Issue No. 15, December 2001

ICARDA Caravan

Review of agriculture in the dry areas

In this special issue on ICARDA's work in Africa:

Friendships bloom in the desert
- *Research for development on Egypt's northwest coast*

Sub-Saharan Partnerships
- *Cultivating a sustainable seed sector in Africa*

Rangeland Degradation
- *Holding back the desert in Morocco*

Participatory Research
- *Farmers breed better barley*

Integrated Cereal Disease Management
- *Cutting crop losses in Eritrea*

And more ...

From the Director General

Although Africa is a continent of enormous natural resources, its agricultural production has not kept pace with demand from its growing population. The continent, therefore, has been drawing major attention of the Consultative Group on International Agricultural Research (CGIAR) in its drive to improve food security, alleviate poverty, and improve the livelihood of the poor. Four of the 16 CGIAR Centers (ICRAF, IITA, ILRI, and WARDA) are based in Africa, and others are contributing through their regional programs. ICARDA, with its focus on the dry areas of Central and West Asia and North Africa, is at the forefront in developing technologies that increase agricultural production through the efficient use of natural resources, or that stimulate the rural economy by enhancing the returns to poor farmers through improved crop varieties and better management practices for small-ruminant production in Africa.

ICARDA serves its African stakeholders through two of its seven regional programs. These are the Nile Valley and Red Sea Regional Program (NVRSRP), which covers Egypt, Ethiopia, Eritrea, and Sudan; and the North Africa Regional Program (NARP), which covers Algeria, Morocco, Mauritania, Libya, and Tunisia. Partnership and cooperation are key components of ICARDA's strategy in improving the welfare of resource-poor farmers.

Germplasm improvement, in cooperation with national programs in Sudan, Ethiopia, Eritrea, and countries in North Africa, has led to the development of superior crop varieties, many of which have been successfully introduced in most of these countries, as well as elsewhere. For example, in Sudan, improved cultivars of heat-tolerant bread wheat have helped in expanding the area of this strategic crop well beyond its traditional limits and have led to enhanced food security. Improved disease and pest-resistant lines of faba bean, lentil, and chickpea have been developed for Sudan to provide a cheap source of good quality protein.

In Ethiopia and Eritrea, major progress has been made in developing barley varieties with higher yield and disease and pest resistance. A major achievement in Ethiopia has been the development of low-neurotoxin and high-yielding cultivars of grasspea, safe for human consumption. A protein-rich legume, grasspea is the only hope for the poor in times of drought, but it contains a neurotoxin that causes paralysis of the legs. Ethiopia has also released new disease-resistant varieties of faba bean, chickpea, and lentil, which are key components of the farming system and the diet of the poor in the country.

In Morocco, a joint effort with national researchers has resulted in the release of improved durum wheat cultivars that carry resistance to Hessian fly, a devastating insect pest. By using these varieties, farmers in the dry areas of Morocco alone could prevent wheat crop losses worth an estimated US$20 million annually. In other countries of North Africa, ICARDA is involved in the improvement of indigenous water-harvesting techniques, such as the *jessour* system, which originated in ancient times. People designing such water capture and retention systems relied previously on visual assessment of prospective catchment and feeder areas. By using satellite mapping and geographic information systems (GIS), researchers are now able to computer-design accurate catchment systems to harvest the greatest possible amount of useful water.

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Cover: *Women play a critical role in agriculture in Africa, from production, to marketing, to processing, and food preparation. Here, women in Ethiopia thresh a sun-dried food legume, the seeds of which are inspected for their suitability as seed stock.*

News

Focus on Africa

Also in North Africa, technologies have been developed that make use of shrubs and spineless cactus to combat desertification. In a larger effort, ICARDA and ICRISAT are co-conveners of a Systemwide Ecoregional Program for Optimizing Soil Water Use (OSWU), which follows a consortium approach and involves national agricultural research systems of West Asia, North Africa, and Sub-Saharan Africa. As part of the Systemwide Livestock Program, ICARDA is coordinating a project on "Production and Utilization of Multi-Purpose Fodder Shrubs and Trees in West Asia, North Africa and the Sahel," with active participation of national scientists, to augment local feed resources for livestock and improve the livelihood of herders.

Targets for sustainable increases in agricultural productivity in Africa will not be met without the application of cutting-edge science. To this end, ICARDA plays a vital role in encouraging advanced research institutions to collaborate in technology development, capacity building, technology transfer, and policy research in Africa. The Center's strategy incorporates participatory, integrated approaches to increase sustainable market-oriented production of crops and livestock in partnership with national program scientists. This issue of *Caravan* provides glimpses of the Center's research achievements in Africa made possible through these partnerships.

Prof. Dr Adel El-Beltagy
Director General

About ICARDA and the CGIAR

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

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

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs is offered, from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and specialized information services.

The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. The CGIAR receives support from many country and institutional members worldwide. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South-North partnership to reduce poverty and hunger.

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

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

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Agricultural Research Priority Setting for Central and West Asia and North Africa

During the mid-term meeting of the Consultative Group on International Agricultural Research (CGIAR) in Dresden, Germany, in 2000, the CGIAR Technical Advisory Committee's proposal for a regional approach to agricultural research priority setting and for greater integration of the CGIAR Center activities in national agricultural research system (NARS) regional priorities was approved. This process is now underway, facilitated by a CGIAR Center in each key region. The Center Directors General Committee (CDC) assigned ICARDA to facilitate the priority setting process in Central and West Asia and North Africa (CWANA).

The goal is to enhance the effectiveness of the CGIAR in helping NARS address key problems at the sub-regional and regional levels. The process in CWANA is undertaken in close collaboration with the Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA) and the NARS Forum for Central Asia and the Caucasus (CAC). ICARDA is following a bottom-up approach that encourages broad participation from a wide range of stakeholders. It began with the development of an exhaustive inventory of CGIAR activities in CWANA, followed by a questionnaire and consultation meetings.

Three sub-regional priority setting meetings were held: for CAC on 20 September 2001 in Tashkent, for the Nile Valley and Red Sea countries, 27 September in Cairo, and for West Asia, 18-19 November at ICARDA headquarters. Meetings are planned for North Africa, in Tunis, Tunisia, and the Arabian Peninsula, in Kuwait, in January 2002. Outputs from these meetings will provide a basis for a larger exercise for the whole region planned for May 2002 at ICARDA.

The process is supported in part by the Global Forum for Agricultural Research.

Research Priority Setting for Central Asia and the Caucasus

Seventy-one stakeholders, representing NARS, international agricultural research centers, donors, national research institutions, non-governmental organizations (NGOs), the private sector, and farmers, participated in the Tashkent meeting organized by ICARDA in association with the CAC Regional Forum on 20 September. Participants included Prof. A. Satybaldin, Chairman, CAC Regional Forum; Acad. J. Akimaliyev, President, Kyrgyz Academy of Agriculture; country representatives Dr U. Kazaryan from Armenia, Dr A. Musaev, Azerbaijan, Acad. G. Agladze, Georgia, Dr B. Sanginov, Tajikistan, Dr Shamurad Kheremov, Turkmenistan, and Dr Sherali Nurmatov, Uzbekistan; Dr M. Ul-Hassan from the International Water Management Institute (IWMI); Ms. M. Turdyeva from the International Plant Genetic Resources Institute (IPGRI); and Dr A. Morgounov from the International Center for the Improvement of Maize and Wheat (CIMMYT). The meeting discussed the importance of priority setting and the efforts to link national with regional priorities, and, after deliberations, identified national and regional priorities.

Participants in the Fifth ICARDA-CAC Annual Regional Coordination Meeting, held in Tashkent, brainstorming workshop on 20 September on agricultural priority setting for CAC. Dr U. Kazaryan from Armenia, Dr A. Musaev from Azerbaijan, Acad. G. Agladze from Georgia, Prof. A. Satybaldin from Kazakstan, Acad. J. Akimaliev from Kyrgyzstan, Dr B. Sanginov from Tajikistan, Dr Shamurad Kheremov from Turkmenistan, and Dr Sh. Nurmatov from Uzbekistan made presentations on behalf of their respective countries and highlighted their priorities. These were then discussed in detail by the participants.

Research Priority Setting for the Nile Valley countries

The Nile Valley and Red Sea Sub-region priority setting meeting, organized by AARINENA and ICARDA on 27 September, was moderated by Dr Osman Ageeb, Former Director General, Agricultural Research Center (ARC), Sudan. More than 50 representatives of stakeholders in the Nile Valley and Red Sea Regional Program (NVRSRP) attended the workshop, among them: Dr Fawzi Naim, Director General, ARC, Egypt; Dr Salih H. Salih, Director General, ARC, Sudan; Dr Ismail Muharram, Chairman of the Agricultural Research and Extension Authority, Yemen; Dr Geletu Bejiga, Director, Field Crops Research Division, Ethiopean Agricultural Research Organization; and representatives from national research institutes, universities, the private development sector, and NGOs in Egypt, Ethiopia, Yemen, and Sudan. Dr Nawfal Rasheed, Advisor to the President of the Arab Authority for Agricultural Investment and Development, Sudan, also participated in the workshop, along with representatives from AARINENA, ICARDA, the Food and Agriculture Organization of the United Nations (FAO), the International Center for Living Aquatic Resources Management (ICLARM), IPGRI, and CIMMYT. Dr Christo Hilan, representing AARINENA, gave the NARS perspective. NARS Directors General presented and discussed their countries' agricultural research strategies for the next 10-25 years. This was followed by a panel discussion involving all stakeholders.

More than 50 stakeholders' representatives from the Nile Valley and Red Sea sub-region attended a priority setting workshop in Cairo in September. Dr Fawzi Naim, Director General, ARC, Egypt; Dr Salih H. Salih, Director General, ARC, Sudan; Dr Ismail Muharram, Chairman of AREA, Yemen; Dr Geletu Bejiga, Director, Field Crops Research Division, EARO, Ethiopia; Dr Nawfal Rasheed, Advisor to the President of the Arab Authority for Agricultural Investment and Development in Sudan; and Dr Christo Hilan, representing AARINENA, participated in the workshop.

Research Priority Setting for West Asia

Among those who took part in the West Asia sub-region priority setting meeting held at ICARDA were Dr C. Papachristoforou, Deputy Director General, Agricultural Research Institute, Cyprus; Dr Abbas Keshavarz, Director General, Seed and Plant Improvement Institute (Karaj), Iran; Dr Basil Dalali, First Under Secretary, Ministry of Agriculture, Iraq; Dr Abdelnabi Fardous, Director General, National Center for Agricultural Research and Technology Transfer, Jordan; Mr Hassan Nabulsi, President, Jordan Farmers Union; Dr Moustafa Mroueh, Dean, Faculty of Agriculture, Lebanese University, Lebanon; Mr Nader Hreimat, Assistant Director General, Applied Research Institute, Jerusalem, Palestinian Authority; Dr Walid Taweel, Director General, Syrian Directorate of Agricultural Scientific Research; Dr Khalid Al-Sharaa, United Nations Convention to Combat Desertification, National Focal Point, Ministry of Environment, Syria; Dr Adib Rahmi, Dean of the Faculty of Agriculture, Aleppo University, Syria; Dr Selahattin Mermer, Acting Director

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Senior researchers, research managers, farmers, and NGO representatives from eight countries in West Asia, along with their ICARDA colleagues, participated in the "Brainstorming Meeting on Agricultural Research Priority Setting in West Asia," held at ICARDA, 18-19 November.

Rabat Declaration

Opportunities for Sustainable Investment in Rainfed Areas of West Asia and North Africa

Thirteen West Asian and North African countries (Algeria, Egypt, Iran, Jordan, Libya, Mauritania, Morocco, Oman, Palestinian Authority, Sudan, Syria, Tunisia, and Yemen), represented by ministerial delegations, and representatives of donor agencies and regional and international organizations, met in Rabat, Morocco on 25-26 June 2001, to consider challenges critical to development of drylands in the region: to reduce rural poverty, arrest natural resource degradation, accelerate economic growth, diversify economic opportunities, and enhance food security. These challenges are exacerbated by lack of water resources, drought, high population growth, and low investment. The participants issued the following declaration:

As further expansion of irrigated areas is limited, we believe that it is crucial to optimize the use of scarce land and water resources for improving the quality of life of the people through increasing the productivity, profitability and sustainability of the overall natural resource use of the countries, including both irrigated and rainfed areas.

We agree to forge a partnership that will focus on the overall sustainable development of drylands in WANA. We emphasize our long-term commitment to reducing poverty, arresting desertification, enhancing socioeconomic growth and diversifying economic opportunities in these areas, as well as to supporting the implementation of the UN Convention to Combat Desertification. To realize these goals, we agree to give higher priority to resource allocation to rainfed areas.

In particular, we emphasize the need to: (a) develop appropriate policies and implement integrated drought management strategies; (b) develop and implement a regional approach to drought preparedness; (c) provide appropriate incentives and safety nets that encourage rural communities to undertake environmentally friendly land-use practices to combat desertification and natural resource degradation and consequently adopt improved national policies and strategies to that end; (d) strengthen institutional arrangements and mechanisms for more effective participation of the local communities and civil society in defining the priorities for investment; (e) identify investment opportunities for both the private and public sectors to improve the social and economic infrastructure necessary for dryland development; and (f) examine the potential for all projects aiming at mitigating climate change.

We endorse the development of a program for the drylands of WANA which will build a foundation for regional cooperation; promote technical collaboration; share local and global information and knowledge; strengthen national capacities to facilitate the design and implementation of national policy and institutional improvements as well as investment programs. It will also support the implementation of the UN Conventions such as the Convention to Combat Desertification and promote synergies between the UNCCC, UNCBD and UNCCD.

We, all the participants of the Ministerial meeting on "Opportunities for Sustainable Investment in Rainfed Areas in West Asia and North Africa (WANA)," express our deepest gratitude to His Majesty the King Mohammed VI of Morocco for his patronage, support and sincere interest in supporting improvement of the well-being of the vast number of people depending on the natural resource base in the drylands. We are also grateful to the Government and the People of the Kingdom of Morocco for their hospitality and support, and for making this meeting a success.

Continued form page 5

General, General Directorate of Agricultural Research (GDAR), Turkey; Dr Servet Kefi, Director of Industrial Crops Division, GDAR; Prof. Dr Ersin Istanbulluoglu, Vice-Dean, Kirikakale University, Rektorlugu, Turkey; Dr Mustafa Yaghi, President, AARINENA; Dr Mohammad Hassan Roozitalab, Regional Representative (Iran), AARINENA; Dr Ihsan Fargi, Deputy Director, Plant Studies Division, Arab Center for Studies of the Arid Zones and Dry Lands, Syria; Dr Mohammed Gabr, Chief, Agriculture Section, United Nations Economic and Social Commission for Western Asia, Beirut, Lebanon; Dr Abdullah A. Jaradat, Plant Genetic Resources, International Center for Biosaline Agriculture, Dubai, United Arab Emirates.

Demand Strong for Chickpea Variety 'Gokce' in Turkey

Turkish consumers and exporters are generating strong demand for 'Gokce', a chickpea variety developed from ICARDA line FLIP 86-87C and released in Turkey in 1997.

Seed is being produced in Turkey and in nearby countries. Farmers and consumers in Turkey and other countries like the variety's large seeds.

Dr Ismail Kusmenogulu, Director General of the Mediterranean Exporters Union (MEU) reports that, to meet strong demand, MEU contracted farmers to produce 'Gokce' on 2000 ha in 2001/02. The variety has also shown its potential in Kyrgyzstan and Kazakstan, where it is grown by MEU.

New Lathyrus Variety for Kazakstan

The Kazakh Research Institute of Agriculture, Almalybak, submited to official state trials a new ICARDA Lathyrus line, IFLS 225 Sel 554, because of its good performance in ecological yield trials during the past three years. The pedigree of this line is: IFLLS197/450 (male parent from Afghanistan) crossed with IFLLS 416/514 (female parent from Ethiopia). The new variety, when released, is proposed to be named 'Ali-Bar', after the names of the scientists who developed it, Dr Ali Abd El-Moneim, ICARDA, and Dr Bayzhomart Zhanizbaev, Kazakstan.

Cooperation: Key to Progress in Uzbekistan

Cooperation between ICARDA and Uzbekistan is bearing fruit, but success in achieving the full potential of that country's agriculture sector requires commitment to a team approach.

ICARDA Director General Prof. Dr Adel El-Beltagy visited Uzbekistan, 21-24 November, to review the progress of collaborative research and development activities.

One of the highlights of the visit was a meeting with Uzbekistan's Vice-Prime Minister and Minister of Agriculture and Water Resources, H.E. Mr Turop Holtayev, in Tashkent, who expressed satisfaction on the country's work with ICARDA and assured that any constraints to strengthening cooperation would be addressed. He emphasized that, for Uzbekistan, wheat improvement for rainfed conditions is a priority, with emphasis on drought resistance.

At the centennial celebrations of the Uzbek Research Institute of Horticulture and Viticulture, ICARDA Director General Prof. Dr Adel El-Beltagy spoke about the progress and future potential of ICARDA's cooperative programs in Uzbekistan and the CAC region. Seated from left to right: Dr (Mrs) Anna Zhukova, distinguished scientist; Dr M. Mirzaev, Director of the Institute; Dr Geoffrey Hawtin, Director General of the International Plant Genetic Resources Institute (IPGRI); and H.E. Mr T. Holtayev, Vice-Prime Minister and Minister of Agriculture and Water Resources, Uzbekistan.

Souvenir photo after Prof. Dr Adel El-Beltagy's meetings with high-ranking officials in Uzbekistan. Left to right: Dr Geoffrey Hawtin, IPGRI DG; Prof. Dr Adel El-Beltagy, ICARDA DG; H.E. Mr Ismail Jurabekov, State Counselor to the President of Uzbekistan; Mr Myrzakulov, Governor of Tashkent region; Mr Tadjiboy Rizaev, Distinguished Farmer; and H.E. Mr Turob Holtayev, Vice-Prime Minister and Minister of Agriculture and Water Resources, Uzbekistan.

Prof. Dr El-Beltagy briefed H.E. Mr Holtayev on the follow-up of work plans developed during previous meetings. Among the planned activites, one tonne of seed of new high-yielding wheat variety 'Dostlik' has been planted for multiplication. This variety was identified in cooperation with the national agricultural research system.

In a meeting with Dr K. Khbibulayev, Chairman of the State Committee on Science and Technology, and leading scientists in the area of plant genetic resources, Prof. Dr El-Beltagy said that all the CGIAR Centers are working together to ensure conservation and utilization of genetic resources. "Uzbekistan has good

Dr P. Khodjaev (second from left), Director of the Plant Industry Institute (PII), Uzbekistan, leads (from left) Prof. Dr Adel El-Beltagy, ICARDA DG, and Dr Geoffrey Hawtin, IPGRI DG, on a tour of the PII germplasm storage facility.

institutions with great history and we wish to work with them as partners for the future of the country," he said.

Another highlight of the trip was centennial celebrations of the Uzbek Research Institute of Horticulture and Viticulture, which were attended by more than 500 people. H.E. Mr Ismail Jurabekov, State Counselor to the President of Uzbekistan, read a congratulatory message on behalf of the President, H.E. Mr Islom Karimov.

ICARDA's program in CAC and the CGIAR's program are headed by Dr Rajendra Paroda, who, along with other colleagues from ICARDA's Tashkent office, accompanied Prof. Dr El-Beltagy on his tour.

At the Central Asian Research Institute of Irrigation, the group met Director General Dr R. Ikramov, who acknowledged the "excellent assistance to the Institute from ICARDA, especially through activities of the Asian Development Bank-supported project on Soil and Water Management for Sustainable Agricultural Systems."

Later, the Director of the Market Reforms Research Institute, Acad. Rasulmat Khusanov, briefed the group on cooperation with ICARDA in socioeconomic research, and he stressed the importance of studies on small ruminant production systems.

The group also toured the Boykozon shirkat (cooperative) farm, where shirkat Chairman, Mr Tohir Holtayev, expressed satisfaction on cooperation with ICARDA, which focuses on water management, forage production, livestock management, and socioeconomic assessment.

Mr F. Gapparov, who was trained at ICARDA in automatic weather station maintenance, showed the farm's new weather station to Prof. Dr El-Beltagy. The DG saw the various technologies being tested, and a field office/ laboratory facility renovated through project assistance.

