ICARDA

Caravan

Issue No. 2 Winter 1995/96

Review of dryland agriculture

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The lost resource

Water scarcity may be the most pressing issue in agriculture. ICARDA is meeting the challenge with satellite images to help us find, and harvest, water

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Feed blocks

A new way to make good feed

From the Director General

By definition, dry areas are water thirsty, but things are getting worse. In 1950, the water availability in Asia was 10,000 m^3 per person; it is projected at only 3,000 m^3 in the year 2,000. For Africa, it is expected to be 5,000 m^3 against 21,000 m^3 in 1950.

Sustainable agricultural systems are not possible without sufficient water. Demand for cereals is leading to increasing use of irrigation, and agriculture is using 80% of the water in the Middle East. Moreover, the Food and Agriculture Organization of the United Nations (FAO) estimates that as much as 60% of the water diverted or pumped for irrigation is wasted through leakage, system faults or misapplication. Also, the consequences of growing cereals on the desert margin in areas with annual rainfall of just 100 mm are worrisome. There is no water to waste in the world's dry areas, and water-use efficiency in agriculture in these areas remains the crucial area for research.

So, what should be done about it? ICARDA and the National Agricultural Research Systems (NARS) of nine countries of West Asia and North Africa have got together recently to launch an ecoregional initiative on water. More details on this can be found on page 4, but the outcome of our discussions with the NARS is that we will be looking hard at water-use efficiency, rather than trying to expand supply. One of the two main areas of this research will be supplemental irrigation— which is far more efficient than full irrigation in many circumstances, and less likely to turn the

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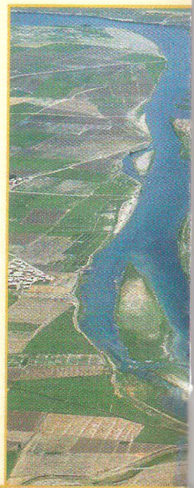


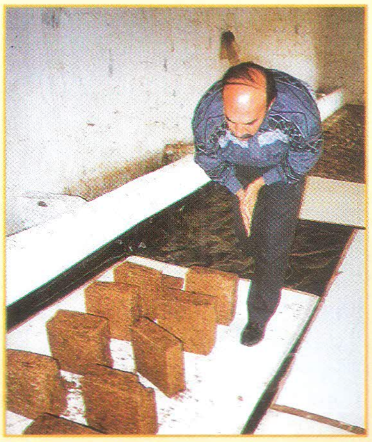
soil saline. The second will be water harvesting.

There is nothing new about water harvesting. It has been a success for thousands of years. Our task is to update and refine the concept so that it is an economic option for farmers. As a first step, satellite images are being used to identify areas of potential. A report on this appears on page 10.

There is much more in this issue of *Caravan*. But water is featured as our key item because of its importance. We will be looking at it again in future issues. It is a large subject, and water harvesting is just one aspect of improved water use. The FAO figures I quoted above make that lamentably clear.

If the balance between water supply and demand cannot be put right, the consequences for food supply and the environment will be abominable.

Prof. Dr Adel El-Beltagy
Director General



Iraqi scientist Dr Ala' Salman with feed blocks (right) made from crop residues which could help farmers all over the region feed their sheep at lean times.
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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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Speeding the breeding

Cooperation with a US university will mean faster response to new pests and diseases

It took 20 years for barley stripe rust to move from Colombia in South America to the Klamath Basin of Oregon, United States. It can take almost that long to develop a resistant variety for large-scale commercial production.

There is a sinister side to this delay; farmers can see an absolute menace moving towards them and scientists, working frantically to produce resistant lines to protect the crop, can see themselves running out of time.

Perhaps this is changing. Thanks to an extensive collaboration between Dr Hugo Vivar, coordinator of ICARDA's Latin America Regional Program (LARP), based in Mexico, and Dr Patrick Hayes, Associate Professor of Crop and Soil Science at Oregon State University in the northwest USA, barley growers in the Pacific Northwest will not be waiting that long for varieties with stripe-rust resistance.

Mandate

ICARDA holds the worldwide mandate for barley improvement, and in South America barley is a subsistence crop. Over the past decade, Dr Vivar, in cooperation with national programs, has developed an impressive array of barley germplasm with resistance to barley stripe rust and other biotic stresses, leading to the release of several varieties such as Calicuchima and Shyri in Ecuador.

"I'm particularly excited about Shyri at the moment," says Dr Vivar. "The latest crosses being

Researchers from Oregon at work in Mexico

ICARDA is the lead center for a new ecoregional program on water conservation. The initiative, *On-farm Water Husbandry in West Asia and North Africa* (or *Water in WANA* for short), was jointly designed last year by ICARDA, national researchers from the region and international specialists.

Green light for regional water project

It has now been endorsed by the Technical Advisory Committee (TAC) of the CGIAR, ICARDA's parent body, and is included in the CGIAR research agenda.

Water is a scarce resource of great strategic importance for the countries of West Asia and North Africa (WANA), and water security is of increasing concern to national governments and research institutions. Around 80% of the total available water in the region is currently allocated to agriculture, but socio-economic pressures seem certain to divert it away from agriculture to other sectors. There is no prospect of any substantial improvement in water supply. In fact, it is thought that, by 2025, the Middle East will have only about 25% of the water it needs. So, if agricultural production and livelihoods are to be sustained even at current levels, much greater priority must be given to efficiency of water procurement and use. At the same time, a great proportion of the region's agricultural livelihoods are based in dryland farming systems where production is dependent on a low and extremely variable rainfall. The challenge is to enhance productivity in these areas through the improved and efficient on-farm use of the limited water resources.

These concerns are not limited to ICARDA and the dry areas of WANA. They are strategic issues of global significance. Problems of on-farm water husbandry must be addressed through an holistic systems-based approach. ICARDA and its partners in the region are responding to this need by taking the lead in developing a research program of global relevance in the optimization of dryland on-farm water husbandry. This is defined as "the strategic and tactical integration of the use of marginal water supplies from more than one source (rainfall, surface runoff, groundwater, etc) to optimize agricultural production in dry environments". The ecoregional initiative is seen as but a first step towards achieving the long-term objective of sustainable agricultural production in dry rainfed areas based upon efficient use of the available water from rainfall, groundwater and surface sources.

Research themes have been identified in which the complementary strengths of all partners will be combined. The research themes tested in Ecuador right now are giving very good results—five times the national yield average. That doesn't necessarily give Ecuadorean farmers five times the yield. As any crop breeder or farmer will tell you, it depends on seed quality and agronomic practices. But I think a doubling of barley production is realistic."

These are no ordinary crosses, however. They are the key to stripe-rust resistance. Ten years ago, Dr Hayes started to work with the double-haploid technique. This works by isolating one-half of the chromosomes and then doubling them with the chemical colchicine, producing a plant that is homozygous—that is, which breeds true to its characteristics in every generation. This permits much faster production of true breeding lines. Four years ago, the two men teamed up to try and characterize and manipulate multiple disease-resistant germplasm.

Now they are using molecular markers to speed up the identification of stripe-rust resistant lines. Of 134 double-haploid lines of Oregon-grown barley, 13 were found to have high resistance to stripe rust. The work took two years, and yield-testing of these disease-resistant lines will start next year. It is a tremendous improvement on earlier techniques.

The strategy has been for Dr Hayes' laboratory to develop doubled-haploid mapping populations from crosses of Dr Vivar's resistant germplasm with genotypes adapted to the Pacific Northwest of the USA. Dr Vivar's team then conducts extensive tests for disease reaction in central Mexico, while Dr Hayes' group does molecular marker analysis in order to map the genes and find the sources of resistance. They have found them in Calicuchima and are now working on Shyri.

Staying ahead

"What this means," says Dr. Hayes, "is that plant breeders will be one step *ahead* of pest and diseases as they move around the world."

The benefits of this for farmers should be important in the US, but in the developing world it is vital. There are real implications for food security.

> "Plant breeders will be one step ahead of pest and diseases as they move around the world."

Barley is also a crucial crop in the Middle East, North Africa and Ethiopia, and ICARDA is working with national programs there to stabilize yields by exploiting sources of resistance found in local material, and by collaborating with farmers in crop trials.

"Agricultural research isn't going to remove all the risk from farming just yet!" says Dr Vivar. "And if it was, plant breeders would not be able to do it on their own.

"Still, we are protecting the poor. Barley is mainly used as cattle feed, but is also a staple part of the diet in the mountains of Bolivia, Peru and Ecuador—I am Ecuadorean myself, by the way.

"But we are all in the same business—Ecuadoreans, Ethiopians, North Americans. That business is farming. And the way Pat and I see it, anything which helps farmers in both Oregon and Ecuador can't be bad."

