# Africa and ICARDA

## Ties That Bind

ICARDA

International Center for Agricultural Research
in the Dry Areas

## About ICARDA and the CGIAR


Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is one of 15 centers supported by the CGIAR. ICARDA's mission is to contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small-ruminant production. In the Central and West Asia and North Africa (CWANA) region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.


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

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

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# Contents

# Foreword

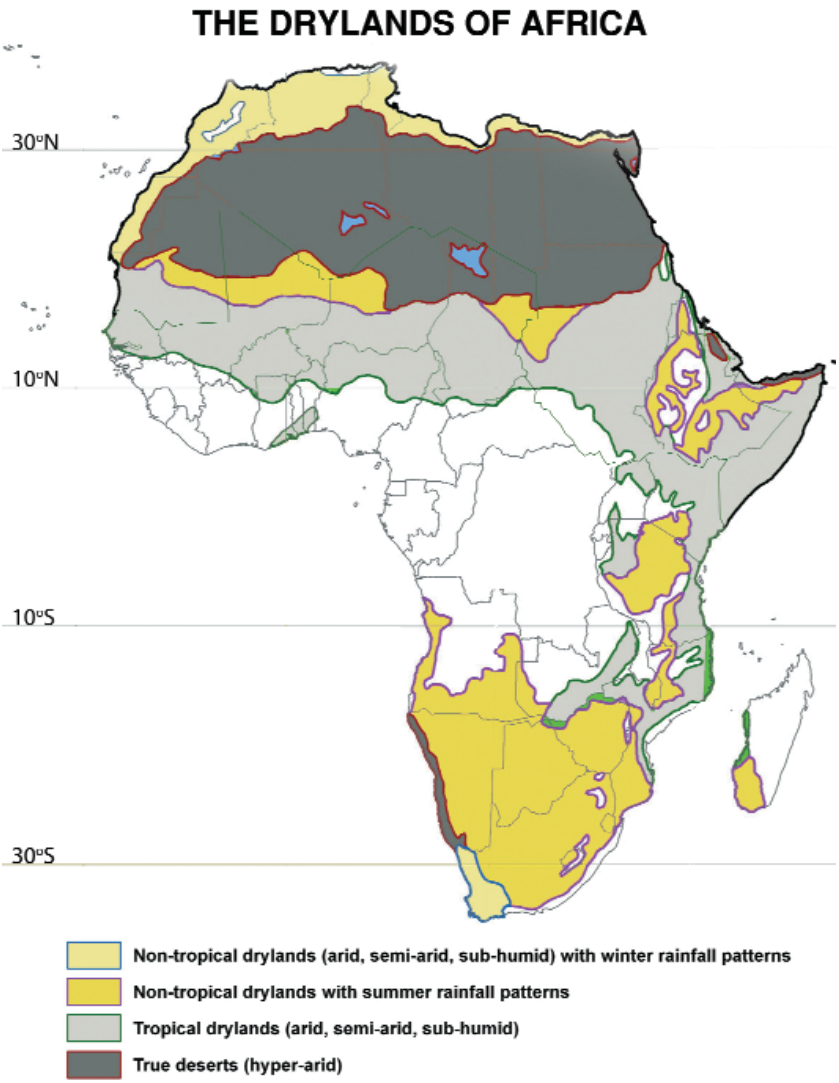
Farmers in Africa's drylands face a number of challenges: low crop and livestock productivity, frequent drought, poor soils, and degradation of the natural resource base. Poverty and food insecurity are widespread, and despite considerable effort, technology penetration is still low. The future is likely to bring even more formidable challenges – the impacts of climate change on agriculture will be felt globally, but drylands in Africa will be particularly affected.

ICARDA's mandate is to develop practical, effective low-cost technologies that will increase productivity in drylands while protecting these fragile ecosystems. Given that most economies in Africa are heavily dependent on agriculture, such technologies are vital. The Center has worked in Africa for three decades, in close partnership with national, regional and international partners. The Center has three regional programs operating in Africa, which help link national research centers with the global scientific comunity. ICARDA's research-for-development agenda aligns closely with the New Partnership for Africa's Development (NEPAD). ICARDA and Africa share the same goals – economic growth, food security and poverty reduction through agriculture-led development.

ICARDA and its partners take a farming systems based approach, aiming to improve crop and livestock productivity, increase water productivity, and diversify production systems and sources of income. The impacts have been substantial and well documented. Improved technologies have been developed and disseminated. Indigenous genetic resources are being conserved, documented and utilized. Training programs have strengthened capacity among national researchers, extension staff and farmers. Perhaps most important, community-led participatory research approaches are being institutionalized, empowering rural communities.

ICARDA remains firmly committed to sustainable development in Africa, and to building and strengthening partnerships to achieve this goal.

**Mahmoud Solh**
**Director General, ICARDA**




Source: World atlas of desertification, 2nd ed. United Nations Environment Program, 1994

# Fighting Poverty in Africa

## *A focus on the rural poor in drylands*

The African drylands, excluding deserts, are home to 268 million people, or 40% of the continent's population, and make up 43% of the continent's surface area. Throughout the dry areas of Africa, food demand is outstripping production, due to rapid population growth and limited arable land (Table 1). For example, The projected trends for cereal imports in Sub-Saharan Africa, where there are extensive drylands, are alarming (Fig 1).

**Climate change**
The threat to the dry areas in Africa from climate change is particularly acute. North Africa and Sub-Saharan Africa are already among the world's most water-scarce regions. Climate change models predict that northern and southern Africa will become even hotter and drier. The technology and management options that ICARDA is developing will be crucial in helping people in these areas adapt to climate change.

**Migration**
Poverty, unemployment, limited livelihood opportunities, and population growth are driving migration from rural areas to towns and cities. Emigration to developed countries is already pervasive, for example from North and Sub-Saharan Africa to the European Union. ICARDA's work to diversify rural livelihoods opens up opportunities that help stem the exodus from drylands.

**Conflict**
Poverty, food insecurity, poor land tenure systems, and lack of rights to natural resources often lead to conflict. Conflicts damage or destroy crops, biodiversity and seed systems, and have long-term negative effects on the environment. ICARDA's work for better management of natural resources and pro-poor policies can help reduce conflict.

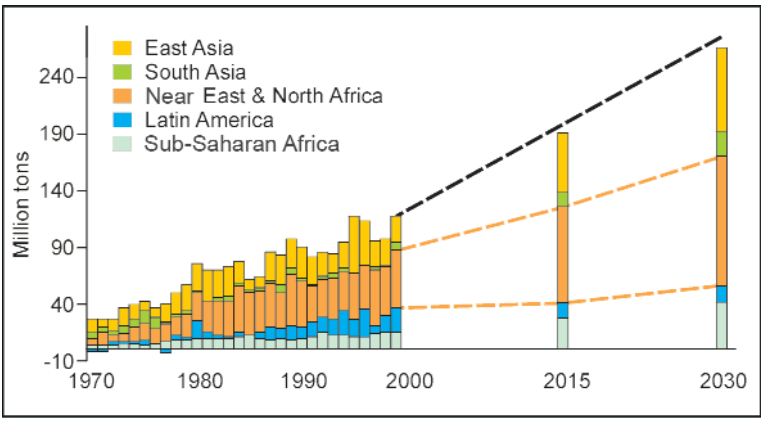
**Helping the rural poor escape the poverty trap**
These converging trends – water scarcity, land degradation, population growth, climate change, conflict – exacerbate the challenges found in the dry areas. Each adds to the growing uncertainties faced

by the rural poor who depend almost entirely on natural resources. ICARDA's integrated approaches, which fully involve communities and other stakeholders, help release the poor from the poverty trap. Research priorities have evolved from an emphasis on quantity towards quality, cash crops, processing and market orientation.