Prof. Dr El-Beltagy and the group also visited the Uzbek Research Institute of Plant Industry, where the Institute's Director, Dr P. Khodjaev, and Deputy Director, Dr R. Movlaynova, gave them a tour of facilities.

The ICARDA group's final stop was at the Institute of Genetics and Experimental Biology of Plants, where Director General Acad. Abdusattar Abdukarimov made a presentation of the Institute's activities and expressed appreciation for the cooperation with ICARDA and other CGIAR Centers.

On 18 September, ICARDA Director General Prof. Dr Adel El-Beltagy (left) and Academician Asad Musaev, Director General of Research and Production Association, Azerbaijan, signed an agreement outlining collaboration in plant genetic resources.

ICARDA Director General Prof. Dr Adel El-Beltagy and scientists from the Central Asian Research Institute of Irrigation inspect an automatic weather station established with help from ICARDA at Boykozon shirkat farm, Uzbekistan.

ICARDA Participates in UNCCD COP5

ICARDA Director General, Prof. Dr Adel El-Beltagy; Assistant Director General, International Cooperation, Dr Mahmoud Solh; and Senior Irrigation and Water Management Scientist, Dr Theib Oweis, participated in the United Nations Convention to Combat Desertification (UNCCD) COP5, 1-12 October 2001, in Geneva, Switzerland. They followed up on the Center's involvement in the preparations for and implementation of the UNCCD National Action Plans, Sub-Regional Action Programs (SRAPs), and the Thematic Program Networks. ICARDA is the Facilitator of the SRAP Thematic Network on Water Resources (TN1) and a partner in TN2 on Vegetative Cover in West Asia and TPN4 on Water Resources in Asia.■

A Pilgrim's Progress in Egypt

As one exits Cairo, leaving the Pyramids of Giza behind, realization soon dawns of the harshness of the environment and the fragility of the natural resource base, typical of much of Egypt. Thanks to efforts made by government and the private sector, green farms interrupt the large stretches of pure sand on either side of the desert road to Alexandria. The welcoming green patches, plantations of olive, date, banana, citrus, and several food and feed crops, all depend on water brought by canal or drawn from deep wells.

After a couple of hours' drive, the road approaches the Mediterranean coast and splits, to the east going to Alexandria and to the west marching to the Libyan border. We head west, flanked on our right by festive seaside holiday resorts. The landscape to our left, however, speaks more of hard work in a tough environment—fig trees planted on dry patches of land, an attempt by the local people to eke a living. Our destination is far from the holiday crowds, a stretch of land along the northwest coast, the site of pastoral communities where people struggle to earn a living, but find themselves trapped in a cycle of poverty and resource degradation. We are going there to visit the Matrouh Resource Management Project, which is working to break this cycle in an area that stretches 320 km along the coast and some 60 km inland.

The project area is semi desert, moderated by maritime influences in the more populated north. The main source of water is rainfall, which is low and extremely erratic. It averages 150 mm on the coast, but deceases drastically beyond 20 km inland. Agriculture is the main source of livelihood for 70% of the population, mostly Bedouins who have traded nomadic life for scattered settlements and sedentary agriculture. They produce barley, figs, and olives, and raise livestock, mainly sheep and goats. Most of the area is rangeland; cultivated land accounts for only 7% of total area. It is the least developed area on the northwest coast, and has the most degraded resources. Its

Mohan Saxena, Abdul Bari Salkini, Habib Halila, and Ali Akhtar

physiography and geohydrology are ideal, however, for water harvesting, which could serve as the basis for agricultural development.

Recognizing the problems of resource development and institutional constraints, the Project has worked to:

- Enhance availability and use-efficiency of water, soil, and biodiversity through implementation of research-based improved resource development and conservation technologies;
- Introduce improved germplasm of crop, range plants, and livestock, along with improved production practices, through a farming-systems approach;
- Create employment opportunities and sources of income for project beneficiaries, particularly rural women, by supporting small scale income-generating projects;
- Build up the skills and capacity of human resources by training project staff and beneficiaries, including rural women; and
- Monitor and evaluate the environmental and socioeconomic impact of the Project.

To realize these objectives, the Projects' research and development programs include:

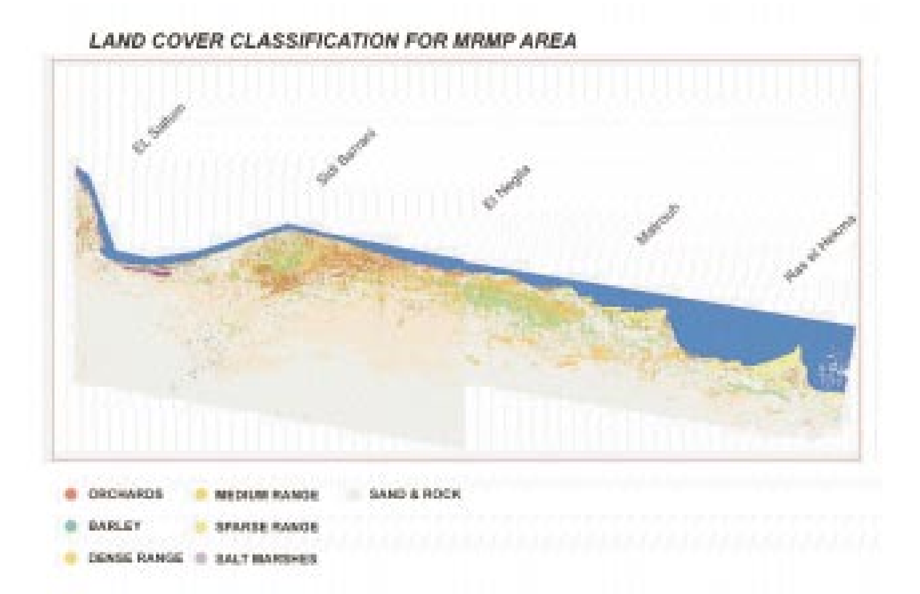
- Development and conservation of natural resources—soil, water, and vegetative cover;
- Adaptive research for production of crops, range, and livestock in an integrated manner;
- Extension, training, and social development, including rural women in development;
- Provision of credit and rural finance for small scale income-generating projects; and
- Management, including monitoring and evaluation of performance and impact.

Participatory approaches to research and development have been followed. Management is decentralized and the efforts of researchers, extensionists, development agents, and farmers have been integrated. The Project Area is divided into five sub-regional support centers (SRSC) and the population has been grouped into 38 local communities. An 'integrated watershed planning approach' that treats the whole watershed as a development unit, has helped ensure resource sustainability and social equity. A 'farming systems research approach' that treats the farm as an agricultural development unit has helped promote adoption of suitable technologies. And a 'community action planning approach' that addresses each community as a social development unit has ensured effective community participation.

After viewing a map of the Project area, we drive from headquarters to Wadi El-Matareih. The scatter of small pyramids made of piles of stone attracts immediate attention. Come close and you see the cisterns, built by the communities, with expert advice and support from the Project staff. Each cistern can hold about 300 m^3 of harvested rainwater, for domestic use, for livestock, and for supplemental irrigation for herbs or other high value crops. Community members Nassif and Jueda grow a patch of mint, Lucerne, and pepper, fertilized with sheep manure. They also grow rainfed barley using improved seeds provided by the Project, based on the research done in collaboration with ICARDA. They have enjoyed a 60% increase in barley yield.

"With participation of Bedouin communities and technical assistance from ICARDA, the Project has implemented holistic multidisciplinary approaches to research and development integrating the themes of resource sustainability, production improvement, and social development," says Dr. Sobhi El-Najjar, Deputy Director General and the technical brain behind the Project.

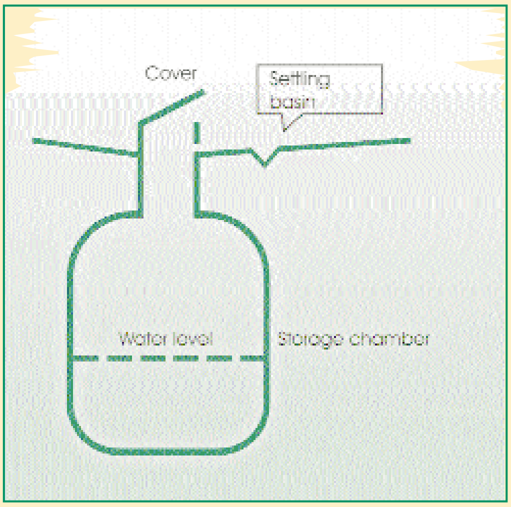
Members of the local community discuss project activities with General Abd El-Wahab El-Wateedy, Director General (second left), and Dr Sobhi El-Najjar, Deputy Director General (left).



Advance a little and you see the wadies, indentations formed by water flow during the rainy season. Now dry, they would hold sizable streams if a flash rainstorm were to occur; and, if left to nature, the precious water would all be lost to the Mediterranean Sea. The farmers' need is too great to allow that. They have built dykes that allow them to grow crops, including vegetables, on land reclaimed on the down-stream side of the wadies. The Project hydrologist and engineer have helped in the design of these dykes, based on careful monitoring of rainfall and precise measurements of the terrain. On the wadi tips, the Project is promoting farming practices that will result in water infiltration, prevent soil erosion, and provide additional income to farmers. Fig, olive, and other tree crops are taking root.

Wadi El-Matarieh also has so-called selected range management areas (SRMAs), each comprising more than 100 feddans (1 feddan = 0.42 hectares), and each assigned to a Bedouin *bait*, or clan. The land is allocated for deferred grazing on fodder shrubs and for production of annual cereal and legume crops. The SRMA we visited had 125 feddans set aside for fodder shrubs (*Acacia* sp., *Atriplex* sp.) and deferred grazing, 15 feddans for annual legumes, and 15 feddans for barley–legume rotation. It had a cistern to accumulate 350 m^3 of harvested water, a shed for 50 sheep and goats, and an animal cart to transport fodder after harvest. The women are also provided poultry and beehives to generate additional income. The healthy goats and turkeys feeding near the house of the bait, and the bright faces of the children playing hide and seek with us from behind the wall of the farm house were testimony that the system is working. A total of 250 SRMAs are operating in the project area, as a pre-extension test.

We travel on to El-Sequifa. Land here is less stony and the soil cover thicker than in Wadi El-Matarieh. Water harvesting and conservation for the production of high value fruit trees and other crops is the Project's main agricultural activity at this site. With



Structure of a typical cistern.

assistance from the Project, the communities have constructed water cisterns, reservoirs, and stone dykes to retain water for their plantations of pomegranate, almond, olive, fig, date, and jojoba (*Simmondisa Californica*), and fodder shrubs, such as spineless cactus. Jojoba was promoted because of the high value of its oil, which is used in airplanes, cosmetics, and pharmaceuticals. The Project is helping with intermediate technology to extract oil and is helping the community find markets for their produce. Families have also been helped to start home vegetable gardens, and to diversify their income through honey and poultry production, and through carpet weaving. An all-weather road constructed under the 'World Food Program Project 5586' has made transporting produce to market a lot easier.

All of the Project's development initiatives have a basis in research. We therefore move to Wadi Abu El-Goroof to learn about research into integrated watershed management. Here, after close monitoring of precipitation and water flows, the Project staff built dykes with spillways. Back slopes and slope terraces have been developed using rolled compacted concrete. The land here is similar to Wadi El-Matarieh, and less productive than in El-Sequifa. The Project's civil engineer gives technical advice to the community, while the Project provides construction material on credit. Agricultural experts advise on the choice of crops, varieties, and optimum cultivation practices.

As we marvel at the work done by the community, our attention is diverted to a nearby hillock. A group of Bedouins is working amid the boulders, while their donkey cart stays put, about 200 m away. Curiosity takes hold and we cross the dry streambed to learn what is going on. We meet brothers Basher, Adel, Saber, and Atyeh, who are drawing water from a cistern constructed by the Project. The level of water has gone down, so one of the brothers is lowered by rope into the cistern. A jerry can of water is pulled up and transferred to a battery of jerry cans, which are ferried to the cart. Once the cart is loaded, the water is pulled another 200 m down to flat terraced land where the brothers have established a plantation of figs. The

Brothers Basher, Adel, Saber, and Atyeh draw water from a cistern constructed by the Project. The water will nourish a small plantation of figs the brothers have established on terraced land many meters away. Their seedlings are small, and will need irrigation for at least another year.

Above: Cisterns are an ancient technology being put to good use by the Matrouh Resource Management Project. A large tank of mortar and stone stores rainwater caught in natural and man-made channels.

Right: Simple structures, such as this stone dyke, help farmers retain precious rainwater to maintain their plantations of fruit trees and fodder plants, such as the spineless cactus, foreground.

Structures, such as the reservoir above, can help communities in dry areas make the most of the little rain they receive. Without reservoirs, and the other water conserving technologies promoted by the Project, the erratic annual rainfall would simply flow away.

seedlings are small and will need irrigation for at least one more year. When they are fully established, they will survive on rainwater caught in the terraces. But for now, the plantation demands backbreaking work of the four brothers, who nonetheless remain convinced of the value of their labor. They intend to clean the cistern so it will hold more water in the coming rainy season. For the Project's Deputy Director General, Dr Sobhi El-Najjar, who accompanied us, it was a highly satisfying experience. Figs are an important income generator for the community. A good tree can in some cases produce up to 1000 kg of fruit per year.

Integrated development of communities is at the core of the Project. No wonder, then, that great emphasis is paid to human resource development. Extension agents are given regular training and a range of instructional material is prepared. The SRSCs play an important role. We visited one in Ras El-Hekma equipped with classrooms used to teach children, youths, women, and men how to read and write. They are also the venue for workshops where women are trained in art, knitting, weaving, carpet and jewelry making, and other handicrafts that might enable them to generate additional income.

The project is a success because it facilitates the convergence of essential elements:

- A willing group of local rural communities determined to break free from poverty and malnutrition;
- A government convinced that investment in research for development will generate knowledge essential to local communities;
- A donor with foresight willing to grant a loan for the Project; and
- A highly dedicated group of research and development professionals from the national system and an international agricultural research center working in partnership with local communities to devise practical solutions to problems constraining livelihoods and sustainability of fragile resources.

For us, the visit to the Matrouh Resource Management Project was like a pilgrimage in honor of people's striving for a peaceful, socially equitable, and sustainable existence, for this generation and generations to come. ■

Handicraft production for income generation is another important initiative of the Project

"Matrouh Resource Management Project, a development project with a strong adaptive research and technology transfer base, has been implemented to break the degradation cycle and alleviate poverty in the rainfed areas of the region," says Dr Mamdouh Sharafeldin, Technical Counselor, Egyptian Ministry of Agriculture and Land Reclamation.

Operating since 1994, the Project has been co-financed by the government of Egypt and a World Bank credit. Its first phase came to an end in 2001.

Mohan Saxena is ICARDA's Assistant Director General; Dr Abdul Bari Salkini is Coordinator of the Matrouh Research Management Project; Dr Habib Halila is Coordinator of ICARDA's Nile Valley and Red Sea Regional Program (NVRSRP); and Mr Ali Akhtar is Water and Soil Engineer, NVRSRP.

Note: See article on page 13 for more information on this project.

Friendships Bloom in the Desert

Bedouin Entrepreneurs Prosper on the Harsh Northwest Coast of Egypt

Those who have found a calling in agricultural research and development learn to be patient. A new variety can take years to develop; a new technology might take just as long to become accepted by farmers. Along the way, agriculturists can take encouragement from improvements they see in the lives of the people they work with, and sometimes, friendships bloom in the desert.

By Abdul Bari Salkini and Sobhi El-Naggar

On a chilly, sunny day in late winter 1986, we made our first visit to the northwest coast of Egypt. We were a small team of ICARDA scientists and a national expert exploring the area as part of a regional study to assess the potential of water harvesting and supplemental irrigation systems. The team comprised Dr Eugene Perrier, water management expert, and the authors of this article. Dr Perrier led ICARDA's water management project for five years before retiring from the Center in 1990. The authors were fortunate enough to be involved in the Matrouh Resource Management Project (MRMP), enjoying the most productive and challenging times of their professional lives. In the early 1990s, a few years after this first visit, Dr Naggar contributed to the preparation of MRMP, which began in 1994. He was later appointed the project's deputy director general. In 1996, ICARDA was contracted to implement the project, and Dr Salkini was appointed resident coordinator of technical assistance.

On that late-winter day in 1986, we also made our first contact with Hajji Idreis and Hajji Hmeida, a meeting that would later develop into close friendship. Before telling the story of this scientist-Bedouin friendship, we would like to briefly introduce these two farmer entrepreneurs and the challenging land in which they live.

The Mediterranean coastal zone is semi-desert extending more than 500 km between Alexandria in the east and the Libyan border in the west. Until a few decades ago the region was occupied by Bedouin pastoralists who lived exclusively off livestock grazing. Except for the gorgeous sea and sand, we caught sight of nothing on that first visit but a few scattered settlements, a poor plantation of figs and olives, small flocks of sheep and goats grazing, and a few camels here and there roaming vast stretches of barren land. Development efforts by the Egyptian government, supported by the international community, have, however, led to the settlement of most of the Bedouins, and the once dominant pastoral grazing system has evolved into sedentary agriculture.

The Bedouins were first semi-settled along the *wadis* (seasonal stream and river beds) and land depressions, where they were encouraged to cultivate barley for food and feed. They were then settled more permanently following the planting of fig and olive trees on the *wadi* beds and the installation of water harvesting systems meant to regulate runoff.

Sheep and camel graze in degraded community grazing ranges in need of rehabilitation by the Project.

Despite good intentions, the subsequent pressure from humans and livestock disturbed the balance of the region's fragile ecosystems and led to rangeland degradation.

Our new friends Hajji Idries and Hajji Hmeida were typical of Bedouin farmers on the northwest coast. Both have an extended family of 20-25 members, a small landholding, most of which is rangeland with a few acres sown every year to barley, a few acres of fig trees, a small flock of small ruminants (15-20 sheep and goats), and 20-25 chickens, mainly for domestic use. It's a farm resource base that barely allows for survival, and farmers face many risks that threaten sustainability and make development outputs and outcomes highly vulnerable.

MRMP was designed to tackle the vulnerability and risk faced by the more than 19,000 rural households in the project area facing conditions similar to those of Hajji Idries and Hajji Hmeida. The project has implemented extensive research and development programs and has promoted technologies for soil and water conservation and use, and crop, rangeland, and livestock improvement. Research and technology transfer activities were conducted exclusively in farmers' fields. Our two farmer friends were members of a large network of pioneer farmers who participated in project implementation, monitoring, and evaluation. The project has provided technical, financial, and logistical support to help Bedouin communities tackle their problems, to adopt coping strategies and measures that ensure sustainable resource management and poverty alleviation (see *Pilgrim's Progress* in this issue).

Monocropping of barley is common on the northwest coast, where crop diversity is constrained by physical and economic factors. The vagaries of the climate, low and erratic rainfall in particular, account for most of the risk faced by farmers. Farm production can suffer even in years of relatively high rainfall, if the rainfall is not properly distributed over the growing season. In years of good early rains, farmers sow barley on most of their cropland, saving the best plots for watermelon, a highly profitable summer crop. If the mid-to-late-season rains of spring don't come, farmers suffer multiple losses: poor barley production, no seed for the next year (necessitating a cash outlay), and no watermelon to sell.

Local crop varieties and livestock breeds, though well adapted, have low genetic potential for productivity improvement. Pests are another major source of biophysical vulnerability. They have increased drastically in seriousness with increased development and agricultural intensity. Insects and diseases, combined with improper management practices, made hundreds of orchards unproductive, requiring substantial measures for their rejuvenation. Rodents are another threat to crops and earthen dikes.

Resource scarcity and poverty add to the risk and vulnerability. Most households in the project area live below the poverty line, while the ultra poor must seek off-farm employment. Farm income is not only low, but uncertain: it might decline by one-third, two years out of five, and it might be negligible one out of every five years. The illiteracy rate is high and professional skills lacking. Economic opportunities and employment are very limited. In successive years of drought, a good proportion of the population suffers dramatic hardship. Bedouin traditions and tribal solidarity have always stood against such threats, but traditional bonds have begun to loosen with the onset of development and the thrust toward modernization and individualism. The age-old concept of the Bedouin tribe as 'consolidated socioeconomic unit' is no longer valid.