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are:

* ***Water in present land-use systems: indigenous knowledge, and end-user perceptions and participation.***
* ***Water resources and capture potential.***
* ***Options for water utilization.***
* ***Dissemination, development and impact.***

Activities will vary from country to country, depending on the comparative strengths and priorities of national research programs and ICARDA, and ensuring the efficient use of scarce research resources.

Based on the presentations and discussions at the workshop, *Water in WANA*, held at ICARDA in March 1995, the main thrust of the proposed project is towards water harvesting (*see article* The Lost Resource, *page 10*). But each set of research activities is planned within the 'water husbandry' context of the local environment. According to that environment, we expect to develop extensive and intensive systems that use small or large catchments. Via run-on or reservoir storage techniques and in tactical combination with rainfall and renewable groundwater supplies, these will yield mixed outputs of animal, crop and horticultural products. The aim is to improve and modify existing land-use systems, in collaboration with land users, to create new systems that are more productive and both socially and environmentally acceptable.

Water-harvesting experiment at ICARDA headquarters.

ICARDA will serve as the convening center for the ecoregional initiative, which will be managed as part of ICARDA's long-term program of research in dryland water husbandry. There will also be participation from the International Irrigation Management Institute (IIMI) and the International Service for National Agricultural Research (ISNAR), both sister CG Centers. National institutions from Morocco, Tunisia, Libya, Egypt, Jordan, Syria, Iraq, Oman and Pakistan are responsible for leading the coordination and implementation of their national research activities within each theme. Regional organizations such as the Economic and Social Commission for Western Asia (ESCWA), the Arab Center for Studies of the Arid Zones (ACSAD) and advanced institutions will contribute expertise and research support.

Feed blocks prove a hit

Shortage of feed for livestock is a growing threat to farmers in the West Asia and North Africa (WANA) region. But Iraqi scientists seem to have found part of the answer, and trials with farmers have gone well. Now a major long-term project is starting which should feed two million sheep.

By Dr Nasri Haddad

It's the use of feed blocks made from agro-industrial by-products which are locally available. These by-products can include rice bran, date pulp, poultry waste and whey, among others. The feed, which requires processing methods such as mixing, baking and pressing, can produce a useful source of supplementary feed for sheep. Moreover, the blocks are relatively easy to transport. Encouraging results from trials have led to the new long-term project in Iraq. During the first three-year phase, which started this year, 18 new plants will be constructed in various provinces; each plant should produce at least 3000 tons of feed blocks annually.

Feed blocks ready for distribution in Iraq. There is nothing new in using crop residues for feed, but this project should take it a long step further.

Collaboration

The scientists have been working in collaboration with ICARDA's Mashreq project, which is supported by the Arab Fund for Economic and Social Development (AFESD), United Nations Development Program (UNDP) and International Fund for Agricultural Development (IFAD). ICARDA is now hoping that the technology will spread, giving the region another weapon with which to fight degradation of rangeland and loss of biodiversity being caused by overgrazing.

Sheep are an integral component of the farming system in the region. When we talk about feeding West Asia over the next quarter century, we are not just talking food; we are talking food and feed. And the implications of this project are not confined to Iraq. ICARDA's new Mashreq/Maghreb Project, which takes over from the Mashreq Project, looks forward to helping other national programs take advantage of it. It should have plenty of opportunity, covering as it does Jordan, Syria, Iraq, Lebanon, Morocco, Tunisia, Algeria and Libya.

Background

The Iraqi experimental manufacture of feed blocks started in November 1992. Besides the ingredients mentioned above, tests were carried out with brewer's grain, wheat bran and corn gluten, amongst others. Urea was used as a nitrogen source. In 1993, field trials began in the Mosul area in Iraq to establish the nutritional value of the feed blocks. These trials, held both on Government research stations and with commercial flocks, indicated that their use could lead to a reduction in barley grain and concentrate rations for feed of up to 50% and maybe 100% in combination with stubble grazing. Moreover, body-weight gain was higher, resulting in an additional net return of 90 Iraqi Dinar (ID) per ewe at 1993 prices an extra profit of 67 ID per head. These results convinced farmers that it was worth giving it a try.

In fact, the Iraqis and the Mashreq Project made sure farmers knew about it. During 1993, several television programs, field days and leaflets extolled the virtues of feed blocks. And the Iraqi national team followed these up in the field. During 1993 sales totalled 86 tonnes, with 42 farmers being regular users at the end of the year. At this time, the experimental plant's capacity was 1.5 tonnes a day.

The next steps were to increase production capacity on the one hand, and technology transfer on the other. With regard to the first, a private plant with a capacity of 4 tonnes/day opened in July 1994. Total production of the two plants that year was 1043 tonnes. In the meantime, Iraq's national program developed a step-by-step mechanism for technology transfer. By June 1995, 3152 tonnes of blocks

Making blocks manually. Technology is now taking over.

with farmers

had been distributed among 1356 sheep owners. Now, the new phase of construction and production is intended eventually to feed 2 million head. It sounds ambitious, but given the way the project has snowballed since 1993, perhaps it is not.

The Mashreq Project is itself expanding its activities. Phase 1 began in 1989, with a brief to improve barley, forage and sheep production in Syria, Jordan and Iraq. Funding was from AFESD and UNDP. The second phase began in 1995 and it was then that it changed its name, having been expanded to cover the four North African countries and Lebanon. It is still generously assisted by AFESD, although cofinancing now comes from IFAD.

The Mashreq/Maghreb project is, in fact, a good example of how ICARDA encourages the transfer of technology between one country and another.

Now Syria and Jordan are looking at feed block technology as well, which is what was hoped would happen. Iraq's particular situation led to the development of this technology but there is no reason why it should not be used elsewhere.

With livestock numbers spiralling beyond the carrying capacity of the region's pasture and rangeland, causing increasing land degradation and loss of biodiversity, such developments can not come too soon.

> "A major long-term project is starting which should feed two million sheep."

Dr Nasri Haddad is Coordinator of ICARDA's West Asia Regional Program.

Japan steps up contribution to ICARDA

Japan, the world's largest official aid donor, increased its contribution to ICARDA from US$ 371,000 in 1994 to about US$ 575,000 (¥56,950,000) for fiscal year 1995. In recent years Japan has contributed, on average, around US$ 370,000 directly to ICARDA's core funding annually. It also gives support to specific projects as well as considerable aid in kind, including scientific equipment and the secondment of Japanese scientists to ICARDA.

Some US$ 280,000 of Japan's contribution for the fiscal year 1995 is directed towards two specific projects on the nutrition and management of small ruminants, and on the improvement of native pastures and rangelands. This is crucial to the region's future; not only because sheep and goats are important to the economy, but because it will help fight the degradation of pasture through overgrazing, which has a direct bearing on soil erosion.

The balance of the contribution will go to ICARDA's unrestricted core budget and will help support a diverse range of activities that includes crop improvement, resource management, socioeconomic research and the development of sustainable agronomic practices.

Ever since ICARDA's foundation in 1977, Japan has been a supportive partner of the Center. In that year, Dr Giro Orita of JICA (Japan International Cooperation Agency) moved to the Center's headquarters in Aleppo, Syria to establish a laboratory for the study of sheep and goat diseases and parasites. Dr Orita has now retired, but retains an advisory role in ICARDA's affairs, and Dr Tomio Yoshida, Professor of Soil Science at Chiba University in Japan, is on ICARDA's Board of Trustees.

To date, 11 Japanese scientists have worked at ICARDA— in a number of disciplines, which have included animal health and remote sensing. There have also been a number of shorter visits. There is close collaboration with the Japan International Research Center for Agricultural Sciences (JIRCAS); for example, on a project to record changing distribution of rangeland, for which cameras were floated above the ground on a balloon and the photographs used to construct vegetation maps indicating species distribution, as well as monitoring damage from overgrazing.

Japanese scientists have also made a contribution to the preservation of biodiversity in WANA. In the 1950s, before the foundation of ICARDA, a team under Dr Kihara toured the region, establishing the importance of conserving and using wild relatives of bread and durum wheat. The germplasm collected on that mission is now held by the University of Kyoto and shared with ICARDA (the Center itself holds 111,000 accessions at its Aleppo headquarters).

Now, how's our rangeland doing? Japanese scientists working at ICARDA used this balloon to find out.

The farming future for eigh

The newly-independent Central and West Asian republics of the former USSR are taking a long, hard look at the state of their agriculture. ICARDA and other bodies met them in Tashkent in December and the agenda was set for research and reform.