**Table 1. Land area, population, and population growth in dry regions in Africa** (Source: FAOSTAT 2006)

| Region | Land area (million ha) | Arable land 2005 (%) | Pop. 2006 (millions) | Projected pop. 2030 (millions) |
|---|---|---|---|---|
| North Africa | 838 | 5 | 192 | 270 |
| Sub-Saharan Africa | 2156 | 8 | 768 | 1193 |

**Figure 1. Cereal imports by developing regions, 1970-2030** (Source: FAO)




**Putting the poor first**

Research approaches have also changed. ICARDA has been particularly successful in developing participatory and community-based approaches to incorporate users' perspectives. This not only increases the efficiency and effectiveness of agricultural research, but delivers what farmers want. Development of integrated crop-livestock production systems in the low-rainfall areas of West Asia and North Africa has

shown the importance of the community approach in the sustainable management of collective property resources, such as rangelands and water. This approach has been widely adopted by national programs in dry areas.

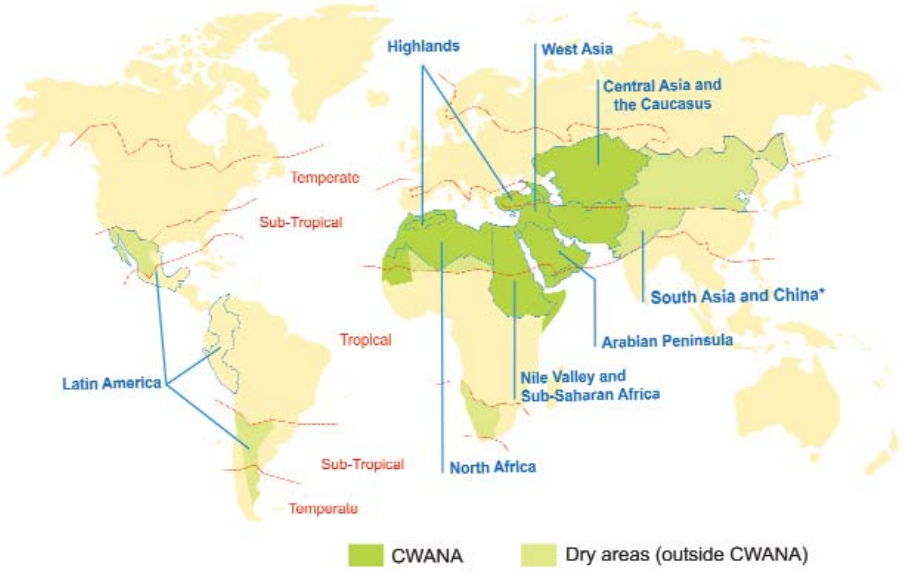
*Scientists work with communities and national research and extension partners in Africa to strengthen farming system productivity and improve livelihoods.*

## *ICARDA's regional programs in Africa*

ICARDA has long-standing outreach programs in North Africa, the Nile Valley, and the Red Sea region (Fig 2). In its current strategic plan, the Center will extend its work to the drylands of Sub-Saharan Africa.

**Nile Valley and Sub-Saharan Africa Regional Program**
The Nile Valley and Sub-Saharan Africa Regional Program covers Egypt, Eritrea, Ethiopia, Sudan and Yemen. The five countries have a total population of over 165 million, and some of the highest population growth rates in the world. With the exception of Egypt, they are some of the poorest countries in the world. Agriculture contributes over 40% of gross domestic product in Ethiopia and Sudan.

**Figure 2. ICARDA outreach programs cover dry areas worldwide**




This was ICARDA's first outreach program, launched in 1979 as the Nile Valley Project, covering Egypt and Sudan. It expanded to include Ethiopia in 1989 and Yemen and Eritrea in 1995. The Program has made substantial impact, raising agricultural productivity , improving management of natural resources, and building national research capacity (Box 1). It is also playing an important role in regional efforts to address the two biggest challenges to agriculture: water scarcity and climate change.

**North Africa Regional Program**

ICARDA has been active in the Maghreb since 1977. The North Africa Regional Program covers Algeria, Libya, Mauritania, Morocco and Tunisia. Although these countries have similar climatic conditions, they include varied agroecologies: Mediterranean, arid, semi-arid and desert. The program started out by testing crop technologies at research stations and demonstrating them in farmers' fields. Over time, the approach became more participatory, fully involving the community, and taking into account not only technical issues but also socio-economic, institutional, and policy factors.

Joint research (Box 2) to strengthen the capacity of national agricultural research systems has been an integral part of the program. Regional networks and meetings have fostered exchange of experience between countries, and many scientists and technicians have been trained at ICARDA.

**Highlands Regional Program**

The Highlands Regional Program was established in 1990 to serve the special needs of highland environments in Afghanistan, Iran, Pakistan, Turkey, and the Atlas Mountains of Algeria and Morocco. Productivity in these mountain areas is low and rural poverty widespread. The farming communities are often extremely poor. Farmers subsist mainly on drought-resistant crops such as barley, fruits and vegetables, and flocks of small ruminants that graze mountain pastures in summer. Because slopes are steep, water run-off and soil erosion are major problems, especially in areas degraded by overgrazing.

ICARDA's focus is on inter-disciplinary research involving various institutions and national partners. This has led to new methods of participatory community development, and effective technology development and transfer.

*New technologies developed by ICARDA and its partners are tailored to the needs of small-scale farmers with limited resources.*

**Box 1. Nile Valley and Sub-Saharan Africa Regional Program**

**Achievements**

- Since 1993, 42 improved varieties of wheat, barley, faba bean, lentil and chickpea released for cultivation by national agricultural research systems
- Improved production packages demonstrated to farmers
- Adoption of improved wheat technology increased wheat yields by up to 33% in Egypt and 46% in Sudan
- Leaf rust resistance genes identified and incorporated into high-yielding but susceptible wheat cultivars
- Races of wilt and root-rot diseases in food legume crops identified and resistant sources shared
- Heat- and drought-tolerant varieties of food legumes developed
- Farmers in Yemen adopting new technologies developed on national research stations and tested on farmers' fields

**Current research**

- Development of germplasm tolerant to major biotic and abiotic stresses
- Natural resource management
  - Options for crop rotation, crop management and irrigation in Egypt
  - Options for crop rotation, soil moisture conservation, water-shed management, water harvesting, soil conservation, rangeland rehabilitation and crop-livestock integration in rainfed areas
  - Management of traditional terrace cultivation systems in Yemen

**Future directions**

- Crop improvement and control of biotic stresses (diseases, viruses, insect pests) through integrated pest management
- Options for combating abiotic stresses, especially drought and salinity
- Natural resource management

**Box 2. North Africa Regional Program**

**Achievements**

- Improved varieties of wheat, barley and winter chickpea widely adopted, e.g. improved barley varieties now grown on 40% of cultivated area in Morocco, increasing productivity by 35%
- Improved varieties outyield local lines by 20% to 50%
- Water productivity in rainfed areas increased by 40% through supplemental irrigation
- Animal nutrition improved: several fodder species successfully introduced (*Lathyrus*, vetch, oat, *Acacia*, *Atriplex*, spineless cactus), feed block technology widely adopted
- Participatory community approach institutionalized in national R&D programs

**Current research**

- Conservation and promotion of aromatic and medicinal plants in Morocco and Tunisia
- Assessment of mountain products and market chains in Algeria, Morocco and Tunisia
- New low-cost technologies for durum wheat (varieties, seeds, conservation agriculture, value-added products)
- Assessment of livelihoods of agro-pastoral communities in Maghreb countries
- Participatory research on water and soil conservation, rangeland and livestock management, Mauritania
- IPM, natural resources management in Morocco and Libya
- Water benchmark project: improved water-use efficiency and management in Algeria, Egypt, Libya, Morocco, Sudan and Tunisia

**Future directions**

- Improving adaptation of rural communities to climate change and other global challenges: drought risk mitigation, small ruminant management, crop and resource management
- Conservation agriculture
- Watershed management

## Improving Agricultural Production

ICARDA's work to improve agricultural productivity in the drylands of Africa focuses on low-cost technologies to help the rural poor raise yields of wheat, barley, maize, and food and forage legumes. To do this, scientists are developing improved varieties and cultivation methods that will give better yields in the face of climate change, heat, drought, pests and diseases.

