Jordan and ICARDA

Ties That Bind

ICARDA

International Center for Agricultural Research
in the Dry Areas

About ICARDA and the CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is one of 15 centers supported by the CGIAR. ICARDA's mission is to improve the welfare of poor people through research and training in dry areas of the developing world, by increasing the production, productivity and nutritional quality of food, while preserving and enhancing the natural resource base.

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production; and the West and Central Asia and North Africa (CWANA) region for the improvement of bread and durum wheats, chickpea, pasture and forage legumes, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural-resource management practices. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national, regional and international agricultural research and development systems.

The Consultative Group on International Agricultural Research (CGIAR) is a strategic alliance of countries, international and regional organizations, and private foundations supporting 15 international agricultural Centers that work with national agricultural research systems and civil society organizations including the private sector. The alliance mobilizes agricultural science to reduce poverty, foster human well being, promote agricultural growth and protect the environment. The CGIAR generates global public goods that are available to all.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD) are cosponsors of the CGIAR. The World Bank provides the CGIAR with a System Office in Washington, DC. A Science Council, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

Jordan and ICARDA

30 years of partnership for sustainable agriculture

Ties That Bind
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Acronyms

AARINENA	Association of Agricultural Research Institutions in the Near East and North Africa
ACSAD	Arab Center for Studies of the Arid Zones and Dry Lands, Syria
AFESD	Arab Fund for Economic and Social Development
AOAD	Arab Organization for Agricultural Development
BRDC	Badia Research and Development Center
CARDNE	Regional Center on Agrarian Reform and Rural Development for the Near East
CBD	Convention on Biological Diversity
CWANA	Central and West Asia and North Africa
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GIS	Geographic Information System
HCST	Higher Council for Science and Technology
IBPGR	International Board for Plant Genetic Resources (now Bioversity International)
ICARDA	International Center for Agricultural Research in the Dry Areas, Syria
ICRAF	World Agroforestry Center, Kenya
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, India
IDRC	International Development Research Center, Canada
IFAD	International Fund for Agricultural Development, Italy
IFPRI	International Food Policy Research Institute, USA
ILRI	International Livestock Research Institute, Kenya
IPGRI	International Plant Genetic Resources Institute, Italy (now Bioversity International)
ISNAR	International Service for National Agricultural Research (now part of IFPRI)
JES	Jordan Environment Society
JOHUD	Jordanian Hashemite Fund for Human Development
JUST	Jordan University for Science and Technology
MoA	Ministry of Agriculture, Government of Jordan
NARS	National Agricultural Research System
NCARE	National Center for Agricultural Research and Extension
NCARTT	National Center for Agricultural Research and Technology Transfer
NENA	Near East and North Africa
NGO	Non Governmental Organization
OFID	OPEC Fund for International Development
OPEC	Organization of Petroleum Exporting Countries, Austria
UNCCC	United Nations Convention on Climate Change
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UoJ	University of Jordan
USAID	United States Agency for International Development
USDA-ARS	United States Department of Agriculture – Agricultural Research Service

Agriculture in Jordan

Jordan has a land area of around 8.94 million hectares, with three distinct agro-climatic zones: the Rift valley (5.6%), the highlands (6.4%), and marginal and desert areas (88%). In 90% of the country, average rainfall is below 200 mm per year. Only 2% receives more than 400 mm of rain. Natural resources for agriculture are scarce; Jordan is among the world's most water-deficient countries. But it is rich in biodiversity – with over 2700 plant species – and lies within the center of diversity for many globally important crops including barley, lentil, some feed legumes and many fruit trees. About 90.4% of the country is used as rangeland (largely dry or marginal areas); 1.5% is classified as forest. Around half a million hectares, 5.7% of the country's area, is suitable for agriculture. Rainfed agriculture occupies 222,794 ha, of which supplemental irrigation is applied on some 83,707 ha, mainly in the Jordan valley, to produce banana, citrus, and off-season vegetables. Since 1997, the area planted to field crops has fluctuated between 70,000 and 130,000 ha. Around 54,000 ha are planted with fruit trees, 90% of which are olives.

Multiplication of improved barley varieties, developed by Jordanian researchers from ICARDA germplasm

Agriculture contributes less than 4% of Jordan's GDP, but nevertheless plays important social, economic and environmental roles. It contributes to food security to some extent and employs over 120,000 workers – including a significant proportion of the country's retirees – limiting and sometimes even reversing migration to the cities. For these reasons, the government places great importance on agricultural development.

The National Strategy for Agricultural Development (2002-2010) emphasizes the importance of research to support agriculture and rural development in the dry areas. The strategy focuses on three main areas: management of water resources; improvement of rangeland, livestock and dryland farming systems; and intensified farming of high-value cash crops. The National Center for Agricultural Research and Extension (NCARE) is the umbrella agency for research. Other organizations, including universities, also conduct research projects. In the early 1990s ICARDA and the International Service for National Agricultural Research (ISNAR) worked with NCARE to develop its research strategy and medium-term plan. Similarly, Jordanian research institutions have worked closely with ICARDA, the Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA) and other institutions, to set research and development priorities for the region.

ICARDA has a mandate to help improve the livelihoods of communities and the sustainable management of natural resources. The Center will continue to strengthen its partnership with research centers, NGOs and farm communities in Jordan to achieve these goals.