By Dr S.P.S. Beniwal

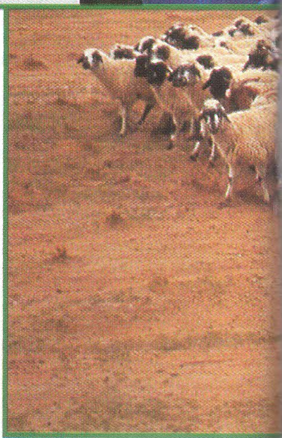
December is a cold month in Tashkent. Living as I do in Ankara, where I coordinate ICARDA's Highland Regional Program (HRP), I am used to winter; but one wondered if the cold wind sweeping through the broad streets of the city came straight from an uncertain future.

There is some cause for optimism in Central Asia. There is no lack of energy and commitment among our colleagues in the five newly-independent republics; indeed, Uzbekistan itself has increased its wheat area by 25% in the last five years. But there are also some frightening problems; monocropping, salinity and rangeland degradation. It was to establish just what the research needs and priorities were that the delegation from ICARDA had come, so that, as the main International Agricultural Research Center (IARC) cooperating with the region, we could help draw up a plan of action. The meeting was a success, and ended with the signing of an agreement for future cooperation in agricultural research and development.

The participating nations were those of Central Asia (Kazakhstan, Tadjikistan, Turkmenistan and Uzbekistan; Kyrgystan did not make the meeting, but is involved). Also at the meeting were representatives from the West Asian republics of Armenia, Azerbaijan and Georgia— a different agroecological zone, but one that has much in common with parts of Turkey and Iran where the Highland Regional Program of ICARDA is active. There was also a high-level Turkish presence, reflecting that country's commitment to assist the new republics in any way it can.

ICARDA organized the meeting with assistance from the German aid arm, GTZ. Also among the 60 participants were representatives from the German development organization, BMZ; colleagues from other organizations involved in agricultural development in the region; and CIMMYT, IPGRI and ISNAR.

The participation of the CG system, ICARDA's parent body, was, therefore, broad-based. ICARDA is coordinating the system's assistance to Central Asia, and sits on the CGIAR's committee on the Former Soviet Union and Eastern Europe. But the others have key roles to play. CIMMYT is the Centro Internacional de Mejoramiento de Maiz y Trigo, one of the oldest IARCs and well-known for its pioneering work in wheat, on which it has collaborative research with ICARDA. IPGRI is the International Plant Genetic Resources Institute. The center of genetic origin of several key crops lies in the southern part of the former USSR; moreover IPGRI has a regional office at ICARDA's Aleppo headquarters. So its participation is important in view of the threat to genetic resources that hangs over the Central Asia region. ISNAR is the International Service for National Agricultural Research. Based in The Netherlands, it will have a key role in working with the national researchers in the new republics to strengthen their research systems and organization. Last but not least, there is IFPRI— the International Food Policy Research Institute. Its name is self-explanatory. If the new republics are to analyze their real needs, then IFPRI's work has obvious relevance.



Defining problems

The meeting had two tasks: to define the challenges facing agriculture in the region; and to decide what should be done.

It is an enormous area; the five Central Asian Republics have 400 million hectares, of which some 80% is farm land. In fact, it was 30% of the USSR's total. Wheat and cotton are important as are livestock; about 70% of the farm land is permanent pasture. The rural population is 51% of the total. The environment is familiar to ICARDA— low rainfall, extremes of temperature and a mixture of mountain, desert and steppe.

It does not help simply to lay the problems of the region at the door of the former USSR. After all, degradation and salinity are hardly unique to Central Asia. Nonetheless, the immense changes since the 1980s are in themselves a problem. Agricultural research and production have hitherto been directed by a centralized command economy, and the end of the USSR, and change to market-driven economies, has dislocated both. The centralized research system and the collaboration across borders has also gone, leaving some scientists very isolated and anxious to learn new techniques. Down on the farm, privatization has not been an unqualified success, as the workforce is unprepared and the right equipment not always available; the meeting participants thought that keeping larger farms intact but under improved management might be better. At the policy level, governments must be ready to take decisions which had hitherto been made centrally.

Food imports from elsewhere in the

t new nations

USSR no longer supplement production, and this has led to a drive for food security and thus concentration on cereals. This can be done by intensification, or expansion of area; the first has caused monoculture with a lack of fertilizer that has damaged soil fertility, while the second has tended to reduce crop diversity. Uzbekistan, despite its success since 1990, is trying to diversify its production, and to increase feed and forage supply. Kazakhstan is fortunate in that it produces three times its domestic needs in cereals, but yields are low and, again, there is a wish to diversify; the country aims to reduce cereals area while increasing yields

Environmental damage has been aggravated by infrastructural problems. Some are new, some are not. There is nothing new about excessive monoculture; cotton is an example. This causes reduced fertility and increased problems from pests and diseases. Meanwhile, that cold wind is being felt in some new ways; for example, reduced availability of agricultural inputs, which, like food imports, often came from elsewhere in the USSR.

There are other threats. The importance of livestock, especially in Kazakhstan and Kyrgystan, has led to feed and fodder supply problems and livestock numbers are declining in places. And the seed sector cannot usually meet the demands upon it.

This last was a subject which received considerable attention at the Tashkent meeting. Seed supply is essential to effective agricultural development; before farmers can be persuaded to adopt new varieties, they must know that the seed will be available, affordable, and reliable. ICARDA's Seed Unit has an extremely active program in the Middle East and North Africa. Thus seed supply was the focus of as much discussion at Tashkent as all the other topics put together.

It would be wrong to present too gloomy a picture. The local Karakul sheep provides excellent and valuable export products. Although there is insufficient research on rainfed agriculture, there is plenty on irrigated production. And the achievement of Kazakhstan in wheat has already been noted. The national programs of the new republics have felt the wind from the future and intend to stand up to it and deal with it. If ICARDA, the other IARCs, aid organizations and Turkey can help in any way, they will do so.

ICARDA's Director General, Prof. Dr Adel El Beltagy (second right) in Tashkent in December with (right to left) ICARDA's Assistant Director General for International Cooperation, Dr Robert Booth; the President of the Uzbekistan Academy of Sciences, Academician Dr S. N. Usmanov; and Dr Z. Khalikoulov of the Uzbekistan Ministry of Foreign Affairs. (Below): Grazing in Uzbekistan. Rangeland is a key issue in Central Asia.

What is to be done?

ICARDA has already been developing contacts with the region. Since 1991 we have conducted germplasm collection missions in both Central Asia and the Caucasus, and three scientists from CIS countries have made long-term visits to Aleppo to do collaborative work on cereals. There have been other contacts.

At the end of the Tashkent meeting, ICARDA and its collaborators signed an agreement with the five Central Asian republics for a plan of action. The main points are as follows:

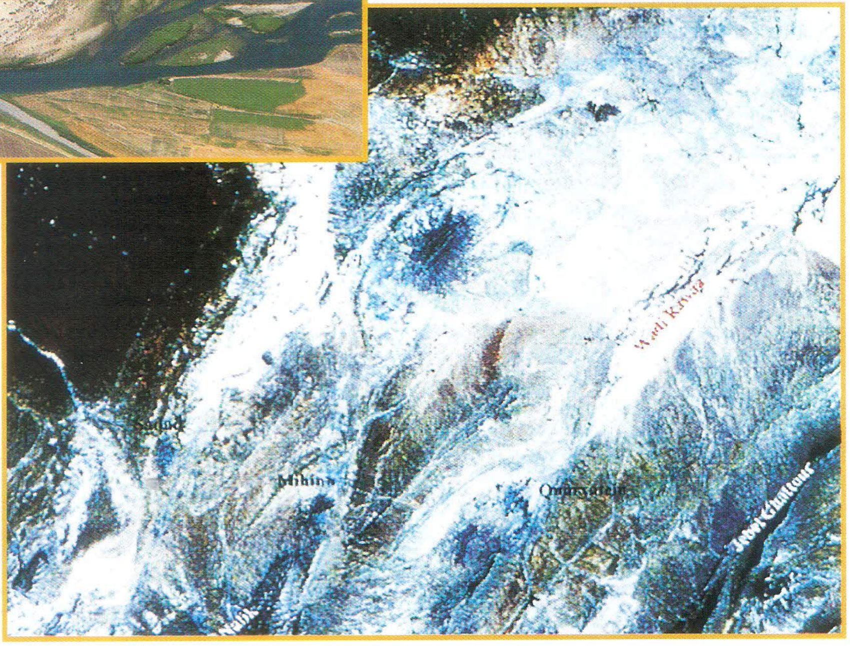
* *Establishment of national research strategies and program plans.* This would require an assessment of existing facilities. We envisage drawing up a detailed plan for perhaps one Republic which would include institutional linkages and which could be used as a model by the others. ISNAR would have the key role here.

