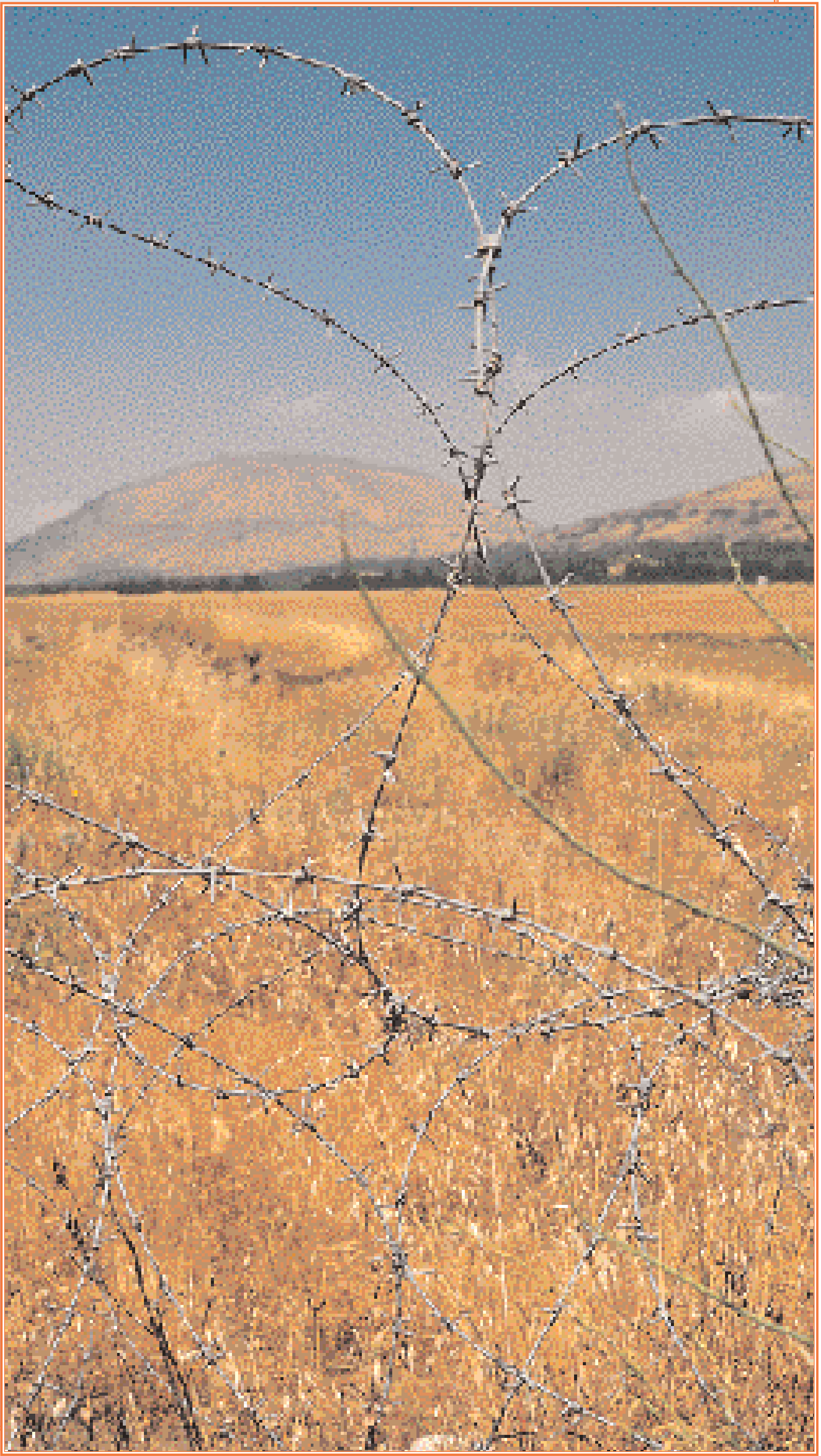
ICARDA
# Caravan

Issue No. 4 Autumn/Winter 1996

Review of agriculture in the dry areas



## *In this issue:*

### Guarding the genes of our future food crops

*If we don't preserve biodiversity, there will be no raw material for the crops we will need to breed in the 21st century. Marginal land like this—on the Golan Heights, untouched for nearly 30 years—and the genetic heritage it holds, must be preserved. We explain how ICARDA preserves—and uses—plant genetic resources.*

*Flood or drought?*

*How Tunisian scientists are fighting both—with farmers as allies*

*Yes, but will it grow here?*

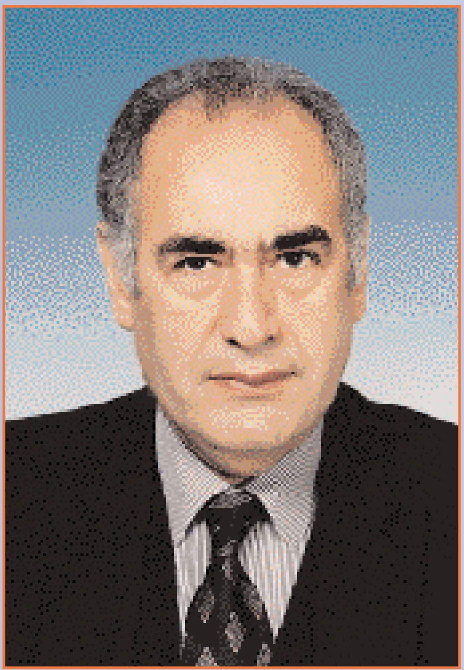
*Finding out if new lines will grow in more than one place*

*Balochistan*

*A rangeland challenge*

# From the Director General

*It is probably fair to say that, until the United Nations Conference on Environment and Development (UNCED) at Rio in 1992, many people in the developed world had never heard of the word biodiversity. It would be interesting to find out what the word actually suggests to them. When they did hear the number of threatened animal and plant species quoted in thousands or tens of thousands, they must have asked themselves: "Not every one of these can be of value. Why is this such an issue?"*



*Since Rio, however, organizations like ICARDA have worked hard to spread the word that agrobiodiversity—the store of genetic material used in agriculture—is the most important area of biodiversity to human existence. It is where we find the genetic material we need to breed crops that will give stable yields and fight off pests and diseases. And in agrobiodiversity, relatively small genetic variations, detected only by scientists, can mean the difference between a plant that is desperately important, and one that is useless.*

*Dryland agrobiodiversity is especially important, because of the harsh nature of such areas. That harshness means that food security is always threatened by changes in the environment, variations in the weather and assaults by fast-mutating pathogens. A plant that has survived in such areas does have something to offer the plant breeder.*

*But now we must stop just talking and worrying about the loss of biodiversity, and start doing something about it instead. I am struck by the words of Prof. Kamal Batanouny, Vice-Dean of the Faculty of Science at Cairo University and General Supervisor of the Desert Research Centre, on this subject. In a paper presented to the conference* Biological Diversity: Its Conservation and Sustainability in the Arab World, *held in Bahrain in 1995, he said: "In the last few years, numerous meetings, workshops and conferences have been held...Sometimes participants of these meetings are the same. It seems very important to start putting the good ideas given in these*

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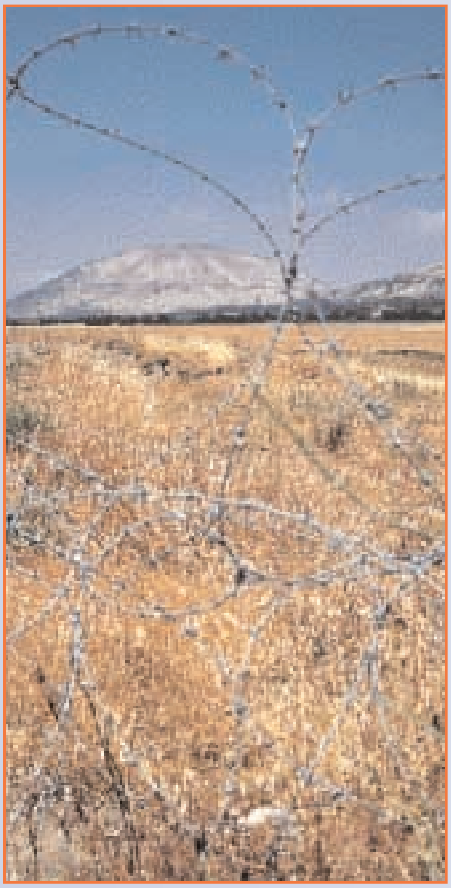
## *Cover story: Guarding biodiversity*

ICARDA believes that it is not enough simply to collect and preserve plant genetic resources. We must use them in a way that assists their conservation—protecting on-farm biodiversity as well.





**Cover picture:** *Syria's Golan Heights, closed to agriculture for decades, may support a fantastic store of genetic resources.*

***meetings into action plans. It is hoped that the present conference will foster the implementation of the innumerable recommendations."***

***It is good to be able to report that two of ICARDA's senior staff gave a paper at that same conference showing that, here at least, implementation is well under way. They reported, for example, that ICARDA had participated in 91 collection missions and collected 17,190 accessions in Arab countries alone up to the end of 1995. In this issue of*** Caravan, ***we describe how we are already altering our plant-breeding techniques so that they not only exploit biodiversity, but conserve it in farmers' fields as well, in the form of farmers' varieties (landraces) that are fast disappearing in favor of improved varieties. We describe, too, how we are helping mount a multinational project in the Levant that will not only pioneer large-scale*** in-situ ***conservation, but perhaps provide a model for similar projects all over the world. We describe how we have helped broaden the genetic base of a key subsistence crop in South Asia. And we describe just how a collection mission goes about its business.***

***It is no longer enough to talk about the importance of biodiversity. ICARDA implements.***

***Professor Adel El-Beltagy***
***Director General***

# Plus:



***Keep that soil for crops, say Tunisian researchers. Page 18.***

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

*The CGIAR seeks to enhance and sustain food production and, at the same time, improve socioeconomic conditions of people, through strengthening national research systems in developing countries.*

*ICARDA's mission is to meet the challenge posed by a harsh, stressful, and variable environment in which the productivity of winter rainfed agricultural systems must be increased to higher sustainable levels; in which soil degradation must be arrested and possibly reversed, and in which the quality of the environment needs to be assured. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.*

*The Center has a world responsibility for the improvement of barley, lentil, and faba bean, and a regional responsibility in West Asia and North Africa for the improvement of wheat, chickpea, forage and pasture crops—with emphasis on rangeland improvement and small ruminant management and nutrition—and of the farming systems associated with them. The full scope of ICARDA's activities can be appreciated only when account is taken of the cooperative research carried out with many countries in West Asia and North Africa.*

*The results of research are transferred through 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 and these efforts are supported by seminars, publications, and specialized information services.*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# ICARDA D.G. elected Chairman of international development organization

ICARDA's Director General, Prof. Adel El-Beltagy, was elected Chairman of the International Desert Development Commission (IDDC) at its fifth conference in the United States, 12-17 August. The Conference, which was subtitled *The Endless Frontier*, took place at Texas Tech University in Lubbock, Texas—a town which claims to have "the biggest feed-lot in the world". The Conference was organized by the Texas Tech Office of International Affairs and the International Center for Arid and Semiarid Land Studies under the auspices of the IDDC. It was decided in Lubbock that the next Conference would be held at ICARDA's Tel Hadya headquarters in 1999. Prof. El-Beltagy was, in fact, one of the three founders of the IDDC 15 years ago.