History of Jordan-ICARDA collaboration

Collaboration between ICARDA and Jordan began when ICARDA was established in 1977. A bilateral agreement was signed on 27 October that year. The first Memorandum of Understanding (MoU) was signed with the Ministry of Agriculture, identifying NCARE as the focal institution. In mid-1989, ICARDA opened its West Asia Regional Program office in Amman, the capital of Jordan, to coordinate joint bilateral and regional activities with Cyprus, Iraq, Jordan, Lebanon, the Palestinian Authority, Syria and southern Turkey. Collaboration was developed through the years with many national institutions: the

Faculties of Agriculture of the University of Jordan (UoJ), the Jordan University for Science and Technology (JUST) and the Universities of Mu'ta, Yarmouk and Balqa; the Higher Council for Science and Technology (HCST), the Jordan Cooperative Corporation, the Royal Science Society and the Agricultural Marketing Organization. MoUs were signed with JUST in 1988 (revised in 2004); with UoJ in 2005; and with HCST in 2007. The latter sought to strengthen collaboration with the Badia Research and Development Center (BRDC). ICARDA participated in a peer review of BRDC in 2004, which helped develop its new strategy and action plan.

These partnerships were progressively extended to several NGOs including the Jordanian Hashemite Fund for Human Development (JOHUD), the Royal Society for Conservation of Nature, the Farmer Association and many local communities. ICARDA partners BRDC and the Ministry of Environment on projects under the framework of international conventions on climate change (UNCCC), desertification (UNCCD) and biodiversity (CBD). ICARDA also works with international and regional organizations – ACSAD, AOAD, CARDNE, FAO, IPGRI, UNDP, UNEP, USAID, USDA-ARS, the World Bank and others – to serve agricultural development in Jordan. (See list of acronyms on page v.)

Regular interactions, closer ties. HE Mozahem Mohaisin, Jordan's Minister of Agriculture (left) with Dr Mahmoud Solh, ICARDA Director General

HIGHLIGHTS OF ACHIEVEMENTS

Thirty years of collaboration have led to major impacts in several areas: conservation of genetic resources, germplasm improvement, natural resources management, socioeconomics and policy, as well as targeted development-oriented projects in diverse dryland ecosystems. The capacities of national research centers as well as farmers have been greatly strengthened. Collaboration has covered both research and technology transfer, through a combination of bilateral projects and broader regional projects. ICARDA has played a catalytic role in strengthening collaboration among national research institutions and in enhancing regional integration.

1. Plant Genetic Resources

Activities include collection, evaluation, conservation and documentation of indigenous germplasm, and provision of germplasm, training and technical backstopping. Jordan, located in one of the world's most important centers of crop diversity, was among the first countries to sign the International Treaty on Plant Genetic Resources for Food and Agriculture. Since 1977, 23 germplasm collection missions have been conducted in Jordan, of which 18 were organized jointly by ICARDA and the national agricultural research system (NARS) (Table 1).

ICARDA's genebank conserves over 4600 Jordanian accessions belonging to 179 taxa (Tables 2 and 3). Of these accessions, 82% were collected during these missions; the rest are breeding material either bred from the accessions collected and/or developed at ICARDA to suit Jordanian environments. ICARDA has provided training and technical backstopping for NARS institutions, and helped NCARE establish the national genebank. Since 2002, we have been repatriating Jordanian accessions held at ICARDA; 1371 accessions are now duplicated at the national genebank. NCARE's genetic resources database was jointly developed. ICARDA initiated work on medicinal, herbal and aromatic plants under the Dryland Initiative Project and helped develop the ongoing project on medicinal and aromatic plants funded by the Global Environment Facility (GEF) and the World Bank. The Dryland Agrobiodiversity Project initiated extensive work on *in-situ*/on-farm agrobiodiversity conservation, as well as seed collection and grafting of fruit tree species (landraces and wild relatives).

Table 1. Preserving diversity: joint collection missions in Jordan

Mission	Year	No. of accessions collected	Institutions involved
JOR77	1977	236	NCARTT, ICARDA
JOR81-2	1981	93	NCARTT, ICARDA
JOR81-3	1981	10	NCARTT, ICARDA
JOR81-1	1981	60	NCARTT, ICARDA
JOR83-2	1983	60	IBPGR, JUST
JOR83-1	1983	57	NCARTT, ICARDA
JOR84	1984	183	Saskatchewan Univ , IPGRI, JUST
JOR85	1985	409	NCARTT, ICARDA
JOR86	1986	33	IBPGR, JUST
JOR88-4	1988	15	JUST
JOR88-1	1988	85	NCARTT, ICARDA
JOR88-2	1988	85	NCARTT, ICARDA
JOR88-3	1988	92	NCARTT, ICARDA
JOR89-2	1989	6	JUST
JOR89	1989	618	NCARTT, ICARDA
JOR90	1990	1040	NCARTT, ICARDA
JOR91	1991	182	NCARTT, ICARDA
JOR92	1992	19	NCARTT, ICARDA
JOR95	1995	56	NCARTT, ICARDA
JOR02-1	2002	108	NCARTT, ICARDA (GEF project)
JOR02-2	2002	276	NCARTT, ICARDA (GEF project)
JOR03	2003	91	NCARTT, ICARDA (GEF project)
JOR08	2008	20	NCARE, ICARDA
Total	**23 missions**	**3834**	

Table 2. Accessions of legumes and cereals from Jordan, conserved in the ICARDA genebank as back-up duplicates

Crop	No. of accessions
Barley	190
Bread wheat	22
Durum wheat	316
Faba bean	23
Lentil	456
Chickpea	156
Pea	11
Lathyrus	1
Common vetch	18
Total	**1193**

Table 3. Accessions of wild relatives and forage species from Jordan, conserved in the ICARDA genebank as back-up duplicates

Genus	No. of species/subsp.	No. of accessions
Aegilops	16	288
Astragalus	15	229
Cicer	2	165
Coronilla	1	43
Hordeum	1	171
Hymenocarpus	2	72
Hyppocrepis	2	83
Lathyrus	9	39
Lens	2	11
Lotus	4	14
Medicago	41	724
Onobrychis	2	106
Ononis	4	27
Pisum	1	14
Scorpiurus	5	49
Trifolium	31	603
Trigonella	10	138
Triticum	3	557
Vicia	14	133
Others	5	13
Total	**170**	**3479**

