ICARDA Caravan

Issue No. 6 Spring/Summer 1997

Review of agriculture in the dry areas

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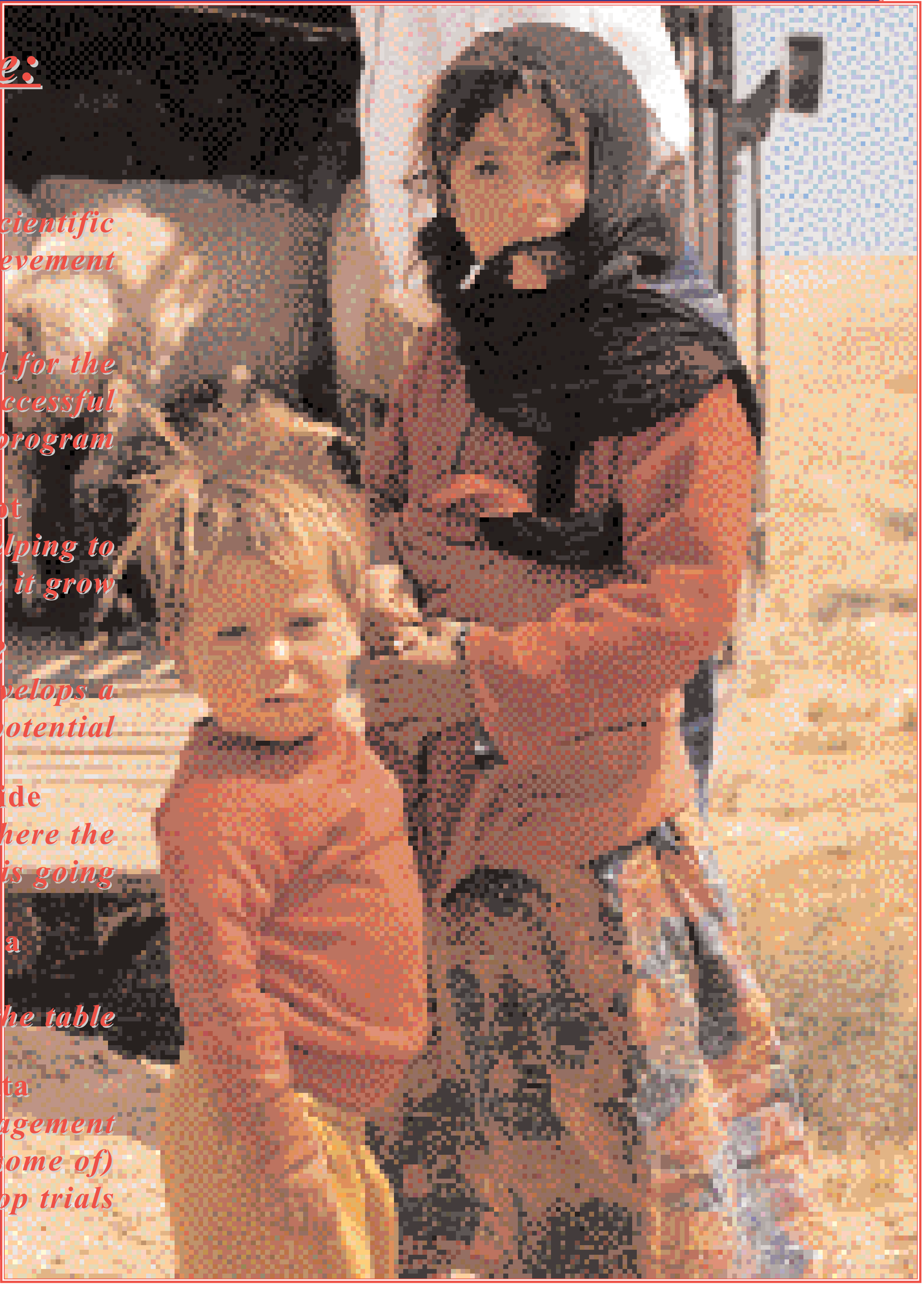


From the Director General

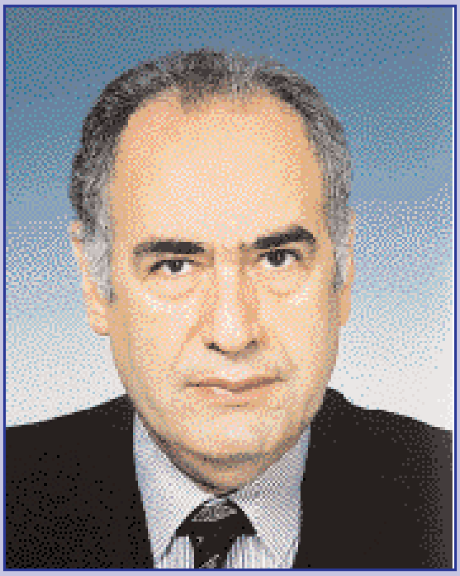
ICARDA is now 20 years old. They have not been easy years; agricultural research for a fragile environment is difficult.

What have we learned in 20 years? If I were to highlight a single point, it would be the dynamic nature of agricultural research. Those who read the first issue of Caravan at the end of 1995 may remember why the title was chosen: because such research moves from place to place; may carry untold wealth; but must also move, at times, through uncharted territory.

Nothing highlights the changing, dynamic nature of agricultural research better than the Green Revolution itself. A few years ago, we were being told that it had failed—the world was still hungry; it was not reaching the poorer farmers; it was encouraging monocropping, loss of biodiversity, environmental damage—indeed, at times, it seemed that the Green Revolution was responsible for every evil known to mankind.

Today, we have a more mature understanding of the Green Revolution; it was actually a success to the extent that it was ever meant to be. It averted a catastrophe in world food supplies. To be sure, we know now that concern for scarce resources such as water, soil and genetic diversity must be an integral part of research planning. We also realize that benefits must reach farmers who cannot afford large investment in technology. But I suspect that none of this is news to the pioneers of the Green Revolution. They always knew what they were doing. They also knew what they were not doing. It was a rescue operation, and we have moved beyond it, as they always knew we would.

This is expressed in ICARDA's new Medium-Term Plan. Our crop-development strategy revolves around increasing yield and stability over time, with special emphasis on less-favored environments and low-input systems. Emphasis will be on:



decentralization and farmer participation in crop improvement; improving water-use efficiency at the farm level; integrated pest management; rangeland and pastoral systems; feed resource use and animal products; and conserving the natural resources of land, water and biodiversity. We will be pursuing methods of crop development that keep biodiversity in the field, as well as promoting its conservation *in situ*. And we will continue to take a farming systems approach, trying to bal-

ICARDA

Caravan

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Bangladesh has been updating its lentil technology in a big way—and the results have been satisfying. ICARDA has been helping breed the varieties of the future.

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Bread wheat—the most important staple of all? How wheat research has helped to feed millions.

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The deserts of Egypt are springing into life. An enlightened approach has ensured that women take a full part in this process.

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ICARDA has been bringing farmers from the region to Syria again. Recently they've been looking at range management and water harvesting.

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Vanishing hillsides...Overgrazing renders slopes vulnerable to water erosion. But high-tech tools can help us understand what's happening—and start looking for an answer.

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Seeds—you can't grow much without them. Ethiopia has found a way of getting them to farmers.

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Plus...**A birthday party. ICARDA is 20 years old this year, and it's been celebrating.**

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ance production and environment within the context of the farm itself.

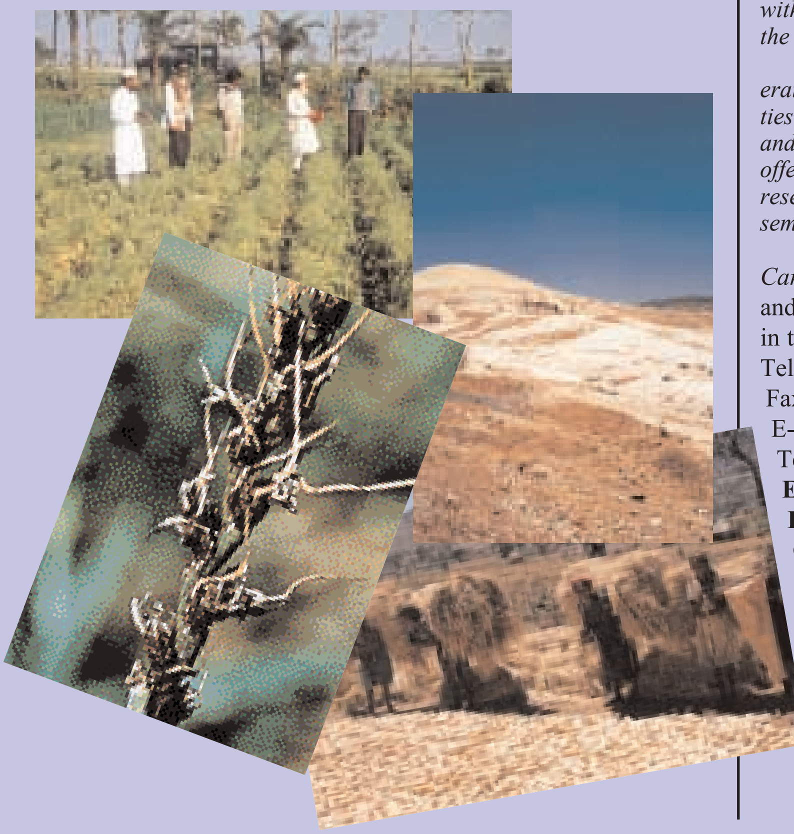
The dynamic nature of research may also be seen in changes in research technology and methodology. This year saw the appearance of a sheep cloned by Scottish scientists. But in fact, biotechnology has been quietly at work for some years, and will raise many new issues of safety and legality. Geographical Information Systems, or GIS, can transform the world into a giant database which can be manipulated at will; we must learn to harness it to the real world so that it can be used for the development of agricultural research. Software is needed to manage complex multilocation experiments. All of this is in progress at ICARDA; meanwhile, in computing, Expert Systems are on the horizon, and much else besides.

If the new technology is to be exploited effectively in the developing world, there is a need to train the rising generations of national scientists and give them hands-on experience with the new research tools. Train-the-trainers and colleague-to-colleague approaches will play a big part in this.

Agricultural research is broadening its approach; it is going farther upstream and farther downstream with every passing day. It is dynamic. That, to me, is the chief lesson of these two decades.

The next 20 years are poised to bring a lot more.

Prof. Dr Adel El-Beltagy
Director General



About ICARDA

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

The 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 strengthening agricultural research in developing countries.

In the context of the challenges posed by the physical, social and economic environments of the dry areas, ICARDA's mission is to improve the welfare of people in the dry areas of the developing world by increasing the production and nutritional quality of food while preserving and enhancing the resource base. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production; and the West 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.

Much of ICARDA's research is carried out on a 948-hectare farm at its headquarters at Tel Hadya, about 35 km southwest of Aleppo. ICARDA also manages other sites where it tests material under a variety of agroecological conditions in Syria and Lebanon. However, the full scope of ICARDA's activities can be appreciated only when account is taken of the cooperative research carried out with many countries in West Asia and North Africa and elsewhere in the world.

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

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Two decades of chall achievement

On 2 June 1997, ICARDA commemorated its 20th anniversary two decades of grappling with the problems of raising productivity in a fragile environment where drought and heat in summer; freezing cold in winter; shallow, hard-used soils, and scarce and unpredictable rainfall make the life of a farmer harder than anywhere else.

To mark the occasion, ICARDA held its annual Presentation Day to coincide with the anniversary celebration. A comprehensive program was arranged, which involved visits to field sites and to historic monuments; and a spectacular evening at Aleppo Citadel, where a long and colorful cultural program in the open amphitheater followed a dinner in the magnificent Throne Room itself.

The Presentation Day was attended by distinguished guests, who were welcomed by the Syrian Minister of Agriculture and Agrarian Reform, H. E. Assad Mustapha, and ICARDA s Board Chairman, Dr Alfred Bronnimann. The Director General, Prof. Dr Adel El-Beltagy, made a comprehensive and well-illustrated presentation of past achievements and future directions of the Center (see page 6). A keynote address was given by the Chairman of the Arab Fund for Economic and Social Development (AFESD), Mr Abdellatif Al-Hamad. Dr Ismail Serageldin, Chairman of the CGIAR, delivered the Anniversary Address. Representatives of donors and cosponsors also participated.

The Center took the opportunity to honor the

Majed Khatib, Jamil Zarneji, Razek Makdis

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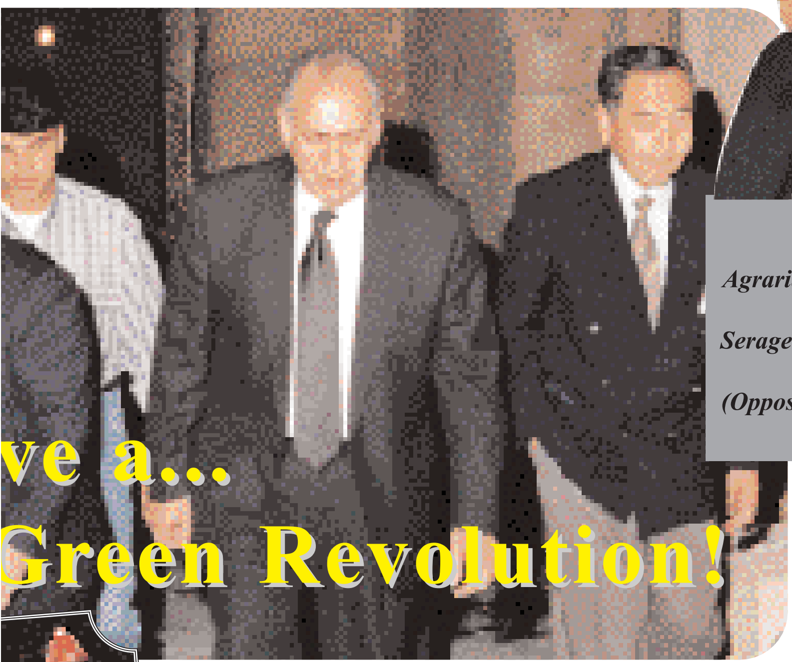


Images of a successful celebration. CGIAR Chairman Dr Ismail Serageldin (above, right) with Syria's Minister of Agriculture and Agrarian Reform, H.E. Assad Mustapha. Left: ICARDA Director General Prof. Dr Adel El-Beltagy (second right) enters the Citadel with Dr Serageldin (left), Aleppo Governor H.E. Mohammed Mustapha Miro (second left), and Japanese Ambassador H.E. Tomio Uchida (right). (Opposite page, bottom left): Two former ICARDA Directors General, Drs Nasrat Fadda (left) and Mohamed A. Nour.