The first and most pressing problem for Hajji Hmeida and Hajji Idries, and most of their thousands of neighbors, relates to water scarcity and management. Hajji Hmeida and his extended family live on a piece of land at the foot of the 200-m-high Libyan plateau, at the tips of two *wadis* initiated high up on the plateau. The *wadis* join at what is the start of the landholding, forming a great *wadi* that runs many kilometers before melting into the sea. Annual rainfall is around 150 mm, not sufficient to grow crops, but enough to sustain fruit trees (more than 2.5 million fruit trees grow in the project area). The trouble is, the rain usually comes in a few heavy and often damaging winter storms. Rain accumulates in vast catchments on the plateau and flows down a 65-m ridge, generating violent torrents that bombard the *wadi* through Haj Hmeida's land. Thousands of farmers face a similar problem. Hajji Idries has a water problem of a different kind. His water problem lasts year-round, because the winter runoff barely reaches his farm located near the tail end of another watershed with different physical and geo-hydrological features.

A team of ICARDA scientists and MRMP specialists visited Hajji Hmeida's farm after a damaging rainstorm in 1997. "This is incredible," was the first comment heard, as the team inspected the old cement and stone dike shattered into pieces, the deep grooves carved in the *wadi* bed, the small fig trees uprooted and washed away, and the very old and strong trees suffocated by sediment up to the top terminals. How could a single rainstorm cause such damage, in a desert?

Runoff is extremely useful and needed, but it must be controlled and regulated. On the spot, the project engineers and ICARDA consultants assessed the damage and its causes. A development plan for the watershed was set, based on analysis of long-term rainfall data, a topographic survey, assessment of hydrology and land use, and socioeconomic analysis. The plan included the vast catchment area on the plateau, and many kilometers of *wadi*, all the way downstream to the coast. Hajji Hmeida and other beneficiaries in the local community helped build a strong concrete and stone weir and a series of dry-stone dikes across the *wadi*. The old earthen dikes were reformed, compacted, and strengthened with concrete spillways. Since then, neither Hajji Hmeida nor the other farmers in the watershed have suffered damaging torrents.

Very little was known about the geo-hydrology, soils, plant requirements, and other characteristics on the northwest coast. So, the weir on Hajji Hmeida's land was fitted with an automated rain gauge and other devices to measure precipitation and runoff volume and velocity. An adaptive, on-farm research site was also established nearby to investigate runoff

Rainwater is the primary water source in the Matrouh project area. Runoff not captured is lost to the sea.

coefficients for soils of different types, structures, slopes, and vegetative cover. Different types and specifications of micro water harvesting systems were also investigated.

The second major problem was lack of clean water for domestic use and livestock.

Project staff inspect a site installed with water measurement devices (above). Micro water harvesting techniques being tested at Hajji Hmeida's on-farm research site (left).

The women and boys of the families were used to collecting water harvested and stored in excavated cisterns a couple of miles away on a neighbor's property. The project has since given Hajji Idries and Hajji Hmeida 300-m^3 capacity cisterns. The collected water takes care of their household and livestock needs, and helps the families maintain small gardens, which even produce a surplus from time to time. MRMP has supported the installation of more than 8000 cisterns, amounting to a storage capacity of more than 1.75 million m^3. Water handling is mostly the task of Bedouin women. To save them time and to reduce water losses, the project provided the two farmers (and about 1000 other households) with in-kind loans to purchase pumps. And, to make the most of seasonal runoff, a research program was initiated to test the possibility of frequent emptying and refilling of cisterns.

The third major problem for Hajji Hmeida and more than 16,000 crop producers was the monocropping of barley, and the low and highly fluctuating yields. The average yield was less than 700 kg/ha. In two out of 10 years the average yield might exceed 1200 kg/ha, but in four out of 10 years there might be no grain yield at all, and the crop would be grazed green by livestock. Yields were not only low and fluctuating, but also declining, most likely due to the effects of monocropping, although Hajji Hmeida and most of the other farmers blamed it on successive droughts.

With technical assistance from ICARDA and effective participation of local communities, MRMP tackled these problems by developing a simple technological package for improved barley production. The package was developed and tested on farmers' fields, in a range of biophysical and socioeconomic conditions, and then disseminated to farmers. The package consists of a new barley variety ('Giza 126') developed by the ICARDA-Egypt cooperative research program, a small increase in seed rate (70 kg/ha instead of the farmer practice of less than 58 kg/ha), a small quantity of phosphorus fertilizer (23-35 kg P/ha), and double-cross plowing instead of the typical single seed-covering cultivation. The package, in whole or in part, was adopted by more than 40% of the 16,000 barley producers. Hajji Idries reported a yield increase of more than 80% for grain and more than 100% for straw.

Barley-legume rotations were tested as an alternative to barley monocropping. The best and most farmer-accepted rotation was the barley-local vetch (*Vicia sativa*). Within three years of the tests and dissemination, 20% of barley producers adopted this rotation, and more farmers are expected to take it up. Most adopters reported a yield increase, in terms of feed units, of

New barley varieties adopted by the Bedouin farmers surpass the local varieties by more than 60% (above). Hajji Idries (in headgear) and a project scientist monitor volume and quality of cistern water (left).

more than 50%, but the increase on the research and demonstration plot on Hajji Hmeida's farm amounted to more than 80%. Barley-vetch mixtures were also tested for their ability to increase feed units per hectare and improve the barley cropping system. The best seed mixture comprised 70% barley and 30% local vetch, with the latter sown only in the first year as it regenerates itself thereafter. So far, 20% of farmers have adopted the mixture. They report a yield increase of around 50%, but Hajji Idries enjoyed a yield increase of more than 100%.

Interplanting fodder shrubs in barley fields was also tested as a means to increase feed production and improve the cropping system. The optimum spacing of Atriplex (saltbush) was 10-15 m between shrub rows and 3-5 m between shrubs in the row. The technology of interplanting has already been adopted by about 20% of the barley producers in the project area. The technology has contributed substantially to improved barley productivity and forage production, reported Hajji Idries, who at first doubted the value of interplanting with Atriplex. He wasn't alone. It was only after a study tour to ICARDA in Aleppo and a visit to farmers on the Syrian steppe that Hajji Idries and other pioneer farmers became convinced.

The fourth major problem for our Bedouin friends (and 75% of households in the project area) was related to fruit and vegetable production, which suffered from improper traditional practices of orchard establishment and management. This was reflected in severe deterioration of hundreds of olive and fig orchards, and low output from the productive orchards. Orchard productivity also fluctuates with rainfall. In years of good rainfall, olive yield can be 40-50% higher than in years of normal rainfall, and can be lower than normal by the same percent range in years of low rainfall. Horticulture also lacked diversity. Figs covered more than 70% of orchard area, olives about 25%, and grapes, some almonds, and pomegranates accounted for most of the rest. Of the vegetables, watermelon was the sole vegetable grown by about 35% of farmers, with some other species grown on very small plots, mainly for domestic use.

Hajji Idries inspects his fields and the results of crop improvement technologies promoted by the Project: improved varieties, and mixtures of barley and vetch interplanted with fodder shrubs.

Hajji Idries reported a yield increase of more than 100% in his fig orchard following adoption of the recommended technologies of improved pruning and harvesting, coupled with modest supplementary irrigation, organic fertilization, and pest control. He expects to treble income from fig production because of these improvements, and by planting new varieties suitable for drying. Hajji Idries, using the savings gained from crop improvement, especially from seed production, has installed another cistern. He uses it to grow vegetables and provide supplementary irrigation for his orchard. "Thanks to God, and to the support of MRMP," our Bedouin friend whispered smiling, clasping his hands together to signal victorious accomplishment. "Now, I am not only self-sufficient in all vegetables, but I'm also gaining an additional monthly income of 300 Egyptian Pounds," he said. The sum is equivalent to the monthly salary of an agricultural laborer, or a minor public service officer.

The Project has encouraged Bedouin farmers to use supplemental irrigation to grow vegetables and high value spices, such as mint, shown here, for improved nutrition and income.

The fifth major problem that our friends helped to solve was the deteriorated rangelands and scarcity of natural feeds, reflected in the rising use of feed concentrates. Hajji Idries has participated in all project activities aimed at fodder production improvement. These have included diversified strategies and measures for range rehabilitation, such as fenced fodder shrub planting, shrub interplanting, barley-forage mixtures, reseeding with annuals and perennials, and protected and controlled grazing of natural ranges.

A project staff member and a farmer monitor the survival and growth of fodder shrubs.

On a shiny autumn day, after one season of range rehabilitation, we paid a visit to Hajji Idries. He and his eldest son joined us to inspect protected sites. About 30 threatened range species were observed, including those belonging to the following genera: *Periploca*, *Panicum*, *Oryzopsis*, *Moricandia*, *Gymenocarpos*, *Salsola*, *Dactylis*, *Salvia*, *Plantago*, *Vicia*, and *Medicago*. Some medicinal and herbal species were also revived, including Chamomile, *Matricaria chamomilia*; Harmal, *Peganum harmal*; El-Sheih, *Artemisia judaica*; Anise, *Pimpinella anisum*; Sweet basil, *Ocimum basilicum*; Marjoram, *Marjorana hortensis*; Rosemary, *Rosmarinus officinalis*; Thyme, *Thymus capitatus*; and Sage, *Salvia officinalis*. An excellent cover of vegetation protected the site.

We inspected many fields of different farming and herding activities, and then we were led to the family residence. On the way we much enjoyed, as usual, the wisest and most knowledgeable conversation you could dream of. This Bedouin entrepreneur is not only an exceptionally talented, exceptionally industrious, and persistent producer, but also a mobile encyclopedia of inherited and accumulated indigenous knowledge. He was the best local, no-cost advisor the project had, highly honored and respected. Passing by old ruined premises, we approached a fancy, newly constructed, modern residence. Inside, it was well furnished, and on tabletops laid a variety of newspapers, magazines, and books. And in the backyard we were deeply impressed to find a seed 'workshop' where the family processed and packed seeds of indigenous range species.

Everyone in the family helps collect from the farm's protected range area and from neighboring communal rangelands. For some species they collect seeds from shattered pods. For other species they cut the productive parts of plants, set them aside for drying, then thresh, clean, sieve, and pack them. The eldest son, a bright chap in his late teens, was trained by the project in aspects of range plant identification, classification, collection timing and methods, and post-harvest handling. He was contracted for two years by another ICARDA-supported project, the Regional Initiative for Desertification Control, to collect and reproduce range seeds. MRMP has supported this household enterprise by buying all the seed produced. Seed of indigenous species is essential for the rehabilitation of rangeland, so it's a great help to have clean packed seeds ready to use.

We finished off a generous and tasty Bedouin lunch with an extremely sweet cup of green tea, a Bedouin hospitality never to be escaped, and our enjoyable chat with Hajji Idries was drawing to a close. "How much do you usually get from this industry, Hajji Idries?" we asked hesitantly. "I won't tell you my old friends. I'm really afraid of a black eye," Hajji Idries said, nodding his head right and left. "However, I'll disclose a small secret for you and only for you my old friends. You certainly have noticed the difference between the old ruined shabby house and these new fancy buildings. This is the difference between Hajji Idries before and Hajji Idries after MRMP. And that is only part of it," he said, with a very broad smile that masked half of his pleasant and comforting face.

We recalled the scene of years past, on that chilly sunny day in late-winter 1986. There was the gorgeous sea, the sand, and the scattered poor plantations of barley and fig. Today, we can't help but marvel at what is possible if people are given the right support to deal with their problems.

"Praise to God almighty, and thanks to MRMP, thanks to ICARDA, and thanks to the World Bank," said Hajji Idries, on our last visit to our friends on the northwest coast. "Now we and our families feel really secure. No more fear of the climate. No more serious worries about our future generations," he said. "And, no more fear of the damaging torrents," hollered Hajji Hmeida, laughing and waving goodbye as our car stumbled and bumped over the dirt road headed to the Matrouh highway, under the cover of deeply clouded sky, just about to give birth to one of the great rainstorms of the northwest coast.■

Hajji Idries' family-run seed processing 'workshop' in full operation.

Dr Abdul Bari Salkini is Coordinator of MRMP-ICARDA and Dr Sobhi El-Naggar is Deputy Director General, MRMP.

African Seed Sector Challenges

Building Seed Systems for Greater Food Security through Partnerships

By Sam Kugbei, Michael Turner, and Zewdie Bishaw

Food security in Africa depends on seed security, but in many countries seed supply is precarious. Coaxing the private sector to take up the challenge of supplying high quality seed of well-adapted varieties will require sound government policy and imaginative approaches. ICARDA can help.

Why seeds?

Plant breeding to produce improved crop varieties remains one of the major strategies of the International agricultural research centers (IARCs) and seeds are the vehicle by which the products of that research are delivered to farmers. Therefore, crop improvement research by the IARCs and the National Agricultural Research Systems (NARS) must be matched by an effective seed supply system if full impact is to be achieved at the farm level.

The Seed Unit at ICARDA has been focusing its attention increasingly on institutional problems in the seed supply system—particularly in its mandate areas of North Africa and the Nile Valley. Because such problems are common in most developing countries, the Unit also maintains strong contacts with seed organizations in Africa south of the Sahara.

The changing seed system

It is nearly three decades since the developing world saw the first wave of seed projects. They followed the early success of the Green Revolution in Asia, which introduced packages of new technologies including high yielding varieties. National seed projects and programs in Africa were expected to put in place the institutions and facilities for ensuring the rapid delivery of improved varieties and quality seed to farmers as a basis for increased productivity. In practice, experience in much of Africa has not lived up to these early expectations and this is a source of frustration to those who work in the seed sector and agricultural development. The failure has largely been due to too much emphasis on the techniques of seed production and less consideration to factors that contribute to seed use.

Participants in a seed workshop co-organized by ICARDA in Zimbabwe in 1997.

Developing seed systems to deliver the results of research to farmers was seen as such a simple message that early seed projects assumed that once quality seed was made available, farmers would rush to buy it. With the benefit of hindsight we understand the limitations of this approach, reflected in the poor adoption of improved varieties in developing countries. Many countries are now paying greater attention to ways of creating a more sustainable seed supply without dependence on subsidies. Participation of the private sector is being encouraged, particularly small-scale seed enterprises that can deliver seed to farmers at economically attractive prices.

Seed and food security

Food security is a necessary component of poverty reduction, and for countries to be food secure they must be seed secure. But seed security is a challenge for many African countries, particularly those that suffer recurrent natural and/or man-made disasters. The restoration of productive agriculture after such disasters is a costly and difficult task for national governments and international relief organizations. Nonetheless, working together, IARCs, NARS, nongovernmental organizations, United Nations agencies, and the donor community have successfully responded to disaster situations in Rwanda, Somalia, and, more recently, in Mozambique, through the Seeds of Hope program. IARCs played an active part in coordinating that response, which was implemented in collaboration with NARS from the region. Besides meeting farmers' immediate seed requirements, efforts were made to restore valuable genetic resources that were lost. An international conference on the seed industry, held in Libya in 2000 and organized in cooperation with various organizations including ICARDA, provided a forum for deliberation and exchange of ideas on how to improve seed programs in less-developed countries.

Key challenges

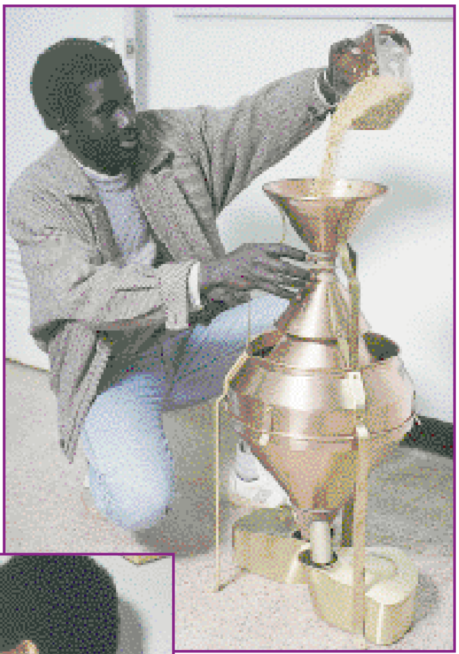
So what are the special challenges facing the African seed sector and what are we doing to meet those challenges? First, we must recognize the effect of risk, which forms a backdrop to much of African agriculture. Farmers are cautious about investing in inputs at the start of the season for fear of losing their investment if the weather turns bad. Next, we must consider the suitability of the varieties offered to farmers. Often these have been released with little regard to the complex needs of subsistence farmers, for whom yield is seldom the main consideration. Apart from yield, small farmers give importance to other attributes, such as byproducts, cooking quality, and taste. Finally, we must consider alternative systems that are potentially more effective in making seed widely available, particularly to smallholders located in remote areas. The seed needs of this group have not been adequately addressed by large enterprises. We believe that small indigenous enterprises with low-cost structures and close trustworthy relationships with the farming communities they serve are better suited to the task.

ICARDA maintains an active dialog with countries in Africa with regard to seeds and food security. Ethiopia, Eritrea, and Sudan were part of a study on seed security assessment in drought-prone areas, which was conducted between 1996 and 1998. The study was undertaken to find ways to mitigate food insecurity by restoring or maintaining the food production capacity of farmers in disaster stricken environments. These farmers are often at risk of losing all the seed they have, including indigenous varieties adapted and passed along for generations. The ICARDA Seed Unit also contributed to international debates organized by the Food and Agriculture Organization of the United Nations (FAO) in 1997 and 1998 to formulate strategies and policies for improving seed security within the wider context of achieving food security. The proceedings of these meetings are proving useful to many developing countries.

Alternative delivery systems

In 1997, ICARDA also co-organized a workshop in Harare, Zimbabwe, with the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) and the German Agency for Technical Cooperation (GTZ), on Alternative Strategies for Smallholder Seed Supply. The workshop brought together more than 60 specialists from around the world to discuss seed issues related to small farmers in Africa. It was followed in 1998 by a workshop organized by ICARDA in Addis Ababa, Ethiopia, on the Finance and Management of Small-scale Seed Enterprises. The proceedings of these two meetings have been published and serve as valuable reference material in guiding project formulation and management in developing countries.

The Seed Unit is currently implementing a project sponsored by GTZ to examine ways of raising the efficiency and effectiveness of seed delivery for small farmers in eight countries within West Asia and North Africa (WANA), including Egypt, Ethiopia, and Morocco. The project will produce, among other things, models for supplying quality seed to small farmers. These models will be of use in many farming situations since the problems faced are broadly similar.



Two former research students, Abdoul Aziz Niane (above), from Senegal, and Mohammed Makkawi, from Sudan, now work in ICARDA's Seed Unit.

Strengthening human resource capacity

Weak technical expertise has constrained the development of seed programs in many countries, so ICARDA is working actively to strengthen human resource capacity. The Center's train-the-trainers program, workshops, and seminars have attracted participants from many African countries, including Ghana, Kenya, Malawi, Nigeria, Uganda, Senegal, Tanzania, Zambia, and Zimbabwe. Training covers the technical aspects of seed production and handling, policy, and business management, and is tailored to meet a country's specific needs.

Promoting information exchange

To promote the exchange of information and expertise, ICARDA established the WANA Seed Network in 1992. It is a catalyst for seed sector development, encouraging interaction among countries and the harmonization of policies and regulations in broadly similar agro-ecological sub-regions. This Network seeks to pave the way for increased seed trade that would generate enough demand to attract private investment and create a more diverse, competitive, and sustainable seed industry in the region. Such an industry could also be of great practical benefit in times of emergency when rapid movement of seed might be critical.

The WANA Seed Network provided a stimulus for similar regional initiatives in East and Central Africa, South Africa, and West Africa. Harmonization of seed policies and regulations is now high on the policy agenda in these regions. The Network's newsletter, *Seed Info*, is distributed widely in Africa and attracts considerable interest as a source of valuable information on seed science, technology, and related issues in seed industry development.

Policy implications

In most African countries, the seed industry is dominated by public sector seed enterprises, while private companies occupy selected markets. Establishing a more diverse seed system requires broader participation of the private sector to attract both domestic and foreign investment. In 2000, the African Seed Trade Association (AFSTA) was established to provide a forum for a more commercially oriented and dynamic seed industry. ICARDA contributed to debate on regional collaboration leading up to the establishment of AFSTA, which held its first congress in March 2001 in Cairo. The congress was a resounding success, attracting 262 delegates from 40 countries in Africa, Asia, Australia, Europe, USA, and the Middle East. Delegates discussed policy reforms required to mobilize the commercial seed sector. These included intellectual property rights, biotechnology, and biosafety regulations. ICARDA contributed to these deliberations.