ICARDA's genebank holds over 4600 Jordanian accessions in trust, helping to preserve and utilize the country's plant diversity for agricultural development

2. Germplasm Development

Each year, ICARDA provides Jordanian institutions with nurseries of improved germplasm: segregating populations, advanced lines and yield trials of barley, durum wheat, bread wheat, lentil, chickpea, vetch, grasspea and medics. During the period 1979-86, the Center stationed a senior scientist in Jordan to coordinate cereals improvement research under a project with UoJ and the Ministry of Agriculture, on on-farm verification and demonstration of improved varieties and associated agronomic packages. The project developed recommendations on planting date, seed rate and fertilization management for wheat and barley cultivation in different agro-ecologies.

NCARE has used breeding nurseries from ICARDA to select and release improved cereal and legume varieties, often through research by Jordanian graduate students. Twenty-seven varieties have been released to date, of which 13 were directly derived from ICARDA's advanced lines (Table 4). Four of the five varieties registered in the official catalog in 2004 were selected from ICARDA germplasm: durum wheat Omrabia 6, bread wheat Tsi/Vee S, barley Roho/A. Abiad//6250/1161 and Esp/1808-4L//Harmel-02. ICARDA introduced the participatory plant breeding approach for barley in Jordan, which is being institutionalized and extended to wheat and food legumes. A series of workshops were held with researchers, policy makers and farmers to discuss the issues of property rights, benefit sharing, and seed production of varieties to be released using this new approach.

Table 4. Cereal and legume landraces and improved varieties released in Jordan, as of 2008

Species	Total varieties released	Varieties of ICARDA origin
Barley	6	2
Bread wheat	4	1
Durum wheat	10	3
Chickpea	3	3
Lentil	3	1
Vetch	1	3
Total	**27**	**13**

ICARDA and NCARE teams undertook three surveys to identify the major diseases and insect pests of cereals and food legumes. A fourth survey in 2005 focused on the cereal leaf miner, which is becoming the country's most serious pest on cereal crops.

Unavailability of seed often hampers the dissemination of new varieties. ICARDA therefore provides training and technical backstopping to strengthen the national seed multiplication program. In addition, several collaborative projects provided expertise and initial pure seed to initiate community-based multiplication of improved varieties. Furthermore, ICARDA regularly provides, in response to NARS requests, breeder or foundation seed of newly released varieties. Limited quantities of seeds are also supplied to farmers participating in collaborative projects.

New wheat varieties being tested at the Maru Research Station

Promising, drought-tolerant 2-row barley derived from ICARDA germplasm

3. Natural Resources Management

Activities include development and demonstration of technology packages for cereal and legume varieties, rangeland improvement, water management and socioeconomic surveys. The Winter Cereals Improvement Cooperative Project (1979-86) with UoJ and the Ministry of Agriculture successfully developed and demonstrated a 'best-bet' package with several components: seed bed preparation using chisel and ducksfoot plows, use of a seed drill, fertilizer dosages and herbicide treatment. Farmers who used the package obtained substantial increases in grain yield. A 5-year ICARDA-JUST project, initiated in 1988, helped map and characterize agricultural production systems in the marginal zone in northern Jordan. The results confirmed the importance of livestock as the main source of farm income and showed how feed production could be increased by using new barley varieties in rotation with feed legumes, supplemented with good management techniques.

Other collaborative activities included tillage and residue management (with NCARE and UoJ), design of water harvesting techniques (with UoJ and Concordia University in Canada), and estimation of soil erosion in the Muwaqqar region (with UoJ). These studies were conducted as part of graduate research. The dryland resources management project (with NCARE and UoJ) studied the socioeconomic characteristics of production systems in the Al-Lajoun area in southern Jordan and assessed the production and level of degradation of rangelands. More information on these results is available in project reports published by ICARDA.

Collaborative research on water and land management by ICARDA, NCARE and Jordanian universities has identified several options for better management of scarce water resources. For example, supplemental irrigation can improve water productivity in rainfed systems. Results have shown how small quantities of water can more than double wheat production, if applied during the spring when rainfall is insufficient to meet the crop's water requirements. Water harvesting using low-cost micro-catchments can arrest land degradation and rehabilitate degraded rangelands in the *badia*. By capturing and redirecting rainwater runoff, the micro-catchments provide favorable conditions for shrubs and grasses, increasing productivity substantially and

controlling erosion. Local communities are fully involved in the research, and have shown great appreciation for these technologies, suggesting very high potential for adoption.

In addition to the *badia* water benchmark site established in Jordan (to serve the whole region), a water harvesting research site for use by graduate students was established on the JUST campus. The site is fully operational and serves dry environments throughout Jordan.

A major international conference on 'Water Resources Management, Use and Policy in Dry Areas' was held in Amman in December 1999, under the patronage of His Majesty King Abdullah II. It attracted 140 participants from 28 countries, including representatives of eight international organizations. The conference was inaugurated by HRH Prince Feisal, Prince Regent of Jordan, and catalyzed vigorous new efforts to address the problem of water scarcity in the region. Water-related issues now receive the highest priority from Jordanian researchers and policy makers, as well as ICARDA scientists and management.

Laser guidance system for tractors: this innovation has greatly increased the speed and accuracy of preparing contour ridges

4. Socioeconomics, Institutional and Policy Research

Policy research

Community models were developed to evaluate the effects of different policy reforms and technologies on farmers' welfare and resource allocation. This included an innovative decision making tool to preddict the potential effects of technical, policy, and institutional options. This is a bio-economic model designed to represent the behavior of farmers, herders and households. It helps understand how different members of a community are likely to respond to the introduction of a new technology, resource management strategy or policy reform, and the effect of these responses on productivity, incomes, income distribution, and the sustainability of the natural resource base.