...ve a... Green Revolution!

Don't blame the Green Revolution. It saved lives. But bring it up to date, says CGIAR Chairman

The Green Revolution was not a failure. But there were some things it couldn't do. It's time to update it so that it helps everybody, including the poorest farmers—and is environment-friendly.

That was part of the message from Dr Ismail Serageldin, Chairman of the Consultative Group on International Agricultural Research (CGIAR), which is ICARDA's parent organization. He was speaking on the occasion of ICARDA's 20th Anniversary on 2 June, when he addressed a distinguished audience of invited guests that included Syrian Minister of Agriculture and Agrarian Reform, H.E. Assad Mustapha, former ICARDA Board chairmen and senior representatives of regional and international organizations.

He argued that the Green Revolution had not actually been a failure as some have suggested. Despite its drawbacks, the Green Revolution in India alone has enabled an increase in production from 87 million tonnes in 1961 to 197 million tonnes in 1995/96, saving at least 300 million hectares of land (an area the size of India itself). This is crucial, because it is now virtually impossible to make a significant impact on agricultural production by bringing more land under cultivation, even assuming that new land was of the same quality as existing farmland (which, as Dr Serageldin pointed out, it would not be). However, the Green Revolution has not reached resource-poor and smallholder farmers. That is what must be done now.

Dr Serageldin suggested that what we need is a "Doubly Green Revolution" which looks at protecting biodiversity, reducing chemical inputs and other measures to protect and enhance our global natural resource base. While the CGIAR's major priority remains increasing productivity, it is closely followed by protecting the environment and saving biodiversity.

He also strongly stressed that development must not overlook the countryside and agriculture, and must be targeted at the infrastructure supporting rural development; moreover the approach needed to be holistic. "The issues are not just about production of food," said Serageldin, "but access to it; not just about output, but also about process; not just about technology, but also about policy; not just about global action, but also about impact in nations; and not just about nations, but about impact in the household; not just rural but also urban; and not just about the quantity of food but about its quality."

In outlining a framework for action, Dr Serageldin emphasised the need to remove the urban bias, for example, in infrastructure investment and health and education services; to move away from centralized, bureaucratic institutions which are distanced from the people, encouraging decentralized, community organizations including effective local government. Similarly, research organizations need to be responsive to extension needs which are themselves fueled by farmers' needs. Most important is that the poorest of the poor, mostly women, can get credit through mechanisms and institutions such as the Grameen Bank in Bangladesh.

He spoke, too, about the CGIAR itself. Founded in 1971, it is a group without a formal charter and acts as an umbrella for ICARDA and a number of other Centers,

Continued on page 6

which are autonomous within its framework. It has had an impact out of all proportion to its size.

"The CGIAR," said Serageldin, "has four great strengths: it is non-political; it is dedicated to excellence; it has a focused agenda; and it has a long-term commitment." Despite its lack of formal rules and regulations, it has worked so well in promoting agricultural research—and impact—that it has served as a model for collaboration and partnership in other sectors, such as health. Although research by the 16 Centers within the CGIAR represents only 3-4% of the total agricultural research in the developing world, its collaborative approach and its excellence—half of the world food prizes have gone to CGIAR scientists—has had an enormous impact on agriculture and food production worldwide.

Dr Serageldin congratulated ICARDA on its anniversary and spoke warmly about its achievements; it was, he said, one of the outstanding Centers of the CGIAR. He talked also about ICARDA's fight against desertification and the urgent need to preserve water and soil.

In so doing, he demonstrated that higher productivity and environmental protection are not necessarily incompatible. He did this by looking at global warming, and some of the work that ICARDA has done on carbon sequestration. ICARDA's research, he explained, had established that careful agronomic practices in fragile environments, coupled with use of crops such as food and feed legumes, could actually increase carbon sequestration; it can also preserve the soil from wind erosion, preventing degradation of steppe and other marginal land which would then cease to act as a carbon sink.

He highlighted ICARDA's work with medics and vetches, which can achieve this end (see *Agriculture—a weapon against global warming* in *Caravan* No.5).

ICARDA: "One of the outstanding Centers of the CGIAR"

Barley breeder Dr Salvatore Ceccarelli (left) briefs guests on ICARDA's crop-breeding activities.

ICARDA's Director General describes past achievement, future vision

The Center's 20th Anniversary was an opportunity to review ICARDA's achievements, to draw lessons from past experiences, and to prepare to face future challenges. And this was the theme of the address delivered by ICARDA's Director General, Prof. Dr Adel El-Beltagy.

ICARDA has both regional and global mandates and Prof. Dr El-Beltagy outlined how the Center's programs, past and present, have been developed to meet these mandates. But what impact has the Center's work had over 20 years? In his address, the Director General gave a number of important examples of the impact of ICARDA's research around the world. For example, ICARDA supplies nearly 2500 sets of international nurseries per year, and as of December 1996 some 442 varieties of ICARDA-mandated crops had been released worldwide. There have been some very significant improvements in production, for example, with wheat in Syria, Tunisia, and Sudan; and with lentil in Sudan and Ecuador; as well as with winter kabuli chickpea and with faba bean in WANA and elsewhere in the world. Multiple resistance has been developed for several diseases in both cereals and legumes, and incorporated into high-yielding cultivars. Protocols have been developed for *in-vitro* culture for making interspecific hybrids, enabling the transfer of desirable genes from wild relatives of crops to cultivated varieties. About 7500 people from 90 countries (17% of whom are women), including more than 350 post-graduate students, have benefited from the Center's training program. ICARDA has also produced an extensive range of publications for a wide-range of audiences. Not least, ICARDA's gene bank holds about 111,000 accessions or 20% of the CGIAR's total collections, which have been systematically characterized for a number of descriptors, and ICARDA is active in *in-situ* conservation of plant genetic resources.

"The Center has worked diligently to forge new partnerships and carefully nurtured them for mutual benefit," said Prof. Dr El-Beltagy. And he stressed, throughout his address, the importance of partnerships in implementing and continuously developing the Center's program—ICARDA has 80 formal agreements with institutions and organizations throughout the world. He described the six regional programs and the specific problem-oriented networks which operate both within and across programs. And there are always new and exciting challenges, as with the recent collaboration ICARDA has begun with the newly independent republics of Central and West Asia, which are now included within the Center's regional mandate.

Taking his audience into the future, Prof Dr El-Beltagy introduced new developments and changing emphasis in ICARDA's research programs, as outlined in the Center's recently approved Mid-Term Plan. There will be even greater emphasis on decentralization and farmer-participation in crop improvement, improving water-use efficiency; integrated pest management; rangeland and pastoral systems; the efficiency of feed-resource use and animal products and conserving the natural resources of land, water and agricultural biodiversity. ICARDA will reduce its location-specific experiments in agronomy and soil fertility and emphasize its role in characterization of dry area production systems using simulation models linked to spatially-referenced agroecological databases. Within socioeconomics and policy, particular emphasis will be placed on participatory research techniques that complement the formal methods already used.

As Prof. Dr El-Beltagy outlined, the strategy is to build upon the knowledge, perspectives and innovative capacities of farmers and local communities in finding solutions to production and resource-management problems. To maintain a critical mass of researchers as a part of ICARDA's strategy to cope with funding uncertainties, the Center will employ Affiliate Research Fellows. These people will be from NARS and will continue to be based in national institutions but will conduct specific components of ICARDA's research agenda. Also, world-renowned scientists will be identified as "mentors" to advise on specific issues. ■

ICARDA gets goats

ICARDA has acquired 10 female Shami goats. Supplied by Syria's Livestock Research Department, which is part of the Directorate of Agricultural Scientific Research, they will soon be joined by another 10 does and two males.

In Syria, there is only about one goat for every 10–12 sheep and these are mostly found in the hilly west and arable areas. Sheep dominate the steppe lands. In fact, there are more sheep than goats in the WANA region as a whole with a ratio of 1:3. So why does ICARDA wish to work on goats?

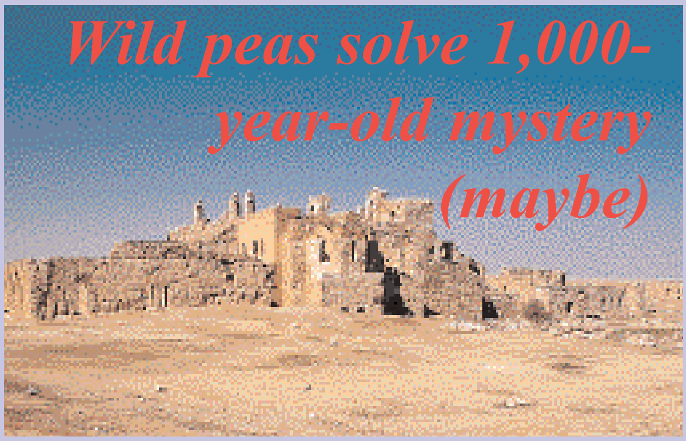
They are efficient milk producers; they can even rival dairy cows.

Goats, particularly Shami goats, are better adapted to the harsh climate, the diet and local diseases and still produce a substantial amount of milk under these conditions. Shami goats (also known as Damascus goats) are famous in the region for their high milk production—they can yield several hundred liters of milk in a lactation period. This, and their higher twinning rate and kidding throughout the year, makes them popular with many farmers who wish to have milk for the family.

ICARDA wants to see just how well goats with different genetic potentials for milk production perform with feeds with varying nutritional content.

The results will be compared with data from similar trials conducted at Tel Hadya on Awassi sheep and with published data from dairy cows.

Wild peas solve 1,000-year-old mystery (maybe)



At the end of April a team from ICARDA's Pasture, Forage and Livestock Program mounted a short expedition into the Syrian steppe to ground-truth several test zones on their vegetation map.

This they did, with great success, using geo-referenced satellite images on a portable computer.

But they also discovered some unexpected biodiversity; a discovery that may help solve the mystery of ancient civilizations.

The team—Dr Gus Gintzburger,Nabil Battikha and Walid Shaar of ICARDA's Natural Resources Management Program, accompanied by Dr Francoise Debaine (GIS-RS Unit Nantes University, France) and Dr R. Jaubert (IUED, Geneva, Switzerland)—collected numerous plant specimens for ICARDA's herbarium from the 130–200 mm rainfall zones south of Esseryeh.

On the top of one of the many rocky basaltic hills not easily accessible to sheep or goats, they found a wild pea which could be* Pisum elathius *Bieb. (or possibly* Pisum fulvum *Sibth. et Sm. in Mouterde 1966) and a* Lathyrus *sp. They intend to go back to collect some seeds soon.

These discoveries could be a clue to a thousand-year mystery: What kind of vegetation and forage sustained the many 15-1800-year-old Roman and Byzantine settlements and large 'livestock' farms with huge stone built enclosures in the 130–180 mm Esseryeh region, in what is now such a hostile environment?

Parts of the Middle East contain spectacular ruined towns and Byzantine villages (known in Syria as the "dead cities"), sometimes in areas that are clearly not able to support much farming activity today. Maybe the past will provide some clues to the future...

Lentil: the Bangladesh breakthrough

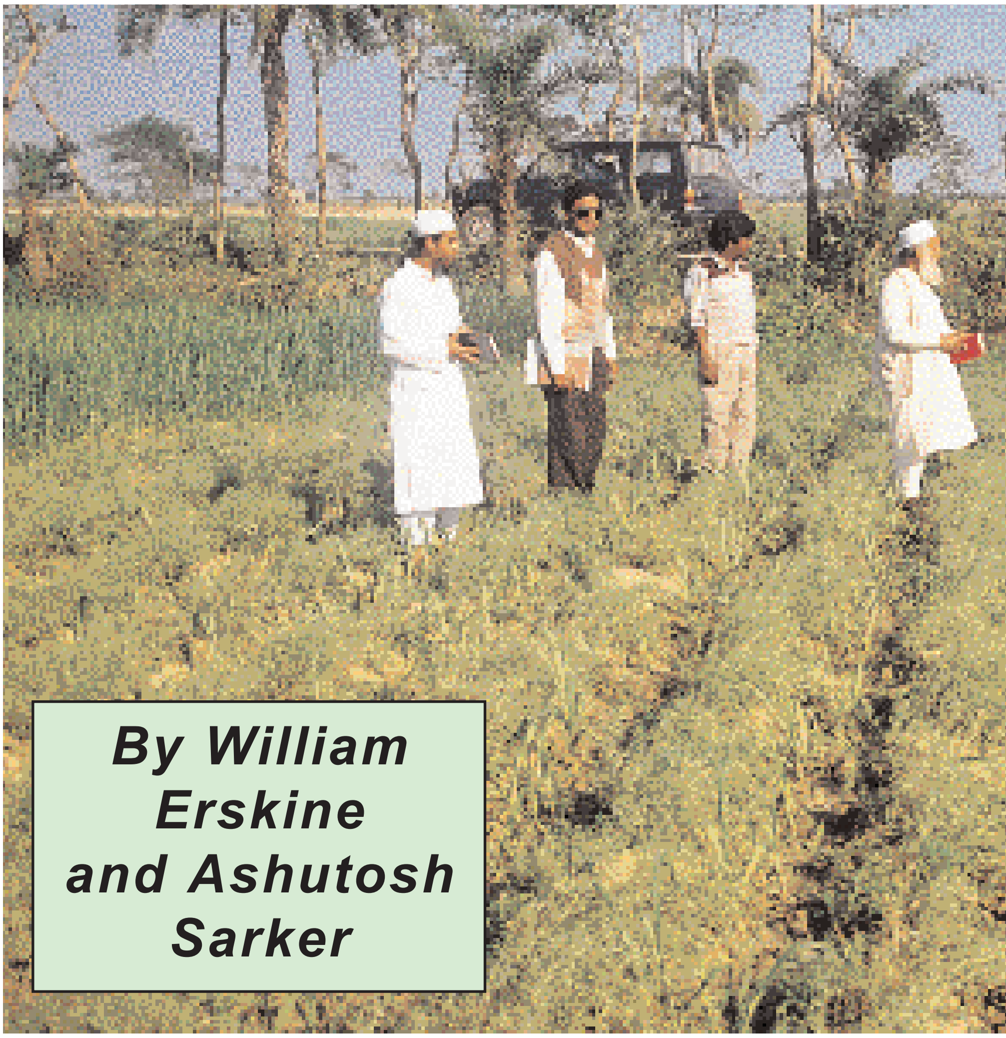
Bangladesh has made great strides in food production. Recently it has achieved a worthwhile improvement in productivity of lentil—one of its most important crops. And ICARDA had a part to play.