Previous conferences took place in Beijing, Mexico and Cairo. At the Conference in Texas, the organization changed its name to the International Drylands Development Commission.

Theib Oweis

***ICARDA Director General Prof. Adel El-Beltagy being interviewed by a Texas television crew beside a lagoon of treated effluent in Lubbock.***

**What are donors looking for in development projects? And why has the crucial agricultural research sector lost out in funding over the last few years? These are essential questions for ICARDA and its partners. Recently, agricultural economist Dr Earl D. Kellogg gave a stimulating address on the subject at ICARDA—and made it clear that the answers are not always obvious.**

# Making the case for research funding

Majed Khateb

Dr Earl D. Kellogg is Senior Vice-President of Winrock International, a non-governmental organization (NGO) committed to sustainable development, which has offices in 17 countries and manages projects in 35. Having studied at Michigan State University, he taught at the University of Illinois from 1970 to 1985; during this period he spent two years in Thailand with the Ford Foundation. He has been involved with different development institutions and projects in 12 countries, as diverse as Bahrain and Trinidad. He has written a number of books on agricultural economics and global agricultural development. He decided to discuss with ICARDA staff the issues he heard talked about in the offices of donors such as USAID, the World Bank and others in Washington D.C.

Dr Kellogg described how, at dinner with representatives of a donor agency recently (he did not specify which one), he had asked them, point-blank, why support for agricultural research was declining. "They could have avoided the question, or argued that they did have it as a high priority," he said. "But they didn't. They gave me straightforward answers." They gave four main reasons.

* ICARDA's own view may be that there will be a desperate food and feed gap by 2020—but to many senior officials in the donor community, there did not appear to be any crisis. There were no starving people on the television screen right now, at least not on the scale that there were a few years ago. In fact, food prices seemed actually to be declining in the long-term.

* Many agricultural projects had, they said, almost always performed badly. Why? Dr Kellogg asked them. They said that their own research staff had found relatively low rates of

Prof. El-Beltagy gave the keynote address, and ICARDA researchers presented four papers at the Conference.

In his keynote address, Prof. El-Beltagy talked about ICARDA's work to combat desertification and to bring about increased food production in harmony with the protection of the natural-resource base. He also emphasized the need for high technology to be harnessed to the fight against desertification.

The name-change reflected one of the themes of the conference as a whole; many of the conference participants felt that desertification is a major threat to food supplies and must be looked at in the context of drylands as a whole; the steppe, for example, is not desert.

***ICARDA participants, led by Director General Prof. Adel El-Beltagy (sixth from left), included Dr Mohammed Abdel Moneim (first left), Dr Theib Oweis (second left), Dr Salvatore Ceccarelli (third left), Dr Stefania Grando (third right) and Dr Ahmed Osman (second right). They are seen here with Dr John Burns (far right), Vice President of Texas A&M University, visiting Native Americans at a traditional tepee during the conference.***

The five other ICARDA speakers were Dr Theib Oweis, who presented a paper on the use of GIS to identify water-harvesting potential; Dr Ahmed Osman, who spoke on rangeland development issues; Dr Mohammed Abdel Moneim of ICARDA's Cairo office, who briefed the participants on the activities of the Nile Valley and Red Sea Regional Program (NVRSRP); and Dr Salvatore Ceccarelli and Dr Stefania Grando, who talked about barley breeding.

The post of Secretary-General of the IDDC was not the only honor conferred upon Prof. Dr Beltagy during the week. He was also made an Honorary Citizen of Lubbock, Texas. ■

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achievement of objectives.

* There is no political clout behind agricultural research; boards of agencies and congressmen put stress on environment and health.

Moreover, there was a feeling that more efficient agriculture worldwide could actually hit the exports of already-developed countries.

* The donors perceived that agriculture had become less important in development, with many people moving to the cities.

"I'm not here to refute all of these, but we in the business of agricultural development do have to be ready to refute these criticisms," said Dr Kellogg. "We've lost ground because we have not kept up with the changing priorities of the agencies." Instead, we talked about the shortfall in food supply; but that alone just wasn't working any more. Instead, he looked at what the goals of donors actually are today, and found five main ones.

"First of all, economic growth. Everyone wants that. Second, environmental protection; they want to see the production base maintained and sustained. Third, health and population. Fourth, poverty alleviation. And fifth, democratization—increasing participation.

"No one puts agriculture there. What are we going to do about it?"

> "There are no starving people on the television right now"

First, growth. Agriculture might be declining, but it's still the biggest sector and the one in which demand must be created for overall growth. It will also be where investment capital and foreign exchange can be obtained. As to environmental protection, of course agriculture is significant. Its implications for soil, water and forestry are obvious.

With regard to health and population, health was related to nutrition; people cannot be healthy if they don't have an adequate diet. Agriculture provides the food. And with regard to population planning, there was evidence that fertility levels could drop quickly in some countries—but only when women can obtain employment and income. Agriculture is a big employer. Moreover, the dry areas in particular were significant. If food production was really to be increased by 250% by 2020, it would be necessary to turn to areas that were not already at their limit of productivity—that means dry areas.

On the poverty alleviation priority, the dryland areas, he said, contained real poverty. It is important to reduce poverty in order to allow people to realize their true potential. "Poverty in rural areas is more prevalent than in the urban areas; the worst incidence of poverty is in the countryside, and if you can increase farm incomes, you can reduce poverty. In any case, if you increase production you reduce food prices, which are a big percentage of the spending of the urban poor also. We need to find new off-farm jobs for rural people; there's a need for important rural infrastructure projects." ■

***Before 1981, they were just three spikes of barley in three different farmers' fields in West Asia. Today, they are Tadmor, Zanbaka and Arta, and are feeding thousands. Together they illustrate why biodiversity is crucial to poverty alleviation and food security. And they explain, too, why farmers must be involved in the plant-breeding process.***

# Three Among The Millions

Stefania Grando

By Salvatore Ceccarelli, Stefania Grando and Joop van Leur

One of the clarion calls of the 1992 United Nations Conference on Environment and Development (UNCED), now generally known as Rio after its venue, was for the preservation of genetic diversity—biodiversity. For many people around the world, this was the first time the phrase had been heard, and they took it to mean the protection of some of the world's vanishing animal species.

They were not wrong about this, but there is an even more pressing need to preserve *plant* biodiversity if we are to feed the world's growing population in the 21st century and beyond—and avoid the drastic fluctuations in agricultural production that lead to poverty and famine. Nowhere is this need more urgent than in the world's drylands. In these harsh environments, biodiversity is the key to better yields, and thus to food security and poverty alleviation.

To understand why, it is necessary to know roughly how crops have hitherto been bred for supply to farmers. Under the methods normally used today, to make plant breeding and seed distribution economic, breeders need to come up with a product that can be grown under the widest possible variety of climatic and environmental conditions. This has two consequences.

First, they select raw genetic material with moderate genotype (G) by environment (E) interaction. This is a complex area of plant genetics, but G x E interaction is basically the extent to which a plant's behavior is affected by its environment. What the conventional breeder is looking for is a plant that is *not* too specifically adapted—because s/he wants to grow it over a broad, diverse area. If s/he can't, then, to put it bluntly, it won't pay. In fact, uniformity and broad adaptation are very useful in enabling large-scale, cetralized seed production; so useful that one wonders whether breeding of this sort was designed for seed companies rather than small farmers.

The second consequence is that s/he will breed for high-input agriculture. Inputs may be defined as external factors introduced by the farmer to make his crop grow, or grow better. Inputs, such as fertilizer, pesticides, or irrigation, tend to make all environments similar; a process of adapting the world to the plants instead of the other way around!

What the breeder gets from this process is a variety that will grow over a diverse area, *provided* it receives plenty of inputs. For developed countries with large-scale farmers who can afford such inputs, that's fine. We are not arguing that conventional breeding is bad; for the appropriate environment, it is not, and indeed it is now a highly-developed technique in which much has been learned over the years.

But ICARDA does not breed only for that sort of farmer. We are very happy when we do produce a genotype that is useful in the developed world (for example, the lentil germplasm we supplied to Australia, and the sources of resistance we found to stripe rust in barley; see *Caravan* No. 2). But our most important target group is the subsistence farmer, who accounts for 60% of the farmers in the world and grows about 15-20% of its food, mainly in developing countries.

S/he doesn't use many (or, often, any) inputs. This is only partly because they are expensive or not available. It is also because, in harsh environments like the those in the West Asia and North Africa (WANA) region, farming is a chancy business. In these low-yielding areas, why spend scarce money on fertilizer for a crop that will never pay for them, and may even fail? These farmers therefore do not adopt modern high-yielding varieties. Conventional plant breeders are all too ready to blame this on weak seed-production systems, poor extension services and conservative, uninformed farmers.

Actually, the farmers are all too well informed! They know not only that varieties bred for high inputs are useless to them, but also that material originating in a high-yielding environment may actually do far worse than their own 'old-fashioned' landraces when grown in a low-yielding site. This is because of a phenomenon called crossover G x E interaction.

What this means is that a plant which has adapted to a specific, often harsh, environment is better able to adapt itself. It will therefore make the transition to a high-yielding environment better than an improved, high-yielding variety will make it to a poor one. We proved this for ourselves. Between 1985/86 and 1993/94, we took the 5% highest-yielding barley genotypes in low-yielding environments, and the 5% highest-yielding in high-yielding environments. Those selected from poor sites gave two-and-a-half times the yield when grown in good ones. In fact, they managed four-fifths of the yield from the high-yielding ones in a good environment. By contrast, yield of the varieties selected from *good* sites dropped by four-fifths when they were grown in more difficult ones. So, for a resource-poor farmer, adopting plants developed under good conditions on a research station could be a disaster. Instead, the strategy used by Third World farmers is to mix both different crops, and different varieties of the same crop, in their fields. There is thus a fantastic on-farm genetic diversity available in their fields.

In the early 1980s, we set out to exploit it in Syria. We tested a large collection of landraces (farmers' varieties) collected by Eva Weltzien in Jordan and Syria in 1981. She was then doing her PhD thesis at ICARDA (she is now doing similar research on pearl millet at ICRISAT, ICARDA's sister Center in India).

In 70 fields—60 in Syria, 10 in Jordan—Dr Weltzien collected 100 heads (spikes) per field. This gave 7,000 individual spikes in 7,000 envelopes; given 20 seeds per spike, this was 140,000 seeds! These envelopes had been kept as separate accessions, not bulked together, and that proved to be the key. Individual testing revealed very broad diversity in growth characteristics and pest and disease resistance. In the end, we hit upon three especially promising accessions, and these emerged as ICARDA lines that were subsequently released for farmers' use. They were Tadmor, Zanbaka and Arta—three among millions of barley spikes in farmers' fields that turned out to be what we were looking for.


