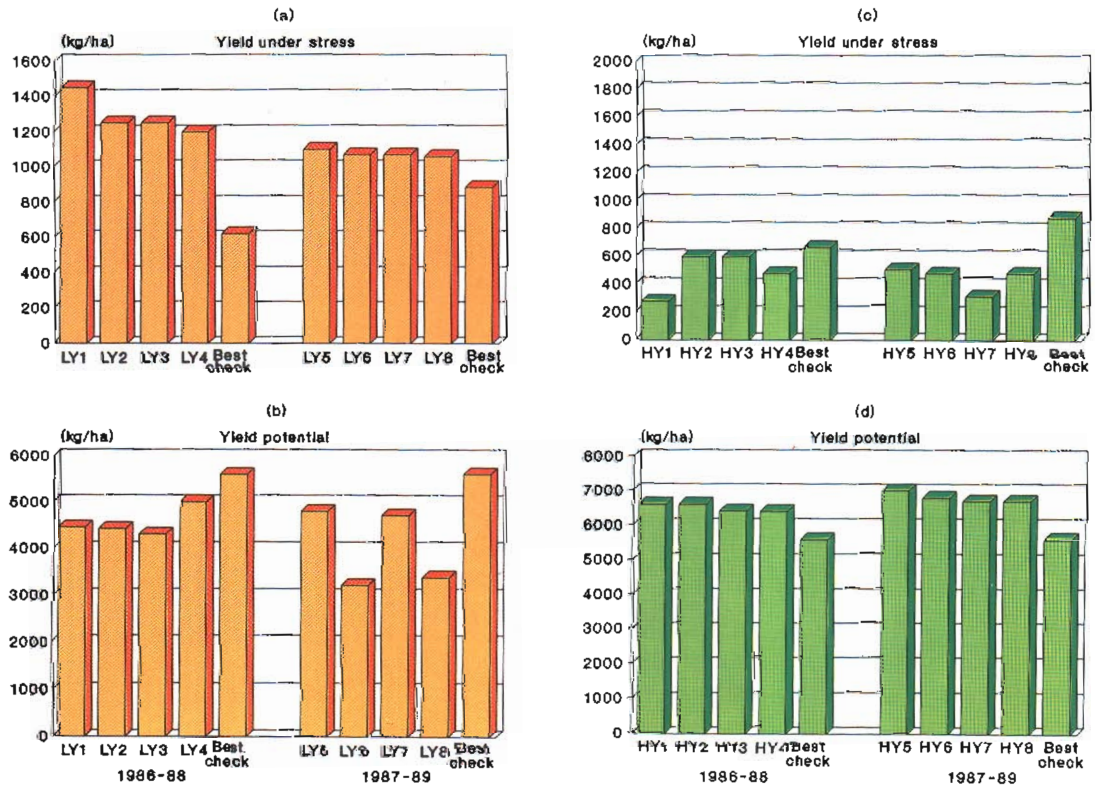


Fig. 16. Yield under stress and yield potential of barley lines with the highest yield under stress (a and b) and of barley lines with the highest yield potential (c and d). See Table 2 for pedigrees of the lines. Best checks are Arabi Aswad for yield under stress and Rihane-03 for yield potential.

(i). lines with high yield under stress could be discarded if testing is done only under high-yielding conditions, and if grain yield is used as the main selection criterion.

(ii). lines selected for high yield potential have a lower yield under stress conditions than local landraces.

(iii). lines selected for specific adaptation to stress conditions can give yield increases between 20 and 113%; their yield potential, however, is up to 50% less than the highest yielding lines in the absence of stress.

The existence of a trade-off between yield under stress and yield potential is also suggested by the pedigrees of the LY lines which have little, if anything, in common with the pedigrees of the HY lines (Table 2).

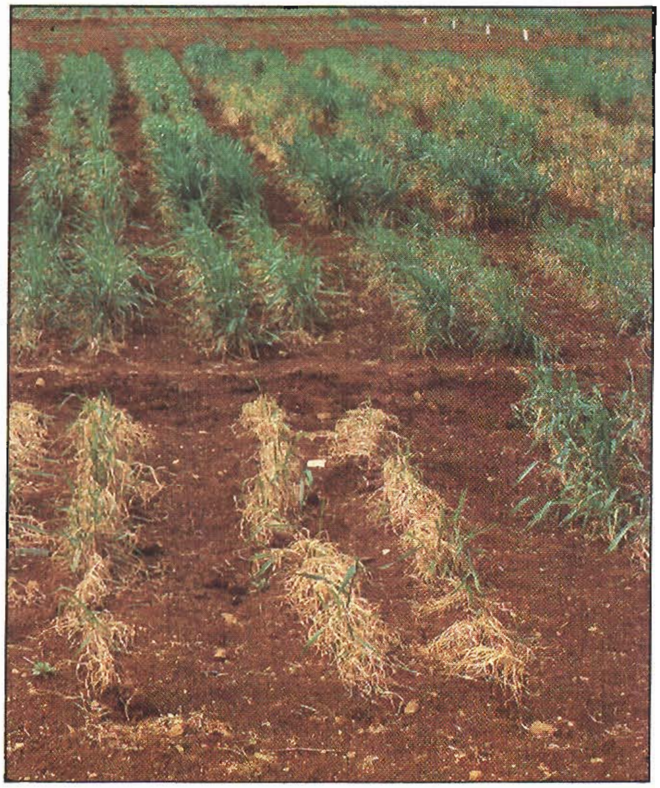
Table 2. Pedigrees of barley lines with highest grain yield in low or high yielding conditions.

Line	1986/87-87/88	Line	1987/88-88/89
	Barley lines for low yielding conditions		
LY1	Harmal-02//Esp/1808-4L	LY5	Mari/Aths*2
LY2	Aths/Lignee 686	LY6	Deir Alla106/ Cel/3/Bco.Mr/-
LY3	Harmal-02/Lignee 131	LY7	Harmal//Kv/Mazurka
LY4	Roho/Arabi Abiad	LY8	Arimar/Aths
	Barley lines for high yielding conditions		
HY1	NK1207/3/Api/ CM67//Mona6577	HY5	Lignee 527//
		HY5	Bathim/DL71/-
HY2	U.Sask.1766/Api//Cel/ 3/Weeah	HY6	Mo.B1337/WI2291
HY3	CI08887/CI05761// Lignee 640	HY7	CI08887/CI05761// Cerise
HY4	Cam/B1//CI08887/CI05761	HY8	ER/Apm/3/Arr/ Esp//Alger/Ceres-

In barley breeding for stress conditions, yield increases can be achieved by conducting testing and selection under the conditions in which future varieties will be used. As these conditions are variable and unpredictable, testing and selection must be repeated for a number of cropping seasons using the variability of stress conditions as an advantage. The lines surviving this test have a relatively low yield potential. It is therefore important to know the frequency of different yield levels in the target area to assess if this strategy, and consequently the type of germplasm being generated, is the most appropriate.

Barley Breeding for Cold Tolerance

Low temperature and frost cause major damage to barley, particularly in high-altitude areas of WANA and other cold areas of the world. Research at ICARDA on developing improved cold/frost-tolerant barley germplasm has been accelerated during the past 2 years. The strategy is to identify sources of genetic tolerance to low temperatures and develop improved germplasm. This has been achieved by subjecting a wide array of barley germplasm from various parts of the world and breeding nurseries to cold stress in the field. Cold tolerance work is carried out in Sarghaya in Syria, Haymana and Konya in Turkey, Annoceur in Morocco, Kan Mehterzai in Pakistan, and Krasnodar in the USSR.



Screening barley for cold tolerance at Sarghaya, Syria.

Crown freezing method, being used at ICARDA, allows the determination of cold tolerance in barley genotypes.

The cold-tolerant material identified and selected in the field is further tested and evaluated under laboratory conditions using the crown freezing test. To obtain detailed information on tolerance of various plant organs (roots, leaves, culms and primordia) and to make the crown freezing test more efficient, the reaction of frozen material to triphenyl tetrazolium chloride (TTC) is observed. TTC produces insoluble triphenyl phormazan (red color) in living tissue. If tissue is alive it turns red in TTC (1%) solution (see page 5); if dead, no change occurs. The color is checked after 24 hours by using a 1 to 5 scale (1, white or pale green; 5, dark red). Dead tissue remains green whereas living tissue turns red. Only tissue that scores 4 or 5 (roots, culms, primordia, etc.) is considered alive. This test clearly identified genetic differences in cold tolerance of the barley genotypes tested at -10°C: cv. Radical (resistant), Gouhar (susceptible), and an Iranian landrace No. 121441 (partially resistant).

CIMMYT/ICARDA Bread Wheat Project

Identification and Distribution of Bread Wheat Genetic Stocks to National Programs in West Asia and North Africa

During 1990, 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 rainfed and low-rainfall (less than 400 mm) areas.

Research in 1989/90 was directed toward breeding and identifying parental material possessing high grain yield and stability with tolerance to abiotic stresses such as terminal drought, cold and terminal heat, and to biotic stresses such as yellow rust, *Septoria* blotch, common bunt, sawfly, Hessian fly, suni bug, and aphids.

Nesser, a promising bread wheat line, was recently released as Cham 6 by the national program of Syria for low-rainfall areas.

Table 3 gives the number of bread wheat lines identified and distributed as genetic stocks to national programs in WANA during the last 5 years; the objective is to decentralize ICARDA's breeding activities and allow national programs to take greater responsibility in generating new sources of genetic variability.

Table 3. Number of bread wheat lines with desirable genetic traits distributed as genetic stocks to national programs during the past 5 years.

Characteristics	1986	1987	1988	1989	1990	Total
High yield and stability:	35	36	36	36	36	179
Abiotic stress resistance:						
Terminal drought	12	25	25	27	22	111
Cold	9	7	9	18	12	55
Terminal heat	7	5	18	19	12	61
Biotic stress resistance:						
Yellow rust	16	15	11	14	16	72
Leaf rust	13	12	5	11	8	49
Stem rust	5	6	5	3	2	21
Septoria leaf blotch	12	12	20	13	8	65
Common bunt	10	7	8	9	12	46
Wheat stem sawfly	8	13	15	17	16	69
Hessian fly	-	-	-	-	3	3
Selected landraces:	-	-	-	6	18	24
Bread making quality:	8	9	7	8	9	41
Total:	135	147	159	181	174	796

CIMMYT/ICARDA Winter/Facultative Bread Wheat Project

Several projects were undertaken in the 1989/90 season:

(i) evaluation of the Turkey/CIMMYT wheat germplasm in the Aleppo environment;

(ii) assessment of germplasm and continuation of breeding activities;

(iii) determination of the role of the Tel Hadya site in the overall activities of the joint Project; and

(iv) strengthening the collaboration between CIMMYT and ICARDA.

Several Turkey/CIMMYT nurseries comprising 898 entries of winter and facultative (W&F) wheat advanced lines and checks were grown in isolation along with 150 entries from ICARDA's Wheat Observation Nursery (High Altitude). Both nurseries have excellent material with the ICARDA lines maturing, on average, about 3 days later than material from Turkey. A mid-July planting showed that 8% of ICARDA lines and 13% of Turkey/CIMMYT lines have the true spring habit with little or no vernalization requirement. The number of facultative types in these nurseries is relatively low.

ICARDA has been using more of eastern Europe and USSR winter wheats and WANA wheat landraces, whereas Turkey/CIMMYT has been using more of the U.S. Great Plains material. This divergence offers further opportunities for germplasm improvement through intermating the derivatives.

ICARDA's Tel Hadya site can play a valuable role in the joint program for the evaluation of drought and common bunt tolerance, assessment of vernalization genes, and the generation of segregating populations. In addition, ICARDA can provide support in pathology, physiology, statistics, and computer analyses.

The relationship between ICARDA and Turkey has significantly improved with the easing of difficulties in exchanging wheat germplasm. An ICARDA outreach presence in Turkey, established recently, is further enhancing the collaboration (see page 80).

Spring Durum Wheat Breeding

Broadening the Genetic Base

To broaden the genetic base of spring durum wheat, promising breeding material was crossed with landraces from different WANA countries and with wild relatives.

Crosses with landraces from the Ibero-Maghreb region received high priority in 1989/90; 270 crosses were made with parents carrying resistance to diseases, wheat stem sawfly, and Hessian fly.

Twenty-one crosses were made between wild emmer (*T. dicoccoides*) and advanced durum wheat lines to improve grain quality and to increase resistance to *Septoria* leaf blotch and yellow rust. More than 50% of the F_1 crosses were backcrossed to durum wheats to reduce the effects of undesirable traits. Several backcrosses to durum will be needed to improve spike threshability.

Eighty-seven crosses were made with *Triticum monococcum* to enhance earliness, rust resistance, and early plant vigor. Sixty-three of these were backcross combinations. Twenty-four crosses with different *Aegilops* species were made with high-yielding and stable durum genotypes to increase fertile tillering and abiotic stress tolerance. Several crosses were also made with *T. carthlicum*, *T. compactum*, and *T. dicoccum*.

Pathology

Collaborative Research in Barley

International centers have used their international nursery systems extensively to expose germplasm to different diseases and to a wide range of virulence of specific pathogens. Multilocation field testing is very useful for identifying material with high levels of resistance, especially if the nurseries are planted in locations where severe disease epidemics occur every season. However, to identify resistance genes the germplasm must be tested against strains with known virulences.

Results of two collaborative projects in barley pathology are highlighted here.

Screening for Resistance to Scald in Ethiopia. Barley is a traditional crop in the Ethiopian highlands where it is grown across a wide range of environments. Temperature and rainfall during crop growth are favorable for the development of most barley diseases. Differences in altitude cause planting and harvesting dates to differ considerably among sites, even within a relatively short distance. The lack of a sufficiently long crop-free period (in some regions two barley crops per year are grown) results in an abundance of inoculum for most pathogens and pests. This, combined with a favorable climate, results in frequent epidemics. However, the continuous pressure of numerous pests and diseases provides opportunities to select germplasm with high variability for many characteristics and high disease resistance. The Ethiopian Institute for Agricultural Research (IAR) has started an extensive testing program of its local germplasm in collaboration with ICARDA, aimed at using superior lines as sources of disease and stress tolerance.

The importance of Ethiopia as a source for disease-resistant germplasm and as a testing site for disease resistance is supported by the data in Table 4.

The 16 lines listed in Table 4 are Ethiopian accessions from the USDA world germplasm collection. These lines are reported to possess a very high level of resistance to the most virulent USA strains of scald (*Rhynchosporium secalis*) in field and seedling tests. Seed of these lines was requested from the USDA germplasm bank, increased at Tel Hadya, and field-tested by Mr. Yitbarek Semeane of IAR at Holetta,

Table 4. Performance of selected Ethiopian germplasm lines for scald at Holetta (Ethiopia) and Tel Hadya (Syria), 1990.

PI-number	Holetta* Date and score 25/8	14/9	28/9	Tel Hadya* percent infection
PI 385629	42	74	73	-
PI 382368	52	85	85	0.5
PI 386731	42	41	41	2.5
PI 386770	31	64	85	0
PI 382523	75	86	87	-
PI 382946	42	52	82	-
PI 383069	63	86	86	1.0
PI 383181	53	53	85	5.0
PI 386771	31	42	82	3.0
PI 386825	31	74	86	-
PI 386880	86	87	88	3.0
PI 386908	31	63	83	-
PI 386966	42	52	84	3.0
PI 387096	63	85	99	4.0
PI 387117	42	84	86	2.0
PI 382375	74	86	88	0

* Notes in Ethiopia (data from Mr Yitbarek Semeane) were taken in 'double digit' score (first digit indicates vertical spread of disease, second the percentage leaf area affected, <10%=1, 10-20%=2 etc.); at Tel Hadya notes were taken as percentage leaf area affected.

Ethiopia, 1 year later. The same lines were tested against Syrian isolates at Tel Hadya. Although the lines were nearly immune to scald in Syria, only one (PI 386731) retained its resistance in Ethiopia. These results demonstrate the high virulence of the Ethiopian scald population, and the importance of testing germplasm for disease resistance in the area of origin.

Through the evaluation of new accessions of Ethiopian germplasm a number of lines have been identified with high levels of scald resistance. These lines are likely to maintain their resistance to less virulent pathogen strains in other countries. This testing program is, thus, important to Ethiopia and to other breeding programs dealing with scald resistance.

Identification of Specific Mildew Resistance in Riso, Denmark. The Riso National Laboratory in Denmark maintains a large collection of mildew strains with known virulence genes through which the resistance of barley can be analyzed. In 1990, Dr. J. H. Jørgensen tested a collection of local Syrian and Jordanian barley lines against 21 strains of *Erysiphe graminis*. These lines had been previously selected for powdery mildew resistance in field tests at Tel Hadya. The collection consisted of 29 lines from eight sites in Syria and Jordan.

Table 5. Variability in resistance genes for *Erysiphe graminis* within and among collection sites for Syrian and Jordanian barleys (data from J.H. Jørgensen).

Site	Number of lines and identified resistance genes
Jordan	
Madaba	1 line : Ml-a6 (Pallas-03) + additional resistance 2 lines: Ml-k (Pallas-24) + additional resistance
Qatrana	1 line: resistant to all isolates (Ml-p?) 2 lines: susceptible to all isolates
Jerash	1 line : resistant to all isolates (Ml-p?) 1 line : Ml-a6 (Pallas-03) + additional resistance 1 line : Ml-k (Pallas-16)
Madaba	1 line : resistant to all isolates (Ml-p?) 1 line : unidentifiable resistance 1 line : susceptible to all isolates
South Syria	
Um Zeitoun	7 lines: Ml-a6 (Pallas-03) + additional resistance 1 line : unidentifiable resistance
Sayaa	3 lines: Ml-a6 (Pallas-03) + additional resistance
West Syria	
Sheikh Ali	3 lines: susceptible to all isolates
Central Syria	
Qasr el Heir	2 lines: Ml-k (Pallas-24) 1 line : susceptible to all isolates

Diverse resistance genes were found (Table 5), especially in the Jordanian material. However, mildew resistance was also identified in material originating from sites with little or no disease pressure such as Qasr El Heir. No specific resistance genes were present in lines from the wetter site, Sheikh Ali, even though these lines showed incomplete resistance during field testing in Syria. Lines with superior resistance will be used in barley breeding projects for Syria and for areas with similar climatic conditions.

Screening for Resistance to Major Wheat Diseases

Useful information on the Durum Wheat KLDN-1989 (Key Location Disease Nursery) was received from one location each for yellow rust (*Puccinia striiformis*) and common bunt (*Tilletia foetida* and *T. caries*); from five locations for leaf rust (*P. recondita*) and *Septoria tritici* blotch (*Mycosphaerella graminicola*); and from three locations for stem rust (*P. graminis*) and barley yellow dwarf virus. The number of lines with resistance to one or more of these diseases is shown in Table 6.

There were 165, 20, 72, 74, 166, and 30 lines with resistance to yellow rust, leaf rust, stem rust, *Septoria* blotch, barley yellow dwarf, and common bunt, respectively. Out of this multilocation screening, 16 lines were found resistant to all three rusts, 59 to *Septoria* blotch and barley yellow dwarf combined, and 24 to yellow rust and common bunt (Table 6). Six of these lines also showed combined resistance to the three rusts, *Septoria* blotch, and barley yellow dwarf virus and their performance for common bunt (% head infection) was acceptable (Table 7).

Information on the Bread Wheat KLDN-89 was received from one location for yellow rust and common bunt, two for stem rust and barley yellow dwarf, three for leaf rust, and five for *Septoria* blotch. The number of lines with single or multiple resistance to these diseases is shown in Table 8. There were 162, 73, 90, 63, 1, and 19 lines resistant to yellow rust, leaf rust, stem rust, *Septoria* blotch, barley yellow dwarf, and common bunt, respectively. Forty-four of these lines were resistant to the three rusts, 1 to *Septoria* blotch and barley yellow dwarf, and 16 to yellow rust and common bunt.

Table 6. Number of durum wheat lines* found resistant** to one or more major diseases, KLDN-89.

Disease	No. of resistant lines
Yellow rust	165
Leaf rust	20
Stem rust	72
Septoria blotch	74
Barley yellow dwarf	166
Commmon bunt	30
Septoria and barley yellow dwarf	59
Yellow rust and common bunt	24
Three rusts	16

* Total number tested 216, checks excluded.

** Selection criteria: yellow rust CI ≤ 1, leaf and stem rust ACI ≤ 10; *Septoria* blotch and barley yellow dwarf average ≤ 5 on a 0-9 scale; common bunt 0-3% head infection.

Table 7. Name and performance* of six durum wheat lines for major diseases in multilocation testing, KLDN-89.

Ent no	Name/Cross	Disease: Yellow rust	Leaf rust	Stem rust	*Septoria* blotch	Barley dwarf	Common bunt %
42	Mrb16/3/Ato//Ibis/Fg	0.8	7.8	8.3	5	5	5
46	Ru/Mrb15	0.0	2.5	3.5	4	5	21
59	Chahba88/Mrb11	0.8	2.6	7.5	5	5	28
68	Mrb16/Guerou 1	0.8	2.0	0.9	4	5	13
86	Guerou 1	0.4	9.5	8.5	5	5	11
147	Jo/Cr//Gs/AA/3/FG/4/USA IIIC/Gs//Cr/Cit/3 3/D67.2	0.0	8.6	4.1	4	5	20

* Selection criteria: yellow rust CI ≤ 1, leaf and stem rust average CI ≤ 10; *Septoria* blotch and barley yellow dwarf: average ≤ 5 (0-9) scale.
CI = Coefficient of infection

Table 8. Number of bread wheat lines* found resistant** to one or more major wheat diseases, KLDN-89.

Disease	No. of resistant lines
Yellow rust	162
Leaf rust	73
Stem rust	90
Septoria blotch	63
Barley yellow dwarf	1
Common bunt	19
Three rusts	44
Septoria and barley yellow dwarf	1
Yellow rust and common bunt	16

* Total number tested 180, checks excluded.

** Selection criteria: yellow rust CI ≤ 1, leaf and stem rust ACI ≤ 10; *Septoria* blotch and barley yellow dwarf: ≤ 5 on a 0-9 scale; common bunt 0-3% head infection.

Entomology

Collaborative Research on Russian Wheat Aphid

The Russian wheat aphid (RWA), *Diuraphis noxia*, can be a serious pest of both wheat and barley. It is generally found within leaf whorls and in tightly rolled flag leaves and secondary leaves. Damage symptoms include longitudinal white, yellow or purple streaks in the leaves and leaf sheaths, inward rolling of the leaves, death of tillers, and stunting of the plant.

A survey of RWA and collection of its natural enemies was conducted in Jordan, Syria, and Turkey during April and May in collaboration with research scientists from WANA national programs and from Washington State University (WSU), USA. Additional surveying and collecting in Morocco was conducted by WSU with assistance from MIAC (MidAmerica International Agricultural Consortium) and INRA staff. The purpose of the RWA project was to document the occurrence of RWA in the Mediterranean region, to foster collaboration between regional, USA and ICARDA scientists for long-term biological control research, and to collect the natural enemies of RWA for forwarding to quarantine/biological control facilities in the USA for use as biological control agents. In 1989, RWA was not widely present in any of the countries explored, but sites were located in each country with low to moderate RWA infestations and accompanying natural enemies. Infestation was noticed in low density drought-stressed crops. In southern Jordan, a drought-stressed field of center-pivot-irrigated wheat was also infested. In Jordan, the researchers suspected that alate RWA may migrate from barley in the lower reaches of the Jordan Valley and Wadi Al Jayb during April-May to later-developing wheat and barley crops of the eastern highlands.

Wheat plant infested with Russian wheat aphid, *Diuraphis noxia*. Symptoms include stunting, tightly rolled leaves, and leaf striping.

In Syria, the highest RWA and natural enemy populations were located in sparse barley patches planted in hilly, rocky terraces near Qatura, about 40 km northwest of Aleppo. RWA was also found on *Hordeum bulbosum* near Qatura. In Turkey, RWA was found on the east side of the coastal mountains near Baglama, Kirikhan, and Antakya. RWA was not observed in lush wheat or barley fields, nor in fields along the humid Mediterranean coast south of Iskenderun.

Table 9 lists the natural enemies of RWA collected. Parasitoids collected consisted primarily of Aphidiine braconids. A total of 572 parasitoids and predators were collected and sent to Texas A&M for testing. Some of them have since been released against RWA populations in the rainfed wheat region of the Pacific Northwest of the USA, a region with a mild Mediterranean climate.

Applied Biotechnology

Development of DNA Molecular Marker Techniques in Barley

The integration of DNA molecular marker techniques, such as Restriction Fragment Length Polymorphism (RFLP), into plant breeding may make possible the simple analysis of complex polygenic characters.

Table 9. Natural enemies of RWA from Morocco[1], Jordan, Syria, and Turkey[2] collected in March and April, 1990 (after Pike et al., in press).

Natural Enemies	Order/ Family	Type	Date	Site	Aphid Host	Plant Host
Aphidiine	Hym/Brac	Para	27 Mar	Morocco, Marrakech	Dn,Rp,Sg	Hv
Aphidiine	Hym/Brac	Para	28 Mar	Morocco, Beni Mellal	Rp,Md	Ta
Aphidiine	Hym/Brac	Para	28 Mar	Morocco, Settat	Rp,Md	Ta
Aphidiine	Hym/Brac	Para	29 Mar	Morocco, Annoceur	Dn,Sg	Hv,Ta
Aphidiine	Hym/Brac	Para	3 Apr	Jordan, Rum-Disi	Dn,Pp	Hv,Ta
Aphidiine	Hym/Brac	Para	5 Apr	Jordan, Ash Shunah	Dn	Ta
Aphidiine	Hym/Brac	Para	8 Apr	Syria, Qatura	Dn	Hv
Aphidiine	Hym/Brac	Para	8 Apr	Syria, Qatura	Dn	Hb
Aphidiine	Hym/Brac	Para	8 Apr	Syria, Tel Hadya	Dn	Hv
Aphidiine	Hym/Brac	Para	8 Apr	Syria, Al Bab	Dn	Hv
Aphidiine	Hym/Brac	Para	11 Apr	Turkey, Baglama	Dn	Ta
Coccinella sp.	Col/Cocc	Pred	10 Apr	Syria, Khafsa	Dn,Rm,Rp	Hv
Coccinella sp.	Col/Cocc	Pred	29 Mar	Morocco, Meknes	Rp,Md	Td
Scymnus sp.	Col/Cocc	Pred	29 Mar	Morocco, Meknes	Rp,Md	Td
Leucopis sp.	Dip/Cham	Pred	3 Apr	Jordan, Rum-Disi	Dn	Hv,Ta
Syrphid	Dip/Syrp	Pred	27 Mar	Morocco, Marrakech	Dn,Rp,Sg	Hv

1 Collected by WSU, MIAC, and INRA-Morocco scientists. Material in Jordan, Turkey, and Syria was collected by ICARDA and WSU scientists.

2 Col = Coleoptera, Dip = Diptera, Hym = Hymenoptera, Brac = Braconidae, Cocc = Coccinellidae, Cham = Chamaemyiidae, Syrp = Syrphidae, Para = parasitoid, Pred = predator, Dn = *Diuraphis noxia*, Md = *Metopolophium dihrodum*, Rm = *Rhopalosiphum maidis*, Rp = *Rhopalosiphum padi*, Sg = *Schizaphis graminum*, Hb = *Hordeum bulbosum*, Hv = *Hordeum vulgare*, Ta = *Triticum aestivum*, Td = *Triticum durum*.

Research in barley was initiated in 1990 with the objective of identifying genes or gene combinations involved in adaptation to Mediterranean low-rainfall environments.

Association of DNA markers with loci affecting a character of interest can succeed only when loci segregating in a cross have relatively large phenotypic effects. Moreover, development of a RFLP linkage map is obviously facilitated when genetically distant genotypes are used as parents. In consequence, parental lines of a cross devoted to RFLP analysis should be chosen on the basis of (i) variation in trait expression and (ii) divergence at the molecular level. Recently, several contrasting barley genotypes have been identified and well characterized. In preliminary work, an estimation of the genetic distance between reference genotypes, based on RFLP and polymerase chain reaction markers (PCR), has been carried out (Table 10) in collaboration with Montana State University (MSU). The cross Tadmor//ER/Apm has been selected for further work. This combination reflects a broad sample of trait expression and genetic variation.

Table 10. Genetic distance between five reference genotypes based on RFLP and PCR markers.

	Tadmor	Hor. Spont. 41.1	ER/Apm	Athenais	Gloria's'/ Copal's'
Tadmor	/	0.23	0.50	0.45	0.54
Hor. Spont. 41.1		/	0.53	0.50	0.64
ER/Apm			/	0.50	0.40
Athenais				/	0.25
Gloria 's'/Copal 's'					/

Distance: ratio of number of polymorphic markers to the number of DNA clones and PCR primer sets tested (13 DNA clones and 3 PCR primer sets).

The existing RFLP technology is not fast enough to allow the screening of a large number of individual plants. The polymerase chain reaction (PCR) has been proposed as an alternative to RFLP analysis. It is a fast and simple non-radioactive technique, but it requires an understanding of the molecular basis of variation between genotypes at specific loci. Once informative RFLP loci are identified, they can be converted to a PCR-based marker. This technique involves synthesizing multiple copies of a gene, or a region of DNA, from oligonucleotide primers which bind opposite DNA strands, flanking the target sequences. Five sets of primers, developed by T. Blake at MSU, were tested against seven barley genotypes for scoring variation. Depending on the set of primers used, single or multiple bands of amplified DNA were obtained. All the sets tested showed distinct patterns among the seven genotypes. However, in some cases, unreproducible results and lack of specificity in the amplification process were important limitations. Optimization of primer design and/or PCR protocol is needed for use with plant genomic DNA. An interesting approach is illustrated in Fig. 17. Only one segment of DNA is amplified and polymorphism is detected in a second step after restriction of the amplified product. This approach has the same advantages as PCR (fast, simple, cheap), and allows a check on the specificity of the amplification as well as the detection of polymorphism that is not easily accessible to the conventional RFLP technique.

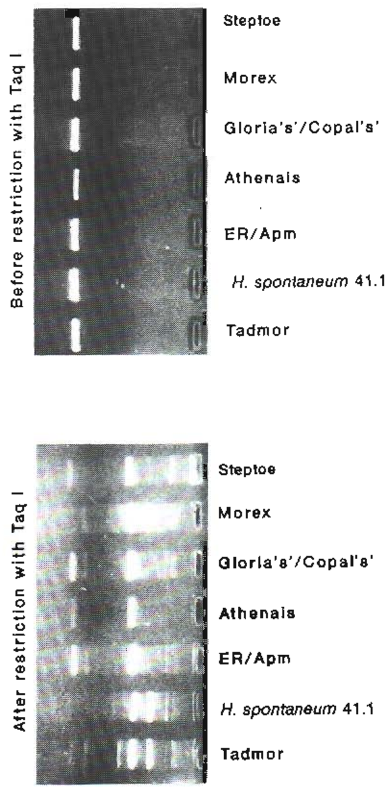


Fig. 17. Agarose-gel electrophoresis of amplified DNA samples from different genotypes using TB 17/18 primer set.

International Nurseries

Evolution of International Nurseries since 1977

The number of different kinds of international cereal nurseries (barley, durum wheat, and bread wheat) has increased (Fig. 18) from 10 in 1977/78 to 33 in 1989/90.

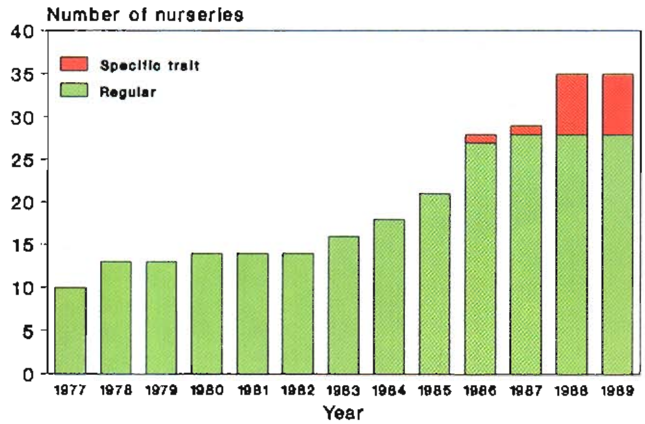


Fig. 18. ICARDA international cereal nurseries, 1977/78 to 1989/90.

Since 1978, four basic types of nursery have been prepared for each of the three crops every year: crossing blocks, segregating populations, and observation nurseries and yield trials. These nurseries cater for the needs of national programs with different levels of infrastructure and technical expertise.

Because global adaptation could mean a sacrifice in yield in diverse environments, materials with specific adaptation to a major environmental zone are desirable. NARSs prefer nurseries containing targeted material with few entries. Starting from 1983, the observation nurseries, yield trials, and eventually the segregating populations were split into those for low-rainfall areas and those for moderate rainfall/supplemental-irrigation areas. Three nurseries consisting of winter and facultative types for high-elevation areas in West Asia and North Africa were added for barley in 1985 and for wheat in 1986.

Heat stress is a major problem in cereal production in the more tropical countries in ICARDA's mandate. In 1986, a Heat Tolerance Observation Nursery was assembled. This was the first specific-trait nursery made available to national programs. With the addition of the Heat and Drought Observation Nursery, and the three germplasm pools for disease resistance, the total number of specific-trait nurseries increased to five in 1988.