Lentil is the most important pulse in Bangladesh. It is the most popular pulse in both urban and rural areas, and rice with lentil soup (known as dhal) is often eaten in the villages; most people try to include it in their daily diet. So it is not surprising that Bangladesh is the world's fourth largest lentil producer, exceeded only by India, Turkey and Canada—all of which have a far greater land area. The sown area of lentil in Bangladesh is about 210,000 ha, giving a production of 160,000 tonnes at an average yield of 769 t/ha.

Even so, this is not enough. In 1994, according to FAO, Bangladesh imported 75,000 tonnes of pulses with a value of around US $19.8 million. This was high; the figure fluctuates, but there is an obvious need to improve production. This can not be done by increasing the sown area. In an intensive cropping pattern, lentil faces tough competition from cereals and oilseeds and from other winter pulses. Indeed, lentil is grown as a sole crop in Bangladesh but also as a mix or intercropped with cereals, oilseeds and sugarcane. Intercropping and mix-cropping are age-old practices, particularly in the north and north-western parts of the country. In this situation, an increase in production can come only from better yield.

About 25-30% of the lentil area is grown in the transplanted autumn rice/lentil cropping pattern, being sown from the last week in November to the first week of December. The late-sown local cultivars perform badly, not only from the short growing period but also due to disease. Lentil is also grown as a relay crop in rice fields under zero tillage. The overriding problem is disease—in particular, two diseases: Stemphylium blight and rust. Incorporating resistance to these would clearly be the key to greater productivity.

Lentil rust, one of the major diseases in Bangladesh, was first reported in 1974. The disease causes variable degrees of damage depending upon the time of its onset, and it varies from year to year according to environmental fluctuations. High humidity, cloudy weather, and 20-22^{o}C temperature are congenial for disease development. Disease often emerges in areas with a dense



By William Erskine and Ashutosh Sarker

canopy and luxuriant vegetative growth. In severe infection, the leaves are shed and the plants dry up prematurely. Disease attack starts from late flowering and continues up to early/mid podding stage. The fungus is autoecious—that is, it completes its life cycle on lentil plants only. Yield loss up to 70% has been noticed in farmers field.

Stemphylium blight, another serious disease of lentil, was first noticed in 1981. Since then the prevalence of the disease has been monitored in farmer's fields. Preliminary studies have indicated that the disease can cause up to 62% yield reduction. The disease emerges with the appearance of small pin-headed light brown to tan colour spots on the leaflets. The spots enlarge rapidly, covering the entire leaf surface within 2-3 days. The foliage and twigs gradually turn dull yellow, giving a blighted appearance to the affected crop. The infected leaves shed severely, leaving only the terminal leaves on the twigs. The twigs bend down, dry up and gradually turn ashy white, but pods remain green. The disease attacks the crop in early pod setting stage. Even the early pods fail to fill with seeds. The pathogen initiates its infection when the ambient night temperature remains above 8°C, the mean day temperature goes above 22°C and the relative humidity inside the canopy goes up to 94%.

The Bangladesh Agricultural Research Institute (BARI) started a lentil-improvement program in the early 1980s. Having established that the local landraces/cultivars were susceptible to

(Main picture, left): Intercropping with sugarcane—a common practice in Bangladesh. (Above): Total crop failure due to Stemphylium blight and rust.

these diseases, it tried introducing germplasm from India. This adapted quite well to local conditions, but was still susceptible. Input was needed from outside the region. In the mid-1980s, BARI started effective collaboration with ICARDA, which has a world-wide mandate to work on lentil. ICARDA was working on lentil for South Asia with the objective of getting round the yield limitations of local landraces, which showed less genetic development than their equivalents elsewhere; success was achieved in crossing for yield (see *Breaking the lentil bottleneck* in *Caravan* No. 4). BARI was an important partner in this, but for Bangladesh disease resistance was the specific problem.

ICARDA had germplasm with resistance to Stemphylium blight and rust, but it was not well adapted to conditions in Bangladesh. So the two institutions planned a joint crossing program to combine resistant material with locally-adapted landraces. Fourth-generation populations from ICARDA were selected for the target environment at BARI, and this resulted in a cultivar, Falguni (also known as Barimasur 2), which was released in 1993. Rust-resistant, it yielded 1.9 t/ha. This was followed two years later by Barimasur 4, which managed 2.3 t/ha against 1.3 t/ha for the improved local variety Utfala. Resistant to Stemphylium blight as well as rust, it has an erect plant stature which makes it suitable for intercropping in sugarcane, as well as mixed cropping with mustard; the latter is a widespread production practice for lentil in Bangladesh.

So far, Barimasur 4 is performing well for disease resistance, and there are another four lines with similar potential at the pre-release stage. Two of them have been identified as suitable for late planting in medium highlands after the harvest of autumn rice; the other two are intended for the main growing season. BARI reports that these will be released quite soon.

BARI has some cause for satisfaction. Rising yields nationwide tell their own story; in 1983, 147,000 tonnes of lentil were grown on 240,000 ha in Bangladesh. In 1994, production had risen to 163,000 tonnes, despite a smaller area (207,000 ha). It is ongoing work; a growing population will always need more food, while the pathogens that cause disease will continue to mutate, calling for constant identification of fresh sources of disease resistance. But for the moment, certainly, BARI is ahead.

Ashutosh Sarker

Dr William Erskine is Lentil Breeder, ICARDA. Dr Ashutosh Sarker is Post-Doctoral Fellow in Lentil Breeding, ICARDA, and was formerly Lentil Breeder at BARI, Joydebpur, Bangladesh, where he carried out the selections that led to the release of the Barimasur varieties.

Bread for the millions

By Guillermo Ortiz-Ferrara, Sanjaya Rajaram and Mike Robbins

Wheat (bread and durum) is the world's most important crop. It originated in ICARDA's home region. And it is as important there today as it is anywhere. ICARDA, its sister Center, CIMMYT, and the national programs have come together to make a real contribution to the region's wheat production—and improve the living standards of millions.

Bread wheat is the staff of life. It is the largest single source of human food. It covers a greater percentage of arable land than any other crop in the world. It was the first mainstay of settled agriculture. It originated in the West Asia and North Africa (WANA) region, and today that region consumes more bread wheat per capita than any other—185 kg per head a year, projected to rise to 219 kg by the end of the century. In fact, about 10%—47.8 million tonnes—of the world's total wheat production was grown in WANA in 1993. Of this, about 37.1 million tonnes was bread wheat; however, durum wheat is also significant. The WANA region is especially important because it produces about 63% of the bread wheat grown under drought conditions. And this is a food product; only about 7% is used for feed. So although CIMMYT—the *Centro Internacional de Mejoramiento de Maiz y Trigo*, based near Mexico City—has a world-wide mandate for wheat, it shares this with ICARDA in the WANA region.

Harvesting on ICARDA's 948-ha headquarters farm in Syria.

Between them, ICARDA and CIMMYT have had an enormous impact on wheat production in WANA and beyond. Three examples in the WANA region are particularly striking; those of Egypt, Sudan and Syria.

In the mid-1980s, Egypt's Agricultural Research Center (ARC) became concerned at the relatively low wheat yields in Upper Egypt—they were about 3.3 t/ha, which ARC felt was below potential. It identified the causes; they included poor agronomic practices, bottlenecks in seed supply and inadequate extension information. And, importantly, they included the use of traditional varieties.

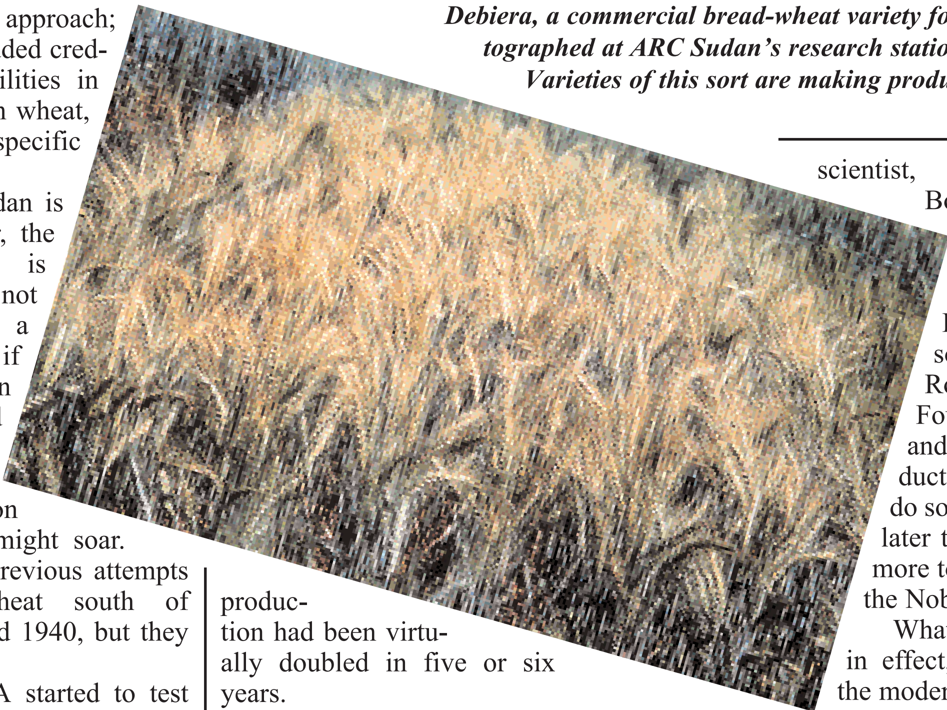
ARC had long had a productive relationship with ICARDA's Nile Valley Regional Program (NVRP). Through NVRP, ARC and ICARDA implemented a program of on-farm trials and demonstrations. After five years, farmers participating in the program saw yields of 6.3 t/ha. In the meantime, wheat production in Egypt as a whole was shooting up—by about 125% between the early 1980s and 1992. Over roughly the same period, the wheat area under modern varieties—many bred by ARC and the CIMMYT-ICARDA wheat program—rose from 32% to 83%.

In 1992/93, ARC and NVRP carried out a study* on the project in Upper Egypt (to be exact, in Sohag and Qena Governorates) to find out what the economic returns to the farmer of the new technology had been. Farmers who adopted the whole package could see returns of LE 4 for every LE 1 spent.

The study stressed that the rate of return on investment in technology had been raised by a series of well-timed reforms by the Government of Egypt; these freed up the market and greatly improved farm-gate prices—a demonstration of how holistic approaches to agricultural development will often achieve more than piecemeal improvement. Nonetheless, the results were also an impressive vindication of agricultural research itself as a tool for fighting poverty and raising productivity.

Meanwhile, scientists at ARC Sudan were also taking a hard look at bread-wheat production. Sudan was badly hit by the famine that struck the Horn of Africa in the 1980s, and since then has been working hard to achieve food security. Part of ARC Sudan's strategy was to raise lentil production, and in this it had considerable success; ICARDA's Nile Valley Regional Program was heavily involved in this (see *Lentil: How Sudan fought back* in *Caravan No. 2*). This was, again, partly

* The report, *Economic returns from improved wheat technology in Upper Egypt*, by Drs A. Aw-Hassan, A.A. Ali, M. Mansour and M.B. Solh, is available from ICARDA, price US $10.



Debiera, a commercial bread-wheat variety for Sudan, photographed at ARC Sudan's research station at Wad Medani. Varieties of this sort are making production viable south of Khartoum.

the result of a holistic approach; the Sudanese had included credit and processing facilities in their calculations. With wheat, however, they faced a specific problem.

The climate in Sudan is harsh. Even in winter, the daytime temperature is over 30°C. Wheat is not generally regarded as a heat-tolerant crop. But if bread-wheat production could be expanded south of Khartoum into the big Gezira and Rahad irrigation schemes, production might soar. There had been two previous attempts to bring bread wheat south of Khartoum, in 1918 and 1940, but they had failed.

ARC and ICARDA started to test heat-tolerant lines developed out of CIMMYT/ICARDA material. The best bet seemed to be Debiera, a cultivar of Indian origin, which is highly heat-tolerant. The next step was to transfer the resulting package of technology to farmers' fields; this was done with the help of Sasakawa-Global 2000, a Japanese/American NGO. By 1992, about 80% of Sudan's wheat area was planted to the new cultivar. Production of bread wheat rose threefold, to an average of around 600,000 tonnes. In 1992, it rose rather higher, giving Sudan virtual self-sufficiency. Since then, production has fluctuated, but it has never fallen back to its former level.

ARC Sudan's achievement in this has been tremendous. It was also a good example of partnership; Sudanese scientists made the breakthrough by, first, seizing the initiative in the drive to raise production, and second, by bringing in the international agricultural research centers and other partners. Something similar has happened in Syria. In the 1980s, wheat yield had risen to 1.5 t/ha, against 0.6 t/ha in the 1950s. However, Syria's Ministry of Agriculture and Agrarian Reform (SMAAR) knew that more could be done.

Syria was a significant bread-wheat producer for the ancient world. It helped feed the Roman Empire. SMAAR saw no reason why the country should not be self-sufficient again. By 1995 yield has reached 2.6 t/ha, and production had been virtually doubled in five or six years.

Syrian scientists had worked through the 1980s to breed new bread-wheat lines in collaboration with CIMMYT/ICARDA scientists. Analysis by SMAAR and ICARDA in 1995 suggested that these new lines were responsible for about 35% of the increase. The remainder came from better packages of agronomic practices, including fertilizer and irrigation, put together by Syrian researchers.