* *Producing recommendations for structural adjustments and policy amendments.* This would involve agriculture-sector policy analysis in at least one Republic, the methodology to be transferred elsewhere. This falls into IFPRI's province.

* *The identification and testing of the right technologies for diversifying the agricultural system and improving both crop and livestock productivity.* This would call for the definition of agroecological zones in the Republics and the establishment of the necessary sub-regional gene banks, along with documentation of existing resources. This component would include development of improved cereals and food legumes and pasture and forage crops, along with testing for biotic and abiotic stress tolerance.

Continued on page 15

Shared water resources (left): the Euphrates River, which flows through three countries and is an important resource for all of them. Satellite images like the Landsat picture below help us find alternative sources through the conservation of scarce, precious rainfall.



Water is fundamental to agricultural production, and its shortage is a serious constraint in any arid region. Moreover, water shortages have the potential to aggravate regional tensions. But are we making the best use of all that is available? ICARDA suspects not. Water harvesting may be part of the answer.

The Lost Resource

Arid and semi-arid areas are increasingly subject to water shortages. Demand for water is outstripping current developments in traditional water resources. In many countries the amount of water allocated for agriculture is continuously decreasing, due to increasing demand for domestic and industrial supply.

By Dr Theib Oweis

At the same time, competition for limited shared water resources between countries is causing some political tension. With high population growth and the need to raise living standards, there is a desperate need for additional water resources. But in the dry areas of Libya, runoff irrigation supported sustainable farming systems for over 400 years during the Roman empire.

Could the past hold the answer to more effective water husbandry? Part of the answer lies in water harvesting, and ICARDA is devoting more and more effort in this direction. An ambitious program of water harvesting in the dry areas was launched by ICARDA several years ago, and has recently been greatly enhanced. The program involves a partnership with national scientists in the region for exploiting this concept where appropriate. The latest phase is the ecoregional initiative *On-farm Water Husbandry in WANA*, which covers several themes on water harvesting to be addressed across the various ecoregions of WANA (West Asia and North Africa). However, the work on water resources management supported by the German aid organization BMZ started earlier and has begun to give results.

Through this work, we are taking an ancient method and bringing it up to date. We are looking at what our ancestors did with the technology they had available— and then adding our own. We will use water their way. But we will use satellites to help us find it.

Thinking again

Much development work on water supply is concentrated on traditional sources such as rivers and ground water. Very little more is to be gained from these, and efforts may have to be redirected to non-traditional resources. Most of these are underexploited— and a key one is rainfall in the dry areas. One's first thought might be that there is, by definition, not much of it. In fact, when one considers the sheer area of arid and semi-arid lands, one can see that— in absolute terms— it is a lot of water. But rainfall *is* low relative to potential evaporation; and hard to exploit because it is non-uniform in distribution over the crop-growing season.

Thus it is not enough to support an economical crop in arid and semi-arid regions. In the cool winter areas, such as those with the Mediterranean type of climate, it is less than 300 mm, part of which is lost to evaporation and runoff. The amount stored in the root zone is well below crop water requirements.

Sporadic

Most rainfall comes sporadically; drought is frequent and when rain does come, so much falls so quickly that it causes severe moisture stress on growing crops and reduces yields, if any. This intensity also causes runoff, and water then is usually lost back to atmosphere by evaporation from the water bodies it joins. A small percentage does become ground water, but most evaporates with no benefit to agriculture. It may even do harm; runoff also has implications for soil erosion. Other characteristics of the area where rainfall has occurred (such as degraded soils, sloping topography, poor vegetative cover, and unfavorable climate) also cause loss of both water and soil and thus the potential for any agricultural production.

Intervention in these areas is needed. Water harvesting is one option for making precipitation water more available to the crops in these areas.

What is water harvesting?

The principle of agricultural water harvesting is based on taking precipitation from areas where it is too low or for other reasons is non-productive, and using it to increase the amount of water available in an area where it can make a difference. It is sometimes defined as "the process of concentrating precipitation through runoff and storing it for beneficial use." In this way part of the land, and most of the precipitation, become productive.

Water harvesting may occur naturally or by human agency. Natural water harvesting can be observed in dry areas after heavy storms, where water flows to lower depressions. Farmers then benefit from it by cultivating these areas. Artificial water harvesting is intervention by man to *improve* that runoff *and direct* it to cultivated land. This may be done either for domestic and animal consumption or for agricultural production.

There is nothing new about this. The earliest water-harvesting structures are believed to have been built 9000 years ago in the Edom mountains in southern Jordan to supply drinking water for people and animals. The *Mesqat* and the *Jessour* in southern Tunisia are old techniques that are still supporting olive and fig trees.

> "The earliest water-harvesting structures are believed to have been built 9000 years ago"

In Algeria, the so-called *Lacs calinaires* were used; whereas in Somalia, the *Caag* and the *Gawans* concentrated runoff water in sloping and flat lands. The ancient *Haffirs* in Sudan are still in use for domestic and livestock purposes as well as for the production of pasture and other crops. An elegant method can be seen in the city of Hama in Syria, not far from ICARDA's headquarters— the *nourias*, which are large wooden water-wheels.

One of the most spectacular examples is the 680m Ma'rib dam constructed in North Yemen during the Sabatean civilization 1400 years ago; this is even now a functioning system. It seems to have irrigated about 20,000 ha, sufficient for production of enough crops for around 300,000 people. Arguably, this has more in common with large-scale modern irrigation schemes than with the farmer-level schemes we need today. But it proves that there is nothing new in water harvesting!

Generally, however, the existing ancient systems are those built for domestic use. These include collection ponds, cisterns, small masonry dams and diversion canals. The importance of these systems declined, unable to satisfy the high demand for water generated by increasing populations and higher standards of living. They were also displaced by pressurized water-supply networks for large and small settlements. Nevertheless, some systems are still operating in remote and less developed regions of the world.

Much arid land, where traditional water resources are not available, suffers from desertification. In this process, the land potential is lost due to lack of proper management. Providing water to these lands through water harvesting would improve the vegetative cover and can help in confronting this major environmental problem in many countries.

Answers from the sky

The key factor in the success of any water harvesting system is the proper selection of the site and the appropriate methods to be used. We must know where to put our effort.

With the cooperation of the University of Karlsruhe in Germany and the General Organization for Remote Sens-

Continued on page 19

Wasted rain water: how can it be directed and used to best effect?

Lentil: how Sudan fought back

Sudan, one of the countries hardest hit by the catastrophic famine of 1984-85, has fought back against hunger, and has achieved major successes in agriculture in the 1990s— especially with lentil.

Sudan, nine o'clock any morning. Staff pour out of offices for *fatur*— breakfast, a welcome break after starting work at six or seven in order to finish in by two or two-thirty, and head home to escape the heat of the afternoon.

The *fatur* menu does not change much. It may well be *ful* (faba bean), a key part of the staple diet in Sudan, often eaten crushed into a puree together with salad or, cash permitting, an egg. Or it may be *addis* (lentils), eaten with bread and perhaps some ground hot red pepper. ICARDA has a global mandate for the improvement of both lentil and faba bean.

The problem for Sudan a few years ago was an import bill for lentils that was high— and rising. According to the Arab Organization for Agricultural Development (AOAD), 2,980 tonnes were imported in 1979, rising to 6,950 the following year and hitting their peak of 15,970 tonnes in 1981. Thereafter there was a drop, but by 1989 the figure had crept back up to 8,340; and the Government of Sudan decided that it was time to look hard at domestic production.

Success story

What followed was a spectacular success story. By 1992 imports were down to 1000 tonnes, with 10,000 hectares planted to lentil in 1992/93 as against just 250 in 1989/90. In April 1993 self-sufficiency was celebrated; there have been setbacks since, but the progress has been real.

Lentil production in Sudan had been concentrated around the Dongola-Wadi Halfa area in the far north, and planting was done after the Nile receded. Farmers had abandoned lentil due to competition with other food crops, bird damage and processing problems. In the early 1970s, the crop was grown under irrigation, but this did not succeed, as there was poor credit availability.

In 1989, the Ministry of Agriculture and the Agricultural Research Corporation (ARC) of Sudan formed a committee to look into the problem. The first author chaired this committee; it included members from the extension service, the Farmers' Union and the Agricultural Bank of Sudan.