***Arta: a good performer which promises stable yields. Opposite page: barley breeding from landraces has been a success in Ethiopia as well as Syria.***

Arta in particular is good news. It was developed from a spike Dr Weltzien collected in a field near Sweda, about 100 km east of Damascus. Oddly, the village was Um Zeitoun, meaning Mother of Olives. It seems we had the mother of barley instead! Arta has been consistently outperforming existing landraces in farmers' fields all over Syria. And it has been doing so because it was developed from a landrace in the first place, selected in the target environment.

There is a danger here. Arta was developed from a single spike. This type of breeding—from a pure selection—could lead to a new genetic homogeneity that could take us back to where we started. In fact, what we have seen of farmers' adoption patterns in the region suggests that this is not so great a danger as it might be, but we should avoid it. In the long term, ICARDA strategy will be to breed-in characteristics *to* landraces *from* landraces in order to preserve genetic diversity in the farmers' fields.

There is also a practical difficulty. We said at the beginning that we were trying to get away from varieties that were not bred for a specific target environment. If we exploit biodiversity we can end up with the huge variety of varieties that we need for the different environments, but how do we get them to farmers? Centralized seed production and distribution would be uneconomic.

We postulate that the way to do it is to bring the farmer into the breeding process. If the new lines are evaluated in his field in the first place, he already has what he needs at the end of the process; it will then be distributed to his neighbors. ICARDA is already working on this (see *Caravan* No. 1).

But the varieties are not going to spread in this way from Sweda to (say) Tunisia. If they did, they might not prove to be the right ones for *that* target environment. ICARDA's own testing of barley lines simultaneously in Syria and the Maghreb has demonstrated this.

So the process must also be decentralized to national programs. Better for Syria and Tunisia to swap lines for testing, and then to do that testing both on the research station and in farmers' fields. Then we really will have got away from the "top-down" approach to plant breeding—and the seeds will be in the farmers' hands. It means a move away from the traditional pattern of varietal testing and release on a national scale, but that procedure was designed for a different set of circumstances, anyway.

A final thought. We started this article with the premise that biodiversity must be preserved in order to produce the food the pople in the dry areas will need in the 21st century. But it is a two-way process. The decentralized, farmer-based breeding methods just mentioned will not only exploit biodiversity, but, by vastly increasing the lines being grown in different places, they will also preserve it in themselves. ■

*Dr Salvatore Ceccarelli is senior barley breeder, and Dr Stefania Grando barley breeder, at ICARDA. Ir Joop van Leur is a barley pathologist with ICARDA and is currently based in Ethiopia, where he is working with Ethiopian scientists to identify barley lines for yield stability in low-input agriculture.**The authors would like to acknowledge the valuable support of OPEC and the Government of Italy for this work; also to thank the German development organization BMZ, which is assisting farmer-participatory breeding work in Syria.*


***Barimasur 4: from Argentina and Aleppo with love! Varieties like this can do much for productivity in South Asia. Inset: the raw material. Top left, a Bangladesh landrace; top right, Precoz; and bottom, a cross between a landrace and a medium-maturity bold-seed variety from outside South Asia. Right: Lentil crossing at ICARDA.***

# *Breaking the* Lentil *Bottleneck*

**By William Erskine and Guy Manners**

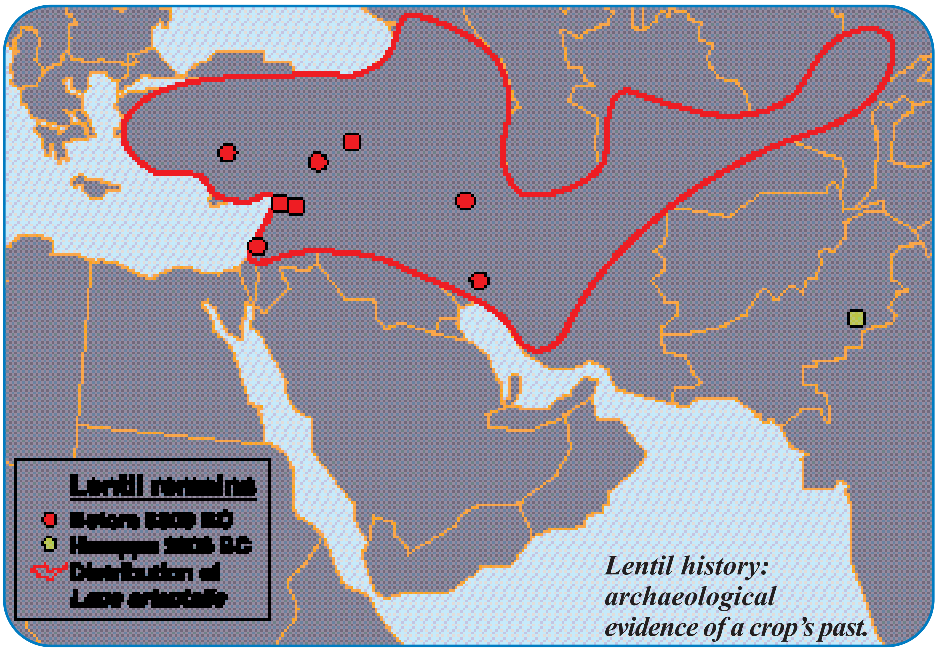
***Lentil is a key part of the diet in South Asia, and the basis for the dhal that many people eat every day. But yields had always been poor - until ICARDA and its partners unleashed the power of biodiversity. They broke a genetic bottleneck. And now they're zapping lentil with gamma rays...***

South Asia grows almost half the world's lentils, but the productivity of the crop in the region has historically been poor. The lentils there were unusual, and lacked the basic variation that breeders need to work on to improve yields. Moreover, differences in the length of the growing season have always made it hard to incorporate genetic material from elsewhere.

ICARDA has a world-wide mandate for the improvement of lentil. This makes sense, as the crop originated in the Center's home region. Along with various other crops, lentil was carried both east and west from its region of domestication in western Asia. Archaeological and linguistic evidence suggests that the crop reached the Indo-Ganges Plain about 4000 years ago. Today, very nearly half of the world's lentil is produced in South Asia. However, until recently, South Asian lentils were unique and there is strong evidence of a genetic bottleneck in the material that arrived there so long ago. ICARDA has been collaborating with the national programs of the region to increase the genetic diversity and improve lentil productivity.

South Asian lentils have grey-green leaves compared with lentils elsewhere, and have short or no tendrils. For this reason, South Asian lentils have been separated as a distinct group, known as the *pilosae*. In addition, lentils from India, Bangladesh and Nepal differ from other lentils in a number of quantifiable features: they flower and mature early, they have small seeds and low yield, and they are short plants with the lowest pods produced closer to the ground than in other lentils. Lentils from Pakistan are technically *pilosae*, but have quantitative traits somewhere between those of the rest of South Asia and those of Afghanistan.

In addition to these physical (mor-



*Lentil history: archaeological evidence of a crop's past.*

pho-logical) differences, South Asian lentils show the lowest variation in character among all lentil-growing regions. This is despite the fact that the crop is grown over large areas and in a variety of environments within South Asia. All these differences point to the so-called founder effect: the lentils which were first introduced to the region were few and were not typical of those grown elsewhere. Over time, the plant has been grown and selected throughout the region, but the basic genetic makeup has remained unaltered. This seriously hampered any breeding efforts in the region, especially those aimed at increasing yield.

Thus, the stage was set for collaboration between ICARDA, which has the mandate for lentil, and the national agricultural research systems of South Asia in a drive to improve lentil productivity by first widening the genetic base.

The easiest way of adding new genes to a plant population is to introduce exotic plants. This was never going to be easy in lowland South Asia, since plants brought in from West Asia were only flowering when the local *pilosae* were maturing. However, one particular large-seeded cultivar, Precoz (originating from Argentina), was sufficiently early-maturing to be viable in the wetter parts of Pakistan, where it was released as "Manserha 89."

In the highlands of western Pakistan (Balochistan province) the growing season is longer, and success has been achieved with the direct introduction of medium-maturing types which are tolerant of cold. Two cultivars from this source are at the pre-release stage there.

The introduction of Precoz has alleviated the problem of differences in flowering stages, and the line has been used extensively in India. In fact, the features introduced by the use of Precoz led directly to the introduction of two new All-India nurseries: Extra Early, for plants maturing in 110 days or less, and Extra Bold, for plants bearing seeds averaging 35 mg or more.

However, one suitable crossing variety alone does not give great scope for genetic improvement. An alternative was sought.

West Asian material can be encouraged to flower at the same time as *pilosae* material by the use of artificially long days. This technique was used at ICARDA's headquarters in Syria. A system was developed whereby targeted crosses were made at ICARDA between exotic material with desirable traits and native South Asian material. The offspring were advanced by using a highland summer nursery, and plants from the third and fourth generations were sent to the national programs for testing and selection in the target areas.

In this way, rust-resistant types have been developed for Bangladesh, where Barimasur-2 was released in 1993, and Barimasur-4 was released in 1995. In fact, Barimasur-4 has combined resistance to rust and stemphylium blight, and an upright structure which allows it to be intercropped with sugarcane.

The same crossing techniques were then transferred to the region. A cross made in Faisalabad, Pakistan using the ICARDA technique resulted in the release of Masur-93, which has larger seeds and yields 31% more than the best local variety, and is resistant to ascochyta blight and rust diseases.

The creation of genetic diversity through artificial mutation is often regarded as a means of speeding up the mutation process and identifying useful features. Work at the Nuclear Institute for Agriculture and Biology, Pakistan, has involved the use of harmless gamma-rays on lentil seeds. Among numerous mutations, plants have been identified which are high yielding, early maturing, short and upright, and which breed true. Some of these are being included in national trials.

