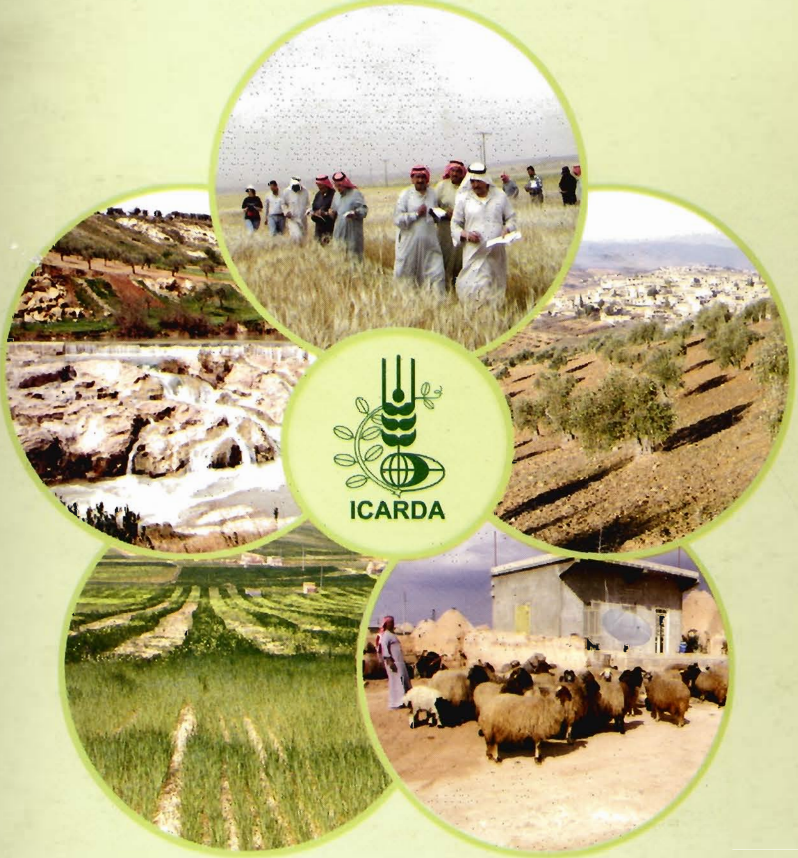
Natural Resource Management Program

Annual Report for 2003



International Center for Agricultural Research in the Dry Areas

About ICARDA and the CGIAR

ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is one of 15 centers supported by the CGIAR. ICARDA's mission is to improve the welfare of poor people through research and training in dry areas of the developing world, by increasing the production, productivity and nutritional quality of food, while preserving and enhancing the natural resource base.

ICARDA serves the entire developing world for the improvement of lentil, barleyand 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 (CWANA) region for the improvement of bread and durum wheats, chickpea, pasture and forage legumes, 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, regional and international agricultural research and development systems.

CGIAR

The Consultative Group on International Agricultural Research (CGIAR) is a strategic alliance of countries, international and regional organizations, and private foundations supporting 15 international agricultural Centers that work with national agricultural research systems and civil society organizations including the private sector. The alliance mobilizes agricultural science to reduce poverty, foster human well being, promote agricultural growth and protect the environment. The CGIAR generates global public goods that are available to all.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD) are cosponsors of the CGIAR. The World Bank provides the CGIAR with a System Office in Washington, DC. A Science Council, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

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The primary objective of this report is to communicate the research results speedily to fellow scientists, particularly those within the Central and West Asia and North Africa (CWANA) region, with whom ICARDA has close collaboration. Written and compiled by the Natural Resource Management Program scientists, the report was, therefore, not subject to rigorous editing. A CD-ROM version of this report is also available and can be requested, free of charge, from the Director, Natural Resources Management Program, ICARDA.

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Foreword

The NRMP annual report continues to evolve as the main reporting vehicle for the program's work. During 2003, implementation of the Integrated Natural Resources Management (INRM) approach was pursued with great vigor mainly at the Integrated Research Site in the Khanasser Valley southeast of Aleppo in Syria. Program staff began to disseminate the approach through the NARS regional coordination meetings and other opportunities such as the joint United Nations University/UNESCO/ICARDA project on the Sustainable Management of Marginal Drylands (SUMAMAD) and at the meeting of the International Dryland Development Commission held in Tehran, Iran.

The program contributed a chapter on the Mashreq/Maghreb integrated crop-livestock project in the Interim Science Council's publication on 'Research Towards Integrated Natural Resources Management: Examples of Research Problems, Approaches and Partnerships in Action in the CGIAR.' This milestone publication outlines the different types of approaches to INRM that are being pursued by the CGIAR centers and their partners to develop international public goods that improve both the productivity and sustainability of production systems through the use and management of natural resources. The ecosystem framework developed by the program in the Mashreq/Maghreb program represents efforts from the entire ICARDA community. It was highlighted by the editors as a prime example 'for selecting and moving technologies across environmental and socio-political gradients.' Thus, the work of ICARDA on NRM has now become internationally recognized.