### *Heat and drought resistant varieties*

**New lentil varieties in Ethiopia**

Lentil is an important food and cash crop in Ethiopia, widely consumed and sold on both domestic and export markets. Ethiopia is one of the world's major producers, and the largest in Africa. However, average lentil yields in Ethiopia are only half the world average. ICARDA's research is helping to change this.

Farmers now grow improved varieties developed by ICARDA and national partners over one-sixth of Ethiopia's lentil-growing regions. The improved varieties produce up to five times the average yield of other Ethiopian varieties and over twice the global average yield.

*The lentil variety Alemaya has dramatically improved food security as well as incomes for smallholder farmers in Ethiopia.*

**Box 3. Improved lentil varieties for Ethiopia**

- Improved varieties produce two to five times as much as local cultivars
- Nine improved varieties – seven from ICARDA – are now grown on one-sixth of the country's lentil area (over 15,000 hectares out of a total of 90,000 hectares)
- Farmers' income from lentils is now US$1200 per hectare

**New varieties**

- Adaa and Alemaya – popular with farmers, consumers and processors
- Assano – exclusively for export
- AlemTina and Teshale – high, stable yields, attractive to both domestic and export markets

Farmers and processors are making higher profits while flourishing lentil mills mean more rural employment, and knock-on effects on local businesses. The improved varieties Adaa and Alemaya fetch US$400-500 per ton from traders, compared with US$250-350 per ton for local cultivars. They are popular with consumers. Millers also like the improved varieties because the recovery percentage is high compared with traditional cultivars, and the milled grain fetches higher prices. Rural youths benefit because the 35-40 lentil processing mills northeast of Addis Ababa provide jobs. The milling industry also stimulates local businesses.

The widespread adoption of the new varieties is largely due to the efforts that ICARDA and national research and extension services make to reach lentil farmers: distributing seed, holding demonstrations and field days, and putting out extension bulletins.

**Low-toxin grasspea fights neurolathyrism in Ethiopia**

Grasspea (*Lathyrus sativus*) is a hardy legume crop that tolerates drought, waterlogging, and poor soils. Because it thrives in such poor conditions, and needs little fertilizer or pesticide, it is widely grown by the rural poor in Ethiopia as a staple food, as fodder for livestock, and as a cash crop. But grasspea seed contains a toxin, called ß-N-oxalyl-a,b-diamino propionic acid (ß-ODAP), that causes lathyrism, an irreversible paralysis of the lower limbs that particularly affects young

men. Synthesis of ß-ODAP in plants is genetically controlled. ICARDA and Ethiopian scientists have developed low-toxin varieties that have no ill effects. The health, economic and social benefits to rural communities will be far reaching.

Grasspea farmers are among the poorest in Ethiopia, with very small farms averaging between 1.26 and 2.21 hectares. They grow grasspea because, unlike many staple crops, it is hardy and seldom fails. What their families or livestock do not consume is sold in local markets or to traders. Even though they are aware of the danger of lathyrism, and even though governments discourage grasspea, farmers are reluctant to abandon it because it is the most reliable crop for their circumstances. Grasspea is grown on an estimated 100,000 plus hectares in Ethiopia.

Waise, a low-toxin grasspea released by ICARDA and the Ethiopian Institute for Agricultural Research in 2005, produces 50% more than local cultivars (1.3 tons versus 0.9 tons per hectare). Farmers have been quick to adopt Waise not only to avoid the danger of lathyrism, but also because it is good to eat and requires no change in farming practices. Large-scale seed multiplication and distribution is underway to spread Waise as widely as possible.

*New crop varieties with higher, more stable yields are helping to reduce food shortages in Sub-Saharan Africa.*

**Eritrean farmers help breed improved varieties**

A distinguishing feature of ICARDA's approach to developing improved varieties tailored to farmers' needs is participatory plant breeding. Farmers' intimate knowledge of local cultivars and the characteristics of their land are important in developing new varieties that suit their particular environments and end uses. ICARDA works with farmers from the outset to find out which crop traits are important to them, and to plan and implement trials. Farmers grow and test promising lines in their own fields. Then, they select those they prefer, not only for how well they grow, but also for how well they cook and how good they taste.

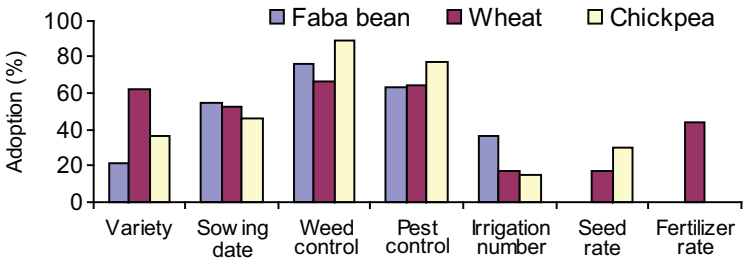
Farmers often have a limited range of varieties to choose from. In Eritrea, farmers have traditionally overcome this by looking beyond their villages for different cultivars and bringing back a few seeds to experiment with. Several local cultivars originated in this way. Even so, the range of germplasm within their reach is limited. ICARDA has been able to help by providing farmers with promising varieties from its own collection to test. From these they select those that adapt well to local conditions for further development.

Farmers really appreciate this involvement in selecting and naming new varieties. They promote the improved varieties in their communities, and produce seed for themselves and others. Not only do they adopt the technologies, they also keep experimenting to improve them. This makes developing improved varieties adapted to specific environmental conditions and consumer preferences much quicker and more efficient than traditional plant breeding.

**Adoption of improved varieties in Sudan**

Major food crops in northern Sudan are faba bean, chickpea and wheat. But all these are susceptible to heat, drought, pests and diseases, which mean that yields are poor and erratic. So food imports are rising. Improved varieties and better ways of growing them can boost yields, secure household food supplies, and raise incomes. Nevertheless, many farmers do not adopt the new varieties even when they know about them. If the constraints to adoption can be overcome then new technology packages could make a big difference to farmers' incomes and food security.

**Figure 3. Adoption rates for faba bean, wheat and chickpea technologies in northern Sudan**




Funded by the International Fund for Agricultural Development, ICARDA and national partners in Sudan studied what effect packages of improved varieties and cultivation technologies to raise production can have on yields, household food security, and incomes (Fig 3), and why not all farmers adopt them.

**Table 2. Average net returns and per capita incomes of adopters and non-adopters of faba bean, wheat and chickpea technologies in northern Sudan**

| | Adopters | Non-adopters | Difference |
|---|---|---|---|
| **Faba bean** | | | |
| Average net return, US$/ha | 369 | 293 | 103 |
| Gini coefficient* | 0.42 | 0.47 | |
| Average costs, US$/ha | 220 | 182 | 38 |
| Per capita income, US$/year | 627 | 540 | 87 |
| **Wheat** | | | |
| Average net return, US$/ha | 510 | 134 | 376 |
| Gini coefficient* | 0.58 | 0.63 | |
| Average costs, US$/ha | 556 | 510 | 46 |
| Per capita income, US$/year | 537 | 468 | 69 |
| **Chickpea** | | | |
| Average net return, US$/ha | 496 | 286 | 210 |
| Gini coefficient* | 0.68 | 0.73 | |
| Average costs, US$/ha | 429 | 397 | 32 |

* Gini coefficient measures income equality: 0 = everyone in the group has the same income; 1 = one person has all the income.