Egypt, Sudan and Syria—just three of the countries that have had success with wheat working with the CIMMYT-ICARDA joint dry-area bread-wheat program. Others include just about all those that have sought to increase wheat production in a hot, arid environment. And CIMMYT, of course, spreads its net even wider, playing a worldwide role in the fight to produce more bread. But the story begins long before the founding of either CIMMYT or ICARDA, going right back to the beginning of international agricultural research in its modern form.

"The earth is so lacking in life force; the plants just cling to existence. They don't really grow; they just fight to stay alive. Nourishment levels are so low that wheat plants produce only a few grains, and even the weeds and diseases lack the food to be aggressive. I don't know what we can do to help these people, but we've got to do something."

Thus wrote a young United States scientist, Dr Norman Borlaug, to his wife shortly after his arrival in Mexico in 1945. He had been sent south by the Rockefeller Foundation to try and raise wheat production. And he *did* do something; 25 years later the poor had a lot more to eat—and he had the Nobel Peace Prize.

What Dr Borlaug did, in effect, was to develop the modern science of plant breeding. His greatest success was to produce dwarf wheat varieties. In brief, wheat landraces the world over had become very tall, a result of generations of intercropping and other factors. This looks impressive, but a tall plant can bend over—and this limited the benefits from fertilizer. Dr Borlaug took Mexican plants he had bred for rust resistance and crossed them with dwarf varieties from Japan. The result was the spectacular yield increase which later became known as the Green Revolution, and which is thought to have saved millions of people in Asia from starvation in the late 1960s.

In the meantime, the shoestring operation with which Dr Borlaug had begun in Mexico in 1945 had developed into what is today CIMMYT. This had become part of the Consultative Group on International Agricultural Research (CGIAR), founded by a group of donors in Washington D.C. in 1971. In 1977, ICARDA was established to serve farmers in the hot, dry environments, and in the 1980s the two centers founded the CIMMYT/ICARDA joint dryarea wheat program for the WANA Region. As a very broad general rule, the CIMMYT side of the partnership produces lines for the better growing conditions in the region, while ICARDA concentrates on the tough marginal areas with rainfall of 500 mm or below.

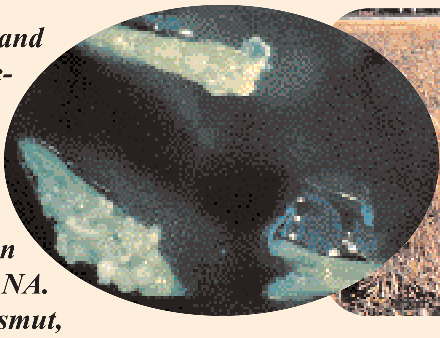
The program is not dogmatic about breeding exclusively for either irrigated or rainfed wheat; the latter is clearly more appropriate in a region where groundwater is now often scarce and/or saline, but in some areas (such as the Gezira and Rahad irrigation schemes in Sudan), irrigated wheat is not only the best but probably the only answer. Fortunately, ICARDA's research stations provide a range of conditions. Its facility at Terbol in Lebanon has long-term average rainfall of 600 mm, fertility is good and bread wheat is grown and tested under supplemental irrigation. But at another of its stations, at Breda in Syria, ICARDA breeds rainfed bread wheat under conditions of poor fertility and just 283 mm rainfall.

This variation is increased by the use of simulated environments on the main ICARDA research farm at Aleppo. Thus early planting, supplemental irrigation and high fertility can "bring on" a crop so that breeders can better test for disease resistance and frost tolerance. But late planting, low-input testing is also used to test for, amongst other things, tolerance to extreme heat. In this way, breeders can identify sources of resistance to a wide range of climatic extremes and pests and diseases.

This testing is backed up by a growing range of biotechnology tools. Gene mapping can pinpoint the source of resistance to (say) Hessian fly (a devastating insect pest in North Africa). But it may have been found in a line that lacks other needed characteristics. So the sources of resistance will be transferred into plants that do have those characteristics through crossing, and varieties rapidly developed through such techniques as double haploid breeding, which ensures that that trait is heritable—that is to say, that it will appear in the plant in each generation. Quality and nutritional value can now be assessed quickly using Near-Infrared Reflectance Spectroscopy, or NIRS, a tool which ICARDA is also using on a wide range of other crops (see *A broad spectrum of barley* in *Caravan* No. 2). Bit by bit, varieties are built up which incorporate an extraordinary range of desirable characteristics, of which outright yield will be just one, and perhaps not even the most important.

This reflects the change in approach over the last few years. Food supplies remain a grave concern all over the developing world today. But the objective now is to bring about yield increas-

Wheat and its enemies: a war of many weapons

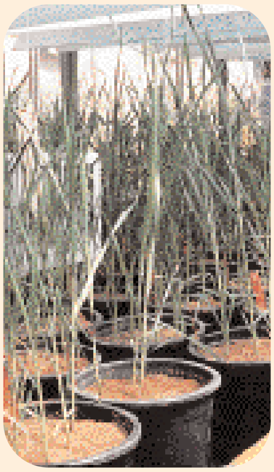


Common bunt (below left) and Septoria triticae (below, second left), important biotic stresses in Wana. Common bunt is an important seed-borne disease in farmers' fields; septoria strikes mainly in higher-rainfall areas of WANA. Below, second right: Loose smut, another important seed-borne disease. Below right: Yellow rust, a devastating foliar disease, especially in West Asia, and one of the worst enemies of wheat everywhere. The spring bread wheat program puts emphasis on developing germplasm resistant to these stresses.

Anther culture (above left), a biotechnological tool used by certain NARS and by CIMMYT/ICARDA in the spring bread-wheat program to develop Hessian-fly and drought-tolerant bread wheat germplasm. The anthers are the male organs of the plant; wheat is self-pollinating. Crosses are made in the field, using parents with different desirable characteristics; anthers are then taken from the first-generation. These anthers are cultured in media in order to develop lines which combine desirable characteristics. An example of this; three double-haploid bread-wheat lines developed using the anther culture technique.

This material is seen, above, at the J'maat Shaim station of the Moroccan national research organization, INRA, under a natural infestation of hessian fly. This is a devastating insect pest in North Africa causing 100% yield losses, especially in the dry areas of those countries. The material was from CIMMYT/ICARDA and is also tested in Syria. The three varieties are showing good resistance. Morocco, which makes its own double haploids, is now the lead country for development of Hessian-fly resistance, among other things, and has had considerable success.

Wheat and the sun: a question of timing



(Near right): Research at ICARDA on photoperiod (effect of duration of light on the maturity and development and phenology of the wheat plant). The CIMMYT/ICARDA program and its partners work as far north as Turkey and as far south as Sudan; there is an enormous difference in latitude and the duration of light during the crop season. Moreover, as it is developing heat- and cold-tolerant varieties, the program studies vernalization (the effect of temperature in the development of the plant).

(Far right): Wheat lines with different vernalization-sensitivity at Tel Hadya in summer . The green plants have excessive temperature-sensitivity and will never flower, while the yellow—early—lines are insensitive to vernalization and will flower. Both the national programs and CIMMYT-ICARDA use these techniques of exposing germplasm to different photoperiods and temperatures to identify germplasm with insensitivity to these factors.

es that will last over a wide range of environments, providing food security and using, rather than eliminating, genetic diversity in plant breeding. This is reflected in the fact that about 35% of the bread wheat crossing program is devoted to abiotic stress tolerance (that is, heat, drought, or cold) and about 44% towards pests and diseases. To do this, the CIMMYT/ICARDA program must test its products under an even wider range of biotic and abiotic stresses than the ICARDA stations can provide. So it screens at at least 75 different locations around the region. This system is called multilocation testing, a very powerful tool in the breeding program.

But the program could not do this on its own.

As can be seen from the examples of Egypt, Sudan and Syria, the program is based firmly around cooperation with national agricultural research systems (NARS). The philosophy is simple; support NARS, and then they will be able to help themselves. Some NARS may lack anything from farm machinery and transport to simple things such as labels and crossing bags. Sometimes the CIMMYT/ICARDA bread wheat project will supply items of this sort, as well as arranging training at ICARDA or CIMMYT headquarters or elsewhere. Over the years, this has led to a strengthening of national programs, so that they have taken a greater share in the collaborative program itself. This has led, for example, to the leading role Morocco now plays in the North African component; it has also had great success breeding for resistance to Hessian fly and Russian Wheat Aphid (RWA). Meanwhile Egypt has been identifying heat-tolerant varieties, and these can now be found in Sudan and Yemen as well.

Cooperation extends to networks for various pests and diseases; for example, on foliar diseases, viruses, heat tolerance and water-use efficiency, organized through ICARDA's Nile Valley and Red Sea Regional Program; collaborative research on entomology, with Morocco; farmer-participatory breeding, with Turkey and Lebanon; epidemiology, with Iran; germplasm characterization, with Tunisia and Turkey; wheat adoption studies, with Syria, Lebanon, Turkey, Tunisia, Morocco and Algeria; and a number of other areas covering, as far as possible, all the national programs in the region.

But perhaps the most exciting is the exchange of genetic material. As we have seen, one of the functions devolved to the national programs is the evaluation of CIMMYT/ICARDA international nurseries.

However, besides reporting on the program's products, the national programs are also supplying a growing amount of germplasm themselves for incorporation into the breeding program. This can include landraces and wild relatives collected by the national scientists in a wide range of environments.

The genetic material in these accessions is priceless. Since the start of the CIMMYT/ICARDA project nearly 20 years ago, about 21% of this material has found its way into the breeding program in one way or another. It finds its way out again in the international nurseries distributed by the program.

Thus a desirable characteristic could have been spotted, and exploited, by a peasant farmer in, say, 10th century Morocco; identified in a descendant landrace by a modern Moroccan scientist; gene-mapped in ICARDA's biotechnology lab; and incorporated, by way of a double-haploid cross, into a line containing another characteristic spotted, and exploited, by a Syrian farmer at any time since settled agriculture began in the region eight thousand years ago.

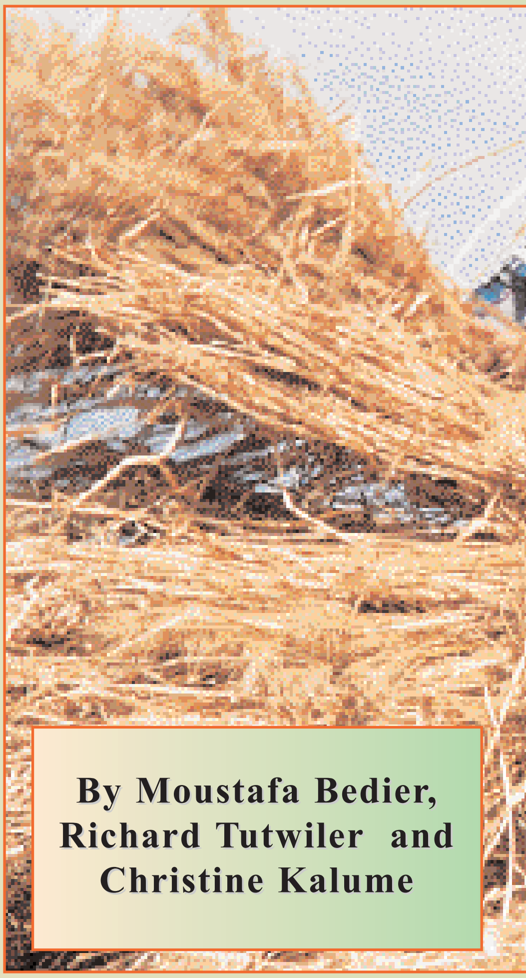
Together these traits, united in one breeding line, will go to the national program in Sudan or Turkey, and, if satisfied with its performance, the national program will release it to farmers. Through CIMMYT, this material will go even farther.

Earlier in this article, we said that the origins of the CIMMYT/ICARDA wheat program go back to the Green Revolution and beyond. We did not claim that it went back eight millenia. But perhaps it does. ■

Guillermo Ortiz-Ferrara was CIMMYT Bread Wheat Breeder and Regional Representative stationed at ICARDA for 14 years until June 1997. He is now CIMMYT's Wheat Breeder and Regional Coordinator for South Asia and is based in Nepal. Sanjaya Rajaram is Director of the Wheat Program at CIMMYT, Mexico. Mike Robbins is

Women: making their mark in the garden of Egypt

The Romans cultivated Egypt's western desert thousands of years ago. Since the late 1950s the Egyptian government has been bringing it back to life—bringing water and agriculture to the desert. Women farmers have been significant there, and are playing another pioneering role—helping the Egyptian Government, ICARDA and national institutions to ensure that farming in these new lands is sustainable. And they are having quite an effect on the research process.



By Moustafa Bedier, Richard Tutwiler and Christine Kalume

Fatma is a strong ally in the fight to make agricultural development sustainable. She is a farmer in the New Lands, reclaimed desert which the Egyptian Government has decided can be productive. Effective natural-resource management work can not ignore the role of women in the farming system. They are half the farming community. And Fatma, in any case, does not intend to be ignored.

She made her point on a hot day in Al-Amerria in Alexandria, Egypt. A workshop was being held as part of a project to monitor long-term sustainability of New Lands agriculture. The farmers taking part had been chosen with random sampling techniques to ensure that they were representative. Fatma was not one of them; however, when a participant in the workshop was on his way to pray, she stopped him and demanded that she be one of the farmers in her village being interviewed for the project.

The workshop was part of the long-term resource management monitoring ICARDA and Egyptian institutions are carrying out under the Egyptian component of the Nile Valley and Red Sea Regional Program (NVRSRP). With a population growth rate of around 2.6%, boosting food production (while providing employment and investment opportunities) are major objectives of Egypt's massive land reclamation schemes. Approximately 0.8 million hectares of Egypt's western desert have been turned into verdant gardens since the late 1950s by bulldozing the dunes flat, installing physical and social infrastructure, and bringing water via canals to the new farms. It is an inspiring project. However, the Government is well aware of the need to ensure that it is sustainable.

ICARDA has been involved since 1994, but has been doing similar work elsewhere in the region for a long time; the idea was to use this experience in Egypt.

This long-term monitoring of farmers, their fields and crops is being carried out in parallel with on-station rotation trials. The aim is to come up with effective, practical recommendations for sustainable farming in the three agroecological areas where the project is working: the Old Lands in the Nile Valley and Delta; the rainfed lands along the Mediterranean coast, and the New Lands, recently reclaimed from desert for modern, irrigated agriculture. Fatma's village is in El Bustan (in Arabic, 'the garden'), one of the two project sites in the New Lands. The area covers about 180,000 fedhans (1 fedhan = 1.038 acres or 0.42 hectares) of which 85–89 settlements covering 38,536 fedhans make up the study area.