For 1990/91, 1027 sets of regular nurseries and 186 sets of specific-trait nurseries were distributed upon request to 104 cooperators in 51 countries for the 1990/91 season. About the same numbers of sets were sent for the 1989/90 season, but the numbers of cooperators and countries increased in 1990.

Food Legumes

Kabuli Chickpea

Yields of kabuli chickpea are low and unstable in WANA, but this can be overcome by sowing the crop in winter in the low-altitude areas. On average, the winter-sown crop has yielded 67% higher than the spring crop in several trials conducted at Tel Hadya, Jindiress, and Terbol research stations during the 1983/84 to 1989/90 seasons (Fig. 19). For genotypes in the top 10% yield group, the increase was 134%. The area under winter sowing has been increasing in WANA, where 31 cultivars have been released to date for winter sowing (see Appendix 2). Adoption and impact studies continue in Morocco and Syria.

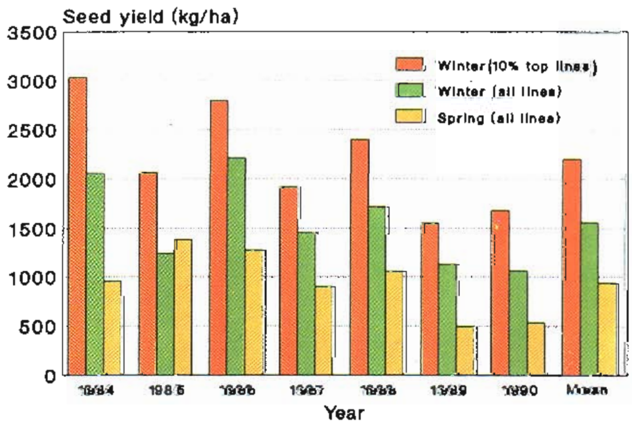
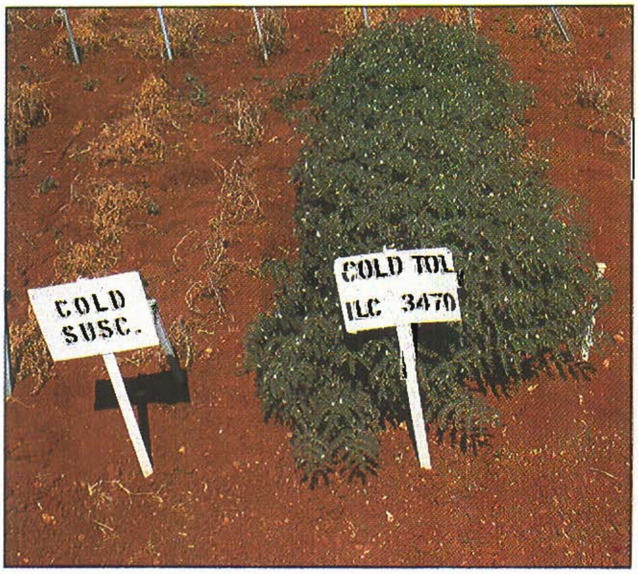


Fig. 19. Mean seed yield of chickpea lines (72 to 384 lines) in Syria (Tel Hadya and Jindiress) and Lebanon (Terbol).

NARSs continued to make good use of ICARDA-enhanced germplasm: more than 15 000 lines were furnished to 47 countries in 1989/90. Forty lines were identified for on-farm trials or prerelease multiplication, and five cultivars were released by various NARSs.

Chickpea cultivars are known to have narrow adaptation. However, yield evaluation of a number of lines in the Mediterranean environment revealed two lines with wide adaptation: ILC 482 and ILC 3279. These lines have been released in several countries (Appendix 2). An analysis of their characteristics showed that for wide adaptation in the Mediterranean region a cultivar should have high yield potential, medium seed size, medium maturity, resistance to *Ascochyta* blight, and tolerance to cold. Suitability of the cultivar to machine harvesting further increases its acceptance.



ILC 3470 has a high level of cold tolerance and is a valuable parent in the crossing program for winter chickpea germplasm enhancement.

To stabilize chickpea productivity, emphasis is being placed on breeding for resistance to the main biotic and abiotic stresses. In 1989/90, evaluation continued for *Ascochyta* blight, *Fusarium* wilt, leaf miner, cyst nematode, cold and drought resistance in both cultivated and wild *Cicer* species, and new sources of resistance were identified. A highly cold-tolerant

Several accessions of wild *Cicer* sp. have been found to possess a higher level of cold tolerance than the cultivated species. Attempts to use these accessions for incorporating cold tolerance into cultivated species are being made through interspecific hybridization.

mutant of ILC 482 was identified which withstood -8.9°C in the middle of March. Line ILC 3470 also showed promise for cold tolerance. Studies on the genetics of cold tolerance revealed that the selection for this trait should be done from later generation material. A screening technique for drought tolerance based on sowing the crop in the third week of March has been found effective in identifying genotypic differences for this trait.

Wild *Cicer* spp. have proved to be the only source of resistance to seed beetle and cyst nematode. They also have greater tolerance to cold and *Ascochyta* blight than the cultivated species. Hence, efforts on inter-specific crossing continued. A karyotype study of *Cicer* spp. has helped in developing some understanding of the cross-incompatibility of certain interspecific combinations.

Work on application of biotechnology for chickpea improvement continued. Collaborative studies with the University of Frankfurt have helped in identifying restriction enzyme/probe combinations for DNA fingerprinting to genetically characterize chickpea lines as well as different isolates of *Ascochyta rabiei* fungus. For pathotyping of different isolates of the fungus, DNA was extracted from mycelia of six single-spored isolates, restricted with EcoRI, Hinf I, Mbo II, and Taq I and hybridized with different synthetic oligodexynucleotides: (TCC)5, (GTG)5, (CA)8, and (GATA)4. A high degree of polymorphism was detected with optimal enzyme/probe combinations, which permitted discrimination between the isolates (Fig. 20). The potential use of DNA fingerprinting, thus, can be expanded for the identification of races, their geographical distribution and genetic variability and, therefore, for the selection of chickpea cultivars suitable for different regions.

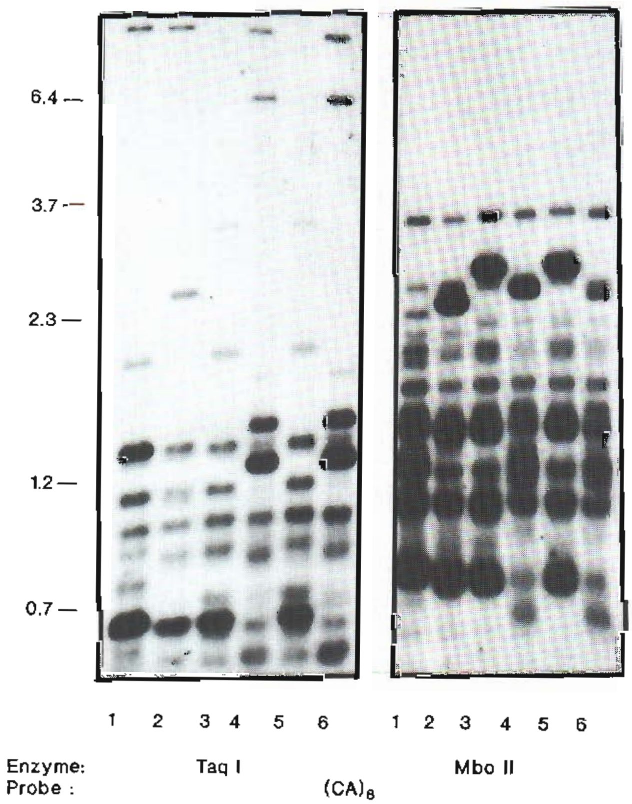


Fig. 20. **Pathotyping different races of *Ascochyta rabiei* by oligonucleotide fingerprinting. DNA was isolated from single-spore-derived mycelia of six different fungal isolates held at ICARDA, representing six races differing in the level of pathogenicity against chickpea. After digestion with Taq I or Mbo II, fungal DNA was electrophoresed and in-gel-hybridized to the (CA)8 oligonucleotide. Four different patterns were obtained, as shown by Race 1, Race 2, Races 3 & 5, and Races 4 & 6. Positions of molecular weight markers are given in kilobases.**

The cold and dry weather conditions during 1989/90 did not permit satisfactory field screening of breeding material for *Ascochyta* blight. Hence, most of the work was done in the greenhouse and growth chamber. Screening of various breeding lines and promising germplasm against a mixture of six *Ascochyta rabiei* isolates revealed that lines ILC 6189 and FLIP 87-509C were resistant and FLIP 84-91C was moderately resistant.

Host-plant resistance of ILC 5601 chickpea to leaf miner was confirmed. Resistance seems to be associated with leaf size and malic acid concentration in the exudate. Neem-seed extract proved to be safe, cheap, and effective to control leafminer in chickpea. Seed treatment with olive oil and salt provided protection against seed beetle (*Collasobruchus chinensis*) in the storage (Fig. 21).

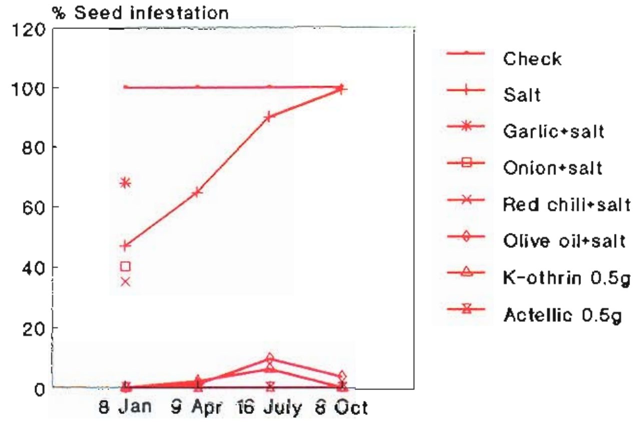


Fig. 21. Effect of two insecticides and alternative treatments on seed infestation (%) with *Callosobruchus chinensis* in stored chickpea.

Studies on improving symbiotic dinitrogen fixation in chickpea revealed that the soil core method to determine the need for inoculation was more accurate than rhizobium population estimates alone in the soil of northern Syria. Evaluation of symbiotic effectiveness using a sterile, hydroponic, N-free system gave the most accurate estimates of soil rhizobia populations and an assessment of the need for inoculation. There was a strong cultivar by strain interaction in affecting symbiotic N_2-fixation. Increasing moisture supply from 280 to 499 mm considerably increased fixation. The percentage of total plant nitrogen coming from symbiosis also increased with increasing moisture supply (Fig. 22).

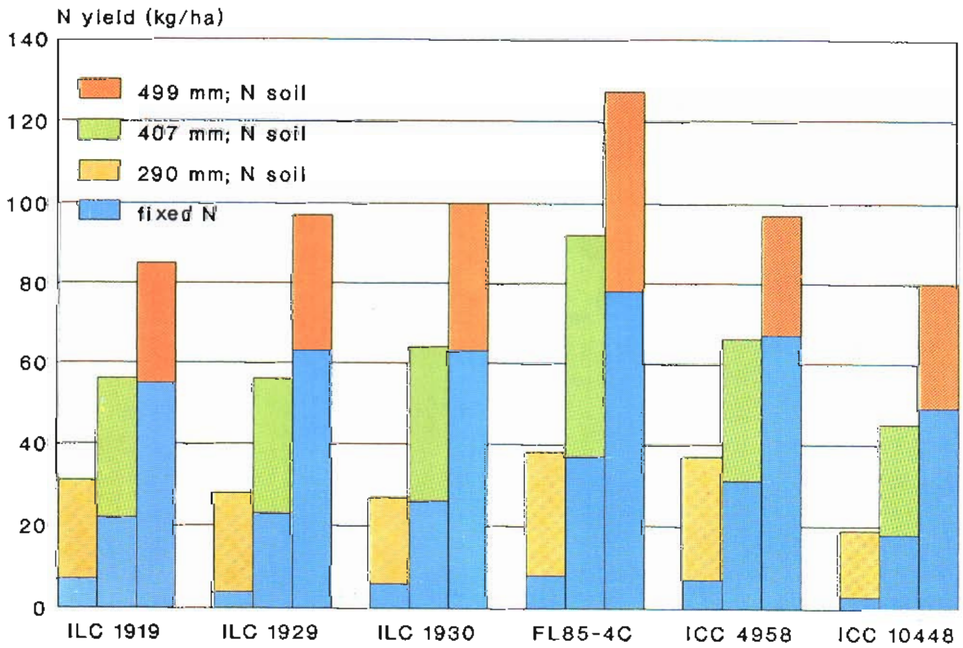


Fig. 22. Nitrogen yield and source in six chickpea cultivars grown at three moisture levels. High, moderate and low levels correspond to 290, 407 and 499 mm rainfall, Tel Hadya, 1988/89.

Lentil

The Center continued its lentil breeding strategy targeted to different agroecological regions. The emphasis is on developing material with high yield potential, drought tolerance, plant architecture for mechanized harvest, and resistance to important diseases (*Fusarium* wilt, *Ascochyta* blight, rust) and the parasite *Orobanche crenata*. Over 300 simple crosses were made and handled by bulk-pedigree system using off-season generation advancement. A new nursery containing rust-resistant sources was launched.

Growing wild *Lens* spp. in hydroponics permits a year-round supply of vigorous plants with profuse flowering to make interspecific crosses. Here, *Lens nigricans* ssp. *ervoides* grows in hydroponics with several crossed flowers developing into pods.

The extremely dry 1989/90 season permitted identification of breeding material with drought tolerance. Several breeding lines identified ranked above the best checks. Considerable progress was also made in screening for resistance to *Fusarium* wilt. A wilt-sick plot was developed and a methodology for screening based on delayed sowing was employed. Two lines (ILL 298 and 6435) were identified as resistant to *Fusarium* wilt at both seedling and adult stages. Also, highly resistant sources were identified in wild species--*Lens culinaris* ssp. *orientalis*, *L. nigricans* ssp. *nigricans*, and *L. nigricans* ssp. *ervoides* (Table 11). One line of cultivated species (ILL 5588) was identified as resistant to both wilt and *Ascochyta* blight. To exploit wild *Lens* spp. in crop improvement, a hydroponics system was developed to ensure a year-round supply of vigorous plants of wild and cultivated species with profuse flowering necessary for wide crossing (Table 12).

Studies continued on the protocol for *in vitro* culture of embryo/ovules.

Table 11. Range, mean, and coefficient of variation (%) of 221 accessions of wild lentil for vascular wilt reaction.

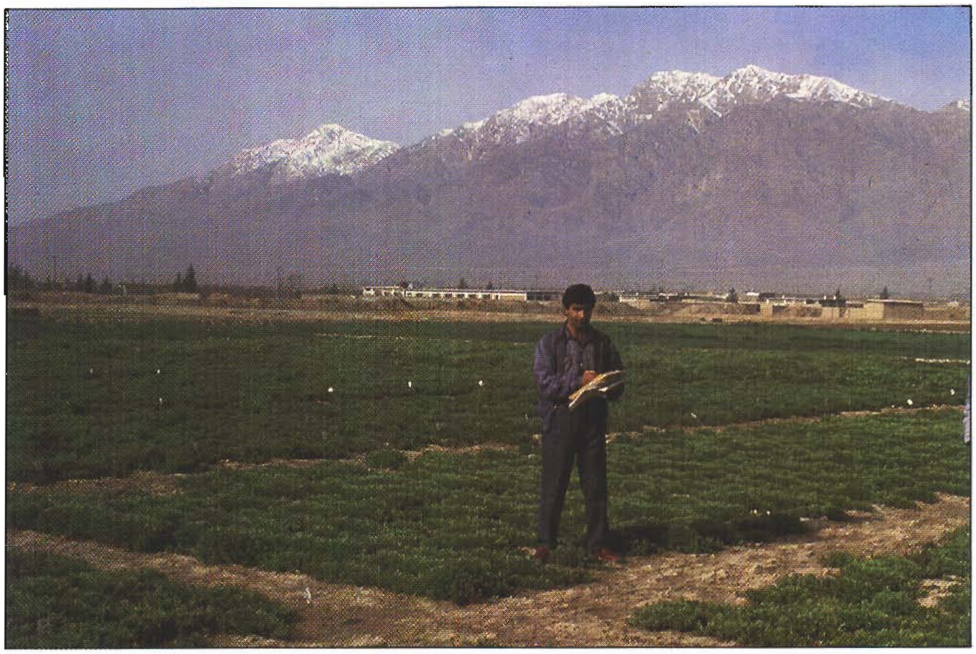
Species name	No. of accessions	Range	Mean	CV (%)
L. culinaris subsp. *orientalis*	109	0.8-8.3	4.8	34.9
L. culinaris subsp. *odemensis*	17	4.3-8.0	6.2	17.7
L. culinaris subsp. *nigricans*	30	0.9-7.3	4.0	39.3
L. culinaris subsp. *ervoides*	63	1.4-7.1	4.3	31.2
V. montbretii	2	3.3-5.1	4.2	21.7
Overall	221	0.8-8.3	4.6	46.4

Table 12. Growth and productivity of wild *Lens* spp. in hydroponics for use in wide crossing program.

Acc. No.	No. of main branches	Pods/plant	Seeds/plant
Nigricans			
ILWL 14	42	540	716
ILWL 18	75	918	1353
ILWL 25	66	891	1224
Ervoides			
ILWL 129	33	658	942
ILWL 134-1	83	3081	4039
ILWL 185	31	704	1110
Range	31-83	540-3081	716-4039

Using a line-source sprinkler system at Breda, lentil genotypes have been identified that perform well under drought, and respond to increased moisture supply as well. Early growth and seedling vigor have proved to be good criteria for predicting genotype performance under drought conditions, but if there is a late frost--as was the case in 1989/90--the significance of these traits is reduced and cold tolerance becomes an additional important trait.

Cold spells in February and March are relatively common but unpredictable in the lowland Mediterranean region, so natural selection in landraces has produced material with sufficient cold tolerance for these areas. However, the thrust to replace spring sowing with winter sowing at high elevations (>1000 m) necessitates the search for highly cold-tolerant genotypes. Results from screening for cold tolerance in 1984/85 and 1989/90 indicate that it can be done at



Evaluation of ICARDA-enhanced lentil germplasm in Quetta, Pakistan. ILL 5845 and ILL 5677, which have both cold tolerance and high yield potential, have been identified as promising genotypes for upland Balochistan.

intermediate elevations (600-800 m) by sowing the crop early to predispose it against damage from cold in most years (Fig. 23). Supplemental light to extend the day length hastened the phenological development of the crop and increased cold susceptibility, accentuating genetic differences. Genotypes originating from warm growing areas, such as ILL 4605 from Argentina, ILL 1744 from Ethiopia and ILL 2501 from India, were more susceptible than those from cooler production areas, such as ILL 4400 from Syria.

The national programs continued making good use of ICARDA-enhanced germplasm. Five lines were released by NARSs in 1989/90 for general cultivation (see Appendix 2), and several others were selected for on-farm multilocation trials and prerelease multiplication. In the southern latitudes, ICARDA-enhanced material is being used in Pakistan, India, Nepal, Bangladesh, and Ethiopia. Selections from ICARDA material are also reported to have been made in Australia, Canada, Chile, and China.

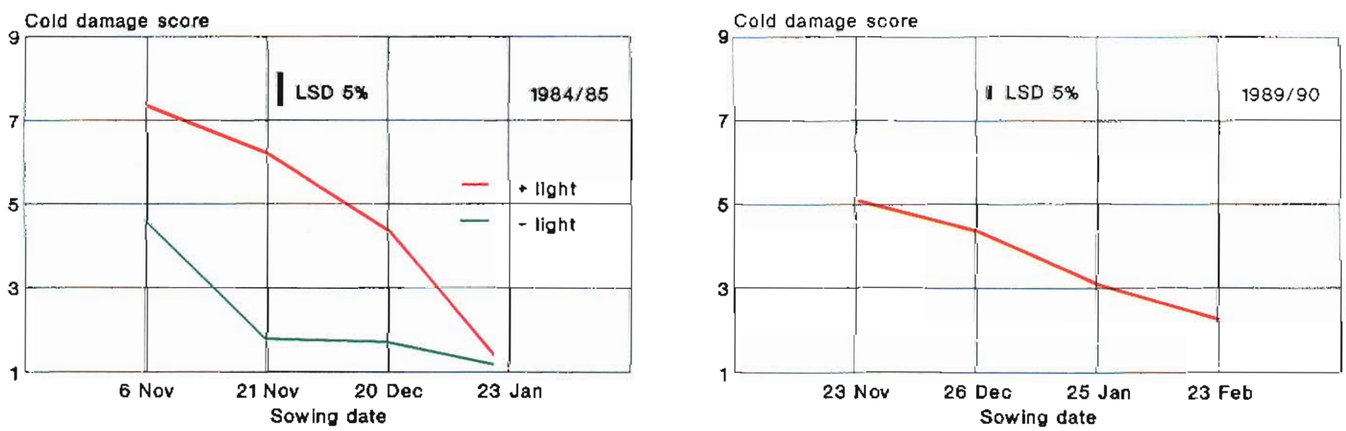


Fig. 23. Cold damage score measured on a 1-9 scale (1=free; 9=killed) on lentil sown at different dates at Tel Hadya in the 1984/85 and 1989/90 seasons. In 1984/85, supplementary lighting (18 hr photoperiod) was provided.

ICARDA continued its efforts to transfer the lentil harvest mechanization technology to NARSs. In 1989/90, the General Organization of Agricultural Mechanization of Syria encouraged the farmers in Kamishly to grow lentil on 80 000 ha, following the technology earlier demonstrated in collaboration with ICARDA. Because of dry weather conditions, the growth was poor and mechanized harvest could only be done with a swathmower. Nearly 25% of the total area in Kamishly was harvested by this method. Seed yield losses were 4.7 to 8.6% higher with a swathmower than by hand harvest.

Research was carried out to increase symbiotic dinitrogen fixation in the wheat-based cropping system. Twenty-one lentil *Rhizobium* strains were tested for their symbiotic efficiency with three Jordanian lentil cultivars using an aseptic, N-free, hydroponic, gravel culture system. Strain LE 867 from Turkey was found consistently superior, although strains LE 835 and 843 from Jordan were also promising (Fig. 24). These strains will be further evaluated for inoculation studies. The N_2-fixation was highly affected by total seasonal moisture supply. As the moisture supply increased from 180 to 376 mm, the percentage of total plant nitrogen derived from fixation increased.

Seed treatment of lentil with a small dose of Promet (12 ml/kg seed) was as effective as the use of 20 kg/ha of Carbofuran (5%G) in controlling damage to nodules by *Sitona* larvae and increasing lentil yield

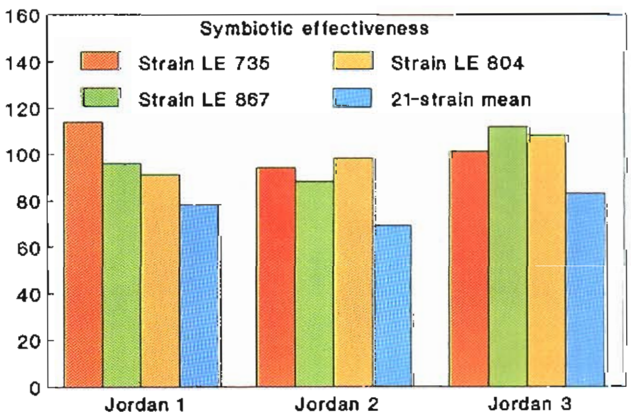


Fig. 24. Symbiotic effectiveness of one "inoculation network" rhizobia strain (LE 735), one Egyptian strain (LE 804), one Turkish strain (LE 897), and the average of 21 superior lentil strains with three Jordanian lentil cultivars. Effectiveness determined as shoot dry weight of strain treatments divided by shoot dry weight of N-fertilized controls.

Swathmower harvest of lentil is being promoted in Kamishly area in Syria by the Syrian General Organization for Agricultural Mechanization.

over untreated check. The damage by *Sitona crinitus* adults feeding in lentil plants was assessed at seven locations using a visual damage score (VDS) of 1 to 9 (1, no damage; 9, severe damage). Promet seed treatment effectively suppressed feeding, whereas in the Carbofuran treatment some feeding occurred (Fig. 25). Low VDS in mid-January was associated with lower oviposition in mid-February ($r = 0.83$, $P<0.01$) and lower nodule damage in mid-March ($r=0.73$, $P<0.01$). Thus, the nodule damage can be effectively predicted by early VDS.

Faba Bean

The ICARDA faba bean improvement team spent its first full season at Douyet, Morocco in 1989/90. Special efforts were made to ensure that the transfer of faba bean research to INRA-Morocco is completed by the end of 1991. Appropriate funding sources were approached for support beyond 1991, when ICARDA's core funding for faba bean improvement research will cease.

Offices and a pathology laboratory were established at Douyet, and the screenhouse facilities for pure-line breeding and field facilities for disease screening were successfully transferred from Aleppo to Morocco. The faba bean germplasm, including inbred and advanced lines with disease resistance, closed flowers, determinate growth habit, independent vascular

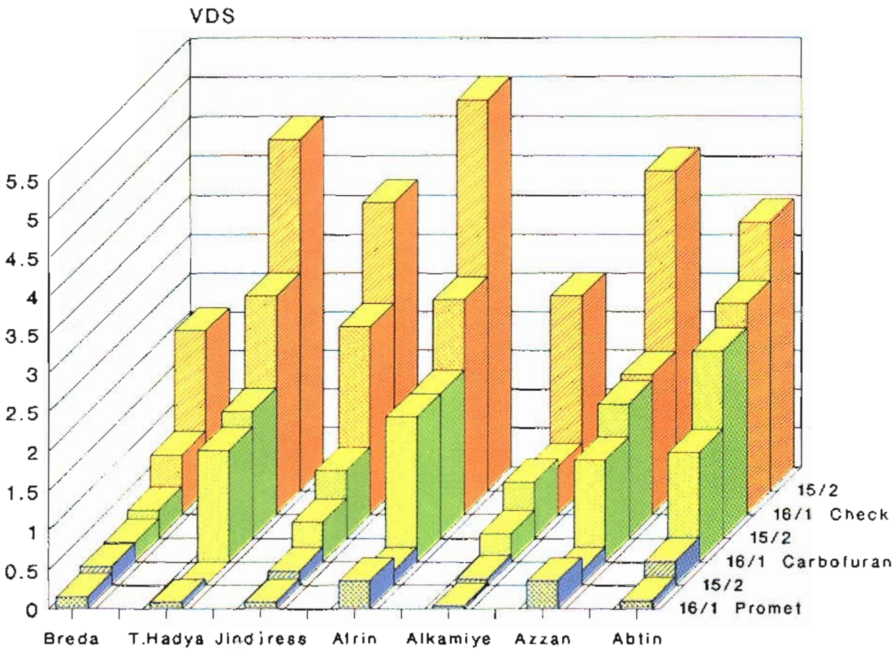
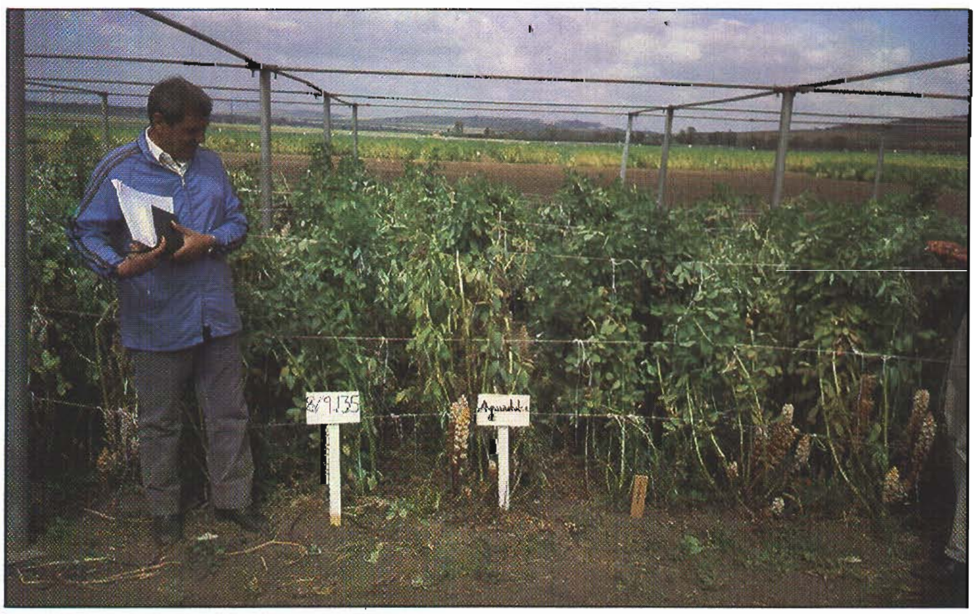


Fig. 25. Effect of seed treatment with Carbofuran (10kg/ha 5%G) and Promet (21ml/kg seed) on visual damage score on lentil on 16 January and 17 February 1990 at seven locations in northern Syria.

supply (IVS), and high yield potential was also transferred from ICARDA to Morocco. The North African regional yield trials were initiated and distributed to Morocco, Algeria, Tunisia, and Libya. The regional *Orobanche* nursery was distributed also to Egypt and Spain. Screening for chocolate spot and *Ascochyta* blight was initiated at Meknes.

The Tunisian national program selected the lines 80S80028, S82113-8, and S82033-1 for prerelease multiplication because of their yield potential in drought conditions. Another line, FLIP 83-106FB (small seeded) was identified for multiplication. In Algeria, 14 lines were placed under multilocation testing.

The most significant development following the transfer of faba bean research to North Africa has been the identification of selections with resistance to *Orobanche* in North Africa. Work on *Orobanche* resistance at Lattakia in Syria was fully transferred to



***Orobanche*-resistant faba bean lines under evaluation at the Douyet Research Station in Morocco.**

Douyet, Morocco. While success from screening the BPL collection has been limited, considerable progress has been made with material received from Spain that used the *Orobanche*-tolerant line from Egypt, namely F402. Selections from the cross (F402 x INIA06) x F402, which were earlier found highly resistant in Syria, were also highly resistant at Douyet research station and in verification trials in farmers' fields in Morocco, and at the research station in Algeria. The yield potential of several of these selections is quite high (Fig. 26). They are being further tested in a regional *Orobanche* resistance nursery in the Mediterranean region. The lines are being increased in about 2 ha area and in greenhouses for breeder's seed. This material will be used for large-scale farmers' trials and for the catalog trial in Morocco next year.

A crossing program has been started in collaboration with Spain to combine this resistance with the preferred large seeds and long pods of Aquadulce. At Douyet, work has been started to combine chocolate spot and *Orobanche* resistance.

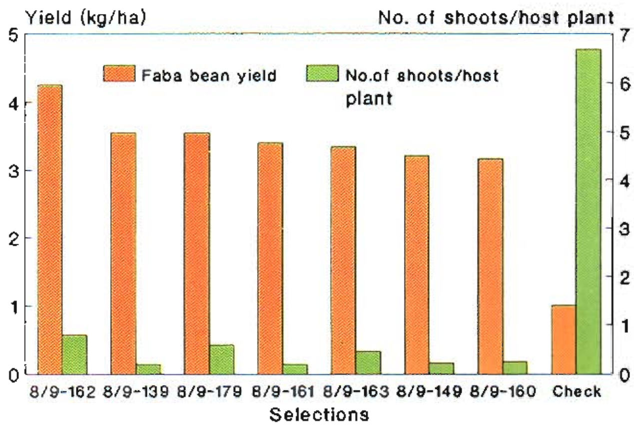


Fig. 26. Performance of seven new *Orobanche*-resistant selections compared to the local check Aquadulce in an artificially infested field at Douyet, Morocco, 1989/90.

Testing of inbred lines with known differential disease reaction to races of *Botrytis fabae* and *Ascochyta fabae* since 1986 in Algeria, Egypt, France, Italy, Morocco, Syria, and Tunisia has permitted characterization of pathogenic races in the Mediterranean region. This will help in developing suitable control strategies for each country using appropriate sources of host-plant resistance.

On-farm evaluation of different insecticides for the control of *Bruchus dentipes* showed that methyl parathion (Metyphon EC 50, 1 ml/l) was most effective. Two spray applications, one at early pod setting and a second 10 days later, were needed (Fig. 27). Laboratory screening for aphid (*Aphis craccivora*) resistance, in collaboration with the Egyptian national program at Giza, was further refined and 600 BPLs were screened. Of these, two lines (BPL 3345 and 3417) were found to be highly resistant and 30 resistant.

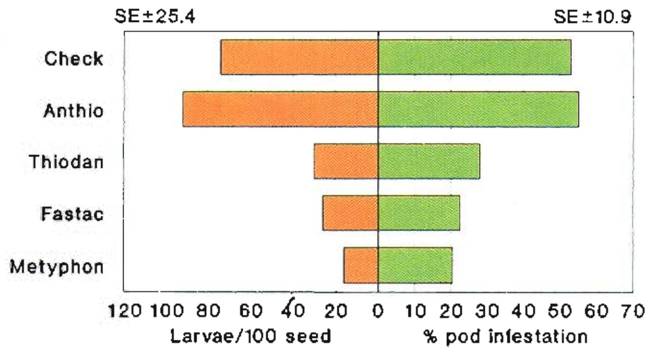


Fig. 27. Effect of two applications of different insecticides on larval infestation of *Bruchus dentipes* in faba bean at farmers' field, Aleppo, 1989/90.