In 1996, the Jordanian government began to implement a major policy change, phasing out feed subsidies. The first phase of the M&M project evaluated the sector-level effects of these reforms at comunity level, specifically in the Mkaifteh community. When subsidies were removed, farmers with large flocks reduced their flock size by 18%, while those with small flocks tended to allocate more land to barley and double the herd size. Landless livestock owners tended to reduce livestock numbers and rely more on off-farm activities. Farmers who integrated crop and livestock activities in a more balanced way were less affected by the policy changes than the other groups. Reduced feed subsidies led to substantially lower farm revenues. Total wealth decreased by 14% among livestock farmers, 9.7% among crop/livestock farmers, and 7.4% among cereal farmers. In contrast, the removal of output support affected cereal farmers more than livestock farmers. On average, farmers' wealth would drop by 14% if output support is removed. The policy change also contributed to land use changes and the extension of cropping to more marginal areas.

Property rights research

This research sought to identify appropriate property rights and rangeland management institutions that promote the efficient, equitable, and environmentally sustainable use of land under the different agroclimatic and socioeconomic conditions found in low-rainfall areas, and to identify conditions under which more formalized institutions are appropriate.

A survey was conducted in parts of Jordan where three range management options were introduced: government grazing reserves, herder-driven cooperatives, and common use rights to formerly tribal pastures. The survey results showed that herder-driven cooperatives were the best option; they reduced household feed expenditure by 21%. State grazing reserves increased feed expenditures by 30%. Land tenure arrangements were crucial factors affecting farmers' investment decisions.

Research on adoption and impact assessment is described in the following section.

5. Special Collaborative Projects

During the 30 years of collaboration between Jordan and ICARDA, over 30 bilateral, multilateral and regional projects have been implemented. Results from the larger projects are summarized below.

- **From formal to participatory plant breeding: improving barley production in the rainfed areas of Jordan**

Partners: NCARE, UoJ, JUST, JOHUD, ICARDA
Period: 2001-2007
Funding: IDRC and OFID

The project aimed to improve the welfare of small-scale, resource-poor farmers by increasing and stabilizing barley and animal production in rainfed areas, through participatory plant breeding (PPB). Local communities were first surveyed to understand variety requirements. Farmers and breeders then jointly conducted selections on nurseries and yield trials planted in farmers' fields and in adjacent experiment stations for two seasons, 2001-03. The impacts have been significant: the new research approach has been successfully introduced; attitudes of farmers and breeders have changed, new ideas have taken root. Scientists now better understand farmer preferences, and have become familiar with new statistical tools for analyzing non-replicated trials. Six promising barley lines, which consistently outyielded 'Rum', the local check, have been submitted for release, and community-based seed multiplication initiated. NCARE is continuing the PPB effort within its wheat and barley programs. Farmers have requested it be extended to other crops like chickpea.

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

Partners: ACSAD, IPGRI, NCARE, UoJ, JUST, JES, ICARDA
Period: 1999-2005
Funding: GEF-UNDP

This regional project, coordinated by ICARDA, aimed at promoting community-driven *in-situ*/on-farm conservation of landraces and wild relatives of cereals, lentils, *Allium*, feed legumes and several fruit trees for which West Asia is the center of diversity. Activities were conducted in the Ajloun and Muwaqqar areas. The project has improved knowledge of the status of local agrobiodiversity and the factors responsible for its decline; and demonstrated low-cost technology packages for improving the productivity of landraces and the management of rangelands. Local communities, especially women, have been trained on value addition (e.g. food processing) and alternative income sources (dairy, mushrooms, honey, medicinal plants, fruit tree nurseries). NARS capacity has been strengthened.

Public awareness of biodiversity issues has increased; biodiversity has been introduced into the school curriculum. Policy, legislation and institutional options for agrobiodiversity conservation have been drafted, to be presented to the government. The use of native wild fruit tree species for afforestation has increased, following the creation of

Agrobiodiversity fair: creating financial incentives for communities to conserve biodiversity

a biodiversity unit in the Forestry Department and training for its staff. NCARE's Genetic Resources Unit has extended its activities to cover *in situ* conservation; seven sites have been selected to protect the most threatened species.

Community-based efforts, with technical backstopping by the project, have been equally successful. In the Mahareb community in Muwaqqar, for example, rangelands are being rehabilitated through a combination of water-harvesting structures, planting of native shrubs, use of contour ridges, and better grazing management. Farmers (mainly women) have created six nurseries to multiply fruit tree landraces and seedlings of medicinal plants. An 'agrobiodiversity tent' has been set up at Ajloun Castle (one of Jordan's biggest tourist attractions), where farmers sell local products to visitors.

Efforts are continuing with the Ministry of Education to introduce biodiversity conservation within the school curriculum, and as an extra-curricular activity. JUST is developing a Masters program on biodiversity and natural habitat management and has taken responsibility for managing a natural reserve for conservation and research. The project has developed socioeconomic, livelihoods, eco-geographic and GIS/Remote Sensing databases, now available at NCARE. It has also contributed significantly to capacity building, supporting 18 Masters students and training over 850 people, including 470 women.