By Dr Abdullah Nourai, Dr Mahmoud Solh and Dr William Erskine

ARC had been doing background research in lentil for some years, but now a program of action was drawn up by the committee. This included:

* *Improvement of seed supply of locally-grown varieties.*
* *Provision of incentives for lentil production. These were to include seeds, fertilizer and petrol.*
* *A worthwhile price for lentil.*
* *More on-farm lentil research— and demonstration plots in areas of potential production.*
* *An intensified extension program, including distribution of circulars, training of extension staff and leading farmers on the technology, and tours of production areas.*
* *Collaboration with ICARDA in germplasm exchange and training.*

Collaboration with ICARDA was through its Nile Valley Regional Program (NVRP), now the Nile Valley and Red Sea Regional Program (NVRSRP). This had been active in the region since the 1970s. It is based in Cairo but has close relationships with the national programs in Egypt, Sudan and Ethiopia, and has now started collaboration with Eritrea and Yemen. The main objectives are improved productivity of cool-season food legumes and cereals, and assured effective resource management, through the transfer of improved production technology to farmers. The Nile Valley project in Egypt is supported by 6 million ECU from the EU. However, other donors, such as the Netherlands Government, fund specific components.

The overall strategy is to capitalise on the strength of NARS in the region. This is done by: reducing the main constraints; assisting NARS in obtaining outside funding; and networking and coordination of research activity in the system and beyond. At the national level, the strategy is to have a qualified multidisciplinary research team with clear objectives and approaches.

In line with this, NVRP began by looking at ARC's earlier research and verifying it under farmers' conditions; it then developed five area-specific packages of germplasm and production technology. This followed the philosophy of making sure that, first of all, you do not introduce germplasm that gives splendid yields on a research station, where the right inputs and practices are available, but is less productive— and vulnerable to climatic stress, disease and insect pests— in the real world of the farmers' fields.

Thus the first package, for Rubatab in Northern State, was based on a local cultivar, Selaim, and included highly specific recommendations on seed-bed preparation, sowing date, seed rate, planting method, irrigation schedule, weed control, pest management and harvesting. The second, for Wad Hamid, also in Northern State, was based on the same cultivar but called for different planting methods, weed control and irrigation schedule. On weed control, both chemical and hand-weeding recommendations were offered so that a farmer could make his own decision based on availability of chemicals and/or labor.

The next step, having developed these packages, was to use them in pilot production fields; this has the joint benefit of further testing the technology, and demonstrating to farmers what it can do. The results were gratifying. The first package, Rubatab, was tested by four farmers in 1989-90. Yield was up by 33% over traditional practices.

However, scientists cannot look at yield alone; they must also see what the package costs a farmer, and how much return he gets once this is taken into account. Thus, Rubatab increased costs to the farmer by 8%. This means his marginal rate of return (MRR) on the costs he incurred from using the new package was 461%— well worthwhile. A later, slightly larger trial with a similar package saw a yield increase of 62%

against a cost increase of 17%, giving an MRR of 2,458%. Sufficient incentive, perhaps, to grow lentil and reduce the cost of everyone's breakfast...

Integrate it!

There is an old saying to the effect that you can build a better mousetrap, but that does not mean the world will beat a path to your door. They need to know that it is available, and they need to be able to afford it.

NVRP and Sudanese Government staff embarked on a campaign to tell farmers about the new opportunities to make money growing lentil. Field days, television broadcasts, extension leaflets and training in the technology for extension staff all played a part in this. So did credit.

The MRRs quoted are more than enough for farmers to finance these improvements themselves, but the money to invest must be available at the beginning. These are not wealthy people. This was why the Sudanese Ministry of Agriculture had involved the Agricultural Bank of Sudan in the planning process from the beginning.

It is also pointless building a better mousetrap if it is for the wrong type of mouse, or the trap is too big to fit in the cellar. That is why bodies like the Ministry and NVRP regularly carry out socio-economic studies to establish what the constraints are to improved production, and see how many people are using it. As a result of all these efforts, the Government of Northern Sudan adopted policies which included not only credit support, but guaranteed good prices for the harvest, and provided threshing and decortication facilities.

It is all part of producing technology that people need, want and can actually afford. We believe strongly that new varieties and packages should be developed with the farmer, not simply thrown at him. Changes in breeding technology mean that we can, in theory, produce a variety that gives outrageous yields. But if farmers can't grow it themselves, and profitably, it will not be much use to anyone.

> "It is all part of producing technology that people need, want and can actually afford."

If we are going to work properly with farmers all over a vast region like this, then we have to integrate our work with the national programs, as well. ICARDA helped boost lentil production in Sudan but it was the Ministry that decided what needed to be done, and why. And their staff are on the spot. Decentralized programs like NVRSP are the key to this, because they can link us together.

Taking stock

Has the Sudanese lentil program achieved the 1989 objectives? Between 1989 and 1993, lentil area increased from 420 to 10,000 ha; yields from 0.8 to 1.4 t/ha; and production from 340 to around 13,000 tonnes. Imports came crashing down to 1000 tonnes. (At their peak in 1981, as we have seen, they hit nearly 16,000 tonnes.) There was a setback over the following two seasons; weather, changing levels of donor and other support and maybe other causes slowed progress, and all this is now being investigated. But Sudan celebrated self-sufficiency in lentil in 1993, and the underlying position is now much stronger.

This can only be good news. ■

(Dr Abdullah Nourai is an agronomist with the Agricultural Research Corporation of Sudan, and is currently Head of its Hudeiba Research Station. In 1993 he received an award from the Governor of the Northern Region of Sudan in recognition of the part he played in the development of lentil production in the region.

Dr Mahmoud Solh is Coordinator of the NVRSRP; Dr William Erskine is ICARDA's lentil breeder.)

A farmer with on-farm trials of lentil. The trials have helped in the development of locally-appropriate technology packages, and have been a major factor in Sudan's march towards self-sufficiency in this important crop.

Cobber, Digger...and transgenic lupins

Lentil is hardly restricted to the Middle East. Australia has founded a US $3 million-plus industry on ICARDA germplasm. Now they have done something very strange with lupins.

Cobber? Digger? They do not sound like ICARDA varieties, but that in effect is what they are. They are lentil lines Australia has released from ICARDA germplasm. In fact, most of the present Australian lines are; and since 1985 lentil production in Australia has gone from nothing to some 10,000 tonnes per annum. The resulting industry was thought to be worth about A$ 4 million (just over US $3 million) in 1995.

By Dr William Erskine

This does not yet make Australia a major player in lentils. But it is growing. In 1994 the total area sown, according to the Australian Bureau of Statistics and The Lentil Company, the Australian concern which distributes seeds, markets production and gives advice to farmers, is still only about 2,400 ha, of which 1,600 are in Victoria (South Australia has about 600 ha planted to lentil and Western Australia a third of that). But in 1995 it grew to 5,000 ha.

The expansion has been so rapid that The Lentil Company expects it to become a significant industry over the next few years. An inducement is a guaranteed price of A$ 425/tonne (US$ 321.3).

The ICARDA/Australia connection was the result of happy chance. Ten years ago, JanBert Brouwer of the Victorian Department of Agriculture contacted us to ask if we could supply germplasm. The Australians had some, but it tended to be either too early- or late-maturing for the climate. The Mediterranean environment in which ICARDA mainly functions is similar, and "off-the-shelf" germplasm from Aleppo proved successful, giving yield increases of 50-100% over that already held in Australia. Suddenly, an Australian lentil industry looked viable.

CLIMA

Today, ICARDA continues to work with Agriculture Victoria but also with the Centre for Legumes in Mediterranean Agriculture (CLIMA), a Commonwealth-supported research institute in Western Australia. (CLIMA's director is Dr John Hamblin, former leader of the Cereals Program at ICARDA.) Suitable varieties

Lentil is an important crop in WANA, and is often hand-harvested, as this picture shows. There are labor constraints in the region, and the cost of harvesting can be quite high, but lentil remains an important source of protein. For this reason ICARDA has continued to devote attention to lentil improvement, and it is gratifying that this is now of use to Australia as well.

are screened by the authorities and their distribution tendered out to The Lentil Company.

Australia's Grain Research and Development Corporation supports ICARDA's breeding work with about US $11,000 a year. It is also providing support of a similar level for the production of adapted material for South Asia. This is part of a much larger project funded by the Australian Centre for International Agricultural Research (ACIAR) for the development of lentil in Pakistan and Nepal, involving Australia and ICARDA.

Australia's own research on another crop is likely to have a useful spinoff for ICARDA's own lentil work. The crop, oddly enough, is lupin. Australian lupins suffer from infestation by herbicide-resistant weeds, but researchers have created transgenic lupins by introducing genes for resistance to herbicide into the crop from other species. Lupins that are resistant can then be sprayed with herbicide to kill weeds that are not.

