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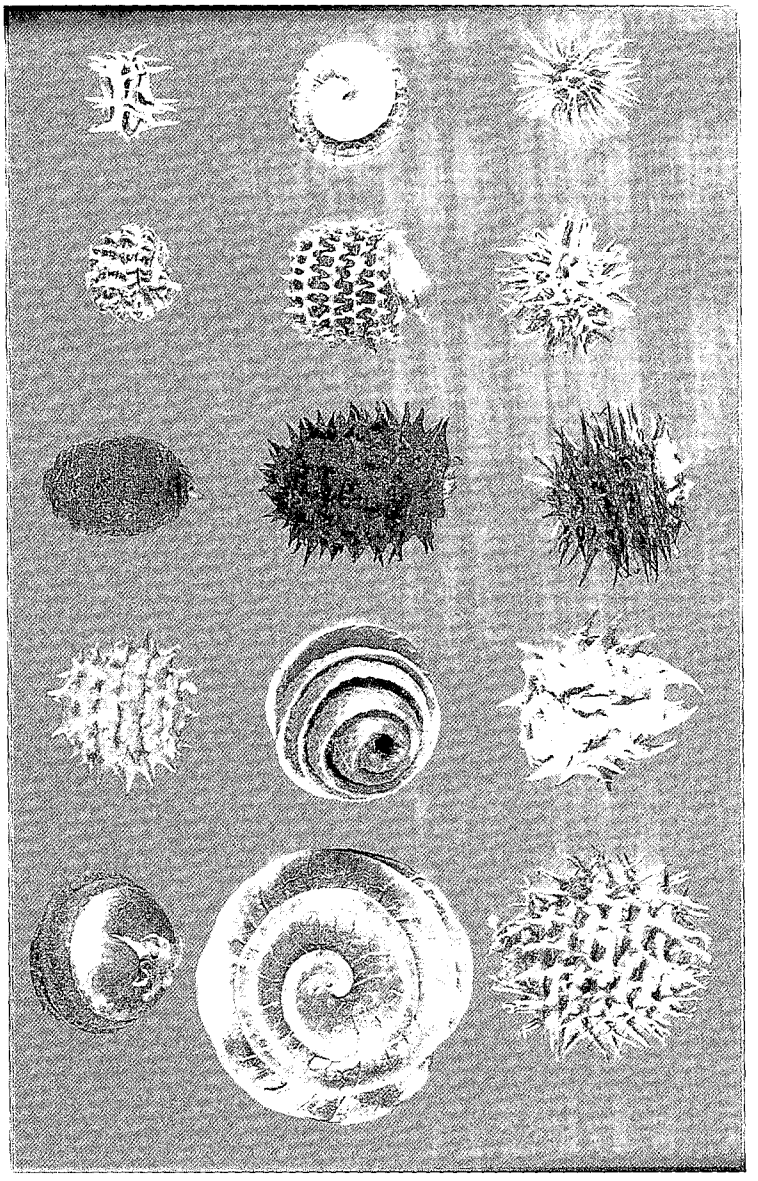
Biodiversity

A Key to Food Security

International Center for Agricultural Research in the Dry Areas

ICARDA



There are many annual *Medicago* species, a sample of which is shown here. Commonly known as "medics," they are related to a perennial form called alfalfa or lucerne. ICARDA's research has demonstrated that medics can play an important role in the rehabilitation of degraded rangeland.

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International Center for Agricultural Research in the Dry Areas

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AGROVOC descriptors: *Cicer arietinum*; chickpeas; *Lens culinaris*; lentils; *Vicia faba*; faba beans; *Hordeum vulgare*; barley; *Triticum aestivum*; soft wheat; *Triticum durum*; hard wheat; *Medicago sativa*; feed legumes; sheep; biodiversity; genetic resources; nature conservation; genetic variation; genetic banks; germplasm conservation; plant collections; rangelands; reclamation; pastures; vegetation; sustainability; agricultural development; food security; arid zones; Middle East; North Africa

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Biodiversity: a Key to Food Security

How does one breed a productive new crop line for the dry areas? By crossing the highest-yielding varieties? But that will not protect farmers from crop failure. ICARDA believes that the preservation of biodiversity is at the heart of a successful breeding program.

In harsh environments with low productivity, the need to increase crop yields is crucial if subsistence farmers are to survive. But so is yield stability. Resource-poor farmers must not be exposed to the risk of crop failure. Crops bred for maximum yield on a research station often do not perform as consistently or as well in the fields, particularly those of resource-poor farmers.

In the past scientists have bred and selected plant material in favorable environments with optimum agricultural inputs. The argument has been that if we select for large increases under optimum conditions, the selections will also give moderate increases in yield in harsh areas. Over the past decade, however, scientists at ICARDA have started to question this logic.