They found that farmers in the study area were well aware of the technology packages. Overall, the farmers who did adopt improved varieties of faba bean, chickpea and wheat raised their incomes, were more food secure and less poor than the non-adopters (Table 2).

However, many farmers could not get seed of the improved varieties or credit for the necessary inputs to grow them. Some of the farmers who did try the packages did not have adequate knowledge to get good yields each year. If difficulties such as these can be overcome then the technology packages could make more of a difference to farmers' incomes and food security in northern Sudan.

## *Pest and disease management*

**Preventing the spread of stem rust**

Stem rust, a devastating disease that destroys wheat could, until recently, be controlled by growing resistant varieties. But, in 1998, scientists discovered a virulent new strain in Uganda, now known as Ug99. This is rampaging through varieties of wheat that have resisted other strains of stem rust. Over the past few years, Ug99 has infected crops in North and East Africa and, in 2006, it was found in Yemen.

Most of the world's commercial wheat varieties are susceptible to the new strain. National agricultural research systems, ICARDA, CIMMYT, FAO, Cornell University and other advanced research centers are working together to develop varieties resistant to Ug99 and other virulent strains that might develop, and to put in place an early warning system. Once alerted to imminent outbreaks farmers can take measures to protect their wheat crops.

***Promising varieties and breeding lines selected.*** Countries at risk need breeding materials to develop wheat varieties resistant to stem rust, as well as crop management methods that prevent or minimize losses. The ICARDA-CIMMYT Wheat Improvement Program (Box 4) has kept yellow rust under control for the last two decades in West Asia. Now researchers are working to identify varieties and potential breeding lines resistant to Ug99 for East Africa and the Red Sea region. To do this they tested accessions from Egypt, Iran, Pakistan, and Turkey, as well as breeding lines from ICARDA, to assess their resistance under field conditions in Kenya and Ethiopia, where Ug99 has been found.

Promising levels of resistance were found in 2% of the Egyptian accessions tested, in 2-16% of the wheat varieties from Iran, Pakistan and Turkey, and in 5% of the lines from the ICARDA breeding program.

***Trap nurseries in rust hot spots.*** The wheat varieties that showed most resistance were planted in biological trap nurseries in rust hot spots in Uganda, Kenya, Ethiopia, Eritrea, and Yemen. National scientists are monitoring stem rust pathogens in the nurseries to see which are present in particular hotspots and which varieties are most resistant in each location.

***Mapping the pathways.*** ICARDA, advanced research institutions, international organizations and national agricultural research system partners are collaborating to map the routes by which the stem rust spores spread. Plotting the distribution of infections shows that Ug99 is likely to follow the same route from East Africa to Yemen as the yellow rust outbreak in the 1980s. Winds could also easily carry stem rust spores towards the Mediterranean, to the Nile Delta in Egypt, and to North Africa.

*Wheat trials at Debre Zeit research station in Ethiopia: identifying sources of resistance to the stem rust fungus Ug99.*

**Box 4. ICARDA-CIMMYT collaboration in North Africa**

ICARDA and CIMMYT share the mandate for wheat improvement research in North Africa. The two centers have a long-standing partnership, formalized in 2005 through the ICARDA-CIMMYT Wheat Improvement Program hosted at ICARDA. Collaboration includes the Borlaug Global Rust Initiative launched in response to the Ug99 threat.

***Early warning system.*** The maps showing how stem rust spreads will help partners set up an early warning system similar to those developed for locust monitoring. Researchers will also be able to advise farmers which varieties are resistant in their particular area – reducing losses and also slowing down the spread of stem rust to new areas.

**Combating viruses in cereals and legumes**

Virus diseases severely affect cereals and legumes in many African countries. Quick, effective ways of diagnosing viruses help countries combat infections. Low-cost integrated management can cut viruses in chickpea and faba bean significantly.

***Free virus diagnostic kits for African laboratories.*** Over the last two decades, ICARDA's virologists and national scientists have identified the main plant viruses in the major production areas in Egypt, Eritrea, Ethiopia, Sudan and Tunisia. The most damaging virus in cereals was barley yellow dwarf virus. In legumes, several viruses are importsnt: faba bean necrotic yellows virus, bean leafroll virus, bean yellow mosaic virus, broad bean mottle virus, pea seed-borne mosaic virus, beet western yellows virus, chickpea chlorotic dwarf virus, chickpea chlorotic stunt virus and soybean dwarf virus; and faba bean necrotic yellows virus is the worst. In Africa, especially in Middle Egypt and the Cap Bon region of Tunisia, it can reach epidemic proportions, causing considerable losses and even wiping out the entire crop.

Using free diagnostic kits provided by ICARDA, national laboratories in Algeria, Egypt, Eritrea, Ethiopia, Morocco, Sudan and Tunisia can now monitor viruses in crops and seed themselves. Where there are no national laboratories ICARDA offers a tissue-blot immunoassay service. National research centers send thousands of blots to ICARDA for testing every year.

***Managing legume viruses in Sudan and Egypt.*** In central and northern Sudan, chickpea stunt caused by chickpea chlorotic dwarf virus often leads to huge crop losses. ICARDA and researchers at the Agricultural Research Corporation tested two resistant cultivars, Shendi and ICCV-2, and two different methods of cultivation, sowing seed at different times, and irrigating under different regimes. Shendi was more resistant to virus infection than ICCV-2 regardless of the date of sowing. Later sowing reduced the incidence of the virus, as did irrigation. Sowing resistant cultivars later and irrigating frequently proved extremely effective in managing virus diseases.

In Egypt, Faba bean necrotic yellows virus is a major problem in Egypt. During the mild winters, aphids carry viruses from summer legumes and the leguminous weeds along irrigation canals to over-wintering faba beans sown in September. As there are no varieties resistant to faba bean necrotic yellows virus, ICARDA and national scientists experimented with integrated management methods. For example, planting beans later, uprooting plants that showed signs of infection, spraying twice with a systemic aphicide once the seedlings had emerged and close planting reduced virus infections from 70-80% to just 5-10%.

**Parasitic weeds in North and East Africa**

Parasitic weeds reduce crop yields or even totally destroy the crop. Again, integrated management successfully eliminates almost all parasitic weeds, boosting yields considerably.

Broomrapes (*Orobanche* spp.) are amongst the world's worst crop weeds. They are parasitic plants that grow on the roots of food legumes and rob them of nutrients and water. Once established, broomrape is extremely difficult to eradicate and is spreading rapidly in North and East Africa. ICARDA, together with national research systems and international organizations, is developing ways of controlling broomrape. The most cost-effective and sustainable way is to develop broomrape-resistant cultivars. Scientists have developed a gene pool of 13 germplasm accessions and 27 F4 lines to breed faba bean varieties resistant or tolerant to broomrape.

Integrated management (late sowing, crop rotation, and intercropping for example), is a low-cost way of dealing with broomrape. Flax and fenugreek intercropped with faba bean reduce broomrape. Late

sowing produces higher yields of beans even with severe infestations. Herbicides, such as foliar sprays of glyphospate when beans begin to flower, are 97-100% effective and boost yields by 34-124%.

Weeding by hand, adding soil nutrients, fumigating the soil, herbicides, trap and catch crops, and biological control also proved effective. Soil solarization works very well in eliminating broomrape and most other weeds from tomato crops.

*Orobanche or broomrape is spreading rapidly. ICARDA and national partners have developed resistant genepools and populations, as well as integrated management packages.*

## Managing soilborne diseases

Cool-season food legumes (faba bean, lentil, chickpea, field pea, grass pea) are important crops, and major sources of dietary protein, in both North and East Africa. They are particularly important in the Nile Valley region. However, yields are low and highly variable. One major problem is soilborne diseases, notably wilt and several types of root rot, which can cause up to 100% yield loss, depending on infestation levels, relative humidity, soil moisture and soil temperature. ICARDA and national research centers in Egypt, Ethiopia and Sudan worked together on a targeted research program that has made major advances in controlling soilborne diseases.