The work is still in its early stages, but, in a land where women traditionally participate in farming as unpaid family workers or as daily laborers under the direction of men, what has most struck the researchers has been the success of women owning and operating their own farms in these New Lands—a phenomenon not so readily apparent in either the Old Lands or in the rainfed areas—and the active participation of the women in the project as Fatma's case illustrates.

The high profile of women in the New Lands is, in part, a result of the Egyptian government's deliberate poli-

Mahmoudh Solh

Richard Tutwiler

Development makes a difference. (Right): Part of the New Lands before agricultural development; (Left, below), as it is following development under the New Lands scheme.

cy of offering young university and higher education graduates, both men and women, the opportunity to own newly-reclaimed farmland. It is selling the land to the graduates who buy it with a long-term loan (like a mortgage). The goal is that the graduates find jobs (on their farms) and at the same time contribute to increasing national food production. A large number of women graduates took up the Government's offer—12% of land owners in Bangar Sukur and 10% in El-Bustan are women—often leaving their families in big cities like Alexandria or in small villages in the delta and valley for the first time. Yet the majority are still on their farms 10 years later and committed to making a success. And this in itself is newsworthy.

"I can survive here and I like the work," says Noura, a graduate woman farmer in Bangar Sukur, the second project site. Her sentiments reflect those of many of the women farmers in the New Lands. Now in her mid-thirties, Noura arrived in Bangar Sukur in the 1980s when she bought two hectares, a house and a cow through the government scheme, and she cultivated the land—mostly under barley—to pay back her loan. Bangar Sukur is very close to Alexandria and it is a popular place for city people to rent land for cultivation, but despite the economic incentives Noura has refused to lease her land to others. She proudly states that she has made her commitment and has no intention of backing out now.

Unmarried, she carries out most of the farm tasks herself, although she, like others, employs young women from the traditional farming areas along the Nile and its Delta region during periods of peak labor demand, particularly at harvest-time. Trucks filled with groups of brightly dressed and chattering girls have become a common sight on the roads in and around the New Lands. The demand for agricultural workers generated by new farmers like Noura not only indicates the success of the pioneering settlers in the New Lands, but also the benefits of land reclamation for the people of the nearby Old Lands. Agricultural development, based on the efforts of dedicated farmers like Noura and Fatma, is providing employment and increased income to other women too.

Continued on page 20

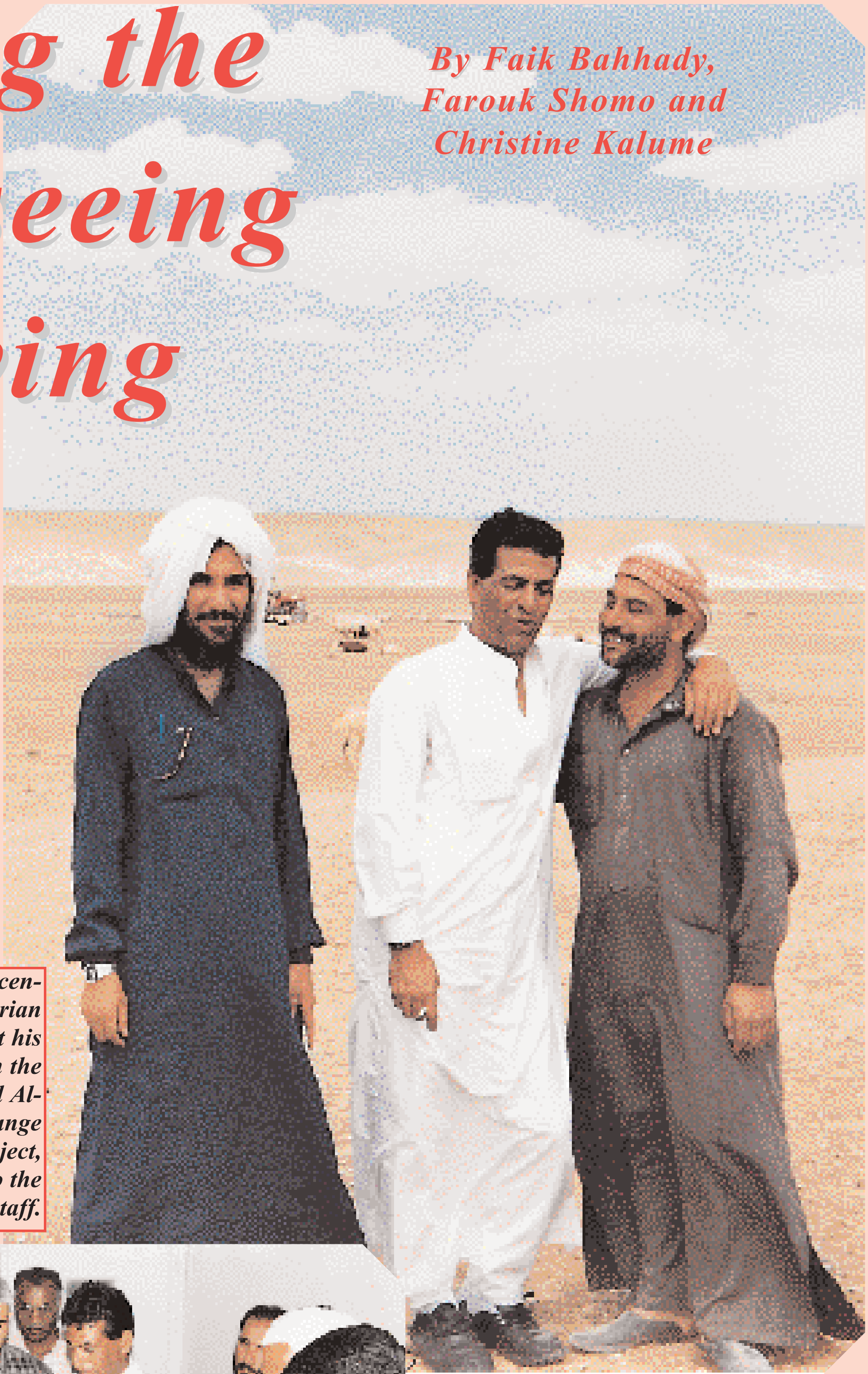
Richard Tutwiler

Rescuing the range: seeing is believing

By Faik Bahhady, Farouk Shomo and Christine Kalume

"I never knew I would see and learn so much—or that it would change my ideas. I now feel motivated to get back to my farm in Egypt and start rehabilitating a piece of the land by resting it, and reintroducing shrub plants like I have seen some of the Syrian farmers doing."

The speaker was Egyptian farmer Idris Yadam Nouh Hassan, from El-Negeila community in Marsa Matrouh, North-West Egypt. And words like his are music to the ears of ICARDA scientists and technicians who, working with the Syrian national program, had just organized a traveling workshop for Mr Hassan and other farmers from Marsa Matrouh.



(Right): These Egyptian farmers (left and center) found plenty to talk about with this Syrian farmer. They had stopped to ask him about his animals as the visitors traveled through the Maragha steppe. (Below): Mohammed Al-Hijazi, Director of the El-Mahasse Range Improvement and Water-Harvesting Project, Syria, explains a model of the project to the visitors and ICARDA staff.

Jamil Zarneji

Farmers can be sceptical about natural-resources management. Sometimes they don't believe it can be done. The answer? Show them. And, with the help of the Syrian national program, ICARDA has been doing just that.

The trip was another activity in the Marsa Matrouh natural-resources management project, an Egyptian Government project supported by the World Bank for which ICARDA is providing technical backstopping (see box, page 21). It is not the first such workshop—a similarly successful one was run on legumes/cereals rotation, amongst other things, in the spring (see *Farmers believe farmers* in *Caravan* No. 5). The latest workshop lasted some days and covered a variety of aspects of the farming system, including rangeland rehabilitation and water harvesting.

One of the gravest threats to natural resources in the West Asia and North Africa (WANA) region is the degradation of rangeland, or steppe, an essential resource for grazing; its loss also opens the way for desert encroachment (see *Caravan* No. 3). And one of the biggest problems facing government technicians working with the Marsa Matrouh project in northwestern Egypt is getting farmers to rehabilitate their rangeland. Farmers can see the reasoning behind it, but they don't know how they can do it in practice, given the already serious pressure of livestock and human populations on the land, and the fact that some of them are already using marginal land. For those who can cordon off parts of their land (i.e. whose land is not communally 'owned'), wouldn't they risk being refused access to other people's rangeland if they refused access to parts of theirs? And they are not sure of the long-term benefits of rangeland rehabilitation.

The other major problem technicians and farmers in the region face is the lack of water. The farmers rely on rain for their crops, and rainfall is limited—around 120 to 130 mm a year—varied and unreliable. Wells are problematic and, although some farmers have water cisterns, these still rely on rain; if there is no rain, there is no water in the cisterns. Most of the area has experienced drought this year and in 1996, and many farmers were forced to sell some of their livestock as they could not afford to buy feed or water. Others left the area to find grazing for their animals.

With these two problems in mind, ICARDA's Natural Resources Management Program and Human Resources Development Unit, in collaboration with the Egyptian government, organized a tour of relevant Syrian projects for five technicians and five farmers representing the five sectors of Marsa Matrouh—and significant individual farmers.

When the sheep move in the Syrian steppe, everybody moves. These young children are waiting for sheep to be loaded so that the family can move in search of better grazing for the animals.

Jamil Zarneji

The trip included visits to two Syrian farmers who, working with ICARDA, had decided to protect areas of their land—with visible success. The Egyptian farmers saw with their own eyes how it was possible to rotate the areas being protected and that, by avoiding grazing during the critical seeding period, it was possible to have quite dramatic results.

The message about rangeland protection was reinforced by their visit to El-Talila National Park, where Mohammed Mireh of the Food and Agriculture Organization (FAO) explained the Syrian government's Italian-funded project to rehabilitate the rangeland and reintroduce wildlife into the park. The idea is to concentrate on degraded but high-potential rangeland rather than rangeland which is naturally poor. As Mr Mireh told the group: "80–90% of land acts as a watershed for high potential areas of rangeland." The project is initially concentrating on 130 hectares of the 22,000-hectare park, of which small areas are being cordoned off and rested to allow rehabilitation. Bedouin are still allowed to graze their animals in some areas, under the project's supervision.

In addition to monitoring changes in vegetation as a result of protection, the project has an active seed-production program. Natural range does not seed every year, as it does not produce every year, usually because of low rainfall. So the project ensures a constant supply of seed for sowing in a good year. Mr Mireh particularly favors *Salsola vermiculata* (shrubs) and *Atriplex leucoclada* (saltbush) and has found direct sowing in a good year very effective. The farmers were soon sharing their experiences with saltbushes and shrubs on their farms—especially the decreasing diversity as a result of overgrazing.

Some of the farmers could remember when *Atriplex* species (saltbushes) and artemesia covered large parts of their range. But these have all but disappeared now, and in dry years, farmers are often forced to sell their livestock as they cannot afford to buy fodder and water to carry them through the drought—which shrubs and saltbushes used to help them do.

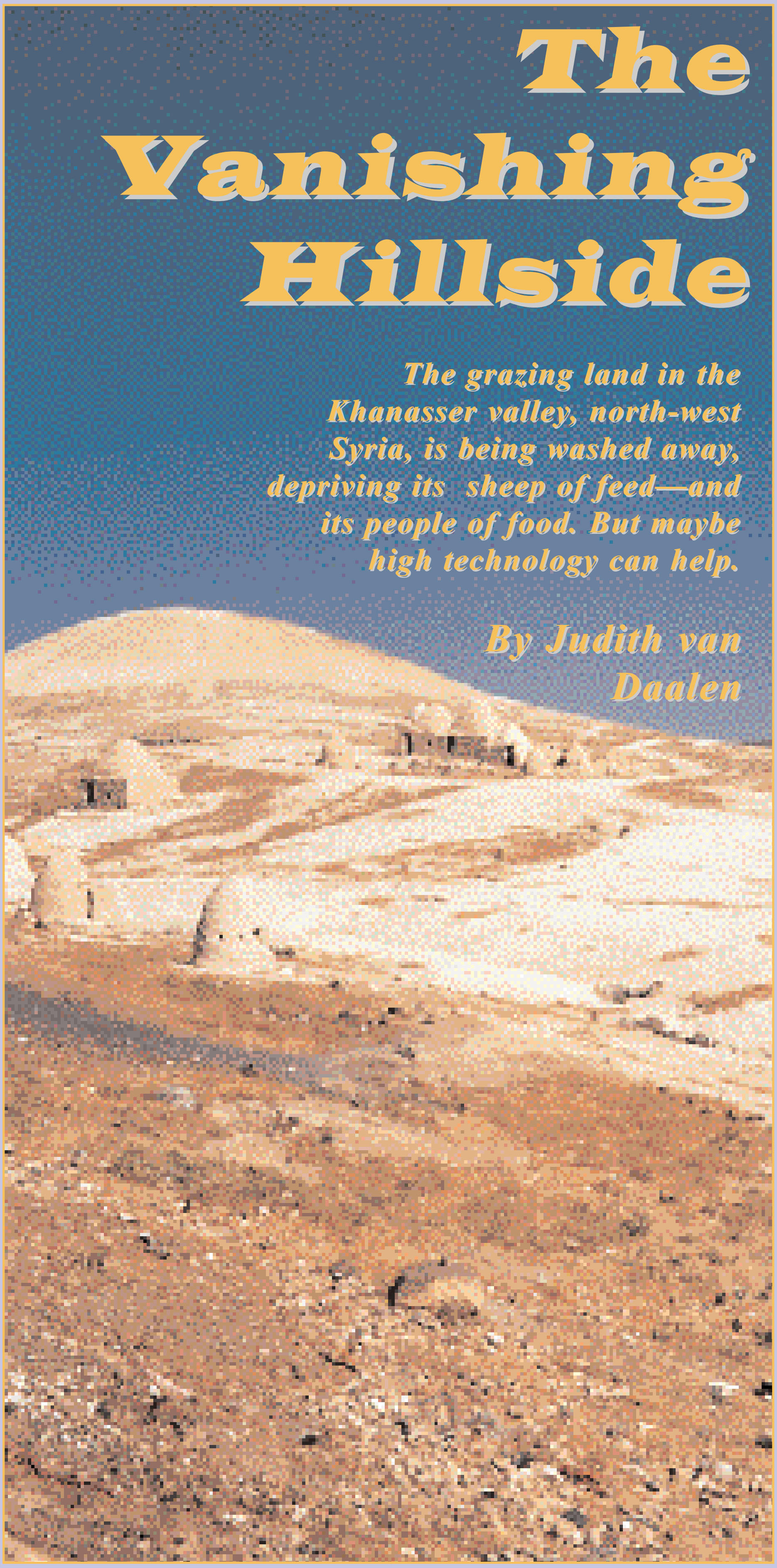
The farmers were therefore very keen on their visit to El-Mahasse Range

Continued on page 21

The Vanishing Hillside

The grazing land in the Khanasser valley, north-west Syria, is being washed away, depriving its sheep of feed—and its people of food. But maybe high technology can help.