A 1993 paper by researchers at ICARDA stated the problem clearly: "At the low-yielding sites, lines selected as high yielding in good conditions yielded 39% less than lines selected for high yield in stress conditions." The implication of this finding is that breeding and selection for harsher environments should be carried out in conditions as close to the farmers' fields as possible. Moreover, material used in the breeding program should be that which can withstand

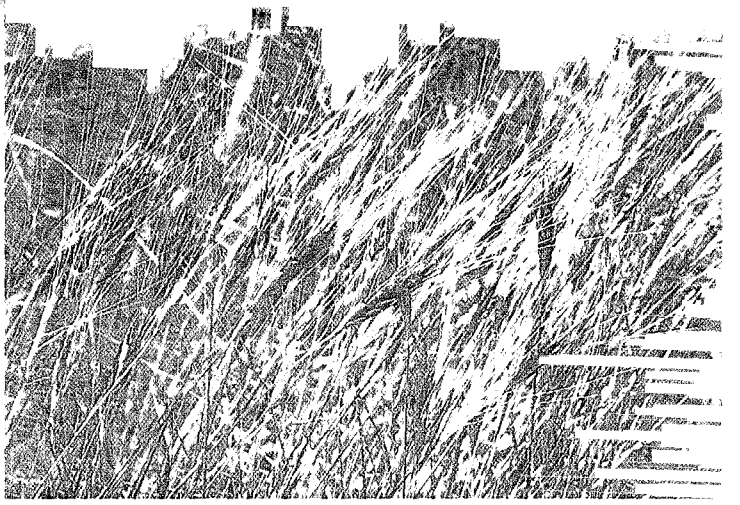
the challenges of nature. So it makes sense to use farmers' own varieties— called landraces— which have characteristics of local adaptation; that is why farmers have been using them for generations.

So ICARDA makes crosses between high-yielding types and landraces. The crosses are performed at the Center's Aleppo headquarters. We then supply unselected material from these crosses for national groups to grow and select in their target environments.

When this selection is done within the target site, it is more specific to local needs. This includes not only climate, abiotic and biotic stresses, but also the level of inputs (such as fertilizers and pesticides) available in the target environment. ICARDA encourages evaluation of selections not only on the research station, but in the farmers' fields— a participatory approach. Previously, crops were made uniform across the region by releasing the same few cultivars in every country. This meant that emergence of a new variant of a disease, to which the variety had no resistance, had serious consequences for production in the whole region.

The first real impact of ICARDA's breeding approach occurred with the release of a lentil variety in Bangladesh. BARI Masur-2 is resistant to lentil rust (the major disease in Bangladesh) and was selected by the national program from material supplied by ICARDA in 1986.

ICARDA
Masur-2
Bang



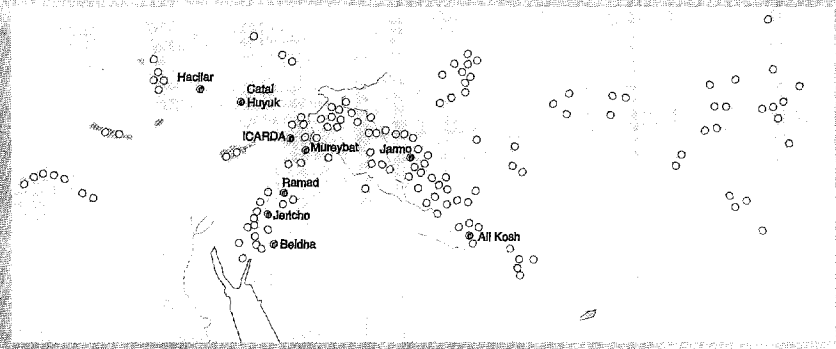
Breeders cannot get the genetic diversity they need to breed for diverse conditions if they do not have access to plants like these wild relatives of wheat.

ut to work this way, breeders must have access to locally-adapted material. Years of centralized breeding for high yield has narrowed the range of genes available. They must be collected from the wild or obtained from farmers' varieties. And they are getting scarcer. It is estimated that up to 60,000 plant species (about 25% of the world's total) might be lost by the year 2025 if the current rate of plant genetic erosion continues. Preserving this gene base is an integral part of ICARDA's breeding approach. To ignore it would be similar to a painter attempting to work with a palette of two or three colors only, each of which merges slowly with the other until only a monotone is left. The painter loses colors; the crop breeder loses sources of resistance to pests, diseases and climatic stress, leading eventually to crop failure and famine.