Dry Peas

Of 348 accessions collected from different parts of the world, 50 high-yielding selections were retained for evaluation of their adaptation to dry areas of WANA. In the Adaptation Trial conducted at Tel Hadya, Jindiress, and Terbol, Accession No. 21 (Syrian Local Collection 1690) was identified as widely adapted. Agronomic studies on plant population with pea genotypes of differing leaf morphology revealed that the optimum plant population for conventional leaf types was 36 plants/m^2, whereas for leafless types it was 80 plants/m^2.

International Testing Program

This program is a vehicle for dissemination of genetic materials and improved production practices, in the form of international trials and nurseries, to national programs. For the 1990/91 season, 1034 sets of 45 different nurseries were distributed to 130 cooperators in 54 countries (Table 13). The nurseries were further diversified and specifically targeted to different areas.

Table 13. Food legume international nurseries supplied for the 1990/91 season.

Trial/Nursery	Chickpea		Lentil		Faba bean		Other legumes	
	Types	Sets distributed	Types	Sets distributed	Types	Sets distributed	Types	Sets distributed
Yield Trials	5	117	3	125	-	-	3	57
Screening Nurseries	5	130	4	132	1	35	-	-
Seg. Pop. Nurseries	2	43	3	37	-	-	-	-
Stress Tolerance Nurseries	5	145	4	57	3	67	-	-
Agronomic Trials	2	46	2	24	3	19	-	-
Total	19	481	16	375	7	121	3	57

They included additional sources of resistance to various stress factors and specific traits rather than finished cultivars.

For faba bean, only a limited number of nurseries with specific characteristics including determinate growth habit and sources of disease and pest resistance were distributed. Regional yield trials were specifically developed and distributed for North African countries from Douyet, Morocco, as part of the faba bean research network in the Maghreb.

Pasture and Forage Crops

A Vetch that Buries its Seeds

Subterranean vetch (*Vicia sativa* subsp. *amphicarpa*) buries some of its seeds. It flowers above and below the ground, the latter on underground stems that grow about 1 cm beneath the soil. The above-ground pods are typical of common vetch (average six seeds per pod), while the underground pods have one, larger seed each. It is a species that survives on overgrazed, stony slopes, because its underground seeds are protected from grazing.

Pasture species that bury their seeds can have enormous agricultural value. For example, subterranean clover, which transformed the agriculture of southern Australia, buries its seeds in sandy soils. It is less efficient than subterranean vetch, flowering above the ground, and later pushing its seeds below the ground as the peduncle reflexes. Subterranean vetch could have similar impact in heavier soils, which are common in West Asia and North Africa.

In 1989/90, ICARDA sought answers to two questions: (i) what effect does grazing have on seed production, and (ii) does subterranean vetch produce sufficient hard seed to ensure its survival? Swards were grazed on 27 March, 22 April, 2 May, and not grazed. Herbage, and underground and above-ground seed yields were measured. An accession collected in Turkey was used in these experiments.

Both herbage and underground seed yields increased with later grazing. Underground seed yield at the 2 May grazing was similar to no grazing, even though herbage production continued to increase after that date. The grazed swards produced no above-ground seed, compared with no grazing, where the seeds produced 236 kg/ha (Table 14). Nearly 1400 kg/ha of underground seed was produced at late or no grazing.

The seeds remained hard until 4 November, but hardseededness fell rapidly to 56% by 15 December. This level is adequate for continuous pasture, but is wasteful in the ley farming system. There is a need to search more widely for hardseededness, and last year ICARDA acquired a further 23 genotypes from Turkey, which will be assessed for levels of hardseededness.

Table 14. Herbage yield (kg/ha) and yield of underground and above-ground seed (kg/ha) of subterranean vetch grazed in March, April, May, or not grazed.

	March 27	April 22	May 2	No grazing
Herbage yield	833	734	859	2025
Underground seed	215	1000	1382	1392
Above-ground seed	0	0	0	236

Conventional methods of measuring hardseededness are slow. The most reliable method is to leave the seeds in the field where they experience natural weather conditions. After several years it is possible to obtain an accurate estimate of hardseededness within a particular farming system. Laboratory ovens, set to alternate between high and low temperatures, also provide an indication of hardseededness.

However, both these methods take time. With laboratory measures it is not possible to predict small differences in species with very hard seeds, such as the pasture legumes with which ICARDA works. A quick method is needed that could relate closely to field conditions.

The seeds of three medics (*Medicago orbicularis*, *M. rigidula*, and *M. rotata*) and three clovers (*Trifolium stellatum*, *T. campestre*, and *T. tomentosum*) were collected from grassland in northwest Syria. Complete and sectioned seeds were examined with an electron microscope. Morphological changes and thickness of the seed coat were related to hardseededness in seeds subjected to natural conditions in one summer.

Except for *T. campestre*, exposure over summer weakened the lens region of the seeds, even when the seeds remained hard. Complete removal of the palisade cells, which took place in *M. rotata*, was not sufficient to permit water uptake. The soft-seeded species (*T. stellatum*) showed a thin and discontinuous cuticular layer, while the hardseeded species (*M. orbicularis*) showed a thick and continuous layer.

Seed coat thickness did not explain all the differences in hardseededness, but when examined as a function of seed size it was a reliable indicator (Fig. 28). Only six species were examined in this study, but more recent evidence shows that the results may be applicable more widely.

An Evolutionary Method to Select Pasture Legumes

Pasture legumes must survive over a long time. This is so in both continuous pasture or as part of a ley farming system, where the pasture alternates with a cereal. Breeders should select new cultivars that persist in the prevailing conditions and farming systems. A

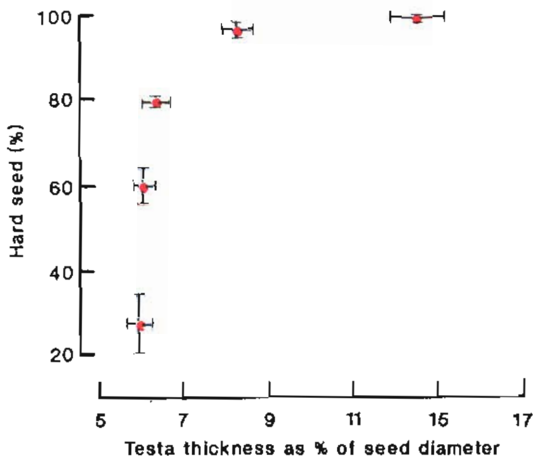


Fig. 28. Hardseededness in six annual legumes related to relative thickness of the seed coat. Relative thickness is thickness of the cuticle as percentage of the diameter of seed.

good method of doing so is to use mixtures of species and ecotypes, apply the relevant farming system, and then select those ecotypes that survive. In effect, the process of evolution selects the best fitted cultivars.

The conventional method of selection is to grow large numbers of ecotypes in nursery rows and use arbitrary selection procedures. For example, breeders select for winter growth, seed size, hardseededness, or simply preferred ecotypes. If these criteria are linked to ecological success, then the approach is sensible. Information to establish the appropriateness of this approach is necessary.

Most pasture plant breeders recognize the importance of including grazing animals in the selection process. However, because they emphasize productivity before persistence, they need large grazing experiments with several rates of stocking. In practice such experiments are far too expensive to be part of the selection process. It is possible, though, to include grazing animals if an evolutionary approach is used.

Several years ago ICARDA commenced an experiment at Tel Hadya to compare ley farming with other rotations. The plots are large enough to permit grazing, and the experiment has continued for several cycles. The design includes two phases (each phase of the rotation exists each year), and there are three replicates. ICARDA published some of the results in its 1989 Annual Report.

A mixture of 84 accessions of 12 medic species was sown in 1984 (phase 1) and 1985 (phase 2). The resulting pastures were grazed by eight sheep/ha, from December or January, until seed reserves fell to about 200 kg/ha, a quantity necessary to ensure survival of the pasture. The seed bank was sampled in winter or spring each year (when the pasture was green) and throughout the summer, when sheep grazed the dried pasture residues. The winter or spring sampling was to a depth of 10 cm, to ensure that all seeds were sampled. Only seed on the surface was sampled in summer.

The medic pods present in the soil samples were hand-separated into species based on pod characteristics. Accessions within each species were identified by growing a sample of seed of each species. Growth habit, flowering time, leaf markings, flower color and shape, and pod characteristics of the unknown plants were compared with rows of named plants originally sown in the mixture.

To analyze the results, a "success" index (S) was calculated that measures the change in proportion of each ecotype in the mixture.

$$S = \log_{10}(P_{(t0)}/P_{(ti)})$$

where $P_{(t0)}$ is the proportion of an accession in the original seed mixture, and $P_{(ti)}$ is the proportion of the accession in later samplings. Positive values of S show that the species is increasing, and negative values that it is decreasing.

Changes in Seed Bank Size

The pattern of change in the seed bank was similar for phases 1 and 2, even though they were sown in successive years. Seed number was highest in May of the pasture year, and fell rapidly during the grazing that immediately followed (Fig 29). A small increase in the seed bank during the first wheat year was caused by seed production of volunteer medics. Size of the seed bank fell sharply at the time of germination.

Changes in Seed Bank Species Composition

Three species increased their proportion of the seed population (had S values above zero): *M. rigidula*, *M. noeana*, and *M. rotata* (Table 15). *M. noeana* and *M. rigidula* were the best in the first phase, and *M. rotata* in the second phase. The success of individual ecotypes was reflected in these species: of the best 10 in phase 1 were six ecotypes of *M. rigidula*, two of *M. noeana*, and two of *M. rotata*, while in phase 2 there were seven of *M. rotata*, two of *M. noeana*, and one of *M. rigidula*. None of the Australian cultivars had S values greater than zero, nor did the species from which they were selected (*M. truncatula*, *M. scutellata*, *M. littoralis*, *M. rugosa*, and *M. polymorpha*) persist over the course of the experiment (except in small quantities).

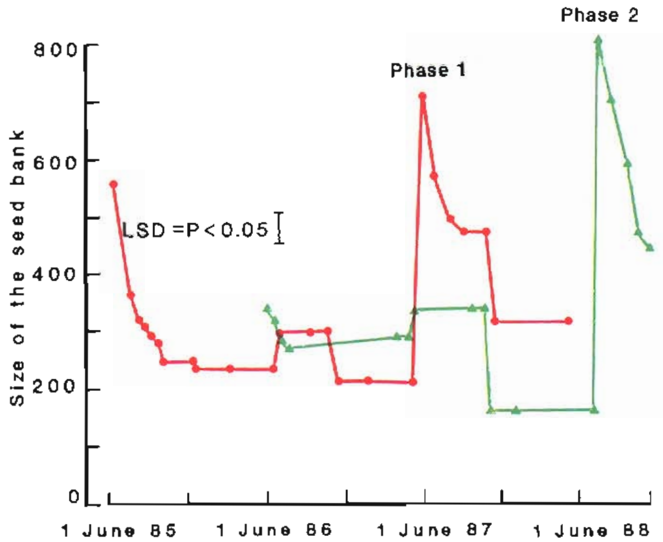


Fig. 29. Changes in seed bank size (kg/ha) with time in phases 1 and 2 of the cereal/pasture rotation. The first and third years of each phase were pasture, and the second and fourth years were food crop.

Table 15. The five most successful medic accessions in phase 1 (sown 1984) and phase 2 (sown 1985) at Tel Hadya, Syria.

Accession	Success	Origin
(a) Phase 1		
M. rigidula (1304)	1.34	Turkey
M. rotata (2352)	0.84	Syria
M. rigidula (2454)	0.78	Syria
M. rigidula (1865)	0.72	Turkey
M. noeana (2351)	0.61	Syria
(b) Phase 2		
M. rotata (2475)	1.06	Syria
M. noeana (2351)	0.98	Syria
M. rotata (2119)	0.93	Jordan
M. rotata (2123)	0.88	Syria
M. rotata (2116)	0.83	Iraq

Plant Attributes for Ecological Success

The experiment provided an opportunity to relate ecological success to plant attributes, an assessment that would greatly improve the value of conventional selection. The attributes measured were petiole length, leaf area, internode length, time to flower, peduncle length, flowers per node, flower survival, pods per plant, pod mass, seeds per pod, seed mass, and hardseededness. They were related to **S** using principal component analysis and backward stepwise multiple regression.

Principal component analysis showed a clear distinction between species. For example, *M. rigidula* had short petioles, high cold tolerance, many seeds per pod, and large leaves and seeds. *M. noeana* had many flowers per pod, was very hardseeded, flowered late, produced small pods and seeds, and long peduncles. For most attributes, *M. polymorpha* was the opposite of *M. rigidula*, and *M. aculeata* was the opposite of *M. noeana*.

Peduncle length and hardseededness were associated with success in both phases (Table 16). Hardseededness tended to be associated with success in the later stages of the experiment, and peduncle length from the beginning. Principal component analysis and multiple regression showed that several other attributes, including good flower survival, short internodes, short petioles, small leaves, and small seeds and pods, were related to success in at least one of the phases.

Table 16. The regression coefficient (b) and its signifance (t) in plant attributes affecting success in phases 1 and 2 of a rotation of pasture with wheat at Tel Hadya, Syria.

Attribute	Phase 1		Phase 2	
	b	t	b	t
Flower survival	0.0132	2.73**	NS	NS
Petiole length	-0.0751	4.47***	NS	NS
Peduncle length	0.0402	3.30**	0.0974	5.54***
Hard seededness	0.0294	4.79***	0.0311	4.23***
Internode length	NS	NS	-0.0303	2.35*
Leaf area	NS	NS	-0.2529	3.65***
Pod mass	NS	NS	-0.0748	3.30**
Seed mass	NS	NS	0.2067	3.24**

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Conclusions

The most successful species were those indigenous to Syria and the surrounding areas of Turkey, Iraq, and Jordan. The Australian cultivars, and species or ecotypes from North Africa, were less successful. The first principle in selecting pasture legumes, therefore, should be the collection and evaluation of local material.

The local medics in this experiment were highly successful. The size of the seed bank increased throughout the experiment, and successful pastures were established in each pasture year. Some ecotypes were more successful than others, and these will form the basis of recommendations to the Syrian Government.

The successful medics tended to be small in winter (short petioles and internodes) with a capacity to grow rapidly in spring (long peduncles). They produced hard seeds, and the reproductive process was efficient (high flower survival and many small seeds). There was a trend towards ability to avoid or survive ingestion by sheep (small seeds and pods).

Resource Management and Conservation

Tillage Trials at Tel Hadya

The widespread introduction of mechanization into the rainfed farming systems of West Asia and North Africa during the last 40 years has resulted in quite dramatic changes in tillage practices. The minimal tillage practised when only draught animals and simple implements were available has now, in many places, given way to disc or moldboard plowing to depths of 20 to 30 cm. This operation usually takes place in the autumn before the onset of rain, and is followed by the use of offset discs (North Africa) or tined cultivators (West Asia) to prepare a seedbed.

Researchers at ICARDA question the need for deep tillage. The justifications advanced for it include the promotion of more rapid infiltration and the disruption of compacted soil to aid root extension. But swelling clay soils predominate in many of the production areas of the region. These soils crack extensively when dry. The cracks, which at the surface may be several centimeters wide, extend to depths of over 1 meter and form pathways for the rapid intake of water from early rains. As the soil swells with wetting, the cracks close at the surface and infiltration rates are slowed, although the cracks may remain at depth.

Deep tillage is costly in both time and fuel use, and it necessitates further cultivation to prepare the seedbed. Since tillage is increasingly recognized as destructive of soil structure, it is also undoubtedly 'costly' in terms of the long-term maintenance of the soil resource. A reduction in tillage should bring economic and environmental benefits.

A trial was initiated at Tel Hadya in the 1985/86 cropping season to test the general hypothesis that, on swelling clay soils, tillage and production costs can be reduced without lowering crop yields. The trial compares four tillage treatments, based on farmers' practice: deep discing (20 cm); chisel plowing (20 cm); sweep (ducksfoot) cultivation (8-10 cm); and zero tillage, imposed on two 3-course crop rotations of cereal-legume-summer crop--specifically, bread wheat-chickpea-watermelon and durum wheat-lentil-water melon. The main findings from this trial as of 1989/90 are as follows:

1. No significant effect of tillage type was observed on the yield of legumes (Table 17). In watermelon, reduced yield from zero-till plots was due largely to difficulties of plant establishment. Satisfactory techniques for planting into reserve moisture without tillage have yet to be devised. Differences between the tillage treatments in wheat yields, though significant, have not been consistent, although values tend to be lowest in zero-till plots.

Table 17. Crop yields (kg/ha) in four tillage treatments within three-course rotations, Tel Hadya, 1985/86 to 1989/90.

		Tillage Treatment [1]					
Crop	Season	DD	CP	Df	ZT	Signif.	LSD
Chickpea	85/86	765	860	845	875	ns	
	86/87	860	880	935	915	ns	
	87/88	1230	1205	1220	1150	ns	
	88/89	220	225	245	285	ns	
	89/90	195	165	215	215	ns	
Lentil	85/86	745	795	760	790	ns	
	86/87	1265	1245	1235	1365	ns	
	87/88	660	705	635	595	ns	
	88/89	280	355	345	375	ns	
	89/90	60	105	70	60	ns	
Water melon [2&3]	85/86	1395	1810	1565	940	ns	
	86/87	2490	3070	3060	810	***	684
	87/88	7825	7280	7915	5095	***	1527
Bread wheat	85/86	2305	2245	2360	2195	ns	
	86/87	2275	2335	2440	2400	ns	
	87/88	4480	4420	4560	4255	ns	
	88/89	1725	1630	1815	1390	*	275
	89/90	1015	1340	1175	1395	***	104
Durum wheat	85/86	2720	2615	2620	2535	**	82
	86/87	2175	2390	2680	2235	*	306
	87/88	4255	4325	4090	3880	ns	
	88/89	1235	1250	1305	975	***	95
	89/90	1630	1775	1910	1600	ns	

1. DD = Deep Disc; CP = Chisel Plow; Df = Ducksfoot; ZT = Zero Till.
2. Yield of fresh fruit.
3. Water melon was not planted in 1988/89 or 1989/90.
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$. ns = non-significant.

This is undoubtedly due, in part, to the configuration of the zero-till planter which has 30-cm row spacing, whereas the other plots are sown with a local seed drill at 17.5 cm spacing.

Poor performance of legumes in 1988/89 and 1989/90 was only partly the result of the dry conditions. Their planting was delayed by rain to December in both years; the cold weather during January and February delayed germination and emergence, resulting in poor crop stands; and in 1989/90 the late frost further severely reduced yields. Planting of lentil was also delayed in the wet year of 1987/88, so that in 3 out of 5 years there has been some difficulty in implementing winter planting of legumes. This factor needs to be taken into account in assessing the potential impact of changed practices.

2. No increased storage of water in the soil due to deep tillage was observed. If anything, the trend was rather the opposite, and, in the wet year especially, reduced or zero tillage led to more water storage at depth in the profile (Fig. 30). There was

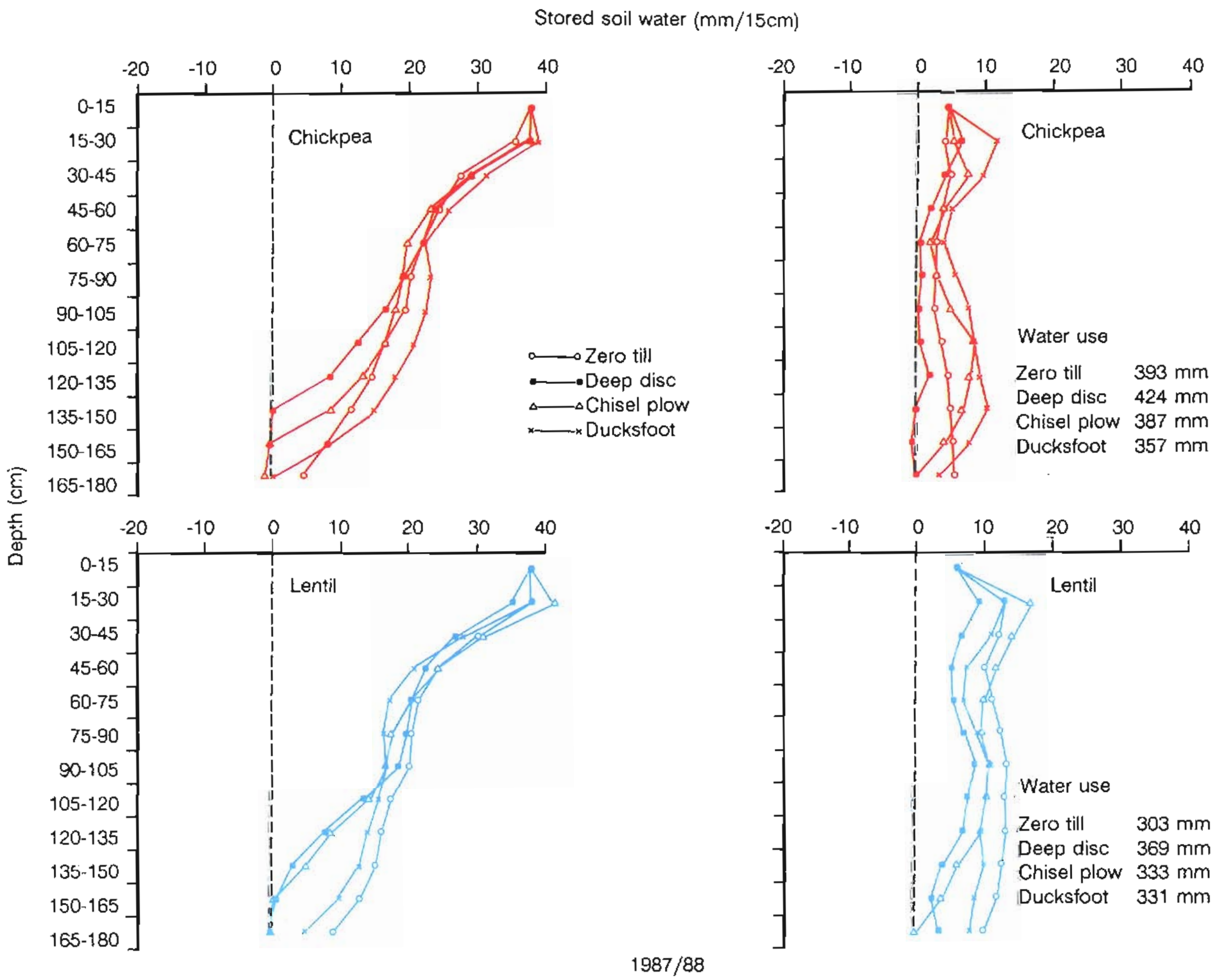


Fig. 30. Stored water in the soil profile at maximum recharge (left) and harvest (right) in four tillage treatments. Data are for legume crops. Total water use for the crop season is also shown.

no consistency among tillage treatments in the extent to which the soil was dried out by harvest time; and there was no evidence in the data to suggest that root depths differed with tillage treatment.

3. There was little consistency in the patterns of water use during crop growth. Values for chickpea are illustrated in Fig. 31. Apparently, greater use with deep discing in the wet year is the inverse of the water storage pattern. Rates of use during the spring period of most rapid crop growth were quite similar in all tillage treatments within each season.

The conclusions so far both from yield values and water relations indicate no advantage from deep tillage. Of course, the results are both site and season specific. Different results may be expected on other soil types, and even on similar soils in different situations. For example, on sites with greater slopes, the increased surface roughness from deep discing (or moldboard plowing) may help to hold back water longer after high intensity rainfall and thereby reduce runoff and increase infiltration. However, there is a need to critically reappraise the use of deep tillage where it is practised on flat or gently sloping land with swelling clay soils.

Supplemental Irrigation

Full irrigation provides water for stress-free crop growth where there is insufficient rainfall for crop production. In contrast, irrigation is termed 'supplemental' where most of the crop water requirement is met from rainfall but small quantities of additional water are applied to prevent stress, especially at sensitive growth stages. The normal result is a substantial yield response, representing a very efficient use of the applied water, and more stable yields. Removal of the risk of drought justifies the use of inputs such as high-yielding cultivars, fertilizers, and herbicides, but it is important to identify appropriate management practices for individual crops. Studies were carried out on barley, wheat (bread and durum), and oilseeds (rapeseed and sunflower) in the 1989/90 season.

Barley

Trials in Aleppo province over three seasons have aimed at selecting barley genotypes showing good

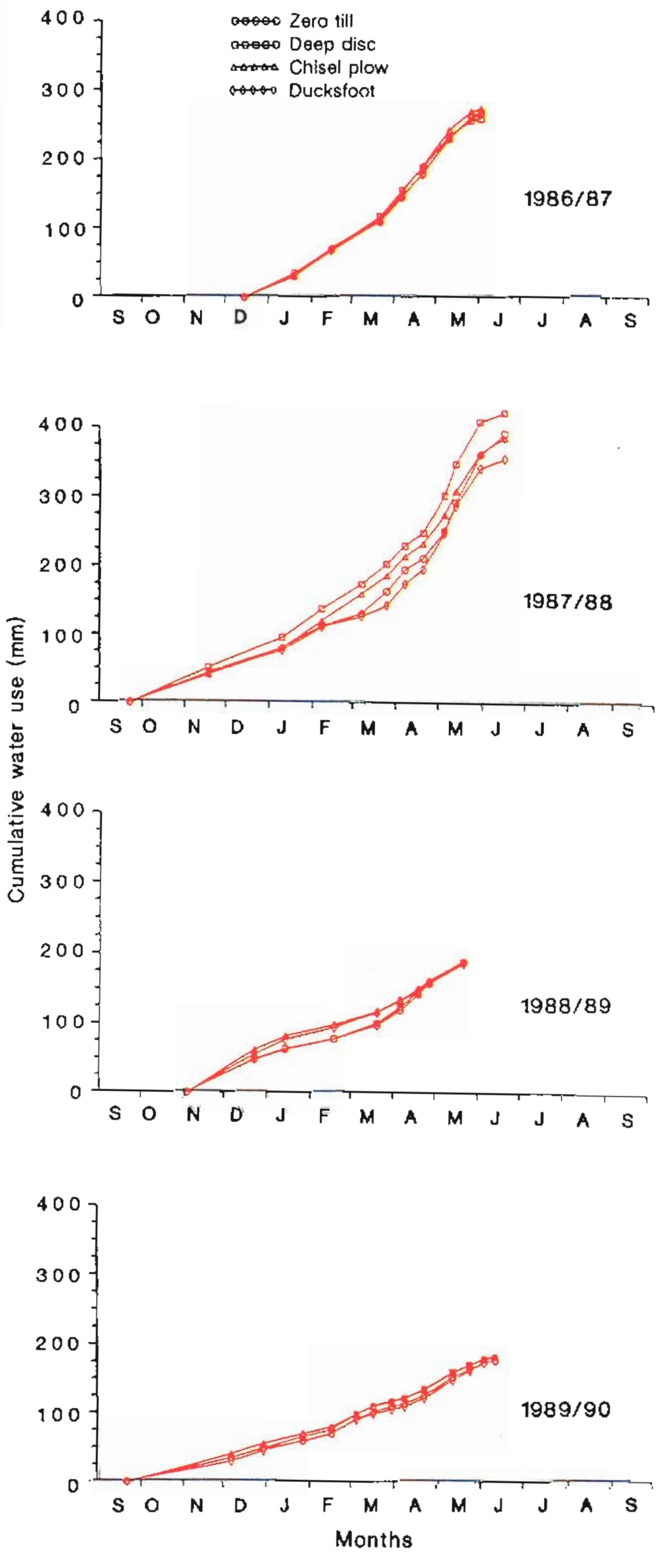


Fig. 31. Cumulative water use by chickpea in four tillage treatments and four crop seasons at Tel Hadya, Syria.

environmental adaptation and a favorable grain and straw response to additional water. In 1989/90, 37 genotypes were compared in a line-source trial on farmers' land at Breda, Syria. These genotypes were divided into three groups, HR, MR, LR, adapted to high-, medium- and low-rainfall regimes, respectively. Watering was scheduled by water balance methods (verified by soil water measurements) and carried out when 50% of the available water in the active root zone of the wettest treatment had been used. Six water regimes were distinguished: replenishment of 0, 11, 33, 57, 81, and 100% of the deficit, and designated I-0 to I-5.

Grain yield and total biomass showed a dramatic increase from I-0 to I-5 treatments (Table 18). This was because of the low rainfall in 1989/90 (see Appendix 1) and the consequent necessity to apply more water than might normally be required for supplemental irrigation at this station (mean annual rainfall: 270 mm approx.). However, these yield increases were accompanied by large increases also in harvest index and crop water-use efficiency. Supplemental irrigation promoted a more effective utilization even of the limited rain that fell.

However, there was significant interaction between barley genotypes and supplemental irrigation. The group of genotypes adapted to high-rainfall regimes showed a greater response to increasing availability of water than those adapted to medium- and low-rainfall regimes (Table 19); and Rihane-03 confirmed its previous high-yielding performance at higher rates of supplemental irrigation. In this season, it significantly outyielded all other genotypes at the I-5 rate. At lower irrigation rates, however, this superiority was less marked, and yields of Assala-04 (HR), SLB 39/60 (LR), CI08887/CI05761 (HR), Matnan (HR), Alger/Ceres (HR), WI2291/1I2269 (LR), and six other genotypes approached or equalled those of Rihane-03.

For lower rates of supplemental irrigation, SLB 38/60 was particularly interesting. At I-0, I-1, and I-2, it appreciably (though not significantly) outyielded all other genotypes including Rihane-03.

Table 18. Effect of supplemental irrigation on barley yields and water-use efficiency at Breda, Syria, 1989/90.

Treatments	Supplemental irrigation (m)	Water use by crop (mm)	Yield, kg/ha* Grain	Total biomass	Harvest index	Water-use efficiency, kg biomass/ha/mm
I-0	0.0	201.7	400	2050	20	10.2
I-1	25.0	226.3	430	2060	21	9.2
I-2	76.1	277.2	960	3180	30	11.5
I-3	131.8	318.2	1700	4640	37	14.7
I-4	186.4	365.1	2480	6100	41	16.7
I-5	232.4	381.7	3370	7570	45	19.8

* Means of 37 genotypes (all at field moisture content, approx 5% for grain)

Table 19. Mean above-ground biomass (kg/ha at field moisture content) of barley genotypes adapted to high-rainfall (HR), moderate-rainfall (MR), and low-rainfall (LR) environments and grown under supplemental irrigation at Breda, Syria, 1989/90.

Genotype group	Supplemental irrigation treatments I-0	I-1	I-2	I-3	I-4	I-5
HR	1950	2040	3210	4780	6260	7790
MR	2000	1390	2930	4300	5820	7130
LR	2440	1990	3250	4360	5720	6870

It is concluded that genotypes adapted to high-rainfall regimes should be introduced in those situations where supplemental irrigation of barley is feasible, because the local varieties are unable to make efficient use of the extra water. Where water availability is restricted, SLB 39/60 should be considered, because it seems to be able to utilize limited amounts of water to produce grain more efficiently than other genotypes.

Wheat

Twenty genotypes each of durum and bread wheat were evaluated in a similar manner, using a line-source sprinkler at Tel Hadya. In this case the five irrigation rates were a theoretical 20, 40, 60, 80, and 100% of the water-balance requirement.

All genotypes responded significantly to irrigation, and mean grain, straw, and 1000-kernel weight values all increased linearly with increasing rate of water application (Table 20). However, grain protein content was negatively correlated with water rate. For higher rates of water application it may be necessary to apply more N fertilizer. Again, as with barley, the water-use efficiency of the wheat crop increased with increasing amount of water.

Interactions between genotypes and water rates were not significant. Nevertheless, within both durum and bread wheat groups, the difference between the highest and the lowest yielding genotypes widened with increasing water (Fig. 32). Thus, for bread wheat, the steepest slope was that of Cham 4, the least steep slope that of Zidane 89. All other genotypes were distributed between these cultivars. Differences between the highest and the lowest yielding genotypes began to be appreciable above about 300-350 mm total water receipt.

Table 20. Effect of supplemental irrigation on mean wheat yields and water-use efficiency at Tel Hadya, Syria, 1989/90.