The story of South Asian lentil demonstrates the advantages of international cooperation in increasing the productivity of a crop which has historically poor yields—an especially useful exercise in this case, in a region which already produces half of the world's lentil. The collaboration between ICARDA and the national programs of South Asia has achieved this, and will continue. But the story is also one of biodiversity helping people to eat better food. There can be few better illustrations of just why we need to conserve the genetic treasure of agrobiodiversity—conserve it, and *use* it.■

*Dr William Erskine is Lentil Breeder, and Guy Manners is Science Editor/Writer at ICARDA.*

## The bottleneck breakers

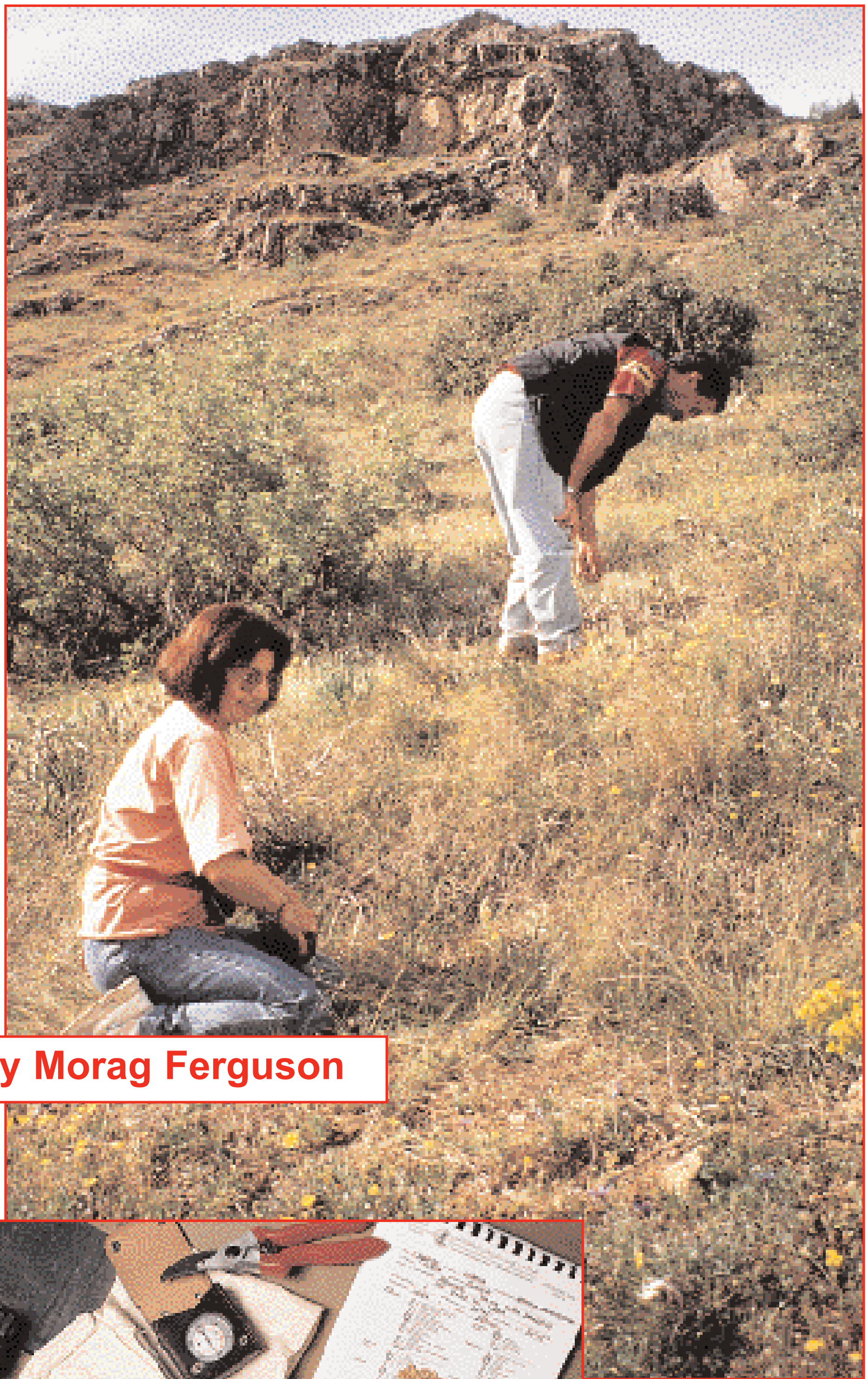
***Breaking the genetic bottleneck of lentil in South Asia has been a collaborative effort between ICARDA and the National Agricultural Research Systems (NARS) of Bangladesh, India and Pakistan.***

***NARS personnel who have been taking the lead in their respective institutions include Drs S. Chandra, Lentil Breeder, Indian Institute for Pulses Research, Kanpur; M. Chaudhry, formerly Lentil Breeder, Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan; I.A. Malik, formerly Pulse Breeder, Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan; Ashutosh Sarker, formerly Lentil Breeder, Bangladesh Agricultural Research Institute (BARI), Joydebpur (now Post-Doctoral Fellow in Lentil Breeding, ICARDA); B. Sharma and M.C. Tyagi, Lentil Breeders, Genetics Division, Indian Agricultural Research Institute (IARI), New Delhi; and M. Tufail, Director of Pulses (Punjab), AARI.***

# *First, find your lentil!*

*If we are to use genetic diversity in plant breeding, we have to find it first. Some of it is in farmers' fields (see* Three Among The Millions*, page 6). Some of it is harder to find. But ICARDA's Genetic Resources Unit (GRU) have their ways of finding it.*

**By Morag Ferguson**



Morag Ferguson

Mike Major

***Above: Collecting wild relatives near Burdur in Turkey as part of a joint collection mission of ICARDA and the Aegean Agricultural Research Institute. Left: Some of the paraphernalia that goes into the car on a collection mission. Umbrellas are useful, as well.***

Sir Joseph Banks (1743-1820) was president of the royal gardens at Kew, and an intrepid plant collector who sailed with Captain Cook. He spoke of the "dedication required for plant hunting, the single-mindedness, the stamina and cheerful indifference to discomfort and to continuous disappointment." Less polite variations of these words ring in the ears of ICARDA plant collectors as they grapple through bushes and entangled undergrowth day after day, battling with snakes and potentially rabid dogs in their quest for their elusive treasure—genetic diversity. And that includes the wild relatives of lentils.

Lentils provide a valuable source of protein and calories for millions of people in South Asia, West Asia and North Africa. They are thought to have been brought into cultivation somewhere in southeast Turkey or northern Syria near the Tigris and Euphrates rivers. The crop was domesticated from a wild lentil species which grows naturally in the area (*L. culinaris* subsp. *orientalis*). This wild progenitor still exists in the region and further afield. There are currently three additional wild taxa which are also closely related to the lentil and share the same genus. They are *L. odemensis*, *L. ervoides* and *L. nigricans*. Together they contain a huge reservoir of genetic variability which can be used in lentil-improvement programs. These wild species are, however, at risk from genetic erosion, primarily through habitat destruction. It is essential that these genetic resources are collected and conserved. There is no way of telling what tomorrow's needs will be, and what genes may be required to meet them. The problem is finding them!

Morag Ferguson

***An unusually large wild population of* Lens odemensis*, Sweda Province, Syria.***

Detective work is needed, and a bit of luck. Preparation must start well in advance of the expedition. A target area and a target species must be decided upon. This could be based on: a known area of high genetic diversity; or unique genetic diversity; an area which is under-represented in the collection; a need for a particular attribute, such as salt tolerance or cold tolerance; a region in which a species is particularly at risk; or a particular request from colleagues in other institutions or governments.

The collection team must be appointed and an agreement signed with the appropriate national program. Once this is done, the plant collector must gain as much information as possible about where and when to find the target species in the selected area. This largely centers around determining the characteristics of the preferred ecological environment of the species and includes information on soil type, topography, geology, temperature range, water relations, its ability to withstand grazing pressure, and information regarding other species with which it is likely to be associated. Information can be gleaned from floras, past expedition reports, from existing passport data (see below) and from climatic and vegetation maps.

Timing is crucial. The seeds *must* be ripe for collection. This is particularly important in the case of wild lentils, as the pods shatter to disperse their seed. The expedition must be timed to catch the pods just before they shatter. This is never easy, as the time varies from year to year and site to site. To fix it, the collectors need up-to-date weather reports from the region right up to the date of departure. It may even be necessary to carry out an initial survey to locate the populations in a specified area prior to collection.

The collector must also have a sampling strategy in order to maximize the genetic diversity that is collected. This should be based on a knowledge of the genetic structure of the population, how much genetic variation exists between seeds of a single plant, between seeds of different plants, and between populations.

Once all the preparations are complete, a sturdy vehicle is piled high with plant presses, paper envelopes, cloth bags, soil augers, an altimeter, maps, collection books, cameras, medical supplies, and water containers. And there is a new tool for collectors, although it has long been in use for marine navigation. This is a global positioning system (GPS) receiver, used to establish exact position from satellites.

The hunt is on, scanning the environment for appropriate ecosystems. A stop and search all too often ends in disappointment. A sixth sense must be cultivated. Sometimes a chat with the local inhabitants will reap rewards. Even though they might not know the scientific name, they will sometimes recognise the plant from a picture and point you in the right direction. A wise collector will also inspect a few areas which do not correspond to his or her idea of the characteristic habitat, just to make sure that s/he is on the right track and that the ecological preference of the species is no less specific than originally thought.

Shrieks of delight erupt as one of the team spots a fragile lentil. Closer examination in the immediate environment usually reveals a few more plants, occasionally a couple of hundred, but usually in a very restricted location. If the team is in luck the pods won't have shattered, and the seeds will be easy to collect; otherwise they will be down on their hands and knees with a pair of tweezers, looking for soil-colored seeds of no more than 4mm in diameter. Fortunately there is no problem in keeping the seed viable until the end of the collection mission, as there is with some other species; the seeds of wild lentils are adapted to survive the summer months at very low moisture content. But, with such small populations, the

***Continued on page 15***

# *Safety for the seeds of the future*

There are wildlife reserves where endangered animal species can live in the wild. So why not plant reservations? Now, through a wide partnership of countries and institutions in the Eastern Mediterranean, they are becoming a reality in four countries in West Asia. But with an important difference: *these* reservations will be working farms.

**By John Peacock and Mike Robbins**

An hour or two's drive inland from the Syrian Mediterranean coast, the Rift Valley finally runs out. Thousands of kilometers away in Kenya and Ethiopia, it is a deep slash in the landscape that takes hours even to descend by car. Here it is on a more modest scale. But the traveller still takes a long time to climb the edge. One follows a twisting series of hairpins up from the Ghab, the fertile valley fed by centuries of soil runoff from the hills above, and now irrigated so that it is a glaring emerald green in spring, a sharp contrast to the darker green of the forested hillsides that overlook it. Before long, the road is over a thousand meters above the valley floor and, in season, in cloud; here and there it may part to give a sudden glimpse of the Ghab itself or of the medieval castle that nestles at the foot of the valley. As winter draws in, the road can be treacherous with snow. It's an inspiring sight.

But we are not there to admire the scenery. For the mountains around Slenfeh in the Levantine Highlands of Western Syria are one of eight areas now designated as sites for *in-situ* conservation of dryland biodiversity.

Genetic material at this site which we can't afford to lose includes more than 500 species found in marginal areas and field borders, including wild relatives of forage crops (medics and vetches), wheat, olive, fruit and apricot. Even the forest area contains wild relatives of fruit trees. But cutting, deforestation, fire, overgrazing and agricultural expansion are all threats to their survival.

Herein lies the difficulty; West Asia is not wealthy, and scientists cannot go to farmers and ask them to restrict their activities because they think this barley spike or that ear of wheat may one day provide genes for the miracle crop of the future (even though it might). That is why, along with seven other sites in Lebanon, Jordan, the Palestinian National Authority and elsewhere in Syria, it is a focus for a project called *Conservation and Sustainable Use of Dryland Agro-Biodiversity in the Near East.* This project should start during 1997.