Agrobacterium

The technique for this is the use of transgenic *Agrobacterium tumefaciens*. This occurs in nature; it will cause tumors to develop in plant tissue. So it was obvious that the bacterium is somehow introducing a gene to the plant cell which causes it to grow. Using a transgenic *Agrobacterium*, the Australians transferred the gene for resistance to herbicide into lupins. They have now done it with lentil as well.

The results look promising, and we will use similar techniques to transfer a gene for herbicide resistance into lentil so that we can spray it for *Orobanche*, a parasitic weed that attacks several crops in the region but is particularly hard on lentil. It is hard to eradicate, as its seeds can remain dormant in the soil for 15 years. We will also transfer into lentil already-existing genes for toxin production in their nodules to prevent damage by *Sitona*, a weevil that attacks the nodules; the latter are important, as they fix nitrogen. Both *Orobanche* and *Sitona* are a serious problem in the West Asia and North Africa (WANA) region, especially in Morocco, south Turkey and parts of Syria.

Australians may not (yet) have many experts in lentil production, but their knowledge of lupin could be an odd trade-off for that US $3 million industry our germplasm has founded in 10 short years. ■

A market in Tashkent. Livestock products are important in the region, and many farmers are heavily dependent on this sector.

Eight new nations *continued from page 9*

And, crucially, soil and water strategies need attention; this would include water-use efficiency. Livestock are the subject of a special workshop (supported by USAID) in Tashkent at present, and we will know the recommendations in the spring. It is a crucial issue; there are 33 million small ruminants in the region, not to mention camels and horses. ICARDA, CIMMYT, IPGRI and Turkey are all likely to give support to these aspects.

* *Strengthening of national seed programs.* This was the subject of much discussion at Tashkent. It is an area where ICARDA has done much collaborative work through the WANA Seed Network, through which the WANA countries "carve up" various aspects of development work between them, and there has been fruitful cooperation with Germany and The Netherlands in this area as well. The plans made at Tashkent include a regional coordination unit and a variety testing system.

* *Strengthening human resources.* This means training, but for ICARDA it has also always meant exchange visits and travelling workshops. ISNAR will be involved in this work.

* *Establishing cooperation* between the research and educational institutions in the region, including training networks in areas of common interest.

There is a lot of work involved in all this, and, of course, money as well. But we think it is good value. We are talking about a fresh start in agriculture for five nations totalling 51 million people and 400 million hectares, and with massive implications for environmental protection and regional stability. All for the price of a second-hand jet fighter.

Perhaps that wind of change will not be so chilly after all ■

A broad spectrum of barley

Can infrared light tell us how good a new variety is, even before we've tested it in sheep? Yes, and new research will allow it to be judged by wider, more useful criteria.

Feed for sheep must be palatable and digestible. Farmers in the Middle East often feed their sheep on barley straw. This means that there is a requirement for characteristics in new barley lines that has sometimes been overlooked.

By Dr Tony Goodchild and Fouad Jaby El-Haramein

Orthodox research on enhancing the feeding quality of straw has tended to focus on treating it mechanically or chemically. In the 1970s, much was done worldwide on the chemical treatment of straw to make it palatable and nutritious. Anhydrous ammonia was tried, and later urea; the latter is having some success, especially in China, where it works well. Elsewhere, however, farmers have been slow to adopt this technology, despite considerable applied research. By the early 1980s, some of us at ICARDA had become rather skeptical about chemical treatment of straw.

One day in 1981, a scientist from ICARDA was talking with a farmer who was growing an improved barley variety, Beecher; but he intended to stop doing so, as his sheep generally refused to eat the very fibrous straw. Adoption rates of Beecher had been disappointing, despite its high grain yield, and this chance comment helped a lot of things to fall into place. The idea was born: If breeding can produce bad straw, it ought to be able to produce good straw as well. Why treat straw with chemicals? Why not breed barley for palatability and nutrition as well as other qualities? After all, ICARDA has the worldwide mandate for barley improvement. And the Syrian landraces, Arabi Aswad/Abiad, have fundamentally good straw quality. Quite soon afterwards, ICARDA began this work, and over the next 10 years we obtained over 100 values of voluntary straw intake by sheep for about a dozen barley varieties.

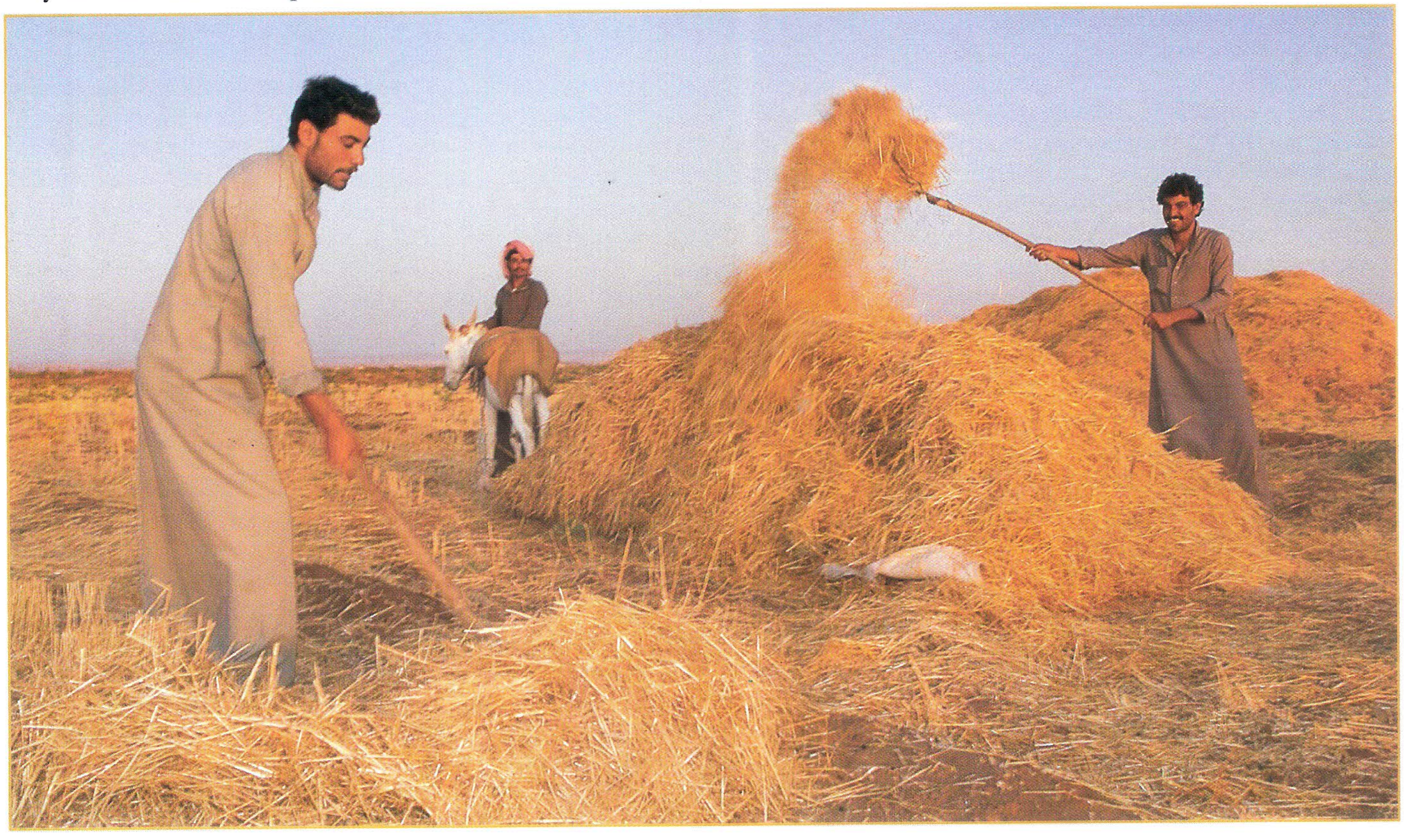
But there is a major difficulty with this. How do you test every potential variety for nutrition? You would need a huge work force— and a vast sheep farm on which to grow and graze the different varieties of barley. We needed an indirect method of assessing quality.

About NIRS

We found it in Near Infra-Red Reflectance Spectroscopy, or NIRS. Using a light of a wavelength three times as long as visible light, we can "look" at straw samples and search for characteristics that will make for good feed quality. ICARDA researchers are amongst the pioneers in using NIRS for crop-breeding work.

Near-infrared light is found in the electromagnetic spectrum between the visible and the medium-infrared wavelengths (700-2500 nm).