Supplemental[1] irrigation mm		Grain kg/ha	Straw kg/ha	1000-kernel weight g	Grain protein %	Water-use efficiency: Biomass kg/ha/mm	Water-use efficiency: Grain kg/ha/mm
				Durum wheat, n = 20			
		**	**	**	*	**	**
I-0	-	59	2211	26.3	16.3	9.74	0.25
I-1	25	200	2547	29.2	15.9	10.65	0.77
I-2	76	1398	4221	31.2	14.2	18.18	4.52
I-3	129	2467	5916	35.9	11.7	23.16	6.82
I-4	191	3404	6291	42.6	10.2	22.86	8.03
I-5	253	4271	6851	45.0	9.9	22.88	8.79
LSD (0.05)		368	891	3.3	3.3	2.36	0.87
SE (±)		165	400	1.5	1.5	1.06	0.39
				Bread wheat, n = 20			
		**	**	**	**	**	**
I-0	-	43	2409	24.1	16.3	10.53	0.19
I-1	25	137	2110	24.1	15.7	8.71	0.53
I-2	76	7208	5796	26.8	14.3	21.09	2.33
I-3	129	1513	7007	29.7	12.4	23.54	4.18
I-4	191	2262	7403	31.5	11.1	22.79	5.34
I-5	253	3788	11585	33.6	10.4	31.63	7.79
LSD (0.05)		111	1663	0.5	0.5	3.58	0.26
SE (±)		50	747	0.2	0.2	1.61	0.12

* $P<0.05$ ** $P<0.01$

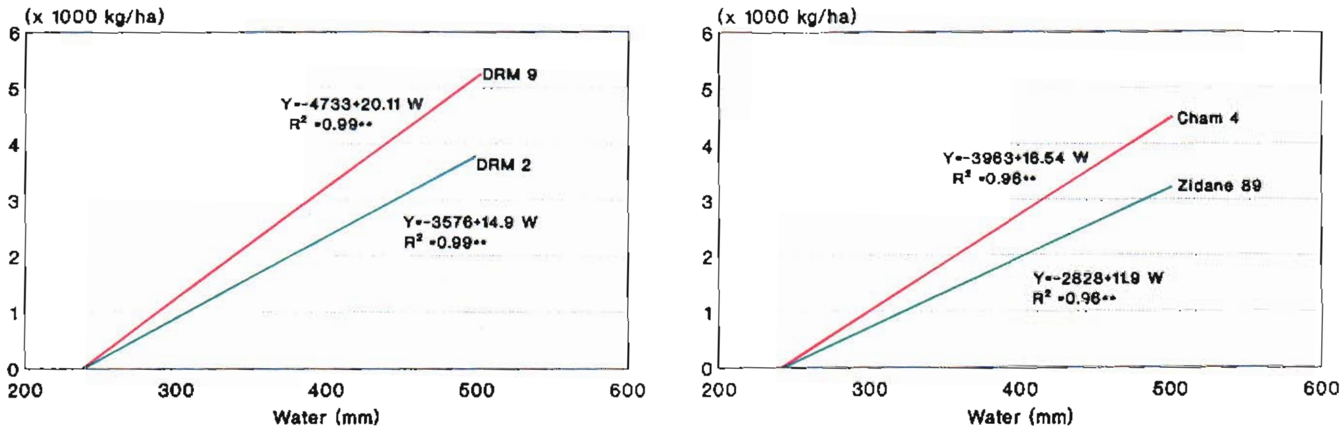


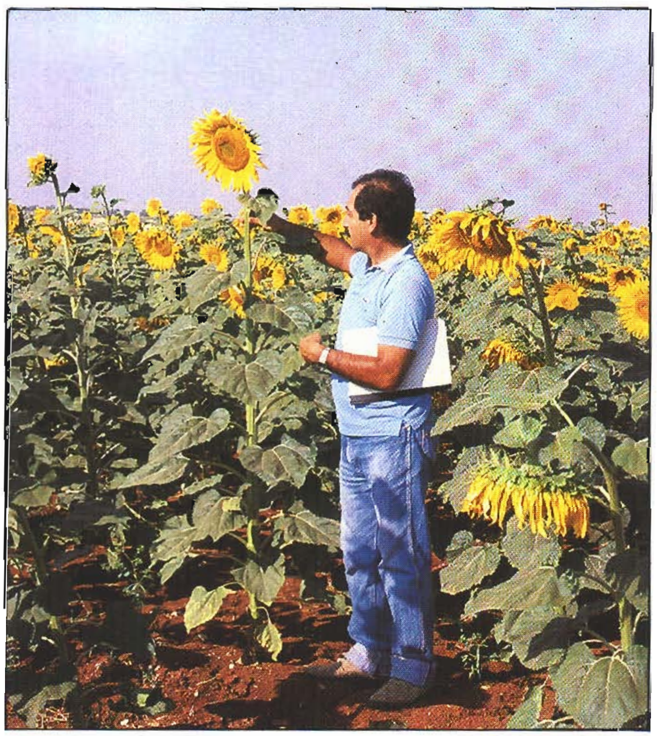
Fig. 32. Linear regressions of the grain yield of the highest and lowest yielding genotypes on the total water receipt (rainfall + supplemental irrigation).

Oilseed Crops

Most countries of the ICARDA region have a deficit of vegetable oil. Currently, the main source is olives, but to overcome the shortage there is a need to introduce such oilseed crops as sunflower (*Helianthus annus*), rapeseed (*Brassica napus* and *B. campestris*), safflower (*Carthamus tinctorius*), and sesame (*Sesamum indicum*) into the farming systems. Two trials were conducted at Tel Hadya in 1989/90: (i) to test the three available rapeseed cultivars under different moisture regimes; and (ii) to study two sunflower cultivars at different plant densities under supplemental irrigation. One of the aims was to assess the lower limit of water supply required to obtain an economic yield from oilseed crops in a rainfed environment.

Three cultivars were an inadequate sample of rapeseed potential, but the large differences found between them were instructive. Those differences appear to reflect the agroecological environment of cultivar origin. The most productive, Maluka, comes from a Mediterranean environment in Australia. All three cultivars responded similarly to irrigation. Mean values (Fig. 33) suggest that mean seasonal rainfall, in the absence of irrigation, should exceed 400 mm, although no firm conclusions can be drawn from just 1 year's data.

In the sunflower trial, grain yield was not significantly affected by plant density (between 10 and 40 thousand/ha) but increased almost linearly up to the highest rate of total water receipt, around 600 mm; but water-use efficiency of grain production was little affected by either parameter. This work will be continued and expanded.



To overcome the shortage of vegetable oil in the region, ICARDA is encouraging the introduction of oilseed crops, such as sunflower, into the farming systems.

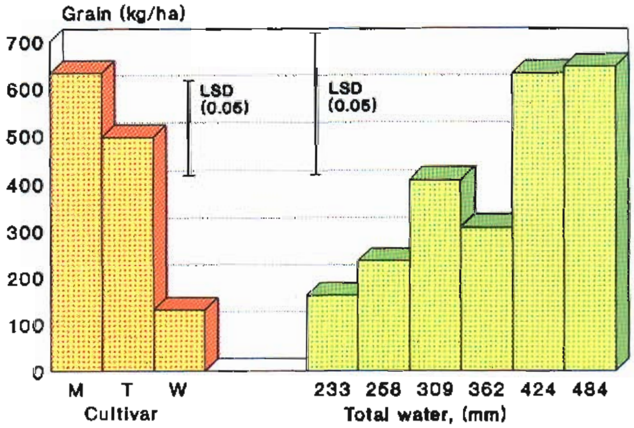


Fig. 33. Mean grain yield of each of three repeseed cultivars (Maluka, Tabin, and Weslar) across six water regimes (rain + supplemental irrigation), left; and mean grain yield of all three cultivars in each of the six water regimes (right).

On-farm Fertilizer Research on Wheat

In Syria, wheat is grown from the wettest to the driest areas. In the wetter areas (mean annual rainfall > 325 mm), it is the dominant crop, grown in rotation with food legumes and summer crops. In such areas, wheat growers know about fertilizers, have access to them, and have been using them for some time. Actual use is variable, but this is a response to local factors, particularly soil type, previous crop, and rainfall. For these conditions, fertilizer research needs to be directed toward technology optimization rather than generation. Important criteria for optimum use include the nutrient status of the soil at sowing time and rainfall probability.

In parallel with a similar set of barley on-farm fertilizer trials (reported last year), a series of 70 on-farm trials were conducted on farmers' fields across northwest Syria in areas above the 300 mm isohyet over four seasons, 1986-1990, with the objectives of (i) assessing the biological and economic responses of wheat to N and P fertilizers; (ii) determining the relationship between N and P soil-test values and wheat response to fertilizer; and (iii) establishing fertilizer recommendations for wheat, based on soil N and P tests and rainfall values.

The trial sites represented a range of rainfall conditions, soil types, soil fertility status values, and cropping sequences--wheat after lentil, chickpea or summer crop (usually melon), W-L, W-Ch and W-SC, respectively. Each site was characterized for environmental variables that could affect fertilizer response. Each trial comprised two replicates of the 16 factorial combinations of four rates each of nitrogen (0, 40, 80, and 120 kg N/ha) and phosphate (0, 20, 40, and 80 kg P_2O_5/ha) fertilizers.

Seasonal rainfall totals (October-May) ranged from 153 to 907 mm, with a mean of 363 (± 151.5) mm. Wheat yield was positively and linearly related to seasonal rainfall only in 1986/87, an average season, and in 1989/90, a dry season. Yield showed little relation to rainfall in 1987/88, a very wet season, or in the dry season 1988/89, when crops utilized much soil water stored from the high rainfall of 1987/88. Altogether, the 4-year data show a yield-rainfall trend that is better described by a quadratic equation. This general trend was little affected by fertilizer, although response to rainfall was greater under maximum fertilizer application (Fig. 34).

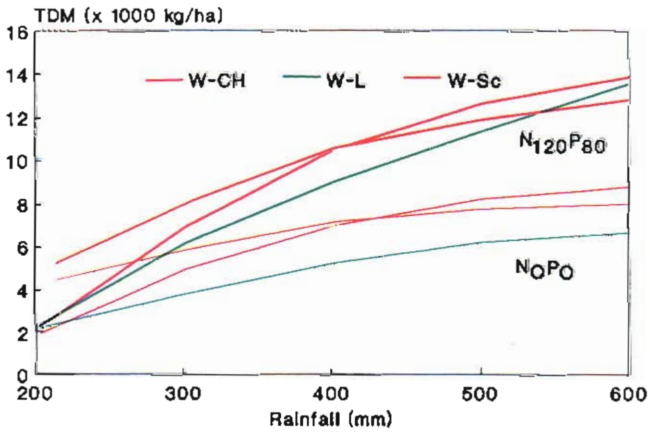


Fig. 34. Relationships of total dry matter yield to rainfall under zero and high fertilizer regimes in wheat-lentil, wheat-chickpea, and wheat-summer crop rotations separately in farmers' fields in Syria, 1986-1990.

Initial soil contents of available-P and mineral-N had little influence on the general yield level at each site, mainly because of the confounding effect of rainfall; but there were large rotation differences almost irrespective of rainfall. Wheat preceded by a summer crop tended to yield more than wheat preceded by lentil or chickpeas, particularly in lower rainfall situations.

Grain and straw yields responded positively to N fertilizer at almost all sites, those responses being significant at 38 and 61 sites, respectively; but significant positive responses to P were limited to 15 and 10 sites. Responses to N were more frequent at sites where rainfall was higher; and the mean size of the response was strongly rainfall dependent (Fig. 35). The effect of previous crop was also appreciable. Nitrogen application (120 kg N/ha) increased grain yield by 34, 22, and 19% over control in W-L, W-Ch and W-SC rotations, respectively.

Mean responses to applied P were small and interactions between N and P fertilizers almost negligible. In the derivation of regression equations to summarize crop response to fertilizer, the coefficients of the linear and quadratic P terms were generally non-significant. The equation (response function) best representing wheat yield in terms of fertilizer rate and rainfall was found to be

$$Y = aN + bN^2 + cQ + dQN + eQ^2 + \text{const}$$

where N is kg fertilizer-N/ha and Q is total seasonal rainfall.

To accommodate the effects of rotation and soil nutrient content at planting time on crop response to applied N, equations of the above form were derived from appropriate subsets of the experimental data (Fig. 36). Wheat response to N was very similar in all rotations at low rainfall but became much larger in the W-L rotation, relative to W-Ch and W-SC, at higher rainfall. Sites with lower mineral-N content gave lower total dry-matter production at each rainfall level but larger responses to applied N with increasing rainfall.

It follows that, to be economic, any N-application should be based on soil nutrient status and the rainfall likely to be received in the growing season. Since most nitrogen is topdressed at the tillering stage, in late winter or early spring, there is scope to do this. At topdressing time, soil water storage is at its maximum for the season, and one can judge better how much nitrogen to apply. Analyses of long-term climatic records can be used to predict the probabilities of receiving different amounts of rainfall thereafter, and "best-bet" nitrogen topdressing requirements can be determined.

Economic analysis is as essential as biological analysis to this study. Farmers are interested in net

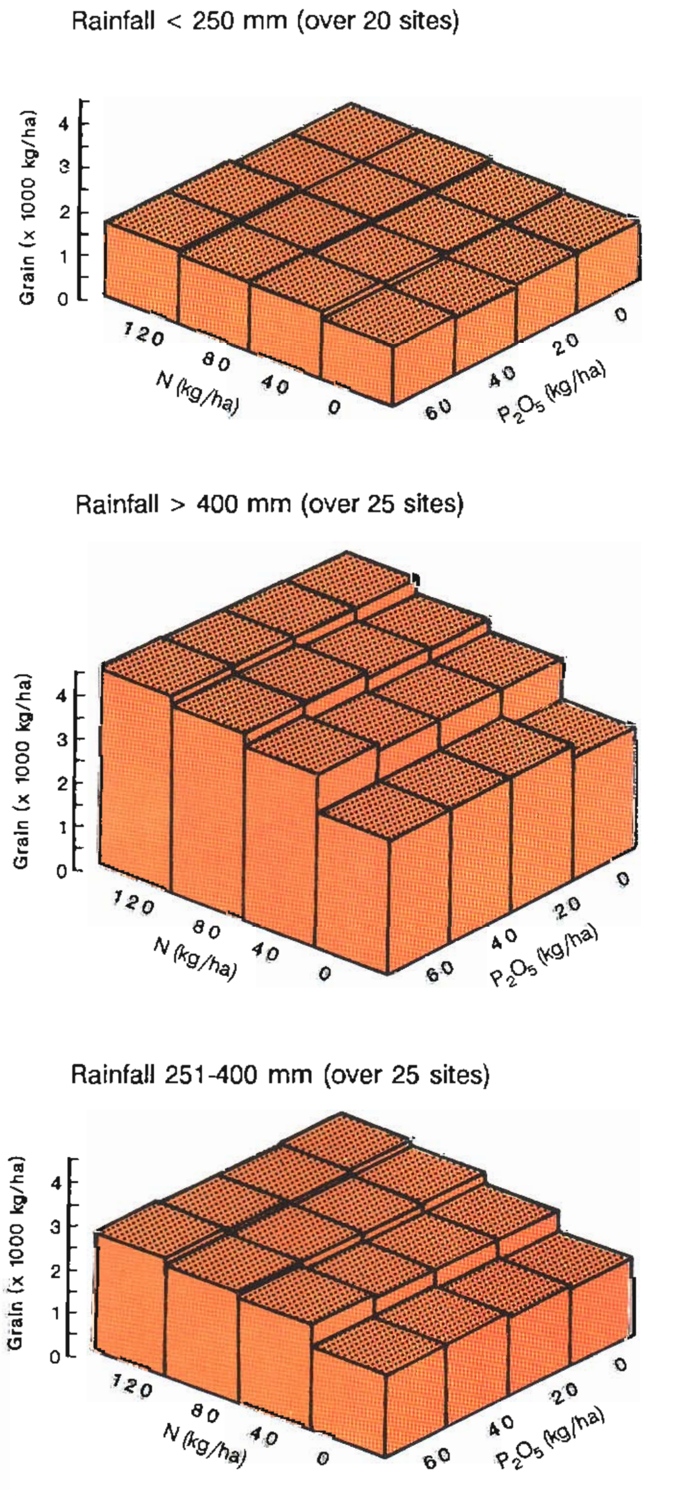


Fig. 35. Effect of rainfall on grain response to N and P fertilizers in Northwest Syria, 1986-1990.

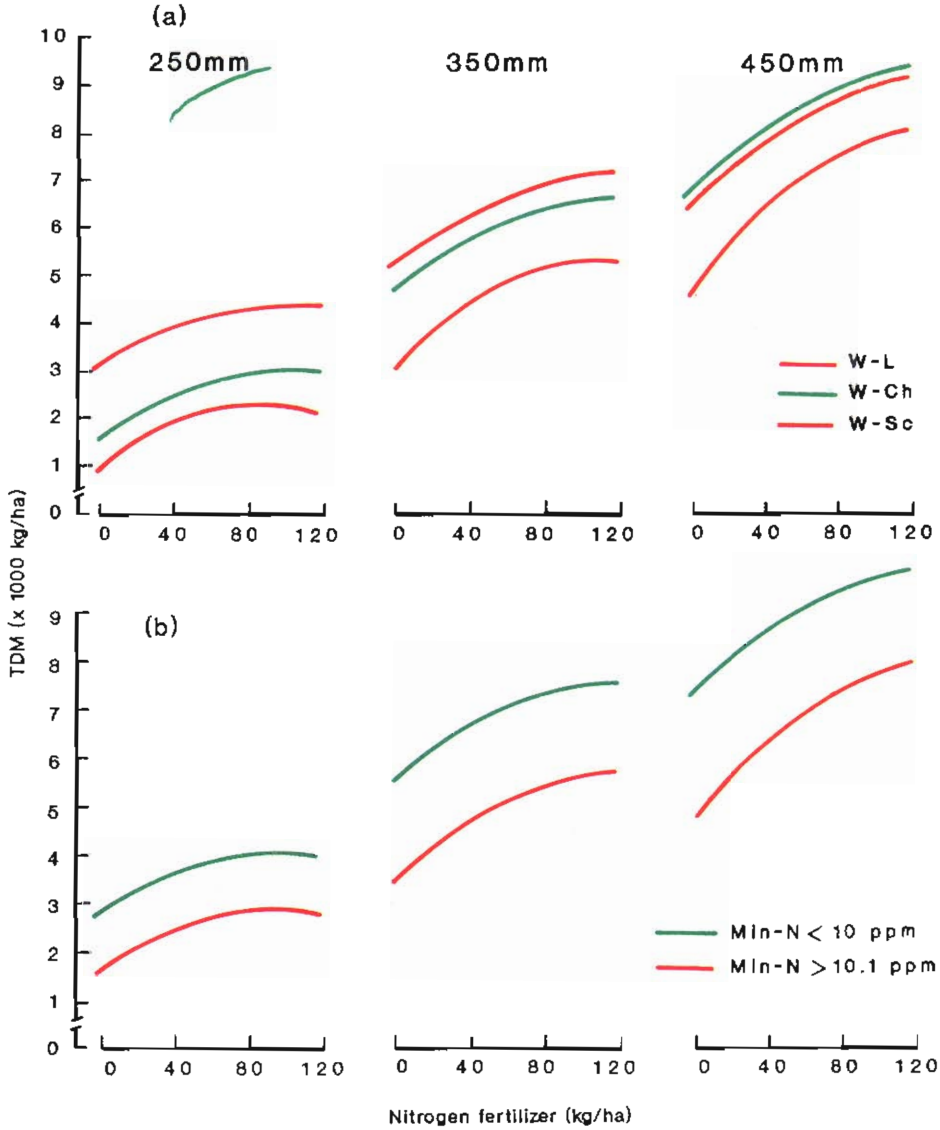


Fig. 36. Effect of previous crop (a) and initial soil nutrient content (b) on total dry-matter response to N fertilizer at three rainfall levels.

benefits and in protecting themselves against risk. Net revenue values from a partial budget analysis of the full 70-site data set showed that all fertilizer treatments were profitable. Marginal analysis showed that the optimum rate was 120 kg N/ha, without P for wheat preceded by either lentil or chickpea but with 40 kg P_2O_5/ha where preceded by a summer crop.

Economic input optima were found by equating the partial derivative of the appropriate form of the above response function to the price ratio, fertilizer:grain, using the government prices for the 1989/90 season; and mean yields, increases in net revenue, and marginal benefit:cost ratio at each optima were calculated (Table 21).

Table 21. Calculated mean economic optima, assuming a marginal rate of return of 40% under different rainfall and initial soil nutrient conditions .

Rainfall	Soil nutrient status	At yield optimum N (kg/ha)	Grain yield (kg/ha)	Increase in net revenue as grain equivalent (kg/ha)	Marginal benefit:cost ratio (%)
250 mm	PaNa	61	1462	204	170
	PaNA	67	1799	234	178
	PANa	42	1075	118	141
	PANA	44	1586	88	101
350 mm	PaNa	86	2470	406	240
	PaNA	89	2998	413	236
	PANa	67	2315	292	222
	PANA	65	3080	191	149
450 mm	PaNa	111	3307	678	310
	PaNA	111	3748	642	295
	PANa	91	3300	544	303
	PANA	86	4196	355	197

Calculations are based on relative price of fertilizer N to wheat grain of 1.4066. Upper and lower case print for PA and NA (available N and P in soil) indicate high and low values, NA > 10 ppm, PA > 5 ppm.

Crop Nitrogen Contents

The usual criterion by which the effectiveness of a new variety or crop management practice is judged is yield quantity; but yield quality should not be ignored. One important parameter of cereal quality, both for grain and straw, is its nitrogen (or protein = N x 6.25) content (%). Cereal breeders are often adjured to breed for high N-content, particularly because cereal straw is used for animal feed. Nevertheless, the fact is that both management factors (notably, rates of irrigation and fertilization) and environmental conditions (especially rainfall) may induce much larger differences in percentage N content than normally occur between different cultivars. A number of different examples of this emerged in 1989/90 from analyses of crop material from ongoing trials.

Supplemental irrigation reduced the mean N-content of durum wheat grain from 2.61% under rainfed conditions to a minimum of 1.58% at the highest rate of irrigation (data taken from Table 20). Corresponding values for bread wheat were 2.61 and 1.66%. These decreases in percentage N-content

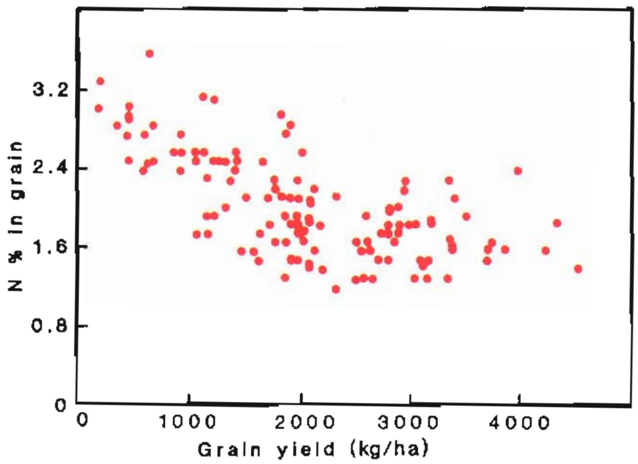


Fig. 37. Relationship between grain N content (%) and grain yield of barley. (Data from four seasons and from two rates of fertilizer-N application, 0 and 60 kg N/ha.)

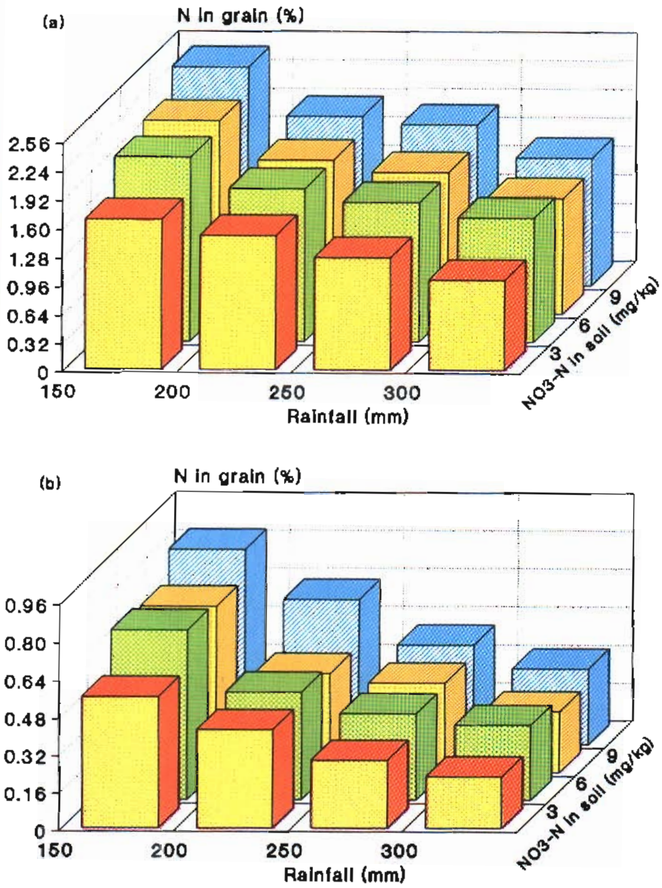


Fig. 38. Effect of rainfall and 0-60 cm soil nitrate-N content at sowing time on the N-content (%) of (a) barley grain and (b) barley straw (uniform application of 90 kg P_2O_5/ha but no N-fertilizer).

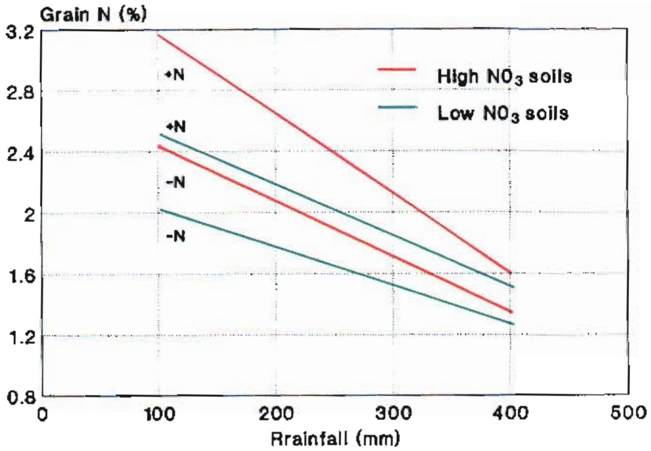


Fig. 39. Simultaneous effect of rainfall, initial soil nitrate-N status and N-fertilizer rate (0 and 60 kg/ha) on the N-content of barley grain.

accompanied large increases in both yield quantity and total N uptake; but, almost inevitably, where yields are increased by some other factor, such as water, without any increase in the soil N (and fertilizer) supply, some "dilution" of the N concentration in the plant material occurs. This is illustrated by barley data from 75 on-farm fertilizer trials (Fig. 37). Grain N% declined almost linearly with increasing mass of grain yield. This was largely a function of rainfall, which diluted the available nitrogen within a proportionately greater biomass; but initial mineral-N status of the soil was also influential both in the absence and presence of fertilizer (Figs. 38 and 39).

Similarly, in long-term trials at Tel Hadya and Breda comparing barley grown annually in the same plots with barley grown in rotation with fallow, the absolute ranges over 2 years, 1988/89 and 1989/90, of N-contents were 1.22-3.09% for grain and 0.40-1.94% for straw. Nitrogen fertilizer greatly increased crop N percentage, but this effect was greater in the continuous barley rotation where growth was more limited by water stress.

Reversing the Degradation of Marginal Lands

Prior to the advent of civilization, the marginal lands (rangelands receiving 150-250 mm of rain) of Syria were richer in trees, shrubs, and grasses than at present. Sheep and goats roamed widely at low stocking rates. Herbage production was more than 1000 kg/ha/year.

As the human population increased, the trees and shrubs were removed to provide building materials and fuel. Sheep and goats grazed the remaining grasses and herbs. Farmers used the best land for cereals. The demand for meat and milk increased, so the stocking rate on the remaining land increased enormously. It became necessary to grow barley to feed the animals, and this further decreased the land available for grazing. The result is intense overgrazing, cultivation of unsuitable land, and loss of the perennial vegetation. All that remains is annual grasses and herbs.

Severe soil erosion accompanied the land degradation. Seed populations and top soil were blown or washed away. Herbage production today is less than one quarter that of the original vegetation.

Reestablishing the vegetation is expensive. Seed must be collected and increased, and sowing is often by hand. The land needs to be rested. Policymakers and managers need guidelines to assess the feasibility of renovating these lands.

ICARDA, the Syrian Steppe and Range Directorate, and ACSAD commenced an experiment at Maragha near Aleppo, in which the productivity of degraded land is being compared with land resown to *Atriplex halimus* and *Salsola vermiculata*. The work aims to determine the land's productivity, measure the economic benefits of improvement, and monitor the effects of three stocking rates (2.50, 1.25, and 0.75 ha/sheep) on sustainability of sheep production.

The available pasture in March from unimproved land was small, a result of low rainfall (Table 22). However, the improved land produced more than twice the unimproved land, and the difference was because of the presence of shrubs. The data in Table 22 do not include the woody parts of the shrubs, and underestimate yield because the experiment was sampled before shrub growth was complete. In June, the seed population was higher in the unimproved pasture, because plowing to establish the shrubs destroyed many of the annuals. However, by September, many of the seeds had been grazed or blown away from the unimproved pasture, especially at high stocking rate (Table 23).

Table 22. Available herbage (kg/ha) in March 1990 on native and improved pasture at Maragha, Syria, as affected by stocking rate.

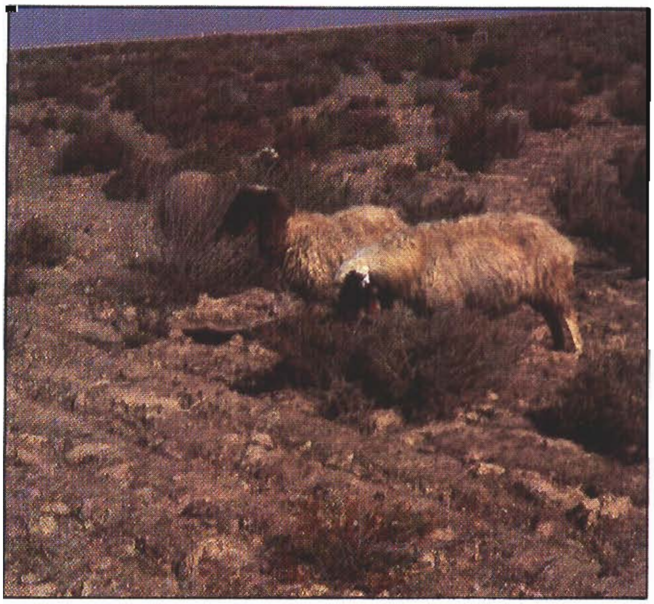
Type of pasture	Stocking rate Low	Medium	High	Mean
Unimproved	142	114	100	119
Improved	260	347	191	266
Mean	201	231	146	192

LSD between stocking rates = 43; LSD between stocking rates within pastures = 60; No significant difference between pasture types.

Table 23. Size of seed bank (g/m^2) of annual species on unimproved and improved marginal land at Maragha, Syria, in September 1990.

Type of pasture	Stocking rate Low	Medium	High	Mean
Unimproved	2.2	0.4	0.5	1.0
Improved	0.8	0.6	1.2	0.9
Mean	1.5	0.5	0.8	0.9

LSD (1%) for stocking rates = 0.46; LSD for stocking rates within pasture types = 0.65.



Sheep grazing shrubs in improved rangeland in ICARDA's trial at Maragha in Syria.

Severe wind storms in April ended the grazing of unimproved pasture. The improved pasture continued to be grazed for the entire summer (although some supplementary feed was needed). The wind buried the vegetation in parts of the unimproved pasture, presumably blowing away the seeds.

Managing Seed Banks for Maximum Pasture Production

Natural pastures, and those in the ley farming system, depend on seed set and seed longevity for survival. Herbage, and hence animal production, depends strongly on plant number, which in turn depends on the number of seeds that germinate. ICARDA is studying both seed production of pasture plants and the survival of seeds in the seed bank.

The annual medics are used in both the ley farming system and to improve grasslands. These medics were the subject of an experiment at Tel Hadya that began in November 1986 and ended in May 1991. (Note: since data for 1991 had become available at the time of writing this report for 1990, they are included here.) The objectives were to (1) measure the survival of six medics during four seasons and (2) determine whether conditions at seed set influenced seed survival. The six medics were sown in a factorial design with two seeding rates. At the low seeding rate there would be little stress at seed set, and at the high seeding rate seeds would be produced under the stresses of competition for light and moisture. Seed production was measured in the spring of 1987. Further seed set was prevented, and the amount of seeds remaining (from 1987) measured in March of 1988, 1989, 1990, and 1991. The number of seedlings that appeared each autumn was also counted.

Table 24 shows seed yields in 1987 and the weight of individual seeds. The differences in seed weight at low and high density confirm that the seeds at high density were produced under stress. The number of seeds per pod was slightly less at high density, and the seed to pod ratio was greater, showing that the pods were smaller at high density.

At the time of writing, the seed population in the spring of 1991 had not been measured. In spring

Table 24. Seed yield (kg/ha) and seed weight (mg per seed) of six medics grown at low (10 kg/ha) and high (200 kg/ha) density at Tel Hadya, 1987.

	Seed yield		Seed weight	
	Density		Density	
	Low	High	Low	High
M. noeana	478	320	3.32	2.29
M. polymorpha	306	801	2.70	2.30
M. rigidula 1900	397	199	2.94	2.28
M. rigidula 716	516	374	4.41	3.48
M. rotata	446	418	5.01	4.77
M. truncatula	83	472	3.07	2.70
LSD (P=0.05)	115		0.22	

1990, *M. polymorpha* and *M. rotata* had fallen to around 20% of the original population and would be unlikely to persist beyond 1991 (Table 25). On the other hand, almost half of the original *M. noeana* seeds had survived. This species germinated poorly in the first year after seed set, which, in ley farming, is the year when the cereal is sown. It would seem ideally suited to that system. *M. polymorpha*, too, did not germinate freely in the first year. *M. rigidula* sel. 1900 would seem better suited to grassland, and germinated best in 1988. A mixture of the species covers most situations faced by farmers.