ICARDA is well-placed to tackle this problem. The eco-region in which ICARDA is located—West Asia and North Africa, or WANA—contains three of the eight centers of crop origin identified by Vavilov in the early part of the century. Of ICARDA's mandate crops, barley, bread wheat, durum wheat, lentil, and vetch were all domesticated in western Asia, mostly in the so-called Fertile Crescent. The wild progenitors and relatives of these crops occur in the region to this day—as has been seen from the results of

crossing lentil landraces with high-yielding cultivars. a rust-resistant line selected from these crosses in sh, was the first fruit of the Center's new breeding approach.

Distribution of wild *Hordeum spontaneum* and of early archeological sites for cultivated barley, *H. vulgare*
(after Harlan and Zohary, 1966).



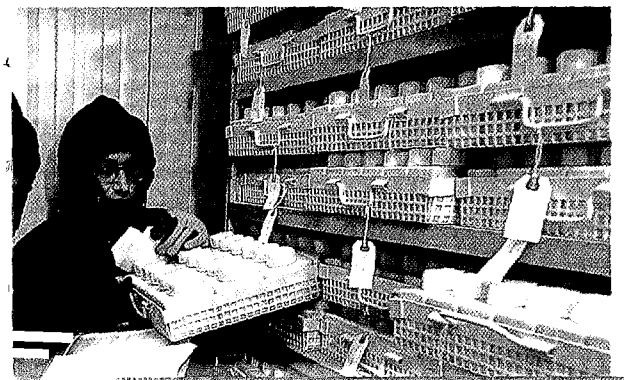
○ Wild locations of wild barley ● Archeological sites with wild or cultivated barley, 6000-8000 B.C.

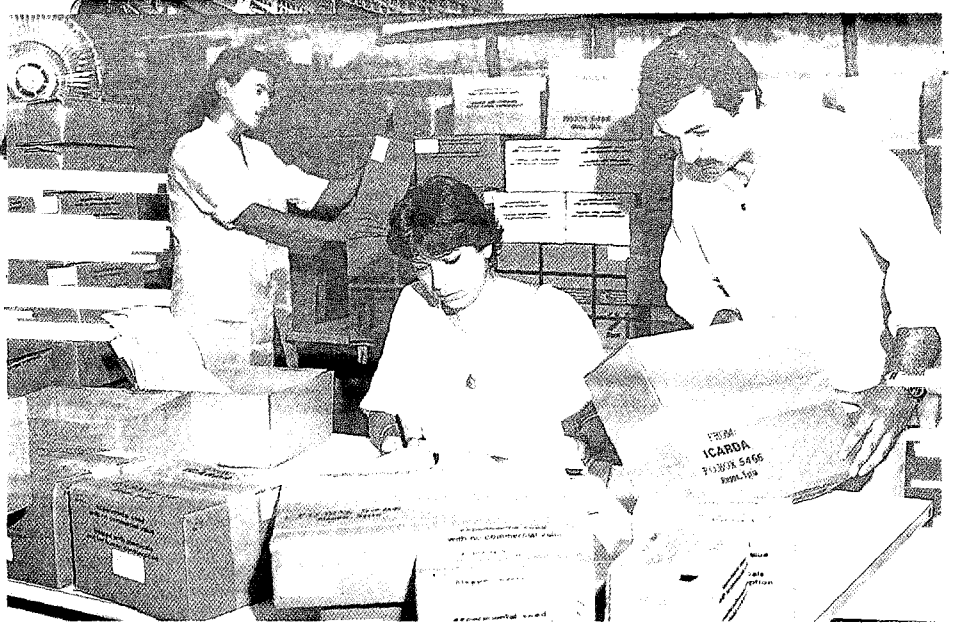
ICARDA's studies, for example on the distribution of the wild progenitor of both bread and durum wheat.

CARDA's genetic-resource program is committed to collect, evaluate, document and conserve biodiversity and use it for genetic enhancement of crops. This diversity occurs in two forms: wild relatives of crop species; and farmer-selected crop landraces. As we have seen, the latter