When crops get sick and can no longer cope with the pests, diseases and environmental stresses of the place where they are grown, two things happen. First of all, poor farmers get poorer. Secondly, crop breeders are forced to come up with a solution. More and more, they will "go back to the drawing board"—to the genetic material from which the crop was developed. (There are other reasons for using this material in breeding—see *Three Among The Millions*, page 6). This material could well be the wild plants, called wild relatives, descendants of those from which they were first grown up to 10,000 years ago. That is why we have to preserve agricultural biodiversity.

The broad region in which Slenfeh is situated, including Jordan, Lebanon, Palestine, southeast Turkey and southern Iran, is a treasure-house of what can justifiably be called megadiversity. Many of today's food crops originated here, and we can still find their wild relatives in the area. These include lentil, pea, vetch, almond, olive and pistachio among others—and wheat and barley, upon which a third of the world depends.

This biodiversity can be preserved in genebanks. ICARDA does this, as do a number of national programs and institutions within the region. In fact, ICARDA's genebank is one of the world's biggest, with 110,000 accessions so far, and distributes about 26,000 a year to scientists all over the world to use in crop breeding.

But this alone is not enough. We don't know how long we can store the material without it degenerating; more-

***The mountains near Slenfeh in Syria. This is marginal land, typical of the areas where biodiversity is being reduced by grazing and cultivation.***

over, while it is in a coldstore, it is not adapting to the changing world outside, which limits its usefulness in breeding. Just as important, genebanks cannot preserve more than a fraction of what we need to keep. *Ex-situ* conservation, as it is known, is important and has helped enormously, but we need *in-situ* conservation as well.

*Conservation and Sustainable Use* aims to do that, right in the environment to which we will need it to be adapted. That is part of the reason why scientists do not want to just create reservations for biodiversity; we need to use working farms, where the genetic material is tested by changes in farming practices and can be watched over by farmers who know what to look for. Anyway, simple reservations would dig too deep into scarce land resources. People must eat today, as well as tomorrow.

*Conservation and Sustainable Use* has been put together with Jordan, Syria, Lebanon and Palestine, and a number of important institutions (*see box on page 14*). ICARDA will administer and coordinate the project, but will not spend the money; as the implementing bodies, the national programs will do that.

Total cost over five years will be roughly US$18.5 million, of which the crucial US$8 million core is expected to come from GEF, subject to remaining administrative and policy decisions. GEF is the Global Environment Facility, a financial mechanism providing grant and concessional funds to developing countries for projects and activities to protect the world's environment. By the end of 1991, the framework for action for the GEF gained the support of a sufficient number of countries to become a reality. At the Rio Earth Summit in 1992, it was decided that GEF would operate the financial mechanisms for implementation of the Conventions on Climate Change and Biological Diversity. Today, responsibility for implementing the GEF is shared by UNDP, UNEP and the World Bank. Projects thus funded fall under four basic areas; climate change, biological diversity, international waters and ozone depletion.

GEF's contribution is the key to making the *Conservation and Sustainable Use* project fly; other generous

Mike Robbins

# An international partnership

A wide variety of organizations are contributing to *Conservation and Sustainable Use of Dryland Agro-Biodiversity in the Near East.* The governments of Syria, Jordan, Lebanon and the Palestinian Authority, who helped to put the project together, will be implementing agencies and will therefore be making an enormous contribution in kind as well as cash over the five years. Other financing institutions, besides GEF (to be confirmed), include ICARDA, IPGRI and the Arab Centre for the Study of Arid Zones and Dry Lands (ACSAD), an affiliated organization of the Arab League. All three have been involved in biodiversity conservation for some time, with ACSAD's work including farm animals as well as plants. IPGRI's actual reason for existence is biodiversity; its activities through its regional office at Aleppo have included the founding, in 1992, of the West Asia and North Africa Plant Genetic Resources Network (WANANET), which links national programs, identifies common problems in plant genetic resources and initiates collaborative work.

Other collaborating institutions in *Conservation and Sustainable Use of Dryland Biodiversity* include Wageningen and Utrecht Universities in The Netherlands, the Universities of Birmingham and Reading, CAB International and the World Conservation Monitoring Centre in Britain, and the University of California and Washington State University in the USA.

***Above: The Palestinian Authority is one of the participants in the project, and this marginal land will be part of it. Left and below: Caution—land in use! Firewood collection and grazing by livestock are a threat to wild relatives, but they cannot simply be stopped by order. People depend on the land.***

contributions in cash and kind have been pledged on this basis.

Besides *in-situ* conservation at the eight sites, the project's objectives are to:

*Gather information on the genetic base of 10 target crops and the social and farming practices which affect them;

*Produce a working model for *in-situ*, on-farm conservation that can be repeated elsewhere in the world;

*Devise a broad range of policy measures that can safeguard and enable such work;

*Strengthen national capacities for the sustainable conservation of agrobiodiversity.

None of this will be simple. For example, producing the database means using Geographic Information Systems (GIS). The scientists will have some help; one of the participating institutions is the International Plant Genetic Resources Institute (IPGRI), which is based in Rome but has its regional office on the ICARDA campus. It already holds some data for the area. But there will be a need to train national scientists in the use of GIS, so that training will be part of the project.

If the project is to gather information on the way the genetic material is affected by changing social and land-use practices, it will need to be monitored. This will be done through a network of extension officers. Farmers can also help—they know what to look for. Other assistance will also be needed from farmers. One of the key parts of the project is to persuade them to (say) keep sheep away from wild relatives of forage legumes at the flowering stage, let a wild variety of crop wild relatives grow at the margins of their fields, and grow a good mix of landraces (farmer-bred crop varieties) in the fields themselves. In the main, farmers do not need to be persuaded of the importance of biodiversity (see *Three Among The Millions*, page 6). But—again—people must eat today, as well as tomorrow. So there will have to be compensation in cash and kind for farmers who are asked to change their farming patterns.

The development of policies to make sustainable conservation practicable is, again, not going to happen by magic. Most national programs are weaker in socioeconomics than in other fields, so training will be needed. Fortunately a number of universities inside and outside the region are involved in *Conservation and Sustainable Use of Dryland Biodiversity*. So Ph.D training will be given at the University of California in the USA or at Birmingham University in England (others will be involved; these are just two good examples). This might be called the "train the trainers" stage, after which courses in agrobiodiversity will be produced. Institutes participating in this latter phase are likely to include the University of Jordan, the American University of Beirut and the University of Damascus.

Meanwhile, on the ground, land-use survey will be done of the target sites and "buffer strips" introduced. Stone-clearing for land exploitation often destroys the wild relatives' habitat, but is necessary for income generation, so the project will get these cleared stones used to make new, similar habitats. Small, simple dams and terraces will be built to provide niches for alternative income generation and diversified plant production. Where there is no alternative to discouraging agricultural activity in a given area, the project will go for imaginative solutions such as apiculture. (This can work well, and ICARDA's Highland Regional Project has helped encourage beekeeping in the Taurus Mountains in Turkey with some success.) Field gene banks will be established for vulnerable species in field margins.

There is much more to this project, and the activities above are only a sample; it is impossible to describe them all. *Conservation and Sustainable Use of Dryland Biodiversity* is one of the most exciting projects with which ICARDA has become involved, not least for the unanimity that has been achieved across nations, institutions and disciplines in putting it together. But perhaps its most important feature is this: what we learn in Lebanon, Jordan, Syria and Palestine over the next five years could provide a model for sustainable *in-situ* conservation of agrobiodiversity around the world.

Now *that* would be responding to Rio in a big way.

*Dr John Peacock, formerly Plant Physiologist at ICARDA, is now leading the Center's Arabian Peninsula Regional Program (APRP) from Dubai. Mike Robbins is Science Writer/Editor and editor of* Caravan.

## First, find your lentil! *Continued from page 11*

collector must be careful. Excessive sampling from a small population may endanger its very existence. After finding the population, the collectors may have to leave empty-handed!

A site number is allocated, and a unique identifier known as the collector number which will accompany the seed sample when it is distributed to users around the world. Exact site location is recorded, as well as a site description including the slope, the soil depth, aspect, soil texture and the nature of the parent rock. The size of the population, the area over which it is distributed and an indication of the threat to the population such as the proximity of agricultural activities and the grazing pressure are also recorded. All this is known as the passport data. Soil samples are taken for analysis, an entire plant is flattened in a plant press for the herbarium, a *Rhizobia* root nodule is carefully stored in silica gel for culture and inclusion in the *Rhizobium* collection. Then, with no time to waste, the team is back on the road, scanning the environment, searching for that ecosystem. A typical expedition usually last a couple of weeks, and will include moments of both depression and delight.

Before the mission leaves the host country, the seed is divided. Half will remain in the national genebank, and half will be taken back to ICARDA for international distribution. Back at ICARDA, the seed is inspected by the Seed Health Laboratory for insects and diseases, and a part of the original seed is planted for multiplication in a quarantine area. The new accession is given an ICARDA identity number, and the passport data collected on the expedition is entered into a database. Eventually some of the multiplied seed is dried to a low moisture content of 5-6%, vacuum-sealed in a fabricated aluminium foil packet and placed in the base collection at -20 $^{o}$C. Here they can be stored for 50-100 years. The rest of the seed will be maintained in the active collection at around 0 $^{o}$C and 15-20% relative humidity, and used for distribution.

Over the following few growing seasons the material will be characterized and evaluated for traits of interest.

Germplasm is maintained under the auspices of the Food and Agriculture Organisation (FAO), and, under the requirements of the Convention of Biological Diversity, make it freely available for all *bona fide* users with the restriction to recipients that they do not take out variety protection rights nor will patent any naturally occurring genes from germplasm provided, without the consent of the country of origin. The common heritage of humanity is thus conserved for future generations.

*Morag Ferguson was an associate researcher at ICARDA until becoming a lecturer at Southampton University,*

# Working together in WANA

By Abdullah Bari, Yawooz Adham and Abdullah A. Jaradat

***The Consultative Group on International Agricultural Research (CGIAR) is made up of 16 Centers based in different parts of the world. ICARDA is one of the CGIAR Centers, as is the International Plant Genetic Resources Institute (IPGRI), which is devoted to the conservation and use of plant genetic resources and biodiversity. Apart from its headquarters in Rome, IPGRI has five regional offices placed strategically around the world. One of these is the Regional Office for West Asia and North Africa (WANA), which is based on ICARDA's campus. This means that ICARDA and IPGRI are able to collaborate closely in areas of mutual interest.***

The West Asia and North Africa (WANA) region is the center of crop origin and biological diversity for several key crops, including wheat, barley, lentil, vegetables, fruit trees and nuts. The whole region is a living genebank, and IPGRI has had a Regional Group dealing with the area for a number of years.

The Regional Office was originally based in IPGRI headquarters in Rome, Italy, but during 1993 it was moved to the campus of the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. The positioning of IPGRI's WANA office in ICARDA facilitated the day-to-day operation of the group through the sharing of ICARDA's facilities. ICARDA has been exceptionally generous in making available its services to IPGRI. The ICARDA/IPGRI grouping has also enabled close cooperation between the two centers in dealing with regional and national programs.