The number of emerging seedlings was counted each year except the first. In that year the plots were cultivated soon after the opening rains and the seed buried to a depth of 10 cm. In 1988, which, in a ley

Table 25. Loss of seeds from the seed bank of six medics in three consecutive years, and the amount of seed remaining in the seed bank in the fourth year (percentage of original seed populations) at Tel Hadya.

	1988	1989	1990	Remainder
M. noeana	5	24	22	49
M. polymorpha	15	41	26	19
M. rigidula 1900	32	20	20	29
M. rigidula 716	26	19	18	36
M. rotata	20	33	25	22
M. truncatula	18	15	26	41
LSD (P=0.05)	7.2	7.7	NS	4.2

farming system would have been the year of regenerating pasture, all species produced around 1000 seedlings/m² each, and *M. polymorpha* produced nearly 5000 seedlings. Even in 1990, 4 years after the seed had been sown, three of the species produced more than 1000 seedlings/m² each, and the other three more than 700 seedlings each. *M. rigidula* sel. 716 produced slightly more seedlings in the fourth year than it did in the second. It could survive three successive crops (or two crops and a drought) without significantly reducing pasture productivity.

The data showed that the species differed in their germination pattern over years, as well as within a year. For example, in 1990/91, 91% of *M. noeana* germinated after the first rains and there was no further germination. In contrast, only 51% of *M. rotata* seed germinated with the first rains, nearly 25% germinating more than two months later (Fig. 40). This facility was of great value to *M. rotata*. The early rains were followed by a long drought that killed many seedlings including those of *M. noeana* (94%) and *M. rotata* (31%). Later germination of the latter resulted in sufficient plants to form a productive pasture. It was interesting to note that *M. polymorpha* resisted the drought (6% mortality) and delayed its germination (Table 26). There are always problems though--*M. polymorpha* is susceptible to severe frosts.

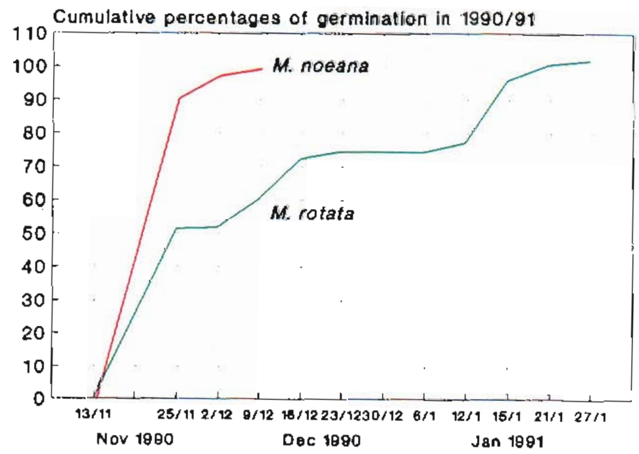


Fig. 40. Cumulative establishment of seedlings of *M. noeana* and *M. rotata*.

Table 26. Mortality of medic species after rains on 5 November through drought which ended on 12 December 1990 at Tel Hadya.

Species	Mortality %
M. noeana	94
M. polymorpha	6
M. rigidula 1900	55
M. rigidula 716	55
M. rotata	31
M. truncatula	30

In two species, large seeds germinated earlier than small seeds. Seed size was less at high density, suggesting that these seeds were produced under stress. On first principles one would expect that the seed coat would be thicker where the seed had ample time to mature in conditions of low stress (large seeds). Such did not appear to be the case, and, although this evidence is somewhat inconclusive, other evidence collected from dry and wet environments supports the idea that seeds produced under stress are likely to live longer.

When the soil was cultivated, the seeds were spread throughout the soil to the depth of cultivation. The soil was sampled at three depths: 0-3 cm, 3-6 cm, and 6-10 cm. In 1988, the seed germinated best from the greatest depth, probably because of better seed/soil contact and better retention of moisture. In the second year, the result was reversed, the seed germinating best from near the surface. This was probably because the buried seeds were subject to a whole summer of alternating high and low temperatures, the process that normally causes the seeds to lose their dormancy. In the first year, the soil was cultivated in late autumn, so all seeds would have experienced the same temperature regime. It was expected that the third year results would be similar to those of the second year, but there were no differences. Perhaps by this time the seed coats had eroded such that all seeds were losing their dormancy.

This research highlights ICARDA's approach to sustainable pasture-based farming systems. There is a need to understand the factors influencing the longevity of seeds and the behavior of seed banks to improve sustainability. The results show that by careful selection of varieties, and careful management of both grazing and cultivating, both the ley farming system and permanent pasture can be sustained indefinitely.

Interactions between Soil Fertility and Rhizobia Strains

In most legumes high soil nitrogen inhibits nitrogen fixation, while high phosphorus encourages it. In medics, however, little is known of the differences between species and their rhizobia in the way they react to low and high levels of nitrogen and phosphorus.

The response of several medics to nitrogen depended on the strain of rhizobia. For example, adding nitrate to *M. rotata* increased the number of nodules formed with rhizobia M28 but decreased it with other strains. Nitrate increased nodulation in *M. truncatula* and *M. polymorpha*, and decreased it in *M. rigidula* and *M. orbicularis*.

Not surprisingly, all hosts responded to phosphorus. However, again there were differences between species that seem to be related to rhizobia strain. For example, *M. rotata* needed less phosphorus when it formed nodules with the native rhizobia than it did with strains M29 and M3. These results could not be explained by differences in the effectiveness of the rhizobia.

ICARDA is increasing its research on the ecology of rhizobia. It hopes to predict the need and value of inoculation, and to use the most efficient medic/rhizobia combinations in conditions of low soil fertility.

A Feed Legume Based Farming System

Where rainfall is less than 300 mm, farmers in the WANA region produce livestock by feeding them barley and grazing the natural pastures. Barley is grown in rotation with fallow or continuously. Barley grown after fallow gives high yields, but only every second year. Total productivity is usually less than continual barley (Table 27), especially after nitrogen fertilizer. Both rotations risk soil degradation by using soil organic matter and nitrogen, and the fallow leaves the soil exposed. An alternative, which uses the land, provides a disease break and maintains soil fertility, is to use legumes in rotation with the barley. In the dry areas there are two categories of legumes available: feed legumes where the crop is resown every year, and pasture legumes where regeneration is spontaneous.

Table 27. The grain and straw yields of barley grown after vetch, lathyrus, barley, and fallow at El-Bab, Syria, in 1989/90.

	Vetch	Lathyrus	Barley	Fallow	SEM	Sig.
Grain	979	903	824	1155	74	**
Straw	1695	1628	1444	2134	100	**
Total	2674	2531	2268	3289	158	**

SEM is the standard error of the mean
** Significance of F value, $P<0.01$

ICARDA has been testing the feasibility of introducing feed legumes. The species chosen are *Vicia sativa* (vetch) and *Lathyrus sativus* (chickling). Both were tested for several years in dry areas. They resist frost, produce adequate amounts of seed and herbage, and are palatable to sheep. There is no evidence that either is toxic to sheep, although in southern India chickling is reported to cause lathyrism, a serious human disease.

The Center has been experimenting on eight farms near El-Bab in Northwest Syria to select varieties with low levels of the causative toxin. The district has areas of deep soils, where it is possible to grow cereal cash crops, and areas of shallow soils that grow barley for feed. Though experiments are being conducted on both soil types, the key objective is to improve rotations on shallow soils. On shallow soils, most farmers use a continual barley system and either graze the crop or harvest it to feed their sheep. ICARDA used two legumes as break crops and compared the resulting rotations with barley/fallow and continual barley.

In 1989/90, barley yields were better after either legume than after barley, but not as good as after fallow (Table 27). Legume yields were less than continual barley and vetch was much better than chickling (Table 28). The quality of the legumes was much higher than of the barley.

Table 28. The grain and straw yields of vetch and lathyrus after barley at El-Bab, Syria, 1989/90.

	Vetch	Lathyrus	SEM	Sig.
Grain (kg/ha)	238	174	42	*
Straw (kg/ha)	1418	567	147	**
Total	1656	741	182	**

SEM is the standard error of the mean. * and ** indicate significance of F values at $P<0.5$ and $P<0.01$, respectively.

Yields in 1989/90 were atypical in two ways: (i) usually chickling outyields vetch and (ii) in most years legume yields are similar to barley yields. Severe frosts in mid-March caused the low chickling yields.

The plots are grazed and lamb growth rates recorded. The experiment will continue and the data will eventually be analyzed by economists, and the results used to formulate advice to national governments. Depending on farmers' needs it should be possible to select productive feed legumes that are adapted to both the environment and the farming system.

Liveweight Changes and Supplementary Feeding of Sheep Grazing Grasslands

Grasslands comprise 30-40% of the land surface of Syria and Lebanon. They provide an important part of the diet of small ruminants, especially in spring. Farmers with access to grasslands own more sheep and make more money from their livestock enterprises than those without access. However, the communally-owned grasslands receive no inputs of fertilizer or seed, with little or no grazing management. Improving their productivity therefore presents ICARDA and its national collaborators with a formidable technical and social challenge.

Often the grasslands contain small but significant legume populations. If these could be increased either by improved grazing management or by applying superphosphate, herbage production and hence livestock productivity would be greatly improved. Low plant numbers are probably the result of over-grazing in spring, so redistributing grazing to winter and summer should increase seed set and hence plant numbers.

ICARDA, at its headquarters, has access to grassland that has small amounts of legumes and is deficient in phosphate. An experiment was therefore designed to compare three phosphate rates (0, 25, and 60 kg/ha) at two stocking rates (1 and 2 ewes/ha), and the plots grazed continuously. The Awassi ewes were weighed every week, and fed whenever their body mass fell below 45 kg. Milk production, and the number and growth rate of lambs were measured so that a full economic analysis will eventually be possible.

As was expected (Table 29), the proportion and amount of legume increased. The increase was least in the first year, and greatest in the last 2 years, showing that the effect of phosphate was cumulative. The increase in legume content will have reduced the dependency of the pasture on soil nitrogen, which at low phosphate would have been limiting. Table 30, which shows changes in organic matter, supports this hypothesis.

There were no significant differences in ewe body weight at the different phosphate rates in the first 2 years, although the lightest ewes were those grazing the zero phosphate plots. In the last 3 years there were significant differences during most of the year, especially in winter and spring (Fig. 41). Differences were greatest in 1987/88, a wet year, and were less in the following drought year. The reason was probably that all ewes had to be fed around lambing in 1988/89, which tended to equalize body weights. A better measure of treatment in the drought is the amount of supplementary feeding.

Table 29. Annual legumes as a percentage of available herbage in April each year at Tel Hadya.

Phosphate	1985	1986	1987	1988	1989	1990
0 kg/ha	20	5	16	43	17	12
25 kg/ha	27	14	32	63	34	24
60 kg/ha	30	15	37	64	46	34
SEM	3.8	2.1	3.0	2.5	3.4	2.3

Table 30. Soil organic matter (%) before (1984) and after (1989) five annual applications of phosphate (mean of two stocking rates) at Tel Hadya.

Phosphate	1984	1989	% increase
0 kg/ha	3.66	3.86	5.5
25 kg/ha	3.68	4.12	12.0
60 kg/ha	3.31	3.98	20.2
SEM	0.61	0.22	

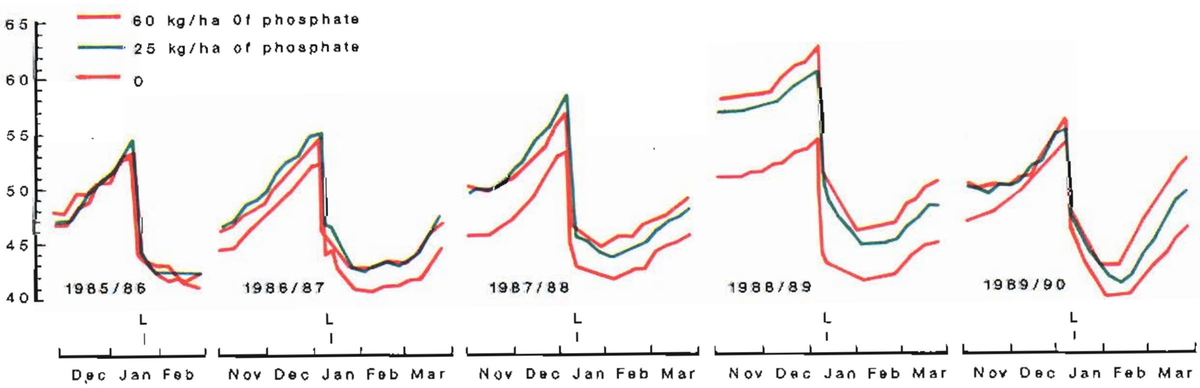
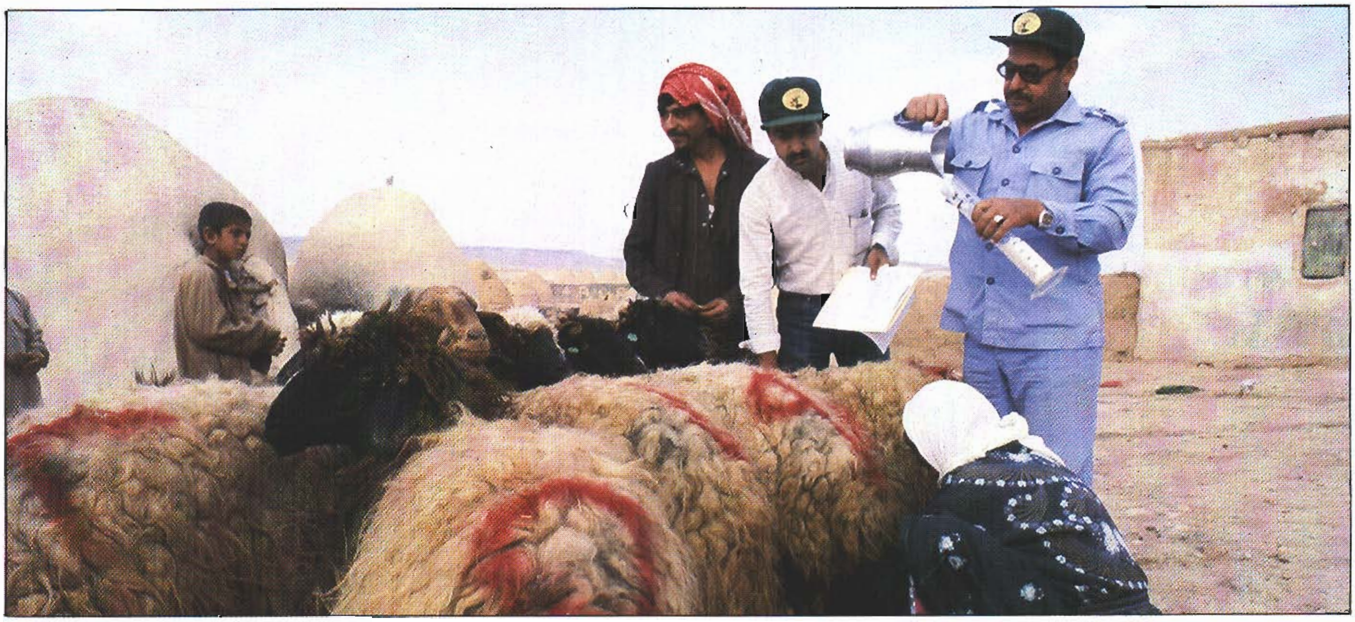


Fig. 41. Liveweight of ewes for 10 weeks before and after lambing (L), grazing pastures topdressed with 0, 10, and 25 kg/ha. Data are from five successive seasons.



Measuring milk yield in on-farm experiments to test the value of feed legumes.

Fig. 42 shows that in all years except the first, more grain needed to be fed to the zero phosphate treatment ewes than to those grazing plots topdressed with phosphate. The difference was 150 kg/ewe in the drought year, or about 400 kg/ha at the high stocking rate (the difference in supplementary feeding was greater at high than at low stocking rate). In 1989/90, phosphate cost 5.2 SYP/kg (SYP 11.2 = US$ 1), and barley 8.5 SYP/kg, so using phosphate at both rates was highly profitable. It is interesting that, in terms of supplementary feeding, using phosphate is likely to be most profitable in dry years, a result in contrast to most other new agricultural technologies.

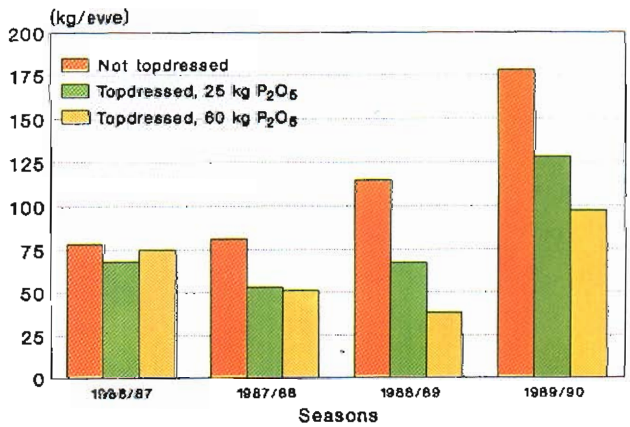


Fig. 42. **Supplementary feed (kg/ewe) fed to animals grazing pasture not topdressed with superphosphate, and pasture topdressed with 25 and 60 kg/ha phosphate.**

Training

During 1989/90, 714 scientists and technicians were trained at ICARDA (Fig. 43)--374 at headquarters in Aleppo, Syria and 340 in collaborative training courses organized in WANA countries. Participants came from 22 countries in WANA, 13 developing countries outside WANA, and 6 industrialized countries (Table 31). The number of women participants rose to 97, compared to 68 in 1988/89.

Of the training courses offered, 21 were short specialized and long-term courses organized at headquarters, and 20 in-country or sub-regional in collaboration with NARSs. Nineteen senior colleagues from WANA countries and two from China worked at the Center for varying duration of time as visiting scientists/research fellows. Over 21 M.Sc. and 19 Ph.D.

scholars representing nine countries conducted their degree-related research at the Center's facilities in Aleppo during 1990.

Apart from the core budget support for training activities, the Arab Fund for Economic and Social Development (AFESD) was the major funding source for Arab participants from WANA, and the Ford Foundation for the graduate research training program with particular emphasis on training women in agricultural and socioeconomic research. Other funding sources included AOAD, FAO, GTZ, IDRC, UNDP, USAID, and a growing number of multilateral/bilateral projects in research institutions.

A draft report on the training follow-up study, conducted in nine WANA countries during 1989, was published. A manual of procedures for training was also developed for use within ICARDA, and by donor organizations and trainees. A training materials specialist joined in mid-1990 to strengthen the production of audiovisuals, training manuals, and other related material.

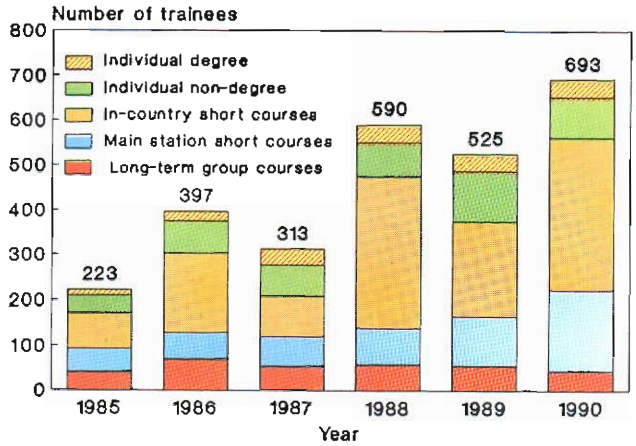


Fig. 43. ICARDA training participants, 1985-1990. Numbers do not include short-term visiting scientists/research fellows.

Table 31. Participants in ICARDA training courses (1985-1990).

	1985	1986	1987	1988	1989	1990	Total
Latin America & The Caribbean							
- Argentina	1	-	-	-	-	-	1
- Bolivia	-	-	-	4	-	2	6
- Chile	-	-	-	-	-	2	2
- Colombia	-	-	1	6	-	4	11
- Ecuador	-	-	1	5	-	15	21
- Mexico	-	-	-	2	-	1	3
- Peru	-	-	-	3	2	8	13
- Venezuela	-	-	-	2	-	-	2
Total	1	-	2	22	2	32	59
South Africa							
- Djibouti	-	-	-	-	-	-	-
- Ethiopia	6	27	38	67	28	15	181
- Kenya	-	-	-	-	-	-	-
- Nigeria	-	-	-	1	-	-	1
- Rwanda	-	-	-	-	-	-	-
- Somalia	1	1	-	1	2	1	6
- Tanzania	1	-	-	-	-	-	1
- Uganda	-	-	-	-	-	1	1
- Zimbabwe	-	-	-	1	-	-	1
Total	8	28	38	70	30	17	191

Table 31. Continued.

North Africa & the Near East							
- Algeria	1	45	63	16	34	33	192
- Bahrain	-	-	-	-	-	-	-
- Cyprus	1	1	-	-	3	5	10
- Egypt	5	33	13	85	58	45	239
- Iran	9	10	2	5	58	42	126
- Iraq	2	7	1	-	-	14	24
- Jordan	2	14	16	20	9	40	111
- Kuwait	-	-	1	1	1	2	5
- Lebanon	4	4	1	-	10	10	29
- Libya	-	3	-	-	1	30	34
- Morocco	62	36	12	82	58	81	331
- Oman	-	-	1	2	-	16	19
- Qatar	-	-	-	-	-	9	9
- Sudan	13	29	25	15	25	20	127
- Saudi Arabia	2	1	-	46	-	1	50
- Syria	53	55	72	67	110	134	491
- Tunisia	9	37	20	39	30	50	185
- Turkey	4	57	11	36	10	40	158
- United Arab Emirates	-	-	1	-	-	2	3
- Yemen, A.R.	4	11	4	41	15	3	78
- Yemen, PDR	5	3	5	6	7	24	50
- Yemen, Republic of (May 1990)	-	-	-	-	-	3	3
Total	176	346	248	461	429	604	2264
Asia and the Pacific							
- Afghanistan	-	1	-	-	-	4	5
- Bangladesh	1	1	-	1	-	2	5
- Bulgaria	-	-	-	-	-	1	1
- China	2	4	3	6	3	4	22
- India	1	1	3	3	-	-	8
- Malaysia	-	-	-	1	-	-	1
- Nepal	1	-	1	1	23	-	26
- Pakistan	28	7	4	6	24	11	80
- S. Korea	-	-	-	-	-	1	1
Total	33	14	11	18	50	23	149
Industrialized Countries							
- Belgium	-	-	-	-	-	3	3
- France	-	-	-	-	-	1	1
- Germany	1	5	8	12	9	7	42
- Greece	-	-	1	-	-	-	1
- Netherlands	2	2	2	2	3	4	15
- Spain	-	2	2	2	1	1	8
- United Kingdom	2	-	1	3	1	1	8
- United States	-	-	-	-	-	-	-
Total	5	9	14	19	14	17	78
Grand total	223	397	313	590	525	693	2741

Information Dissemination

ICARDA's efforts to gain on-line access to international databases continued in 1990. Through the courtesy of the Atomic Energy Commission, Damascus, the Center has gained on-line access to INIS (International Nuclear Information System database), Vienna.

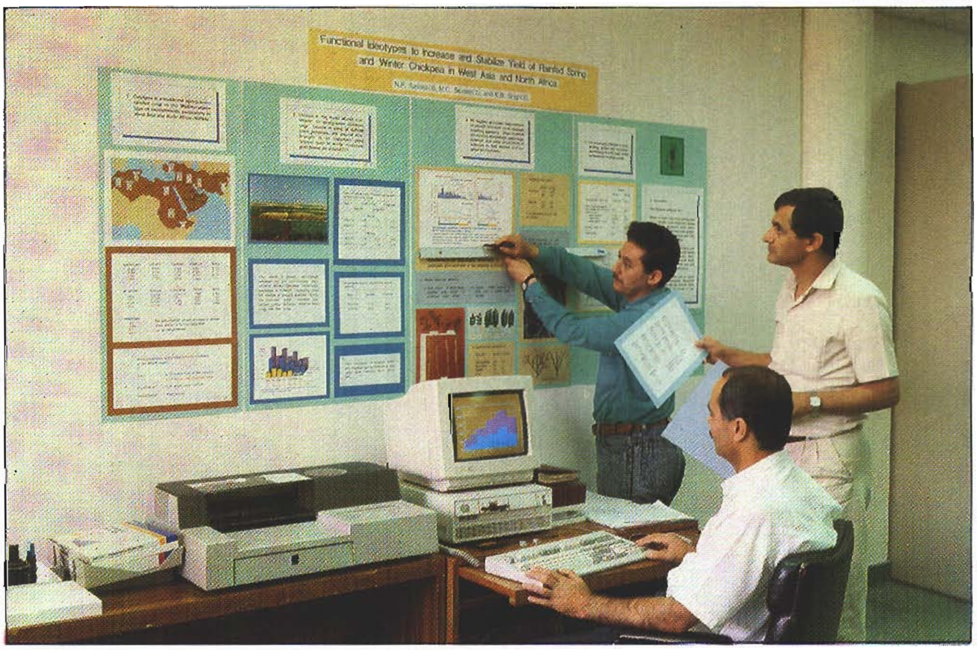
Five CD-ROM databases were acquired during the year: Food, Agriculture and Science (6000 publications of 20 international centers), AGRIS (international literature in agricultural science and technology from over 135 countries), CAB Abstracts (750 000 bibliographic references), AGRICOLA (2.5 million documents), and SESAME (50 000 citations in French).

By extracting bibliographic references from AGRIS, the Center developed its own databases on faba bean (FABIS) and lentil (LENS). An ILDOC database containing references to books, reports, and technical publications in the ICARDA library was established. A database of the Union Catalog of Serials (SRLS), developed by ICRISAT in cooperation with 14 IARCs including ICARDA, was also installed in the library. SLRS provides access to 5400 journals and monographic serials available in the cooperating centers.

As a first step to establishing a network of information personnel in WANA, the Center hosted a meeting of Syrian librarians. The meeting was useful in developing new contacts for information exchange, including ICARDA's access to ACSAD's databanks. The meeting developed guidelines for the expansion of the network to other countries.

Participation in the AGLINET depository libraries continued. In addition, 52 contact points were established with national libraries within and outside WANA to provide documentation services on ICARDA's publications to users outside ICARDA's mailing list. The contact points receive all important ICARDA publications and meet the requests from the readers in those countries by providing photocopies of the material requested or loaning out the document/s.

Sixty-three research articles were submitted to international journals, the highest number ever in any one year since the establishment of ICARDA; of these 40 had been published by the end of 1990. To meet the information needs of the Board of Trustees, publication of a Quarterly Progress Report continued. Thirty-seven major publications were produced in-house, in addition to others produced by external publishers (see Appendix 3). The Center's 1989 Annual Report, published in 1990, was well received by readers from all constituencies.



With the introduction of new computer hardware and software, the quality, speed of production, and output of Information Services products saw an unprecedented improvement in 1990. Here, staff develop a poster using computer technology.

A manual of Publication Policy and Procedures was developed to provide guidelines for producing information material to meet the specific needs of the various audiences of ICARDA.

Efforts to strengthen the public awareness activities continued. News releases on important events were distributed to both regional and international media.

A desk-top publishing facility in Arabic was established. Arabic versions of key documents were produced to accelerate information dissemination. A questionnaire was mailed to cooperators in WANA to explore the possibilities of sharing resources to produce information material in Arabic. A revised draft of "ICARDA Style Guide for Science Writing in Arabic" was developed.

Three Syrian librarians were trained in information management and retrieval.

Impact Assessment and Enhancement

No new technology, however impressive at experiment stations, has much value if it is not taken up and utilized by farmers. An important part of ICARDA's work, therefore, is to evaluate the factors determining the acceptability of new technologies and to develop methods to predict, monitor, and improve their adoption and fruitful impact at the national, community, and farm level. Such work includes

(i) collecting information on the needs and constraints of farmers to assist in the selection and design of relevant new practices that can be easily adopted;
(ii) developing approaches to introducing new practices into existing farming systems;
(iii) refining methods to assess the impact of innovations, the benefits and problems arising from them, and the implications for technology design; and
(iv) monitoring regionally the trends in crop production, policies affecting agriculture, labor supply, and other interacting social and economic factors.

ICARDA recognizes the need for partnership with NARSs in all these endeavors and aims to involve them fully in such work and to encourage them to develop their own capacity to conduct adoption and impact studies on a routine basis.

Adoption of Winter-Sown Chickpea in Syria

Traditionally, in Syria, chickpea is sown in spring. Although this allows the crop to evade conditions favoring the development of *Ascochyta* blight, flowering and grain production occur at a time of low rainfall and high temperature. In consequence, yields are low and unstable. Winter-sown varieties, developed for resistance/tolerance to blight and cold, reach the reproductive stage earlier and, therefore, have much higher yield potential. Over 10 years of trials, winter-sown varieties have consistently outyielded local spring-sown ones. Moreover, partial budgeting, based on records of the variable costs, indicates substantially higher net returns every year from winter chickpeas, despite local and seasonal differences in growth conditions.

A chickpea trial at Tel Hadya, Syria: spring-sown (foreground), winter-sown (background). Over 10 years of trials, ICARDA/NARSs-developed winter-sown chickpea varieties, with resistance/tolerance to *Ascochyta* blight and cold, have consistently outyielded the traditional spring-sown varieties.

Production Trends

Spring-sown chickpea is Syria's second most important food legume after lentil. Over the past 20 years, matching the large increase in the total area planted to rainfed crops, the area under chickpea has increased by an average of about 3% per annum, to around 70 000 ha; but average annual production has increased only by about 1% per annum, to around 40 000 tonnes. Apart from annual fluctuations, the trend of per hectare productivity has been downward (Fig. 44).

One anticipated advantage of winter-sown chickpea was that, with earlier planting and more efficient use of moisture, yields would be less subject to rainfall variation. However, a survey of crop statistics has shown that, on a per hectare basis, mean chickpea yields are already less variable than those of other major crops (coefficient of variation 22%, compared with 35% for lentil and 37% for wheat). Rainfall has a relatively greater impact on the variability of area planted than on actual yield. This is because the later planting time of spring chickpeas allows a planting decision to be made according to rainfall already received and not, like winter-sown crops, on expectations of rainfall. In dry years apparently, some farmers choose not to plant, thereby saving production costs and avoiding the risk of crop failure. The existence of this option for spring but not for winter chickpea has important implications for the adoption of the winter varieties.

Chickpea in the Farming System

Chickpea is largely a rainfed crop, with only about 5% of total production under irrigation. In the past, the main areas of production were in the wetter parts of the northwest and southwest of the country (Fig. 45). Until about 1979, when there was a devastating drought in southern Syria, almost three-quarters of all chickpea planting was in the southwest, and Deraa province (i.e. the Hauran plain) alone accounted for 43% of the national total. But there have been shifts in the national production pattern in recent years. The area planted in the southwest has fallen slightly, but between 1971-75 and 1982-87 that in the northwest grew substantially, with a total increase of 74%. Currently, about 37% of the national chickpea area is in the northwest. Interestingly, the Hassakeh province in the northeastern region has now developed into a production area.

Three factors may have been important for the shift away from the southwest. The first is yield performance; average annual yields declined more steeply in the southwest than the national average. The second factor is mechanization. The terrain in the southwest is difficult. Situated amidst ancient lava flows, the land is rough and full of stones. Mechanization of chickpea, land preparation, seeding, and harvesting has not progressed there as fast as in the northwest and, especially, the northeast. So, relative to the southwest, harvesting costs tend to be lower in the northwest and northeast. The third factor may have been the success of a government program to replace fallow with winter crops in the southwest.

Chickpea presents planners and economists with a problem. National production is almost stagnant and varies widely from year to year, for example 64 000 tonnes in 1981 but 11 000 tonnes in 1979. But at the farm level there is no perceived problem. If the farmer is practising the traditional wheat-based farming system, the spring chickpeas act as a desirable buffer against the risk of economic loss arising from the unreliability of

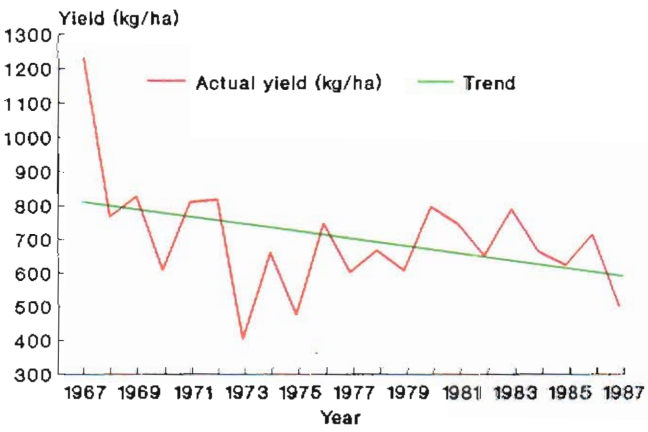


Fig. 44. Chickpea: actual yield and trend T+Yield = 806 - 10t.