The seed business is risky, particularly selling seed of self-pollinating cereal and legume crops.

Seed specialists from West Asia and North Africa visit a farmer's wheat field in Ethiopia.

Business people are naturally reluctant to rely for their survival on a product that farmers can reproduce for themselves. Therefore, governments still have an important role to play, especially in creating favorable policy environments and providing services to assist in establishing seed systems that meet the diverse needs of farmers. For instance, governments can encourage informal on-farm seed production, small to medium-size enterprises, cooperatives, farmer associations, and agribusinesses. Investment in these, and achieving an efficient balance between public and private roles, depends on the policies and programs put in place.

As the seed industry develops, governments should continuously assess the roles they can play. Governments should only intervene as seed suppliers in those areas that other parties, particularly the private sector, do not find attractive. However, there are several policy-related activities that could be undertaken by governments or development agencies interested in promoting appropriate seed systems in Africa. For examples, setting national seed policies, rules, and regulations; training local institutions and enterprises; implementing realistic and effective quality control systems; and promoting linkages between seed organizations and related institutions, such as research and extension services. Involvement of the public sector to handle a range of functions might be justified in the early stages of seed system development, but the public sector should gradually withdraw as the private sector becomes active and competent. Care should be taken that a heavily subsidized public agency does not present unfair competition to emerging private ventures. Depending on the crop, seed production and marketing are usual functions of private enterprises, while regulation and enforcement are the roles of government.

Conclusions

Delivering seeds to small farmers—the major food producers in African countries—is difficult because they live in diverse and often isolated agroecological environments. To raise production and food quality, they need high quality seed of varieties adapted to specific environments. Developing good varieties and delivering quality seed to farmers will, therefore, remain a major objective in Africa, if the agriculture sector is to grow and support the livelihood of farmers and feed the rapidly growing populations. Such research and development, supported by sound government policy, is essential to address the high incidence of poverty and food insecurity suffered in many parts of Africa. ■

Dr Sam Kugbei is Seed Economist; Dr Michael Turner is Consultant to the Seed Unit; and Dr Zewdie Bishaw is Seed Production Specialist at ICARDA.

Farmers Breed Better Barley

New Lines Prove the Worth of Participatory Research

The need for farmer participation in research and development is now well recognized, and there can be few better examples of the benefits of a participatory approach than ICARDA's farmer participatory barley breeding program. After all, farmers have been breeding better crop plants since agriculture began.

Participatory breeding is a partnership between researchers and farmers. Researchers generate plant populations with useful variability, and farmers select potentially useful lines from among those populations, right on their own farms. Above, farmers in Egypt look for useful traits in lines of barley.

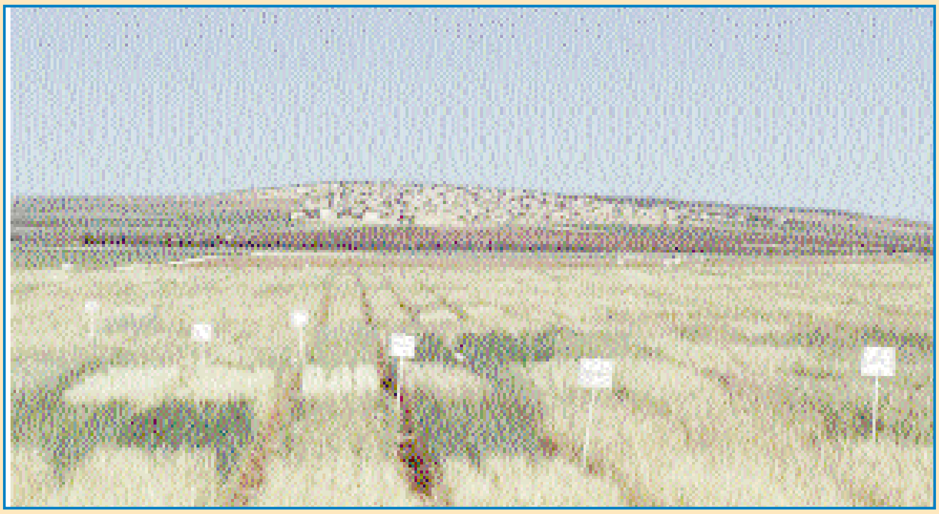
By Salvatore Ceccarelli and David Abbass

Farmers know best–why participation works

Farmers have been selecting better barley for millennia. In fact, virtually every important crop plant was domesticated by farmers who recognized better-performing plants and saved their seed for future sowing. Today, drought-tolerant barley lines developed by ICARDA, using a participatory approach, are proof that farmers still have an important role to play in plant selection.

Some 300 farmers are involved in ICARDA's barley research program in Ecuador, Egypt, Ethiopia, Jordan, Morocco, Syria, Tunisia, and Yemen. They select, right on their own farms, from among the hundreds of breeding lines produced by ICARDA every year.

Their efforts in cooperation with ICARDA will help ensure livelihood and nutrition for some of the poorest people in the world's dry areas, where barley is a critically important food and feed crop.

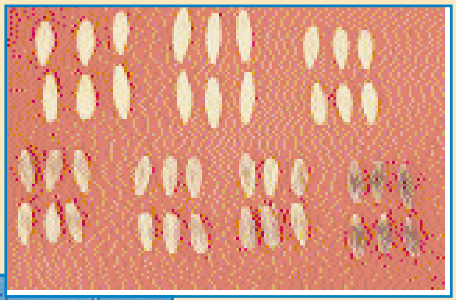


A key strength of an international agricultural research center is its ability to collect, conserve, evaluate, and utilize plant germplasm from around the world. Barley lines from many countries are grown at ICARDA to assess their usefulness in breeding programs run by the Center and its national agricultural research system partners.

Drought-tolerant barley lines for income security

In general, it takes at least 200 mm of rainfall to grow a barley crop in non-irrigated areas, but ‘farmer researchers’ in Syria have produced crops on much less using lines developed by ICARDA. In some locations, farmers managed to harvest a crop from just 87 mm of rain! Yield was measured in kilograms, not tonnes, but in such years of drought, a harvest of barley grain and stubble for livestock can mean the difference between survival and selling off livestock or a piece of the family farm.

Barley was domesticated some 10,000 years ago in the Fertile Crescent nourished by the Tigris and Euphrates rivers in the Near East. The area is still home to a tremendous diversity in crop plant types and their wild relatives. This makes ICARDA ideally placed to conduct research into barley improvement.



Beyond subsistence agriculture

The northwest coast of Egypt is another place where low and erratic rainfall makes rural life precarious. There, the risk of drought discourages farmers from investing in fertilizer. The result is low yields, even in good years. ICARDA researchers figured if farmers had a barley variety they could rely on, then they might be willing to invest in basic inputs.

Host farmers and local expert farmers,' chosen by their neighbors, selected 28 promising barley populations from 53 developed by ICARDA. Some of the lines selected by the farmers out-yielded the local favorite lines by 30-300%.

Had the selections been made on an experiment station, the results could have been much different. In a traditional breeding program, crosses are made to generate variability, and breeders search through the resulting populations for a few outstanding lines that might do well across vast areas. A great many potentially useful lines are passed over and discarded early in the selection process. Participatory breeding involves farmers from diverse locations in the initial stages of selection, when genetic variability is still virtually untapped. Selections reflect farmers' perceived needs, and take advantage of farmers' extensive knowledge of the crop and local environment.

The result is lines better adapted to farm conditions, greater diversity in cropped varieties, and greater utilization of the genetic potential generated by breeders.

Technicians at ICARDA's headquarters cross-pollinate barley plants in an effort to combine specific beneficial traits, such as drought tolerance and high yield potential. Seeds from the crossed plants are grown and breeders and farmers select promising plants.

Better barley comes with sense of ownership

Breeders have been working for more than 100 years to improve barley productivity in Tunisia. Yet farmers stick to their traditional varieties, which are well suited to the harsh, dry conditions so different from the breeders' experiment station. Even lines that seem to suit farmers' needs have gained little acceptance.

ICARDA felt it could help by implementing a program of decentralized breeding and selection, with farmers as key collaborators. The result is 'Momtaz,' a six-row barley variety similar to the ones favored by local farmers, but with much better yield potential in dry conditions. In dry years, the variety yields 14-21% higher than the check varieties, and in semi-dry seasons farmers can expect 30% higher yield than the best checks.

Aside from its improved adaptability and yield potential, 'Momtaz' enjoys the ready acceptance of Tunisian farmers. After all, it's *their* variety.

New responsibilities for professional plant breeders

Will farmers put breeders out of work? No. Farmer participation is not a substitute for the critical work done by professional breeders. Consider the case of the Russian wheat aphid. ICARDA researchers have made good progress developing barley plant resistance, which is the only practical way for cash-poor farmers to withstand the devastating pest.

The Center's search for sources of resistance began in 1997. Since then five sources of resistance have been used in crosses with six varieties grown in North Africa, from which 71 resistant lines were selected at ICARDA's research farm in northern Syria. These lines have been sent to Morocco, Algeria, and Tunisia for further evaluation under local conditions.

Only an international institute with trained breeders, access to a diverse collection of germplasm, and access to advanced tools, including biotechnology, could conduct such a multinational, multifaceted program. If anything, professional breeders have additional roles to play organizing farmer cooperators and making the most of farmers' picks in as many locations as possible.

Yemen: Farmer-selected lines are better suited to local environments, and they come with the pre-approval of the end users, the farmers themselves.

Farmers in Mardabsi, Syria, select barley lines according to their criteria. Crosses with* Hordeum spontaneum *(tall plants with resistance to drought) were generally preferred over modern lines.

ICARDA's barley improvement program

Barley is grown on 70 million ha worldwide, more than half in developing countries. As part of its global mandate, ICARDA works to increase the productivity of barley through the development and adoption of improved varieties in six regions: Near East and West Asia; North Africa; East Africa and Yemen; Central Asia and the Caucasus; Far East; and Central and Latin America.

The major role of ICARDA's barley breeders is to generate useful genetic variability through targeted crosses, to distribute segregating populations, and to coordinate the analysis and utilization of related data. The role of the national agricultural research system breeders, in turn, is to identify useful parental material, such as sources of disease resistance, to design suitable crosses, and to select useful lines in target environments.

The project has released more than 100 cultivars. The average adoption level is 14% and the estimated annual benefit per adopted cultivar ranges from US$1.1 million to US$39.5 million. ■

Dr Salvatore Ceccarelli is Barley Breeder, and Mr David Abbass is Science Writer/Editor at ICARDA.

Durum Improvement Research in Morocco: A Worthwhile Investment

Moroccan farmers have been cultivating durum wheat for centuries. In the 1980s, farmers began to switch from their traditional durum varieties to modern varieties released by the Institut National de la Recherche Agronomique (INRA) in collaboration with ICARDA. A dynamic and efficient transfer of technology program (germplasm and crop management practices), initiated through the Mid-America International Agricultural Consortium (MIAC) project, played a key role in facilitating farmers' access to the new durum varieties.

Measuring grain yield of newly developed drought-tolerant durum lines.

By Abderrezak Belaid, Naserlhak Nsarellah, Abdelali Laamari, Miloudi Nachit, and Ahmed Amri

Durum varieties released

By 1998, 49 durum varieties had been released in Morocco, 26 by INRA and the rest introduced from abroad, mainly from Europe, by private companies. INRA released 19 durum varieties between 1982 and 1998 (excluding private sector introductions and old varieties released prior to the establishment of the official catalog but listed as released in 1982). Widespread adoption cannot be achieved, however, without efficient seed production and distribution systems that ensure timely availability and adequate seed quality. But studies in the region have revealed an acute lack of synchronization between varietal release and seed multiplication and distribution of new developed varieties.

Contribution of the joint CIMMYT/ICARDA durum program

The durum improvement program of Morocco has benefited greatly from its close collaboration with the joint CIMMYT (International Maize and Wheat, improvement Center Mexico)/ICARDA wheat program based at ICARDA, as have other national agricultural research systems (NARS) in West Asia and North Africa (WANA). The origin of parent materials of varieties released by INRA provides a good indication of the contribution of CIMMYT/ ICARDA. With the exception of the very old varieties, e.g., 'Oued Zenati', 'Selbera', and 'Zeramek', virtually all durum varieties released in Morocco were derived from CIMMYT/ ICARDA-based material. Over the period 1988-1993, 72% of durum varieties released in Morocco were derived from CIMMYT/ICARDA crosses, while 28% had a CIMMYT/ICARDA parent. The reverse was true in 1994-1999, reflecting the improved capacity of the Moroccan program for crop improvement as a result of human resource development efforts under taken jointly with ICARDA.

Assessing the economic impact of durum improvement research

As with any other investment, agricultural research has costs and benefits. Among the criteria used to compare the profitability of investment decisions, the internal rate of return (IRR) is by far the most frequently used. It is the rate of return an investor expects to earn on a project over time, expressed as an annual percentage rate. The benefits of durum improvement research in Morocco were estimated using a simplified approach, based on the approximation of economic surplus, i.e., the change in the value of production resulting from the cultivation of modern durum varieties.

Before calculating the returns to durum research, it is necessary to specify the time horizon over which the flows of expenditures and benefits occur and estimate the parameters that enter into the calculations of durum research-induced returns, e.g., adoption rate of modern durum varieties, genetic yield gain of modern varieties, and durum prices.

Time horizon: The impact assessment spans 1970-1999, demarcated into two sub-periods: 1970-1982, corresponding to the development, on-farm testing, release, and early diffusion of the first modern durum varieties released by the Moroccan national program, and 1983-1999, corresponding to the increasing adoption of these first varieties and those released after 1983. Therefore, 1970 is set as the starting point of the flow of durum research expenditures (ceasing in 1995). Returns, on the other hand, consist of a continuous annual flow of benefits starting in 1983 and ceasing in 1999. This implies a time lag of 13 years between the initiation of research and the time farmers have access to released varieties (9 years to release the variety and 4 years for seed production and extension). The length of expenditure and benefit streams were set in this manner to arrive at a "least returns" scenario of the durum improvement program.

Adoption of modern durum varieties: The rate of adoption is a key determinant of the size of returns to crop improvement research. The evidence of high rates of adoption of modern durum varieties is well documented in Morocco. Rates of nearly 80% and over 90% for durum and bread wheat, respectively, have been reported. Results of a 1997 survey showed that 98.2% of durum area of sample farmers was planted to modern varieties, even in arid zones. However, out of the 19 durum varieties released between 1982 and 1997, only seven were grown in 1997 by sample farmers. Two varieties, 'Marzak' released in 1984 and 'Karim' released in 1985, were found to occupy three quarters of the total area planted to modern varieties. In 1997, the newest varieties grown (each occupying less than 5% of total area under modern varieties) were all released in 1988, implying a rate of varietal replacement of about 12 years, as indicated by the weighted average age of durum varieties (Table). Given this long time lag, farmers will not fully benefit from the desirable traits incorporated in the new varieties. This delay in flow of benefits lowers the calculated returns of durum research. For the purpose of this study, it was assumed that peak adoption, conservatively set at 75%, is reached after 12 years.

Spatial distribution (%) of modern durum varieties in Morocco, 1997

Varieties[a]	Area share[b]
'ACSAD 65' (1984)	6.09
'Isly' (1988)	4.76
'Karim' (1985)	43.50
'Marzak' (1984)	32.05
'Massa' 1988)	4.84
'Oum Rabia' (1988)	3.81
'Sebou' (1988)	4.95
WAAV[c] 11.61	

Source: WANADDIN farm survey (Morocco, 1997)

[a] Date of release in parentheses

[b] Area share relative to total durum area under modern varieties

[c] Weighted average age of durum varieties (in years) as of 1997

Genetic yield gain of modern varieties: Benefits from crop improvement can take the form of higher yields, improved yield stability, better grain/straw quality, lower production costs, etc. A series of four-year on-farm yield trials conducted between 1982 and 1998 showed that modern varieties have a clear productivity edge (especially the so-called second generation modern varieties) over traditional varieties. But the genetic yield gain of modern varieties is not sufficient, by itself, to generate benefits. Modern varieties can have a positive impact on crop productivity at the farm level only if there is sufficient supply of seed and if farmers adopt them. Widespread diffusion occurs only when farmers are convinced that modern varieties hold a clear advantage, in terms of cost and benefit. The impact of modern durum varieties on the growth of durum productivity was assessed using a yield time series covering 1970-1999. The results indicate a significant acceleration in the rate of durum yield growth in the period 1983-1999 (2.8% annually), which corresponds to the spread of modern varieties. Although this estimated annual rate of yield gain due to modern varieties might seem high, similar rates were obtained in other studies in Nepal (2.5%) and Morocco (3.8%). The relatively high acceleration rate of yield growth estimated most likely resulted from the combined effect of modern varieties, input intensification, especially chemical fertilizers, and increased use of supplemental irrigation on areas planted to modern varieties. Therefore, the net modern varieties-induced rate of yield gain used to derive the benefits of durum improvement research in Morocco was conservatively estimated at 1.40% per annum, i.e., 50% of the calculated acceleration rate.

Durum prices: Because in Morocco durum wheat prices are not controlled, no durum producer price series is available. In general, regardless of the year, durum prices are at least 15% higher than bread wheat prices. However, FAO-published bread wheat prices (1985-1995) in Morocco are much higher than durum CIF (cost, insurance, and freight) reference import prices, implying that actual durum prices in Morocco would not likely provide a good approximation of durum economic prices and would inflate the internal rate of return. Therefore, CIF prices converted to Moroccan currency, using an average exchange rate of 10 dirhams (Dhs) to the dollar, were used instead.

These parameters were then used to calculate the stream of gross benefits resulting from the gain in durum production attributable to durum research.

Durum research expenditures: The stream of benefits must be compared to the stream of costs associated with durum research in order to determine the stream of net returns. The estimation of annual durum research expenditures was done in two steps. First, the number of scientists (full-time equivalents [FTE]) involved in durum research from 1970 to 1995 was determined in collaboration with INRA. Second, research expenditure data were gathered from INRA. These data included salaries and fringe benefits of scientists, including MIAC expatriate salaries, and associated support staff, research management costs of experiment stations where research was conducted, direct administration costs, training costs, funds allocated to durum research through projects involving CIMMYT, ICARDA, and other regional and international institutions, and overheads. These costs were then used to calculate expenditures per durum scientist. Moreover, an extension cost, estimated at 15% of total staff salary, was added. Using this approach, the 1995 expenditure per researcher was estimated at 1,500,000 Dhs, i.e., around US$150,000. (This expenditure per scientist includes costs that are usually not considered in most research impact studies, and is considered an acceptable approximation of research costs per durum scientist in Morocco.) Nominal expenditures per year were then obtained by multiplying this expenditure per researcher by the number of scientists (in FTE) for each year from 1970 to 1995.

Economic impact of durum research: Based on the calculated benefits and costs, the IRR for durum improvement research for the period 1970-1999 was estimated at 32%. As indicated, this IRR not only accounts for returns to durum breeding but also to breeding support activities (pathology, entomology, physiology), crop management (agronomy), as well as foundation seed production. The estimated IRR for durum improvement research in Morocco falls in the lower side of the range of reported IRRs obtained in Morocco and other WANA countries for other cereal crops, e.g., bread wheat and barley. Recently, for example, an IRR of 69% for barley breeding was reported in Morocco, despite relatively low adoption rates (maximum 19%) as compared to the relatively high adoption rates reported for durum. An IRR of 32% implies that if the national program of Morocco had to borrow the funds invested in durum improvement research between 1970 and 1995 at an interest rate of 32%, the benefits generated by durum research over the 1983-1999 period would be sufficient to repay the principal and accrued interest on such a loan. The net present value of the stream of expenditures and returns over the 1970-1999 period amounts to about US$142 million. Therefore, although the estimated IRR might not compare favorably with previous rates reported in the region and elsewhere, it nevertheless represents a good return on investment.