By Judith van Daalen



Judith van Daalen

Khanasser valley lies about 40 km east of Aleppo in north-west Syria. It's a wide valley between two low hills—Jebel El Has, about 550 m, to the west and Jebel Shebibe, about 400 m, to the east. The valley floor is used for the cultivation of barley, some wheat with supplemental irrigation, and a very little irrigated cotton. On the slopes of the hills, farmers graze their sheep.

It is a harsh environment. It is hot and exposed. In many parts of the area, the ground water is now too saline to drink, and drinking water must be brought from Aleppo. And there is a real problem with grazing. Beyond Jebel Shebibe lies the steppe, on which farmers have traditionally grazed their sheep. They are no longer permitted to do so. This is a conservation measure; large areas of the steppe in the region has become overgrazed, and the authorities have been forced to close off parts of it to allow the natural vegetation to regenerate.

In the case of Khanasser, however, the problem has simply been moved elsewhere. Now the sheep which grazed east of the area also graze on the valley slopes, leading to even more overgrazing of the valley. The slopes of the two jebels have thus been badly affected by water erosion.

Water erosion is a real threat in the region. This may seem curious; surely the problem in the dry areas is too little water, not too much? The problem is that such rainfall as there is, is poorly distributed in time and space. The Mediterranean has winter rainfall, and for much of the year it does not rain at all, but at other times there may be violent precipitation for short periods. This is particularly harmful if the soil surface is not protected by vegetation, such as directly after the dry season. The impact of the rain on the surface may itself loosen the surface, rendering the soil vulnerable to removal by water flow. Where the flow concentrates in channels, this may lead to the formation of erosion rills and gullies, down which further soil will be pushed by the flow. Heavy runoff down bare overgrazed areas may remove so much soil that the grazing will never regenerate.

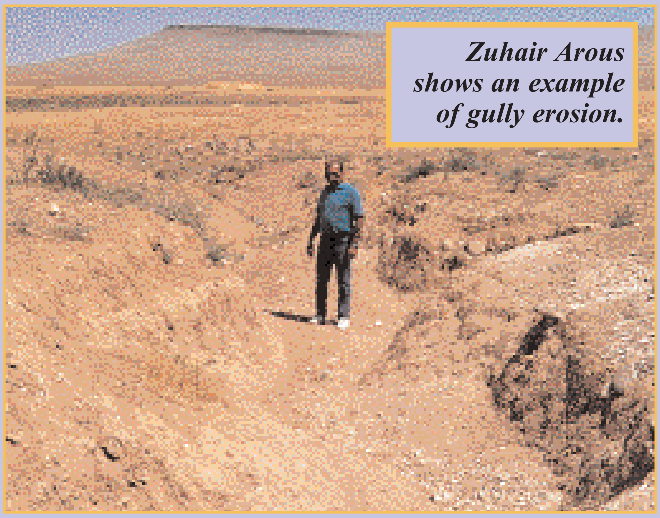
If researchers are to find ways of halting this, they must first understand exactly what is happening. We decided to model the major biophysical factors involved by collecting data on topography, rainfall, soil-nutrient and organic carbon content, and the soil's capacity to hold water. Having done this in a number of locations, one can then enter this data and, using a Geographical Information System (GIS), create a graphical model from which the scientist can see at once the state of the soil in given locations, and the factors that might have influenced it.

Before describing what we did, it is important to state what we did *not* do. Water erosion, like other natural phenomena related to agriculture, is not solely a matter of biophysical factors. Socioeconomic factors are crucial. They were in this case; we guess that the problem has been worsened by overgrazing. It follows that the short answer is to get the sheep away from the affected area. But this may not be possible; after all, they had already been moved on from somewhere else! Agricultural research has to be holistic. We confined ourselves to biophysical factors because we only had three months in which to carry out this work and our resources were limited; moreover the objective was to construct and test a GIS model, no more. This is worthwhile in itself, provided one does not imagine that it will give all the answers.

First came a reconnaissance field trip to get an impression of the area. Before one can decide which measurements can be taken, it is necessary to have a good look around. With the help of local farmers, and a colleague (Zuhair Arous of ICARDA's Natural Resources Management Program, who knows the area well), problem areas were identified and an outline made of the study area. Without this local knowledge, the first stage would have taken far longer.

At this stage, the first overall information model could be made. A selection was made of the most important biophysical factors of water erosion: climate, topography, vegetation and soil and their underlying details. This was the first start of the descriptive water erosion model. Out of the model, the assessment criteria and the extent to which they could be measured were defined. Out of these data were selected which could be collected in the time available to construct a more detailed model.

Back in the field again, the data collection began. The area chosen was a square kilometre; within it, we took four transects—these being lines from the high slopes down to the valley floor below, each a kilometer long, and 250 meters apart. Measurements were taken at ten 100-meter steps, called intersects. Given four transects, there were therefore 40 intersects. The exact location of these intersects was then fixed for mapping purposes with the use of a GPS (Global Positioning System) receiver. The degrees of slope between the intersects were also established using an inclinometer.



Zuhair Arous shows an example of gully erosion.

Judith van Daalen

There were two basic types of sample taken at the intersects: disturbed and undisturbed. A disturbed sample is simply a sample of earth removed from the ground; an undisturbed sample is one lifted as a core within a cylinder, so that soil structure is preserved in the sample. The latter method is necessary to measure the water-holding capacity.

The disturbed samples, however, are quite adequate for chemical analysis. We were looking for the main nutritive elements contained in the soil: nitrogen, phosphorus and potassium (NPK).We were also testing for organic matter content. Variations in this data are not necessarily because of water erosion, but they will help us to assess to what extent the area of a given intersect has been affected by nutrient depletion—which may be caused by water erosion—and how much potential there is for rehabilitation.

The undisturbed samples helped us check the water-infiltration rate. Soils with a low infiltration rate will generate more runoff and are more vulnerable to erosion than soils which can take up water quickly. All this data was entered using a GIS software called ArcInfo, which allowed us to see a picture of the area in terms of soil condition while viewing, for instance, the degree of slope at the same time. The results were revealing. Soil nutrients and organic matter were low everywhere in the sample area. But they were especially so in areas of ancient, abandoned terracing.

Thus, within this square kilometer, an area was found with a very low degree of fertility where further agriculture is almost impossible—on the transect which ran through this terracing. It might be argued that, okay, this is obvious, people used those lands for years, so they are worn out. This might be true, but the real point is that the modeling method allowed us to quickly identify the areas where agriculture is not possible any more. With the help of GIS, these areas can be subjected to fast visual comparison. It can help give an idea of which sites are worthy of further attention, and which are a waste of time.

To test this model properly requires multidisciplinary work; it is also necessary to place what is found within its socioeconomic context, which we did not attempt to do. But the experience in Khanasser suggests that it is worthwhile. GIS is an appropriate tool for natural-resource monitoring and management.

There is something else that must not be forgotten, though. A GIS model is only as good as the data the scientist gave it. She must still go out into the field, and get her boots dirty.

Ms Judith van Daalen is completing her MSc work at the Agricultural University of Wageningen, The Netherlands. *The resources monitoring and land management research in the Khanasser Valley is implemented by the Natural Resources Management Program (NRMP) of ICARDA. This work, carried out in May-July 1997, was part of this research.*

Continued from page 15

Hallah is another remarkable success story. A graduate with a degree in agriculture, she originally came as a pioneer to El-Bustan with her father (who was not a farmer but a retired employee of the electricity company in Alexandria). She settled on two hectares equipped with drip irrigation facilities and a greenhouse. Hallah's dedication to developing her farm to serve as a model to her neighbors bore fruit in more ways than one. She became a leader in the area and the first point on the itinerary for important guests, and she made a record of each of her farming activities, the time and expenses incurred, and her returns. This so impressed visiting officials that before long she was offered scholarships for additional training and studies in Egypt and abroad. Her father has taken greater management responsibilities on her farm in order to allow her to pursue her professional farming career. This is indeed a reversal of the traditional gender roles in Egyptian agriculture.

At first glance, Mouna presents a more traditional picture. Her husband, Hassan, a college graduate and part-time mechanic, is out in the field, so she invites the researchers to her house to sit and wait. Amidst the bits of machinery and spare parts, which clutter the compound, her two young children play. But as the researchers start talking with her, they learn that Mouna is also a graduate with a Diploma in Commerce, who came to El Bustan from Buheira—near El Bustan, but in the West Delta area of the Old Lands—in 1988. She has, on loan from the government, a two-hectare farm—as big as that of her husband (although now they are farming the two pieces of land together). Moreover, she knows all about the farm management, inputs, decisions, market process

As well as being active farmers, the researchers have also been struck by the women's very active role in the research process, which has actually forced the researchers at some points to rethink their approach.

"If you don't give me the information I'm asking for about my land, and if you aren't honest with me, how can you expect me to be honest with you?" Noura, the farmer from Bangar Sukur, asked researchers during her participation in one of the project workshops. The team of social and biophysical scientists had encouraged the participation of farmers such as Noura in the research, but where were the boundaries? It is widely accepted that farmers are in reality researchers themselves, constantly experimenting on their farms for the best results. But what would happen to the scientific aspects and controlled experiment nature of the monitoring exercise if the farmers began to act on the research findings and actually start to experiment with different resource management options, as intelligent and determined people like Noura are bound to do? Clearly, the more that farmers like Noura and Fatma participate in research, the less clear the distinction between farmers and researchers becomes.

In Fatma's case, the issue was over the necessarily limited number of farmers who could be included as direct participants in research activities. The project had already used random sampling to select participants to answer the carefully prepared questionnaires.

And yet, in the face of Fatma's fierce argument, they had to concede the point. According to the selection criteria, she *was* as suitable for inclusion, if not more suitable, than others. After further lengthy discussion, the project team agreed to include Fatma as a participant.

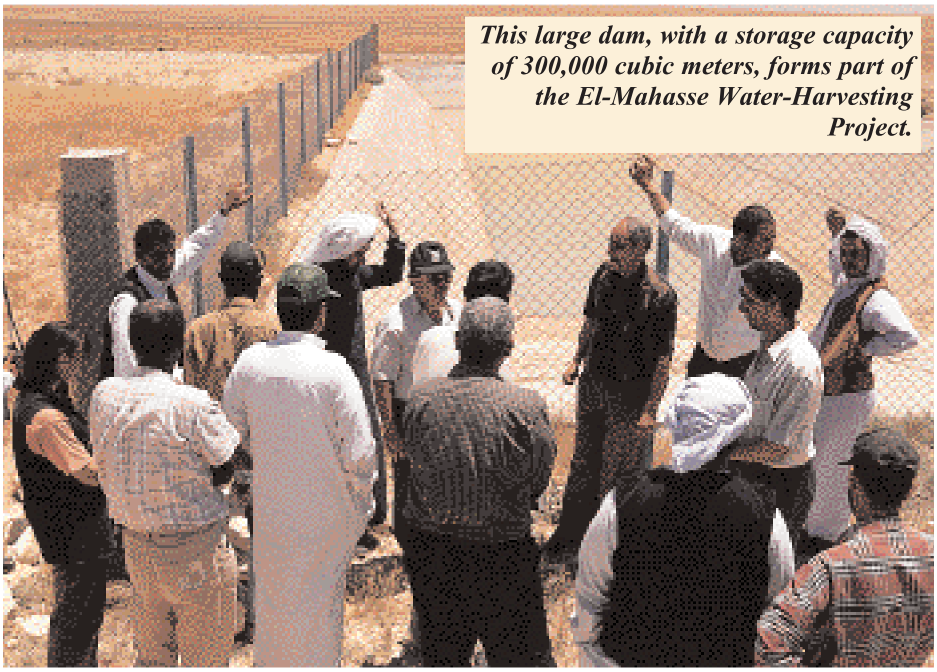
Farmer participation in agricultural research is often a case of farmers selecting themselves as participants, rather than researchers being allowed to select farmer participants on predetermined scientific, objective criteria.

These are some of the problematic situations that arise when researchers truly encourage farmer (male and female) participation in research. However, the benefits of such an approach are also apparent. Fatma, like other community members, saw the project as important and was motivated to be a part of it. The relationship between the researchers and the farmers is good, and the latter are keen to provide information and to assist in the researchers' work.

The NVRSRP and the national program's research in Egypt's New Lands is a good example of the need to uncover women's often invisible contribution to agriculture. It also illustrates another factor in natural-resources management: If you encourage people, including women, to participate, they may actually start to define the research process. And that can only make the research more relevant. ■

ICARDA scientists such as Dr Moustafa Bedier (center) are monitoring the long-term sustainability of farming systems in the New Lands.

Dr Moustafa Bedier is Socioeconomist in the Nile Valley and Red Sea Regional Program of ICARDA, based in Cairo.Dr Richard Tutwiler is Socioeconomist in the Farm Resources Management Program of ICARDA. Ms Christine Kalume is Science Writer/Editor, ICARDA.



This large dam, with a storage capacity of 300,000 cubic meters, forms part of the El-Mahasse Water-Harvesting Project.