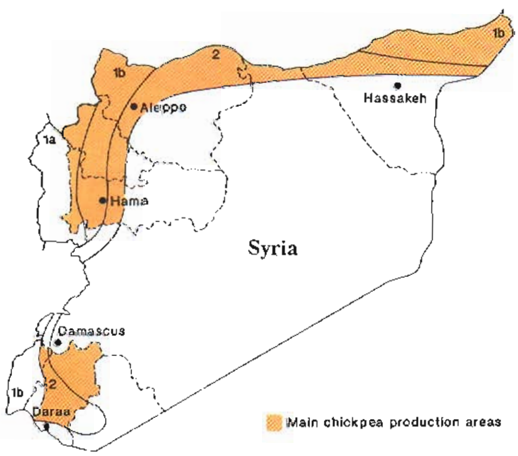


Fig. 45. Location of stability zones and chickpea producing areas.

the winter rains. In fact, being able to vary the area planted to spring chickpeas from year to year as a protection against loss from crop failure is one of the major benefits the crop gives the farmer. A predictable yield, even if low, may be preferred to an unpredictable yield, no matter how potentially high.

Assessment of Potential Adoption of Winter Chickpea

In 1989/90, the Socioeconomic Studies and Training Section of the Syrian Scientific Agricultural Research Center, together with ICARDA, conducted a farm-level survey in Aleppo, Hama, and Hassakeh provinces to assess the performance of winter-sown chickpea under farm conditions. Post-harvest interviews were conducted with two groups of farmers, those growing winter chickpea for the first time and those with at least 1 year's experience. An important question in each case was whether the farmer intended to adopt winter chickpea, i.e., grow it again in 1990/91. Generally, those farmers with longer experience of the crop were more likely to adopt, but in both groups there were large differences between provinces (Table 32).

These differences reflected the nature of the 1989/90 growing season. In Aleppo and, more so in Hama, it was a very dry season, with frosts persisting until late March in some places, whereas in Hassakeh conditions were wet and fairly mild. Thus, yields and financial returns were favorable in Hassakeh but unfavorable or very unfavorable in Aleppo and Hama. In fact, over much of these two western provinces, the season was poor for both winter and spring-sown chickpeas.

Though great caution is required in interpreting a single year's data on adoption, the survey provides useful indicators for subsequent actions. The major reasons cited for growing winter chickpea in 1989/90 were expectations of high yield, high net benefit and, in the case of Hassakeh farmers, many of whom have a large farm area, the possibility of mechanical harvest. Asked to compare winter and spring chickpeas, many farmers noted the more vigorous growth and frost tolerance of the winter varieties and the potential for higher and more assured yields; and these points were made even by some farmers who had decided not to continue with winter chickpea in 1990/91. Weather apart, few serious production problems were reported. Perhaps because of the harsh weather in the northwest, the cost of weed control was not rated as serious a problem as could be the case in better seasons. Comparative evaluations of the two winter varieties available showed notable differences (Table 33). Ghab 1 was slightly more favorably rated than Ghab 2, particularly for seed size.

Determining the economic threshold for adoption is a difficult exercise, requiring a much larger data set than currently available. Each farmer has unique economic circumstances and expectations, and any patterns and commonalities among groups of farmers will likely vary with location, farm size, land use, etc. The net revenue threshold for adoption in 1989/90 appeared to lie somewhere between 2 500 and 6 800 SYP per hectare (SYP 11.2 = US$ 1), but this figure would obviously vary from year to year depending on the season and the comparative performance of spring chickpea. For example, in Aleppo, where the net revenue differences between winter and spring chickpea

Table 32. Distribution of farmers intentions to adopt winter chickpea in three provinces in Syria, 1989/90.

	Farmers growing winter chickpea for first time		More experienced winter chickpea growers		
Location	Adopters	Non-adopters	Adopters	Non-adopters	Total
Hama	5	18	2	7	32
Aleppo	15	19	12	7	53
Hassakeh	11	5	6	2	24
Total	31	42	20	16	109

Table 33. Positive and negative responses of farmers in varietal comparison of Ghab 1 and Ghab 2 (frequency mentioned in percentages*) in Syria, 1989/90.

	Ghab 1		Ghab 2	
Characteristics	Positive	Negative	Positive	Negative
Seed size	70	16	50	25
Frost tolerance	49	29	35	33
Blight resistance	57	20	57	13
Wilt resistance	56	21	55	15
Orobanche resistance	59	16	65	5

* Neutral and 'don't know' answers not counted.

were relatively slight, the adoption rate was markedly lower than in Hassakeh. In addition, net revenues (and risks) from winter chickpea need to be compared with those for other crops in the farming system. Substitutability with spring chickpea is not the only issue in winter chickpea adoption. Because winter sowing requires a land-use decision and allocation of resources early in the season before the rains, it is better understood as a separate crop in terms of management and adoption rather than simply a variation, albeit an improved one, of spring chickpea.

Questions exploring the subject of expanding winter chickpea go beyond the various constraints faced by farmers during the initial adoption year. The most important of them appears to be low selling price. This reinforces the impression given by farmers of their initial reasons for growing winter chickpea and of their adoption decisions following harvest. Economic return will be the key variable influencing the future course of winter chickpea adoption in Syria.

Conclusions

The present chickpea situation in Syria is one of uncertain production from one year to the next. Although spring planting allows farmers to escape the risk of crop failure due to poor rainfall, it also means they must accept lower production levels and a less than optimal land-use intensity. Since economic pressure on land is constantly increasing, the economic benefit farmers can obtain from spring chickpea is arguably in decline relative to other crops in the farming system.

Winter chickpea promises to solve these problems by means of a higher yield potential and more productive use of land. In principle, winter varieties could serve as a mechanism for stabilizing the area planted, allowing planners and farmers alike to allocate resources in a more rational manner than presently possible. However, even if winter sowing stabilizes crop area, there remains the question of whether it will stabilize yields and economic returns. With spring planting, in a dry year a farmer may decide not to plant. He gets no yield, but neither does he lose an investment. With winter planting, there can be no such guarantee. Nonetheless, prerelease experiments and verification trials indicate that the higher yields obtained in most years could outweigh the risk of losing planting investments in very dry years. Whether or not farmers share this logic can be established only by continuing the monitoring of adoption in future years.

Supplemental Irrigation: From Research to Extension

In 1985/86, ICARDA started a cooperative research program with the Syrian Ministry of Agriculture and Agrarian Reform (SMAAR) on the supplemental irrigation of winter crops, particularly wheat. It included diagnostic surveys of rainfed and supplementally irrigated wheat production, basic on-station research into supplemental irrigation, and on-farm research and demonstrations. Throughout, the philosophy has been "deficit irrigation," scheduling supplemental irrigation according to minimum and maximum crop water requirement, based on estimated profitability. It was shown that, except in below-normal rainfall seasons, optimum yields are obtained by applying only 40-60% of the irrigation required to replenish fully the soil profile. The 4-year mean application in the optimum treatments in trials at Tel Hadya was 117 mm, but this was sufficient to double grain yields and greatly reduce their annual variability (Table 34). More generally it was concluded (from research data, surveys, and secondary sources) that yields of rainfed wheat in zone 1 (annual rainfall 350-600 mm and not less than 300 mm in 2 years out of 3) and zone 2 (annual rainfall 250-350 mm and not less than 250 in 2 years out of 3) can be increased from an average of 1500 kg/ha to about 5000 kg/ha by supplementing rainfall with 600-1800 m^2/ha of irrigation water (60-180 mm of rainfall equivalent).

The high water-use efficiency of supplementally irrigated wheat shown in Table 34 implies high economic returns. One cubic meter of rainwater produced, on average, 2.11 kg dry matter (0.69 kg grain and 1.42 kg straw), equivalent to a gross revenue of 3.78 SYP, whereas one cubic meter of irrigation produced, on average, 5.27 kg dry matter (2.97 kg grain and 2.30 kg straw), equivalent to 13.35 SYP.* Taking the cost of water in 1988 to be 1.23 SYP/m^3, the net revenue was

* Prices used are 3.90 SYP/kg for grain, and 0.77 SYP/kg for straw as estimated from the farm survey conducted in 1988; corresponding prices for 1990 are 8.50 SYP/kg for grain and 1.50 SYP/kg for straw.

Table 34. Effects of rainfall and optimum supplemental irrigation on grain and straw yields over 4 years at Tel Hadya.

	Water (mm)			Grain yield, kg/ha		Straw yield, kg/ha	
	Rainfall	SI	Total	Rainfall	SI	Rainfall	SI
1985/86	315	150*	465	2970	5820	3710	6680
1986/87	316	60	376	1780	5350	4620	8000
1987/88	504	75	579	5040	6440	9400	9250
1988/89	234	183	417	740	3830	2980	5330
Mean	342	117	459	2630	5360	5170	7320
SD	115	67	88	1850	1120	2890	1690
CV%				70	21	56	23

* Includes 30mm added to all plots (including rainfed) to promote germination.

12.12 SYP/m^3 of irrigation water. Profitability has increased considerably in the last 2 years, as grain and straw prices have approximately doubled. Estimated net revenue per cubic meter, based on 1989/90 prices, is about 26.90 SYP.

However, farm survey data indicate that farmers' net revenue from their use of supplemental irrigation is much less, due both to lower yield levels and much higher application rates. Farmers' yields have been found to be 22% lower than those of researchers', on average, even though they apply three times the optimum amount of water (Fig. 46). In terms of 1988 prices, per hectare net profit of farmers in normal rainfall seasons was only 20-25% of that

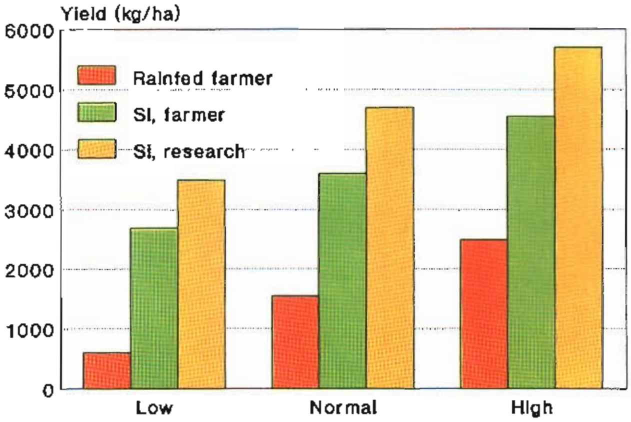


Fig. 46. Wheat yields in low, medium, and high rainfall seasons: research vs. farmers' practices. SI = Supplemental Irrigation.

achieved under research conditions; and in low-yielding seasons farmer investment in supplemental irrigation of wheat could result in monetary loss. Yet, in such seasons, rainfed wheat could give even greater losses (Table 35).

Recent increases in the official wheat price have now substantially altered the situation, and supplemental irrigation, even well below optimum efficiency, has become more attractive to farmers. Even

Table 35. Comparison of per hectare profitability of supplemental irrigated and rainfed wheat in high, low, and normal rainfall seasons: research vs. farmer plots in Syria, 1985/86-1990/91.

	High	Low	Normal	Av. 3 season
Research, SI				
Profit 1 kg (SYP)	2.57	1.73	2.31	2.28
Yield (kg/ha)	5640	3450	4720	4620
Total profit (SYP/ha)	14495	5970	10900	10530
Farmer, SI				
Profit 1 kg (SYP)	1.35	-0.26	0.71	0.72
Yield (kg/ha)	4500	2760	3600	3620
Total profit (SYP/ha)	6075	-720	2560	2610
Farmer, rainfed				
Profit 1 kg (SYP)	2.45	-2.55	1.66	1.56
Yield (kg/ha)	2490	560	1610	1540
Totral profit (SYP/ha)	6100	-1430	2670	2400

SYP = Syrian Pounds.

so, there is apparent potential for greater profit: from water saving, using improved irrigation scheduling; from savings in other inputs like seed and nitrogen fertilizer; and from potential yield increases. Extra benefits from research practice over farmers' practices are estimated at 7 800 SYP/ha and 14 330 SYP/ha according to 1988 and 1990 prices, respectively.

To check this potential, it was necessary to test and demonstrate improved supplemental irrigation techniques to a wide range of farming communities. So, the cooperative work between ICARDA and the Syrian Directorate of Irrigation and Water Use was extended to include the Directorate of Agricultural Extension, and seven farm demonstration trials were successfully completed in 1989/90.

As the season was very dry (see Appendix 1), differences between rainfed, deficit, and non-deficit irrigation treatments were large (Table 36), but between-sites variability was greatly reduced by both irrigation treatments. In agreement with research results, these demonstrations showed that in dry seasons wheat should be irrigated to 100% of the water balance requirement, because deficit irrigation, under such conditions, may significantly reduce the profitability. Gains from water saved by deficit irrigation averaged about 3045 SYP/ha, but losses due to yield reduction were estimated at 6296 SYP/ha, making a net loss of 3251 SYP/ha.

Nevertheless, deficit irrigation (averaging 1240 m^3/ha) increased yields over those of rainfed wheat by 660% and greatly reduced variability. An extra investment of about 3000 SYP/ha in deficit irrigation increased gross revenue by 31 000 SYP/ha. Whether farmers should employ a deficit or non-deficit approach in dry seasons depends both on actual water availability and on the opportunity cost of not using the water on other crops.

It is hoped to continue these demonstrations for 4-6 more years to verify crop performance under deficit irrigation conditions over a range of weather conditions, and to provide experience to extension agents on irrigation scheduling. This experience is the core element for a successful transfer and adoption by farmers. Given the very different annual rainfall patterns, each year has its own supplemental irrigation schedule. Farmers are not able to determine this themselves. So, it is necessary to establish as many demonstrations as possible and to transfer their schedules to neighboring wheat producers by personal contact or, more effectively, by radio/TV.

Table 36. Grain yield and water applied in seven demonstration fields in Syria, 1989/90.

	100% water balance		50% water balance		Rainfed
	kg/ha	m^3/ha	kg/ha	m^3/ha	kg/ha
Um Housch	4320	1350	3790	675	1620
Kebbaseen	5250	2200	4500	1100	750
Abu Kalkal	4320	2500	3960	1250	450
El Kubba	5040	2250	4320	1125	300
Bozhic	5400	3000	4320	1500	Grazed
Susian	5250	3000	4500	1500	750
Karakuzac	5445	3060	4125	1530	Grazed
Av. 7 sites	5003		4216		553
SD±	485		270		568
CV%	10%		6%		103%

Outreach Activities

Since its establishment, ICARDA has consistently strived to develop, maintain, and strengthen partnerships with NARSs, particularly those in WANA, to jointly pursue the common goal of sustainable agricultural production and preservation of the natural resource base. In most cases the partnerships have been formalized into written agreements (see Appendix 8) which spell out the areas of cooperation, program of work, and division of responsibilities.

While a greater proportion of the outreach activities is supported from the core budget, the special project funding (see Appendix 6) plays an important role in "filling the gaps" in these activities. The special projects are useful in areas in which an ICARDA involvement may be needed for a few years, after which the national programs themselves become responsible for those activities. In addition, ICARDA has been increasingly strengthening its collaboration with advanced institutes in industrialized countries for the benefit of its headquarters and outreach research programs (see Appendix 12).

The Center has grouped its outreach activities into six regional programs (Fig. 47) with a view to (i) ensure an efficient use of its resources, (ii) eliminate duplication of effort, (iii) balance activities according to the needs of each country, and (iv) use the spillover of research results from one region to another with similar agroecologies and infrastructure. Other considerations that have guided the establishment of these programs include the commonalities of geography, ecology, and constraints to production in each region. The programs are:

1. The Highland Regional Program
2. The Arabian Peninsula Regional Program
3. The West Asia Regional Program
4. The Nile Valley Regional Program
5. The North Africa Regional Program
6. The Latin America Regional Program

The regional programs link scientists both within countries and within the region; promote leadership at the national and regional levels; engender cooperation in solving problems common to a group of countries; capitalize on the complementarity between countries; acquire, pool, and optimize the use of scarce resources; and encourage self-reliance in research and development.

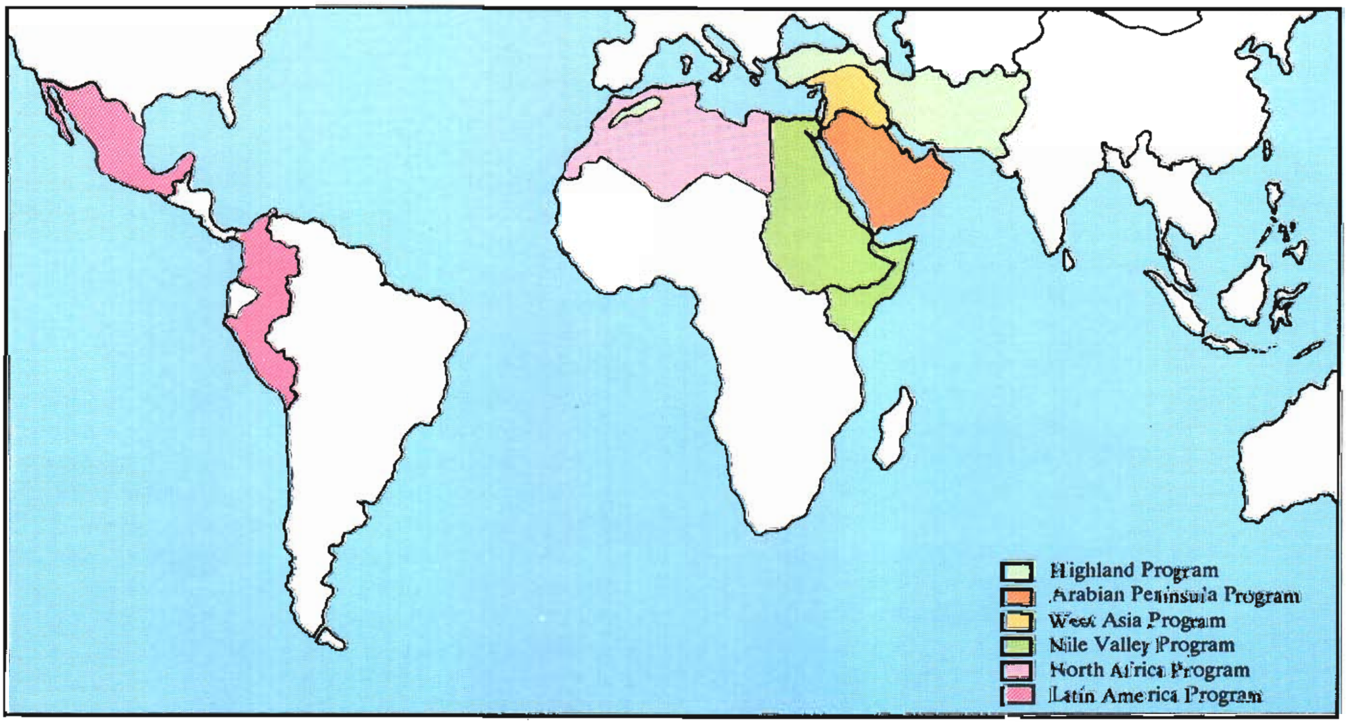


Fig. 47. ICARDA has grouped its outreach activities into six regional programs, based on commonalities of geography, ecology, and constraints to production in each region.

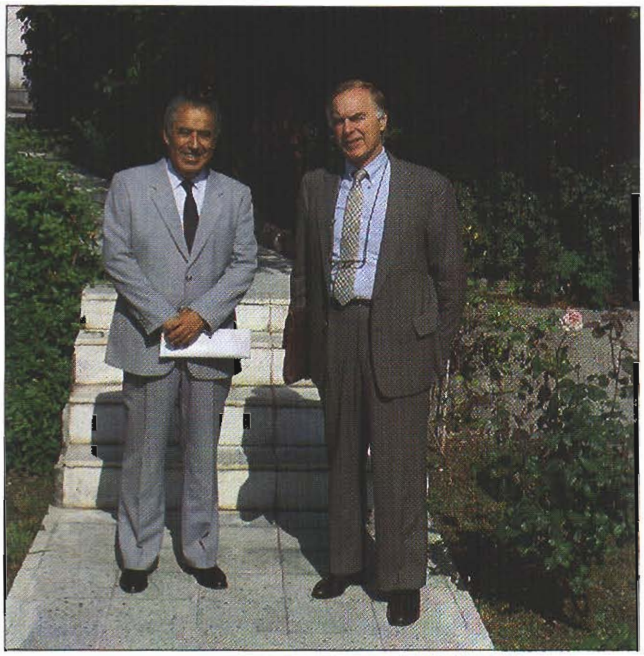
While the regional program activities emphasize interdisciplinary collaboration between neighboring countries, specific problem-oriented networks operate both within and across the programs. These networks are built around a commodity or discipline, and bring together scientists working within the same or different countries, foster a two-way flow of information between national scientists and ICARDA, and extend appropriate technologies to NARSs.

Highland Regional Program

This Program focuses on the highlands of WANA, which constitute about 40% of the total agricultural land and contribute nearly 30% to the region's overall agricultural production. However, the potential of highlands remains underexploited by research and development programs because, among other reasons, they are subject to extremes of weather conditions, are not easily accessible, and their soils are degraded. In WANA, highlands are found in Turkey, Iraq, Afghanistan and Pakistan in the east; and in Algeria and Morocco (the Atlas mountain range) in the west.

With generous funding from the Government of Italy, ICARDA's Highland Regional Program (HRP) was formally established at the joint CIMMYT/ICARDA office in Ankara, Turkey in July 1990. The major objective of HRP is to support agricultural research in areas in WANA with elevations over 1000 meters above sea level, or where winter wheat/barley is the dominant crop. To develop a work plan, HRP organized a first full-scale coordination meeting between ICARDA, CIMMYT and the Turkish Ministry of Agriculture, Forestry and Rural Affairs in October 1990 at the Ministry's Central Research Institute for Field Crops. Agreements were signed between ICARDA and the Universities of Cukurova and Ankara to facilitate future collaborative research and training activities (see Appendix 8).

In mid-November the long awaited agreement between the Ministry of Agriculture of the Islamic Republic of Iran and ICARDA was signed for the establishment of a large-scale outreach project in 1991/92 in Marageh in Northwest Iran. Fully financed by the host country, the project will assist the Ministry to strengthen its research capabilities in the highland and rainfed areas of Northwest Iran. The project will run for 5 years initially, and will involve large-scale breeding and agronomy efforts for cereal and food and forage legume crops.



In furtherance of their cooperative efforts, ICARDA's DG, Dr Nasrat Fadda (left), and CIMMYT's DG, Dr Donald Winklemann, visited the joint CIMMYT/ICARDA office in Ankara, Turkey, which, in 1990, became the new home for ICARDA's Highland Regional Program.

With the establishment of the Highland Regional Program, ICARDA's oldest highland outreach project--MART/AZR (Management of Agricultural Research and Technology/Arid Zone Research), funded by USAID, and based at the Arid Zone Research Institute (AZRI), Quetta, Pakistan, found a place in the Center's regular regional program structure. In late spring 1990, a reshuffle of ICARDA personnel took place at AZRI to match the changes in research activities in the second phase of the grant for the MART/AZR project. The new research thrusts will be pursued in a collaborative mode between AZRI and ICARDA until late 1992. There are four specific areas that will be emphasized: (i) sustainable range and small ruminant management strategies, (ii) improved water-harvesting systems, (iii) germplasm evaluation, and (iv) the economic evaluation of new technologies. This new endeavor will help transfer to farmers the new technologies identified and tested during the first phase of the MART/AZR project.

During 1990, the MART/AZR project activities were carefully reviewed and consolidated. A selection of important achievements of the project is reported below.

The benefits of improved feeding during pregnancy and lactation on ewe fertility and lamb growth rates have been demonstrated to farmers. A survey of livestock marketing suggested that, contrary to common assumptions, intermediaries may not be taking an unfair share of the retail price.

Fourwing saltbush was found to be a valuable winter feed to supplement the sparse range vegetation which is usually unable to provide sufficient energy, protein, and phosphorus to meet the small ruminants' needs.

Catchment basin water-harvesting continued to produce modest increases in yields of cereal and forage crops but waterlogging sometimes reduced yields.

Seed yields of woollypod vetch decreased after seed rates increased above 60 kg/ha. Cereal responses to manure and fertilizer application were low under rainfed conditions; a yellow rust epidemic on wheat indicated the importance of releasing new lines resistant to this fungal disease.

Arabian Peninsula Regional Program

The Arabian Peninsula Regional Program (APRP), supported by the Arab Fund for Economic and Social Development (AFESD), serves the following countries: the United Arab Emirates (UAE), Bahrain, Qatar, Kuwait, Saudi Arabia, the Sultanate of Oman, and the Republic of Yemen. The main objectives of this program are to enhance agricultural research and provide appropriate training for the improvement of barley, bread wheat, durum wheat, food and feed legumes, pasture, forage and livestock production and the related farming systems; and to bridge the yield gap between the research station and farmers' fields.

The major constraints common to agricultural development and transfer of improved technology in the Arabian Peninsula region are drought, heat, salinity, diseases and pests, weeds, inadequate seed industry, and lack of trained personnel.

In the 1989/90 season, improved germplasm of barley, wheat, food legumes, and forage crops was provided to the participating countries. Varietal description and evaluation of the common and improved wheat and barley cultivars grown in the

Senior NARS officials and scientists evaluating wheat nurseries in the United Arab Emirates.

Arabian Peninsula was initiated in cooperation with ICARDA's Seed Production and Genetic Resources Units.

Wheat and Barley Regional Crossing Blocks for the Arabian Peninsula were also initiated at ICARDA in the 1989/90 season in cooperation with the Cereal Improvement Program. In this work, ICARDA's high-yielding lines and cultivars are crossed with the adapted cultivars of the Arabian Peninsula to develop high-yielding and widely adapted varieties.

Over 50 trainees from the Arabian Peninsula participated in ICARDA's training courses during 1989/90 (see Table 31).

A traveling workshop on food legumes and cereal crops was organized in the Sultanate of Oman. In response to a request from the Republic of Yemen, a weed control specialist from ARC, Giza, Egypt was appointed to provide consultancy services to that country in March 1990. A weed control research work plan for 1990/91 was developed, and the requested herbicides were provided by ICARDA.

The third Annual Coordination Meeting for the Arabian Peninsula, scheduled for October 1990 in Al-Ain, UAE, had to be postponed due to the unexpected developments in the region.

West Asia Regional Program

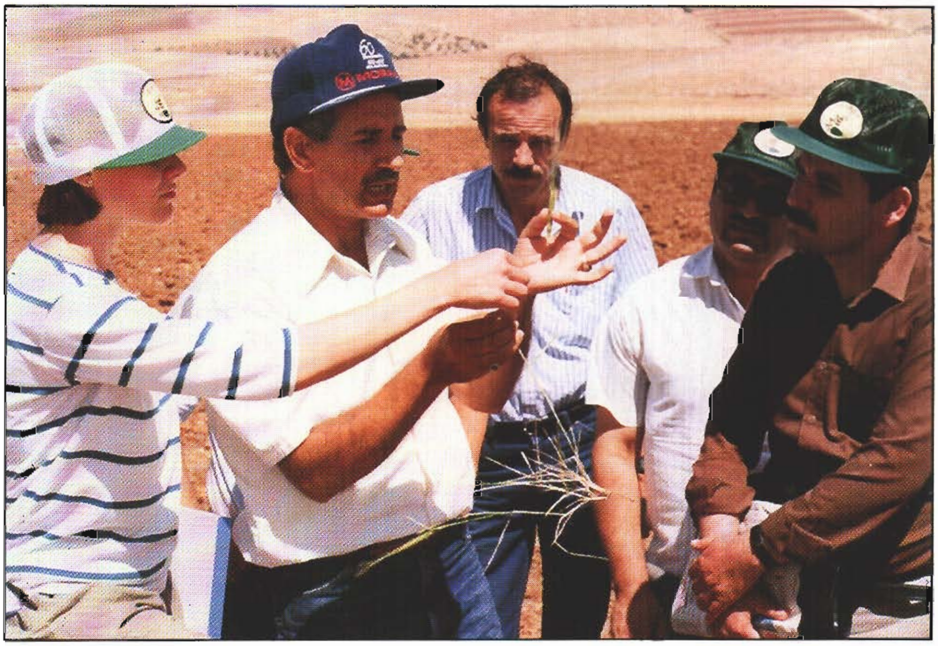
The West Asia Regional Program (WARP) seeks to serve Syria, Jordan, Iraq, Cyprus, Lebanon, and the lowlands of Turkey. Integrated into WARP activities is a Mashreq Project, funded by the UNDP and AFESD, for increasing the productivity of barley, pastures, and sheep in critical rainfall zones of Syria, Jordan and Iraq, and for the transfer of technology to farmers.

In 1989/90, results from eight on-farm trials in zone 2 (annual rainfall 250-350 mm and not less than 250 in 2 years out of 3) and zone 3 (annual rainfall greater than 250 mm and not less than this in 1 year out of 2) in Syria indicated that fertilizer application increased barley grain yield by 30 to 45% in zone 2 and by 35 to 65% in zone 3.

In Jordan, in 25 farmer-managed demonstrations of fertilizer application to barley, a grain yield increase of 5 to 100% was obtained according to site and cultivar. The same trend was observed with straw yield.

Economic analysis showed that fertilizer application in barley could increase farmers' return by over 50%.

The recommended package of practices for barley production was demonstrated in 17 farmers'



The genetic resources training course participants discuss wheat wild species in Jordan.

fields in Jordan. The average grain yield was 40 to 70% higher than from farmers' practices.

Four on-farm barley trials in zones 2 and 3 in Syria showed that seeding rate of 100 kg/ha was optimum, as compared to 150 or 200 kg/ha used by most of the farmers in the area.

Two dual-purpose barley lines were in pre-release seed multiplication in central Iraq.

Several forage legume species were evaluated in five dry sites (rainfall 200-280 mm) in Jordan to replace fallow in the fallow-barley rotation. Direct grazing of these forages by sheep is under investigation with emphasis on crop-livestock integration at the farm level.

In cooperation with farmers, extension personnel and researchers, work on transferring the available technology in animal production was initiated in Syria in May/June 1990. The components of the technology include: increasing birth rate by synchronization (using hormones and other methods), using improved rams for breeding, and demonstrating the effect of flushing ewes on lamb weight (preparing sheep for breeding by improving the ration for a time before turning the rams and ewes together).

In Iraq, WARP assisted in the establishment of a sheep breeding station at Al-Radwanieh, near Baghdad. Seventy improved rams and ewes were purchased from Turkey; the national program provided other breeds.

In Jordan, one lentil and two chickpea cultivars were released (see Appendix 2). One wheat and two barley lines were in the prerelease evaluation phase.

Human resource development through training courses and workshops continued to receive high priority. Four training courses on forage production and technology transfer, and three regional courses in lentil harvest mechanization, genetic resources, and seed testing were organized. A food legumes traveling workshop was hosted in Jordan.

A coordination meeting with Jordan was held in Amman in August 1990. Another coordination meeting was held with Syria in October 1990 at Tel Hadya. The meetings reviewed the 1989/90 season research results and developed work plans for 1990/91.

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, and lentil) and cereals (barley in Egypt and, in cooperation with CIMMYT, wheat in Egypt and Sudan). The program in Ethiopia covers field peas, an additional cool-season legume, and only the training component of barley in cereals. Like its predecessor (the Nile Valley Project), the NVRP follows a strategy which involves a multidisciplinary, multi-institutional, and problem-oriented approach making full use of the expertise, human resource, and infrastructure available in the participating countries. Emphasis is on on-farm research to develop technology suitable for local conditions. ICARDA collaborates with the three countries in developing annual work plans, providing germplasm and technical, logistic and management support, and training.

A Regional Research Coordinator was appointed for NVRP in August 1990 to further enhance coordination at national and regional levels. Funding continued from the EEC for Egypt, the Government of the Netherlands for Sudan, and SAREC of Sweden for Ethiopia.

Both the Ethiopian and Sudanese Governments have requested the respective donors for an extension of the grant for 3 more years beyond December 1990. EEC support for the Egyptian component will continue until the end of 1993.

Faba Bean

Back-up research and on-farm activities over the past 5 years have contributed to a 32% increase in faba bean production in Egypt, with average yield rising from 2520 kg/ha to 2740 kg/ha. Yields increased by 73 to 102% in pilot production plots sown with *Orobanche*-tolerant cultivars and those treated for *Orobanche* control. Two hybrid populations, 714 and 717, found promising for chocolate spot and rust resistance, yielded 21 to 43% higher than the local checks Giza 3 and Giza 402. Two new *Orobanche*-resistant cultivars, Giza 461 (selection from the cross Giza 3 X ILB 938) and Reina Blanca will soon be released to farmers in the North Delta region and new areas (Nubaria region), respectively.

Pilot production demonstration plot of lentil (F 370) in Bahera, Egypt, jointly managed by farmers and researchers.

Both cultivars have proved to be high yielding, resistant to chocolate spot and rust, and have a good seed quality. Of 792 lines screened for aphid resistance, the following seven were identified as promising: BPL 3116, 3129, 3345, 3347, 3351, 3416, and 3474.

In Sudan, cost: benefit analysis of the faba bean improved production package (newly released cultivar, weed and insect pest control) at Dongola showed a net profit of LS 5420 (about US$ 450) per hectare, averaged over six farmers. Similar results were obtained in other demonstration plots in traditional and non-traditional faba bean areas. The breeding line 00104 will be recommended for release in the non-traditional areas in view of its yield superiority and stability over several seasons. The herbicide Pursuit (0.05 kg a.i./ha) alone and in mixture with Goal (0.24 kg a.i./ha) increased faba bean yields by 130 and 170%, respectively, over the unweeded check (1160 kg/ha).

