

ICARDA *Issue No. 12, June 2000*

Caravan



Review of agriculture in the dry areas

In this Special IPM issue:

- *How Egypt will overcome the virus threat to its faba beans*
- *Wind-blown spores lose their puff*
- *Biological insecticides save wheat from insect pests*
- *Environmentally-kind pesticides promise to safeguard chickpeas*
- *Beat a lentil parasite hidden in the soil*
- *Re-inventing the plow will stop mountain olives from slipping down the slopes*
- *Waste not, want not. Feed-block technology puts discarded protein to good use*



From the Director General

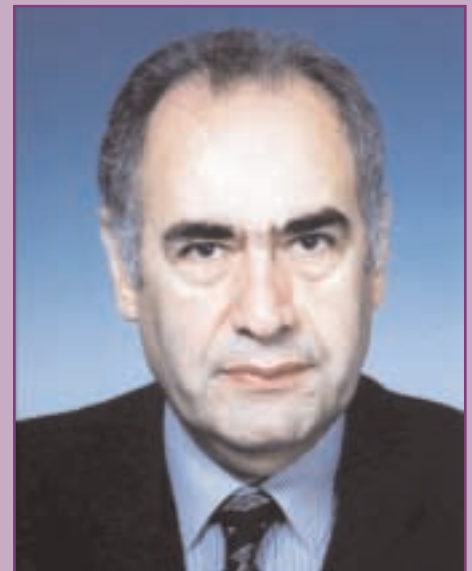
This issue of *Caravan* focuses on Integrated Pest Management or IPM (pages 9-18). IPM is based on commonsense principles of agriculture backed by sound scientific understanding and confirmation of techniques and practices. The dictionary defines 'integrated' as "composed of separate parts united together to form a more complete, harmonious or coordinated entity."

This is where ICARDA is successfully working with its national partners to find new IPM components, verify and refine traditional practices, evaluate the economics of using these in strategic combinations to address specific problems, and then pass them on as a package of options to the farmers.

Farmers know that some landraces will withstand a pest or disease attack better than others, and they have selected for these traits over many generations.

They know that using pesticides will eliminate or control a problem. They also know that there have been trade-offs in the past with resistant landraces that may produce less nutritious grains, or with insecticides that kill even useful pest predators. While it is true that most farmers will happily embrace individual components of pest control, few have the confidence or immediate knowledge to blend several of these components into a harmonious IPM strategy.

Thanks to the tools and expertise available at ICARDA, these components of IPM are being successfully packaged. Traditional plant breeding methods continue to play an important role in developing new improved cultivars that combine several desirable traits, but the use of biotechnology allows the process from first cross to farmer-acceptable variety to be speeded up. It also permits the incorporation of specific desirable



genes into cultivars for resistance to both biotic and abiotic stresses.

Pesticides remain among these components as the last resort. Through knowledge generated by science, we can help the farmer choose the most appropriate pesticide for addressing his immediate problem and the most benign towards the environment. Research is confirming the existence and effectiveness of, for example, naturally-occurring

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Cover: Attractive but deadly. This weed, called Orobanche, can completely wipe out lentil and faba bean fields. See page 16.

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entomopathogenic fungi which will target only the economically-damaging Sunn Pest. Other fungi are being discovered in the natural world, which could be used as biological pesticides of tomorrow.

In developing IPM packages, indigenous knowledge is not overlooked by ICARDA's research teams. Trials are now confirming the value of natural extracts and oils taken from trees such as the neem (*Azadirachta indica*) and *Melia azedarach* in controlling insect pests such as chickpea leaf miner. Armed with verifiable information on the best spraying methodology and effectiveness against specific pests, it will soon be possible to supplant older generation, broad-spectrum pesticides within IPM strategies.

As always, it will be the pioneer farmers who will first adopt such technologies. The benefits of IPM are already sufficiently evident, and we are confident that the rate of adoption by farmers of the IPM packages available will continue to increase. This is yet another step forward on the road to eradicating hunger and poverty.

Prof. Dr Adel El-Beltagy
Director General

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The cowpea aphid, tiny but destructive. Page 10.

About ICARDA and the CGIAR



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).

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production; and the West and Central Asia and North Africa region for the improvement of bread and durum wheats, chickpea, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural-resource management practices. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs is offered extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and specialized information services.



The CGIAR 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 receives support from a wide variety of country and institutional members worldwide. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South-North partnership to reduce poverty and hunger.

The mission of the CGIAR is to promote sustainable agriculture to alleviate poverty and hunger and achieve food security in developing countries. The CGIAR conducts strategic and applied research, with its products being international public goods, and focuses its research agenda on problem-solving through interdisciplinary programs implemented by one or more of its international centers, in collaboration with a full range of partners. Such programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and contributing to strengthening agricultural research in developing countries.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP) are cosponsors of the CGIAR. The World Bank provides the CGIAR System with a Secretariat in Washington, DC. A Technical Advisory Committee, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

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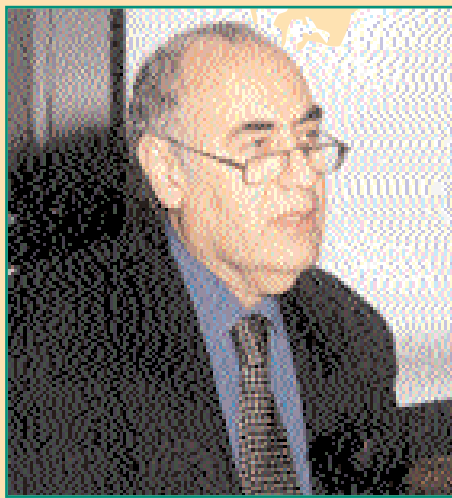
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Annual Presentation Day 2000

A Day to Recommit to Poverty Alleviation

ICARDA organized its Annual Presentation Day on 25 April 2000 at its headquarters. The Chairman of the Center's Board of Trustees, Mr Robert Havener, welcomed the distinguished guests including the Syrian Minister of Planning, Dr Issam Al-Za'em; the Palestinian Minister of Environment, Dr Yousef Abu-Safieh; Ambassadors and other members of the diplomatic corps; senior government officials and representatives of collaborating institutes from the CWANA countries; NGO representatives; members of the press; and others.

Prof. Dr Adel El-Beltagy, Director General, made a comprehensive presentation, in which he highlighted ICARDA's achievements and future strategy, and the Center's commitment to alleviate hunger and poverty in the dry areas.



Prof. Dr Adel El-Beltagy, Director General of ICARDA

Agriculture is the engine driving the economic growth of a country and has a key role in poverty alleviation, Prof. Dr Adel El-Beltagy, ICARDA Director General, told visitors to the annual ICARDA Presentation Day at Tel Hadya.

He warned that human activity continues to create 'new' deserts at the same time as expanding populations increase the demand for more food from the water-scarce areas of Central and West Asia and North Africa. Dr El-Beltagy underlined the role that ICARDA could play in defeating desertification, poverty and malnutrition. "We have a strong conviction that agriculture can play a key role in poverty alleviation," he added.

Dr El-Beltagy pointed out over 840 million people already go hungry and two billion are malnourished in today's world. Although just 70 square meters is the minimum area of arable land

No More 'New' Deserts

required to feed one person, even a medium-rate increase in population growth will make land scarcity a reality for about four billion people by the year 2050.

Good arable land is lost to desertification through wind and water erosion, overgrazing, unsustainable farming practices that damage soil health—such as salinization and depletion of soil nutrients—and urbanization. The world loses over 6 million hectares of land per year to desertification. These deserts in more than 100 countries differ from the 'natural' deserts in being a result of human activity, and they can be controlled if the causes are recognized early enough.

ICARDA contributes to the control of desertification and overgrazing, biodiversity conservation, and developing

new crop varieties tolerant to drought and heat. There is great potential for collaboration between ICARDA and international organizations such as JIRCAS of Japan in these areas, particularly in genetic transformation in ICARDA mandate crops—barley, lentil, faba bean and forage legumes on a global level and regionally for bread and durum wheats and chickpea—using the genes for drought and heat tolerance.

In spite of its scarcity, water continues to be misused in the region, said Dr El-Beltagy. As a result, the water table is falling, and aquifers are being depleted to exhaustion. "We must pay increased attention to water conservation to avoid any further worsening of this situation," he added.

Unabated population growth, pro-



The distinguished guests at the Presentation Day included H.E. Dr Issam Al-Zaeem (second from right), Minister of Planning, Syria; H.E. Dr Yousef Abu-Safieh (right), Minister of Environment, Palestine; Ambassadors of India, Japan, Morocco, Sudan, and the Netherlands, and other high-ranking officials from diplomatic missions in Syria; leaders of the National Agricultural Research Systems in the countries of Central and West Asia and North Africa; members of the Press; and friends of ICARDA.

jected to reach 8 billion by 2020, compounds these problems. About 86% of the projected population growth will take place in developing countries. Currently, more than one billion people inhabit the dry areas of the world. The six most economically disadvantaged states in the region are Eritrea, Ethiopia, Mauritania, Somalia, Sudan and Yemen. GNP for more than 510 million people is less than 2 dollars a day *per capita*, and some 271 million live on one dollar a day.

Dr El-Beltagy did not underestimate the challenge to research institutions such as ICARDA. If *per capita* consumption of all grains remained constant at 1995 levels to the year 2020, the population projections showed a total aggregate grain consumption of about 323 million tonnes in 29 CWANA countries. The expected total grain production by 2020 is about 247 million tonnes with 2% annual production growth rate.

Without Turkey and Kazakstan, the 27-country CWANA grain gap in 1995 was about 54 million tonnes. This deficit could easily reach 114 million tonnes by 2020, worth US\$ 14.8 billion at a grain price of \$130/tonne.

ICARDA research is directed to improving yield and crop production efficiency in a variety of ways. Research on supplemental irrigation demonstrates that reducing the irrigation by 50% of the full irrigation requirement causes a yield loss of only 10%. Water saved can be used to irrigate additional areas that would otherwise remain unirrigated and less productive. With this strategy Syrian farmers participating in ICARDA trials have increased total wheat output by an average of 38%.