• Mashreq and Mashreq-Maghreb integrated crop-livestock projects

Partners: IFPRI, NCARE, ICARDA
Period: 1989-2008
Funding: IFAD, AFESD

Jordan is an active member of the Mashreq-Maghreb project, which covers eight countries: Iraq, Jordan, Lebanon, Syria (Mashreq), Algeria, Libya, Morocco and Tunisia (Maghreb). The project, initiated in 1994 and now in its third phase, aims to develop technological, institutional and policy options for better crop-rangeland-livestock integration in low-rainfall areas. In Jordan, activities in Phases I and II were implemented with three communities in Mkaifteh, Harsh/Braiqa and Bowedah Gharbeh. The initial Mashreq project (1989-93) worked on research stations and with individual farmers to test and demonstrate

selected technologies including new barley varieties, low-cost agronomic packages, and introduction of vetch, forage legumes and shrubs. The larger Mashreq-Maghreb project, during its first two phases (1994-2002), worked with pilot communities to improve productivity, incomes and livelihoods of small-scale crop and/or livestock producers. It introduced simple but innovative technologies, with full community participation; combined with policy reforms relating to land tenure, land use, marketing and credit systems.

The impacts have been significant. Multinutrient feed blocks, made from agro-industrial by-products, have been introduced. Cactus plantations, cultivation of vetch and *Lathyrus*, and barley-cactus intercropping have improved the quality and availability of animal feed. New livestock technologies introduced by the project have improved sheep husbandry: for example hormone sponges to increase fertility, and feed supplementation for better fattening. Lambs are being weaned earlier, and Awassi ewes are breeding 4 to 5 months earlier. Project teams have worked with communities to develop community development plans which create closer links between the community and government institutions, and better integration of adaptive research with socioeconomic and policy factors such as property rights and the environment. This approach has now been adopted as a model not only by many new research and development projects but also by governments in the region.

During the period 1989-2002, the projects helped train 2894 farmers, 1802 research and extension staff, 455 rural women and 384 students.

An impact study conducted jointly with national research agencies, showed high adoption rates: 58% for improved barley varieties, 29% for vetch cultivation, 29% for early weaning, and 21% for feed blocks. This has led to significant increases in income. For example, adopters of the new feed block technology earned 16% higher net returns than non-adopters.

Phase III of the project was initiated in 2006. It focused on three areas: assisting communities to design and implement community development plans; establishing (with full community involvement) a national development project building on previous or ongoing IFAD-funded projects; and scaling out the project's participatory approach to other dryland areas.

Impact of the Mashreq-Maghreb project

A study was conducted in Jordan in 2000/01, to measure the adoption and impact of technologies introduced by the Mashreq-Maghreb project. The results clearly demonstrate that these technologies are practical and relevant for small-scale farmers in Jordan, that they have been widely adopted in the project's target areas, and have resulted in measurable increases in farm income. This would also suggest that the project's technology transfer strategies have been highly effective.

Data were collected, using a questionnaire and personal interviews, from 155 farmers in different parts of the country: 70 in the north, 45 in central Jordan, and 40 in the south. Farmers were classified into three groups: participants in demonstrations, participants in field days, and non-participants. This will help draw lessons for future dissemination efforts. Adopters were also categorized according to land tenure, farm size, flock size and production system, in order to improve technology targeting.

Technology adoption

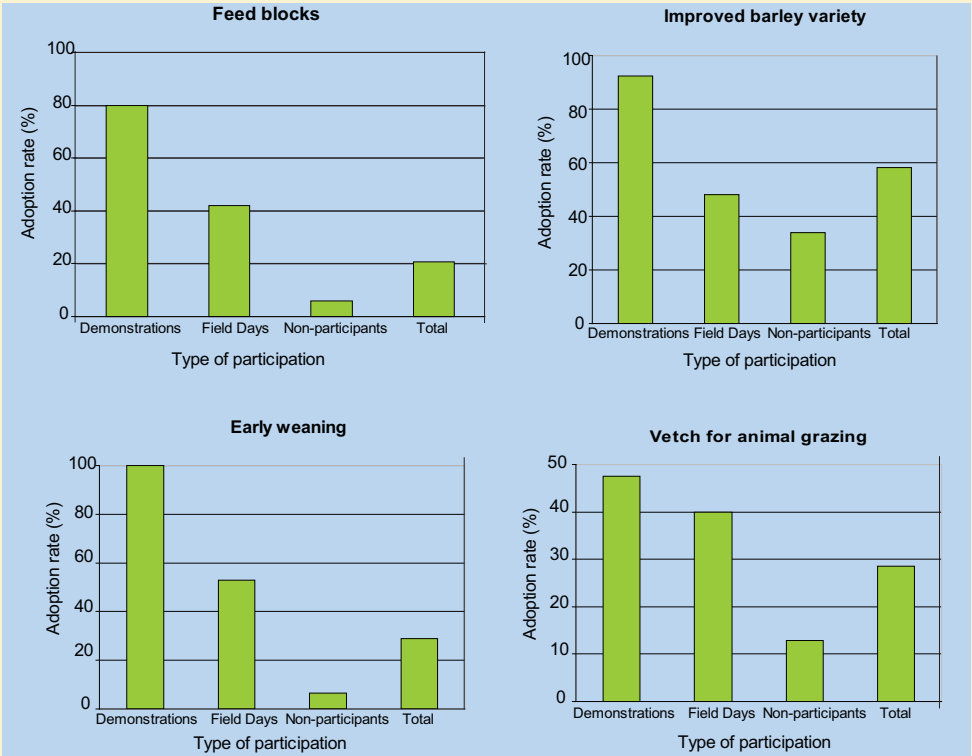
- *Feed blocks.* Average adoption rate (across the whole sample) was about 21%. Adoption was as high as 80% among farmers who had participated in demonstrations.
- *Early weaning*. Every farmer who participated in demonstrations, and over half of field day participants, adopted this technology. Average adoption rate 29%
- *Improved barley variety*. Adopted by over 92% of demonstration participants. Average adoption rate 58%, with significant adoption even by non-participants.
- *Introduction of vetch* (*Vicia sativa*, locally called Bekia). Adopted by almost 48% of demonstration participants. Average adoption rate 29%.