When infrared radiation of a given wavelength passes through a sample, part of the energy is absorbed and the other part is reflected. A NIRS instrument



detects the radiation diffusely reflected from a sample surface, and amplifies the signals at specific wavelengths into composition data such as protein or moisture content.

NIRS analysis is much faster than chemicals. In a seven-hour period, one person using a pre-calibrated NIRS instrument can analyze 200 samples for many constituents. The same work would require at least four days for protein analysis by conventional chemical (Kjeldahl) method. There are further savings when NIRS is used for more complex and expensive analyses.

Saving of ingredients is another advantages of NIRS. ICARDA's protein analyses now number 17,200 a year, done by NIRS at minimal cost, with perhaps 1000 checks by the Kjeldahl method. If they had all been done by Kjeldahl, it would have cost us about US$ 25,000. With these savings and the savings on the other analyses we do, the NIRS instrument pays for itself about once every year!

The success of NIRS applications depends on the calibration of the instrument using reference samples of known composition. In fact, NIRS determination relies heavily on reference analysis and statistical methods. Nevertheless, after the instrument is calibrated to analyze samples of a particular product, operating the instrument and analyzing samples is very easy.

Developing a technology

The principles behind NIRS are not new. From early this century, organic chemists have been using infrared light of slightly longer wavelengths than used in NIRS to probe the structure of molecules. They measured how much of the energy beamed through the matter was absorbed. By using a number of different wavelengths of infrared, they could detect the different chemical bonds between pairs of atoms inside the different molecules. Here we are talking about the bonds, or linkages, between atoms of carbon, hydrogen, oxygen or nitrogen and adjacent atoms. Each kind of bond has its own "signature" of wavelengths at which it absorbs infrared light. Similarly, each kind of nutrient or quality component in agricultural materials has a different infrared signature.

In about the middle of the century, agricultural chemists started using instruments that measured near-infrared light *reflected* from samples. Quite simply, radiation that is reflected has not been absorbed! By measuring reflection at, say, 700 different wavelengths, we can get an excellent idea of what chemical compounds are present. But because the first desktop computers were several years away in the future, and lengthy calculations were needed to compute the results of near-infrared analysis, the more traditional "wet chemical" methods of analysis held sway.

Sheep feeding on barley straw— an important part of the farming system.

The turning point for forage quality came in 1976. By that time, mini-computers had spread to the larger feed-quality laboratories. Karl Norris, Ralph Barnes, John Shenk and others working for the United States Department of Agriculture published a relationship between the nutritive value of feed for animals, measured by voluntary intake and digestibility, and reflection from the feed at several near-infrared wavelengths. ICARDA acquired the capacity to do such work in 1992, although it had first entered the NIRS field as early as 1979 (see item *Not just barley straw* on next page).

> "The equipment pays for itself in a few seasons."

Making it work

But although NIRS as a method of establishing intake in small samples was accepted theory, no researcher had obtained satisfactory results. We began to wonder whether anyone had gone about it in the right way. The problem, we have found, lay in the precision of measurement of what the sheep will eat and the methods of establishing a correlation with the NIRS readings.

Starting in 1993, we have obtained promising correlations between voluntary intake and the NIRS spectra, in 42 samples of barley straw harvested in different years. Testing of 32 varieties of barley straw for animal feed in 3 years— a total of 96 different straws— is now going on at ICARDA. Each variety is grown and harvested under our supervision, and then its straw is chopped and fed to four sheep for five weeks. We shall use these results, with earlier data, to provide a precise calibration for NIRS, which will then allow us to analyse tens of thousands of straw samples. As we hinted earlier, sheep could never be used to test all these thousands of varieties because it is time-consuming and expensive. Testing each variety with animals requires over 200 kilograms of straw; but the amount required for NIRS is very small; a few grams are sufficient. So the first plant can be used, and results obtained right at the beginning of the breeding process. NIRS also allows near-instant analysis of digestibility and protein. In fact, one pass through the machine gives a read-out of all the constituents in which we are interested. Using this method, we are making straw for feed an integral part of barley-breeding.

Sheep (and feed quality laboratories) will always be needed for this research, however, as an enormous amount of baseline data is required if calibration of the NIRS technique is to keep up with subtle changes in straw chemistry that will come about with the development of new varieties. In fact, in a sense, having a wide range of relevant baseline data has been the key to ICARDA's success with NIRS. Research on straw nutrient-value is not confined to ICARDA; there is work

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being done at ILRI on sorghum, and at ICRISAT on sorghum and millet. IRRI is doing similar tests on rice. But we like to think that our particular approach is productive.

Heritability

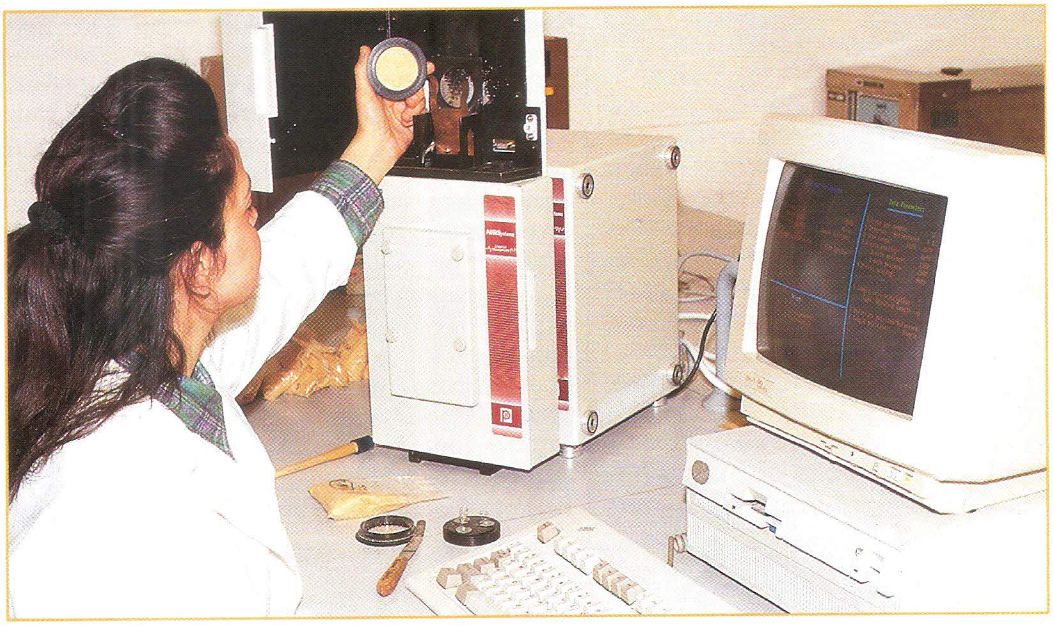
There is plenty more to be done before NIRS can be fully integrated into crop-breeding work. We need to improve our equations not so much to detect differences in nutritive value, but to point out differences that are likely to be heritable; that is to say, whether or not they will be passed from one generation to another in the barley-breeding process. We are making progress on this. Some portions of the infrared spectrum are not heritable; we have already found that the spectral indicators of protein content, despite its importance in the nutritive value of the straw, aren't heritable. But those for fiber are. And that, not protein, was the key to the problem with Beecher. So NIRS *can* now be used early in the breeding process, even though we may not have all the answers yet.

This work has important implications for the farming system as a whole. One of the constraints to development in agriculture is that new technologies, including improved varieties, are useless if farmers do not adopt them.

The farmer in 1981 intended to stop growing Beecher because of concerns about the straw's quality as animal feed. There is evidence that farmers often avoid new varieties for that reason.

We think that the link between straw yield/feed performance and adoption rates is an important one, and a project within ICARDA is now being planned to study it. It will be multidisciplinary, involving socio-economists, plant breeders, anthropologists and animal nutritionists. NIRS will complement this process.

We believe that every bit of plant matter produced in agriculture will, in future, be used in *some* way. NIRS will help us understand every new variety's potential for a number of purposes, not just yield, and improve the range of by-products the farmer can use, making agriculture more efficient in a way that is truly systems-led.



Laboratory technician Farida Mustafa loads a sample for NIRS analysis in ICARDA's Cereals Quality Laboratory.

Not just barley straw

NIRS came early to ICARDA and is used for a number of purposes, as Fouad Jaby El-Haramein explains

Because of the high demand for simple and fast methods to evaluate the quality of early generation germplasm produced by ICARDA's breeding programs every year, the Near-Infrared Reflectance Spectroscopy (NIRS) technology has been used at ICARDA since 1979.