Clearly, reported IRRs reflect the assumptions used in evaluating the research investment considered. The estimation of returns to agricultural research is obviously sensitive to the parameters generally incorporated in the estimation of gross annual research benefits. Moreover, in addition to the size of research costs and benefits, their distribution through time is of paramount importance. Because of discounting, IRR will greatly depend on the lag between the first year that research expenditures are incurred and the first year that research benefits flow. For durum research in Morocco, this lag is set at 13 years. Moreover, for the first three years of benefits, adoption is usually so low that benefits are negligible. It is clear that because of discounting benefits accruing toward the end of the period of analysis, which coincides with relatively large gains in production, a much lower present value is arrived at. On the other hand, however, costs incurred early in the research process will have a higher present value. Sensitivity analysis clearly shows that substantial increases in returns to investment in durum research could be achieved through the reduction of the research lag. For example, reducing the research lag to 9 years, instead of 13 years, would lead to a 21% increase in IRR, while a reduction of the research lag to 5 years would lead to a 40% increase in IRR.

Adoption of improved durum varieties is widespread in Morocco, even among resource-poor farmers. Here, a farmer harvests durum by hand.

As a matter of strategy, the Moroccan durum research program should set the reduction of the research lag as a priority, in view of the potential economic implications.

Conclusion

Although derived under a rather conservative scenario, the IRR obtained provides strong support for sustained investment in durum improvement research in Morocco. Policymakers must understand that in order to prevent extreme fluctuations in production, such as those experienced in 1994 and 1995, when, in the favorable zone, average durum yield fell from nearly 2 t/ha to less than 0.4 t/ha, more research is needed in breeding (for resistance/tolerance to drought) and crop management to enable farmers to use soil moisture as efficiently as possible (soil moisture is the binding constraint to crop productivity under rainfed conditions.) Durum improvement research, an important component of INRA's portfolio, should be strengthened for at least two reasons: 1) the development and utilization of modern durum varieties with desired traits is a cost-effective way to increase durum production, and 2) unlike knowledge-intensive technologies, early and widespread use of new modern varieties by farmers, including smallholders, can be rapidly and substantialy improved. In addition to economic considerations, increased investment in durum research is also justified on food security and equity grounds, given that it reduces the vulnerability of smallholders to fluctuations. Moreover, as evidenced by this study, durum improvement research generates relatively high returns. Therefore, any policy decision associated with durum research will necessarily be of high significance.■

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Sustainable Production through Improved Soil, Water, and Nutrient Management in Africa

Demand for food and feed is rising, and it is expected to continue to rise, placing more pressure on already strained natural resources. In response, ICARDA scientists and their partners in Africa are conducting research into soil, water, and nutrient management. Their approach combines modern science with traditional practices.

By Mustafa Pala, Richard Thomas, and R.J.K. Myers

By year 2030, the world's population is expected to increase by more than 2 billion to 8.27 billion people. This is an alarming prospect given that more food and feed will have to be produced from land resources already suffering degradation due to human and livestock pressure. Agenda 21 of the United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, and the 2020 Vision Initiative of the Consultative Group on International Agricultural Research (CGIAR) question the capacity of available production systems to meet the demands of this growing population for food and other agricultural commodities without simultaneously accelerating the degradation of the natural resource base.

The situation in Africa is critical. Land available for expansion of agricultural area is limited to a few parts of the continent where the production potential has been proven but current output is low due to poor soils and mismanagement. Production increases from fertile lands have been reported to be declining. Marginal and fertile lands are currently undergoing varying degrees of degradation, including nutrient depletion, soil acidification, soil erosion, and reduction in soil water retention. As a result, water is becoming scarce in some areas and its quality is deteriorating.

Studies estimate that nearly a quarter of the world's agricultural land, pasture, and forests have been degraded in the last 50 years. Soil quality, fertility, and water supplies need to be managed effectively, conserved through better husbandry of natural resources and through investments in land improvement. Effective soil, water, and nutrient management (SWNM) requires action, not only at the farm level, but also at the community, regional, and national levels.

Farmers and a project worker in Zimbabwe share ideas during a field observation tour.

As global food production has expanded to meet growing demand, the soils of both marginal and fertile lands have suffered. The effects of degradation, which also bring problems of water quantity and quality, cannot always be compensated for, even partially, by application of fertilizers. Instead, natural soil fertility must be maintained and conserved. This demands that greater emphasis be placed on research into soil, water, and nutrient management.

The SWNM Program at ICARDA addresses this challenge by bringing together four complementary research consortia that develop strategies to implement improved management practices for sustainable agricultural production on both fertile and marginal soils.

SWNM activities focus on four themes involving several partners:

- Combating nutrient depletion (CNDC) in East and West African sub-humid savannas and hillsides: International Fertilizer Development Center (IFDC), Tropical Soil Biology and Fertility Programme (TSBF), Kenya Agricultural Research Institute (KARI)
- Managing infertile soils (MIS) in Latin America and Africa: Centro Internacional de Agricultura Tropical (CIAT), Colombia, Universidad Nacional Agraria, Nicaragua (UNA), Nicaragua),
- Managing soil erosion in South and Southeast Asia: International Board for Soil Research and Management (IBSRAM) now incorporated into International Water Management Institute (IWMI), Sri Lanka and Center for Soil and Agroclimate Research, Indonesia (CSAR)
- Optimizing soil water use (OSWU) in West Asia and North Africa and sub-Saharan Africa: International Center for Agricultural Research in the Dry Areas (ICARDA), Syria, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India, Agricultural Research Council-Institute for Soil, Climate and Water (ARC-ISCW), South Africa.

Program goals

The goals of the SWNM program are to increase long-term agricultural productivity, reduce human poverty, and conserve and enhance land and water resources. The program has the following objectives:

- Effective, efficient, and environmentally sound technologies and systems for land management and conservation developed and made available to farmers and other users
- Community-based new institutional mechanisms developed, tested, and promoted, which encourage the use of sustainable SWNM technologies
- Partnerships and capacity of all stakeholders of the ecoregional program (national agricultural research systems and non-governmental organizations) enhanced in order to plan and implement research and dissemination programs for sustainable land management systems
- Workable policy options and advice, including issues concerning equity (gender, resource access, tenure), developed and promoted.

The corresponding anticipated outputs linked to program objectives include:

- Economically viable, socially acceptable, and environmentally sound technologies for SWNM
- Improved methodologies and diagnostic tools for participatory SWNM research
- Improved indicators for sustainable and unsustainable land use systems that monitor environmental and economic impacts
- Easily accessible decision support systems (models, expert systems, geographical information systems, global data bases, etc.) for generating, testing, and extrapolating SWNM options
- Better trained people capable of implementing SWNM programs and policies
- Effective framework for full cooperation and partnership between stakeholder groups
- Appropriate policy dialog that promotes sustainable SWNM practices
- Effective mechanisms for information exchange.

A project worker interviews farmers in a Zimbabwe community to help identify problems related to soil, water, and nutrient management.

The long-term goal of the OSWU project, is to achieve sustainable and profitable agricultural production in dry areas based upon the optimal use of the limited available water at different watershed scales.

The overall objective of the project is to develop and promote the adoption of integrated land management strategies and techniques that capture and retain rainwater, using crop husbandry techniques that maximize productive transpiration and minimize evaporative and drainage losses.

OSWU achievements in Africa

- The Agricultural Production Systems Simulator (APSIM) package: APSIM, a state of the art cropping systems simulator, has been further developed to make it more useful in the African semi-arid tropics. Pigeonpea and pearl millet growth and development modules have been developed jointly with the Agricultural Production Systems Research Unit (APSRU), which is a partnership between scientists from several organizations, including the Commonwealth Scientific and Industrial Research Organization, the Queensland Departments of Primary Industries and Natural Resources, and the University of Queensland in Australia. A manure module that simulates decomposition and nutrient mineralization of manure in relation to manure quantity and quality; a phosphorus module developed by APSRU with assistance from OSWU; and a weeds module for maize are also now in use at ICRISAT to assist research in African semi-arid tropical regions.
- Key research and development issues in the context of optimizing soil water use in the semi-arid regions include soil surface management to increase infiltration and decrease run-off and evaporation, and the manipulation and adaptation of cropping systems to optimize crop water use. Ways to optimize soil water use in low-input production systems are often different from those in high-input situations. A decision support tool for choosing optimum technologies was developed for use by researchers, extension agents, and farmers.
- OSWU has looked at the use of organic amendments to increase nutrient uptake by millet grown using the *zai* water harvesting technique in the Nigerien Sahel. This study addressed the issue of resource use efficiency of organic inputs (animal manure, compost, and millet stover) with different sized catchment areas (zero, 25 cm diameter, and 50 cm diameter). *Zai* is one of many traditional techniques used in sub-Saharan Africa to reduce the risks to production in drought-prone areas, where there is a great variation in rainfall across and within the seasons. Other techniques include

half-moons, stone bunds, and other surface management practices, such as tied-ridging, plowing, and crop residue management. These technologies are mostly related to appropriate soil management, including no-till options for conservation, the use of adapted crop cultivars, inorganic fertilizer, crop residue management, cropping system management, pest control, integrated watershed management, and combinations of these factors. A steady release of nutrients from the organic amendment, in combination with the water collected in the *zai*, favors the development of a larger rooting system to make better use of water and nutrients.

- The potential impact of OSWU research was evaluated using the 'Bayesian belief network approach,' which is a method for representing relationships between variables, even if those relationships involve uncertainty, unpredictability, or imprecision. Preliminary analysis using a simple belief network showed that the impact on agricultural production could be significant in areas with a high demand for OSWU technologies and where there is significant scope for yield improvement.
- In South African semi-arid areas, runoff and evaporation limit the efficient use of water for crop production. Runoff can be minimized by use of basins and in-field water harvesting, and evaporation can be reduced during fallow and cropping periods. OSWU researchers conducted summer and winter studies on sandy loam and clay soils to evaluate the effects of crop residue and stone mulches on evaporation from the soil surface, and on soil temperature. A 50% stone mulch was as effective as a 50% organic mulch in inhibiting evaporative water losses and reducing soil temperatures. This result has beneficial socioeconomic implications for smallscale farmers, because crop residues are important animalfeedstuffs. The effects were more pronounced on the clay than on the sandy loam soils.
- On-farm experimentation in Zimbabwe is aimed at increasing the productivity and incomes of small-scale farmers in the semi-arid tropics. The work follows an on-farm participatory approach at three locations representing a transect from the better-endowed to the marginal semi-arid tropics. Included are researcher-designed, replicated trials implemented by farmers, and farmer-led and implemented unreplicated trials. Technologies tested included those aimed at making more efficient use of water (modified tied ridging, seed priming, weed management) and nutrients (manure inputs using different types and storage, small inputs of fertilizer with or without manure, legume rotations). The results of the experiments were evaluated both by researchers and farmers. In some cases the design of the experiments was aided by using the APSIM simulation model to provide an *ex ante* scenario analysis of promising technologies. Modified tied ridging is a less labor-intensive modification of tied ridging that conserves rainwater in the field, controls weeds, and reduces erosion. Both farmyard manure and fertilizer-N increased yield in an average season. On-farm research at these sites is brought together through modeling using the APSIM package.

Farmer–researcher dialog

Can the knowledge of agricultural researchers be made compatible with what small-scale farmers know about farming systems? Can the participatory researchers communicate with the computer-based modelers? OSWU scientists were well represented at an international workshop in Bulawayo, Zimbabwe, in September 2001, that put farmers and scientists on equal terms. The participants (50 researchers and 150 farmers) tested the hypothesis that computer models could help promote collaboration between farmers and researchers, and could provide new insights into farmers' production systems in a climatically risky environment. While many participants were initially skeptical about the value of models, most left the workshop convinced that models are an exciting new tool that can help farmers in the semi-arid tropics. In fact, the Zimbabwe researchers are back in the villages, because the farmers requested continued collaboration. And researchers in other countries are considering how they can use the modeling tool.

Conclusions

The actual water-use efficiency in farming systems in the drought-prone countries of sub-Saharan Africa is often very low, and a surprisingly small proportion of the available water is actually transpired by crops. At the field level, water is lost through surface runoff, percolation below the rooting zone, evaporation from the soil surface, seepage in deep cracks, and transpiration by weeds. These vary according to site- and situation-specific conditions, which are often poorly quantified. Viable farm-level techniques, such as those developed by ICARDA for Central and West Asia and North Africa (see *Caravan* No. 13), can be put to good use in many dry countries to reduce these losses and to increase the capture and retention of water, as well as to maximize the proportion of water that is productively transpired by crops. Development of water-efficient cultivars is one way to achieve this. Such new varieties, often developed by national programs from material supplied by ICARDA, ICRISAT, and other CGIAR Centers, usually can only achieve their potential with improved soil, crop, and cropping system management. Better soil and crop management can make a major contribution to improved productivity from scarce and erratic rainfall if tested through farmer participation, from planning to implementation and evaluation.■

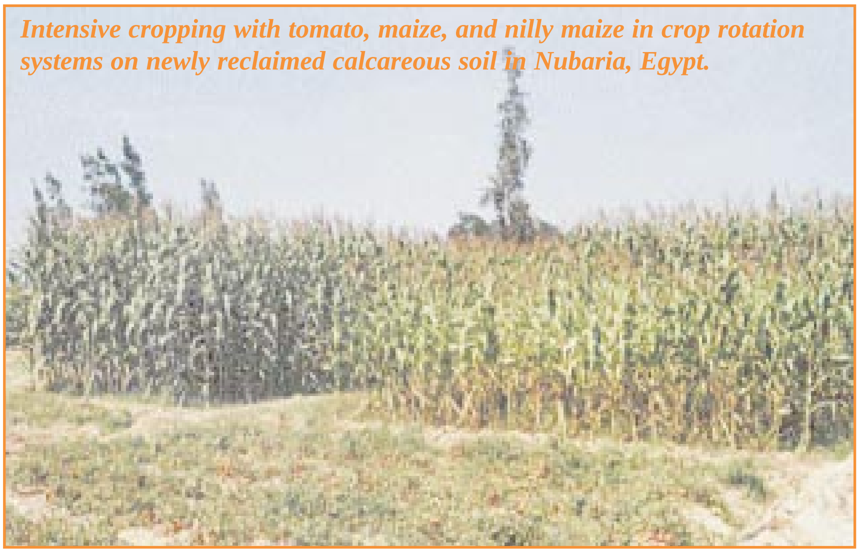
Dr Mustafa Pala is Wheat-based Systems Agronomist and Dr Richard Thomas is Director of the Natural Resources Management Program at ICARDA; and Dr R.J.K. Myers is Principal Scientist, Soils, based in the office of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), at Bulawayo,

Taking the Long View in Egypt

Anticipatory Long-term Research Yields Answers

Natural resources management requires a broad perspective and a willingness to take a long-term view. So-called anticipatory long-term research is yielding answers in Egypt that might help ensure the sustainabilty of the country's agricultural systems.

Intensive cropping with tomato, maize, and nilly maize in crop rotation systems on newly reclaimed calcareous soil in Nubaria, Egypt.



By M. Pala, R. Abou Elenien, A.M. Abdel Safi, M. Abdel Ghani, A. Abdel Naim, A. Hammam, M. Sherif, N. Haddad, H. Halila and M. Solh

Agriculture in Egypt relies heavily on irrigation water from the Nile. Compared to a century ago, the annual per capita share of fresh water resources has declined about 80%, to 930 m^3, and this amount is expected to drop to 350m^3 by the year 2025.

Land use intensification is reducing the capital of the natural resource base and its productive potential. Research is needed that will quickly lead to impact at the farm level to generate income and relieve poverty. The need to anticipate natural resource problems has never been greater. To reconcile the immediate need for increased productivity with the need for sustained production, the research community is adopting an 'anticipatory' research paradigm based on: (a) long-term trials (LTT), (b) long-term monitoring (LTM) of resource management at the farm level, and (c) strategic research for sustainable productivity.

A case study from Egypt

Agriculture in Egypt is, for the most part, intensive and highly productive. Sustainability of the agricultural system is endangered, however, by loss of agricultural land, increasing soil salinity, fertilizer abuse, soil pollution from chemical fertilizers and drainage water, and low on-farm irrigation efficiency.

Most of these problems are at the edge of farmers' awareness. Most smallholders proceed from season to season planting crops to match substistence needs and likely market opportunities according to local constraints on water and availability of other inputs. In many cases, good advice is unavailable, or action is needed at the community or higher level.

The Egyptian national agricultural research system and ICARDA have developed a long-term resource management approach, funded by the European Union, aimed at sustainable high productivity through sound management that protects the resource base (land and water). The approach combines long-term, on-station cropping systems and management research with extensive on-farm monitoring of resources and their management, and an analysis of farmer decision making. Information from preparatory studies, such as inventories, rapid rural appraisal, and multi-disciplinary surveys, was used to plan long-term research activities at

Fruit tree establishment in Rafah, North Sinai, which receives 200-250 mm of rainfall annually.

five locations on old land (middle and northern Delta), newly reclaimed land (sandy and calcareous soils), and rainfed areas (Rafah–El Barth). High priority researchable resource management problems were identified, in the context of realistic cropping sequences and farm level economics. The main experimental variables are crop rotation, water quality and/or quantity, and use of mineral fertilizer and organic manure.

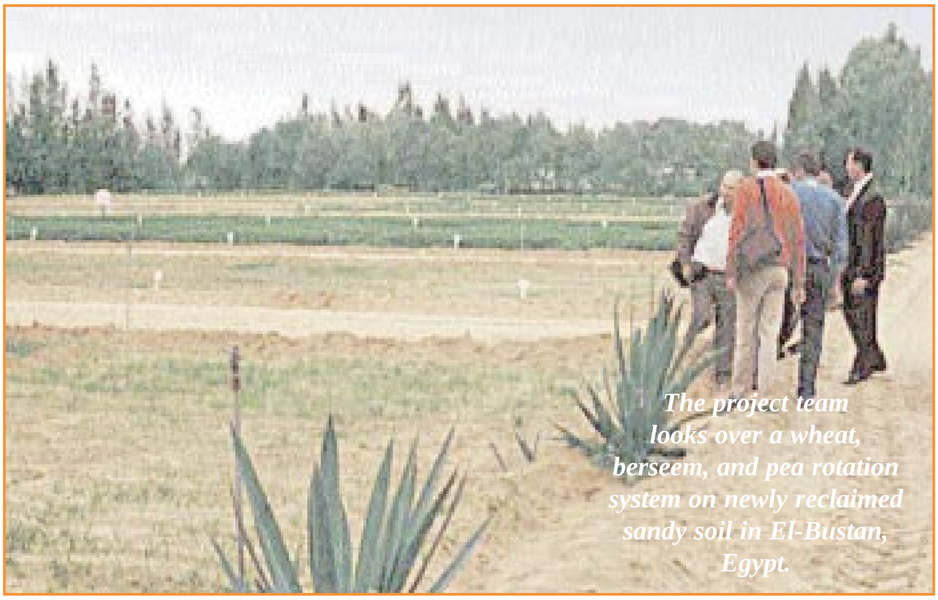
Eighty-seven farmers are participating in the monitoring aspect of the project, which hopes to glean information about farmer practices and management and their effect on productivity, profitability, and soil and water resources. Farmers were selected to represent the range of social, economic, and natural-resource conditions at each location. The program should lead to better understanding of the resource base and its management, and more efficient ways of using resources, to maintain high productivity while minimizing adverse effects on the environment.

Achievements

- Eighteen reports summarizing and interpreting information gained in the Preparatory Phase were published.
- Long-term trials were established and local resource management teams (agronomist, and soil, water and crop nutrition specialists) were formed to manage the trials and to take measurements of crop yields and parameters of soil and water condition.
- Farmers to take part in long-term monitoring were identified and were surveyed twice a year by a local team consisting of a socioeconomist and soil and water specialists. Data on socioeconomics, production, and soil and water conditions were collected. Cross-membership of the LTT and LTM teams, and joint focus on the same biophysical and technical issues provided coherence of purpose between the farm-level and research station activities.
- A database management system was established for LTT and LTM data, facilitating interpretation, information generation, and reporting.