In Ethiopia, field observations (crop was being harvested at the time of writing) of the 1990 popularization plots at Sademo and Guntula confirmed the superiority of the recommended production package (improved cultivar CS 20DK at 200 kg/ha seed rate, 100 kg/ha DAP fertilizer and one handweeding) compared to farmers' practices. Yield was estimated at about 3000 kg/ha and 1200 kg/ha from the recommended package and traditional practices, respectively. A diagnostic survey (54 farmers at random) of adoption of recommended practices in the central zone indicated that 61% of the farmers had adopted the recommended improved cultivars; 32%, P fertilizer application; and 50%, weed control. Several lines selected from local landraces were found to be promising and showed higher pod set compared to the standard improved check CS 20 DK, particularly in the pre-national trials.

Lentil

The recently started program of lentil demonstration plots in Egypt has inspired the farmers to introduce the crop to the Delta region. The Sharkia and Kafr El-Sheikh Governorates in the Delta accounted for more than 50% of the 1989/90 hectarage (8000 ha). Pilot production plots of the recommended package (cultivar, seed rate, P fertilizer application, irrigation, weed and insect pest control) produced yield increases of up to 22% over farmers' practices. In back-up research, 70 lentil lines outyielded the standard check Giza 9. Of these, 10 were resistant to aphids, 5 tolerant to waterlogging, and 47 showed a good response to irrigation. In the wilt-sick plot at Giza, five entries (H4/9/83, ILL 2490, ILL 5748, FLIP 86-38L, and FLIP

87-16L) were resistant to wilt (less than 20% mortality). Screening for aphid resistance in lentil revealed three lines (ILL 1573, FLIP 84-26, FLIP 86-64L) to be highly resistant.

In Sudan, an improved production package was demonstrated in Wad Hamid and Rubatab areas of the Blue Nile, where the potential for expanding lentil production exists. In Rubatab, a yield increase of 33%, averaged over four locations, was recorded (1020 to 2200 kg/ha compared to 990 to 1870 kg/ha from traditional farmers' practices). In Wad Hamid, where lentil was grown for the first time, yield levels averaged 1560 kg/ha.

In Ethiopia, lentil was seriously affected by *Ascochyta* blight at Debre Zeit and by rust at Akaki. Seven lines were selected that survived the disease pressure: FLIP 84-78L, FLIP 84-112L, FLIP 85-33L, FLIP 86-16L, FLIP 86-38L, FLIP 86-41L, and FLIP 87-74L. Of these, FLIP 86-38L will be recommended for release because of its wide adaptation, high yield, field resistance/tolerance to rust and *Ascochyta* blight, and good seed quality.

Chickpea

In researcher-managed verification trials in Egypt, three promising lines (L 70, ILC 249, and FLIP 80-14C) outyielded local cultivars by 12 to 24% over three locations, with a maximum yield advantage of 56% in Quina. ICARDA *Rhizobium* strain Nos. 39 and 31 increased yield by 68% at Quina (maximum yield 4200 kg/ha) and by 37% at Assiut (maximum yield 2600 kg/ha), respectively.

In Sudan, the recommended chickpea production package (cultivar, sowing date, seed rate, and insect pest control) produced a yield increase of 24% at Wad Hamid and 42% at Rubatab.

In Ethiopia, ICCL 12551, ICCL 85115, and ICCL 85225 performed better than the improved standard check Marye 1 (K 850 desi). Screening for resistance to wilt/root rot in the disease-sick plot in Debre Zeit confirmed the resistance of 12 selected lines for the third season.

Wheat

The enthusiastic support of the Sudanese Government, and the high wheat yields in the NVRP demonstration and pilot production plots, have led to an increase in wheat hectarage from 0.177 million hectares in 1988/89 to 0.260 million hectares in 1989/90, and wheat production from 0.233 million tonnes in 1988/89 to 0.378 million tonnes in 1989/90. Wheat production was extended to Rahad, Blue Nile, and Suki schemes in 1989/90.

On-farm verification of promising cultivars revealed two entries, VEE'S' CM 33027 and S 948-A Se 7, as potential candidates for release. In researcher-managed on-farm trials, 43 kg P_2O_5/ha and 86 kg N/ha increased wheat yield by 1200 and 1400 kg/ha in Rahad and Blue Nile, respectively. In on-station testing, three lines were identified as highly resistant to aphids; 43% lines were resistant to leaf rust and 50% to stem rust.

In Egypt, the recommended wheat production package increased yields by 17, 26, 41, 45, and 63% in pilot production plots in New Valley, Fayoum, Sohag, Aswan and Qena, respectively. In back-up research under rainfed conditions, a number of promising durum and bread wheat cultivars were identified as suitable for cultivation in the Northwest Coast (Beni Suef 1, Sohag 2, Sakha 8, Sakha 69, Giza 164 and L.S. 9). Screening for heat tolerance revealed three genotypes (Debeira, Genaro 81, and Giza 160) with high yield potential under heat stress. Aphid resistance screening of wheat and its wild relatives revealed 13 promising *Aegilops* lines, while in backcrosses (BC 3 and BC 4) four lines were highly resistant and 16 fairly resistant. Brominal, Grasp, Puma 3, and Arelon proved to be effective in controlling broadleaf weeds and wild oat in wheat.

Barley

In on-farm verification trials the two promising cultivars, Giza 123 and Giza 124, outyielded the traditional local cultivar by 44 and 43%, respectively, in the northwestern coastal region of Egypt. Laboratory screening of 128 barley genotypes for aphid resistance in Giza revealed 7 genotypes resistant and 15 moderately resistant to *Rhabalasiphum padi* L. and *Shizaphis gramium*, respectively.

Regional cooperation among the three participating countries involved exchange of germplasm, technical information and improved technology, in addition to participation in regional traveling 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 on the biological control of aphids. Work on heat stress in wheat is led by Sudan, while that on drought and salinity tolerance is coordinated between Egypt and Sudan.

During 1990, over 40 national scientists received training (see Table 31) and 62 participated in professional visits, workshops, and conferences related to cool-season food legumes and cereals.

North Africa Regional Program

The North Africa Regional Program (NARP) covers Algeria, Libya, Morocco, and Tunisia. During 1990, five senior scientists were based in Morocco and Tunisia. The NARP activities are coordinated from Tunis.

The Italy/IFAD Technology Transfer Project, integrated into NARP activities, aims at increasing barley, food legumes, and livestock production in North Africa. Field activities were initiated in the semi-arid zones of le Kef in Tunisia, Khemisset/Meknes in Morocco, Sidi Bel-Abbes in Algeria, and Djebel Lakhdar in Libya.

In Morocco, the project activities in 1990 included diagnostic studies, on-farm research, and training. The first included the agroclimatic characterization, soil analysis and characterization, survey of production systems and previous recommendations, description of existing extension units, agronomic diagnosis, and a survey of the production and marketing systems in the project zone. The on-farm research included variety trials, variety x cultural practices trials, rotation trials, and field verification tests at 14 sites in the project zone. The training activities, directed to extension and development agents, involved meetings; round table discussions; and training courses to increase awareness about the project goals, methodology, information dissemination, and collaboration between extension, research and development agents for technology transfer. The work in Algeria and Tunisia was also carried out along the same lines.

The UNDP-funded project on disease surveillance and germplasm enhancement for cereals and food legumes, also integrated into NARP activities, deals primarily with the development of research on cereals and food legumes in Algeria, Morocco, and Tunisia. The project aims at increasing and stabilizing the overall production of winter cereals and food legumes by reducing losses caused by the major diseases through the development of disease-resistant varieties. Researchers from four institutes in Algeria and three each in Morocco and Tunisia are working together and have established viable networks to facilitate joint research. Forty-six presentations on barley, wheat, faba bean, chickpea and lentil diseases and breeding methodology were made at the second Coordination Meeting of the project.

In both Italy/IFAD and UNDP projects, national researchers are participating actively in organizing and coordinating regional activities and in exchanging specialized germplasm nurseries of cereals and food legumes.

Through collaborative research in the four countries, new varieties of barley, bread and durum wheats, chickpea, and lentils were released to farmers (see Appendix 2). In addition, some promising lines are in the prerelease multiplication phase. Production packages for new varieties were also developed for different zones.

In Tunisia, the durum wheat variety Chen"S"/Altar confirmed its high yield potential under the dry conditions that prevailed during the past 3 seasons. The variety was increased this year and will be distributed to farmers next season. Similarly the barley varieties Lignee 527/3/Harbing/Avt/3/Aths; Ceres/Faiz; Faiz/Tej; Tej/Lignee 131; Cres/Faiz; Lignee 527/U566; CI 8887/CI 5761 and Deir Alla 106/DL 71/Strain 205 will be increased for possible release. In bread wheat, nine sister selections of the crosses Kaus"S" and Chilero"S" showed high yield potential in the past 3 dry years.

In food legumes, improved lentil germplasm showed good yield potential in sub-optimal dry conditions of Tunisia. The yield potential of line 78S

Cereal traveling workshop organized in Morocco. Participants included scientists from Morocco, Algeria, Tunisia, Libya, Spain, Portugal, Egypt, ICARDA, and CIMMYT.

26002 was confirmed across locations and years; this line is being considered for release. Similarly, results over the past 6 years have confirmed the superiority of the large-seeded faba bean variety Reina Blanca. Over the past 3 dry years (1988-1990) the large-seeded faba bean lines S82113-8 and S82033-3 have yielded 18-20% more than the checks. The small-seeded faba bean line FLIP 83-106B outyielded the check varieties by 8% during the period 1987 to 1990. In chickpea, promising lines with large seed size, good level of resistance to *Ascochyta* blight, and mechanical harvest attributes were identified. The chickpea lines FLIP 84-92C and FLIP 84-79C are at the prerelease seed multiplication stage. Seed of Amdoun-1 chickpea (resistant to wilt) was increased for distribution to farmers.

In all food legume crops, weeds caused yield losses of up to 80 to 90%. Therefore, chemical and manual weed control measures are receiving increased attention. Faba bean lines resistant to *Orobanche crenata* were susceptible to the red-flowered type present in Tunisia. Efforts are being made to identify sources of resistance to the red-flowered type.

Collaboration with Libya was strengthened considerably in 1989/90. The activities included in-country training course on cereal improvement, disease surveys, and germplasm collection missions. The number of Libyan researchers participating in ICARDA training courses at headquarters and in North Africa also increased in 1989/90. Additional areas of collaboration were also identified: soil fertility, crop rotation, supplemental irrigation, and germplasm collection.

Two case studies were planned for Tunisia and Libya. Germplasm collection missions were organized in 1990 in Morocco, Tunisia, and Libya to collect cereals and their wild relatives.

ICARDA is also using the capacity of NARSs to the benefit of the region. For example, a Moroccan scientist with his ICARDA colleagues participated in a cereal insect survey in Algeria; similarly, in collaboration with ICARDA, a researcher each from Morocco, Algeria and Tunisia conducted a cereal disease survey in Libya.

Over 135 trainees from the four countries (see Table 31) participated in training courses offered by ICARDA, and 142 benefitted from professional visits during 1989/90.

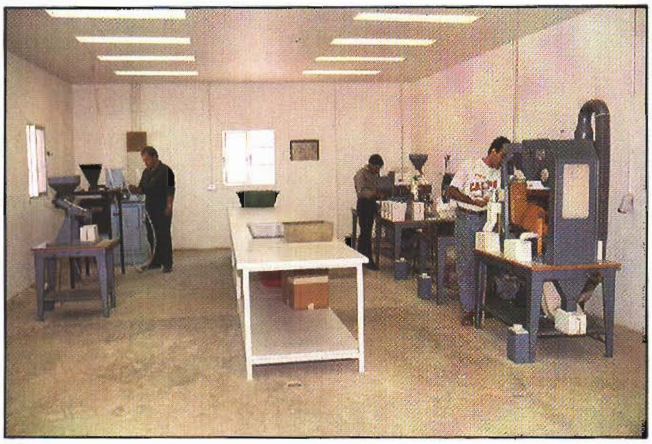
The Annual Coordination meetings with Algeria, Morocco, Libya, and Tunisia were organized in September 1990. The second Regional Coordination Meeting for the UNDP/ICARDA project on Surveillance of Diseases and Germplasm Enhancement for Cereals and Food Legumes was held at Skikda, Algeria in July 1990; 48 researchers from Algeria, Morocco, Tunisia, UNDP, and participated. Research results from the 1989/90 season were reviewed and work plans for 1990/91 were developed at these meetings.

Latin America Regional Program

Activities of this program during 1990 continued to be largely confined to the ICARDA-CIMMYT Barley Project. This collaborative inter-center activity has concentrated on the (i) incorporation of multiple disease resistance into barley germplasm adapted to Latin American conditions, (ii) improvement of hull-less barley genotypes suitable as human food in the Andean region, (iii) exploitation of early-maturing barley genotypes, (iv) resistance to the Russian wheat aphid and other pests, and (v) an examination of the potential of medic-barley rotations in the region. The national programs of Peru, Brazil, Chile, China, and Australia have recently released barley varieties originating from ICARDA-CIMMYT germplasm.

Seed Production

ICARDA's Seed Unit is a special-funded project, supported by the Governments of the Netherlands and the Federal Republic of Germany. A second 3-year phase of the project started in 1988.



A view of the new seed cleaning laboratory established at ICARDA in 1990.

In 1990, the Seed Unit continued its active assistance to NARSs in WANA in strengthening their seed programs to realize the full benefits of improved technologies. The Unit also provided valuable service to ICARDA's commodity programs by cleaning, treating, and quality testing their seed. The seed cleaning laboratory of the Unit became operative in 1990 and was extensively used.

In addition to its regular activities during 1990 (training, strengthening of infrastructure in NARSs, dissemination of information, etc.), the Unit increased its emphasis on seed health and morphological varietal description. Cooperation with the seed programs of Ethiopia, Jordan, Sudan, and the Republic of Yemen was considerably strengthened.

In its future activities, the Unit will pay increased attention to the seed production aspects of food and feed legumes, and to the region-related seed technology research. Alternative seed production systems, in which farmers produce their own seed, will be explored. Cooperation with the private seed sector will be sought through (i) training their staff, (ii) encouraging their participation in Seed Unit activities, and (iii) disseminating information to them. An economic analyses of seed programs and seed program components will be undertaken.

Resources for Research and Training

Finance

ICARDA's programs are funded by its generous donors. In 1990 the Center received a donor funding of 18.886 million USD. Combined with the income of 2.955 million USD from other sources (Table 37), the Center operated its programs on a total of 21.841 million USD in 1990. Compared to this, ICARDA's income in 1989 was 25.002 million USD which included 3.646 million USD for 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 1990 in-trust project funding totalled 3.4 million USD (see Appendixes 6 and 11).

During 1990 ICARDA and the CGIAR System agreed that in-trust projects should not be part of the operating budget funding; therefore, the funding for 1989 and 1990 reported in Table 37 does not include these projects.

A significant development in the accounting system in 1990 was the Financial Accounting Standard Board Statement No. 93, which requires all non-profit organizations to recognize depreciation expense as part of their operating expenditures. This resulted in an operating deficit of 4.29 million USD for 1990; also, the 1989 statement of activity had to be restated to include depreciation expense as an operating expenditure resulting in a deficit of 1.066 million USD. The change to depreciation accounting allows ICARDA to quantify the amount in which assets are reducing in value each year, and to plan for their replacement through additional donor contributions.

Table 37. Sources of funds for ICARDA's programs and capital requirement (x1000 USD), 1990 and 1989.

	1990	1989		1990	1989
Arab Fund	635	512a	Near East	16	
Australia	320	349	Netherlands	909	535
Austria	175	175	Norway	457	440
Canada	871	797	OPEC	-5	60a
FAO	18		Rockfeller Foundation	32	
China	30	30	Spain	125	125
Denmark	396	285	Stabilization mechanism fund	490	
Ford Foundation	302	170	Sweden	638	572
France	438	345a	UNDP	129	
Finland	251		United Kingdom	983	899
Germany	2310	2325a	USAID	4416	4696a
IBRD (World Bank)	4300	4250	Exchange gain (net)	1189	1771b
IDRC	227	122a	Earned Income	1766	1153c
IDRC	25	25	Provision	-528	
Iran	16				
Italy	1400	1230a	Total	21,841	21,356

[a] Part or all of these amounts were provided for specified activities ("restricted core").

[b] The exchange gains for 1990 were USD 1.189 million. The Central Bank of Syria permitted ICARDA to covert 50% of its U.S. dollars transferred to the country at the official rate of SYP 11.2 to 1 USD, and the other 50% at an "encouragement rate," which was SYP 20.00 to 1 USD in 1989. This resulted in an effective exchange rate of SYP 15.60 for local currency purchase. The gain of USD 1.189 million represents the difference between the official rate used for accounting purposes and the effective exchange rate.

[c] Investment income and sale of crops.

Staff

During 1990, the following senior staff joined ICARDA: Mr J. T. McMahon, Deputy Director General (Operations); Dr Hassan Seoud, Assistant Director General (Government Liaison); Dr Robert Booth, Assistant Director General (International Cooperation); Mr John Noisette, Director of Finance; Dr R. Tutwiler, Socioeconomist; Dr Scott Christiansen, Grazing Management Specialist; Dr T. Treacher, Visiting Scientist, Livestock; Dr A. Allan, Water Harvesting Specialist/Agronomist; Dr Nasri Haddad, Regional Coordinator, West Asia; Dr A. Rodriguez, Agricultural Economist; Dr K. Timmerman, Post-doctoral Fellow; Dr A. Hamdi Ismail, Post-doctoral Fellow; Dr Peter White, Post-doctoral Fellow; and Dr W. Khoury, Visiting Scientist. Dr S. Varma, who was already on ICARDA staff as Senior Science Editor, was appointed as Head of Communication, Documentation, and Information Services.

Six senior staff members proceeded on sabbatical leave: Dr Mohamed Habib Ibrahim, Senior Training Scientist; Dr Omar Mamluk, (Plant Pathologist); Dr Philip Cocks, Leader, Pasture, Forage and Livestock Program; Dr Thomas Nordblom, Agricultural Economist; Mr Khaled El-Bizri, Director, Computer Services; and Dr Miloudi Nachit (CIMMYT staff posted at ICARDA), Durum Wheat Breeder.

The following staff members left ICARDA during 1990: Dr J.P. Srivastava, Assistant Director General (International Cooperation); Dr Adnan Shuman, Assistant Director General (Government Liaison); Dr P. Cooper, Leader, Farm Resource Management Program; Dr Lawrence Przekop, Head of Training; Mr Allan Deutsch, Head, Communication, Documentation, and Information Services; Mr A. Briet, Director of Finance; Dr L. Holly, Genetic Resources Scientist; Dr P. Beale, Pasture and Forage Scientist; ; Dr Edmundo Acevedo, Physiologist; Dr Eugene Perrier, Water Harvesting Specialist; Dr M. Inagaki, Cereal Scientist; Dr A. Wahbe, Post-doctoral Fellow; Dr O. Tahhan, Post-doctoral Fellow; Dr J. Bejiga, Post-doctoral Fellow, and Dr S. Silim, Post-doctoral Fellow.

A list of senior staff as of 31 December 1990 is given in Appendix 13, and a summary of the list is presented in Table 38.

Table 38. Staff of ICARDA at various locations on 31 December 1990.

Location		International professional	Regional professional	Other staff	Total
Syria	Aleppo-Tel Hadya	47	50	466	563
	Damascus	-	1	6	7
Ethiopia	Addis Ababa	-	-	-	-
Egypt	Cairo	2	-	7	9
Italy		-	-	10	10
France		-	-	1	1
Jordan	Amman	1	-	1	2
Lebanon	Beirut	-	1	6	7
	Terbol	-	-	27	27
Mexico	CIMMYT	1	-	-	1
Morocco	Fez	4	-	1	5
Pakistan	Quetta	3	-	8	11
Tunisia	Tunis	1	-	3	4
Turkey	Ankara	1	-	1	2
Total		60*	52	537	649

* Includes senior scientists seconded from other organizations.

Farms

ICARDA operates five sites in Syria and two in Lebanon (Table 39). These sites represent a variety of agroclimatic conditions, typical of those prevailing in West Asia and North Africa.

Table 39. 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

A new site of about 200 hectares, identified in 1988/89, is managed jointly by ICARDA and the Steppe Directorate of the Ministry of Agriculture and Agrarian Reforms, Syria. It is located at Maragha, about 120 km southeast of Aleppo, and receives an average annual precipitation of 200 mm. The site is being used for marginal land rehabilitation research, using edible shrubs.

The very dry 1989/90 season, second in a row, started with good rains, but there was a lack of moisture from the beginning of March onward. The total precipitation at Tel Hadya was 233 mm, 100 mm less than average. The poor yields, however, cannot be attributed entirely to the lack of moisture. On 17 March, when crops looked relatively well developed, a -9°C frost, accompanied by strong winds, occurred. After the frost, there was not enough moisture for the development of new shoots.

The ground-water table has been dropping considerably, as the area outside Tel Hadya Station is mostly used for irrigated crops. Data on three wells at Tel Hadya show that the water table has been dropping by about 1 m per year.

The greenhouse facility at Tel Hadya, which became operational in 1989, was fully used during 1990 for research experiments.

Small Ruminants Unit

A research flock of over 700 Awassi sheep is maintained at Tel Hadya. The sheep are used in large-scale grazing trials, research on nutritive value of feeds, and studies on improved husbandry. Modest research facilities are also available for feeding trials, measurement of digestibility and feed intake, and counting helminth parasites. A small flock of goats has been added to the sheep flock for research on management of pastures using mixed ruminant species.

Computers

Systems Management

Uninterrupted Power Supply (UPS) lines were installed at several new locations at Tel Hadya. A number of new IBM PCs and LaserJet and DeskJet printers were also installed, and the Kermit facility for data transfer was provided to all programs and units. Necessary assistance on hardware, software, and power supply systems was provided to users at Tel Hadya, as well as to the sister center, ACSAD, in Damascus, to help maintain their computing systems.

Biometrics, Applied Statistics, and Statistical Computing

Statistical advisory services were rendered to ICARDA's researchers on planning experiments and surveys, analysis of data, and interpretation of results. Some of the salient features of the advisory services included errors in variable model, detection of outliers, transferrability of regression models, and correspondence analysis. In experimental designs, it was recommended to include lattice blocks in main plots for investigating two factors (the subplot factor being estimated with greater precision, accounting the variability even within main plots). The need for 'Independent Randomizations in Nursery Trials' was stressed.

A project on evaluation of eight statistical packages, namely, SPSS, GENSTAT, SAS, MSTAT-C, MINITAB, PSTAT, SYSTAT, and CRISP, was initiated and completed in 1990. The evaluation was undertaken with a view to highlight the computing options available. A comparison was made using sample cases on ANOVA for designed experiments based on generally balanced designs, regression and multivariate analyses. The biometrical techniques developed included:

Evaluation of standard errors of the estimates of genotypic and phenotypic correlations. Crop scientists often require an assessment of the correlation coefficients for developing a selection strategy for better plant type. Experimental data on the desired traits are then generated on a number of genotypes grown in a randomized complete block design. Using the data from such experiments, the asymptotic standard error of estimates of genotypic and phenotypic correlations were obtained and tests of significance suggested.

Inverse estimation in non-linear models. The estimation of x-variable (independent) for a given proportion of an observed value of y-variable (dependent) is performed when the relationship between x- and y - variables is non-linear. Asymptotic confidence limits were obtained. In deriving an expression for the standard error of estimate for x, the nature of observed y, considered to yield the required proportion, is treated as random variable instead of a fixed quantity often reported in the literature. This gives a more realistic approach to the problem of inverse-estimation. This methodology was applied on estimating doses of gamma and EMS irradiation in a mutation study in chickpea.

Transferrability of selection models. Collaboration was established with chickpea scientists to examine the transferrability of various selection models for drought tolerance in chickpea.

Clustering strains with variable weights. In collaboration with the ICARDA virologist, a procedure was developed for introducing selected weights in calculating similarity matrices to be used in clustering. These weights can be chosen to reflect the importance of the traits forming similarity matrices. The procedure allows the computation of similarity matrices based on individual traits and then combining them to obtain a weighted similarity matrix to perform clustering.

Financial and Administrative Application Software Systems

During the year, MAS (Management Accounting System) witnessed several major changes in response to the 1988 EMR (External Management Review) recommendations and the CG Accounting Guidelines:

1. For a close monitoring, a periodic budget system was introduced to support the yearly budget system.
2. The expense code was expatiated from two digits to four digits to accommodate additional expense classifications.
3. Monthly budget allocations were made by analysis of the previous year's time series data.
4. Changes were made to retrospectively reflect the exchange rate conversions.
5. The payroll system was upgraded to include the newly created RA-III cadre.
6. The existing literature on MAS was updated.

Store Accounting

The existing stock control system programs were optimized to give better response along with such additional features as minimum and maximum quantities, retrieval of transactions, summary report on stock movements, etc. The stock control User Manual was revised and reformatted.

Training

Several training courses on biometrical techniques and statistical computing were conducted for participants from NARSs and ICARDA: five group courses in biometrics for NARSs; three group courses in Statistical Computing (GENSTAT, MSTAT-C, SPSS software) for ICARDA participants; three courses on graphics (Harvard Graphics, 35mm Express Graphics); two courses in dBase III and dBase IV, one in Lotus 1-2-3, one in ICADET and wordprocessing packages (WordPerfect 5.1 , Al- Kaatib Arabic Word Processor, Saturn); and one in MAS. Eight students from Aleppo University were trained on systems hardware and operating systems, and four faculty members on installation and maintenance of mainframe systems and personal computers.

Appendixes

Contents

Appendix 1

Precipitation (mm) in 1989/90

	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	TOTAL
SYRIA													
Tel Hadya													
1989/90 season	0.0	10.2	78.5	34.9	30.4	50.5	8.6	13.9	6.3	0.1	0.0	0.0	233.4
Long-term average (12 seasons)	0.4	25.9	51.0	56.5	60.1	51.5	41.4	27.6	13.7	3.3	0.0	0.1	331.5
% of long-term average	0	39	154	62	51	98	21	50	46	3	n/a	0	70
Breda													
1989/90 season	0.0	24.6	27.8	34.2	37.0	42.6	8.4	3.0	5.6	0.0	0.0	0.0	183.2
Long-term average (32 seasons)	1.3	17.3	31.0	54.6	48.7	38.9	33.6	31.3	15.7	1.6	0.2	0.0	274.2
% of long-term average	0	142	90	63	76	110	25	10	36	0	0	n/a	67
Boueider													
1989/90 season	0.0	34.7	12.0	31.4	24.4	33.8	8.0	4.8	1.4	0.0	0.0	0.0	150.5
Long-tem average (17 seasons)	0.1	15.4	23.5	35.9	36.8	34.8	27.8	17.2	9.0	0.8	0.1	0.0	201.4
% of long-term average	0	225	51	87	66	97	29	28	16	0	0	n/a	75
Ghrerife													
1989/90 season	0.0	26.0	26.0	34.0	28.8	35.2	10.4	3.0	6.2	0.0	0.0	0.0	169.6
Long-term average (5 seasons)	0.0	45.5	24.1	42.5	41.3	39.3	32.0	11.4	10.5	0.8	0.0	0.0	247.4
% of long-term average	n/a	57	108	80	70	90	33	26	59	0	n/a	n/a	69
Jindiress													
1989/90 season	0.0	54.0	71.2	57.8	41.8	90.4	6.6	1.0	9.6	1.2	0.0	0.0	333.6
Long-term average (30 seasons)	1.4	30.5	55.7	94.0	84.6	74.7	65.8	42.4	19.0	2.4	0.4	0.9	471.8
% of long-term average	0	177	128	61	49	121	10	2	51	50	0	0	71
LEBANON													
Terbol													
1989/90 season	0.0	9.4	56.8	43.8	54.6	91.5	40.2	13.2	8.4	0.0	0.0	0.0	317.1
Long-term average (9 seasons)	0.0	25.7	64.1	81.9	87.1	99.4	92.7	24.2	8.5	0.7	0.4	0.0	484.7
% of long-term average	n/a	37	89	53	63	92	43	55	99	0	0	n/a	65

Note: The long-term average is subject to some fluctuation as each year's new data are averaged in. For location, elevation, etc. of these sites, see Table 39 on page 90.

Appendix 2

Cereal and Legume Varieties Released by National Programs

Country	Year of release	Variety
Barley		
Algeria	1987	Harmal
Australia	1989	Yagan
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
Qatar	1982	Gulf
	1983	Harma
Saudi Arabia	1985	Gusto
Spain	1987	Rihane
Syria	1987	Furat 1113
Barley (contd).		
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
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

Durum Wheat (contd.)

Syria	1984	Cham 1
	1987	Cham 3
		Bohouth 5
Tunisia	1987	Razzak
Turkey	1984	Susf bird
	1985	Balcili
	1988	EGE 88

Bread Wheat

Algeria	1982	Setif 82
		HD 1220
	1989	Zidane 89
Egypt	1982	Giza 160
	1988	Sakha 92
		Giza 162
		Giza 163
		Giza 164
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

Bread Wheat (contd.)

Syria	1984	Cham 2
	1986	Cham 4
	1987	Bohouth 4
	1991	Cham 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

Kabuli Chickpea

Algeria	1988	ILC 482
		ILC 3279
Cyprus	1984	Yialousa (ILC 3279)
	1987	Kyrenia (ILC 464)
France	1988	TS 1009 (ILC 482)
		TS 1502 (FLIP 81-293C)
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)

Kabuli Chickpea (contd.)

Syria	1982/86	Ghab 1 (ILC 482)
	1986	Ghab 2 (ILC 3279)
Tunisia	1986	Chetoui (ILC 3279)
		Kassab (FLIP 83-46C)
		Amdoun 1 (Be-sel-81-48)
Turkey	1986	ILC 195, Guney Sarisi 482 (ILC 482)
	1990	Damla 89 (FLIP 85-7C)
		Tasova 89 (FLIP 85-135C)

Lentil

Australia	1989	ILL 5750
Algeria	1987	Syrie 229
	1988	Balkan 755
		ILL 4400
Canada	1989	Indian head (ILL 481)
Chile	1989	Centinela (74TA 470)
Ecuador	1987	INIAP-406 (FLIP 84-94L)
Ethiopia	1980	R 186
	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)

Faba bean

Iran	1986	Barkat (ILC 1268)
Portugal	1989	Favel (80S 43977)

Dry Peas

Sudan	1989	Karima-1

Forage Legumes

Morocco	1990	*Vicia sativa* (ILF-V-1812)

Appendix 3

Publications

Articles in scientific journals

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Jegatheeswaran, Peethambaram. Meeting Hi-tech need based transfer of technology for agricultural research in developing countries. Der Tropenlandwirt, Zeitschrift fur die Landwirtschaft in den Tropen und Subtropen 91: 29-50. (German abstract).

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Tutwiler, R. Yemeni agriculture: structural change and development choices.

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Weigand, F. and P. Lashermes. ICARDA's strategy for biotechnology: objectives, organizational structure and areas of research.

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Makkouk, K.M., S.G. Kumari, and L. Bos. Broad bean wilt virus, host range, purification, serology, transmission characteristics and occurrence in West Asia and North Africa.

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Iguazu Falls BR. International Symposium on Wheat for the Non-Traditional Warmer Areas

Acevedo, E., M. Nachit, and G. Ortiz Ferrara. Selection tools for heat tolerance in wheat--potential usefulness in breeding.

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Rabat MA. International BYDV Workshop

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Rome IT. FAO Expert Consultation on Strategies for Sustainable Animal Agriculture in Developing Countries

Treacher, T. Policy issues in livestock production in arid regions and the management of extensive grazing lands.

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Ali, A., J.D.H. Keatinge, B.R. Khan, and S. Ahmed. Germplasm evaluation of lentil lines for the arid highlands of West Asia. 24 pp. Research report No. 56.

Atiq-ur-Rehman, S. Rafique, A. Ali, and M. Munir. Nutritive evaluation of fourwing saltbush in growth and digestibility trials with Harnai lambs in highland Balochistan. 7 pp. Research report No. 58.

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Keatinge, J.D.H. and B.R. Khan. The conduct and impact of research in the agricultural management of the arid mountain areas of West Asia: the example of Balochistan highlands, Pakistan. 12 pp. Research report No. 61.

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Annual report 1988/89, Egypt. 143 pp. ICARDA/NVRP-DOC-008.

Workplan and budget, Sudan 1989-90. 71 pp. ICARDA/NVRP-DOC-004.

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Workplan and budget, Ethiopia 1990/91. 82 pp. ICARDA/NVRP-DOC-006.

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Workplan and budget, Egypt 1990-91. 88 pp. ICARDA/NVRP-DOC-010. ICARDA-193.

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Increased productivity of barley, pasture and sheep in the critical rainfall zones: Workplan for Syria 1990/1991. 81 pp.

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Lentil abstracts (1981-1990) (Wallingford GB: CAB International, ISSN 0260-8464).

Other Publications

Journal articles from ICARDA: supplement 1989. 8 pp. ICARDA-171.

Housing policies: P-level staff and RA-level staff. 24 pp. ICARDA-173.

Faba bean pathology progress report 1988/89. 49 pp. ICARDA-174.

Farm resource management program: core research and training plans 1989/90 season. 55 pp. ICARDA-175.