The region's diversity is endangered by a number of factors. IPGRI's long-term strategy in the WANA region is to combine work towards achieving IPGRI's own objectives with regional priorities that take into account the rapidly-growing human population, destruction of original habitats of wild relatives of crops, and changes in agricultural practice resulting in rapid genetic erosion of landraces (farmers' varieties).

IPGRI's medium-term objectives have been addressed through specific working groups established by WANANET. This is the WANA Plant Genetic Resources Network, established in 1992 in collaboration with ICARDA, the Food and Agriculture Organization of the United Nations (FAO) and the Arab Center for Studies of the Arid Zones and Dry Lands (ACSAD), with the participation of national plant genetic resources programs from the WANA region. The working groups of WANANET are: cereals; horticultural crops; pasture and forages; food legumes; industrial crops; and *in situ* conservation of biodiversity. The Working Groups allow the National Programs of the area to collaborate very closely with other groups, IPGRI and ICARDA. For example, when WANANET reviewed its Phase I in Cyprus during October 1994, the opportunity was taken to discuss among the participants the preparation of country reports on plant genetic resources and sub-regional meetings in preparation for the FAO International Technical Conference (ICPPGR), which took place in Leipzig, Germany, during June 1996. A synthesis report for the Mediterranean, Central and West Asia was developed and published for the above meetings, in consultation with all concerned parties in the region.

Another example of regional collaboration is the development with ICARDA, ACSAD and national programs of the Near East project entitled *Conservation, Management and Sustainable Use of Dryland Biodiversity in the Near East* (see page 12). This project is being formulated in the context of implementing the Convention on Biological Diversity (CBD). Further, the establishment of a Central Asian Network on Plant Genetic Resources (CAN/PGR) last October was a result of a Workshop organized by ICARDA, IPGRI and the Academy of Science of the Republic of Uzbekistan. The workshop was attended by the Central Asian republics, IPGRI (WANA and Europe Groups), ICARDA and the Vavilov Institute of Plant Industry (VIR, Russia). The first meeting of the CAN/PGR Committee will take place early in 1997 at ICARDA/IPGRI-WANA and will allow Central Asian groups to work closely with other regional organizations.

IPGRI and ICARDA have also worked together on a number of training initiatives. Hands-on practi-

## IPGRI-WANA and ICARDA: some forthcoming activities

International Symposium: IPGRI WANA and ICARDA are working togther to host the International Triticeae Symposium that will take place next year 4-8 May, 1997. The major topics of the symposium are: Evolutionary Genomic Relationships in the Triticeae; Biodiversity and Biogeography; Genetic Resources and Core Collections in Breeding and Research; Evaluation and Pre-breeding of Cereals and Forages; and Quality and Utilization. Just after the Triticeae Symposium (10-14 May, 1997), a symposium on the Origins of Agriculture and the Domestication of Crop Plants in the Near East will be organized by ICARDA, the University of California, Centre National de la Recherche Scientifique (CNRS), IPGRI-WANA, the Department of Antiquities of Syria and the Institut Fancais d'Archeologie au Proche Orient (IFAPO).

### *Training courses*

The Moroccan Institute (IAV Hassan II), in collaboration with GTZ, IPGRI and ICARDA, is organizing a course early next year (February-March). The course will be for Francophone countries. The Vavilov Institute of Plant Industry (VIR) with IPGRI and ICARDA are planning to have a joint course during June 1997, to be held in Saint Petersburg, Russia. The course will be attended by participants from Central Asian countries.

cal training courses on documentation, data management and conservation were conducted during 1993, 1994, 1995 and 1996 at the Genetic Resources Unit of ICARDA. Trainees from Cyprus, Egypt, Iran, Oman, Morocco, Syria and Yemen attended this program. And, in collaboration with ICARDA, a training course on documentation was held in Morocco from 20 September to 1 October 1993. The course was designed to provide an overview of procedures and technologies relevant to documentation of plant genetic resources information and to provide hands-on training in data handling and processing.

During 1994, an advanced course was organized jointly with ICARDA on the conservation of plant genetic resources in Aleppo, Syria. The course targeted senior staff involved in coordinating national plant genetic resources programs and/or genebank management. Major aspects of genetic resources management were dealt with in the course, including the legal aspects. Topics on collecting strategies, conservation, characterization, evaluation and utilization were also covered in the course. Lectures were given on *in situ* conservation, and international treaties—mainly, the Convention on Biological Diversity.

> "Past history has shown how effective a collaborative approach can be in developing regional initiative"

In Jordan, during 1995, a training course on Collection and Conservation of Drylands Genetic Resources was organized by ICARDA and IPGRI-WANA. This was within the framework of the Near East project (Conservation, Management and Sustainable Use of Dryland Agro-Biodiversity in the Near East), with the support of UNEP.

Past history has shown how effective a collaborative approach can be in developing regional initiatives. ICARDA and IPGRI have been able to take maximum advantage of their shared interests and close regional proximity.

There are a number of other areas of potential collaboration between IPGRI, ICARDA and the national programs and various institutions committed to protecting the genetic diversity of the WANA region. With continued collaboration, we can work to preserve the region's rich heritage for future generations. ■

*Dr Yawooz Adham is Group Director, Dr Abdullah A. Jaradat is Genetic Resources Specialist and Mr Abdullah Bari is Documentation, Information and Training Officer at IPGRI-WANA Regional Office, Aleppo, Syria.*

# *Genetic resources: urgent action needed now*

Two eminent scientists recently launched an urgent appeal for the conservation of biodiversity, timed to coincide with the World Food Summit, convened by the Food and Agriculture Organization of the United Nations (FAO), which took place between 13 and 17 November 1996.

M.S. Swaminathan, President of the National Academy of Agricultural Sciences and Chairman of the M.S. Swaminathan Research Foundation in Madras, India, and Prof. Gian Tommaso Scarascia Mugnozza, President National Academy of Sciences, Rome, and Rector University of Tuscia, Viterbo, Italy, urged all colleagues to give their names to a document addressed to the governments represented at the Summit. The document was headed *Appeal to concerned scientists throughout the world for the safe conservation and optimal utilization of biodiversity and genetic resources for food and agriculture, and the fair and equitable sharing of the benefits*.

Dr Swaminathan is a former Director General of ICARDA's sister Center, IRRI, and has served as Chair or Member on several of the CG Centers' Boards of Trustees.

As part of the preamble to the *Appeal*, Prof. Mugnozza and Dr Swaminathan wrote that they believe "that it is the moral duty of all men and women of culture and science towards humanity to contribute to forming public policy, and to educating public opinion about the fundamental need to conserve biological diversity, to use its components sustainably, and to share fairly and equitably the benefits arising from the utilization of these resources."

They strongly expressed their support for "the farsighted programs initiated a long time ago by the United Nations and the Food and Agriculture Organization in favor of an equitable and sustainable use of biological diversity, which is the key element in the achievement of sustainable food and nutrition security."

Among the measures called for by Prof. Mugnozza and Dr Swaminathan, several struck a chord with ICARDA, which is already practising them. They call for "the effective conservation *in situ* of the wild relatives of crops and agricultural animals and the development of *in situ* gene parks", a strategy being followed by ICARDA and a number of its partners in their project *Conservation and Sustainable Use of Dryland Agro-Biodiversity in the Near East* (see page 12). Also desired are "dynamic on-farm conservation strategies which aim both at ensuring the long-term conservation of agricultural genetic diversity, and at the economic and social development of the farmers themselves, and their farming communities." This is being pursued as an integral part of the crop breeding strategy (*Three Among The Millions*, page 6).

The authors of the Appeal also urge "the secure conservation of resources by completing *ex situ* collections, particularly of materials at risk, and also by bringing such collections to the International Network of *ex situ* collections under the auspices of the FAO." ICARDA's *ex situ* collection, which is one of the world's largest with 110,000 accessions, was placed under the auspices of the FAO in 1994. Several other policies advocated by Prof. Mugnozza and Dr Swaminathan are already being implemented at ICARDA. ■

# Roots, pipes—and soil harvesting

*Everyone in development talks about using a participatory approach and using indigenous knowledge. Some people are actually doing it. In Tunisia, national scientists are showing how it could lead to far more effective soil and water conservation in farming. And ICARDA is working to make sure it becomes a trend.*

**By Dr Aden Aw-Hassan**

On a warm early-autumn morning, a group of scientists and officials are standing in an olive grove in Gasre Jawame, near Benekhedeche in southern Tunisia. They are from several countries, and include three from Tunisia's *Institut des Regions Arides* (IRA) at nearby Medenine and another three from the Farm Resource Management Program of ICARDA. It's a pretty healthy olive grove; and, unusually, there are vegetables here too. In fact the farmer, Mr Najeh, is thinking of growing potatoes as well. That would certainly be breaking new ground for Gasre Jawame. How has he done it?

The answer lies just below the surface of the ground. The water is being carried direct to the roots of the trees and crops by polyurethane pipe, fed by gravity (the cistern is on the hillside above and is fed by surface run-off). The supply can be opened and closed with a tap Mr Najeh has installed in the grove. This prevents waste, as does the use of a closed below-ground system in which the water will not evaporate. Last but not least, taking the water straight to the root system is a boon for water-use efficiency.

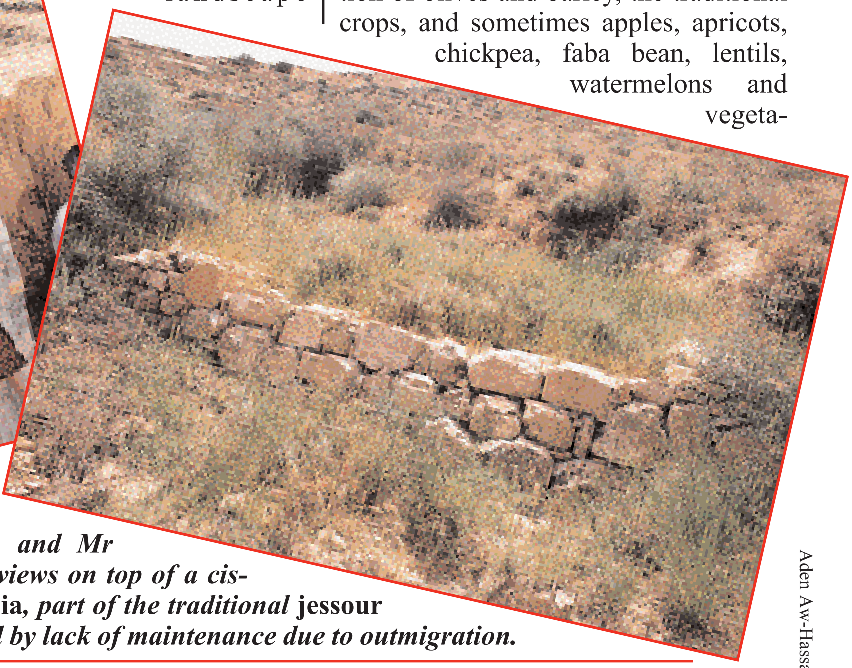
Abelardo Rodriguez

The three Tunisian scientists with us that day had reason to celebrate. They worked with Mr. Najeh to develop the system, which is designed to supplement the threatened indigenous *jessour* system. It was devised by Dr Bellachheb Chehbani, who is a hydrologist, and the other two members of the team, agricultural economist Dr Mongi Sghaier and anthropologist Dr Noureddine Nasr. It is a multidisciplinary approach which ensures that whatever is developed is feasible, economic and transferrable.