Jamil Zarneji

Continued from page 17

Improvement and Water-Harvesting Project managed by the Syrian Ministry of Agriculture and Agrarian Reform, Directorate of Irrigation, which consists of a large water-harvesting and catchment project. Rainfall is measured and harvested over 1000 hectares, then spread and collected through a complex system of contour ditches and small dams before ending up in a large dam with a storage capacity of 300,000 cubic meters of water, and five large cisterns, with a total storage capacity of 11,000 cubic meters, used to supply water for animals. The project has planted 16,100 olive trees and 4500 pistachio trees. The farmers were particularly interested in looking at rainfall-use efficiency of fodder and fodder/shrub rotations. This complemented their discussions with farmers working with ICARDA and practicing fodder-vetch rotations in El Bab 60 kilometers northeast of Aleppo, Syria (see *Shrubs could help save the steppe* in *Caravan* No. 3).

As Idris Yadam Nouh Hassan said, seeing is believing. For Egyptian technicians like Salama Abdel Rahman, who traveled with the party, a large part of their problem had been solved; the farmers understand what they were suggesting. And they now knew that it could work, for them, their households, animals and for the environment on which they depend.

Mr Faik Bahhady is Assistant Livestock Scientist in ICARDA. Dr Farouk Shomo is Economics Research Associate, and Ms Christine Kalume is Science Writer/Editor, ICARDA.

Marsa Matrouh: collaboration for natural-resource management

During the first year of ICARDA's Technical Assistance to the Matrouh Resource Management Project (MRMP), significant progress has been realized in the field of farming systems research and development. Between 9 and 12 June a team of ICARDA scientists headed by the Director of International Cooperation, Dr M. Solh, went to Matrouh for the first Annual Meeting with the project's management and scientists, and the World Bank Advisory Panel, to discuss the 1996/97 project achievements and the workplans for 1997/98.

It is a large area, running 400 km along Egypt's north-west coast and extending 50 km inland. It is not an easy environment; with rainfall as little as 130 mm a year, farmers' options are limited.

A number of ICARDA's scientists have been working with their Egyptian colleagues in Marsa Matrouh during the last year. Activities during May, for example, included identifying and characterizing the major farming systems and assessing their distribution, defining agroclimatic constraints and socioeconomic problems, and identifying what are called "recommendation domains;" the latter help scientists target research and development activities.

According to ICARDA's Dr Abdul Bari Salkini, who carried out this work, very impressive development in farming systems has taken place in the region over the last few decades and what not so long ago was a totally nomadic grazing system has developed into a variety of sedentary farming systems. The region's closeness to the Mediterranean sea moderates the harsh environment, and this, plus not excluding human aspirations, have been significant factors promoting these changes in farming systems.

The first change in the traditional bedouin grazing system was the move to a barley and livestock farming systems; then, fruit tree production (mainly figs and olives, with some almond and grapes), and other crops, including wheat, and some vegetables were introduced and developed.

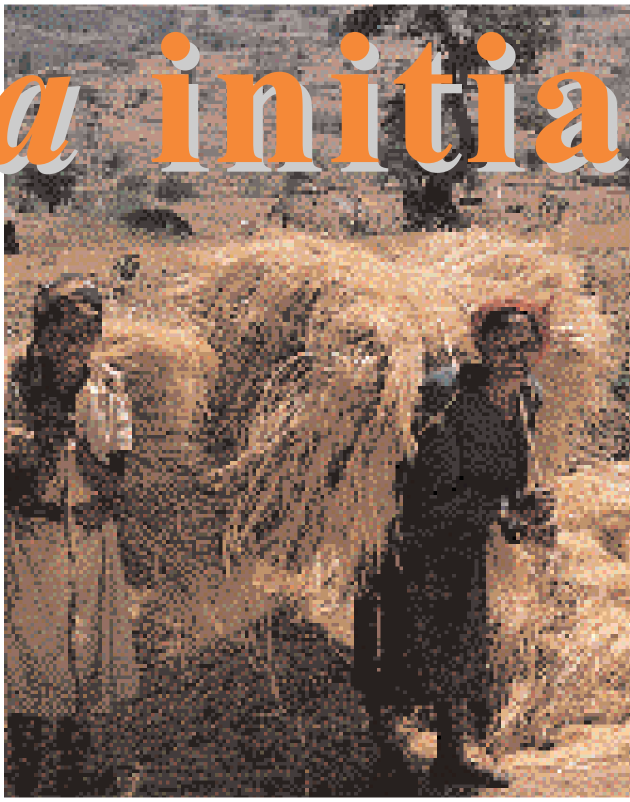
What is also impressive in Matrouh is the adoption of participatory approaches to farming systems research and development. The region has been administratively divided into Sub-Regional Support Systems (SRSC), and the households of each SRSC are administratively grouped into Local Communities (LC). All research and development activities of an LC are planned and implemented by its Committee, which is elected by all the households, in collaboration with representatives from the respective project departments.

ICARDA's assistance to the project covers a wide variety of disciplines; anything, in fact, involved in natural-resource management.

While Dr Salkini was at work in the field, his ICARDA colleague Dr Ahmed Mazid was training Egyptian colleagues in statistical analysis of agronomic and socioeconomic data.

Meanwhile, other ICARDA scientists are involved in a variety of activities—from range management to soil erosion.

The *injera* initiative



Reliable seed supply is a cornerstone of food security. Centralized supply systems find it difficult to meet the needs of subsistence farmers. But farmer-saved seed has its drawbacks. An appropriate compromise is needed. The Ethiopian Seed Enterprise seems to have found one for *tef*, the major subsistence crop in Ethiopia. It recently worked with ICARDA to assess the scheme—which could be a transferrable model for other regions and crops. Now it is being extended to one of ICARDA's most important mandate crops—food barley for subsistence.

By Sam Kugbei and Abeba Fikru

Seed supply is a frequent, and serious, bottleneck in improving crop varieties for resource-poor smallholders. This can be as great a constraint to adoption of improved varieties as any other factor. Centralized seed production systems aren't always very effective in providing seeds for specifically-adapted crops, which are needed by small-scale farmers in order to provide food security. Centralized systems inherently limit the number of varieties available, they may not have outlets in the right place, and their efficiency may vary (although it may of course be excellent). The private sector is not usually an alternative for subsistence farmers, who can not pay a price that would make commercial seed production worthwhile.

This problem is exacerbated by the fact that, in ICARDA's view, subsistence crops must be specifically adapted for location and inputs, or they won't give the yield stability needed by the very poor. This can expose them to famine. So biodiversity must be kept in the field as well as in the genebank—a policy being energetically pursued by ICARDA in its barley-breeding strategy (see *Three Among The Millions* in *Caravan* No. 4).

As an alternative, farmers can fall back on farmer-saved seed, either theirs or their neighbors'. But this does have disadvantages. The seed itself may not be quite what it appears, and supply may not be completely reliable.

ICARDA's Seed Unit works with small farmers to seek alternative cost-effective approaches to seed production and distribution within rural farming communities. To this end, a study on an innovative seed distribution system is currently underway in Ethiopia in cooperation with the Ethiopian Seed Enterprise (ESE). The scheme has been designed around *Eragrostis tef* (commonly known as *tef*), a crop on which ICARDA does not work, but the seed system is likely to be transferrable to other crops. Partly as a result of ICARDA's input, ESE is now extending the scheme to barley, for which ICARDA has a world-wide mandate. In the meantime, some explanation of what *tef* is, and what it is used for, may help put the ESE experiment, and how it began, in context.

Injera for breakfast, *injera* for lunch, *injera* for dinner—it's the favorite daily dish for most Ethiopians. The basic ingredient in *injera*, a pancake-like local bread, is flour produced from the grain of a cereal called *tef*, one of the tiniest of cultivated grains. *Injera* is consumed by Ethiopians, irrespective of where they are, and provides a highly-nutritious diet, being rich in protein. It also contains a good balance of essential amino acids—with the exception of lysine. This is essential to growth, but local people are well aware of the deficiency and supplement *injera* with an accompanying soup or *wot*, prepared from ground pulses such as lentils, chickpea or faba bean. This eating habit is reflected strongly in a farming system where almost all small farmers cultivate a variety of crops—including *tef* and food legumes.

Tef is characterized by a great wealth of genetic diversity, with many wild relatives currently being used in crop improvement work such as yield enhancement and drought tolerance and disease resistance. This diversity makes it all the more worthwhile to devise a seed-distribution system which does not reduce the genetic variation to be found in farmers' fields.

There is a specific problem with seed production in *tef*. Maintaining pure unmixed seed of white and red *tef* is as important as obtaining high yield. Consumers, particularly in urban areas (there is some commercial production), prefer white *tef* and are prepared to pay up to 50 per cent mark-up in price over the red for the white type. Consumer preference for white *tef* seems a purely

Sam Kugbei

From tef *to barley. Top left: Women carrying* tef *to the threshing floor after the harvest in Ginchi, Western Showa, in December. Above: Storage facility at Addis Alen made of stakes and* tef *straw; cool, and raised to give extra protection, it is very effective. Left: ESE's scheme is now being extended to barley-seed production, initially involving about 50 farmers in Gondar. Below: Members of an external review team, led by a Dutch donor representative (center), study the Barley Improvement Project run by the Ethiopian national program and ICARDA. The project's goal—sustainable crop development through the use of landraces—would be assisted by the seed distribution system that ESE has developed.*

Majed Khatib

Mahmoudh Solh

Sam Kugbei

Selling* tef *at a local store on the road from Debre Zeit to Addis Abeba.

market issue and appears to have little to do with differences in taste or nutritional value. Farmers usually grow both types, keeping red *tef* for home consumption and taking white *tef* to the market. It is essential to ensure that the two types don't mix.

Keeping pure seeds of both forms is difficult, but possible, since *tef* is self-pollinating, and is not known to undergo out-crossing. Admixture of white with red *tef* often arises from mechanical causes, such as volunteer plants in the field, poor cleaning of threshers or processing equipment between varieties, mixing of seed on threshing and drying floors, and use of old sacks for seed storage.

The Ethiopian Seed Enterprise (ESE) has found that attempts to produce seed on contracted state farms has resulted in large stocks of 'mixed material' which is of far inferior quality compared to white *tef* produced from local varieties by small farmers. An innovative approach by ESE of contracting smallholders to produce certified seed of *tef* holds a lot of promise: it generates income for peasants in the rural areas, creates a community of seed producers, and helps develop effective distribution mechanisms that could spread improved cultivars through farmer-to-farmer exchange. ESE purchases part of the seed produced by growers, providing income for the contracting farmers. At the same time, the latter are encouraged to distribute seed through local exchange mechanisms to other farmers in the community. This helps to build a sustainable seed-supply system that strengthens the informal sector and links it well to the formal sector, while enhancing indigenous capability in quality seed production. The pilot scheme has now been underway for a few years, and involves about 150 farmers, including some women farmers, with around 0.5 ha each. They are happy about the role; contract seed production is something they have always associated with larger, well-to-do farmers, and they regard it as prestigious. There has been growing evidence of farmer-to-farmer exchange, with seeds being given in exhange for crops rather than cash.

Recently ESE decided that it was time to expand the scheme to cover other major *tef*-growing areas in Ethiopia. But it was thought wise to assess progress so far before this was continuing; and this was done in collaboration with ICARDA.

It is logical to think that if smallholders were to become successful contract growers, this would provide a more reliable source of improved/certified seed for resource-poor farmers. Even more important, this could be a useful linkage between the formal and informal (traditional) seed sectors, a hitherto rather loose relationship.

ICARDA's survey amongst *tef* growers in Ethiopia suggests that ESE's methodology works, and could provide a good model for other countries and crops. But ICARDA also identified some effective ways of promoting this village-level seed production, while fostering functional relationships with formal sector institutions.

Firstly, instead of seed enterprises establishing direct contacts with small farmers, it is more effective to cooperate with extension agents of the Ministry of Agriculture, who often already work with these farmers in various aspects of general agriculture. These agents will, however, require some seed-specific training to assist their advisory function.

Secondly, it has been observed that small farmers do not rely solely on messages from extension agents; they prefer to see things for themselves in the field and learn from experience. This means, that prior to initiating a contract scheme, on-farm demonstration of new varieties is useful; moreover, this encourages collaboration between extension agents, seed staff and farmers.

Thirdly, where credit is required, this should be given in kind (e.g. foundation seed, fertilizer, herbicide, etc.) as much as possible to minimize misuse of funds, often a risk with cash advances. Moreover, such credit should be channelled through extension agents to local organizations such as Peasant Associations, and not given to individual farmers. It is recognized that peer group pressure within farmer organizations tends to encourage partnership, motivate farmers to work hard, and hence pay back their loans.

Fourthly, almost all small farmers generally save their own seed for planting the following season. In the event that they are short of seed, their best alternative source is a trusted neighbor whose crop they have already seen growing in the field. If this source is not available, they then proceed to the nearby local market where a wide range of grain is sold for seed from which they can choose. This, of course, indicates that a village market place is an ideal location for an outlet selling seed to small farmers.

A fifth conclusion was that simple attempts at crop improvement—in this case, merely preventing physical admixture of red and white *tef*—can produce a superior, commercially- competitive material. It has been shown that even at subsistence level, sowing of clean, pure seed, followed by careful crop husbandry and post-harvest handling, and use of simple cleaning and storage facilities may be all that an ingenious farmer needs to develop a sustainable small-scale seed enterprise for *tef.*

ESE's innovation in contracting smallholders to produce *tef* seed has only been going a few years, and more time is required to demonstrate long-term sustainability. But the positive report from ICARDA's investigation has encouraged ESE to extend the scheme to food barley, which is grown for subsistence. About 50 small-scale farmers are involved for the 1997-98 cropping season, in the province of Gondar. ICARDA's work on barley in Ethiopia has stressed breeding from local landraces, and this type of distribution system would help preserve them.

The bottom line in making this work sustainable is a close partnership between researchers, seed technologists, extension agents, economists and farmers, all working together to remove constraints to *tef,* and now barley, production and improve quality.

ICARDA's Seed Unit, and the WANA Seed Network it coordinates, could play a major role in this. ESE could find that its work is, indirectly, protecting farmers from seed shortage and even famine a long way from the Horn of Africa.

Dr Sam Kugbei is Seed Economist, ICARDA. Mrs Abeba Fikru is Head of ESE Finance Section and Coordinator of ESE/ICARDA collaborative work in seed economics.