A multidisciplinary approach allows ICARDA to use both conventional and modern technologies. A three-year project on using remote sensing and geographic information system, or GIS, has identified areas of water-harvesting potential in Syria. Similar techniques are used in the Marsa Matrouh Resource Management Project in Egypt to identify sites for water harvesting.

"Take Pride in Top Marks for ICARDA"

"These are important times for everyone who lives in, works in or simply feels strongly about opportunities in the dry areas," said Mr Robert Havener, ICARDA Board of Trustees Chairman, in his welcome address to the Presentation Day guests on 25 April.

The Center had undergone in 1999 an External Program and Management Review (EPMR) of its mandate, mission, research and training programs. "We were given high marks in many areas and it is a strong endorsement of the work and worth of ICARDA, of which we can be proud," said Mr Havener.

Drought remains a persistent threat to the ecology of most of the region, he reminded them, and poverty continues. Much development potential can be realized and ICARDA is an important part of the effort to achieve the goals and objectives of the people of the region.

The Program Committee of the Board of Trustees, under the chairmanship of Prof. Dr Raoul Dudal, would now consider the EPMR report and how ICARDA can adopt its recommendations into the Center's workplan.

On the System-wide scale, Mr Havener said the CGIAR was undergoing its periodic self-evaluation with a view to develop a new vision and structure to ensure that the System can meet the underlying objectives of its mission to eradicate poverty and achieve food security in these fast-changing times. Centers, as well as donors and others, are putting their best efforts into this important exercise. It was very important that the donors received strong signals of support for ICARDA from its various stakeholders.

Mr Havener appealed to everyone in his distinguished audience to use their influence with donor organizations to maintain the support that is needed to continue ICARDA's valuable work.



Mr Robert Havener, Chairman of the ICARDA Board of Trustees

During their field visit, H.E. Dr Issam Al-Zaeem (fourth right), Syria's Minister of Planning, and H.E. Dr Yousef Abu-Safieh (fourth left), Minister of Environment in the Palestinian Authority, saw ICARDA's research on chickpea diseases.



A digital agroecological atlas has been developed for Syria, and a land suitability atlas is also being developed for Morocco, in collaboration with Moroccan scientists, to help researchers and policy makers develop appropriate strategies for drought mitigation in Morocco.

ICARDA is now heavily involved in a new partnership with the Central Asia and the Caucasus (CAC) region, comprising Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Armenia, Azerbaijan and Georgia.

The region has 255 million hectares of rangelands, but the total number of small ruminants has dropped from 60 million in 1990 to 28 million in 1998 because of feed shortages. ICARDA has developed technologies for Central Asia, but these need to be fine-tuned to meet the specific requirements of the region. In this connection the Center is implementing a new project on crop-livestock integration in Central Asia, with funding from IFAD.



In a meeting with key visitors, the Board Chair and the DG highlighted the problems of dryland agriculture and discussed the future strategy to address them. Clockwise (from right to left): H.E. Dr Issam Al-Zaeem, Minister of Planning, Syria; H.E. Dr Yousef Abu-Safieh, Minister of Environment, Palestine; H.E. Mr Mohamed Sharief Abdallah, Minister Plenipotentiary, Sudan; H.E. Mr Cornelius Wilhelmus Andreae, Ambassador of the Netherlands; Prof. Dr Adel El-Beltagy, DG; H.E. Mr Mohamed Faredji Doukkhali, Ambassador of Morocco; Mr Robert Havener, Chairman, ICARDA's Board of Trustees; H.E. Mr K.M. Meena, Ambassador of India; and H.E. Judge Mahmoud Damlakhi, Deputy Chairperson of the Executive Bureau of the Governorate's Council, Aleppo.



Increased collaboration with Palestine was on the agenda when Mr Havener and Dr El-Beltagy talked with H.E. Dr Yousef Abu-Safieh, (right) Palestinian Minister of the Environment.

Another strategy is to develop new forage legume production systems for improved livestock productivity with better nutrition. The system introduces vetch in rotation with a cereal to replace monocropping. Vetch provides good-quality feed for sheep and goats, besides raising yields of the following barley or wheat crop because of improved soil fertility and breaking the cycle of cereal diseases and pests. Vetch has been successfully introduced in China, Jordan, Morocco, Syria and Turkey.

Participatory research, involving farmers in selecting crop genotypes, is increasingly used by ICARDA. For

example, in Eritrea where farmers are selecting barleys for further development, the likelihood of variety adoption is much improved.

More than 100 cultivars of barley developed from ICARDA-supplied germplasm have been released in 34 countries.

Improving the nutritional and technological quality of wheat is another important objective in ICARDA's crop improvement work. Biotechnological tools permit the effi-

cient use of the enormous amount of variability existing in the Center's collection of landraces.

ICARDA's biotech team is working on Hessian fly-resistant durum varieties through the Dryland Durum Wheat Improvement Program, a joint effort with sister center, CIMMYT, and national partners in the region. Morocco has developed new durum cultivars resistant to Hessian fly, and is addressing the problems of root rot, leaf rust and wheat aphids; Tunisia is working on improving durum for resistance to drought; Algeria focuses on crop adaptation to the Atlas high plateau and on grain quality; while Turkey focuses on adaptation to severely-cold areas of the Anatolian plateau, crop nutritional disorders and grain quality.

Over 80 varieties of wheat have



The Japanese Ambassador to Syria, H.E. Mr Kishichiro Amae (right) met with the Board Chair Mr Havener and Prof. Dr El-Beltagy, DG, and discussed research links and further collaboration.

Biotechnology Laboratory



Gene Bank



Shami Goats



Lentil Wilt Resistance Screening in Field



Water Harvesting Research



Traditional Fresh Bread for the Guests



been released in WANA and South Europe. By almost quadrupling yields in Syria since the 1970s, about 3.5 million hectares of land has been saved, and total impact exceeds more than 500 million dollars per year. Good progress has been made in developing high-yielding and disease-resistant lentil lines in the major lentil-producing countries in WANA as well as South Asia. In Ethiopia, new, improved varieties and production packages of lentil resulted in a 70% yield increase without costly inputs, leading to 42% of farmers in the target areas adopting the new varieties.

The Center works with national

programs on packages of faba-bean technology based on both new cultivars and improved agronomic practices. Farmers in Egypt, Sudan and Ethiopia now obtain up to 200% extra yield.

ICARDA has been working to develop improved cultivars of grass pea that are nutritionally safe. In 1999, several promising lines were identified and shared with national program scientists. Also, through *in vitro* techniques, new clonal lines are being developed.

Dr El-Beltagy also drew attention to ICARDA's role in promoting *in situ* conservation as coordinator of a major project on Dryland Agrobiodiversity, in

which Syria, Palestine, Jordan and Lebanon are partners. The Project is supported by the Global Environment Facility (GEF) of the United Nations Environment Programme.

Training is also an essential activity in ICARDA's agenda. Since its inception, ICARDA has trained some 8000 researchers from national programs, including 715 from 45 countries in 1999.

Prof. Dr El-Beltagy emphasized the debt of gratitude owed by ICARDA to the donors supporting its work. "On behalf of the Center I would like to say 'Thank You' to all of them," he said. ■

Alleviating Poverty through Support to the Rural Poor

A major step forward has been taken in ensuring that the fruits of agricultural research reach target farmers and help the rural poor in dry areas of Central and West Asia and North Africa.

Three major donor organizations met at ICARDA's Aleppo headquarters in February with scientists from ICARDA, and regional and national agricultural research systems to start the process of translating research results into technical advisory notes, or TANS, which will help in identifying suitable new or improved technologies for use in development projects.

At no more than two pages in length, these notes can be readily distributed to inform project designers, researchers, extension staff, farmers and small-scale rural entrepreneurs of the technologies that could help them. The TANS are the brainchild of IFAD, the International Fund for Agricultural Development, and the only multilateral donor with an explicit mandate to support agricultural research specifically focused on developing technologies relevant to the rural poor.

Dr Klemens van de Sand, IFAD Assistant President, attended the Aleppo workshop at which he pledged to stop the drift of development support away from the countryside where



Advisory notes will summarize new technology for farmers and advisers.



TANs workshop opening session: Dr Klemens van de Sand (center), explained the objectives of TANs. Prof. El-Beltagy (second from right), DG, ICARDA, spoke of the impact of rural poverty on urban areas, and of the need to alleviate it through agricultural research. Also present on this occasion were Dr Ahmed E. Sidahmed (right) and Dr Abdelhamid Abdouli (left), IFAD Country Portfolio Manager for Syria, and Dr Mahmoud Solh, ADG (International Cooperation), ICARDA.

so many of the world's poor live. Also present were Mr Samir Jarrad, of the Arab Fund for Economic and Social Development (AFESD), and Dr Eglal Rashed, of the International Development Research Centre (IDRC) of Canada. All three organizations are long-time partners of ICARDA, and their representatives confirmed their continuing support for ICARDA and, in particular, for the Mashreq & Maghreb Project which seeks to improve the integration of crop and livestock production in the low-rainfall areas of eight participating countries – Algeria, Lebanon, Libya, Iraq, Jordan, Morocco, Tunisia and Syria.

Dr van de Sand, who was making his first visit to ICARDA, said the Center was IFAD's main research partner not just in the West Asia and North Africa region but worldwide, having first formed a partnership 22 years ago when ICARDA was founded. The relationship had worked well because of ICARDA's ability to contribute to meeting IFAD's objectives for investment in agricultural research in the service of the rural poor.

He supported comments by ICARDA Director General Prof. Dr Adel El-Beltagy that the impact of the Center's research programs was not just economic but had social and political dimensions where the economic improvement was helping prevent rural migration to urban areas. The social dimension was exemplified by the movement of rural poor to urban areas in search of better life, but this leads to

increased demand for resources and services and can often contribute to social and political upheaval in those areas. These hidden dangers, and how they could be alleviated by the transfer of technology to rural areas, must be appreciated by donor organizations in assessing the impact of their investment. The IFAD-sponsored meetings held at ICARDA paved the way for the transfer of technology to the rural poor, said Prof. Dr El-Beltagy.