Surveys were conducted to map the extent and severity of the problem. Fusarium wilt, caused by two subspecies of *Fusarium oxysporum*, was a major constraint to chickpea and lentil production in all three countries. Black root rot, caused by a different species (*F. solani*), was a major problem in faba bean in all three countries. Sclerotinia stem rot of chickpea was a major problem in Egypt, but not in Ethiopia and Sudan. Dry root rot was widespread in both chickpea and lentil in Ethiopia and Sudan.

Improved germplasm was identified at ICARDA, and distributed through the Center's international nurseries program. National research centers directly selected promising lines from the nurseries, or used them as raw material in their breeding programs. An extensive screening program helped select and test lines with resistance to soilborne diseases, as well as other desirable attributes. Other studies focused on identifying pathogen races, biocontrol methods, and integrated disease management packages. Responsibilities were shared across countries. Ethiopia was responsible for coordinating resistance screening. Sudan led the work on disease management, while Egypt took the lead in biocontrol, chemical screening, and race identification.

Four biocontrol agents were found to successfully control wilt as well as root rots under greenhouse conditions. *Trichoderma harzianum* was the most effective on faba bean, lentil, and lupin, with the highest number of surviving plants and the lowest disease severity; *Pacellomyces farinasus* was the most effective biocontrol agent on chickpea.

Several varieties of lentil, chickpea and faba bean have been developed, that combine resistance to multiple fungal and foliar diseases with high yield potential, and other characteristics such as tolerance to waterlogging and suitability for specific cropping systems.

- Three wilt-resistant chickpea varieties have been released in Ethiopia: Shasho, Arerti and ICC 12442. In Egypt, two varieties (ICCX 8500498-P-PBN-SH and Giza 88) have proved resistant to eight different isolates of the fungus *Sclerotinia sclerotiorum*.

- Several lentil genotypes are resistant/tolerant to fusarium wilt in all three countries. These include Adaa, released in Ethiopia, HC-972, F 130 and SPS ILL 669. Other lines such as FLIP 84-43L, 81515 and 78596013 are resistant to the disease in Egypt.
- Four faba bean varieties have been released, with good levels of disease resistance: Moti, Gebelcho, Obsie and Walki.

ICARDA is helping to facilitate seed production of the new varieties, by providing technical support and training for farmer groups, extension staff and small-scale seed entrepreneurs.

*Lentil genotypes resistant to wilt/root rot complex: field trials in Ethiopia, 2008*

## Better Management of Natural Resources

Improved varieties make a huge difference to yields. But improved varieties are only part of boosting agricultural production. Integrated approaches are especially relevant to the crop-livestock production systems that prevail over much of the African drylands. Here, better farming practices, and better management of collective rangelands and water, are vital to reduce poverty.

### *Land and water management*

**Integrated land and water management in Bedouin communities in Egypt**

The Matrouh Resource Management Project in Egypt is a fine example of ICARDA's holistic inter-disciplinary approaches to research and development. Bedouin communities fully participated in bottom-up planning for watershed, farm, and community development of natural resources to reduce poverty

**Whole-watershed management alleviates poverty**

The five-year Matrouh Resource Management Project (1996-2001), covers 20,000 $km^2$ in northwest Egypt. The critical constraint to livelihoods and environmental sustainability in this region is scarcity of water. Communities were introduced to integrated watershed management as a tool to manage and conserve resources sustainably and equitably. Topographic, soil and catchment surveys, and hydrological studies were completed for 64 watersheds. Thirty-eight communities benefited from community action to manage these watersheds (Box 5). This holistic, inter-disciplinary approach is helping to alleviate poverty, arrest degradation and conserve natural resources.

**Soil and water conservation in Mauritania**

The agro-pastoral systems of the Sahel of Mauritania are severely degraded due to overgrazing, inappropriate cultivation, water and wind erosion, and recurrent droughts. The result is desertification, and low and erratic productivity of rangeland and livestock. To reduce soil erosion and runoff, and to increase food and feed production, ICARDA and national partners ran a pilot program on participatory integrated natural resources management at Kiffa East, 600 km from Nouakchott. The communities tested ways of conserving soil and

**Box 5. Whole watershed management in northwest Egypt**

**Productivity**
- Production increased by 60% in fig and olive, 27% in vegetables
- Productivity increased by 91%, net income by 52% (10-year weighted average)
- Investments in water harvesting structures yielded annual returns above 300%

**Crops**
- 40% of farmers increased barley yields by 70-100%
- 93% of adopters increased productivity, 70% increased yields by 25%
- 63% of horticulture producers benefited from one or more components of the technology package
- 300 farmers (one-third) expanded their orchards by 5 feddan* on average

**Rangeland**
- 67% of farmers benefited directly or indirectly from range improvement
- 7.27 million fodder shrubs planted on 18,000 feddan, 1800 feddan of degraded rangelands reseeded
- 40% of beneficiaries saved on average 37% on feed costs
- One-fifth of farmers began rotating crops, 16% now intercrop fodder shrubs with barley

**Soil erosion**
- Vegetation cover improved, soil losses reduced on 2260 feddan
- 69 km of windbreaks planted to fight wind erosion
- Check dams controlled gully and channel erosion, and harvested enough water to irrigate 830 feddan

**Health**
- Water harvesting improved water supplies for 6000 households
- 3620 illiterate girls educated
- Thousands of women more aware of environmental, nutritional, and health issues

* 1 feddan = approximately 0.42 ha

*Many dryland areas in Africa are prone to severe rainstorms, which accelerate soil loss, degradation and desertification.*

water, and producing new fodder and rangeland species. The results were very positive and the work is expanding to five other agro-pastoral communities in the Sahel.

**Participatory integrated natural resources management**

Informal groups for water and soil conservation were set up and farmers and technicians were given hands-on training in building small dams, dikes, stone contour ridges, semi-circular bunds, terraces and runoff strips. After a year, the effects of the conservation techniques were significant (Box 6).

**Box 6. Participatory soil and water management in Mauritania**

- Contour ridges captured 14 cm of soil (2.5 $m^3$) per meter length per year
- Bunds and terraces retained 60% of the runoff during the first year
- A small dam retained 45,000 $m^3$ in one season, enough to irrigate 6 ha
- Runoff strips 230 m long by 1.2 m high saved 15,000-30,000 $m^3$ of water, enough to irrigate 2.5 ha
- Around 60,000 to 80,000 $m^3$ per year harvested and used

*CNRADA Ten Souilem nursery in Mauritania, where seedlings are multiplied for distribution to farmers. ICARDA has helped introduce over 70 forage, pasture and food species to help diversify livelihoods in North Africa.*

The communities also tested 72 new fodder and rangeland species. They grew 11,000 plants in nurseries. Eight fodder shrubs, eleven legumes and six grasses proved good candidates for improving pastures in the Sahel of Mauritania.

## *Rangeland management*

**More productive rangelands in Morocco and Tunisia**
Overgrazing has led to serious rangeland degradation in North Africa. To stem the degradation, ICARDA and national partners in Morocco and Tunisia designed alley cropping systems that provide more and better fodder and reduce overgrazing.

**More feed for livestock, less soil erosion**
ICARDA scientists and national partners introduced alley cropping on marginal lands in Morocco and Tunisia through an adaptive research project. This combined research on natural resources management with research on integrated crop-livestock production. The aim was to make more fodder available for small ruminants in the dry season. More forage means that livestock do not graze the rangelands so heavily and there is less soil erosion.