Salient results after five years of trials

- The recommended irrigation regime resulted in higher yields and 25-30% water savings in trials in Sids and Nubaria, compared to farmer practice.
- In trials in rainfed areas, application of organic manure produced cereal yields equal to those produced by NP fertilization. A wheat–legume rotation reduced weed infestation in wheat compared to the continuous wheat system. It also increased water-use efficiency (WUE). Mean WUE values for barley in barley–barley rotation (0.38 kg grain/m^3 water) were low compared with those for barley in rotation with fallow, lentil, or forage pea (0.81, 0.73, and 0.72 kg grain/m^3 water, respectively).
- A mole drain system (at 1.5 m depth filled with woody cotton plant residue, perpendicular to lateral field drains) decreased the water table at El-Serw research station (salt affected soils) from 61 cm to 100 cm, resulting in increased crop productivity, particularly for rice.
- In the El-Bustan area (sandy soil), stable yield was maintained with the new crop rotation (groundnut once in three years). The prevailing practice (groundnut every year) reduced yields considerably. Moreover, the new rotation was more effective in reducing root-knot nematode.
- In all locations, most participating farmers overused nitrogen fertilizers. Nitrogen-use efficiency values for wheat in farmers' fields in Sids and Nubaria were about half those recorded in LTT research plots; but values improved where manure was applied.
- WUE values for wheat in farmers' fields at Sids and Nubaria were low (0.6 and 0.7 kg grain/m^3) compared with those in LTT plots (1.5 and 1.3 kg grain/m^3, respectively), attributed to differences in overall management.
- Monitoring inlet water (canal or well) and field drain water in farmers' fields at Sids, El-Serw, and Nubaria revealed increased nitrate content in drain water. The team recorded mean inlet and outlet values of 1.6 and 12.1 mg NO_3/liter, respectively, in Nubaria, indicating considerable leaching loss of nitrogen fertilizer and water pollution.
- The team found that farmers on the newly reclaimed land have started to introduce new crops into their summer rotations. These include vegetables, in addition to groundnut in sandy soils, and cotton in addition to maize and tomato in the calcareous soils. On the old land, medicinal plants have replaced some faba bean. Farmers close to the coast in north Sinai have expanded their fruit tree plantations and vegetable production using



The project team looks over a wheat, berseem, and pea rotation system on newly reclaimed sandy soil in El-Bustan, Egypt.

Mole drainage systems establishment in El-Serw on salt-affected old land in the lower Nile Delta.

underground water. Manuring, subsoiling, and the planting of legume crops were the soil fertility enhancing methods preferred by most of the farmers sampled in the newly reclaimed land, whereas manure and residue incorporation were preferred by the old land farmers. However, on the old land of Sids, where alkalinity is a problem, subsoiling and gypsum application are practiced. It was found that most farmers on the old land were not sensitive to price increase of chemical fertilizers.

Results from strategic research

- A shallow water table (<50cm depth) at El-Serw significantly reduced wheat yield and N uptake. However, findings also suggest that the water table contribution to crop water consumption should be considered in relation to irrigation quantity and frequency in the management of salt-affected soils of the northern Delta.
- At Nubaria, under flood (basin) irrigation, planting wheat in short strips (30 or 50 m long instead of 80 m) resulted in more uniform distribution of water, greater application efficiency, greater water and nitrogen use efficiencies, and higher yield.
- Losses (mainly leaching) from applied nitrogen fertilizer, estimated by nitrogen isotope dilution methodology, ranged from 31% to 58% for a sandy soil (at Ismailieh, conditions comparable to El-Bustan) and 17% to 41% for a heavy clay soil, at Sids.
- Applications of the biofertilizer *Azospirillum parazilinse* or the commercial seed inoculant Sirialine maintained maize yields with lower N fertilizer inputs, lowering cost and reducing the water pollution hazard at Sids.

Tests in farmers' fields

The following practices were tested on farmers' fields:

- Producing and applying composite manure (fermented) at LTT sites and farmers' fields, especially in the newly reclaimed area to:
  - utilize farm residues,
  - increase soil fertility and crop productivity,
  - reduce salinity and alkalinity hazards,
  - minimize nematode problems,
  - control weeds,
- Planting wheat in furrows followed by maize and/or sunflower to test/achieve:
  - better control of irrigation
  - save water by applying recommended levels,
- Zero-tillage application for:
  - optimum planting dates for summer crops,
  - more intensive cropping system,
  - reduced operating costs,
- Mole drains in salt-affected clay soils to:
  - increase drainage efficiency.

Immediate impact

The project has resulted in increased awareness about the hazards to natural resources. This increased awareness is due mostly to the dissemination of information and technologies meant to encourage improved management of soil and water resources. Data from LTT and LTM indicate the merit of conducting on-farm activities, and taking into account the yearly cropping patterns instead of only commodities. The activities have resulted in a methodology for studying resource management from a holistic approach. The project should lead to the institutionalization of natural resources management research within national agricultural research system programs, adopting a multidisciplinary approach to ensure long-term sustainability of agricultural systems. Next, the data collected will be used in developing decision support systems. ■

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Rangeland Degradation in Morocco: A Concern for All

Livestock producers in northeastern Morocco face tremendous challenges due to overgrazing and encroachment of rangelands for crop production. It is essential that stakeholders share experiences and research findings if the land degradation and the rural exodus it has spurred are to be reversed. To this end, ICARDA, national institutions, development agencies, farmers, and non-governmental organizations are working together to add value to the ambitious programs launched by the Moroccan government aimed at sustainable development of rangelands in the country.

The pastoral system in notheastern Morocco is evolving into an agropastoral system. More land is being put to the plow, often in areas too dry to sustain crop production.

By Mustapha Bounejmate, Hamid Mahyou, and Abdelamajid Bechchari

An important resource threatened

In northeastern Morocco, rangelands and livestock have important environmental and socioeconomic roles. Small ruminants number over 2 million head (12% of total small ruminants in Morocco) and are a main source of income in the region. The 'Beni Guil' is the predominant breed of sheep, which is well adapted to the harsh environment and famous for its meat and wool. The region used to supply meat to other parts of the country and for export.

Rangelands cover about 5 million ha in northeastern Morocco. These are placed in four categories depending on dominant vegetation: *Stipa* 2,230,000 ha, *Artemisia* 957,100 ha, *Chenopodiacea* 1,302,000 ha, and 233,000 ha of desert steppes. Mean annual rainfall is around 210 mm, with high variablility, ranging from 80 to 320 mm. Maximum temperature is around 40ºC (July-August). January is the coldest month, with a minimum temperature of 0ºC. Frost is frequent in February, March, and April, often causing death of newly born small ruminants. The area also suffers from frequent strong winds and sand storms. Soils are generally shallow and poor.

For a long time, rangelands in northeastern Morocco were managed in an efficient and sustainable way. Grazing pressure was monitored to allow maintenance of range species diversity and a high turnover of biomass to meet animal needs. But, today, throughout the region, degradation of the rangelands has reached an alarming level, calling for prompt action. The capacity of rangelands to provide a sustainable livelihood for herders has been drastically reduced due to a combination of factors, including degradation due to overgrazing and expansion of cultivation. Rangelands now meet only a small proportion of the feed needs of grazing animals.

The disempowerment of traditional institutions has led to the disruption of management of rangelands. Transhumance has practically disappeared. Settling within rangelands has become the rule, and cultivation and privatization of the rangeland is expanding. And what remains of the original rangeland is exposed to fierce overexploitation. Rangeland rehabilitation, therefore, is a high priority for the Moroccan government, which has initiated activities aimed at halting degradation, increasing farmers' income, and stemming the rural exodus.

The land available for grazing is coming under increasing pressure with more animals grazing fewer hectares. The perennial vegetation has been almost totally lost to overgrazing and firewood collection, leaving the soil exposed.

Involving stakeholders

Several collaborative research and development projects (‘Multipurpose Fodder shrubs and Trees’, ‘Sustainable Management of the Agro-Pastoral Resource Base in the Oujda Region’, the ‘Mashreq/Maghreb’ project, the ‘Taourirt-Tafoghalt’ project, and the ‘Pastoral and Herding Development’ project) are operating in the region. ICARDA and the Moroccan national program are key participants. A common feature of these projects is the use of a participatory approach involving all stakeholders concerned with sustainable development of agropastoral resources. Involvement of pastoral communities within the ‘Sustainable Management of the Agro-Pastoral Resource Base in the Oujda Region’ project, supported by the Swiss government, is described below to illustrate this participatory approach.

Many meetings were organized with local authorities, representatives of different ethnic groups, herders, and local extension centers. A workshop was organized with the local communities to involve them in the project, to identify their problems and preoccupations, and to build trust.

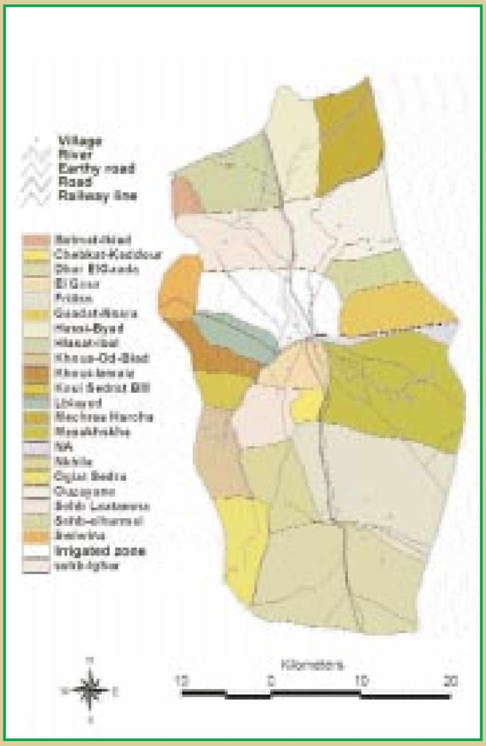
Local communities expressed four major concerns that they felt the project could address:

- The problem of the extension of crop production into rangeland
- Water point durability and functioning
- Urban encroachment of rangeland area
- Extension of the irrigated zone

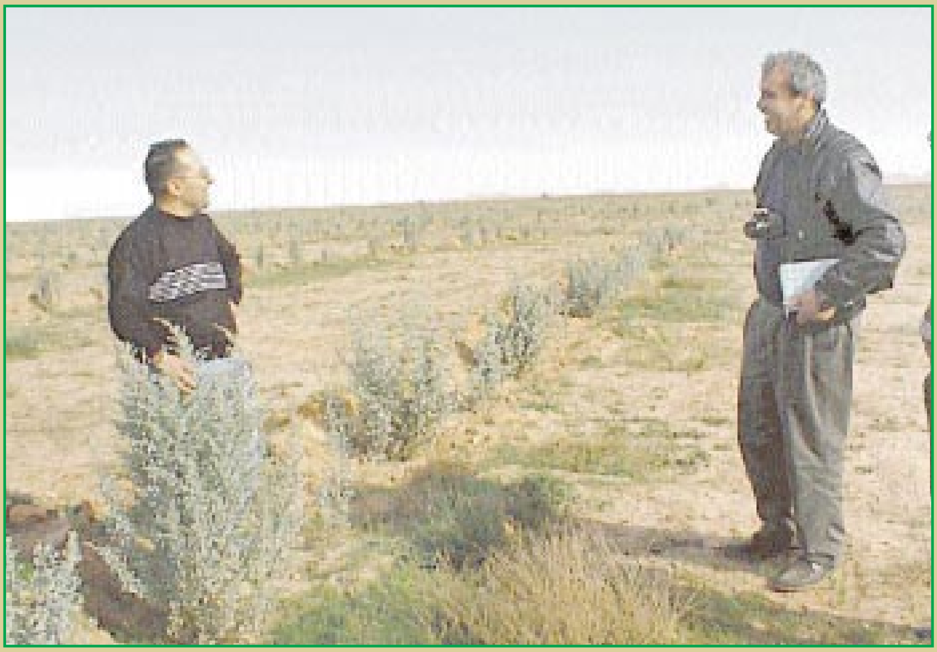
Another workshop was organized to determine, with local communities, the limits of sub-tribes and rangeland by sub-tribe. Interviews were held with breeders, heads of sub-tribes, and presidents and members of pastoral cooperatives. The team explained to herders how to use and read cartographic maps of 1/100,000 scale, and then herders themselves drew maps of the rangeland.

The participants agreed on boundaries, rangeland membership, and other matters. Boundaries of sub-tribes and of different rangeland areas of the rural commune of Ain Beni Mathar were delimited on a map.

For example, the map reproduced here, showing the location of the different rangelands, was drawn based on information provided by local communities.



Localization of the different rangelands as recognized by the people of Ain Beni Mathar, Morocco.



A good reason to smile: Mohamed Acherkouk (left), rangeland specialist at INRA-Oujda, Morocco, and Mohamed Hammoudi, rangeland specialist at the Directorate of Agriculture, Oujda, Morocco, discuss the benefits of introducing fodder shrubs into farmers' fields. The combination of crops with wide-spaced hedgerows of drought-tolerant fodder shrubs proved a feasible solution. About 6000 ha have already been alley-cropped on private farms within the Taourirt-Tafoghalt project.

An evolving pastoral system

A socioeconomic study was conducted to understand the changes in the pastoral practices in the Ain Beni Mathar rural community. The study showed that livestock remains the main source of income, but that the pastoral system has evolved during the last decades:

- The ancestral grazing practices, based on tribal organization and using large areas for grazing, are disappearing and rangeland is degrading at a quicker pace.
- The system is evolving towards an agropastoral one, characterized by the intensification of livestock production.
- Pastoral cooperatives are replacing the traditional mode of organization based on tribes.
- There is less transhumance. The best sites are cleared for cultivation.
- Pastoralists with small flocks are more sedentary and, therefore, contribute to rangeland degradation.
- More farmers are raising the Ouled Djellal breed of sheep.
- The contribution of concentrate to livestock feeding is increasing.
- The rural exodus is increasing due to a decline in livestock

productivity and the high cost of feed concentrates.

Encroachment of traditional rangeland for crop production

With financial support from the Swiss Agency for Development and Cooperation (SDC), a study was conducted on the extent of encroachment of cultivation into traditional rangeland in the Ain Beni Mathar area. Participatory approaches were used that involved all rangeland stakeholders.

The local population was asked to identify on a map different characteristics of their sub-tribe's areas, such as rivers, tracks, habitations, etc. Assisted by scientists, the respondents learned easily to read maps. Then they indicated boundaries of their fractions as well as rangeland boundaries. Collected data were put into a database, including, in particular, the characteristics of each rangeland area: name of the rangeland, land tenure, type of soil, topography, estimated area, rangeland cultivated area, number of people cultivating crops on the rangeland, type of crops, and the existing infrastructure and its type.

Geographical information systems and remote sensing were then used to assess encroachment. A comparison of 1988 and 2000 showed that:

- The *Stipa tenacissima* steppe in good condition decreased from 22,457 ha to 15,929 ha.
- Degraded *S. tenacissima* steppe increased from 54,149 ha to 56,188 ha.
- Overall degraded area increased from 53,541 ha to 72,228 ha due to the clearing of *S. tenacissima* and *Artemisia herba-alba* steppes.
- Degraded *A. herba-alba* steppe decreased from 5,674 ha to 1,354 ha, mainly due to its conversion to cropland.

The overall state of the non-cultivated vegetation cover diminished between the two dates. The study showed a major increase in cultivation in the northern sector of the study area, which has more favorable conditions for agricultural production due to slightly higher rainfall and lower soil salinity.

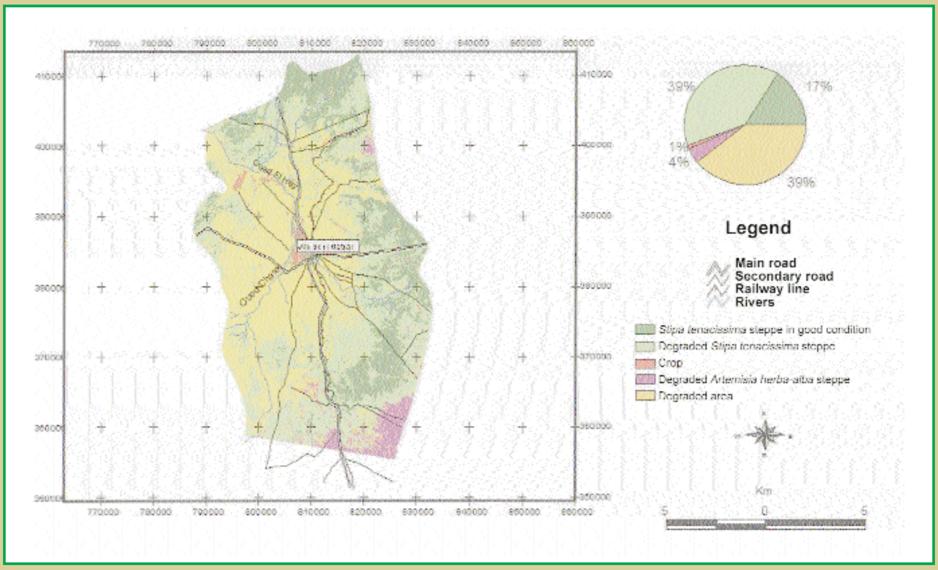
A better understanding has been gained into the causes of encroachment of cultivation. A database was created on rangeland management systems, and the maps and documents it contains, including transcriptions of interviews with farmers. This will be useful in coming up with strategies to control rangeland cultivation.

Win/win technologies

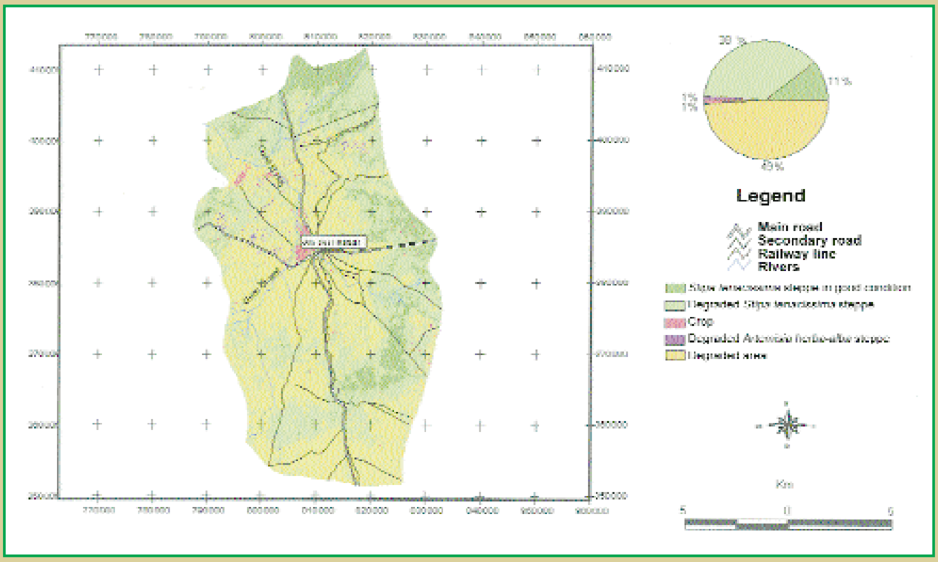
Due to human and animal population growth, cropping has expanded into low rainfall areas and into very fragile environments to the detriment of rangeland, resulting in increased feed deficit and soil erosion. To reverse the situation, ICARDA and its Moroccan partners are testing the suitability of shrubs as an intercrop (alley cropping) with barley and other common crops, such as oats, and mixtures of barley and fodder pea, and barley and vetch.

On-station and on-farm testing suggests that alley cropping with *Atriplex* (saltbush) could greatly increase crop and animal production, and at the same time help to protect fragile soils from wind and water erosion.

Total biomass and grain yield were higher in alley cropped systems. Energy and crude protein yields also increased by 11-93% and 16-196%, respectively. Alley cropping increased land-equivalent ratios from 1 (barley or weedy fallow) to 1.20–1.46, suggesting that this technology will be particularly useful in areas where farm size is small. (A land-equivalent ratio of more than one indicates that growing an intercrop gives higher total output per unit area than a single crop.)



Land use of the Ain Beni Mathar rural community in Morocco in March 1988.



Land use of the Ain Beni Mathar rural community in Morocco in March 2000.

The technology is taking off. Indeed, a total of 6000 ha of alley cropping systems have already been established on private farms within the Taourirt-Tafoghalt project. This was a result of collaboration between different research and development projects, such as the CGIAR System-wide Livestock Programme's Multipurpose Fodder Shrubs and Trees project led by ICARDA, ICARDA's Mashreq/Maghreb project, and the Taourirt-Tafoghalt project. A further 8000 ha are to be alley cropped in the next two years.