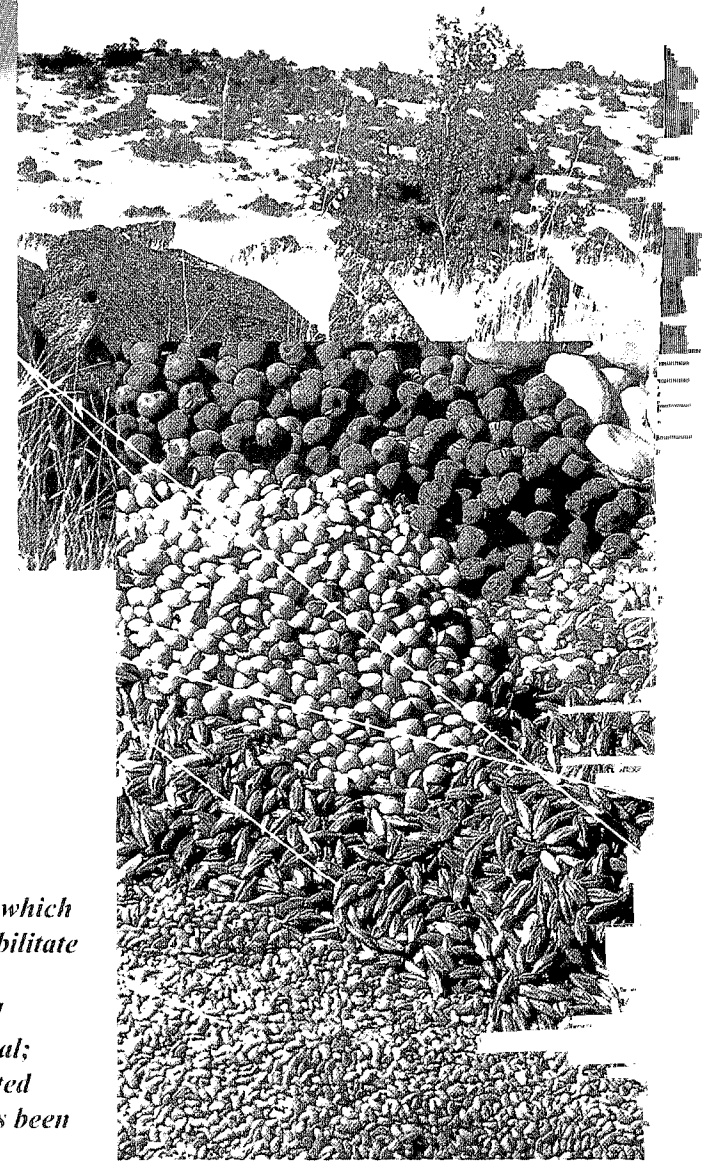
are the end result of thousands of years of risk-averse selection by the farmers themselves; but the wild relatives are equally important, for they are constantly adapting in order to survive changes in climate, soil, pollution levels and other aspects of their environment.

It is not just the crop species which are diverse. Much of the land area of WANA was once range and shrubland. Even today, there is a vast array of species and ecotypes of annual legumes living out there, capable of surviving some of the most arid conditions in the world. Our collection efforts have netted a formidable assortment of accessions from hundreds of species; in fact, at ICARDA there are holdings of nearly 27,000 forage legumes alone.





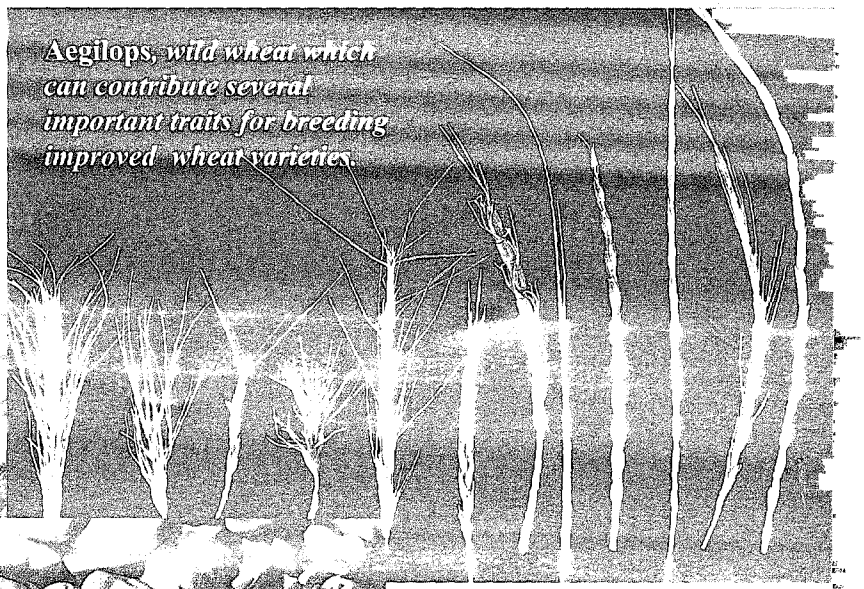
Right: A site on Mount Hermon where ICARDA plans to develop in-situ conservation of wild relatives.