The work is urgent in southern Tunisia. The region is dry, with a long-term rainfall of around 200mm. The landscape consists of undulating hills and mountains denuded of natural vegetation. Soils are poor and extremely shallow and rocky. Poverty is more prevalent in rural areas in Tunisia than it is in urban ones, and this is exacerbated by the low rainfall and poor soil—and, as IRA has established, by increasing pressure on marginal rangelands by overgrazing and accelerated soil erosion.

It is a vicious circle; as agricultural land is degraded and productivity drops, communities seek other ways to earn a living, and there is mass out-migration. The resulting labor shortage leads to neglected fields. Moreover, it causes a loss of indigenous skills which leads to further environmental damage.

The clearest example of this is that of *jessour*. This is an ancient system consisting of a series of stone and earth walls, called *tabias*, built across the stream beds of narrow valley watersheds. The *tabias* collect and retain soil washed down hillsides by torrential rains (that 200mm tends to come all at once), forming terraces in a stairstep fashion down the natural slope. Soil harvesting! The rainfall also collects on these steps and permits cultivation of olives and barley, the traditional crops, and sometimes apples, apricots, chickpea, faba bean, lentils, watermelons and vegeta-



Aden Aw-Hassan

***Dr Chehbani (nearest camera) and Mr Najeh exchange views on top of a cistern. Right: a* tabia*, part of the traditional* jessour *system threatened by lack of maintenance due to outmigration.***

bles. In the Matmata mountains, with their higher rainfall, the *jessour* system has allowed cultivation of figs, grapes and apples as well.

This has worked well for centuries, but recently the *jessours* have not been well maintained, due to outmigration and the shortage of skills and labor. This has led to increasing run-off during the storms, destroying the systems and causing not only waste of water but faster soil erosion.

The Tunisian Government is well aware of all this. Dr Chehbani and his colleagues in IRA have been researching improved traditional water and soil systems for many years. Indeed HE Abderrahman Limam, the Governor of Medenine, is implementing a policy firmly based on conservation principles, and he and the former IRA Director General Dr N. Akrimi both took part in the traveling workshop that had brought the participants to the region.

What is innovative about the current Tunisian approach is participatory improvement and two-way technology transfer. It is in this respect that ICARDA is involved. In 1990 it founded, with several national research programs, the Dryland Resource Management Project (DRMP), known, perhaps inevitably, as Drump. Drump is a story in itself (see box). But its basic function is to initiate interdisciplinary and participatory research on natural-resource management. This became linked to a broader system-wide initiative in the CGIAR, ICARDA's parent body, and it was following a conference on the subject at our sister Center, CIAT, in Colombia that the idea took hold in Tunisia. It was as part of Drump's work that the ICARDA team was there: the author, agricultural economist Dr Abelardo Rodríguez and soil and land management specialist Dr Michael Zöbisch.

Part of Drump's work is to organize multidisciplinary work in the field, with farmer participation. And that was what was happening at Gasre Jawame last September. We didn't go there just to marvel at Mr. Najeh's olive groves. Because the farm and the Tunisian work has attracted attention, we were using it as a venue for a traveling workshop for

***Continued on page 21***

Michael Zöbisch

***Disaster—Tunisian cropping land swept away by a flood. If properly maintained, the* jessour *system can help prevent this. But just how strong do the* tabias *have to be? This is the sort of question that the Tunisian team must answer.***

## What is DRUMP?

Drump is DRMP—the Dryland Resource Management Project. It was set up by ICARDA in 1990 in collaboration with national scientists from countries in the West Asia/North Africa (WANA) region in order to initiate multidisciplinary and participatory research into natural-resource management. It is coordinated by ICARDA's Dr Aden Aw-Hassan, who succeeded Dr Elizabeth Bailey, the project's first coordinator and now ICARDA's Project Officer, at the end of the first five-year phase. Seed money came from ICARDA itself but also from the International Development Research Center (IDRC) of Canada, the Ford Foundation and the Organization of Petroleum-Exporting Countries (OPEC).

DRMP's rationale was, first, that natural-resource management involves many factors, and that it must be multidisciplinary; second, that natural-resource management is ultimately implemented by the resource users—that is, farmers—and that they must participate in research and decision-making; and third, that scarce funds in developing countries are likely to go first to research that enhances productivity, while resource management could prove to be the loser.

Seven countries are now involved, and at least two besides Tunisia (Yemen and Lebanon) are actively pursuing this type of research. Others are held back by a lack of external funding. There is also sometimes a perception that participatory research is more expensive, but there is good evidence that this is not the case. It could be argued that, if farmers are offered technology they do not want, there is no harm done - they will simply reject it. They certainly will, but by then much time and effort has been expended. To preserve scarce natural resources with equally scarce financial resources, we need to get it right from the beginning.

# *But will it grow in my field?*

*ICARDA's researchers want to breed crops that are as closely matched to the growing environment as possible. But how can they know they've succeeded? There is a way.*

***Crop trials: they don't always give you the whole answer.***

By Mike Robbins

In the developing world, where yield stability is important and expensive inputs are impracticable, new crop lines must be bred for their ability to adapt to a harsh environment and low-input techniques. That is the only way to food security (see page 6).

But how do you know you've bred a line which will grow well in the fields of the target area? The answer lies in the science of biometrics. Crudely defined, biometrics is the science of statistics related to biological phenomena: what do the figures really mean?

There is an image of the agricultural researcher as a man with a clipboard, a waterproof coat and a pair of rubber boots, crouching in a windswept field, frowning with concentration as he examines his latest experiment for signs of stripe rust or ascochyta blight. This is not the whole picture. Experimental results must be analyzed before you know what they are actually telling you. Biometrics is a key part of this process, and biometricians dispense with the muddy boots; instead, they manipulate statistics using an ever-growing arsenal of sophisticated software.

ICARDA's biometrician, Dr. Murari Singh, explains how he and his colleagues tackled the problem of measuring adaptability to farmers' fields. "What we are talking about is G x E interaction, where G is the genotype—that is, the plant material, or variety, you have bred and are testing—and E is the environment. What you have to measure is varietal sensitivity to the environment.

"In fact, there has been considerable research on using statistics to measure that sensitivity. What we set out to do in 1991 was to take that a step further, and examine the potential of a variety for its transferrability *within* a given environment. Because even within a given ecoregion, exact circumstances are going to vary."

A quick glance at the rainfall for ICARDA's research stations bears this out. Breda, Boueidar, Ghrerife and Jindiress are all in the same general region as the main headquarters research station at Tel Hadya, yet in September 1996 their accumulated rainfall for the season was 5.4, 1.6, 1.2 and 7.1mm, respectively. The figure for Tel Hadya itself was 22.9mm. Substantial variations may also be found in mean averages of minimum and maximum temperature.

"Practically speaking, you can't breed for every conceivable variation in climate and soil, so you have to breed instead for adaptability. And if you have a variety adaptable to a number of environments, you may like to examine if the same is adaptable/transferrable to a new (or an additional) environment," says Dr Singh.

"To obtain an index of inter-site transferrability, we model the response of a variety, using linear regression, based on data from all the test sites except the target site, to which it is intended to be transferred; we then compare observed performance with the predicted performance at that site. This process is repeated for each site, considering it as a target site. The inter-site transferrability index is a function of the squared differences between observed and the predicted response, and the plot residual sum of squares with each site.

"It is, in fact, more complicated than that because each value of the transferrability index obtained is judged against an environmental index, which itself is an integration of various conditions which could affect the transferrability of a variety to a particular site. This would certainly include rainfall, but it also takes account of soil type, mean maximum and minimum as well as average temperatures, incidence of pests and diseases and other factors. You have not just to include these, but also assess the way in which they act upon each other. Remember that we are trying to breed for adaptability to *all* stresses, including biotic ones such as insects as well as abiotic stresses like drought, moisture stress, heat and cold."

Interim conclusions were published in *Inter-site transferrability of crop varieties: another approach for analyzing multi-locational variety trials* (Euphytica 89:305-311) in 1996. The authors were Dr Singh; Dr S. K. Yau of ICARDA's Germplasm Program; Dr John Hamblin, formerly of ICARDA and now at CLIMA in Australia; and Dr Enrico Porceddu of the Institute of Agricultural Biology in Viterbo, Italy, who is a Professor of Genetics and a former member of ICARDA's Board of Trustees.

"A number of statistics to measure varietal sensitivity to environmental variation have been introduced...based on the response of a genotype to a changing environment...These statistics play an important role in studying G x E interaction, but this in itself is not the final step in the process of developing, evaluating and releasing a variety. The present approach takes the varietal assessment process further to the level where the potential of the variety could be estimated for its transferability within the target domain," they write.

Since 1991, Dr Singh and the ICARDA breeders have been testing the viability of the statistical model they have obtained.

It is an example of the sort of work that must be done using modern software tools if experiment results are to bring maximum benefit to the farmers. Biometrics is, in fact, part of the Computer and Biometrics Support Unit (CBSU) of ICARDA, which, besides maintaining and developing the Center's computer hardware and software, also carries out research computing; it is making growing use of Geographic Information Systems (GIS) for identification of water sources, environmental and degradation hazards, land-use patterns and sources of biodiversity, and has also developed research application tools such as the Trials Management System (TMS), a Windows-based program that helps scientists plan, manage and analyze data and report results, manage meterological information through the METDB (Meteorological Data Base) system and keep track of their experiments from the desktop.

It is hoped that these developments will be covered in future issues of *Caravan*.

In the meantime, anyone who feels that the work done by Dr Singh and his colleagues could have a useful application to their own trials should contact him at ICARDA, or by email to M.SINGH@CGNET.COM. He promises not to bring muddy boots into your laboratory...

# Roots, pipes—and soil harvesting

**Continued from page 19**

scientists from Spain, Syria, Yemen, Jordan and Pakistan, as well as Tunisia and ICARDA.

We found ourselves in a heated but cheerful discussion between scientists, farmers and the local village head, or *Omda*, about cost, risk, the role of the farmer, plant/water/soil relationships and other matters. The *Omda*, for example, asked who was expected to pay for such systems? The regional representative from Tunisia's soil and water conservation department promptly said that a grant of up to 50% and soft loans would be made available—a demonstration of Tunisia's serious commitment to conservation work in the field, and one we found shared by the District Governor, the *Mutamed*, when we visited him earlier that day. However, the Tunisian team felt that some of the questions the farmers had raised required more analysis.

They also faced questions from farmers on the measures they have devised for safeguarding and improving the *jessour* system. Dr Chehbani and his team have developed water-retention, damage-control and erosion-control measures using a computer-based watershed runoff model. These included additional terraces, planting of medicinal and forage plant species on the degraded hilltop to capture surface runoff, flood-water discharge systems and other measures; tested without farmer participation in the first instance, they proved feasible.