Training the trainers: an investment in the future

Cooperation between ICARDA's Seed Unit and ESE is not confined to research. Ethiopia is also a partner in an extensive training program which ICARDA coordinates. Since 1990, a "train-the-trainers" approach has been built in to the program. Like many of the Seed Unit's activities, it receives strong support from the German development organization, GTZ, and DGIS of The Netherlands. An excellent example of just how the successful "train-the-trainers" model should work was a follow-up course in economics of seed production, held recently in Addis Abeba, Ethiopia.

A record number of 32 senior officers from across the country (selected from diverse backgrounds of agricultural economics, agronomy, finance and marketing) participated in this course, which was held jointly with the Ethiopian Seed Enterprise (ESE), ICARDA's main collaborator in seeds in Ethiopia.

Besides formal presentations, the participants and resource persons were given specific tasks by the General Manager of ESE, Dr Ato Aberu Dagnew. In his keynote speech, Dr Ato Aberu told the course participants to examine critically operations of ESE with a view to making practical recommendations on two areas which he considered as priority for the enterprise: developing a market-oriented strategy that is based on real demand for seed; and ensuring the participation of smallholders in the production and marketing of seed.

A two-day workshop session was included in the course to deliberate these issues in working groups. There was also a field visit to the Gonde-Iteya Basic Seed Farm some way from Addis Abeba.The General Manager expressed his full satisfaction with the outcome of the course and commended everyone for their efforts and dedication; this was reflected in the high quality of recommendations made. The participants, too, evaluated the course as very useful.

As an expression of this satisfaction, ESE hosted a closing dinner for all, to which some members of the board of management of the enterprise were invited.

At this occasion, ICARDA's cooperation and contribution towards strengthening the seed sector in Ethiopia were highly commended in the speeches made.

ICARDA Seed Economist Dr Sam Kugbei acted as the facilitator, assisted by two key local staff, Ato Ketsela Shewarega and Mrs Abeba Fikru, who attended the course held last year at the Center's Aleppo headquarters.

ICARDA provided training materials and contributed towards the cost of participation. Domestic costs, including transport and other course expenses were borne by ESE, as part of a close collaboration between the two organizations.

A worker at the Gonde-Iteya Basic Seed Farm (left) demonstrates wheat roguing techniques to the course participants.

Making sense of a mass of data

Crop trials are not simple. Multilocation trials, covering different climates, soil types, management practices and pests and diseases, generate so much information that exploiting it needs a special tool. ICARDA has developed one.

By Bijan Chakraborty and Mike Robbins

ICARDA's Computer and Biometric Services Unit, or CBSU, does not restrict itself to maintaining the Center's computing facilities. It must also develop a range of software tools for scientists who are performing a series of complex tasks. One of CBSU's operations is biometrics—the treatment of statistics to see what they are actually telling you (see Caravan No. 4). Another related, but separate, task is to assist the scientists with the decision support tools in the form of information management and statistical computation on diverse types of data collected from their experiments. It was the lack of sufficiently powerful and user-friendly software for this that led ICARDA to develop the Trials Management System—TMS.

To understand why TMS is needed, and what its development involves, it is necessary to describe how and why trials throw up so much data. To the layman, a crop experiment must seem simple enough. One takes seeds of the variety one wishes to test, plants them in the appropriate environment and sees how they perform. But it is not that simple. The environments in the ICARDA region are diverse. A crop will face a huge variety of climatic conditions and pests and diseases from site to site—to say nothing of different soil types, fertilizer and pesticide use (or lack of them). Lines for possible release to farmers must be tested for all of these.

So ICARDA collaborates with national scientists all over the West Asia and North Africa region and beyond to carry out multi-location, multi-year testing of advanced lines to identify improved germplasm. The heart of this cooperation is the international nursery system, which not only distributes ICARDA's improved germplasm but also functions as a cooperative testing vehicle. Candidate lines are evaluated at many key sites with stresses such as drought, heat, cold, salt, disease and insects. Data returned from cooperators provides valuable information on the performance and adaptation of test genotypes. Such efforts are an integral part of ICARDA's collaboration with the national programs.

Every year, ICARDA's crop improvement program receives data from an average of 30-35 locations around the region for around 80 yield and stress nurseries with an average of 40 test lines. The information received includes performance data such as seed yield, total biomass and 100-seed weight, days to maturity and plant height. But it also includes data which could have a bearing on the test results—the fortnightly meteorological data, agronomic information such as amount of irrigation, types and quantity of pesticides, herbicides and fertilizer used, and damages due to pests and diseases, drought or cold.

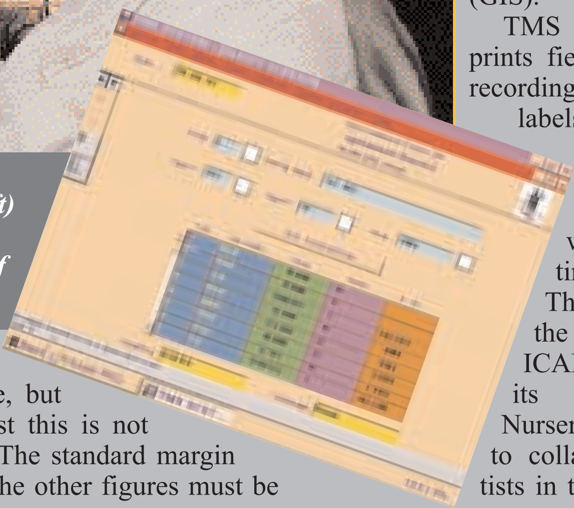
There is no suitable commercial software available that can be readily used to first manage the complex distribution system, and then process and produce the reports based on such a mass of information, correlating all the factors involved. Line X performed well at 14 sites out of 16 but was lousy at two. Why? The scientist's comparison must incorporate all relevant factors. Line Y incorporates good yield and stress-resistance characteristics from several previous lines, but was a mediocre performer. Why? What's missing? Attempt to answer these questions from piles of computer printouts, and you will never have time to do anything else. And you may still overlook the answers. A tool was needed not only for statistical analysis, but also for administration of the collaborative testing system.

Now CBSU has developed a powerful user-friendly software tool called Trials Management System (TMS) to automate the various functions of the international nursery system.TMS manages and produces the reports from the relational data of test lines and its parentage, information on experimental design and the field plan, site-specific information including the meteorological information, agronomic management and the observed attributes using a Relational Data Management System (RDBMS). The statistical analyses on the stored data are performed using commercial SAS (Statistical Analysis System) software.

Making sense of data: S
ICARDA's Legume Inte
and programmer andan
TMS through its paces.
chickpea trials in Algeri

TMS correlates all the information, which will be gathered by the scientist in the field (often using a palmtop computer). TMS is able to report on a given line, or a group of lines at a given location or across all locations and years; it can present this information graphically if required.

TMS has other analytical tasks besides comparing lines under different conditions. For example, in a large number of field experiments there is bound to be the odd gap; a specific test line was not planted on one site, or the plants of a variety in a plot within a replication got damaged when a flock of sheep got loose in the field. Statistical analysis of such missing data requires special treatment (statistically expected mean with adjusted precision for that mean). This is difficult; a standard spreadsheet could "fill the gaps" by working out a simple average, but for the scientist this is not good enough. The standard margin of error from the other figures must be incorporated.



uhaila Arslan of rnational Nurseries (left) alyst Sawra Bitar put Small picture: results of a in 1994.

Majed Khatib

Also, it would be very easy to analyze genotype by environment (G x E) interaction of the lines tested using data stored in TMS database. This is the extent to which the line will or will not adapt to different environments (see Three among the millions in Caravan No. 4). As part of its biometrics function, CBSU has developed a method for indexing the inter-site transferability of lines from the experiment data (see Yes, but will it grow in my field? in *Caravan* No. 4).

But the extent of G x E interaction is not a simple arithmetical figure; before selecting lines for multilocation trials at different sites, the breeder must know over which environments that transferability extends. Agroecological characterization of a given zone involves not just climatic data, but soils, slopes and other factors. So TMS must take a range of site data and correlate it with that on, for example, pests and diseases. There is little point in sending a line for testing to a site where winter cold tolerance is required if that is the line's one weakness. TMS will eventually be able to warn the breeder. To strengthen this part of its capability, CBSU's engineers are working on links to other programs that ICARDA is developing and/or using. These include a germplasm bank database, a meteorological database and Geographical Information Systems (GIS).

TMS produces and prints fieldbooks for the recording of data, and labels for the dispatch of international nurseries, together with the quarantine certificate. This can help in the summer, when ICARDA prepares its International Nurseries for dispatch to collaborating scientists in the national programs.

This is a lynchpin of the Center's collaboration with the countries of the region. It is also a major task performed under considerable time pressure. The Dispatch subsystem in TMS provides the tool for preparation of list of nurseries and the test lines in each nursery for the cooperators' nomination. Once the information from the cooperators is received, it calculates total seed weight and number of boxes for all nurseries to a cooperator, prepares quarantine and donation certificates and finally prepares the follow-up letters for the airlines and the cooperators.

This is a system designed for the real world. The modern crop breeder is computer-literate, but his first business is plants, not software. So TMS runs under Windows, making it a user-friendly tool.

To the same end, it is set up to receive data from commonly used formats such as commercial databases and ASCII files. It is this that has allowed scientists to take palmtops into the field, thus avoiding double inputting of data. Linkages exist not only for input but also for output; for example, to Excel for better graphical presentation of data and to WordPerfect for report formatting.

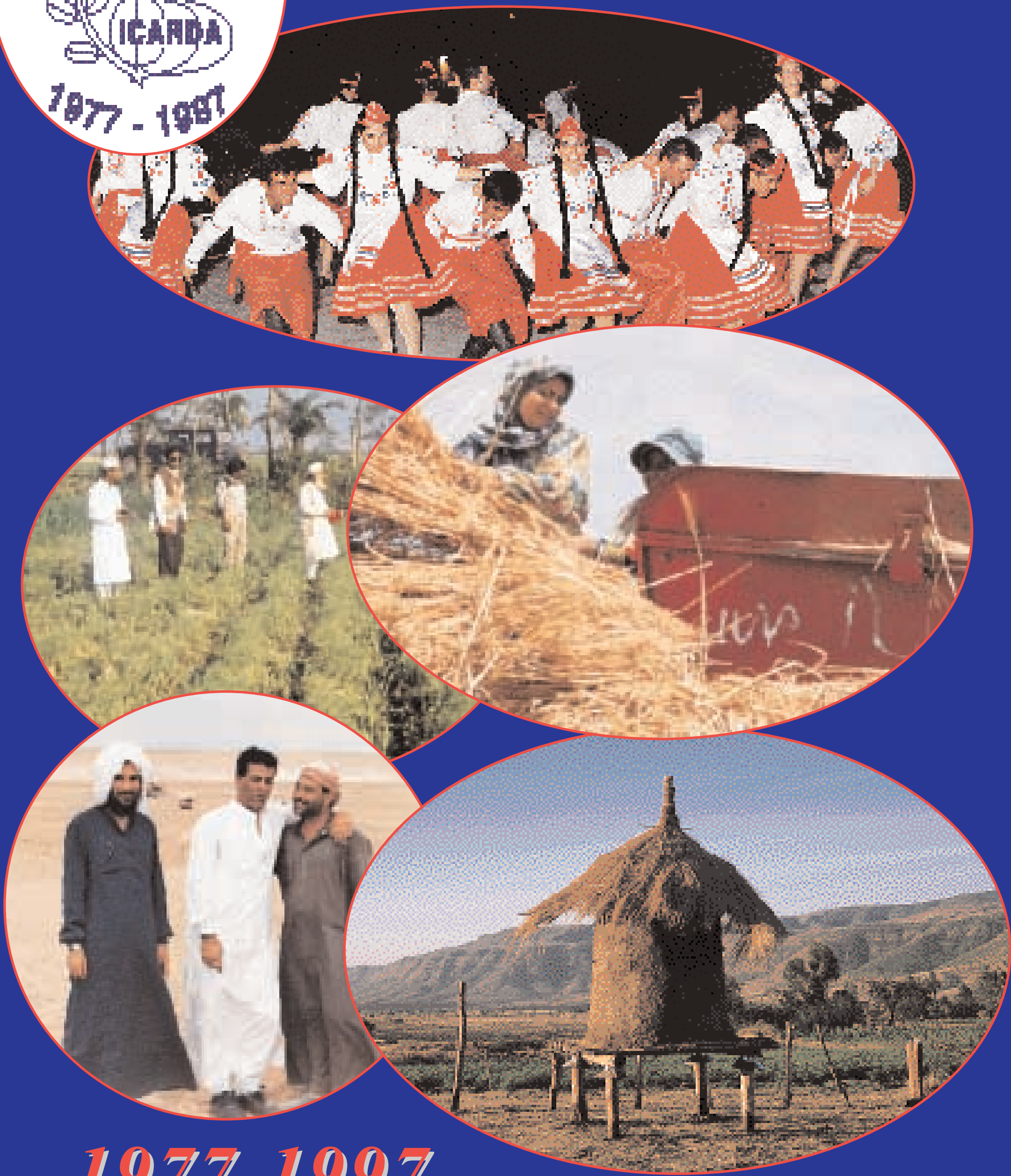
The program has been developed in collaboration with ICARDA's Legumes International Nurseries Scientist, Dr R. S. Malhotra, who has been testing its application to the legumes international nurseries. He feels significant benefits may emerge. "Some reports—such as finding the five best lines across all locations, or comparison of performance of common lines over two consecutive years—have hitherto been very difficult to obtain," he says. "With TMS's relational database, it is very easy."

Moreover, adds Dr Malhotra, TMS allows any query on a test line, sites, observed attributes and summary statistics. And information is gathered into a single database, reports are produced. Dr Malhotra is also pleased by the way in which TMS ensures data validation. It will not permit incorrect entry of figures.

And there are exciting possibilities for the future. Besides incorporating the links to other advanced applications mentioned above, ICARDA may arrange access to the system through the World Wide Web, allowing national scientists to gather/input data from their desktops. TMS will then become more than simply an advanced research tool. It will be a way to pull together plant breeders in tens of different countries—a scientific community working more closely than ever towards a common goal: more food. ■

Bijan Chakraborty is Scientific Applications Team Leader in ICARDA's Computing and Biometrics Support Unit. Mike Robbins is Science

ICARDA: 20 years of agricultural research in the dry areas



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