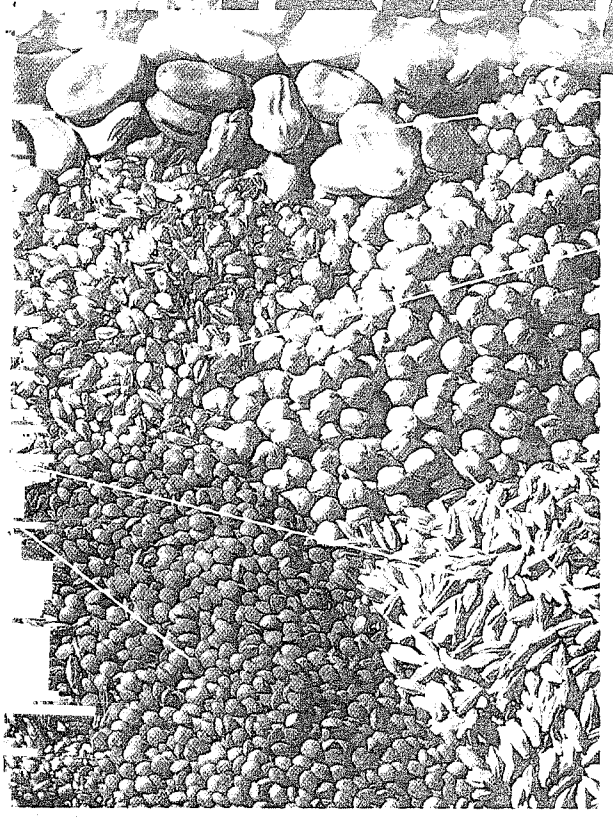
Lentil: ICARDA has the global mandate for this crop. It has developed germplasm which has revived the industry in Sudan— and founded one in Australia.

Another of ICARDA's global-mandate crops: barley. These are Arabi Aswad and Arabi Abiad, local landraces which have proved successful as breeding material.

Medic is a forage legume which ICARDA is using to rehabilitate degraded rangelands and provide grazing. But local genetic diversity is essential; material bred from imported germplasm has not always been suitable.



Aegilops, *wild wheat which can contribute several important traits for breeding improved wheat varieties.*



Faba bean is the raw material for foul, a key part of the diet of millions of people all over the Middle East and North Africa.

Wheat: ICARDA collaborates with its sister center, CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo), on wheat breeding for the West Asian and North African drylands. This program has helped in the development of heat-tolerant varieties; for example, it has been possible to introduce wheat production south of Khartoum in Sudan.

Chickpea: ICARDA, working with ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), has bred varieties adapted for winter sowing, resulting in huge increases in yield.

Up to 1996, ICARDA had conducted 71 collection missions in 40 countries. This is one such mission— in this case, in Syria; but others have been in many other regions of the world, including Bangladesh, Tibet and Ecuador.

issions are sent out each year to known and potential sites of wild species and landraces, both inside and outside the region. So far, ICARDA has conducted 71 such missions in 40 countries. Most of these missions are conducted in collaboration with national programs. Samples are then processed and stored in national and international seed banks— and especially ICARDA's own, in Aleppo. ICARDA's germplasm collection (see box, page 8) is a vital resource, not just for the Center's own breeding work but for that of other scientists as well.

As part of the collection effort, in 1994, ICARDA,

in collaboration with national agricultural research systems (NARS) and the University of California, collected 107 accessions of wild progenitors and 65 of landraces of wheat and barley in Lebanon and Syria. Missions to Morocco and Tunisia in the same year, which were conducted together with the respective NARS and CLIMA (the Center for Legumes in Mediterranean Agriculture, Perth, Australia), yielded 1120 new accessions of forage and pasture legumes and ample data on species distribution and natural habitat characteristics. As the missions were focused on low-rainfall areas and/or high elevations, the germplasm collected may contain genes for drought and cold tolerance and can be adapted to stress-affected, marginal environments.

However, plants in the wild are continually evolving; and there is always the frightening prospect that samples deposited in seed banks now may not survive in the wild after 10 or 20 years, because of environmental changes. Thus, ICARDA has also laid emphasis on *in-situ* conservation of agricultural biodiversity.

In-situ conservation of germplasm at ICARDA's headquarters at Tel Hadya, Aleppo, Syria.

ICARDA is spearheading efforts to link IARCs and NARS in both developing and industrialized countries to conserve and utilize the biodiversity of the Near East *in situ* through a project currently up for funding by the Global Environment Facility (GEF). Modern tools of geographical information systems (GIS) enable us to combine satellite and ground-survey data to identify potential sites for *in-situ* conservation.