*Low-cost contour ridges have proved remarkably effective in fighting erosion and improving soil moisture in several countries in North Africa.*

Communities planted rows of saltbush in Morocco and rows of spineless cactus in Tunisia, in between cereal or pasture crops. Both shrubs thrive in difficult dryland areas and prevent soil erosion (Box 7).

Unlike in favorable environments, adoption of new technologies in marginal lands is often low because of the variability of returns to farmers, and institutional constraints such as land tenure. In this project, subsidies encouraged the adoption of new technologies. In Morocco, subsidies increased the area planted to saltbush by 79%. The area planted to saltbush increased by 6% annually between 1999 and 2004.

**Box 7. Saltbush and spineless cactus stem land degradation**

- Saltbush controls soil erosion and improves soil organic matter
- Spineless cactus increases biomass on natural rangelands, acts as a wind-break, increases soil moisture, and also shelters seeds of valuable native species

**Sustainable management of pastoral resources in Mauritania**
Pastoral codes are a solution to degradation of rangelands as flocks grow and overgrazing becomes severe. In Mauritania ICARDA and national researchers have studied how well the Pastoral Code, passed by decree in 2004, is working in the communities of Moït and Bokoul in the Monguel area (Gorgol region). Using participatory approaches the project team is defining the parties involved and their respective roles, determining the relationship between the Code and decentralization, and studying potential areas of conflict and bottlenecks that may emerge when the Code is applied.

**Building lives, saving lands – the Oasis project**
Africa has an enormous amount of marginal land, much of which is being degraded and even abandoned. African countries with extensive drylands are co-signatories to the United Nations Convention to Combat Desertification (UNCCD) and, with the assistance of the UNCCD's Global Mechanism, are preparing National Action Plans to invest in drylands.

ICARDA is a lead partner in the CGIAR Oasis consortium set up to fight widespread poverty, land degradation, and human suffering through more sustainable and productive agriculture in drylands.

*Spineless cactus is now grown in home gardens in Morocco and Tunisia, providing food for poor households as well as fodder for their animals.*

The Oasis consortium draws on expertise from ICARDA, ICRISAT, CIRAD, IRD, the European Commission for Agricultural Research in the Tropics, European DesertNet, the Institute for Environment and Sustainability of the Joint Research Centre of the European Commission, and the Sahel-Sahara Observatory.

Oasis considers land degradation and desertification as an under-development problem rather than a biophysical problem. Secure livelihoods and environmental protection can only be achieved by addressing both at the same time. The first Oasis project in Africa, sponsored by USAID, got underway in Morocco in 2007 and will address both livelihoods and the environment. Oasis is teaming up with the Desert Margins Program – already operating in several African countries – to improve the productivity and resilience of smallholder farming systems.

Key thrusts of Oasis are to understand and overcome key policy, market, land tenure and institutional issues that aggravate land degradation; to identify appropriate, adoptable, pro-poor development pathways, investment opportunities and livelihood options that lead to more sustainable, diverse, remunerative, and resilient dryland management; and to up-scale successful interventions so that large numbers of resource-poor rural people benefit.

## Better Cropping Systems for Improved Livelihoods

Ultimately, the goal of any research-for-development program is to improve livelihoods. ICARDA uses a holistic, integrated approach, focusing on the overall cropping system – crops, livestock, natural resources and the socioeconomic and policy environment. The objective is to take improved technologies to the farmer, as integrated 'packages' that meet farmers' needs and priorities, and create better livelihood opportunities. The key: intensification of production and diversification of both the farming system and potential sources of income. Diversification opportunities could include, for example, new crops, or new value-added products from traditional crops, that boost household incomes.

### *Cereal and legume systems in Ethiopia and Sudan*

Crop technologies that improve livelihoods are vital, because households in dryland areas are almost entirely dependent on crops. Researchers who interviewed 710 households in five locations in Ethiopia and Sudan found that crops accounted for over 70% of farm income.

*An ICARDA project is helping farmers in Algeria, Morocco and Tunisia intensify production by growing high-value vegetable crops such as peas.*

ICARDA, in collaboration with national researchers in Sudan and Ethiopia, studied the uptake and impact of improved technologies such as improved varieties, seeding rates, planting date, rates of fertilizer application, weed and pest control, number and frequency of irrigations, and tillage.

In Ethiopia especially, where most agriculture is rainfed, variety and appropriate seed rate were important in increasing yield. For example, sowing lentil on the recommended date increased yield by 135%.

Farm households in Sudan and Ethiopia that adopted the new technologies raised their income by more than US$300 per hectare compared with non-adopters (Table 3). Estimated Gini coefficients indicate that improved technologies, in most cases, also reduce income inequality among households.

**Table 3. Impact of improved technologies on costs and net returns (US$/ha) in Sudan and Ethiopia**

| | Adopters | Non-adopters | Difference |
|---|---|---|---|
| **Wheat variety in Sudan** | | | |
| Average net return | 510 | 134 | 376 |
| Gini coefficient* | 0.58 | 0.63 | |
| Average costs | 556 | 510 | 46 |
| **Chickpea variety in Ethiopia** | | | |
| Average net return | 551 | 201 | 350 |
| Gini coefficient* | 0.85 | 0.02 | |
| Average costs | 350 | 318 | 32 |
| **Lentil variety** | | | |
| Average net return | 781 | 451 | 330 |
| Gini coefficient* | 0.52 | 0.96 | |
| Average costs | 411 | 323 | 88 |

* Gini coefficient measures income equality: 0 = everyone in the group has the same income; 1 = one person has all the income.

**Improving food security, reducing poverty**

Analyses of household food security (measured by per capita crop production), showed that households who adopted new faba bean technologies produced more beans per person than non-adopting households did: 8% more in Sudan, and 39% more in Ethiopia.

Overall, the new technologies reduced poverty in the study areas. Adaptive research improved crop productivity, increased farm incomes, improved food security, and reduced poverty among farmers who adopted new technologies.

The study also showed that better seed delivery systems and credit and extension services for poor farmers will lead to wider adoption and impact. Farmers, being risk averse, may also not adopt new technologies until they have proved effective.

## *Chickpea and faba bean technologies in Ethiopia*

ICARDA and the national research system in Ethiopia, funded by the International Fund for Agricultural Development (IFAD), have set up village-based seed production to disseminate improved varieties of faba bean and chickpea. This has increased productivity, food security and incomes, and reduced income inequality. Higher incomes mean that farming households can buy food if they do not grow enough for themselves, as well as pay for health, education, and housing.

**Village-based seed production helps spread new varieties**
Although improved varieties of chickpea and faba bean have been available in Ethiopia for some time, the formal seed system has not been able to multiply and disseminate enough. To supplement the formal seed system, village-based seed production enterprises were set up in Arsi. Over four years, 800 farmers were each given 20 kilograms of faba bean seed and trained to multiply seed. A revolving seed scheme, exchange, and sale of seed helped transfer seed between farmers and led to wider adoption. Field days showed farmers how to grow the improved varieties and how they perform

**New varieties improve incomes and food security**
Adopters of faba bean technologies benefited from higher yields, more food for the household, and higher incomes (Table 4). Farmers found that, of all the technologies, they could adopt improved seed and weed control most easily.

Adopters of chickpea technologies benefited from improved livelihoods (14%), better housing (9%), more food for the household (23%),

higher incomes (30%), better yields (13%), more livestock (9%), and being able to pay for farm inputs (6%). Almost all (99%) saw seed multiplication as the most suitable technology for their situation. Adopters of improved chickpea varieties have higher annual per capita incomes relative to non-adopters. More adopters than non-adopters were originally below the poverty line, indicating that most of the beneficiaries were poor.