At that time, Dr. Phil Williams, from the Canadian Grain Commission, Winnipeg, Canada, introduced NIRS applications and operated ICARDA's first NIRS instrument; the Neotec 31-EL Grain Quality Analyzer for protein determination in cereal and legume grain. From 1981, the Pacific Scientific Feed Quality Analyzer model 51-A was operated, to cover a wider range of applications.

In 1992, the advanced NIRSystems Model 5000 Scanning Monochromator Instrument came into operation in ICARDA's Cereal Quality Laboratory. Patient effort during the last four years created many successful equations for calculating quality parameters from NIRS spectra.

Grain, flour and straw can be analysed. The best calibrations were for— in addition to voluntary intake of barley straw— protein content in barley, bread wheat, durum wheat, lathyrus, peas and vetch; hardness of bread wheat; fiber; lignin content and digestibility in the straw of the same feeds; and oil in safflower. We have also acheived good calibrations for oil content in sunflower and rapeseed, for dough strength in bread wheat, pasta-making quality in durum wheat, and the amount of a compound harmful to humans in lathyrus grain (BOAA).

The beauty of the NIRS method is that quality parameters can be measured almost as accurately in whole grains as in flour, not only saving time but also letting crop breeders plant the very same seeds next season. ■

The Lost Resource

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Elegant water exploitation: the famous water-wheels, or **nourias,** *of the city of Hama in Syria. There are many traditional water-use methods in the region.*

ing in Syria, ICARDA started a study for developing the methodology of identifying potential areas and suitable methods of water harvesting in central Syria, using satellite images. The project area covers the region between Latitudes 33,8° and 35,5° North and Longitudes 36,6° and 38,8° East. Several key parameters have to be considered to determine the suitability of any site for water harvesting and for various methods. Topography, natural vegetation cover, soil characteristics, drainage systems, rainfall characteristics, runoff potential and crop water requirements are among the major factors. Such information may be obtained easily for a limited area, but using conventional methods to plan water harvesting systems on large scale is both tedious, time consuming and costly.

Enter GIS

Studies at the University of Karlrsuhe revealed that remote sensing, used together with GIS (Geographic Information Systems), is much more efficient for investigating areas with limited information and infrastructure.

GIS is a large subject. In a nutshell, however, it involves the digitalization of information about your target area, classified by subject, so that you can display what you need and hide what you don't. This information can be obtained from the digitalization of satellite images— in our case, from the American Landsat satellite, one scene from which covers our project area— or from ground information; in the former case, the latter method can be used to sample and check it. It can then be classified into (for example) land-use patterns or sources of biodiversity (both important for other ICARDA research work), hydrology, topography and meteorology— or vegetation.

The latter is important for us. We are looking at the earth to see where the rain is falling, but we won't see it when it falls. There will be clouds in the way...So we measure vegetation. Its appearance and disappearance will tell us where rain is falling and roughly how much. A similar technique is used in reverse by bedouin crossing remote areas with camels; the traveller Wilfred Thesiger, in his description of crossing the Empy Quarter of Saudi Arabia, recalled looking at the horizon for clouds, then heading in that direction to find grazing vegetation. Well, we use the vegetation to find the clouds.

A GIS was constructed for the 33,000-sq-km area with digital data sets of classified satellite images. Topography, drainage systems, soil types, vegetation, and climate were produced. Image processing, classification and the entry of all data sets, together with special expert criteria for the applicability of various water harvesting methods, will give the information needed to decide which, if any, of those methods can best be used. The results can be used by the Syrian national program for water harvesting development.

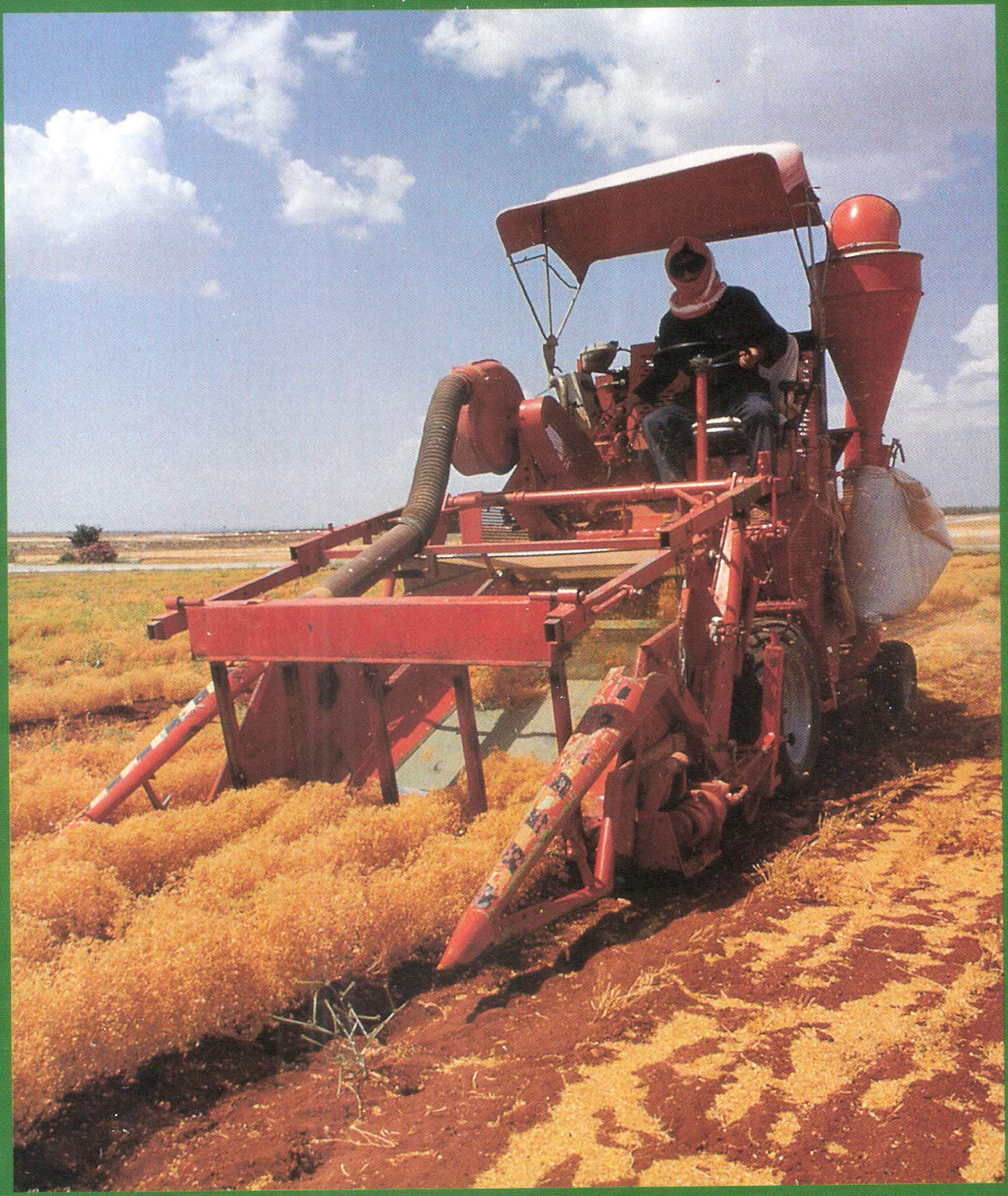
> "We use the vegetation to find the clouds."

It is not an easy region in which to do this work. For example, geometric distortions of the satellite image can be caused by earth rotation effects. These can be rectified by plotting against ground control points. These can be hills, street-crossings, or bridges; in fact, any easily-recognised feature. The trouble is that, in the steppe, there aren't very many. Where they do exist, they may be absent from the most recent conventional maps, which could be very old. The problem is solved by using the Global Positioning System; a GPS receiver on the ground can calculate its exact position using signals from different satellites.

For all dry regions

The developed methodology can be applied for the determination of potential sites for water harvesting in any region with similar conditions; it is not applicable only to West Asia and North Africa, but to many places with rainfall over a wide range, from 50-600 mm. The data sets compiled in the GIS can also be used in approaches to other problems; these could include the improvement of infrastructure or general evaluation of land degradation. As already indicated, GIS techniques can help us find sources of biodiversity. The information base of the GIS can also be enlarged by including data like socioeconomic features concerning land tenure systems in the area. This is invaluable for land-use planning in general.

Answers from the sky? No. *We* have to find the answers. But the use of satellite imagery and GIS represents a quantum leap in the information-gathering that should precede any development decision. In this case, use of the technology of the future will help us repeat the achievements of the distant past. ■



Mechanizing the lentil harvest. ICARDA is involved in the design and construction of machinery and the breeding of crop varieties to make them suitable for mechanical harvesting. In this way, it can help farmers to reduce labor costs— and provide cheaper food.