International nursery report No. 12. Food legume nurseries 1987-88. 508 pp. ICARDA-176.

Vehicle policy and procedures. 30 pp. ICARDA-177.

ICARDA's research projects: an inventory 1989/90 season. 66 pp. ICARDA-178.

Charter of the International Center for Agricultural Research in the Dry Areas: second amended version Sept 1990. 20 pp. ICARDA-180 .

General by-laws of the International Center for Agricultural Research in the Dry Areas (ICARDA). By-law No. 1. 20 pp. ICARDA-181 .

Progress report on the recommendations of the 1988 external program and management reviews. 32 pp. ICARDA-182.

Annual report for CIMMYT/ICARDA regional durum wheat nurseries 1988/89. 248 pp. ICARDA-184.

Annual report for CIMMYT/ICARDA regional bread wheat nurseries 1988/89. 272 pp. ICARDA-185.

Annual report for the international barley nurseries 1988/89. 259 pp. ICARDA-186.

ICARDA medical directory. 23 pp. ICARDA-187.

Publication policy and procedures. 15 pp. ICARDA-191.

Board of trustees handbook. 30 pp. ICARDA-192.

Cereal improvement program: research and training plans 1989/90 season, 149 pp.

Food legumes improvement program: research and training plans 1989/90, 131 pp.

Pasture, forage, and livestock program: research and training plans 1989/90 season, 136 pp.

Guidelines for visitors to ICARDA, 8 pp.

ICARDA information retrieval services, 4 pp.

ICARDA telephone directory 1990, 107 pp.

Syrian agriculture: basic data 1987, 3 pp.

The United States and ICARDA: meeting the challenge together, 10 pp.

Appendix 4

Graduate Theses Produced with ICARDA's Assistance

Master's

DE* Universitaet Hohenheim

Markus Knapp (DE). Untersuchungen zur Transpiration von *Orobanche crenata* Forsk. und zum Einfluss des Parasitismus auf Transpiration und Photosynthese Verschiedener Wirtspflanzen. (Studies on transpiration of *Orobanche crenata* Forsk. and on the effect of parasitism on transpiration and photosynthesis of various host plants.) 67 p. (In German).

SY Tishreen University

Ibrahim Mahmoud Ajami Irani (SY). A study on population dynamics of aphid vectors of barley yellow dwarf virus in relation to virus spread on cereals along the Syrian coast and Ghab regions. 91 p. (In Arabic; English summary).

SY University of Aleppo

Ghada Hanti (SY). Effects of seeding rates and soil moisture on lodging and harvesting methods of some lentil varieties. 148 p. (In Arabic; English summary).

Jasim al-Isawi (IQ). Effect of plant density on efficiency of different selection methods in bulk populations and on the performance and yield components of lentil. 147 p. (In Arabic; English summary).

Mahmoud Haitham Sayed (SY). Ecological study of important wild genetic resources of wheat and barley. 235 p. (In Arabic; English summary).

* See Appendix 15 for country codes.

Doctoral

DE Justus-Liebig-Universitaet Giessen

Martin Engelhard (DE). Untersuchungen zur Verbesserung des Anbaues von Trockenspeiseerbsen auf einem semi-ariden Standort in Syrien. (Investigations on the improvement of dry pea cultivation in a semi-arid location in Syria.) (In German). 321 p.

PK Quaid-I-Azam University, Islamabad

Bashir Ahmed Malik (PK). Genetics of resistance to *Ascochyta rabiei* in chickpea (*Cicer arietinum* L.). 140 p.

GB University of Reading

Brian Stephen Capper (GB). Factors influencing the nutritive value of barley straw for ruminants. 300 p.

GB University of Nottingham, Loughborough

Talal Ahmad Razzouk (SY). A study of the adoption of innovations by Syrian farmers. 421 p.

Appendix 5

ICARDA Calendar 1990

January

13-14 Kuwait. Committee on Arab Agricultural Research (CAAR) Meeting
20-Feb. 1 PDR Yemen. Course on Wheat Seed Production
22-31 Tunisia. Course on Evaluation Strategies for Supplemental Irrigation
27-Feb. 2 Qatar. Course on Soil Tillage and Seedbed Preparation, Pest Control and Safety, Irrigation Systems at Research Station
29-Feb. 1 Morocco. Coordination Meeting (Maghreb Diseases, UNDP)

February

1-2 Rabat. Ley Farming Seminar
3-8 Jordan. Course on Techniques and Methodologies of Barley Improvement
14-22 Aleppo. Course on Biometrical Techniques for Cereal Breeders
18-Mar. 7 Aleppo. Course on Development of Effective Fertilizer Recommendations for the Mediterranean Region
24-Mar. 2 Morocco. Travelling Workshop, Ley Farming/Seed Production
25-Mar. 6 Libya. Course on Crossing Techniques and Note Taking in Cereals

March

1-June 30 Aleppo. Long-Term Course: Food Legume Improvement
1-June 30 Aleppo. Long-Term Course: Cereal Improvement
1-June 30 Aleppo. Long-Term Course: Seed Production
4-11 Jordan. Course on Farm Methodology for Technology Transfer
7-8 Rome. 21st Executive Committee Meeting
12-14 Rome. Center Directors Meeting
12-16 Oman. Food Legumes and Cereals Regional Travelling Workshop
12-17 Rome. 51st TAC Meeting
18-Apr. 19 Aleppo. Long-Term Course: Fallow Replacement
20-Apr. 04 Aleppo. Course on Cereal Disease Methodologies
25-Apr. 25 Ramadan Fast
26-27 Aleppo. Benefits Committee Meeting

April

7-11 Nicosia. Course on Hay Production
8-19 Aleppo. Course on Insect Control in Food Legumes and Cereals
9-20 Morocco. Course on Faba Bean Improvement
10-19 Aleppo. Course on Biology and Control of *Orobanche* spp.
11-19 Aleppo. Course on Seed Certification
21-23 Amman. West Asia Workshop for Food Legumes
21-24 Egypt. Course on Wheat Seed: Field Inspection Methodology
22-May 4 Morocco. Techniques in Rhizobiology of Pasture and Forage Program
25-28 Eid El-Fitr Holiday
30-May 3 Algeria. Seed Technology: Field Inspection of Food Legume Diseases and Seed Multiplication

May

2-9 Ecuador. Course on Barley Improvement with Emphasis on Disease Resistance
2-5 Addis Ababa. Nile Valley Regional Program Steering Committee Meeting
6-17 Aleppo. Course on Morphological Variety Description and Varietal Maintenance
6-17 Aleppo. Course on the Use of Crop Modelling
6-17 Aleppo. Course on Breeding Methodology for Food and Feed Legumes
7-13 Morocco. Maghreb Cereals Travelling Workshop
9 Aleppo. Agricultural Engineers Day
12-21 Amman. Course on Lentil Harvest Mechanization
12-24 Oman. Course on Experimental Designs and Trial Management
13-27 Aleppo. Course on Virus Diseases of Food Legumes
20-June 28 Aleppo. Course on the Use of Spatial Weather Generator
21-24 Morocco. Course on Agronomy of Winter Chickpea
21-25 The Hague. CGIAR Mid-Term Meeting
27 Aleppo. Program Committee Meeting
27 Aleppo. Audit Committee Meeting
28-June 1 Turkey. Course on Breeding Methodology for Food Legumes
28 Aleppo. Executive Committee Meeting
29-31 Aleppo. Board of Trustees Meeting

June

3-4 Aleppo. NVRP Steering Committee Meeting
10-21 Jordan. Course on Genetic Resources for Crop Improvement

11-16 Ibadan. 52nd TAC Meeting
18-20 Valencia. Seminar on "Place and Role of Biotechnologies in the Agricultural Research Systems of the Mediterranean Countries"
18-24 Iran. Course on Food Legume Improvement
19-29 Aleppo. Course on Seed Processing and Storage
24-29 Aleppo. Internal Review: Programs and Units

July

1-5 Eid El-Adha Holiday
8-12 Annaba. UNDP Cereal and Food Legumes Pathology Project Coordination Meeting/Algeria
10-11 Damascus. Mashreq Project Coordination Meeting/Syria
16-17 Amman. Mashreq Project Coordination Meeting/Jordan
22-Aug. 2 Aleppo. Course on Biotechnology in Food Legumes
24-26 Baghdad/Mosul. Mashreq Project Coordination Meeting/Iraq
31-Aug. 3 MSU/USA. Coordination Meeting: Collaborative Project on Barley Diseases and Related Breeding Strategies

August

27-31 Khartoum. NVRP Annual Coordination Meeting/Sudan
29-31 Amman. ICARDA/Jordan Coordination Meeting

September

1-7 Beijing. IARC Exhibit - International Book Fair
8-10 Amman. Mashreq Project - Regional Technical Meeting
10-12 Ravello. Conference on Breeding for Stress Tolerance in Cool-Season Legumes
15-16 Algiers. North Africa Coordination Meeting/Algeria
17-19 Rabat. North Africa Coordination Meeting/Morocco
20-22 Tunis. North Africa Coordination Meeting/Tunisia
24-25 Tripoli. North Africa Coordination Meeting/Libya
23-27 Cairo. NVRP Annual Coordination Meeting/Egypt
29-Oct. 5 NVRP Travelling Workshop/Ethiopia

October

3-5 Aleppo. IX Annual Coordination Meeting-ICARDA/SMAAR
5-8 Addis Ababa. NVRP Steering Committee/Ethiopia
7-10 Rabat. Symposium on Livestock Production in the Mediterranean Cereal Systems
14-16 Damascus. UNDP Mid-Term Review of the Regional Programme of Arab States
15-30 Aleppo. Course on the Use of Electrophoresis in Cereal Improvement
16-18 Aleppo. Syrian University Librarians Meeting
16-29 Aleppo. Course on Seed Testing
17-18 Amman. Mashreq Project Steering Committee
22-27 Washington. 53rd TAC Meeting
25-26 Ankara. Turkey/ICARDA Coordination Meeting
25-27 Washington. Center Directors Meeting
29-Nov. 2 Washington. International Centers Week

November

3-8 Damascus. 30th Science Week
5-6 Washington. 23rd Executive Committee Meeting
25-26 Damascus. Plant Protection Seminar

December

3-13 Morocco. Course on Farm Survey Methods

Appendix 6

Special Projects

During 1990, 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

Graduate Research and Visiting Scientist Fellowship Program at ICARDA

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 'Techniques in Rhizobiology' and 'Morphological Varietal Descriptors'.

Ford Foundation

Graduate and Post-doctoral Fellowships

France

Associate expert and capital equipment in support of ICARDA project on 'Use of Biotechnology for the Improvement of ICARDA Mandated Crops.'

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

Seed Poduction

IDRC (International Development Research Centre, Canada)

Rhizobial Carrier System

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.

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

Near East Foundation

Fertilizer in Dryland Barley/Livestock Systems

Netherlands (Directorate General for International Cooperation)

Collection and Characterization of Wild Relatives of Wheat

Seed Production

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

Improved Wheat Technology/Sudan

Rockefeller Foundation

Social Science Post-doctoral Fellowship/Adoption and Impact Studies

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

Networks

The use of both formal and informal networks as a tool to increase the effectiveness of agricultural research and training has expanded rapidly during recent years. In this context, dictionaries variously define 'Networks' as "a group or system of interconnected or cooperating individuals". Within such definitions various types of networks have been recognized and include: information exchange networks, technology (including germplasm) exchange networks, personnel (scientist) exchange networks, and collaborative research networks.

In previous Annual Reports attempts were made to list "Research Networks Coordinated by ICARDA". With the increasing recognition and exploitation of complementarities between ICARDA and its NARS partners, the number of collaborative research and training activities and 'Networks' has increased substantially. Existing networks include examples of all the above types within fields such as genetic enhancement, seed production, soil-test calibration, pest control, stress tolerance, biological nitrogen fixation, and library and information exchange. These now encompass such an extensive proportion of ICARDA's activities that it is no longer realistic to list them separately and so this has not been attempted in this Annual Report.

ICARDA will continue to promote networking as an effective means of utilizing limited resources available to agricultural research and training in the WANA region and will encourage NARSs of the region to accept greater organizational and coordination responsibilities.

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.

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

During 1990, the International School of Aleppo (ISA) continued to develop its program in a variety of areas. The following programs received special attention:

1. Curriculum development: The curriculum written for 18 areas in 1989 was reviewed, assessed, and further developed. Curriculum development will continue to be an ongoing and important process for the overall development of ISA.

2. Accreditation: The development of an accreditation protocol was continually worked upon. The final step of this development will be a visit from the Middle States Association of Philadelphia in May 1991. The goal of ISA is to attain accreditation during the fall of 1991.

3. Quality of education: ISA continued its thrust on upgrading the quality of education offered by it. Several areas were addressed:

   (i) The number of internationally hired staff was increased from 9 to 14. Among other positions, ISA hired its first Librarian, and will be adding a Counselor to its staff in 1991.

   (ii) Separate classrooms were provided for KG1, KG2, Arabic, Art, and Music.

   (iii) Several capital items were added: playground equipment, computers, tables, chairs, and bookshelves.

ISA's program saw a considerable expansion during 1990, both in terms of its student body (from 208 in 1989 to 250 in 1990) and facilities. The school continues to be a vibrant place, both for students and the faculty.

Appendix 10

Visitors to ICARDA

During 1990, ICARDA received 2154 visitors (Fig. 48), representing a 22% increase over 1989. This increase reflects the growing interest in the Center both at national and international levels.

The visitors included scientists, consultants, members of the CGIAR System, diplomats, USA Congress representatives, senior government officials, Board of Trustees members, conference participants, outreach staff, auditors, farmers, students, job interviewees, and others from all over the world representing 120 universities and national, international, and private organizations.

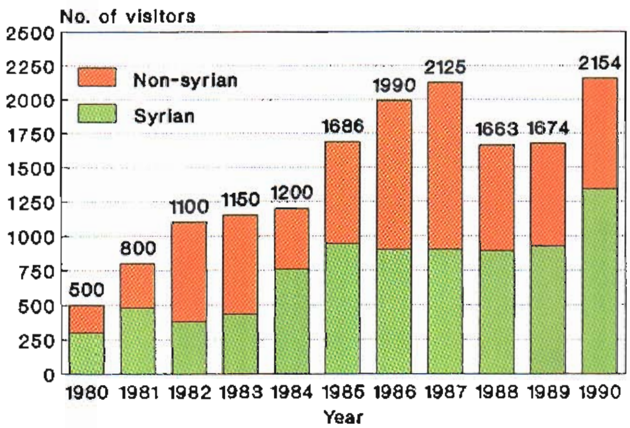

Fig. 48. Visitors to ICARDA, 1980-1990.

Appendix 11

Statement of Activity
For the Year Ended 31 December 1990
(x 000 USD)

	1990 ACTUAL AMT	1989 ACTUAL AMT
REVENUE		
Grants	18,886	22,078
Exchange gains	1,189	1,771
Interest income	989	1,230
Other income	777	(77)
Total revenue	21,841	25,002
EXPENSES		
Research		
Farm resource management	2,015	2,125
Cereal improvement	2,729	2,806
Food legume improvement	2,523	2,596
Pasture, forage, and livestock	1,898	1,950
Total research	9,165	9,477
Research support	4,383	4,125
Cooperative programs	1,831	3,054
Training	1,057	744
Information	960	1,021
General administration	3,196	2,850
General operations	1,678	2,699
Sub-total	13,105	14,493
Total operating expenses	22,270	23,970
EXCESS OF EXPENSES OVER REVENUE	(429)	(1,066)
ALLOCATED TO		
Capital fund	(1,064)	1,441
Capital development fund	(180)	432
Operating fund	-	-
Locally-generated fund	815	(2,939)
Deficit	(429)	(1,066)

Statement of Grant Revenue
For the Year Ended 31 December 1990
(x 000 USD)

	Current year grants	Funds received	Receivable 31 Dec 1990	(Advance) 31 Dec 1990
CORE UNRESTRICTED				
Australia	320	(320)	-	-
Austria	175	(175)	-	-
Canada	871	(871)	-	-
China	30	(30)	-	-
Denmark	396	(396)	-	-
Finland	251	(251)	-	-
Ford Foundation	100	(100)	-	-
Germany	1,211	(1,211)	-	-
India	25	(24)	1	-
International Bank for Reconstruction and Development (World Bank)	4,300	(4,000)	300	-
Italy	171	(171)	-	-
Netherlands	640	(470)	170	
Norway	457	(457)	-	-
Spain	125	(125)	-	-
Stabilization Mechanism Fund	-	(490)	-	-
Sweden	638	(638)	-	-
United Kingdom	983	(983)	-	-
United States Agency for International Development	4,132	(4,132)	-	-
	14,825	(14,844)	471	-
CORE RESTRICTED				
Arab Fund	514	-	514	-
France	331	(130)	286	(152)
Germany	962	(1,212)	-	(792)
International Development Research Centre	213	(34)	28	(59)
Italy	510	(382)	-	(533)
United States Agency for International Development	275	(303)	-	(109)
Closed projects	-	(236)	301	-
	2805	(2,297)	1,129	1,645

	Current year grants	Funds received	Receivable 31 Dec 1990	(Advance) 31 Dec 1990
SPECIAL PROJECTS				
Arab Fund	121	(173)	-	(103)
Food and Agriculture Organisation	18	(10)	8	-
Ford Foundation	188	(137)	17	(136)
France	107	(669)	46	(283)
German Agency for Technical Cooperation	138	(262)	57	-
International Development Research Centre	14	(14)	3	-
Iran	16	-	-	(148)
Italy	718	(560)	-	(1,340)
Near East Foundation	16	(11)	-	(4)
Netherlands	269	-	333	-
Nile Valley Project	-	-	50	(37)
The OPEC Fund for International Development	(5)	-	35	-
Rockefeller Foundation	32	(40)	-	-
United Nations Development Programme	129	(278)	9	(158)
United States Agency for International Development	9	-	9	-
Closed projects	-	(236)	397	(1)
Future projects	-	(28)	-	(28)
	-	-	886	-
	1,770	(2,418)	964	(2,238)
Less: provision for doubtful accounts	(514)	-	(886)	-
GRAND TOTAL	18,886	19,559	1,678	(3,883)

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 have already been 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 Atomic Energy Agency, Vienna, Austria
- Studies of biological nitrogen fixation in food and forage legumes, employing the isotope-dilution method with nitrogen-15.

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 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 Paris South
- Haploid breeding and anther culture for cereal improvement

Federal Republic of Germany

University of Bonn
- Decline in cereal yield in continuous cropping systems
- Wid crossing in lentil

University of Giessen
- Weed control and water-use efficiency in peas

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

Max-Planck Institute for Biochemistry, Munich
- Resistance mechanisms in chickpea to leafminer

University of Frankfurt and MAX-Planck Institute of Psychiatry, Munich
- RFLP analysis in chickpea and lentil

University of Frankfurt
- DNA fingerprinting in chickpea and *Ascochyta rabiei*

Italy

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

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; Germplasm Institute, Bari; and ENEA, Rome
- Evaluation and documentation of durum wheat germplasm

University of Tuscia, Viterbo
- Enhancing wheat productivity in stress environments utilizing wild progenitors primitive forms

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

Japan

Tropical Agriculture Research Center, Tskuba, Ibaraki
- Ecophysiological studies for improvement of high-yielding wheat varieties
- Haploid breeding in wheat using *Hordeum bulbosum*

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

Portugal

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

Spain

University of Cordoba
- Effect of environmental stresses on nitrogen fixation
- Developing *Orobanche* resistance in faba bean
- Developing wilt resistance in chickpea

University of Cordoba and INIA
- Barley stress physiology

University of Granada
- Isolation of VA-Mycorrhiza from forage legumes

Polytechnical University, Madrid
- Improvement of the energy efficiency of medic rhizobia

United Kingdom

Plant Breeding Institute, Cambridge
- Characterization of barley genotypes
- Study of resistance of faba bean to *Botrytis fabae*

Overseas Development Natural Resources Institute, London
- Evaluating the nutritive value of straws for small ruminants

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 Reading
- Root studies of barley and wheat
- Investigation of seed dormancy in plant populations on grazed marginal land

Wye College, University of London
- Studies on the quality of barley straw

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 in *Rhizobium* for the control of *Sitona* larvae in lentil and peas

Appendix 13

Board of Trustees

Dr Mouin Hamze of Lebanon joined the Board of Trustees in 1990. He is currently serving as Dean of the Lebanese University's Faculty of Agriculture, where he is also Professor of Plant Sciences; he is also the President of the Board of Directors, Agricultural Research Institute, Beirut Lebanon. Prior to joining the Lebanese University in 1979, Dr Hamze earned a reputation for excellent research while working as a researcher at the Lebanese National Research Council. At the same time he has worked closely with staff of the American University of Beirut, conducting extensive field work, teaching courses, and advising post-graduate students.

In 1988 the French Ministry of Agriculture and Forestry awarded Dr Hamze with the "Chevalier de l'Ordre du Merite Agricole" (Order of Agricultural Merit - Cavalier Class) in recognition of his efforts in agricultural research. Also, in 1988 Dr Hamze was sponsored by the United States Department of Agriculture as a Fulbright Scholar at the Agricultural Research Station, Beltsville, Maryland. In 1986, the Abdul-Hamid Shouman Foundation in Amman, Jordan, presented Dr Hamze with the Foundation's coveted Prize for Agricultural Sciences Research.

Dr Hamze holds degrees from the University of Montpellier (France), and the Lebanese University.

Dr Hamze's persistent involvement in agricultural research and development in Lebanon throughout the long years of war and upheaval are an indication of his unswerving commitment to increasing food production in West Asia and North Africa.

At the end of 1990, the membership of ICARDA's Board of Trustees was as follows:

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Institute of Agricultural Biology
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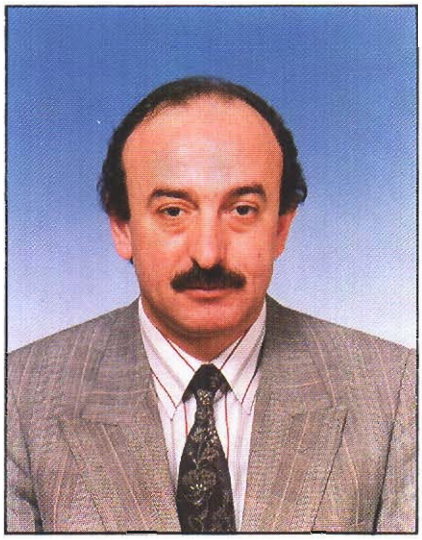

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The Board held the following meetings during 1990:

7-8 March	21th Executive Committee meeting, Rome
27-28 May	18th Program Committee meeting, Aleppo
28 May	22nd Executive Committee meeting, Aleppo
29-31 May	24th meeting of the Board of Trustees, Aleppo
5-6 November	23rd Executive Committee meeting, Washington

Appendix 14

Senior Staff
(as of 31 December 1990)

SYRIA
Aleppo: Headquarters

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 (Operation)
Dr Robert Booth, Assistant Director General (International Cooperation)
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

Dr Samir El-Sebae Ahmed, Regional Program Coordinator for the Arabian Peninsula
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 Vijay Sridharan, Finance Officer, Financial Reporting
Mr Mohamed Samman, Pre-Audit and Control

Computer Services

Mr Khaled El Bizri, Director, Computer Services
Dr Murari Singh, Senior Biometrician
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

Farm Resource Management Program

Dr Michael Jones, Barley-Based Systems Agronomist/ Acting Program Leader
Dr Hazel Harris, Soil Water Conservation Scientist
Dr Abdullah Matar, Soil Chemist
Dr Mustafa Pala, Wheat-Based Systems Agronomist
Dr Mohamed Bakheit Said, Senior Training Scientist
Dr Richard Tutwiler, Socioeconomist
Dr Elizabeth Bailey, Visiting Agricultural Economist
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)

Cereal Improvement Program

Dr Habib Ketata, Senior Training Scientist/Acting Program Leader
Dr Salvatore Ceccarelli, Barley Breeder
Dr Guillermo Ortiz Ferrara, Bread-Wheat Breeder (seconded from CIMMYT)
Dr Philippe Lasherme, Biotechnologist
Dr Byrd Curtis, 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
Mr Issam Naji, Agronomist
Dr Stefania Grando, Research Scientist
Dr Sui K. Yau, International Nurseries Scientist
Mr Mohamed Asaad Mousa, Research Associate
Mr Alfredo Impiglia, Research Associate

Food Legume Improvement Program

Dr Mohan C. Saxena, Program Leader/Agronomist-Physiologist

Dr Douglas Beck, Food Legume Microbiologist
Dr William Erskine, Lentil Breeder
Dr Mohamed Habib Ibrahim, Senior Training Scientist
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
Dr Karl H. Linke, Post-Doctoral Fellow, *Orobanche* (seconded from GTZ)
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Mr Hasan Mashlab, Research Associate
Mr Fadel Afandi, Research Associate

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Dr Luis Materon, Microbiologist
Dr Ahmed El Tayeb Osman, Pasture Ecologist
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Dr A.B. Damania, Cereal Germplasm Curator
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Mr Benjamin Wedeman, Communications Specialist
Mr Nihad Maliha, Information Specialist-FABIS

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Mr Michael Major, Training Materials Specialist

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Dr N.P. Saxena, Consultant (Aleppo)
Dr Abdullah Dakheel, Consultant (Aleppo)

Appendix 15

Acronyms and Abbreviations

ACSAD	Arab Center for Studies of the Arid Zones and Dry Lands (Syria)
AFESD	Arab Fund for Economic and Social Development (Kuwait)
AGRIS	International Information System for Agricultural Science and Technology (FAO, Italy)
AOAD	Arab Organization for Agricultural Development (Sudan)
APRP	Arabian Peninsula Regional Program
AZRI	Arid Zone Research Institute (Pakistan)
BLRV	Bean Leaf Roll Virus
BYDV	Barley Yellow Dwarf Virus
BYMV	Bean Yellow Mosaic Virus
CARIS	Current Agricultural Research Information System
CERES	Crop-Environment Resource Synthesis Nitrogen
CG	Consultative Group
CGIAR	Consultative Group on International Agricultural Research (USA)
CIMMYT	Centro Internacional de Mejoramiento de Maiz Trigo (Mexico)
DGIS	Directorate Central for International Cooperation (the Netherlands)
EEC	European Economic Community
ENSA	Ecole Nationale Superieure d'Agriculture
EMR	External Management Review
EPR	External Program Review
FRG	Federal Republic of Germany
FABIS	Faba Bean Information Service (managed by ICARDA)
FLIP	Food Legume Improvement Program (ICARDA)
FAO	Food and Agriculture Organisation of the United Nations (Italy)
FRMP	Farm Resource Management Program (ICARDA)
GCC	Gulf Cooperation Council (Saudi Arabia)
GRU	Genetic Resources Unit (ICARDA)
GOSM	Central Organization of Seed Multiplication (Syria)
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit (German Agency for Technical Cooperation, West Germany)
IARCs	International Agricultural Research Centers
IBPGR	International Board for Plant Genetic Resources (FAO, Italy)
IBRD	International Bank for Reconstruction and Development (World Bank, USA)
ICARDA	International Center for Agricultural Research in the Dry Areas (Syria)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (Italy)
IDRC	International Development Research Centre (Canada)
IFAD	International Fund for Agricultural Development (Italy)
IFPRI	International Food Policy Research Institute (USA)
IMPHOS	Institut Mondial de Phosphate

INRA	Institut Nationalde la Recherche Agronomique (Morocco)
IRRI	International Rice Research Institute (Philippines)
ISA	International School of Aleppo
JUST	Jordan University of Science and Technology (Jordan)
LENS	Lentil News Service (managed jointly by ICARDA and the University of Saskatchewan)
MART/AZR	Management of Agricultural Research and Technology/Arid-Zone Research project
NARP	North Africa Regional Program
NARSs	National Agricultural Research Systems
NVRP	Nile Valley Regional Program
OPEC	Organization of Petroleum-Exporting Countries (Austria)
PFLP	Pasture, Forage and Livestock Program (ICARDA)
SAREC	Swedish Agency for Research Cooperation with Developing Countries (Sweden)
SMAAR	Syrian Ministry of Agriculture and Agrarian Reform
TAC	Technical Advisory Committee (FAO, Italy)
UAE	United Arab Emirates
UNDP	United Nations Development Programme (USA)
USAID	United States Agency for International Development
WANA	West Asia and North Africa
WARP	West Asia Regional Program

Units of measurement

°C	degree Celsius
cm	centimeter
hr	hour
ha	hectare
g	gram
kg	kilogram
km	kilometer
m	meter
mm	millimeter
t	tonne (1000 kg)

Languages

Ar	Arabic
Ch	Chinese
En	English
Fa	Farsi
Fr	French
Hi	Hindi
It	Italian
Ru	Russian

Countries

AR	Argentina
CN	China
DE	Federal Republic of Germany
ES	Spain
FR	France
GB	United Kingdom
IN	India
IR	Iran
IT	Italy
JO	Jordan
JP	Japan
MA	Morocco
MX	Mexico
PT	Portugal
SY	Syria
TN	Tunisia
TR	Turkey
US	United States

Appendix 16

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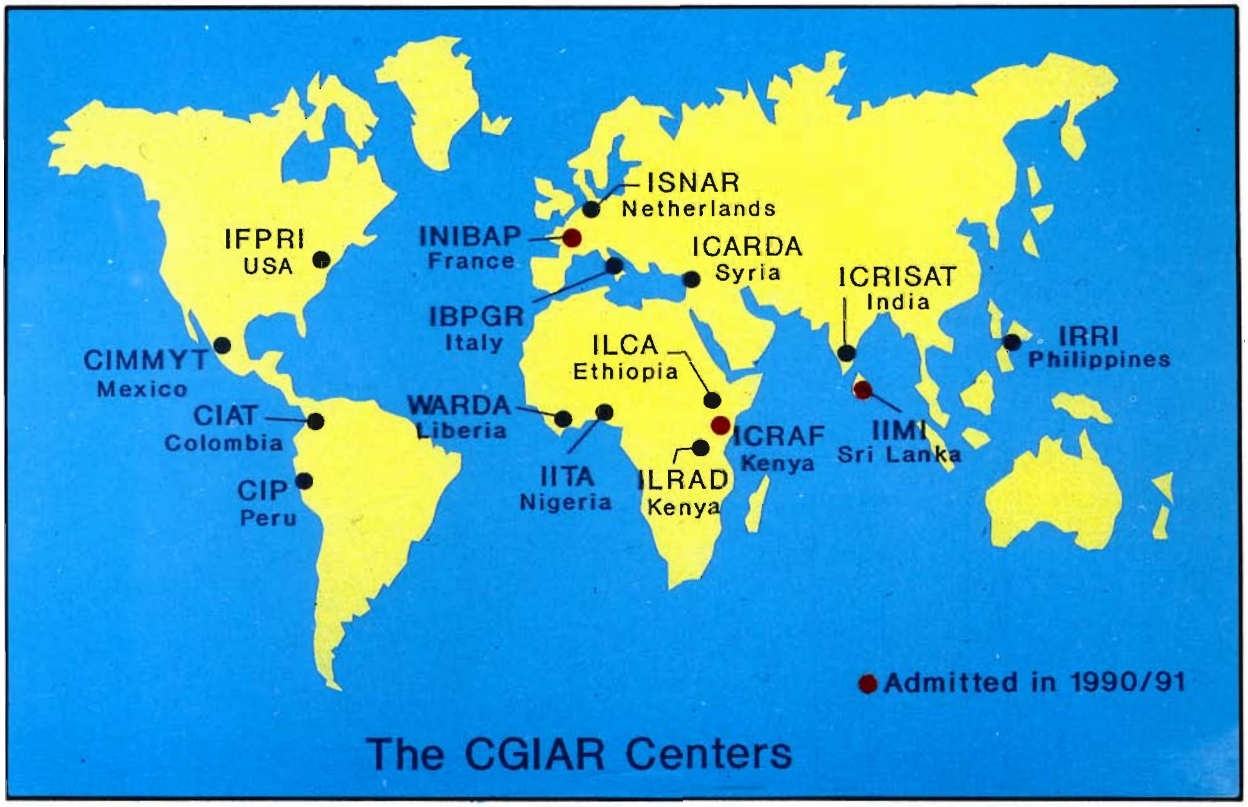
The CGIAR

ICARDA is one of 16 international centers supported by the Consultative Group on International Agricultural Research (CGIAR). Established in 1971, the CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

Cosponsored by the World Bank, the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Development Programme (UNDP), the CGIAR operates without a formal character, relying on a consensus deriving from a sense of common purpose.

The CGIAR has the following mission: "Through international research and related activities, and in partnership with national research systems, to contribute to sustainable improvements in the productivity of agriculture, forestry, and fisheries in developing countries in ways that enhance nutrition and well-being, especially of low-income people." The mission implies a focus on: international research that complements and supports national research efforts; complementary activities aimed at strengthening national research capacities such as specialized training and information services, but excluding other development or technical assistance activities; satisfying human needs from agriculture, forestry and fisheries, without degrading environment or the natural resources on which they depend; the large numbers of poor people; and the importance of technological change in generating new income streams for the poor.



The CGIAR is serviced by an executive secretariat, provided by the World Bank and located in Washington. A Technical Advisory Committee (TAC), with its headquarters at FAO in Rome, guides the research programs and priorities of the Group.

ICARDA-238/5000/Oct 1991