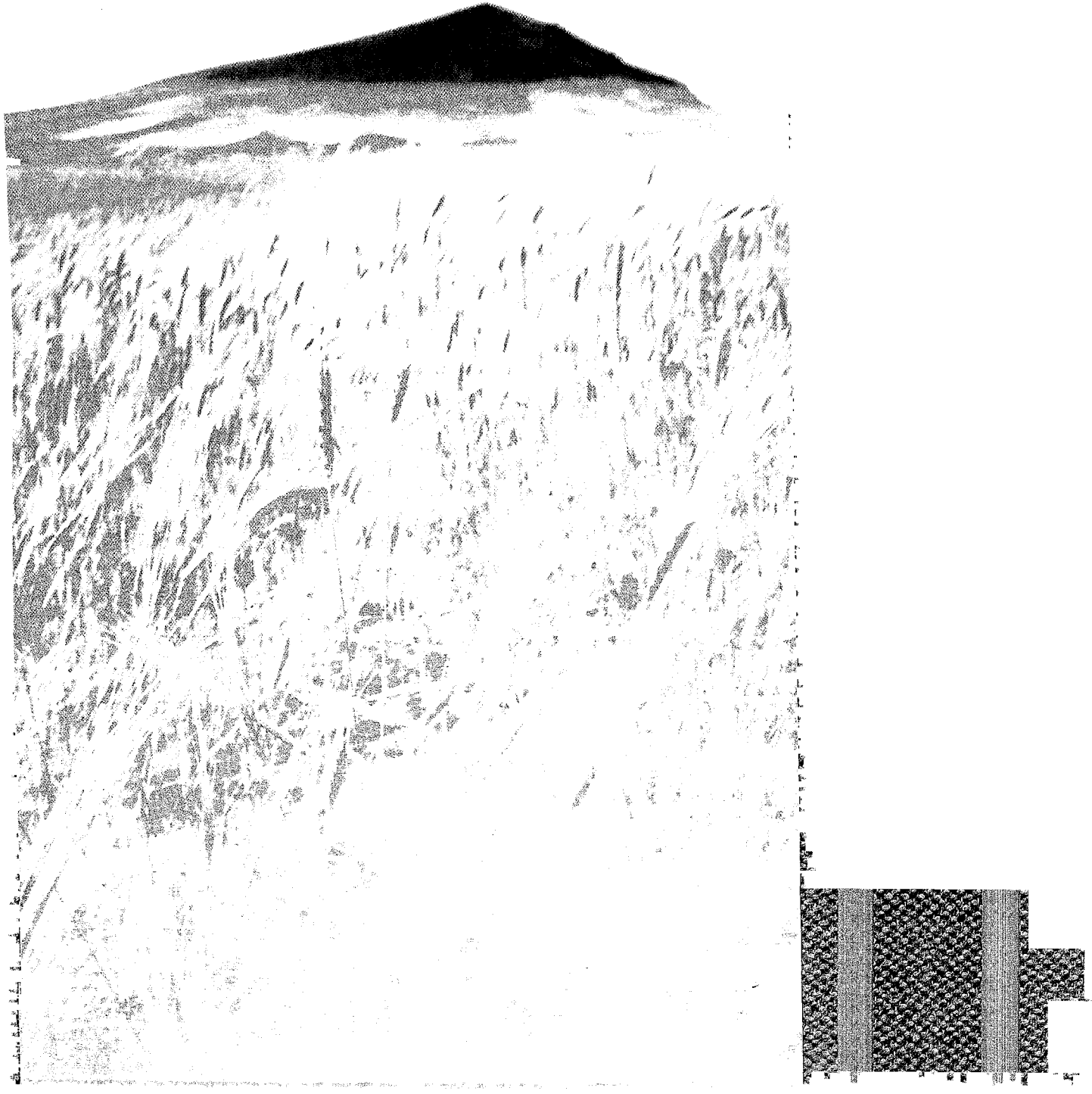
To develop sound *in-situ* conservation techniques, simulated *in-situ* conservation experiments are under way at our station in Syria. To widen the scope, we have expanded this project in collaboration with the Syrian national program to three other sites in Syria—all closer to the natural populations and planted with accessions from the immediate vicinity.

> "We have expanded this project...to three other sites in Syria– all closer to the natural populations and planted with accessions from the immediate vicinity"

How do you know what you have collected, and how useful it is going to be? Observation of field conditions in which the sample was collected may provide a clue. But there must be more detailed investigation. A painter does not use a color that he cannot see.

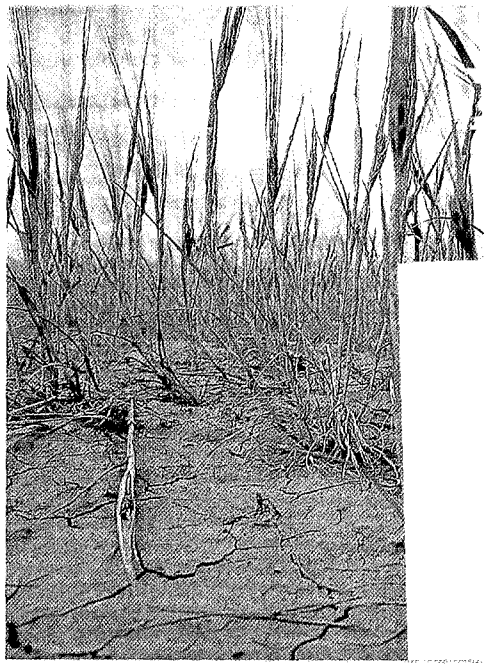
In the past, assessment of inbuilt diversity depended on growing collected seeds under a variety of conditions, and characterizing them. The use of modern molecular marker techniques, such as RAPDs (Randomly Applied Polymorphic DNA), is proving invaluable in demonstrating

Jebel Arab, Syria, a proposed* in-situ *conservation site under the planned biodiversity project.



diversity at the gene level. It also speeds up the process of identifying genetically diverse individuals and populations. Studies such as these have enabled ICARDA to construct a wild lentil cluster map which put the center of biodiversity right where its headquarters are— at the top of the Fertile Crescent! Molecular markers are being increasingly used to assess all ICARDA's genetic resources.