Impact assessment

The impact of each technology was assessed in terms of sustainability of the technology and its impact on productivity.

Sustainability. Once a farmer has tried a particular technology, will he or she continue to use it? Interest in continued use is a measure of whether the technology will continue to spread in the absence of project support. A high proportion of farmers declared their interest in continued use: over 95% of farmers who had used feed block adopters, 43% of those who adopted early weaning technology, 92% of farmers who had tried improved barley varieties, and 49% of farmers who adopted vetch cultivation.

Productivity. Farmers who adopted early weaning technology increased their revenues by 6.96 JD per lamb (1 JD = 1.40 US$). Those who adopted feed blocks increased their revenues by 3.56 JD per animal, and their net returns by 5.35 JD per animal, i.e. 16% higher than non-adopters. These data were collected during a drought season.



- **Regional initiative for dryland farming**

Partners: Regional organizations, MoA, NCARE, ICARDA
Period: 1987-2005
Funding: World Bank

The objective of the program was to help control natural resource degradation, and, where possible, restore productivity of arid land in the Middle East. In Jordan, the project was implemented on a 2000 hectare watershed in Ktiefa, Mahareb and Chouchane areas in central and southern Jordan. To improve management of the watershed the project built water harvesting structures and earth dams at several locations, as well as 40 cisterns and 30 watering pans for livestock. A mobile animal health clinic and a dairy production unit were provided to collaborating communities. Cactus plantation was introduced on 60 hectares. Medicinal and aromatic plants were tested over a 600 hectare area for five seasons. In another component, treated sewage water was used for irrigation to produce ryegrass (100 ha) and trees. The project examined how use of this water affected soil characteristics, forage production and quality, and animal performance. The project also introduced low-cost methods for manure treatment.

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

Partners: Regional organizations, ICARDA, ILRI, ICRISAT, ICRAF, and NCARE in Jordan
Period: 1997-2000
Funding: System-Wide Livestock Program

The project aimed at improving the production and utility of forage shrubs and trees in order to increase supplies of animal feed. A series of studies focused on various aspects. One study identified the optimum density at which forage shrubs (*Atriplex halimus* and *A. nummularia*) should be planted. It found that densities of 1000-2000 shrubs per hectare are optimal when all factors are considered, e.g. seedling survival, cost of installation, inter-plant competition and productivity. The native species *A. halimus* seems better adapted to the dry local conditions, compared to *A. nummularia*, and more suitable for the rehabilitation of degraded rangelands. The project identified five local

fodder shrubs (*A. halimus, A. leucoclada, Salsola vermiculata, S. inermis* and *Anabasis*) that can regenerate directly from seeds, and are highly suitable for the rehabilitation of severely degraded rangelands. Planting a combination of these species could ensure that forage is available throughout the year, and also help conserve local biodiversity. Detailed information on the shrubs of Jordan was compiled into a CD, which is available with national libraries and research centers.

- **Projects on water management**

Jordan is among the world's poorest countries in terms of water availability. Currently, 60% of the available water is used for agriculture. This percentage will inevitably decline in the near future; while simultaneously ground and fossil waters are being rapidly depleted. More efficient water management in agriculture is a priority for Jordan-ICARDA research. The country is a key site for the multi-country Water Benchmarks Project, launched in 2004, which aims to improve mobilization and management of rainwater in dry areas. The project's *badia* (dry rangelands) benchmark site is located in Jordan. Three subprojects (summarized below) studied water harvesting techniques. A 'model' site has been established at JUST, to facilitate research on water harvesting by graduate students.

Contour ridges, built using the Vallerani machine: the technology is being rapidly scaled out over large areas

a) Optimizing soil and water use

Partners: Multilateral, NCARE, UoJ, ICARDA
Period: 1999-2001
Funding: System-Wide Program on Soil Water and Nutrient Management

This project studied the use of mulching and water harvesting techniques to optimize the use of rainwater. Trials at two sites (Khanasreh and Shoubak) used simple structures of different configurations (diamond and semi-circle) to harvest water to support *Atriplex* plantations. Data on runoff and soil moisture showed that these structures increased infiltration rates by 42% with minimal disturbance to the catchment area. This project has linked Jordan with other research networks dealing with soil and water management. A new consortium has been established to strengthen soil and water management in several countries in West Asia and North Africa, including Jordan.

b) Communal management and optimization of mechanized micro-catchment water harvesting for combating desertification in the East Mediterranean Region

Partners: Regional, NCARE, ICARDA
Period: 2004-2006
Funding: Swiss Agency for Development and Cooperation

Water harvesting structures are effective, but laborious to build. This project used the innovative Vallerani machine to mechanize construction of these structures, and eventually rehabilitate marginal areas and rangelands, improve livelihoods, and combat desertification in *badia* areas in Jordan and Syria. A representative watershed was selected in Mahareb using methods developed by the Benchmark Project. Bunds and contour ridges were constructed on more than 300 ha in Mahareb and Al Majidyya and planted with native shrub species such as *Atriplex* and *Salsola*. The results have encouraged other development projects and the Ministry of Agriculture to use the Vallerani machine to promote water harvesting in other parts of the *badia*. The willingness of *badia* farmers in Jordan to adopt these technologies tripled during the three years of project operations. Policy makers, struck by the visible impacts on land management and the level of community support, are now looking to build on the project results.