**Table 4. Impact of improved faba bean and chickpea technologies on income distribution and food security in Arsi, Ethiopia**

| Indicator | | Adopters | Non-adopters |
|---|---|---|---|
| **Faba bean** | | | |
| Income and costs | Av. net return, US$/ha | 164 | 108 |
| | Av. costs, US$/ha | 190 | 159 |
| Food security | Av. production per household, kg | 467 | 339 |
| | Family consumption, kg | 198 | 144 |
| **Chickpea** | | | |
| Income and costs | Av. net return, US$/ha | 551 | 201 |
| | Av. costs, US$/ha | 350 | 318 |
| Food security | Av. production per household, kg | 1068 | 960 |
| | Family consumption, kg | 90 | 62 |

**Improving crop diversity**

Improved varieties have encouraged farmers to diversify away from wheat. Although wheat is the main crop in Arsi, by 2004-05, more barley and faba bean were being grown, accounting for 14% and 6% of cropland respectively. Other crops such as linseed and rapeseed were expanding. Faba bean and chickpea fetch higher prices than wheat, which also encourages farmers to diversify.

## *Improving drought resilience in Eritrea*

Food production in Eritrea has dropped 40% over the last decade. Little progress has been made in farming methods over the last 30 years and subsistence farming still prevails.

Rainfed cropping accounts for 95% of Eritrean crop production but is extremely vulnerable to frequent droughts. Land degradation is acute as a result of deforestation and overgrazing. The rainy season is short and highly unpredictable. Farmers have learned to cope with this by making the most of the highly diverse nature of local Eritrean landraces, and growing *hanfets*, a mixture of wheat and barley. In wet years wheat does better, in dry years the more drought-tolerant barley does better. *Hanfets* are also less prone to diseases, particularly rusts in wheat. But varieties that are more resistant to drought could improve yields significantly.

*Farmers select drought-resistant barley lines in Eritrea, to serve as the raw material for the next generation of varieties.*

ICARDA, a partner in the CGIAR Challenge Program on Water and Food, is working with farmers to select drought-tolerant Eritrean landraces of barley, wheat, chickpea, lentil, and faba bean. These, and ICARDA breeding lines, will be the raw materials for developing new varieties that are drought, pest and disease resistant, and also have high levels of nutrients.

The Eritrean landraces selected by farmers and tested on their farms produced yield increases of up to 20% in barley, 31% in wheat, almost 100% in lentil, and 6% in faba bean (Box 8).

**Box 8. Drought tolerant barley, lentil and hanfets selected by farmers in Eritrea**

**Barley**
- Shishai for medium altitude areas
- Rhawa, a population of the landrace Atsa, released in Embaderho, northeast of Asmara
- Tokonda, a pure line from Atsa, released in Adi Keyh, about 100 km south of Asmara

**Lentil**
- ILL 7978 from ICARDA is not affected by wilt and rust. It outyielded the local check in two consecutive years in three villages.

**Hanfets**
- The best performing hanfets (barley+wheat) over three years and three locations were Kunto + Pavon 78, Yeha + Mana, Atsa + HAR 1685 and Kulih + Pavon 78

## *Crop-livestock systems in Morocco and Tunisia*

Land degradation is severe in North Africa where millions of people are dependent on crop-livestock farming for their livelihoods. Rangelands are suffering from serious overgrazing because of the increase in the number of animals and inappropriate land-use policies.

To help poor crop-livestock farmers, ICARDA and national partners in Morocco and Tunisia designed systems to provide more and better fodder for animals. Alley cropping with saltbush (*Atriplex*) and spineless cactus (*Opuntia*) can improve livelihoods by increasing and stabilizing reserves of animal food.

**More browse for livestock**
Alley cropping of saltbush and spineless cactus was introduced on marginal lands in Morocco and Tunisia (Box 9). The aim was to make more fodder available for small ruminants in the dry season to boost farm returns and reduce overgrazing and soil erosion. Both saltbush and spineless cactus thrive in difficult dryland areas and compensate for seasonal shortages of other feeds. Saltbush provides animals with protein and spineless cactus has a lot of carbohydrates.

**Box 9. Improved forage production in Morocco and Tunisia**

**Spineless cactus**

- Biomass yields in spineless-cactus alley-cropping systems in Tunisia were 57% higher than in the traditional barley cropping system
- Introduction of cactus increased herbaceous biomass from 3.30 tons to 4.98 tons per hectare – with no adverse effects on the main barley crop
- With more fodder now available, farners reduced their costs of animal feed by 13%

**Atriplex**

- Adopters increased the size of their flocks by 25% because more fodder was available
- Adopters, using a combination of saltbush fodder and barley straw, saved 33% in feed costs, compared to non-adopters

The main adopters were farmers with good land, water, and stable off-farm incomes, and farmers with livestock. Subsidies, size of farm and size of flock were the main factors determining adoption. Small-scale farmers who lost their animals in the 1998-2002 drought were attracted by subsidies and new market opportunities. In Tunisia, markets have a strong influence on rates of return. Adoption was higher in areas with good access to markets.

*Barley-saltbush alley-crops are transforming livestock production in North Africa.*

## Strengthening Capacity

### *Problem-solving networks*

One key aspect of ICARDA's capacity building efforts has been to establish or strengthen research networks. The Center works as a facilitator, helping to bring researchers (and institutions) from different countries together to pool skills and resources to address common problems. Such regional networks are particularly important given the resource shortages faced by almost every national agricultural research system in Africa. One good example of this approach is that taken by ICARDA's Nile Valley and Sub-Saharan Africa program. Before the program was established in 1979, inter-country networking was limited and generally informal. ICARDA played a key role in formalizing and strengthening these partnerships, with collaboration in sharing germplasm, exchanging information, and strengthening research capacity through study visits, training courses and workshops

A major project was launched in 1995, funded by IFAD. The project targeted Egypt, Ethiopia, Sudan and Yemen, with research and technology dissemination of a range of crops. Problem-solving networks were established, focusing on specific areas. The broad approach was for a country to lead research on a particular subject, depending on comparative advantage. Results were then verified through adaptive research in other countries, and shared across the region. ICARDA's role was to act a bridge between countries, and between the region and the global scientific community. The problem-solving networks included:

- Rust diseases of wheat, led by Egypt
- Wilt and root rot diseases in legume crops, led by Ethiopia
- Aphids and virus diseases, led by ICARDA and Sudan
- Thermo-tolerance and yield stability in wheat in hot environments, led by Sudan
- Drought and water-use efficiency, led by Egypt
- Socioeconomics research, led by Sudan

One key factor in the success of these networks was the management, designed to generate maximum output from limited resources.

In each network, national scientists and international experts worked together to implement an agreed workplan with clearly defined activities, targets, budget and timeframe. Network partners also helped upgrade research facilities, and provided training and skill-development opportunities for scientists, technical staff and extension officers. The entire planning process is inclusive; implementation was closely – and jointly – monitored by all partners.

The Nile Valley project, which served as a model for many subsequent research-for-development initiatives, included other innovations. There was a strong technology transfer component to ensure that new technologies quickly impacted on the food security and livelihoods of rural households. It built on the know-how and experience of national research systems. All research was participatory, with the community closely involved at every stage. The focus was on integrated technology packages for a cropping system, rather than individual commodities or technology components. Using this approach, a range of new technologies was developed and rapidly disseminated; examples are described throughout this book. Equally important, this approach is being institutionalized by national R&D agencies, and will contribute to building stronger research and extension programs, and sustainable improvements in food security, across Africa.

*Problem-solving networks combined research with capacity building, helping to create a cadre of highy trained researchers in national programs.*

ICARDA is deeply committed to building the capacity of national agricultural research systems in Africa. A well-trained cadre of scientists is critical for quality research. Over the years, many African research managers, scientists, technicians and farmers have taken part in ICARDA courses and workshops to boost their knowledge and skills.