All this work does have a practical application. A recent analysis of wild wheat germplasm, sampled in previous missions, revealed that some populations were composed of very diverse individuals with regard to seed storage proteins and agronomically important traits, e.g. yellow rust resistance and response to day length and temperature. Therefore, variation within the natural populations may be a rich source of useful genes. A number of different stable lines derived from these populations are available to breeders and scientists.

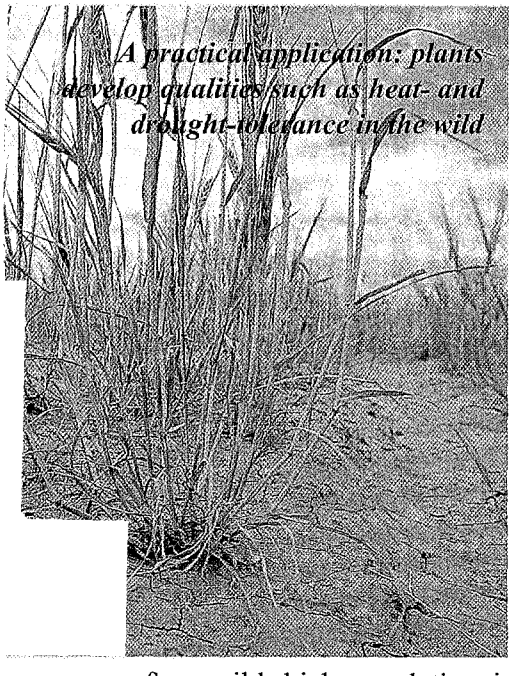


Variation within the landraces has also been exploited. This technique has led to the release of several lines of barley, including Arta, an improved version of the local landrace *Arabi Abiad*, and to the development of cold-tolerant kabuli chickpea cultivars in several countries of West Asia and North Africa. These permit winter sowing, which gives yields 60–100% more than spring sowing. Landrace lines can also provide the genetic background of adaptation

to the environment for the incorporation of genes for high yield. This technique has had major successes in durum wheat, lentil and chickpea.

And it is not only the developing countries in dry areas which benefit. Dryland-adapted lentil from ICARDA has been used in breeding programs in Australia to initiate production there on a wide scale. Similarly, ICARDA-provided germplasm enabled recent expansion of hull-less barley in China.

Wide-crossing of advanced lines with wild species is also proving valuable, as many wild types are adapted to even harsher environments than the landraces are. Work over the past few years on improving drought tolerance in barley by crossing it with the wild progenitor, *Hordeum spontaneum*, has produced spectacular results, with the new plants far outyielding the most drought-adapted of the landrace selections. ICARDA also believes that there is potential in transferring genetic material from related, but incompatible wild species into some crops. We are using biotechnological tools — embryo/ovule rescue and *in-vitro* culture — to incorporate genes for cold and drought tolerance and ascochyta blight and cyst nematode resistance from wild chickpea relatives into our winter-sowing chickpea lines.



A practical application: plants develop qualities such as heat- and drought-tolerance in the wild