The Vallerani plow has mechanized the process of building water harvesting structures and rehabilitating degraded rangeland

The government of Jordan has purchased the high-power tractor needed to operate the Vallerani machine, and is planning to buy three more units to scale out the integrated technology package across the *badia*.

c) Integrated natural resources management program to combat desertification in Lebanon and Jordan

Partners: Regional, NCARE, ICARDA
Period: 2004-2006
Funding: UNCCD Sub-Regional Action Program for West Asia

This project targeted the Faa' area in northern Jordan. The objective was to demonstrate effective, transferable technologies to combat desertification and mitigate the effects of drought by integrated management of natural resources. Data on land use and vegetation cover were compiled and analyzed using GIS; farming systems, feeding calendar and flock mobility were studied. The project successfully demonstrated technology packages that combine various components: water harvesting, soil erosion control, reseeding of native shrubs and fruit tree species, and alley-cropping of barley and vetch.

d) Community-based optimization of the management of scarce water resources in agriculture in WANA: badia benchmark

Partners: Regional, NCARE, ICARDA
Period: since 2004, ongoing
Funding: IFAD, AFESD, OFID

Research sites for the Water Benchmarks Project were selected to represent the three major agro-ecosystems in the dry areas of WANA. The Rainfed Benchmark was established in Morocco to focus on supplemental irrigation; the Irrigation Benchmark site in Egypt to study how to maximize crop water-use efficiency under full irrigation; and the Badia Benchmark in Jordan, targeting water harvesting for better crop-livestock integration, arresting range degradation, and reviving degraded areas. The project uses an integrated approach, based on community participation. At each site, the local community is a full partner in planning, implementation, monitoring, and evaluation. Farmers work with scientists and extension staff to test a range of 'best-bet' technologies and select those that best meet their needs – often

Researchers from NCARE and ICARDA use satellite data and GIS analysis to select project sites in the badia

adapting the technologies to suit local conditions. This has created a sense of 'ownership', leading to rapid adoption of technologies being introduced by the project.

The project in Jordan has developed a comprehensive approach for selecting watershed and water harvesting sites and is now demonstrating techniques for sustaining rangeland, field crop and fruit tree production. The demonstrations cover over 300 ha in Mahareb and Al Majidyya, and are being implemented in collaboration with local communities. Ongoing studies are analyzing economic and institutional constraints, and identifying policy measures to encourage communities to integrate water harvesting into the agricultural system. Mahareb and Al Majidyya will continue to be the primary research sites, but some work will be replicated at satellite sites in Saudi Arabia and Libya. NCARE, the lead implementer in Jordan, now uses this approach for all its new projects. NCARE also provides technical backstopping to other organizations (e.g. the Yarmouk Development Project), enabling them to use the same approach as well.

- **Small ruminant health: improved livelihoods and market opportunities for poor farmers in the Near East and North Africa**

Partners: Regional, ILRI, MoA, NCARE, JUST, ICARDA
Period: 2004-2006
Funding: IFAD

The project aimed to improve farm livelihoods by improving the health of small ruminants, and enhancing marketing at both national and regional levels. The project partners identified the main constraints to livestock health, assessed the delivery of health/veterinary services, and proposed alternative strategies to strengthen the sector. In order to improve market access, the project also assessed disease risk and helped develop disease control strategies at sub-national, national and regional levels. It has established local capacity to diagnose livestock diseases and design and implement control strategies. Jordan is the hub for the Mashreq region for this component.

Sheep in the badia: researchers aim to optimize farmers' returns from livestock production while preventing further degradation of rangelands

- **Combating dryland degradation**

Period: 2008-2009
Funding: USAID
Countries: Jordan, Morocco, Pakistan, Yemen

Policy, market and institutional deficiencies are major constraints to sustainable dryland development and the main factors causing desertification. Yet these policies continue because of incomplete understanding of local systems, lack of practical solutions, and inability to change the policy-making institutions and frameworks. This project aims to study the relationship between land degradation and policy failures in the four participating countries; and thus contribute to the development of an enabling environment that overcomes the constraints (relating to policy, market and institutional dynamics) that aggravate land degradation. The research will assess the types, status, intensity and severity of land degradation; review existing and potential sector policy frameworks and assess their impacts on land degradation; identify and quantify land degradation indicators (both quan-

titative and qualitative) and identify information gaps; quantify the impact of land degradation on resource productivity and estimate the cost of land degradation; and identify and fully characterize improved land management options. Activities will include sampling and primary data collection at household and community levels, and the use of modeling techniques to evaluate policy options and assess trade-offs.

- **Commodity chain analysis for medicinal and aromatic plants in the NENA region**

Period: 2008-2009
Funding: IFAD
Countries: Egypt, Jordan

Herbal, medicinal and aromatic plants (MAPs) are important options for livelihood diversification and income generation by small-scale farmers in the Near East and North Africa (NENA). These plants have a clear comparative advantage and great potential to contribute to poverty reduction in the region, but marketing constraints and limited access to markets have hampered the expansion of MAP production. This project will analyze various aspects of the MAP value chain: the roles and functions of different actors; market constraints along the value chain; post-harvest activities and processing technology; prices, marketing costs and margins of various agents as well as the whole value chain; and the policy and institutional environment that influence how MAPs are used and marketed. The results will help inform policy makers as they seek to link small-scale farmers to markets.

- **Access and benefit sharing from genetic resources and traditional knowledge in Jordan**

Partners: NCARE, ICARDA
Period: 2008-2010
Funding: IDRC

The development goal of the project is to empower small-scale resource-poor farmers by increasing their awareness of plant genetic resources and enhancing benefit sharing among different stakeholders. The project will work to put in place a legal framework for genetic

ICARDA brings partners together – farmers, national research and extension agencies, development organizations and donors – to plan and implement sustainable interventions

resources, including an access and benefit sharing regime, a traditional knowledge protection system, aspects of farmers' rights, seed system regulations, and a system for supporting participatory plant breeding (PPB). The project aims to address issues relating to recognition of PPB, and fair access to and use of varieties developed through PPB. It will also raise farmer awareness about their rights over genetic resources (in relation to policies and laws), and thus empower poor communities. The results will help inform changes in the current laws governing variety release and seed production to allow access and fair benefit sharing of new varieties developed using (or building on) traditional knowledge.