As well as visiting ICARDA scientists working on IFAD-supported projects, Dr van de Sand attended a meeting of those involved in the Mashreq & Maghreb Project of ICARDA, which he described as a model for the transfer of technology to resource-poor farmers in dry areas.

ICARDA scientists, coordinators from ICARDA's regional programs, national scientists from WANA, and from regional organizations took part in the workshop. Many draft TANS were prepared, most of them from the results of research by the ICARDA team in areas such as crop production, policy and property rights, animal production and feed, and human capacity building.

Progress was made on several joint TANS based on research by ICARDA and IFPRI (International Food Policy Research Institute), and on others by scientists from the Arab Center for Studies of the Arid Zones and Dry Lands (ACSAD) and the Arab Organization for Agricultural Development (AOAD). ■

IPM—Harmony or Hotchpotch?

Lessons in agricultural production and environmental sustainability are continuously being learnt. It is now generally accepted that indiscriminate use of pesticides is not the best solution to a problem. This has brought integrated pest management or IPM to the forefront. On pages 8-17 in this issue of Caravan, we explore ICARDA's work in IPM. But just what is IPM? Caravan asked Dr Khaled Makkouk, Acting Leader of ICARDA's Germplasm Program, for some answers.



Crop spraying with pesticides will only be used, when other available control options cannot provide the desired protection level.

Q. What does Integrated Pest Management really mean?

A. IPM is an effective and structured approach to pest management that is also environmentally-sensitive. It blends commonsense and traditional farming practices with the benefits of technology and scientific understanding of pests and how to deal with them. In this way it is possible to manage pest damage economically with the least possible hazard to people, property and the environment.

Q. How do IPM strategies work?

A. Very often, growers start with a four-step approach. First, they set an action threshold for a pest, disease or environmental condition. Secondly, they monitor and identify the pests to decide upon the appropriate response. Next, they consider preventive methods for controlling the pest or problem before it develops. This might mean earlier or later planting to avoid danger periods for pests; rotating crops to reduce pest numbers; or selecting pest-resistant varieties. Such preventive measures usually have little or no impact on the environment.

Finally, control is required if monitoring indicates that the action thresholds are exceeded. It might be enough to pull out affected plants by hand or machine, or the assessment may show that a highly-targeted chemical is the best response.

Q. Is IPM going to be expensive for growers?

A. Since much of what we are asking growers to do is based on a commonsense approach and often already part of normal practices, those aspects of IPM are no more costly than usual. Options that do not offer a clear return to the grower make no sense and are unlikely to be followed by growers. While sometimes it may be slightly more expensive in terms of inputs for a grower to follow an IPM strategy, the pay-off is in increased yield and extra cash income which more than offsets the initial extra costs.

Q. Does this mean that farmers in CWANA should turn away from expensive pesticides?

A. Appropriate use of pesticides is very much a part of an IPM strategy for some crops. IPM involves taking advantage of all appropriate pest management options, but each option is followed only after careful assessment of the problem, crop, and local situation. The aim is a targeted use of the most suitable pesticides for the required task rather than simply spraying a non-specific product that kills both harmful and beneficial insects or organisms.

Q. Are there other benefits for growers from taking the IPM route?

A. The principles of integrated pest management can be applied to many different agricultural pests whether vertebrate or invertebrate, plant, fungi, bacteria or virus. By attacking the pest in several different ways, the chances of the pest

developing a resistance to, say, a particular pesticide are much reduced. The targeted use of pesticides also makes it likely that natural predators—bacteria, fungi or other organisms—survive to have an impact on pest numbers. This synergy is the hallmark of IPM.

Q. How do you see IPM developing in CWANA?

A. By virtue of adaptability, the principles of IPM are applicable to every crop and to many pests and stresses. Science is adding to the range of options at the disposal of farmers so they are able to bring ever more sophisticated methods to bear on their crops. For example, biotechnology is instrumental in allowing the speedy introduction of new crop varieties with built-in levels of pest resistance undreamed of in the past.

There is also an increasing awareness among the farmers and agriculturalists of CWANA that mistakes have been made in the past that have adversely affected the environment and the conditions under which their next set of crops are grown. Careful choice of control options also takes into account the undesirability of pesticides that can affect humans, especially those handling the materials, as well as the environment. In other words, pesticides should only be used when other control options available cannot provide the desired protection level. ■

Clipping the Wings that Carry a Serious Virus

For 90% of their faba bean crop to shrivel and produce twisted and inedible grains is a disaster for farmers. It is also a disaster for a country where that crop is the main source of protein in people's diets. Luckily, IFM is providing a solution to a problem that could otherwise devastate faba bean yields in a number of dry-area countries.



The cowpea aphid (Aphis craccivora), the main vector which transmits the virus to faba bean after feeding on virus-infected legumes such as cowpea or French bean.

When discussion on a crop disease reaches the Prime Minister's Office, mere concern has turned into a serious problem. So was it with faba bean necrotic yellows virus which was responsible for the devastation of the faba bean production in Egypt in 1992, and again in 1999 for considerable losses.

However, thanks to collaboration between ICARDA and Egyptian researchers, and financial support from the European Union (EU), hopes are high that the 90% losses will not be repeated and that the Prime Minister can rest easy, at least on this issue of crop protection.

Faba bean is the major food legume crop in Egypt, and its dry grain pro-

By Khaled Makkouk, Latif Rizkallah, Samia Mahmoud and Mamdouh Omar

vides the main source of protein for most of the population. Grain production is affected by a number of diseases caused by either fungi or viruses, but in 1992 local advisers were puzzled by a new disease which was decimating plants, particularly in Middle Egypt. The ICARDA plant virologist, who was attending a conference in the country, was able to visit affected fields and take samples of infected plants. These showed the cause was a virus not previously identified in Egypt. Young leaves of infected plants

showed interveinal chlorosis and yellowing, and were cupped upward. When infection occurred early in the season, faba bean plants were severely stunted and killed prematurely.

Further sampling in 1993 confirmed that faba bean necrotic yellows virus (FBNYV) was indeed the culprit, being spread by aphids. In all likelihood, the disease had been present at low levels in Egypt for some time but

had not previously shown itself in quite such devastating magnitude. FBNYV is considered the most economically important disease-inducing agent to the faba bean crop, especially in Middle Egypt. It is also economically damaging in the Jordan Valley and in coastal areas of Syria and Turkey where winters are sufficiently mild to sustain the aphid population.

This virus disease can reach epidemic proportion in Egypt, causing considerable losses, as happened in 1992 and 1999 when some faba bean



Faba bean necrotic yellows virus in a farmer's field in the Fayoum Governorate of Egypt. The virus caused 60-90% yield losses in Middle Egypt in 1991/1992 and 1998/1999 growing seasons.



Symptoms of faba bean necrotic yellows virus infection on a young faba bean plant.

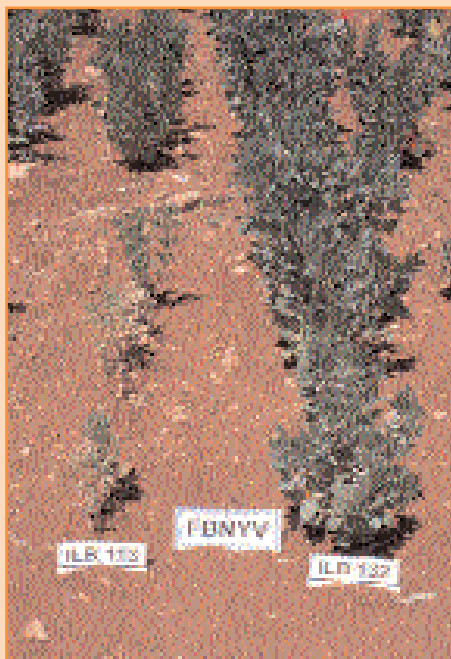
growers were faced with complete crop failure. As a result, many Egyptian growers were reluctant to plant nutritionally-vital faba bean crops in subsequent years.

Because of the seriousness of the disease, and to reduce the losses caused by it, intensive efforts were made by the Agriculture Research Center in Egypt, in collaboration with ICARDA through its Nile Valley and Red Sea Regional Program based in Cairo, with financial support from the EU, to develop measures both acceptable to farmers and without adverse effects on the environment.

The virus causing the disease is introduced to the crop through plant-sucking aphids such as the pea aphid (*Acyrtosiphon pisum*) and the cowpea aphid (*Aphis craccivora*). The aphids acquire the virus when feeding on virus-infected summer legumes such as cowpea (*Vigna unguiculata*) or French bean (*Phaseolus vulgaris*) or a large number of virus-infected leguminous weeds, which are part of the natural habitat along the irrigation canals and between fields in Egyptian agricultural land.

Middle Egypt is characterized by a mild winter where temperatures rarely fall below 5 °C. Accordingly, aphids can actively move from such hosts and fly into the faba bean fields in October-December. They introduce the virus into faba bean plants when they start feeding on them. The virus is contained in the saliva of the aphid and transmitted while feeding takes place.

The joint team of scientists started experiments aimed at finding ways and means to reduce the chances of virus infection of faba bean plants in the field. As there were then no faba bean cultivars resistant to FBNYV infection, experimentation focused on identifying cultural practices that could lead to reduced virus spread. Investigations conducted at Sids Research Station in Middle Egypt for three years (1995-1998) showed that the elimination of virus-infected plants (roguing), by pulling them out by hand, reduced further spread of the virus inside the field. This was because, after arriving in the host crop, the aphids colonize the plants and breed. The subsequent generations pick up the virus from the infected plants, if it is still present, and continue the spread of infection as they



Reaction of a resistant (ILB 132) and a susceptible line (ILB 113) of faba bean to infection with faba bean necrotic yellows virus at ICARDA during 1999.

move around between plants.