Mr Abdelmajid Bechchari, INRA Morocco, collects rangeland species in a joint INRA/ICARDA mission in eastern Morocco.

Collecting native rangeland species

The ranges of northeastern Morocco are home to a diversity of range species. They are an invaluable resource to rehabilitate fragile, dry environments. Due to over-exploitation of these native plants and their habitat, however, many are endangered and some are close to extinction. To this end, ICARDA and national research institutions undertook a mission to assess rangeland biodiversity and collect native rangeland species.

The collection covered 43 sites over an area of 2200 km and rainfall zones of 180 to 500 mm. Samples were collected at intervals of 10-15 km along the collection route. Over 385 accessions of 60 species were collected. *Stipa* spp. were most frequent (51 accessions of four species). *Artemisia* spp. were also frequent. Other species collected included *Heliantheum* spp., *Herniaria* spp., *Paronychia argentea*, *Schismus barbatus*, and *Thymus* spp. Vetch and medic species were found in areas protected from grazing.

Sensitizing donors and decision-makers

ICARDA and the Institut National de la Recherche Agronomique (INRA) of Morocco organized a regional workshop on 'Sustainable Management of Agro-Pastoral Resources' on 20-22 February 2001 in Oujda.

Fifty-six participants attended, among them were: His Excellency Mr Daniel von Muralt, Swiss Ambassador to Morocco; Mr Hans Schellenberg, responsible for the Middle East and North Africa Division of the Swiss Agency for Development and Cooperation (SDC); Mr Abdelaziz Arifi, Director General, INRA; and Mr El Gharbaoui Abdelwahed, Head of the Rangelands Department, Ministry of Agriculture, Morocco. Pastoralists participated actively throughout the workshop, as did representatives from the national agricultural research systems (NARS) of Algeria, Libya, Mauritania, and Tunisia.

The workshop was an opportunity to present results obtained within the 'Sustainable Management of the Agro-Pastoral Resource Base in the Oujda Region' project. Seven papers were presented, and representatives from the Maghreb countries presented progress made in their work on sustainable rangeland management.

Stakeholders and Maghrebian colleagues agreed to join efforts in a regional project on the 'Sustainable Management of the Agro-Pastoral Resource Base in the Maghreb.' This project aims at developing decision-making tools and strengthening the capacities of Maghrebian NARS in sustainable management of the agro-pastoral base, by building on the methodologies developed and the results obtained in the Oujda project. The SDC representatives agreed to consider funding this project. ■

The opening ceremony of the final workshop on "Sustainable Management of the Agro-Pastoral Resource Base in the Oujda Region of Morocco: A Regional Approach." From right, Dr Abdelaziz Arifi, Director General of INRA Morocco; H.E. the Wali of the Grand Oujda; H.E. Daniel von Muralt, Swiss Ambassador to Morocco; Mr Hans Schellenberg, MENA Division, Swiss Agency for Development and Cooperation; and Dr M. El Mourid, ICARDA Coordinator, North Africa Regional Program.

Dr Mustapha Bounejmate is a Feed Resources Specialist at ICARDA; Mr Hamid Mahyou is an Agronomist at INRA-Oujda, Morocco; and Mr Abdelamajid Bechchari is a Livestock Specialist at INRA-Oujda, Morocco.

Seeking Sustainable Solutions: Integrated Pest Management Pilot Sites in Egypt and Morocco

Integrated pest management (IPM) represents a range of environmentally sound, ecologically based approaches to crop protection and is increasingly recognized as a key element in sustainable agricultural development. To enhance the use of IPM it is essential to test, apply, and publicize more effective options for farming communities.

His Excellency Moulary Ismail Alaoui (front left), Minister of Agriculture, is offered a sample of chickpea by one of the authors, Saadia Lhaloui, at the IPM pilot site in Morocco.

By Khaled Makkouk, Saadia Lhaloui, and Mamdouh Omar

The Consultative Group on International Agricultural Research System-wide Program on Integrated Pest Management (SP-IPM) supported the initiation of seven IPM Pilot Sites in Africa during the 2000-2001 growing season, including two sites in North Africa: one in Beni Suef Governorate, Egypt, and the other in Settat, Morocco.

The main objective of the pilot site model is to build an effective farmer-scientist-extension partnership and to permit such a team to analyze production problems, identify ways farmers cope with problems, come up with researcher recommended IPM options and agree on "best bet" options to evaluate jointly. At the pilot site, lead farmers are identified and they select IPM options to evaluate in their fields in collaboration with neighboring farmers.

Egypt IPM pilot site

Faba bean and wheat are important crops in Beni Suef Governorate, Middle Egypt. Around 20,000 ha were planted to faba bean before 1991, with and average yield of about 2.7 t/ha. A virus epidemic in 1991-1992 reduced faba bean yield in Beni Suef by 80%. The virus hit again in the 1998-99 growing season. Due to the virus and other problems, the area planted to faba bean in this governorate dropped from 17,600 ha in 1990-1991 to 800 ha in 1999-2000. To salvage the crop and to restore farmers' confidence in planting faba bean in Beni Suef, the IPM pilot site activities were initiated during the 2000-2001 growing season.

Lead farmers talk with visiting farmers at an IPM pilot site in Morocco

Pest constraints and IPM options evaluated

The preliminary meeting between lead farmers, research scientists, and extension workers identified the major limiting factors for faba bean production as: virus diseases, especially faba bean necrotic yellows virus (FBNYV), aphids, especially the cowpea aphid *Aphis craccivora*, and the parasitic weed *Orobanche*.

Discussion between lead farmers, agricultural research center scientists, and extension workers led to the identification of the following IPM "best bet" options: (i) improved cultivars 'Giza 429' and 'Giza 843' tolerant to *Orobanche*, (ii) sowing during second half of October, (iii) seed rate of 150 kg/ha, (iv) chemical control of aphids with a systemic aphicide, and (v) roguing of virus-infected faba bean plants early in the growing season.

Achievements

Evaluation of the above IPM options was carried out with two clusters of five lead farmers each at El-Fashn and Somosta districts. Faba bean yields were determined at the end of the season in all 10 fields of participating farmers and were compared with yields of non-participating farmers in the same districts. The percent increase in yield in the fields of the participating farmers in El-Fashn district as compared to non-participating farmers ranged from 23% to 125%, with an average of 68%. In the Somosta district the increase ranged from 9% to 83%, with an average of 52%. The average seed yield of the fields of participating farmers in the El-Fashn and Somosta districts was 4.5 t/ha and 3.2 t/ha, respectively.

Neighboring farmers were invited to visit the fields of pilot site farmers. These field days were a big success—the faba bean fields looked healthy and the yields obtained were very promising. Confidence in planting faba bean in Middle Egypt seems to be building, and it is hoped that the success of the pilot sites in 2000-2001 will bring more farmers back to faba bean production.

Morocco IPM pilot site

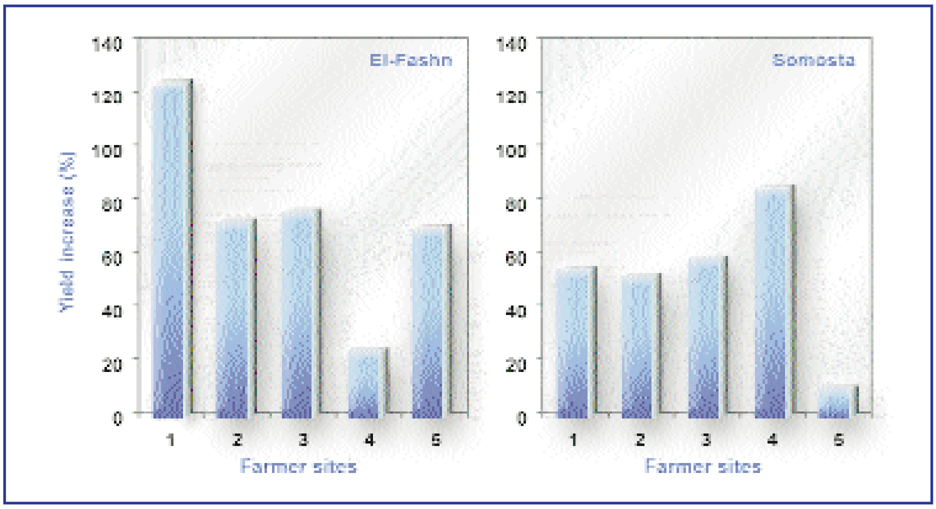
In Settat, Central Morocco, rainfed wheat and chickpea are major crops in rotation. In some years, however, Hessian fly causes complete wheat crop failure, and chickpea suffers from Ascochyta blight. The pilot site was composed of two clusters of three lead farmers each, at the villages of Sidi El-Aidi and Ain Nzagh.

Pest constraints and IPM options evaluated

Farmers, researchers, and extension workers agreed that the IPM options for wheat should center around (i) a wheat variety tolerant to Hessian fly attack, (ii) weed control, (iii) proper fertilization, (iv) optimal planting date, and (v) the use of a drill for planting; and for chickpea (i) a variety with improved tolerance to Ascochyta blight, (ii) optimal (earlier) planting date, (iii) weed control, and (iv) the use of a drill for planting. It was agreed that each lead farmer would evaluate six IPM options for wheat and four for chickpea.

Achievements

Yield was determined for all the IPM options evaluated and was compared with the yield achieved by the neighboring farmers who followed traditional practices. The best IPM option for wheat produced 1630 kg/ha (average of six lead farmers), as compared to an average of 800 kg/ha for the neighboring farmers. Most of the increase was due to the Hessian fly resistant wheat variety 'Arrihane.' In chickpea, the best IPM option produced 945 kg/ha (average of six lead farmers), as compared to an average of 350 kg/ha for the farmers who followed traditional planting in spring. The major factors behind the increase in yield were the use of the Ascochyta blight tolerant variety 'Rizki,' early planting, and use of pre-emergence herbicide 'Granstar.'



Increase in faba bean seed yield (%) in the IPM pilot site farmers' fields as compared to neighboring farmers in El-Fashn and Somosta districts, Egypt.

Farmers' fields as training sites

The fields of the lead farmers in Egypt and Morocco were used as sites to train neighboring farmers throughout the growing season. These sites were visited by many farmers in each country (300-500), by decision makers, and news reporters. The dialog between researchers and lead farmers and visiting farmers was extremely beneficial.

Outlook

Pilot site achievements attracted the attention of policy makers. In Morocco, for example, a visit by the Minister of Agriculture to a pilot site led to the scaling up of the activities nationally. Similarly, in Egypt, site results gave farmers confidence in faba bean. In the future, a series of similar pilot sites will be needed in key locations to serve as focal points for developing and disseminating "best-bet" IPM options. There is a great need to sharpen farmer participatory approaches for rapid, wide, and cost-effective dissemination of results.■

Dr Khaled Makkouk is IPM Coordinator at ICARDA; Dr Saadia Lhaloui is the Pilot Site Coordinator in Morocco and Entomologist, Institut National de la Recherche Agronomique, Settat, Morocco; and Dr Mamdouh Omar is the Pilot Site Coordinator in Egypt and a Legume Scientist, Agricultural Research Center, Egypt.

Managing Wilt and Root Rots of Food Legumes in the Nile Valley Countries

Crop production is tough and risky in the world's dry areas. Along with the stresses imposed by severe heat and drought, crops are subjected to the twin pressures of pests and disease, faced by farmers everywhere. Scientists in the countries of the Nile Valley have banded together to combat two of the most damaging crop diseases in the region, and cooperation is paying off.

Wilt and root-rot sick plots have been developed in Ethiopia, Egypt, and Sudan. They will be used to select for resistant plant lines.

By G. Bejiga, N. Abou-Zeid, W. Suliman, S. Ahmed, and A. Hassanein

The winter cereals—wheat and barley—and the cool season food legumes—faba bean, chickpea, and lentil—are among the most important food crops in Egypt, Ethiopia, Sudan, and Yemen. The food legumes are a major part of the daily diet and an important source of protein. In Ethiopia, for instance, they account for 21% of the protein consumed. Faba bean (dry broad bean) is the most important pulse, representing 80% of the pulses produced in Egypt and 36% in Ethiopia.

In the four countries combined, food legumes are grown on 0.8 million ha. Production of these crops, however, does not meet demand from the population, which is growing at an average annual rate of 2.5%. As a result, a substantial quantity is imported annually.

Crop yields under farmers' conditions are usually low compared to potential yields, and fluctuate considerably from season to season. This is due mainly to variability in rainfall, both within and between years, and the susceptibility of the cultivated landraces and cultivars to diseases, such as rusts, wilt, root rot, and viruses; insect pests, such as aphids; and stress from heat and drought.

Wilt and root rot are major limiting factors in the production of faba bean, chickpea, and lentil in all the Nile Valley countries. The diseases cause up to 100% yield loss under heavy infestation, depending on relative humidity, soil moisture, and soil temperature.

Within the framework of the Nile Valley and Red Sea Regional Program of ICARDA, a network was formed in 1995 to identify and prioritize the major soil-borne diseases of faba bean, chickpea, and lentil in Egypt, Ethiopia, and Sudan. The network includes scientists from the three countries and ICARDA. One of the main goals of the network is to pool the members' resources, such as laboratory facilities, skilled staff, and finances, to overcome the major economically important soil-borne diseases.

Screening chickpea lines for resistance to Fusarium wilt in a wilt-sick plot in Ethiopia. The susceptible check, middle, wilted and turned yellow, while the resistant lines planted left and right faired much better.

Debre Zeit Agricultural Research Center of the Ethiopian Agricultural Research Organization (EARO) took the lead because it had already developed sick-plots for *Fusarium oxysporum* wilt in chickpea and lentil. EARO has also developed a sick-plot for *F. solani*, the pathogen responsible for black root rot in faba bean. In the initial phase of the project, the major activities were subdivided into four categories:

1. Surveys to determine the distribution and importance of soil-borne diseases of the three crops (faba bean, chickpea, and lentil) in the three countries.
2. Screening of germplasm for resistance to the major pathogens.
3. Survey and identification of potential biocontrol agents and races of pathogens.
4. Integrated management of diseases by use of cultural practices, resistant cultivars, and biocontrol agents and chemicals.

All the countries carried out surveys and screening for resistance. Ethiopia was responsible for coordinating the screening. Sudan was responsible for integrated management work, while Egypt took the lead in biocontrol, chemical screening, and race identification.

Some major achievements/findings of the network include:

1. Chickpea wilt caused by *F. oxysporum* f.sp. *ciceris* and lentil wilt caused by *F. oxysporum* f.sp. *lentis* were found to be the common and major diseases of the three legumes in the three countries.
2. Sclerotinia stem rot is the major disease in irrigated chickpea in the black clay soil in Egypt, while it does not occur in Ethiopia and Sudan.
3. Dry root rot caused by *Rhizoctonia bataticola* was the second most important soil-borne disease in both chickpea and lentil in Ethiopia and Sudan.
4. Black root rot caused by *F. solani* appears to be the major soil-borne disease of faba bean in the three countries.

While surveys were being conducted, screening for resistance to Fusarium wilt of chickpea continued at the sick-plots in Debre Zeit (Ethiopia) and Hudeiba (Sudan). Screening for other diseases in Egypt and Sudan was mainly done in pots.

Results

Chickpea

The Ethiopian national program identified two lines of Kabuli chickpea resistant to *F. oxysporum*. They were both from ICARDA. These were officially released for commercial production in the midlands and highlands of Ethiopia under the names ‘Shasho’ and ‘Arerti.’ A desi chickpea line (ICC 12442) was identified for release in northwestern Ethiopia.

Similarly, ICCX 8500498-P-PBN-SH and ‘Giza 88’ chickpea lines proved resistant to eight isolates of *Sclerotinia sclerotiorum* fungus in Egypt. Their resistance needs to be confirmed before the lines are released to farmers. The Sudan national program has also identified resistant chickpea lines.

Lentil

Although the program is in its infancy compared to chickpea program, the sick-plot of *F. oxysporum* at Debre Zeit Research Center has been used to screen large numbers of germplasm accessions each year. The lines identified by the Center were organized into a regional nursery in collaboration with the lentil breeding program at ICARDA. These lines have been tested in Sudan and Egypt, mainly in pots.

Among the tested lines, ‘Adaa,’ a variety released in Ethiopia, and HC-972 were found to be resistant in all three countries. F 130 and SPS ILL 669 were also moderately resistant or tolerant in the three countries. The ICARDA resistant and susceptible checks were susceptible in Ethiopia, indicating the prevalence of different races. It goes without saying that the race situation should be systematically investigated to assist the breeders in designing their approach in their respective countries. Testing in Debre Zeit sick-plots is providing additional sources of resistance. Lentil lines FLIP 84-43L, 81515, and 78596013 were found resistant to *F. oxysporum* f.sp. *lentis* in Egypt.

Faba bean

Screening for black root rot in faba bean is underway. Identified resistance could not be sustained throughout the season, due mainly to cross-pollination. However, the Ethiopian national program identified three lines that are currently being used in the breeding program.

Biocontrol

Under greenhouse conditions in Egypt, four biocontrol agents (*Trichoderma harzianum*, *Gliocladium virens*, *Pacellomyces farinasus*, and *Bacillus subtilis*) were used successfully to control wilt/root rot diseases in food legume crops. It was found that *T. harzianum* was the most effective on faba bean, lentil, and lupin, as it increased the number of surviving plants and decreased the disease severity, while *P. farinasus* was the most effective biocontrol agent on chickpea.

Seed coating of faba bean, lentil, and chickpea with different bioagents (*T. harzianum*, *G. virens*, *P. farinasus*, and *B. subtilis*) in combination with appropriate sowing dates resulted in an increase in plant survival and a decrease in damping-off disease.

Pathogen variability

Variability among isolates of *F. oxysporum* f.sp. *lentis* was characterized using lentil differentials. Variability was confirmed by DNA cluster analysis using molecular marker technique RAPD-PCR.

Isolates of *F. oxysporum* f.sp. *ciceris* were characterized using DNA bands generated by RAPD-PCR, and tested on varieties of chickpea differentials. So far, three races have been identified.

The work continues

Cooperation through networking is generating improved crop plant lines resistant to soil-borne diseases. The result is improved income and nutrition of the rural poor in the countries of the Nile Valley. The work continues. ■

Dr G. Bejiga is Director, Field Crops Division, Ethiopian Agricultural Research Organization (EARO); Dr N. Abou-Zeid is Deputy Director, Plant Pathology Research Institute (PPRI), Agricultural Research Center (ARC), Egypt; Dr W. Suliman is Pathologist, Hudeiba Agricultural Research Station, ARC, Sudan; Dr Seid Ahmed is Coordinator of Legumes, Debre Zeit ARC, Ethiopia; and Dr A. Hassanein is Chief Researcher, PPRI, ARC, Egypt.

Cereal Disease Management in Eritrea

Cereal production in Eritrea is hard hit by diseases, particularly rust and leaf blotch fungal pathogens. ICARDA is working with Eritrea's national agricultural research system on a DANIDA-funded project aimed at coming up with an integrated disease management strategy that will contribute to improved production and income. The object is to control cereal diseases and to reduce their spread. One way researchers propose to do that is by providing various control options, including improved use of the traditional practice of mixing varieties.

Cereal landraces in Eritrea

By Amor Yahyaoui

Agriculture in Eritrea is based on smallholder, traditional agriculture characterized by subsistence farming and low productivity levels. Cereal crops account for about 95% of the area cultivated—some 500,000 ha were planted to cereals in Eritrea in 1998 according to the country's Department of Land Resources and Crop Production. Despite the importance of cereals, average production remains very low, less than 1 t/ha.
This low productivity is due to various biotic and abiotic stresses, and production techniques. Diseases are among the main limiting factors.

Because there is a wide range of virulent rust pathotypes, sources of disease resistance in wheat are broken down swifty. And in barley landrace cultivars, a wide spectra of the leaf blotch diseases have evolved to epidemic levels.

To alleviate the impact of cereal diseases, such as the rusts on wheat and the leaf blotch diseases on barley, farmers plant mixtures of wheat and barley seed. The mixtures are known as *hanfetse*, and the practice is common in many cereal producing areas. Disease incidence in both wheat and barley can be reduced, but the potential benefits of the technique are often lost due to inadequate combination of wheat and barley species, particularly with respect to maturity range, plant height, and seed

Above: Cereal cultivation on terraces in highland region in Eritrea

Right: Sources of resistance to yellow rust in new wheat germplasm from the CIMMYT/ICARDA wheat program.

color. The technique could easily be improved.