- **Other projects**

Numerous other ICARDA-NARS collaborative projects have been implemented in Jordan, as listed in Table 5.

Table 5. Other ICARDA-NARS collaborative projects in Jordan

Project title	Partners	Period
Development of biotechnology in the Arab states (morphological and AFLP analysis of durum landraces)	Regional, Yarmouk University	1996-99
Mixtures of barley landraces and their production dynamics (high-yielding Arta and Arta-based mixtures)	NCARTT	1997-98
Evaluation of drought tolerance in barley lines (early maturity, heat tolerance, selection in target environment)	NCARTT, UoJ	1997-98
WANA dryland improvement network	Regional, NCARTT	1995-98
Mapping drought adaptation in barley (testing of regional nursery)	Regional, NCARTT	2003-05
On-farm water husbandry in WANA	Regional, NCARTT	1996-97
Conjunctive use of treated sewage effluent and rainfall in supplemental irrigation systems	NCARTT	1996-2000
Development of a strategy and medium-term plan for NCARTT	NCARTT, HCST, ISNAR	1994
Water harvesting	Multilateral, ICARDA, UoJ, MoA, Concordia University	1993-96
Tillage and residue management studies	UoJ, NCARTT, MoA	1989-96
Dryland resource management (rangeland studies in Al-Laloun area)	NCARTT, UoJ, JUST	1990-92
Adoption and impact of NARS-ICARDA technologies in West Asia	Regional, NCARTT	1996-98

6. Training, Workshops and Conferences

Capacity development has always been a central component of ICARDA's collaborative projects. The Center offers a wide range of training opportunities, that have contributed significantly to building the capacity of technical and scientific staff from numerous research institutions in Jordan (Fig 1, Table 6). From September 2000 to August 2008, 849 persons from Jordan participated in training courses, meetings, workshops, conferences and scientific visits organized by ICARDA. Training has not been restricted to researchers: Jordan-ICARDA collaborative projects have also trained over 2300 farmers (including 730 women) through field days, workshops and participation in trials and demonstrations.

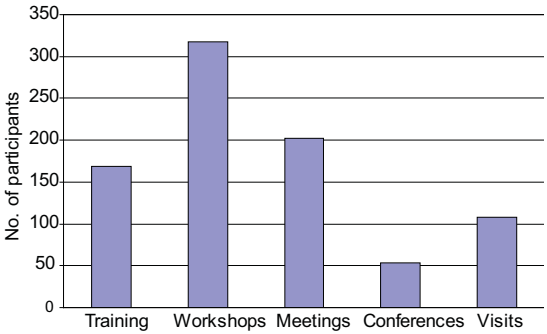


Figure 1. Jordanian participants in ICARDA activities, 2000-2008

Table 6. Participation by Jordanian and ICARDA staff in various collaborative activities, 2000-2008

	No. of participants
Training courses (Jordanian participants)	169
Workshops, meetings and conferences (Jordanian participants)	572
Visits by Jordanian scientists to ICARDA	108
Visits by ICARDA scientists to Jordan	338

Post-graduate degree training supported by ICARDA in Jordan, 2000-2008

- Molecular and field assessment of genetic variation in barley grain yield under low and high yielding environments. Adnan Yassin. PhD thesis, 1996-2001
- Aspects of ecological characterization and introgression from wheat landraces in *Triticum dicoccoides*. Maha Syouf. PhD thesis, 2000-01

- Assessing the adoption and impact of water harvesting techniques in the low-rainfall areas of Jordan. Samia Akroush. PhD thesis, 2005-07
- Genomics of durum wheat: BAC library construction and genomic *in situ* hybridization. Fadel Ismail. PhD thesis, 2003-07
- Construction and characterization of a combined barley partial genomic library using bacterial artificial chromosome. Ghaleb Shalaldeh. PhD thesis, 2003-08
- Impact of microcatchment water harvesting on diversity of rangelands. Nisreen Shawahneh. PhD thesis, ongoing
- Genetic diversity assessment among Jordanian wild barley (*Hordeum spontaneum*) genotypes and relationship with morphological traits revealed by SSR molecular markers. Yahya Shakhatrah. PhD thesis, 2004-06
- Ecogeographic study of *A. fragrantisima*. Ibrahim Rawashdeh. PhD thesis, 2004-07
- Epidemiological studies on peste des petits ruminants (PPR) disease in sheep and goats in northern Jordan. Nazmi Hussein. MSc thesis, 2004-07

Workshop in Tafeleh, south Jordan: farmers, researchers and extension staff work together to adapt modern farming techniques to local situations

7. Awards

The value of Jordan-ICARDA partnerships, and their contribution to the country's agricultural development, are widely recognized. These efforts have been acknowledged in various ways, including awards presented to ICARDA staff by national decision makers.

- Dr Adel El Beltagy, ICARDA's Director General (1995-2006), won the King Abdallah Istiklal Medal in 2005
- NCARE honored two ICARDA teams (West Asia Regional Program, Badia Benchmark Project) with special awards in 2005
- NCARE honored four ICARDA staff in 2006: Director General Dr Mahmoud Solh; and three scientists, Drs Ahmed Amri (plant genetic resources), Salvatore Ceccarelli (barley breeding) and Theib Oweis (water management).

Dr Adel El-Beltagy (third from left), former ICARDA Director General, honored for his role in strengthening Jordan-ICARDA collaboration

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