In addition, the scientists evaluated different sowing dates. It was found that a delay (10-15 days) in sowing the crop until early November led to reduced virus spread. Infection was still present at low levels but the peak of aphid movement was taking place before the plants were fully developed as attractive hosts. Early October planting, by comparison, led to heavy infection levels three to four weeks after aphids flew into the newly-emerged crop.

Since virus infection is brought into the faba bean crop through aphids, experiments were also conducted to find out what was the minimum number of pesticide sprays necessary and at what growth stage they should be applied to reduce virus spread. Two sprays with the systemic aphicide pirimicarb at a concentration of 0.2% (Pirimor) in December and January gave a significant reduction in FBNYV spread.

Alternatively, and based on experimentation at ICARDA research station at Tel Hadya, Aleppo, Syria, it was demonstrated that when faba bean seeds were coated with imidacloprid (Gaucho) at the rate of 2 g per kg of seeds, FBNYV spread was reduced

from 28% in plots with untreated seed to 1.6% in plots with treated seeds. Seed treatment with an appropriate pesticide is less costly than pesticide sprays, and can provide protection for up to two months and is less likely to harm beneficial insects.

However, since the level of infection varies from year-to-year depending on the extent of the inoculum pool and on the weather-dependent activity of aphids, the insurance of a seed treatment may not be the best route for many farmers who prefer a wait-and-see approach. The collaborating scientists have shown it is possible to bring virus infection down from the 70-80% level to just 5-10% by integrating mid-November sowing with the early removal of any virus-infected plants, and the use of two systemic aphicide sprays in December and January. The success of this integrated virus disease management scheme in minimizing disease losses on experimental farms was such that the approach is now being taken to farmers' fields.

Parallel to these investigations, the collection of faba bean germplasm in the ICARDA gene bank was examined in 1998/1999 to identify faba bean genotypes resistant to FBNYV infection. Preliminary results showed that a few genotypes which originated from Ethiopia, Greece, Libya, Morocco, Russia and Turkey were highly resistant. It is still too early to say definitively that there will be fully-resistant varieties. However, if such resistance is confirmed after evaluating these genotypes under Egyptian environmental conditions, then breeders in Egypt will have useful sources of resistance for use in developing faba bean cultivars, both adapted to local conditions and resistant to FBNYV infection.

The availability of an adapted resistant variety might then permit the establishment of an integrated management option without the use of insecticides, or at least it could reduce the number of sprays. This would minimize costs to growers and risk to the environment. ■

Dr Khaled M. Makkouk is Acting Leader of the Germplasm Program at ICARDA. Drs Latif Rizkallah, Samia Mahmoud and Mamdouh Omar are all Senior Scientists at the Agricultural Research Center, Giza, Egypt.

Take the Puff Out of Rusts that Blow in the Wind

Winds do not recognize international boundaries and can carry a wide range of unwanted microorganisms. One such drifter that has severe repercussions for cereal crops in the Horn of Africa is the fungal disease yellow rust.

Leaf and stem rusts are the major diseases limiting both wheat production and the longevity of high-yielding varieties in Egypt, Ethiopia, Sudan and Yemen. The diseases are a truly regional problem because of the ease with which infection is spread by rust spores carried by the wind over long distances within and between countries.

Chemical control is expensive and may not be justified if infection levels turn out to be low. In a bid to find other ways of controlling and limiting the rapid spread of disease, a wheat rusts regional network was established in which Egypt plays the leading technical role, and Ethiopia, Sudan, Yemen, ICARDA and CIMMYT (International Maize and Wheat Improvement Center) are partners. The network is one of six problem-solving networks within the Regional Networks Project established under ICARDA's Nile Valley and Red Sea Regional Program, and is financially supported by the Government of the Netherlands.

To assess the threat from rusts, Burkard mechanical spore traps were installed at a number of locations across the region. Rust trap nurseries were also established at 22 sites throughout the region where monitoring could be carried out on the status of leaf and stem rust pathotypes and on spore movement. The nurseries included wheat rust monogenic lines, wild relatives, check varieties, and high-yielding promising lines and cultivars.

As a result of this monitoring program, 28 different leaf rust races (8 in Egypt, 2 in Sudan, 15 in Ethiopia, and 3 in Yemen) and 30 stem rust races (13 in Egypt, 10 in Ethiopia, and 7 in Yemen) were identified between 1995/96 and 1998/99. Their frequencies of occurrence in the respective



Genes for resistance to yellow rust are being incorporated at ICARDA to develop improved wheat cultivars (left). The susceptible cultivars, grown in the same field (right), were severely damaged by yellow rust.

countries and across the region were recorded. The performance of leaf and stem rust isogenic lines was tested and effective resistant genes for each country and for the region were identified. For the region, these were *Lr's 21, 17, 3Ka, 30, 11, and 21* and *Sr's Gt⁺, 7b, 5, 8a, and 30*.

These genes are now being incorporated into high-yielding but previously-susceptible cultivars in each country. A breeding program is also under way in all four countries to develop high-yielding, adapted, resistant cultivars. Five commercial wheat cultivars and advanced lines were found to be resistant to the prevailing leaf rust races in Egypt, 16 in Ethiopia, 18 in Sudan, and 25 in Yemen, while 15 cultivars had good resistance to stem rust. Monitoring from 1993 to 1999 revealed nine cultivars performing well against both types of rust in the region. In 1998/99, out of the 48 tested cultivars and lines against leaf and stem rusts, 18 cultivars showed multiple disease resistance.

The spore traps are helping researchers to understand the way in which the rusts spread. It has been

established that leaf rust inoculum in Egypt is exogenic—originating from outside the country—and its pathway is from north to south, while in Ethiopia it is endogenic, or permanently present. In Sudan, it also seems that the primary inoculum comes from outside the country, possibly from Yemen, given the presence of spores all year round, or from other African neighboring countries.

Although the question of stem rust primary inoculum needs further investigation, it appears that the inoculum in Ethiopia and Yemen is present all year round due to the two-cycle cropping system, and that in Egypt it may come from the north or from the south depending on wind direction. Rust spores were found throughout the year, with even the smallest quantity of inoculum having the potential to be the source of an epidemic, given the right conditions. Armed with knowledge of disease source, farmers can choose suitable resistant varieties and avoid monoculture which can promote breakdown to resistance. Delayed planting may help, and fungicides may be the best option under conditions of high rainfall or irrigation.

The Regional Networks Project established by ICARDA's Nile Valley and Red Sea Regional Program aims through complementary efforts to utilize expertise, human resources, and infrastructure efficiently in the member countries. A multidisciplinary and multi-institutional approach is used to strengthen basic and applied research on problems arising from biotic and abiotic stresses facing the production of food legumes and cereals in the four countries. Research is jointly planned but conducted and reported by national scientists.

Each network is headed by a lead country based on the country's comparative advantage with respect to the expertise of its national scientists in that area. Basic research is conducted in that country, and the outcome of research is verified through adaptive research under local conditions in the other participating countries. ICARDA provides technical support, germplasm, and training, and facilitates research coordination, logistic support and administration. ■

Saving Our Daily Bread from the Sunn Pest

Bread comes in many shapes and types in the countries around the eastern Mediterranean rim, but all bread has a common requirement for good quality flour. The Sunn Pest is the enemy of the farmer, the miller and the baker when it comes to producing flour suitable for bread making. Help in overcoming this tiny pest is on its way.

By working with nature, scientists plan to reduce a \$42 million annual bill for chemical insecticides used in West Asia to control Sunn Pests.

For now, governments have the choice between paying dearly for chemical control or facing equally crippling crop yield losses of 50-90% in wheat and 20-30% in barley. In addition, even an apparently small amount (2-3%) of grain damage to wheat by this serious pest can lead to rejection of an entire consignment for milling into flour. During feeding, the Sunn Pests inject chemicals into the grain that greatly reduce its baking quality once harvested and milled into flour.

It is now planned to develop miniature insect-killing fungi as alternatives to chemical insecticides. These tiny



Feeding leads to loss of nutrients to the leaves and ears leading to up to 90% devastation in severe outbreaks of Sunn Pest. However, even low-scale damage can ruin the breadmaking capabilities of wheat.

By Bruce Parker, Margaret Skinner and Mustapha El Bouhssini

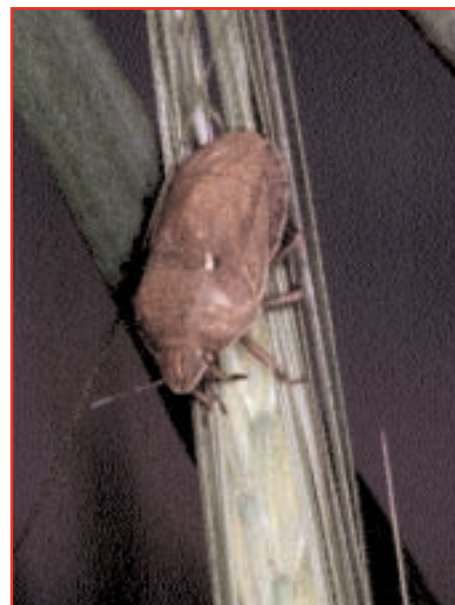
microorganisms, which only attack insects and not the plants, will be used in concert with parasitoids, predators, cultural methods and other strategies in a comprehensive integrated pest management (IPM) program to reduce the impact of Sunn Pest damage regionwide.

At mealtimes, wheat is the preferred choice of the Sunn Pest (*Eurygaster integriceps* Puton), but it will also feed on barley and rye, and occasionally on oats, sorghum and maize. It is a particularly serious pest in Cyprus, Jordan, Lebanon, Iran, Iraq, Palestine, Syria, and Turkey. A relative of the common stinkbug, it feeds on leaves, stems and grains by sucking fluids from them. Heavy attacks cause the stems to break, or empty 'white-heads' to form containing no grain.