Between 1999 and 2008, 1791 national researchers from 9 countries in Africa took part in both formal and informal training (Table 5). Over 20% of these were women. Many African scientists have conducted research for MSc and PhD theses under the joint supervision of ICARDA and African universities (Table 6). ICARDA's Capacity Development Unit facilitated and coordinated 49 training courses, in partner African countries.

At first, most training programs took place at ICARDA headquarters. Now, more than half are delivered in partner countries. Cooperating with ICARDA in capacity development are national agricultural research systems, regional and international agricultural research and training institutes and programs.

*Hands-on training in virus detection is helping to stem the growing problem of plant viruses.*

**Table 5. African scientists trained at/through ICARDA, 1999-2008**

| | Male | Female | Total |
|---|---|---|---|
| Algeria | 91 | 99 | 190 |
| Egypt | 331 | 76 | 407 |
| Eritrea | 135 | 13 | 148 |
| Ethiopia | 278 | 20 | 298 |
| Libya | 104 | 9 | 113 |
| Mauritania | 29 | 1 | 30 |
| Morocco | 164 | 58 | 222 |
| Sudan | 153 | 91 | 244 |
| Tunisia | 99 | 40 | 139 |
| **Total** | **1384** | **407** | **1791** |

**Table 6. Graduate research training for MSc and PhD degrees jointly between ICARDA and African universities, 1999-2008**

| | MSc completed | MSc ongoing | PhD completed | PhD ongoing | Total |
|---|---|---|---|---|---|
| Algeria | 1 | 1 | 2 | 2 | 6 |
| Egypt | | 1 | 2 | | 3 |
| Eritrea | 4 | | | | 4 |
| Ethiopia | 4 | 1 | 4 | 1 | 10 |
| Morocco | 3 | 1 | 4 | 4 | 12 |
| Senegal | | | | 1 | 1 |
| Somalia | | 2 | | | 2 |
| Sudan | 2 | 3 | 1 | | 6 |
| Tunisia | 1 | | 4 | | 5 |
| **Total** | **15** | **9** | **17** | **8** | **49** |

Topics are integral to research themes, and often cut across several themes. Many of the courses include modules to boost institutional capacity in setting research priorities, addressing policy issues, and assessing impact. Courses have become more advanced and more deal with specialist aspects, for example biotechnology (Box 10).

## *Training scientists and extension workers*

**Action learning approach to developing the seed sector in Ethiopia**
Providing seed of improved varieties is an excellent way of getting agricultural innovations to farmers. By growing seed of improved

varieties adapted to their particular circumstances, farmers can increase production, become more food-secure and improve their livelihoods.Ethiopian seed policy recognizes both formal and informal seed sectors and considers them equally important. At present neither the public sector nor the private sector can provide smallholder farmers in less favorable environments and remote areas with a choice of varieties and seeds. To redress this and strengthen the national seed system, Wageningen International and ICARDA's Seed Unit developed a tailor-made training program.

**Box 10. Topics covered by ICARDA training courses for Africa, 2006, 2007**

Genebank management and germplasm conservation
Crop improvement, participatory plant breeding
Crop management
Hybridization techniques
*In vitro* culture
Genetic transformation of plants and detection of GMOs
Experimental design and data analysis
GxE analysis of data from multi-environment trials
Experimental station management
Field plot techniques
Greenhouse management
Integrated crop and livestock production
Integrated pest and disease management
Detection and control of viruses
Variety management and quality assurance
Seed production, processing and quality control
Quarantine
Community-based seed production
GIS analysis
Molecular characterization of small ruminant breeds
Soil analysis
Salinity amelioration
Water management, water harvesting, supplemental irrigation
Modeling water productivity
Livelihood characterization and impact assessment
Library and information management systems
Scientific writing and data presentation

**Tailor-made training**

The training program 'Improvement of Farmer-based Seed Production Schemes and Revitalizing Informal Seed Supply of Local Crops and Varieties in Ethiopia', 2006-2007, funded by the Netherlands Organization for International Cooperation in Higher Education aimed to boost the informal seed supply sector in Ethiopia (Box 11).

The program responded to the needs of the national agricultural research system in Ethiopia for knowledge and skills to develop the national seed industry. The training program graduated a cadre of national experts in farmer-based seed production and informal seed supply. These national experts now have the confidence to collectively address national and regional problems and enlist support from policy makers and senior managers.

**Strengthening national capacity in Mauritania**

Long before the ICARDA-Mauritanian Collaborative Agreement was signed in 2001, more than 100 Mauritanian researchers and managers had taken part in regional and international training courses and workshops organized by ICARDA. ICARDA also sponsored many senior officials and managers to go on exchange visits to countries with similar environments and conditions.

Between 1998 and 2008, 30 Mauritanian researchers and scientists took part in training programs and workshops on:

- Grain quality and molecular markers
- Seed production systems and networks
- Participatory approaches for natural resource management
- Geographical Information Systems
- Research priorities for North Africa.

Since then, 12 Mauritanian scientists and technicians have taken part in a course on participatory approaches at the Aridoculture Center, Settat, Morocco, and 22 veterinarians and engineers have taken an advanced course on participatory approaches in agro-pastoral systems, at the Center of Boghe, Mauritania. In addition, 25 technicians and managers responsible for project field activities attended a workshop on water and soil conservation techniques, while another 20 attended six training sessions on cactus multiplication, planting, management and utilization, at Nouakchott, Kaedi, and Aleg.

**Box 11. Tailor-made training program in farmer-based seed production and informal seed supply**

**Strategies**
- Blends theory and concepts with case studies
- Problem solving: trainees plan, act, reflect, and revisit plans based on experiences gained
- Focuses on building a cadre of professionals and multi-stakeholder approaches rather than individual competencies and single institutions
- Links farmers with seed professionals
- Regional teams develop and implement action plans for local informal seed projects

**Training partners**
- CIMMYT, Bioversity International, ASARECA, Institute of Biodiversity Conservation
- Ethiopian Institute of Agricultural Research
- Regional Agricultural Research Institute, RARI-South
- Mekele, Hawasa and Addis Ababa Universities

**Participants**
- Ethiopian Seed Enterprise
- Bureau of Agriculture & Rural Development, Ministry of Agriculture and Rural Development, other federal research organizations
- Universities and NGOs
- Key stakeholders from every region: Amhara, Oromia, Southern Nations, Nationalities and Peoples Region, and Tigray

**Phases**
1. Integrating theory with practice
2. Technical and institutional issues in iseed sector development
3. Diagnosing seed systems and surveying demand
4. Designing interventions for informal seed supply
5. Engaging stakeholders across the country
6. Rationalizing policy and regulatory frameworks
7. Sharing the experience more widely, through an eastern Africa regional workshop

**Control of parasitic weeds**
ICARDA and FAO are also helping countries in North and East Africa to train technical field staff in ways of controlling broomrape so that they can advise farmers. They are also encouraging countries to share information, resistant germplasm, and integrated management strategies to reduce parasitic weed infestation.

**Epidemiology and control of viruses**
ICARDA runs courses on rust epidemiology, breeding for resistance, and disease management to build the capacity of researchers, scientists and extension workers in national agriculture research systems as part of the Borlaug Global Rust Initiative. Five courses were conducted between 2005 and 2007, attended by participants from Algeria, Egypt, Ethiopia, Kenya, Morocco, Sudan and Tunisia.

The virology laboratory at ICARDA trains African scientists in up-to-date virus detection methods. In addition, ICARDA runs in-country training courses on the detection of plant viruses.

## *Strengthening farming skills*

**Farmer field schools**
ICARDA has arranged farmer field schools in Ethiopia, Sudan, Egypt, Algeria, Morocco and Tunisia to demonstrate ways of controlling broomrape (*Orobanche* species). Farmers are the first line of defense against broomrape and the field schools build farmers' expertise using experiential learning methods.

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## Ties that Bind

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