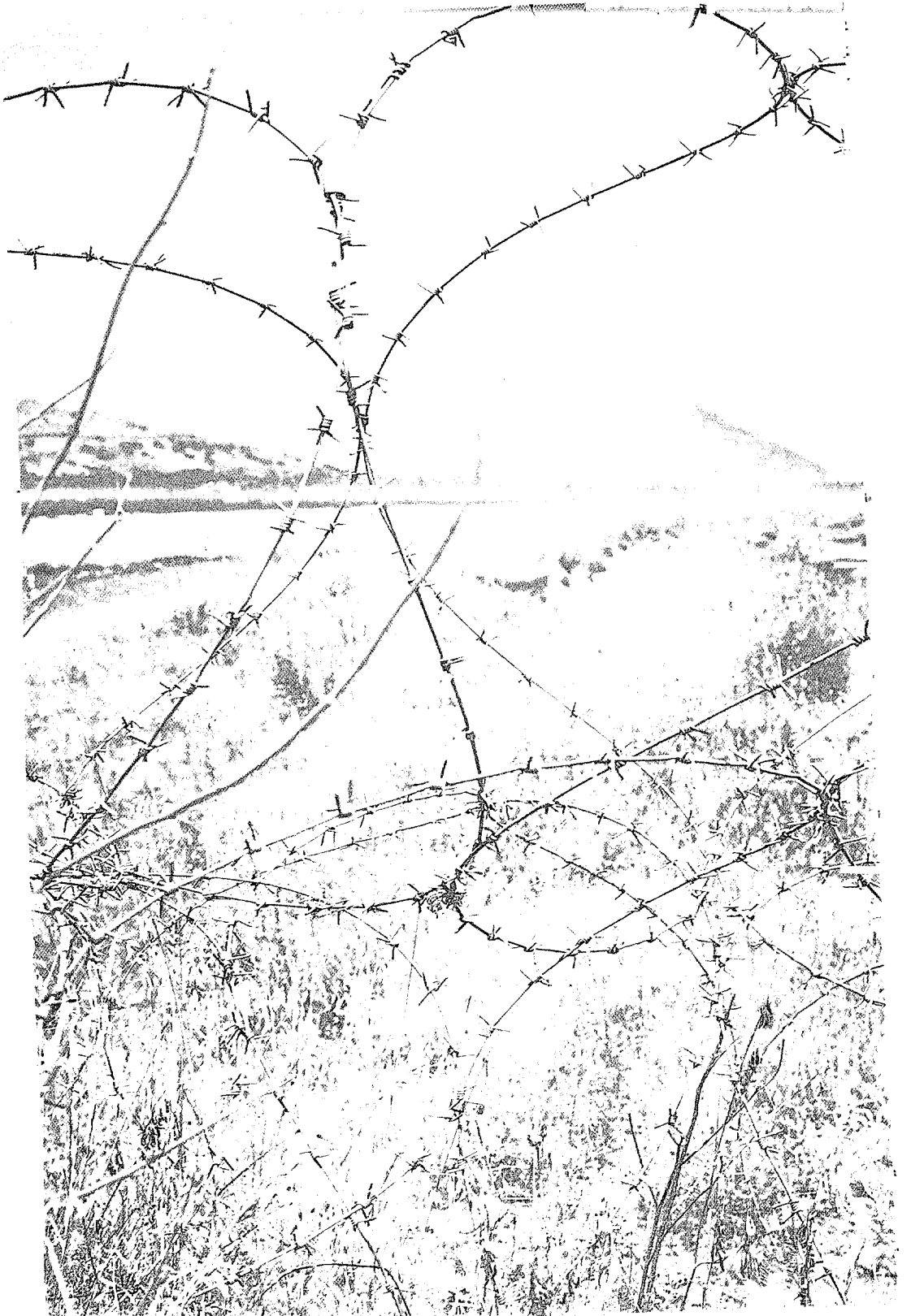
Meanwhile, ICARDA's work on rangeland rehabilitation is putting modern conservation techniques into the

hands of farmers. The secrets of pasture management are being redeveloped with livestock farmers. Once the farmers know how to manage the pasture, the whole system can become self-regenerating and sustainable. In these early stages, farmers are encouraged to oversow with native medic, taking advantage of its hard seeds to extend germination over several years.

ICARDA is also experimenting with clover pastures and using sheep to revegetate new areas. Sheep fed one day on regenerated clover pasture will pass over 50% of the seed the following day. If we have the sheep on degraded land on alternate days, a new pasture is sown—in pre-fertilized packages, too! Thus, sheep grazing on land revegetated with clovers one day can be moved on to the target area (the next piece of marginal land for revegetating) the next. They can be encouraged to stay there for the whole day by the judicious placing of piles of hay. These techniques are being tested on farmers' rehabilitated rangeland in the El Bab area of northwest Syria, and we should know more about the "sheep-shuttle seeder" quite soon.

All of this work is integrated into ICARDA's agricultural development strategy. Preservation of biodiversity, long perceived as an issue by scientists, only really became a popular concern as such after the 1992 Earth Summit in Rio, and is still associated in the public mind with the conservation of cuddly creatures. But although wildlife conservation is an important issue in its own right, the subject of plant biodiversity is actually crucial to human survival. ICARDA and its partners— in particular, the farmers and national scientists it works with for collection of germplasm and for *in-situ* conservation— are determined to ensure that genetic diversity is preserved and used for the benefit of future generations.

Right: Protecting biodiversity: protecting future generations! The Golan Heights may have preserved undisturbed a treasure-house of biodiversity.



Collection of native* Trifolium *spp. in Lebanon.

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 administrators from developed and 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—but in a manner that is sustainable, and within the constaints of the natural-resource base.

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—with emphasis on rangeland improvement and small ruminant management and nutrition—and of the associated farming systems.

ICARDA-021/10,000/May 1996