Its table manners cause problems for flour millers and for farmers who lose a valuable market for their grain. As it feeds on soft young grains, the bug injects enzymes in its saliva into the grain. These enzymes digest the seed proteins and make feeding easier. However, these enzymes are then left in the harvested grain and are reactivated when water is added to flour to make dough.

The enzymes destroy the gluten quality of the dough so that it is impossible to make bread from flour milled from grain with more than 2-3% damage from Sunn Pest.

Whether the damage is to yield or to quality, it is a serious matter for farmers who dread the spring arrival of this pest and the devastation it can cause to their crops. The existing chemical control methods are expensive and undesirable from both envi-



Sunn Pest—not a sight that a wheat grower wants to find in his crop in the CWANA countries.

ronmental and consumer points of view. However, biological control as a component of IPM is a major focus of research at ICARDA into controlling both pests and diseases.

Together with scientists from the University of Vermont, USA, a plan was designed to develop insect-killing fungi as alternatives to the costly



Harmless to beneficial insects but a deadly natural enemy to the Sunn Pest, this naturally-occurring fungus could be sprayed to prevent crop damage.

chemicals. It was already known that tiny fungi infect Sunn Pests so the first move taken by the ICARDA/Vermont scientists was to find and isolate these potentially beneficial pathogens. Sunn Pest leaves the cereal fields after harvest and overwinters under fallen leaves in nearby foothills. This was where the researchers decided to concentrate their search for infected specimens. With support from USAID Linkage Funds and from the Conservation, Food and Health Foundation, collections were made in Kazakhstan, Kyrgyzstan, Syria, Turkey and Uzbekistan.

The result is that entomologists from ICARDA, the University of Vermont and NARS (national agricultural research systems) in West and Central Asia and the Caucasus have now gathered several hundred different strains from which biological controls can be developed. In Syria they were assisted by colleagues from the University of Aleppo, and in Turkey by the University of Çukurova and the Plant Protection Research Institute of Adana. It adds up to the world's largest collection of these fungi, isolated specifically from Sunn Pest.

However, it was also essential to establish that these microorganisms were really capable of performing the expected task—that of killing the adult Sunn Pest. Pathogenicity trials at ICARDA laid any fears to rest. Some of the fungal isolates were so highly pathogenic, they killed all of the treated insects in less than one week. The fungal spores lodge between the protective plates of the insects and then penetrate and develop within the insect, blocking vital life support systems.

The next task for the team of scientists is to further evaluate the most promising of the isolates to select those which are likely to be of most use in the wide range of environmental conditions found across West and Central Asia. It is expected that many of those collected in the southern part of the region will be up to the task of killing the bugs under hot, dry conditions but may not perform as well in the much colder temperatures in the more northerly districts, and *vice versa*.

When those isolates capable of having the widest application have been identified, they will be further tested in



Winter woollens are a must for researchers scouring the upland overwintering areas favored by the Sunn Pest for dead insects that have been affected by entomopathogenic fungi that could be developed as environmentally-friendly pesticides.

the laboratory and in the field for their effectiveness as biological controls. It is unclear at this stage just how farmers can use the fungal isolates. They could be applied to crops as sprays at critical times or it might be more efficient to introduce them into the overwintering



Once isolated the fungi are multiplied and placed in a spray solution for lab trials that compare their effectiveness at killing Sunn Pests under differing conditions.

areas favored by the Sunn Pests so that migration to cereal fields in spring is reduced.

If the Central and West Asia regions are to have any hope of meeting the food needs of their population in the decades ahead, it is imperative that the present insecticide-based strategies are replaced with multi-dimensional IPM approaches. Insecticides must be replaced because they are expensive, frequently have a negative impact on the environment, and have questionable effectiveness because of the ability of insects to develop resistance to them.

The insect-killing fungi have, however, developed over many years without the Sunn Pest being able to develop resistance to their fatal attacks. The next stage of trials will ensure that the most effective strains for a range of environments are identified to form the basis of future biological insecticides.

The progress made so far with fungal pathogens is a clear indication that ICARDA, in cooperation with the University of Vermont, is on the cutting edge of this technology. ■

Drs Bruce L. Parker is Director of Entomology Research Laboratory, and Margaret Skinner is Assistant Professor at the University of Vermont, USA; Dr Mustapha El Bouhssini is a Senior Entomologist at ICARDA.

Sprays that spare pest predators

Using a pesticide to kill insect pests can be a boon. However, the technique is just not that relevant when farmers can't afford to pay for the sprays and they also kill some of the creatures the farmers want to keep. An alternative approach to controlling chickpea leafminer integrates environmentally-friendly pesticides with cultural controls.

Tough times lie ahead for the chickpea leafminer. The high cost of chemical pesticides has previously allowed its larvae to carry on making a meal out of the chickpea crop throughout West Asia and North Africa. Now an integrated pest management (IPM) package is ready to stem the 30% crop yield losses caused by this important pest.

Feeding by larvae on the leaf mesophyll tissue is the cause of the desiccation and premature leaf fall which reduces yields and income for farmers. Research by ICARDA has indicated that the insect can be effectively controlled by insecticides but their use in farmers' fields is limited because of their high prices. Additionally, the environmental hazards associated with the use of insecticides have to be considered, particularly the threat imposed by the insecticides to the useful natural enemies of the leafminer (*Liriomyza cicerina* Rondani).

ICARDA and its partner organizations in West Asia and North Africa (WANA) have been evaluating integrated pest management (IPM) approaches as alternatives to the use of conventional insecticides. These approaches include the employment of host-plant resistance, planting dates and botanical insecticides.

Experiments comparing the effects of planting date (winter rather than spring), varieties (local against improved) and a safe chemical (neem oil versus deltamethrin) on leafminer damage and on natural enemies have been carried out in the field at ICARDA's headquarters for the last four years. The chickpea cultivars used were a Syrian local and the improved Ghab 3. Chemical treatments used were neem oil (2 ml per liter) and deltamethrin (0.25 cc per liter).

Neem oil is a natural insecticidal extract obtained from the fruit and

By Mustapha El Bouhssini, R.S.
Malhotra, A. Babi
and K. Mardini



Chickpea leaflets damaged by leaf miner larvae.

seeds of the Indian neem tree (*Azadirachta indica*). ICARDA scientists are also in the early stages of examining the effect of leaf and fruit extracts from another tree, *Melia azedarach* L., which is native to the Middle East and widely distributed in Asia, the Mediterranean basin, Africa and South America. It appears to have anti-feeding effects against chickpea leafminer and also against *Sitona crinitus* H., the main pest of lentil.

The results of the tests with neem oil have been very encouraging. An IPM package of winter-sown chickpea using the tolerant cultivar Ghab 3 and three sprays of neem oil reduced significantly the number of chickpea leafminers and the leaflet damage caused by larval mining. As tested, the IPM package is also environmentally friendly as it has little effect on natural enemies of leafminer.

On the other hand, using the syn-

thesized pyrethroid insecticide, deltamethrin, reduced the number of parasitoids, by about 70%, compared to the unsprayed check. Natural enemies of chickpea leafminer should be conserved as they play a major role in regulating the insect population. Studies show that the level of parasitism by the larval parasitoid (*Opius monilicornis*) reaches 70% on the third generation of the leafminer.

There is a further bonus for farmers, who are now being encouraged to adopt the IPM package. Besides escaping the chickpea leafminer infestation, the winter-sown (December planting) types of chickpea developed by ICARDA take advantage of early rainfall. This promotes crop establishment and increases the water-use efficiency of the crop. The yield advantage of the winter-sown chickpea is more than double that from traditional planting in spring (March).

A large number of countries in WANA have already adopted winter-sowing technology, and improved cultivars for general cultivation have been developed locally and released in different countries. Most of these varieties for winter-sowing possess tolerance to cold and to *Ascochyta* blight, necessary for winter sowing. ICARDA included these winter varieties in the IPM package for chickpea leafminer. With testing at experimental sites complete, the package is now ready for on-farm evaluation and demonstration in the countries of WANA. ■

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Attractive but Deadly

Orobanche is an attractive-looking weed which sucks nutrients from the roots of lentil plants. The infestation can become so bad that farmers must stop growing lentil, but now a control package is on the way to give relief to lentil growers.

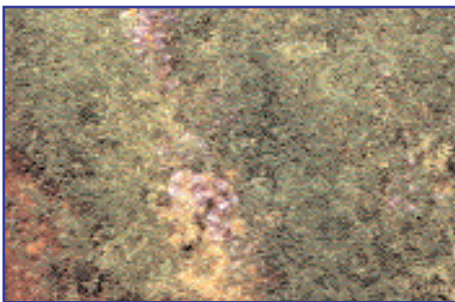
Even for a parasite, orobanche (*Orobanche crenata*) is a particularly nasty weed. No known lentil varieties can withstand its attack, and it has painfully brought lentil growing to a complete halt in many Mediterranean regions.

Early sowings are particularly at risk from this underground parasite. It attaches its specialized sucking apparatus to the root system of the lentil plant from which it then clandestinely withdraws water, minerals and assimilated nutrients, leaving the plant dry and unproductive. All this takes place before the farmer is able to see the aerial shoots of orobanche in his field.

The tiny seeds are produced in enormous numbers in capsules, and can be spread by wind, surface water, or from field to field by equipment. They can remain viable in the soil for 12 years or more, so a severe infestation can mean an end to lentil growing for long periods.

Even after extensive screening of lentil germplasm, ICARDA has not yet been able to identify sources of resistance to this flowering parasitic weed. Farmers in south and east Europe, North Africa and West Asia, therefore, tackle it using different practices:

- Hand weeding—a time-consuming and labor-intensive process



Attractive but deadly, these flowering spikes are often the first warning the farmer has of the presence of orobanche. By then it is too late and up to 100% of lentil yield can be lost.