The inherent variability of cereal diseases in Eritrea requires a broader based, integrated management strategy that enhances durability of disease resistance through an appropriate gene management system, complemented by other control methods, such as cultural practices, safe chemicals, and biological control. Although the research effort over the years has benefited farming communities, crop disease epidemics continue to hit the region. They are costly reminders that disease control efforts must continue. Pathogens have a remarkable capacity to cause widespread damage, evidenced by recurrent stripe rust epidemics in the Middle East throughout much of the 1980s, and in Central Asia in the late 1990s, and

Widespread disease in Eritrea results in serious yield losses.

A delegation from the Office of the Minister of Agriculture, Eritrea, visits the Department of Agricultural Research and Human Resource Development experiment station at Halhale.

yield losses in barley due to leaf blotch. In Eritrea, average annual crop loss of 30% to 60% was observed in the last three cropping seasons in many wheat and barley fields.

A strategy that aims at disease elimination would inadvertently select for more damaging disease strains. So, Eritrea's Department of Agricultural Research and Human Resource Development (DARHRD), ICARDA, the Danish Institute of Agriculture Sciences, and the RISOE National Laboratory, Plant Biology and Biogeochemistry Department are working together to come up with an integrated cereal disease management (ICDM) strategy based on control, rather than complete elimination of predominant diseases. The ICDM approach should reduce the selection pressure of host cereal species and thereby reduce the probability of developing new virulent disease pathotypes. This should also enhance the durability of available crop resistance. The ICDM strategy is a sustainable approach to combating diseases affecting the low-cash-value cereal crops grown in Eritrea.

Danish Development Assistance supports the project, and DARHRD is the direct beneficiary. The enhanced capacity of DARHRD should, in turn, enable the institution to better serve the project's target beneficiaries, small scale, resource-poor farmers, by improving the productivity and sustainability of cereal production systems, and by decreasing the likelihood of production failure.■

Dr Amor Yahyaoui is Senior Cereal Pathologist at ICARDA.

In the Fight Against Viruses, Knowing the Enemy is Half the Battle

In many countries, lack of well-equipped laboratories is a barrier to research and development. Inability to accurately and easily diagnose plant viral diseases, for example, blocks progress in breeding for resistance and results in misapplication of agrochemicals. To address the problem ICARDA has developed virus detection and identification kits and is sharing them with its national partners.

ICARDA's kits take the guesswork out of plant virus detection and identification. Above, a TBIA kit for detection of faba bean necrotic yellows virus, including all the needed reagents and nitrocellulose membrane.

By Khaled Makkouk and Safaa Kumari

Before a problem can be solved, it must be identified. Symptoms of virus infection in cereal and legume crops, however, are often confused with other problems, such as nutritional deficiencies or water logging. ICARDA is helping with a diagnostic kit that lets national agricultural research systems take accurate aim at plant viruses.

Kits for fifteen legume and four cereal viruses are available, each with enough reagents to test 2000 plant samples. They are proving invaluable for plant breeders selecting for virus resistance and are essential for conducting field surveys. In 1994–2001, the kits were used in surveys in Egypt, Ethiopia, Iran, Iraq, Pakistan, Sudan, Syria, Tunisia, Uzbekistan, and Yemen.

Since the kits can detect viruses in sprouted seeds, as well as mature plant tissue, they are also helping to stop the movement of infected seed into unaffected regions.

Blots of thousands of samples on nitrocellulose membrane are received in ICARDA's Virology Laboratory each year for processing.

Kits for the following viruses are available from the Center's Virology Laboratory: alfalfa mosaic virus, barley stripe mosaic virus, barley yellow dwarf virus, barley yellow striate mosaic virus, bean yellow mosaic virus, bean leaf roll virus, beet western yellows virus, broad bean mottle virus, broad bean stain virus, broad bean wilt virus, broad bean true mosaic virus, broad bean yellow band virus, cucumber mosaic virus, faba bean necrotic yellows virus, pea enation mosaic virus, pea early-browning virus, pea seed-borne mosaic virus, soybean dwarf virus, and wheat streak mosaic virus.

The test of choice

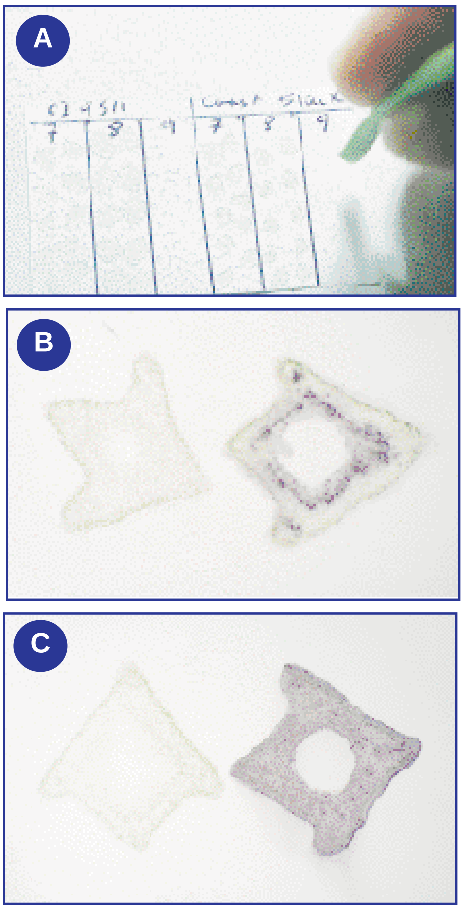
In the past five years, ICARDA has worked hard to adapt and improve tissue-blot immunoassay (TBIA) for the detection and identification of legume and cereal viruses. The relative simplicity of the test makes it the first choice of many laboratories, especially in developing countries.

TBIA is: 1) fast—three hours to complete; 2) sensitive—it can detect

TBIA is completed in five easy steps in about three hours. ICARDA's Virology Laboratory reduced by one hour the time needed to conduct TBIA. They did this by substituting polyvinyl alcohol in place of the standard blocking agents, non-fat dry milk or bovine serum albumin. Polyvinyl alcohol completes the blocking step in one second with no reduction in sensitivity.

1) Cut plant leaf, petiole, stem, or sprouted seedling with a razor blade and immediately blot the cut surface on a nitrocellulose membrane.
   If the plant is infected, then the virus will attach to the tiny pores of the membrane.
2) Soak the membrane in polyvinyl alcohol, for one second.
   This will prevent the antibody reagent, used in Step 3, from attaching to the membrane.
3) Soak the membrane with specific antibody reagent for 45 minutes.
   The specific antibody will attach to the virus on the membrane.
4) Add non-specific antibody conjugated to enzyme (alkaline phosphatase), for 45 minutes.
   The non-specific antibody with enzyme will attach to the specific antibody.
5) Add enzyme substrate.
   Spots on the membrane that contain virus will turn blue.

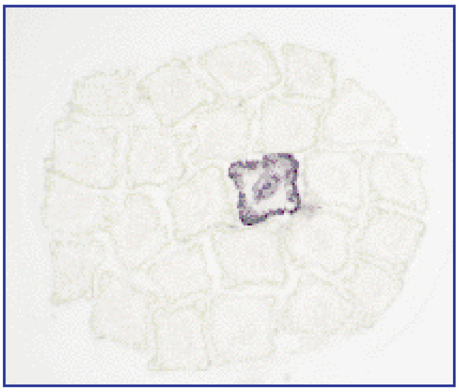
low concentrations of virus; 3) simple—no virus extraction is required, so the laboratory facilities needed are modest; 4) inexpensive; 5) suitable for large-scale surveys—up to 2000 samples can be processed per day to test for the presence of 10-12 viruses; 6) suitable for remote testing—the first step of the test can be done on site and membranes can then be mailed to distant labs for processing; and 7) capable of detecting a wide range of viruses in infected plant tissue (including the phloem) and sprouted seeds.



(A) Freshly cut oat stems are blotted on nitrocellulose membrane. (B) Faba bean necrotic yellows virus detected in faba bean blot (right) by TBIA, as compared to a healthy plant blot (left). (C) Pea seed-borne mosaic virus detected in faba bean blot (right) by TBIA, compared to a healthy plant blot (left). Note, that the virus detected in B is restricted to the phloem. In C, the virus is in the phloem and the surrounding stem tissue, hence the darker positive sample in C. TBIA's ability to detect phloem-limited viruses is an important advantage of the test.

How it Works—Antibodies Key to Virus Detection

When a purified plant virus is injected into a mammal, such as a rabbit, the animal produces an antibody. This antibody can be used to detect the virus in crop plants.



To increase efficiency of TBIA, 10-25 seed sprouts are wrapped together with parafilm membrane and processed as one sample. By this method, used routinely at ICARDA to test incoming and outgoing seeds, it is possible to detect the presence of one or more infected lentil seedlings among the many tested. It is also used to test lentils at flowering stage. Infected plants are eliminated, so only seeds from healthy plants are deposited in the Center's genebank.
Above, a lentil seedling infected with broad bean stain virus is detected among a sample of 25 seedlings.

Purifying viruses for antibody production now takes only days instead of months

Producing purified plant virus in quantities sufficient to induce antibody production in a rabbit can be time consuming and expensive. Until a few years ago it involved growing and infecting plants in a greenhouse and then purifying the virus in a lab. The process took two months.

ICARDA has adopted an alternative approach that takes just two days. To avoid the need for large quantities of purified virus, rabbits are instead inoculated with a protein that coats the virus.

A section of so-called coat protein (supplied initially by BBA in Germany) is placed inside a bacterium. The transformed bacterium facilitates expression of the coat protein, over and over. The resulting protein is then purified and injected in the rabbit.

So far, the Center has used coat protein to produce antibodies for faba bean necrotic yellows virus. ■

Dr Khaled M. Makkouk is Plant Virologist and Dr Safaa G. Kumari is Research Associate in ICARDA's Germplasm Program.

ICARDA Training: An Essential Element for Enhancing Research in Africa

Virtually all of ICARDA's work is done in partnership with scientists working in national agricultural research systems in developing countries. As such, productive and efficient partnerships are essential to the Center's success. For this reason, ICARDA considers human resource development an essential component of its research programs.

By Samir El-Sebae Ahmed

Since its establishment in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) has considered training, capacity building, and networking as essential for institutions and individuals to keep pace academically and professionally with the rapid developments in agricultural sciences, especially in developing countries. ICARDA recognizes that a well-trained cadre of agricultural technicians, scientists, and managers is essential to develop effective and sustainable national agricultural research systems (NARS). The Center has responded to this need for human resource development by working closely with NARS to develop and implement training programs that address their changing needs.

ICARDA's training program is an integral part of its research mandate. It forms an effective means for two-way learning and exchange of knowledge between the Center and NARS. The Center's approach is based on adult-learning methodologies that utilize participants' past experience and allow participants to adapt learning to their own situations. The training courses are highly participatory, and participants are encouraged to share their experience with their colleagues from other programs, thus enriching the overall content of the courses and adding to the knowledge offered by the trainers.

The first training courses were offered during the 1977–1978 cropping season at ICARDA headquarters in Aleppo with a modest number of participants. Thereafter, the number of requested courses, training subjects, and number of training participants increased steadily. The nature of the courses was also diversified. The first in-country training course for ICARDA was held at Hudeiba Research Station in Sudan in January 1981 as part of the Nile Valley Faba Bean Project. Sudanese and Egyptian scientists led that course in partnership with ICARDA scientists. This interaction was very successful and was the basis for a decision to decentralize the Center's training activities. Similarly, due to the fact that training demands are changing, policies directing technical and administrative procedures have also evolved to keep pace.

Mr Tsegaye Habte Kidane from the Ethiopian Agricultural Research Organization works through an assignment during his training at ICARDA on multimedia and audio-visual technology in February-March 2001.

Goal and focus

ICARDA's training activities strive to improve the ability of NARS personnel to implement independent and collaborative research, focused on the rapidly changing needs of their countries or sub-regions. Training helps NARS researchers increase their technical knowledge and skills so they can identify and overcome constraints that limit food and feed production and farm income in their home countries. It also helps them understand the process of technology transfer and the complexity of farmers' decision-making, vis-à-vis the adoption or rejection of new technologies. At the same time, training assists in establishing links between and among NARS scientists and ICARDA, links that will continue to evolve and strengthen over time.

ICARDA focuses its training efforts on relevant, practical, and applicable specialized training courses designed to enhance the Center's research programs, as outlined in its medium-term plan. Courses on general topics and those specific to individual countries are primarily handled by the concerned NARS.

Range of training options

Based on the needs of NARS, the Center offers a range of training options, including long-term group courses, specialized short-term courses, individual non-degree training, and MSc and PhD degree-related studies. In addition, ICARDA organizes courses at the level of the region, sub-region, and individual country, which are usually conducted in close collaboration with NARS. International courses are also organized in collaboration with other international and regional organizations on subjects of mutual interest.

Training at ICARDA changes annually in response to the training priorities of NARS. These priorities are usually presented by national scientists and discussed during the annual national, sub-regional, and regional coordination meetings with NARS, and during regular work visits.

Achievements

To date, more than 10,000 agricultural scientists from about 100 developing and developed countries have been trained at or through ICARDA. Among these trainees were about 500 young scientists who completed degree training toward MSc or PhD degrees, in collaboration between ICARDA and several universities in the developed and developing world.

Traveling workshops are an effective mode of providing training. Here is a delegation of 10 progressive farmers from the International Fund for Agricultural Development-funded project in the White Nile region, Sudan, on a two week traveling workshop to ICARDA headquarters and the Syrian national agricultural research program, November 2001.

In recent years, emphasis has been placed on training in advanced technologies and new research areas, such as geographic information systems and remote sensing, agricultural expert systems, information and knowledge management, scientific writing and data presentation, biotechnology and genetic engineering, crop and livestock biodiversity, and natural resource management.

Several of ICARDA's alumni now occupy leading positions in their respective countries. The Center believes strongly that, regardless of the positions or duties of its trainees today, some will one day become the leaders of their respective NARS and will thus play important roles in enhancing productive interaction with the Center and among the collaborating countries in Africa and beyond.

National Scientists from Africa trained at/through ICARDA during 1978-2001

Region Country	Training Course					
	Headquarters			Non-headquarters		
	Group courses	Individual non-degree	Individual degree (MSc, PhD)**	Regional/sub-regional	In-country	Total
A. NVRSRP*:						
1. Egypt	334	69	11	171	762	1347
2. Ethiopia	97	84	18	50	301	550
3. Eritrea	11	8	4	1	40	64
4. Sudan	121	74	33	44	111	383
Sub-total	563	235	66	266	1214	2344
B. NARP*:						
1 Algeria	141	66	8	-	305	520
2 Libya	110	28	-	49	28	215
3 Mauritania	5	2	-	2	-	9
4 Morocco	161	79	7	163	283	693
5 Tunisia	180	76	8	-	195	459
Sub-total	597	251	23	214	811	1896
C. Others						61
Total	1160	486	89	480	2025	4301

* Nile Valley and Red Sea Regional Program and the North Africa Regional Program, respectively.
** Completed MSc and PhD theses. More candidates are presently conducting degree studies.

Future perspectives

ICARDA will continue to build on its training achievements through continuous consultation with NARS and periodic follow-up studies of its training activities. Greater emphasis is being given to alternative training approaches, such as distance learning and audio-conferencing in collaboration with advanced research and training institutions, and participatory training through "learning by doing" and "training the trainer" approaches. As more NARS trainers are trained, research technician training at ICARDA will be reduced, and the resources shifted toward advanced long-term training in emerging technologies, graduate degree training, and needs-based training of visiting scientists. Emphasis will also be placed on capitalizing on the comparative advantages of ICARDA and the advanced NARS in providing training, and on increasing joint activities with advanced national institutions.■

Dr Samir El-Sebae Ahmed is Head of the Human Resources Development Unit at ICARDA.

Future Harvest Coalition to Help Rebuild Agriculture in Afghanistan

Representatives of the international community began planning how best to restore food security and rebuild the agricultural sector in Afghanistan at a meeting convened by ICARDA recently in Tashkent.

The meeting, supported by the United States Agency for International Development (USAID) and organized by ICARDA's Regional Office for Central Asia and the Caucasus, brought together 74 participants representing 34 organizations, including 10 of the 16 Future Harvest Centers supported by the Consultative Group on International Agricultural Research (CGIAR); non-governmental organizations (NGOs); United Nations agencies; United States institutions; various international agencies; and donors, including the Department for International Development (DFID), U.K.; the International Development Research Centre (IDRC), Canada; USAID, and others. ICARDA Director General Prof. Dr Adel El-Beltagy and USAID Senior Policy Advisor Dr Raymond Morton inaugurated the meeting.

Participants decided to form a Future Harvest Consortium to Rebuild Agriculture in Afghanistan, with ICARDA as the lead Center. The Consortium provides a forum to work together and make the best use of expertise and resources to achieve a rapid impact on rebuilding agriculture in the country.

The immediate aim of the meeting was to develop a work plan for a project on seed systems, and lay a framework for longer-term activities in seeds and crop improvement; soil and water management; livestock, feed, and rangeland improvement; and horticulture.

Another important theme of the meeting was to involve Afghan partners closely to create a sense of ownership, strengthen their capabilities, and ensure that the realities of the Afghanistan situation are reflected in all efforts.

Along with ICARDA, the other Future Harvest Centers represented were: the International Center for Tropical Agriculture (CIAT); International Center for Maize and Wheat Improvement (CIMMYT); International Potato Center (CIP); International Crops Research Institute for the Semi-arid Tropics (ICRISAT); International Food Policy Research Institute (IFPRI); International Livestock Research Institute (ILRI); International Plant Genetic Resources Institute (IPGRI); International Service for National Agricultural Research (ISNAR); and the International Water Management Institute (IWMI).

"Agriculture in Afghanistan is going to need a lot of help," says Prof. Dr Adel El-Beltagy, Director General of ICARDA. "Our mission is to ensure that agricultural reconstruction efforts are based on the best practices science has to offer."

Dr Abdul Rahman Manan, former director of Afghanistan's national agricultural research service, now working on Afghan issues with FAO in Pakistan, says Afghanistan's agriculture is experiencing an unprecedented challenge from the aftermath of the war and three years of extreme drought. "It is not just a matter of repatriating

traditional food crops or providing fertilizers and other agricultural inputs," Manan says. "The country's entire agricultural production system has been disrupted. But with the Consortium's collective scientific expertise and available resources, we can bring significant progress to Afghanistan more quickly."

Agriculture is the largest and most important sector of the economy in Afghanistan, a country of about 22 million people. The Future Harvest Consortium, which has the potential to be the largest-ever seed recovery effort of its kind, will work to replenish damaged seed and irrigation systems to restore critical farming activities, both for near-term requirements and long-term sustainability. The Consortium will provide farmers with seeds to plant for the upcoming spring and fall growing seasons and vaccines to prevent disease in Afghan livestock. The Consortium will also focus on the once-prosperous livestock and horticultural (fruits and vegetables) sectors, as well as land and water management. The nation's important crops include wheat, maize (corn), barley, chickpeas, lentils, carrots, potatoes, melons, apples, and pistachios. According to the Food and Agriculture Organization of the United Nations (FAO), there are 65 million hectares of land in Afghanistan. Of this, about 30 millions hectares are rangeland for livestock and 8 million hectares are cultivated.

Future Harvest (www.futureharvest.org) is a global nonprofit organization that builds awareness and support for food and environmental research for a world with less poverty, a healthier human family, well-nourished children, and a better environment. Future Harvest supports research, promotes partnerships, and sponsors projects that bring the results of research to rural communities, farmers, and families in Africa, Latin America, and Asia. Future Harvest supports the 16 food and environmental research centers that are primarily funded through the Consultative Group on International Agricultural Research (www.cgiar.org).

Targets for sustainable increases in agricultural productivity in Africa will not be met without the application of cutting-edge science. To this end, ICARDA plays a vital role in encouraging advanced research institutions to collaborate in technology development, capacity building, technology transfer, and policy research in Africa. The Center's strategy incorporates participatory, integrated approaches to increase sustainable market-oriented production of crops and livestock in partnership with national program scientists."

—Prof. Dr Adel El-Beltagy
Director General

ICARDA
Caravan
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Review of agriculture in the dry areas

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