But farmers then raised practical concerns; for example, the surface runoff from the degraded land is actually diverted through the elaborate *hamala* canal system to unproductive land lower down, where it is regarded as a key part of the farming system. In the lower land, moreover, runoff spillover from neighbors is brought to whoever is next down the line; again, it is vital to them, and they have no rights in the matter if it is suddenly cut off.

Farmers also pointed out that the improvements IRA had devised were designed to protect the *jessours* from damage by rainstorms causing a flow of up to 200 mm/hour, which is 90 mm/hour more than is ever received; and in any case, the farmers expect to take a risk and repair the systems once every 15-20 years. (Although, as IRA has found, the supply of skilled labor to carry out such repairs is declining.) Last but by no means least, the cost of such improvements was commented upon. In view of all this, IRA will develop computer models to projections of differing rainfall intensity and to cost-benefit analysis.

***Taking water from the cistern —the old way.***

Abelardo Rodiguez

IRA's approach will now be to introduce the improvements to selected sites, rather than attempt to bring them into farmers' fields on a large scale, and then organize field tours so that the farmers can examine the technology, decide what they think is worth testing in their own fields, and reject what they don't.

That is how it works with Drump. Take a farmers' system that has worked for centuries; find out why it doesn't any more; devise a solution in collaboration with farmers; see if they think it will work; and incorporate necessary modifications.

To do that, you need engineers, economists, anthropologists, soil scientists and results from water-use efficiency research. It *must* be interdisciplinary. A little lateral thinking helps, too. But the most important element is farmer participation. It is no longer enough to develop technology and then serve it up to farmers.

They must be in the kitchen with us, helping with the cooking.

*Dr Aden Aw-Hassan is Coordinator of the Dryland Resource Management Project (DRMP).*

# Balochistan:

## Searching for a strategy

*If one estimate is to be believed, the number of sheep and goats in Balochistan, the western province of Pakistan, increased from about 1.5 m in the mid-1950s to 18 million in 1986 and could reach 27 million by the end of the century. What has this done to the rangeland? Can the effects be reversed?*

By Sarwat Mirza, Euan Thomson, Ghulam Akhbar, Abdul Sattar Alvi and Shahid Rafique

Once upon a time, there was no problem. As the Imperial Gazetteer of India (Balochistan) put it in around 1903: "The large herds of sheep and goats, which rove over the hills for six or seven months of the year, keep in excellent condition owing to the numberless small cruciferous and leguminous plants, which afford good pasturage. The goats also obtain grazing from the bush growth."

Euan Thomson

Marvellous! Unfortunately, things have changed. Balochistan, in common with other arid zones, must support far more people than it did then. The exact figures are confused by out-migration to urban centers, but human population has grown from about 1.2 million in 1951 to 7.1 million today. The rate of population increase even reached 7% during the early 1980s, the numbers inflated by the influx of Afghan refugees. At the same time, numbers of small ruminants increased, augmented by the refugees' animals and disruption of seasonal migratory patterns caused by the long war in neighboring Afghanistan. The estimate of small-ruminant numbers above is open to question, but 20 million is reasonably accurate.

The impact on the natural-resource base, and the need to deal with it while ensuring an adequate supply of livestock products, is one of the main problems confronting AZRI — the Arid Zone Research Institute — in Quetta. It is an institute of the Pakistan Agricultural Research Council. During the period 1985 to 1994 ICARDA helped strengthen the research capability of AZRI using a grant from the United States Agency for International Development. ICARDA initially posted four scientists at AZRI, covering the disciplines of germplasm improvement, farming systems research, water harvesting-agronomy and extension. The range/livestock aspects were addressed by a specialist from Colorado State University. During the second phase, after mid-1990, the ICARDA team consisted of a livestock scientist, an agronomist and a socioeconomist. Although its formal input has now finished, ICARDA continues to collaborate extensively with AZRI, and a joint mini-project was started in January 1995 on rangeland monitoring and rehabilitation.

AZRI believes that about 90-95% of the feed for the 20 million small ruminants comes from rangeland grazing; other estimates have put it much lower, particularly if one accounts for the crop residues and stubbles used by transhumant animals that move in winter to the lowland part of Balochistan extending towards the River Indus.

Again, depending on whose definition you accept, 30 million ha is classified as rangeland—well over 90% of the province's land resources—or only about 20 million ha, about two-thirds, if sandy areas and bare mountains are excluded. Either way, it is unable to provide enough feed, especially during winter, when advanced pregnancy and lactation force up the feed requirement. Range productivity is declining, and harvestable dry-matter yield is probably below 100 kg/ha on the areas in moderate and good condition; these amount to some 10 million ha. In fact, we think that much of the area is stocked at five or six times its sustainable carrying capacity—which is probably only about 10-20% of what it was in 1903.

Two immediate consequences can be identified. First, offtake— that is to say, production of livestock products— of the animals is only about 50-60% of their genetic potential, making them less efficient as converters of feed into food since most of the feed is used for maintenance. This in itself increases strain on feed resources, and means a lower standard of living for humans, as the rangeland directly or indirectly provides the livelihood of around 87% of the rural people of Balochistan. The low offtake is one reason why livestock farmers own more animals, just to satisfy the demands of their family for milk products, meat and wool, and to generate some surplus income for essential purchases. And second, vegetation composition is changing, with palatable species decreasing day by day.

We face three major challenges in Balochistan's rangeland. The first is to improve animal health and fertility so that offtake per animal improves, and therefore productivity. The second is to limit grazing to a realistic carrying capacity that permits rangeland regeneration. The third is to ensure that there is sufficient biodiversity for such regeneration to take place. Animal health and fertility is a pressing, but separate, subject; as we are talking about the condition of the rangeland itself, it is the second and third challenges that we are discussing here.

The key to allowing rangeland to regenerate is management. Attempts to manage rangeland sustainably are not new to Balochistan. In 1954 the Maslakh Project was founded with assistance from the USAID to research and implement scientific range management on 46,574 ha near Quetta. Balochistan's Forestry Department was the sole implementing agency; the rangelands are hardly forests, but at that time only this department knew anything at all about rangeland management. The project ran for 16 years but, surprisingly, little documentation has been found on it, even in the USA.

It was not an unqualified success. Although much work was done on reseeding with grasses and establishment of fodder trees and shrubs, progress was limited by low rainfall and low winter temperatures. But better management practices and protection did raise dry-matter yield from below 50 to 140 kg/ha between 1959 and 1964. Moreover, much was learned. A key point raised by the Chief Conservator of Forests in his final report was that the area had to be protected against illegal cutting and grazing — but that fencing-off of vast areas was costly. It would be much better, he argued— as far back as the 1960s— to get the support of local people. He showed considerable vision, since range-user participation in planning and implementation had then largely been forgotten, but today has again become widely acknowledged as an essential ingredient of successful rangeland projects.

This is a key point in rangeland conservation— and nowhere more so than Balochistan, where pastoralists are fiercely independent and strong-willed. Moreover, they may be encouraged to implement sustainable management themselves. The *Gazetteer of Balochistan*, published in 1907, reported that in one area: "...Many tribes or sections of tribes reserve large areas of grazing...from about the 15th of February to the 15th of November. ...When the *pargors* are opened to grazing, outsiders... are entitled to use them in certain defined localities with the consent of the leading man of the tribe. Cases of disputes are common...a case being known in which the owner of the *pargor* took the law into his own hands and killed the trespasser."

Well, AZRI is not advocating the death penalty for illegal grazing! But one implication of this record is that pastoralists have always understood the need for range management, and it would not be unnatural for the range users to assume this responsibility; they are the user group.

Gustave Gintzburger

The second implication is that pastoralists will protect the natural-resource base if the economic pressures on them allow them to. So anyone planning a rangeland management project must look hard at those pressures.

They must also integrate their approach to the many aspects of rangeland conservation; biodiversity, marketing of livestock products, grazing rights, erosion control. It is AZRI's belief that range management should be recognized as the separate discipline that it really is— rather than be amalgamated with the Forestry Department. Thus, a separate agency is needed to take responsibility for rangeland resource development.

In the meantime, community work to encourage conservation is being carried out by the FAO Integrated Range-Livestock Development Project and by the Italian-assisted FAO International Participatory Upland Conservation and Development Project. Extension work takes the form of education, and demonstration of using communal land at a carrying capacity that permits some regeneration. Farmers are also being helped to establish saltbush reserves which can serve as supplementary feed during difficult times of the year. In the meantime, AZRI and ICARDA are continuing to work together, and are currently cooperating on a range management project.

AZRI itself is tackling the biodiversity issue. There is a real threat that some native species will be lost completely, and replaced by undesirable shrubs. This has already virtually happened outside reserved or remote areas. So AZRI's Range Section is collecting seeds of important shrubs and grasses and preserving samples of important species in its herbarium. We are also actively researching the use of an indigenous aromatic shrub, *Artemisia herba alba*, with an eye to using it for rehabilitation. It grows from seed, establishes itself under cold and drought conditions in the highlands, and is an important part of the animal diet, especially during late summer and autumn. AZRI also thinks we should develop the use of fallow land for growing feed crops. Balochistan has about 1.5 million hectares of cultivable land, and about 800,000 ha are above 1,000 metres in altitude. Of this latter area, about 25% is cultivated at any one time; the rest is fallow. It's marginal, so what about using part of it for saltbush, or other forage and fodder species?

It would also help if the present pricing policy for meat, which is currently biased towards the consumer, were changed so that producers were encouraged to market a better quality animal.

Rangeland management and rehabilitation is a big subject, and Balochistan is a big place. This article has only touched on some of the problems and solutions with which we at AZRI and ICARDA are concerned. But let us hope that, one day, it will be possible to write that our beasts "keep in excellent condition owing to the...good pasturage." Because if they do, the people of Balochistan have a chance to keep in excellent condition, too. ■

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# *Preserving and using biodiversity...*


## *For the sake of future food*

*The keys to ICARDA's biodiversity strategy: the diverse farming system (top right), improved varieties from landraces (above), marginal land (left) and livestock (bottom). Since the 1992 United Nations Conference on Environment and Development, everyone in the scientific community has acknowledged the need to conserve biodiversity. What this means to ICARDA is that we must guard our sources of plant genetic resources in the dry areas, so as to preserve our raw material for breeding future crops like Arta—for resistance to pests and diseases and the ability to survive in a harsh, unforgiving environment. We must save these genetic resources in genebanks. ICARDA has a large and diverse stock of genetic material in its genebank: about 110,000 accessions, 26,000 of which are sent out each year for use in breeding programs. But we must also save living genetic biodiversity so that it can adapt to a changing environment. It must be preserved on marginal land, where it is threatened by grazing, woodcutting and stone clearance. And it must be kept alive on the farm, not replaced by single "improved" varieties bred in less hostile conditions, which may fail. ICARDA and its partners are committed to preservation of plant genetic biodiversity—in the genebank, on the farm, and on unproductive land that, by sheltering this diversity, may turn out to be the most useful land of all.*

Pictures: Majed Khateb (Arta), Mike Robbins