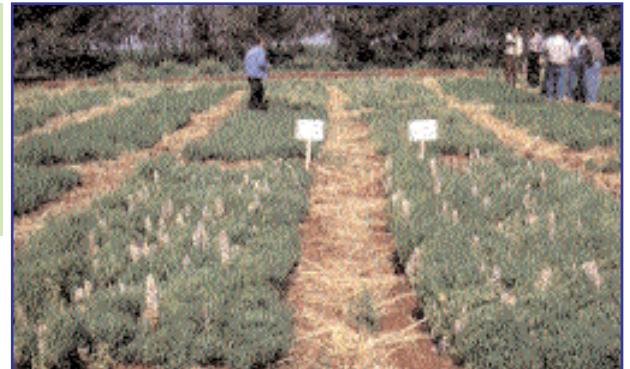
- Delayed sowing—can negatively affect straw and seed yields, especially in dry seasons
- Inclusion of cumin (*Cuminum cyminum*) in the rotation for its apparently adverse effects on seeds of the weed in the soil

Now ICARDA has put together an integrated weed management package for testing under field conditions in collaboration with the Syrian national program. Two sites were chosen at Idlib (wet) and Tel Hadya (relatively dry).

By Bassam Bayaa, N. El-Hossein and Willie Erskine

The package includes two sowing dates (early and normal); three cultivars—Hourani, a Syrian local large, and an early-maturing cultivar adapted to late sowing; and foliar sprays with one of three chemicals. These were imazethapyr, applied either as pre-emergence treatment at a 30 milliliters active ingredient per hectare rate, or as two post-emergence treatments, each at 15 ml ai/ha; imazaquin as two post-emergence treatments each at 7.5 ml ai/ha; or imazapic as two post-emergence treatments, each at a rate of 5 ml ai/ha. Controls were either untreated or weeded twice by hand.

In general, orobanche infestation was higher at the wetter Idlib site than at Tel Hadya. Compared with the first sowing at Idlib and Tel Hadya, the second sowing reduced infestation by 35% and 75%, respectively, at these sites. Best results from the herbicides were from imazapic and imazethapyr. Orobanche shoots were reduced by 80% and 84%, respectively, in the first sowing and by 99% and 100% in the second sowing, at the two sites.



Later sowing has saved the improved lentil line in the center from the orobanche infestation that hit other lines in the foreground in this ICARDA trial comparing sowing dates for avoiding infestation.

These two herbicide treatments also increased the biological yield from the first sowing by 52% and 39%, and by 32% and 38% for the second sowing. This was also associated with a seed yield of between 113 and 224% from the first sowing and 181 and 113% in the second sowing over non-treated plots. Over the two seasons of trials, imazaquin was the least effective treatment.

Not only did imazapic reduce the number of orobanche shoots, it rendered the inflorescence infertile, thereby contributing to the reduction of the parasite's seed bank in the soil.

The herbicide sprays did not affect *Phytomyza orobanchiae*, one of the few natural enemies of orobanche.

Different concentrations of the two successful herbicides are being tried out in the laboratory as seed dressings to control the pest. Since the herbicides allow an earlier sowing date—to take advantage of moisture—the trials are being repeated at field-scale at ICARDA's main station. Next step will be to try the package out with farmers with a view to transfer the techniques to lentil production areas where orobanche is a major problem. ■

Dr Bassam Bayaa is a Consultant Pathologist with ICARDA's Germplasm Program, Mr Naim El-Hossein is an MSc student at the University of Aleppo, and Dr Willie Erskine is Acting Assistant Director General of Research at ICARDA.

Indigenous Integrated Disease Management

Most people keep a lifelong preference for the type of bread they grow up with. Eritreans are no exception but farmers in Eritrea face twin difficulties of drought and then severe disease in their bread wheats when the rainy season does arrive. Since the local varieties that make the best flour are highly susceptible to disease, the growers have devised their own integrated disease management strategy.

In Eritrea, farmers face frequent drought but also a rainy season that can produce severe disease incidence in their vital cereal crops. To limit the potential damage they have devised an indigenous method which dovetails neatly into the concept of integrated disease management.

In 1999 Eritrea, which borders the Red Sea between Egypt and Ethiopia, had the usual low rainfall and early drought. Then in August came humid and warm conditions that enhanced foliar disease development.

ICARDA observations in fall of 1999 revealed many potentially harmful foliar diseases enjoying optimum conditions for their development. The endemic and most severe cereal diseases were leaf rust (*Puccinia recondita*) on wheat, as well as a number of foliar diseases on barley. The most severe foliar diseases of barley were found to be net blotch (*Pyrenophora teres*), spot blotch (*Bipolaris sorokiniana*), and scald (*Rhynchosporium secalis*). But not to be outdone, other barley diseases present included bacterial leaf streak (*Xanthomonas translucens*) and septoria (*Septoria passerinii*).

Left uncontrolled, these diseases hit crop yields badly. However, Eritrean farmers have developed a unique wheat-barley crop mixture called *Hanfetse* that contributes greatly to the reduction of disease levels.

Integrated disease management (IDM) programs normally use differing control methods. It is not unusual to find that, although cultural practices, fungicide combinations, multilines, plant population variations, or varietal mixtures are often advocated for disease reduction, farmers in practice seldom use them.

In Eritrea, however, *Hanfetse* is



An Eritrean researcher (left) from the Department of Agriculture Research, notes farmer opinion on new barley varieties that may eventually form part of a disease-breaking Hanfetse mixture (above).

By Amor Yahyaoui

commonly used by farmers to deal with both drought and foliar diseases. In dry seasons, the barley in the mixture ensures that some production is obtained even when, as often happens, the wheat fails to grow properly. During rainy seasons the wheat makes use of the moisture and not only gives

better yields but also protects the barley, keeping it upright. Invariably, mixing the two shows better yield performance than growing these crops singly.

The major benefit comes from the effect on foliar diseases of growing these crops in mixture. In Eritrea, farmers favor bread wheat, but because the available local bread wheat cultivars are so highly susceptible to leaf rust, they can suffer up to 80% loss when grown alone. The local barley cultivars are tall and susceptible to lodging and to many foliar diseases.

In a *Hanfetse* crop, lower disease incidence was recorded both on experimental sites and in farmers' fields, and good yields obtained in both cases. Less rust develops on the mixture due to the dilution effect caused by the barley. Rust spores are wind-borne and can spread very rapidly over large

areas. When they fall on barley leaves in the mixture, they fail to reproduce and there is a direct reduction of the rust inoculum and consequently a lower infection rate for the wheat plants.

Likewise, there is a similar effect for barley and its specific foliar diseases such as scald, net and spot blotch. These are stubble-borne and are normally splash-dispersed by wind and rain but over short distances and usually within the primary source of inoculum. However, these pathogens fail to infect wheat plants, bringing another major reduction in inoculum level and in disease incidence. So, both crop species in the mixture are protected from the heavy infection of their respective diseases because the foliar cereal pathogens are highly specific. In other words, a wheat rust pathogen does not infect barley, and barley pathogens do not cause diseases on wheat.

Hanfetse is widely grown in Eritrea. The mixed grain is used for traditional 'angera,' a flat bread usually made solely from the grain of *teff* (*Eragrostis abyssinica*).

Of course, the technique has its drawbacks as well as further potential. Although total *Hanfetse* production is adequate compared to that from the individual crop species, its productivity remains very low. A major problem of this mixture system is the wide maturity range in the *Hanfetse* crop. The wheat cultivars available to the farmers are late whereas the barley cultivars are early maturing. Farmers are obliged to cut the *Hanfetse* crop when the wheat is still green to avoid over ripening and shattering of barley.

This useful indigenous knowledge could be exploited and improved with the introduction of new germplasm from the wide range to which ICARDA has access in its gene bank. Plant breeders could help create a *De novo Hanfetse* crop that mixes hull-less barley with awnless bread wheat. The components of such a blend will have a closer maturity range, better nutritional quality, and higher yield potential. In this way *Hanfetse* will realize its true potential and Eritreans can go on enjoying the delights of *angera*. ■

Dr Amor Yahyaoui is Senior Cereal Pathologist at ICARDA.

Taking Blight off Chickpea

Chickpea is a winter winter for most of the crop's growers in West Asia and North Africa but the switch from spring to winter planting opened it up to a new disease risk.

Winter sowing allows chickpea to establish well, thanks to the availability of moisture, yields can be double those of the later plantings, particularly in dry seasons. It is also much less vulnerable to vascular wilt that can destroy spring plantings.

As a result of improved winter varieties, many of them based on germplasm supplied to NARS by ICARDA, chickpea cultivation has spread to drier areas. The only shadow

Chrys Akem, Rajendra Malhotra, Bassam Bayaa, Mohamed Nazir Mouselli, Siham Kabbabeh

on its future was, until now, the increased threat of *Ascochyta blight* (*Didymella rabieie* (Kovach) v. Arx) during the more moist, cooler winter months.

Cultivars with acceptable levels of genetic resistance or tolerance were developed in response to this threat. However, the ability of the fungus populations to produce new variants (races) which can overcome the resistant cultivars prevents complete reliance on genetic resistance, especially in those areas where environmental conditions conducive to disease development prevail.

ICARDA, with the Syrian national program, has investigated integrated disease management over the last three years on three sites representing different agroecological zones. These were at Tel Hadya, El-Ghab and Hemo. The approach included a number of potential control components but four, in particular, showed the greatest promise. These were: use of tolerant cultivars adapted to early sowing; seed dressing with fungicides to prevent seed-borne disease; application of a single foliar spray of the fungicide chlorothalonil (Bravo or Clortosip) at seedling or



An integrated disease management package can eliminate Ascochyta blight seen on these leaves (right) and on pods.

early vegetative growth stages; and delayed sowing until January for lower disease impact than either November or December plantings.

An integrated management package using these components was tested during the 1999/2000 growing season at five sites, with farmers' participation. The package was compared with traditional spring plantings using the local variety without seed dressing or foliar spray.

Although the season did not favor epidemic spread of the disease, the plots where the package was applied performed far better than those planted normally with the same tolerant cultivars, even in researcher-managed trials. The spring planting was a complete failure due to drought.

These pilot experiments will be continued for two more seasons to determine the advantages of the package. Other cultural practices such as deep plow, field burning of debris, and crop rotation to prevent carryover of disease inoculum in chickpea residues to the next crop will also be evaluated for their role in disease management. ■

Dr Chrys Akem was formerly Legume Pathologist at ICARDA; Dr Rajendra Malhotra is Principal Chickpea Breeder and Dr Bassam Bayaa is Consultant Legume Pathologist at ICARDA; Mr Mohamed Nazir Mouselli is Plant Pathologist at the Directorate of Agricultural Research, Ministry of Agriculture and Agrarian Reform, Syria; and Mrs Siham Kabbabeh is Assistant in Legume Pathology at ICARDA.

Technology Transfer Takes Iraq Forward

Farmers in the dry areas of Iraq are reaping a bounty of improved cereal yields and livestock performance. With the second phase of the Mashreq/Maghreb Project now underway, we look at the impact the project has achieved so far in Iraq.

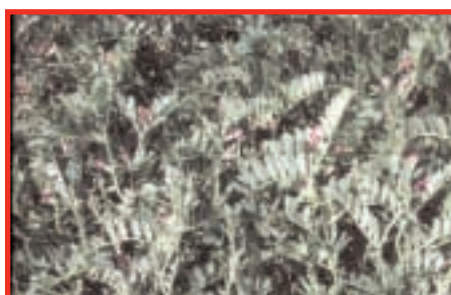
Iraq is beginning to take major strides in production of meat and cereals from its dryland regions, thanks to collaboration between scientists, researchers and farmers in West Asia and North Africa.

The wider difficulties faced by the country have been sidestepped in the agricultural sector by Iraq's involvement in technology transfer activities led by the Ministry of Agriculture and IPA Agricultural Research Center, and to which the Mashreq/Maghreb Project of ICARDA has contributed.

Officially known as the Regional Program for the Development of Integrated Crop/Livestock Production in the Low Rainfall Areas of WANA, the first phase of the project was implemented by ICARDA's West Asia and North Africa Regional Programs in collaboration with the International Food Policy Research Institute (IFPRI), and funded by the Arab Fund for Economic and Social Development (AFESD) and the International Fund for Agricultural Development (IFAD). It brought together scientists, technicians and farmers in the Mashreq (Iraq, Jordan, Lebanon and Syria) and the Maghreb (Algeria, Libya, Morocco and Tunisia) not just for technology exchange but to compare socioeconomic factors in the regions and how common experiences can be used in reshaping a better future for rural communities.

Although the project area in Iraq was confined to part of Ninawa province in the north of the country

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Innovations now being exploited in Iraq as a result of the Mashreq/Maghreb project include the high-yielding barley variety Rihane-03 (top) which is being grown on 250,000 ha this year. Awasi sheep (center) have also been the focus of a ram improvement program to produce higher quality breeding stock in conjunction with the IPA Agricultural Research Center. Ewe milk production has been increased by the introduction of forage legumes such as Vicia sativa (bottom), either into continuous barley cropping systems or instead of fallow.

when the M/M project was set up in 1995, the benefits are now being felt throughout the country, since five national development projects have been set up to use the M/M project mechanism for technology transfer. Nearly 65% of Iraq's wheat production

and almost a half of barley production depend on natural rainfall.

About 60% of cereals in the province are grown in low-rainfall areas, receiving less than 200-350 mm of annual rain, with the result that yields of both wheat and barley averaged just 400-800 kg/ha in 1967-91. This low productivity is mainly due to a combination of traditional farming practices, low adoption rates for improved technologies, and low and erratic rainfall.

Thanks to the M/M project and to the national researchers, these shortcomings are now being addressed in a number of ways:

- improved barley varieties
- forage legumes
- vetch/barley hay mixtures
- better ram selection
- increased lambing rates
- urea treatment of straw
- feed-blocks
- field advisory training

Livestock improvements

Nutritional benefits from enhanced forage mixtures, as well as feed-blocks made from agro-industrial by-products, have reduced ewe feeding costs and contributed to better lambing averages in sheep flocks.

It was clear from a sheep fertility survey that the Awasi sheep in Iraq had a real fertility problem in all the rainfall zones, under all production systems and flock sizes. The low lambing percentages could be attributed to correctable, low ovulation rates.

Introducing feed-blocks (see panel) has been so successful in Iraq that the private sector rapidly saw the potential and lifted production in just three years to more than 24,000 tonnes by the end of 1997 for use by more than 6,500 flock owners. Feeding Awasi ewes from these high-energy blocks during the late stubble grazing and hand feeding periods reduced intake of whole barley by two-thirds — a considerable saving. The vast majority of flock owners were impressed by their flocks' ability to maintain body weight when fed with the blocks.



The feed-block technology is being further developed at ICARDA using a variety of farm residues. Here, H.E. Mr Assad Mustapha (sixth from right, front row), is briefed by Dr Safouh Rihawi, Feed Specialist and Dr Luis Iniguez, Leader of the small-ruminant project at ICARDA, on the progress made by the Center working in collaboration with Iraqi scientists.

Urea feed-blocks, supplemented by Vitamin A, are another success, lifting lambing rate to 77% against 45% for hormonal injections. Overall, Vitamin A supplementation has improved the lambing rate by 8% and the number of twins by 2%. Lamb deaths are slightly down compared with those from untreated ewes.

Hormone treatment of 52 flocks in the project area lifted lambing and twinning rates by 39% and 40%, respectively, under semi-intensive systems, and by 25% and 40% among extensive flocks. An Iraqi team was later able to extract and produce the hormone locally.

Feeding urea-treated straw during late pregnancy and lactation improved the performance of the Awasi ewes, boosting milk yield by 10%. Straw intake was up by 40%, thereby reducing whole barley grain and wheat bran intake by 23% — a worthwhile saving in feeding costs.

A further 175 g/day increase in milk production was one of the benefits of introducing forage legumes, particularly *Vicia sativa*, either into continuous barley cropping systems or instead of fallow. The ewes involved in trials showed a body weight gain of 4.8 kg/head when grazed for 19 days on the vetch forage, compared with ewes grazing natural pasture.

Using the vetch as hay to supplement barley during hand feeding also brought benefits in milk production of an extra 100 g/day. Feeding costs were down considerably where total substi-

tution was made for barley. Such was the interest in vetch that seed availability was a major constraint. The IPA Agricultural Research Center in Baghdad and the Mashreq/Maghreb project eased this shortage by developing an on-farm production program for forage legumes and provided the needed training for this activity.

Ewe culling percentages in Iraq were high but there was reluctance among flock owners to take such measures with rams. The owners were taught how to use simple and applicable physiological traits for lamb selection which helped increase the lambing rate by 17% compared with previous efforts. Distribution of improved rams has also been stepped up by the IPA Center which selected new outlying multiplier flocks. During the life of the M/M project a total of 990 rams were produced and distributed among sheep owners, including 200 from the multiplier flocks, the rest coming from the IPA Center's own breeding station.

Take-up of the various components of improved technology has been effective among the targeted sheep owners. Those operating semi-intensive systems had the greatest take up (62.5%) but a third of those keeping their flocks on one site adopted new technology, and 41% of those who traditionally move their flocks according to season.

Gains in cereals

Dramatic improvements in barley grain yield were matched by equally dramat-

Tasty treats

Feed blocks (left) can be made from a number of agro-industrial by-products, including date and beet pulp, wheat and rice bran, tomato pomace, whey, corn cobs, brewer's grains, bagasse, reed and poultry waste. Urea can be incorporated as a nitrogen source, and supplemental sulphur.

This feed block technology won the first scientific prize in an open research papers competition organized by the Arab Organization for Agricultural Development (AOAD).

ic take-up of the improved cultivar 'Rihane-03' which was introduced to Iraqi farmers during the project. From just 5,000 ha planted in 1994/95, the area planted with 'Rihane-03' leapt to 190,000 ha in the 1996/97 season, and was expected to reach 250,000 ha in 1999. The reason is simple — yield. Tried out in low-yielding environments, 'Rihane-03' gave an extra 41% yield over farmer varieties and up to 262% more yield on high-yielding sites.

In farmer hands the impact has been substantial too. Based on farm data from a survey of 495 growers, 'Rihane-03' increased yields over the local Aswad landrace by 67% on average in the moderate rainfall areas and 28% in low-rainfall areas. Setting the different input requirements of 'Rihane-03' aside and comparing the new variety on an equal basis with the local cultivar, there was still a yield advantage of 19%.

The impact of 'Rihane-03' is so great that agricultural policy now has to be adjusted to encourage an increase in supplies of seeds, fertilizer, machinery and labor. Demand for all of these is up by 15-20% or more.

Two further improved barley lines — 'Tadmor' and 'Arta' — are now being multiplied for release in the drier zones where they have performed better than either 'Rihane-03' or 'Aswad'.

Training and education

Nearly 1,800 Iraqi farmers and technicians attended training courses, workshops, field days and symposiums over three years. The Mashreq/Maghreb project had a major impact on enhanc-

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Halting the Olive's Downward Slip

Patience is a virtue and a necessity for encouraging uptake of new ideas. On the other hand, olive growers in northern Syria are now seizing the opportunities they see in alternative tree management systems first introduced to them following a painstakingly-prepared campaign.

How do you persuade an olive grower who has watched his father and his grandfather pruning their olive trees vigorously that, maybe, a lighter pruning will bring more rewarding yields? Or that following the contour line with the plow might stop his topsoil from slipping downhill into the field of an appreciative neighbor?

Slowly, very slowly and patiently, is the answer. And there has to be a lengthy period of confidence building. There is little point in a 'know-it-all' scientist breezing into a village in northern Syria, decrying local husbandry practices, and announcing "This is how it's done!" before zooming off in a cloud of dust to the next group of perplexed growers.

After all, respond the farmers, what can someone who arrived only yesterday know about the fields, soils and trees a family has nurtured for generations?

Sadly, that care and nurturing is often misguided. Getting the message across in an acceptable manner becomes more important than the message itself when the scientist knows that a slight shift in the pH of the soil will unlock a valuable trace element of long term benefit, yet the grower sees no immediate return.

Confidence building was a key element of the farmer-participatory research carried out by ICARDA's soil conservation and land management specialists at Yakhour in northwestern Syria. Since ancient times, the northwest has been the olive zone in the country. The olive tree itself has a venerable history, with cultivation of olives in the region traceable back 5,500 years. The ancient Greeks considered the olive to be sacred and today the olive branch is still recognized as a

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symbol of peace and plenty.

Olives and olive oil are fundamental elements in Mediterranean cooking. The oil is of high nutritional value, containing natural antioxidants which make it retain its fragrance and taste over long periods. For Syrian agriculture, in the west and northwest, olive trees are the major source of income for small-scale farmers. The area planted with olives has increased substantially in recent decades.

However, traditional land-husbandry practices have not kept pace with the intensification and expansion of olive production into steeper areas. Because no land conservation measures are being taken, and intensive clear tillage leaves the land unprotected, soil erosion is evident everywhere.

Only recently have farmers on the steeper hillsides become conscious of their increasingly unstable and declining yields. Because the degradation of the land had not been identified as a real problem, they have not devised the traditional terracing and other conservation-farming techniques found in other regions.

The mountain village of Yakhour, where Kurdish immigrants first cleared the forest for agriculture in about 1920, is a

AT A GLANCE

Olive growers in Yakhour village in northwestern Syria are adopting new management techniques after just one year's harvest evidence of increased yields.

In particular, they were impressed by the improved moisture conservation from building individual 'mini-terraces' around the base of the olive trees, and by the effectiveness of insect traps in guiding them on the need for insecticide spraying.

Longer term benefits are expected to become evident from using cover crops to prevent erosion, improving soil organic content with manure, and using less frequent contour-following tillage.

The project is being supported by Spain where olive growers are using similar expertise to improve returns from their trees.

typical example of land degradation in steep olive fields. There is a need for location-specific land conservation measures that protect the soil and, at the same time, enhance the productivity of the olive trees. A small project was set up to stabilize and improve the



Yakhour farmer Moustafa Kassem is already seeing better yields after just one season of using the package of soil control, moisture conservation, and careful tree management and harvesting. Many of his neighbours also decided they had seen enough not to wait until the end of the experiment before adopting some of the successful techniques being tried out.

productivity of the olive trees which are grown here mainly for their 25-30% oil content. Most farmers also have one or two trees producing fruit for their own consumption but their prime market is for olive oil.

Early visits to the village to discuss all aspects of olive growing and management established that the main interest of the farmers was to secure and increase their olive production. Environmental concerns, such as soil erosion, had a low priority.

The systems used for working the slopes varied according to gradient but there were common approaches too. Over the course of a confidence-building year, both deficiencies and plus points in the management systems used were teased out and examined.

The Syrian Olive Bureau played a key role in demonstrating how changes in husbandry can have a worthwhile impact on the health of trees and their yield. The Yakhour farmers visited their counterparts in the lower-lying Idleb area southwest of Aleppo to see for themselves the benefits to growers there of using fertilizers and pesticides.

This intensive interaction led to a formal meeting at the village school where the specialists summarized the information they had gathered, and outlined a modest joint research project to address all the issues and problems felt to be of importance to olive production in Yakhour. The aim was to try out and compare new ways of land management for the olive groves under real-world conditions in farmers' fields. It was important to demonstrate that soil conservation is an important part of an olive production system and that only an appropriate combination of all aspects of olive growing would lead to a more productive and sustainable use of the land.

The careful preparation paid off. Now farmers were willing to volunteer their land to try out the two differing 'system packages' designed with their

Right: Ploughing across the slope with a mule team may be slower but is much more likely to keep productive soil where the farmer wants it. Tractor-ploughing up and down the hill for safety reasons encourages soil erosion.



Left: The Syrian Olive Bureau and ICARDA are working together to bring sustainable production techniques to the villagers of Yakhour. By a combination of 'classroom' training and on-site demonstration trials of the improved techniques, every fruit tree grower can see the benefits of improved management.

help. Both packages were aimed at combining the best possible crop husbandry practices, such as pest control and proper pruning.

Olive trees – like many fruit trees found in suburban gardens – have biennial fluctuations in yield. Breeding can offset this but for 40-year-old established trees pruning is the best way to introduce more consistency in yield. Traditionally, the Yakhour farmers used a heavy, post-harvest pruning system but they saw the evidence of benefits at Idleb from waiting for a lighter spring pruning after the frosts have passed. This light pruning may give a slightly lower peak yield in years acknowledged to be high yielding, but in a poor year the grower can expect a higher than average crop.

Two village farmers, deliberately chosen because they were not the village's acknowledged top growers, each agreed to set aside an entire field for the experiments. Each field was divided into three sections, with 75 trees in each of the two system treatments and 50 in the farmer's own area. Each field was mapped intensively and individual trees identified. It was agreed that ICARDA would make up the differ-

ence if the trees in the four experimental treatment areas yielded lower than on the remainder managed by the farmers using their normal systems.

All the work was carried out by the growers, although ICARDA provided regular backstopping, as well as the initial guidance on the treatments to be followed. These were kept relatively simple. Cultivation passes were reduced or dropped altogether since there was no obvious benefit from making three passes with a mule and plow, and indeed the extra disturbance was more likely to contribute to soil erosion. Chemical fertilizer was introduced but only two treatments also received additional animal manure.

This organic manure will help increase soil organic matter content and lower the pH slightly. In the alkaline conditions (8+) prevailing on these slopes, phosphorus is locked up but will become more readily available to boost yield if the pH can be lowered in the long-term by as little as half-a-point.

Various forms of soil erosion prevention were assessed, including vetch cover crops, small catchment barriers and non-tillage. Insect traps, with instructions to spray as necessary, were used on all the experimental treatments, but herbicide was allocated to

just two. Light pruning was used, and nets placed under the trees at harvest to catch the fruit.

Final assessment of the first harvests is still being carried out but the growers saw enough to convince them that yields are up and those compensation payments for low yields won't be paid out. Of their own accord, they and their neighbors are already incorporating some of the innovations into other fields to boost olive harvest.

The experimental treatments are being continued with new growers to test them under as wide a range of conditions as possible. Measurement of the soil translocation is planned. Traditionally, farmers using mules have plow along the contour. However, since the advent of tractors plow downhill for safety reasons has become the norm on the steeper slopes where a top heavy tractor is less surefooted than the low-tech mule. This has added to the degradation bringing soil depth down from a meter or so to 25cm in places. However, with mules it is relatively

simple to work across the contours creating individual tree terracing and incorporating enclosed areas for water conservation.

The project has been supported by funds from the Spanish National Agricultural Research Institute (INIA). There are many lessons that can be drawn from Spanish experience, and the Forest Experiment Station in Granada has been particularly forthcoming with advice.

Just as in Syria, the Spanish have difficulties persuading olive growers to maintain a cover crop between the trees. Farmers all over the world prefer to see 'clean' fields—free of anything a neighbor will disparage as a weed. But in Spain medicinal and aromatic plants—with a high income potential—have been planted along the contour lines to arrest erosion. The returns are high enough to offset any concerns about the cover competing with the trees for moisture. A herbicide applied after flowering can be used in rainfed systems and still leave the dead plant

tissue to protect against run-off and raindrop impact.

Another possible way to maintain a seed reservoir for the cover crop is to kill off only alternate strips of the cover vegetation. Some growers also use a herbicide pre-harvest to create an even mat on which to place nets for catching the fruit.

One suspects that if the Yakhour growers could only make the trip to Spain there would be some very serious questioning of their Spanish counterparts and more than a few new ideas flowing back to the slopes of north-western Syria. ■

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Technology Transfer in Iraq

Forward *Continued from page 19*

Iraqi mixed farming summary

A survey of 250 barley growers in Iraq showed most to be continuously cropping (63%) their overworked ground while only 5% fallowed even part of their land, and 8% used a barley-wheat rotation.

Most of these farmers (78%) are classed as small farmers with less than 125 ha at their disposal, 8% have holdings from 126-250 ha, and the remaining 14% farm more than 250 ha each. About three-quarters of farmers operate mixed systems with barley and sheep while just 25% rely on one enterprise alone. Average flock size is 136 head of sheep.

The farm provided 75-100% of total household income for the vast majority, with just 5.2% of the farmers indicating they were receiving more than half of their total household income from other sources off the farm. The balance of farm income was fairly evenly split between sheep (47%) and crop production (49%).

ing the country's own agricultural extension system by integrating researchers and extension workers at the farm level, and by demonstrating how new technologies can be transferred effectively.

The Iraqi experience with feed-blocks and ram selection was also passed on through training courses or consultancy visits to Jordan, Lebanon, Morocco and Tunisia.

Agricultural policy studies

The effectiveness of support price policies in stimulating crop production was examined. The overall effect of existing support price policy is to make rice and corn producers better off while barley producers are worse. The introduction of 'Rihane-03' has helped correct the distortion for now. Lifting the price of barley by, say 10%, will encourage greater use of inputs more than by reducing the price of those inputs by 10%.

Different commodities are affected by alternative policy regimes. It is estimated that reducing the subsidy on livestock feed would increase meat imports by about 25% while decreasing those of wheat by about 36%.

Removing feed subsidy at the same time as a cut in output price support will result in an average decrease of about 10% in the production of wheat, barley, meat and milk in the low-rain-fall areas.

The future

The MM project has started a second phase, which will last four years and which should consolidate and build on the achievements of the first phase. The main focus will be on working with communities rather than dispersed individual farmers. Integration at the national and the regional levels will be strengthened and the role of farmers, through a participatory approach, will be enhanced. After all they are the ultimate end-users and beneficiaries of the project. ■

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A harvest of plenty for this young farmer and more secure harvest for many growers in the dry areas of Central and West Asia and North Africa, thanks to innovative approaches such as integrated pest management. The combination of techniques and technologies allows the farmer to overcome pests and diseases rationally without threatening the sustainability of his land and the environment.