The trend to develop cross-disciplinary approaches and projects continues with the water interest group gaining success in developing and submitting integrated project proposals on aspects of water management. These new projects involve most NRMP staff and are an example of the transformation of the program into project teams with clear objectives that are the 'glue' that binds together scientists from different disciplines.

Two senior international staff joined the program in 2003. Dr Asamoah Larbi is the new Pasture and Forage Production Specialist, joining ICARDA from ILRI where he worked for 12 years as a research scientist based in Nigeria. Dr Manzoor Qadir is a joint ICARDA/IWMI Marginal Water Management Specialist. He was previously a post-doctoral fellow at the University of Justus Liebig, Giessen, Germany. Their expertise will add greatly to the program.

Richard J. Thomas
Program Director
NRMP
December 2003

ICARDA's Research Portfolio

ICARDA's research is organized within five themes: (1) Germplasm Enhancement, (2) Production Systems Management, (3) Natural Resource Management, (4) Socioeconomics and Policy, and (5) Institutional Strengthening. Implementation is done in close collaboration with NARS in the dry areas within the framework of the seven regional programs of ICARDA (West Asia, North Africa, Nile Valley and Red Sea, Highlands, Arabian Peninsula, Latin America, and Central Asia and Caucasus regional programs). Within the framework of these themes, the Center's research agenda is built around 19 interdisciplinary projects. Of these, 10 projects (2.2, 2.3, 2.4, 2.5, 3.1, 3.2, 3.4, 4.1, 4.2 and 4.3) are based in the Natural Resource Management Program and covered in this report.

Theme 1. Crop Germplasm Enhancement

This theme includes six projects, each developed around a particular crop or group of crops. The overall goal of the projects is to steadily increase yield and stability through genetic improvement and water-use efficiency, with special emphasis on less favored environments and low external-input systems. The strategy is to produce cultivars with stable year-to-year yield adapted to the environments in which they will be grown. The projects are multidisciplinary, with research targeted to specific dry-area farming systems. As such, they integrate genetic improvement with production systems, resource management, and socioeconomic and policy considerations. ICARDA is an active partner in the CGIAR Challenge Program on "Biofortified Crops for Improved Nutrition."
The following projects are in operation under this theme:

Project 1.1. Barley Germplasm Improvement for Increased Productivity and Yield Stability

Project 1.2. Durum Wheat Germplasm Improvement for Increased Productivity, Yield Stability, and Grain Quality in West Asia and North Africa

Project 1.3. Spring Bread Wheat Germplasm Improvement for Increased Productivity, Yield Stability, and Grain Quality in West Asia and North Africa

Project 1.4. Winter and Facultative Bread Wheat Germplasm Improvement for Increased Yield and Yield Stability in Highlands and Cold Winter Areas of Central and West Asia and North Africa

Project 1.5. Food Legume (Lentil, Kabuli Chickpea, and Faba Bean) Germplasm Improvement for Increased Systems Productivity

Project 1.6. Forage Legume Germplasm Improvement for Increased Feed Production and Systems Productivity in Dry Areas

Theme 2. Production Systems Management

Production systems management draws together all the components of research into a farming systems perspective. This approach enables site-specific results to be blended into recommendations that can be applied to broader target areas. Long-term experiments on the productivity of farming systems, particularly those integrating crops and livestock, and the management of soil and water resources, are geared to optimize cropping sequences and the development of appropriate ways to intensify production in the dry areas. Optimizing soil water use is a particularly important area in which ICARDA is a co-convener with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), of the Optimizing Soil Water Use (OSWU) Program, within a "CGIAR Systemwide Soil Water and Nutrient Management (SWNM) Consortium."

Management of crop pests and diseases is increasingly handled in an integrated fashion in order to reduce the environmental and economic impact of chemical interventions. ICARDA views pest and disease management as a dimension of the entire farming system rather than as one component of the production practices for a single crop. ICARDA participates in three sub-programs of the "CGIAR Systemwide Integrated Pest Management Program."
The following projects are in operation under this theme:
Project 2.1. Integrated Pest Management in Cereal- and Legume-based Cropping Systems in Dry Areas
Project 2.2. Agronomic Management of Cropping Systems for Sustainable Production in Dry Areas
Project 2.3. Improvement of Sown Pasture and Forage Production for Livestock Feed in Dry Areas
Project 2.4. Rehabilitation and Improved Management of Native Pastures and Rangelands in Dry Areas
Project 2.5. Improvement of Small-Ruminant Production in Dry Areas

Theme 3. Natural Resource Management

ICARDA's research on natural resource management aims to promote efficient, integrated, and sustainable use of resources for improved productivity and alleviation of poverty. The Center's research plan responds to the vision expressed at the Lucerne meeting in Switzerland 9-10 February 1995 and to recommendations in TAC's 1995 report, "Priorities and Strategies for Soil and Water Aspects of Natural Resource Management Research in the CGIAR," and the Maurice Strong report on "Systemwide Review, 1999." ICARDA is an active partner in the

CGIAR Challenge Program on "Water and Food." While water and its availability are the key issues in the dry areas and are accorded the highest priority, soil, agricultural biodiversity, and land use are all closely linked. ICARDA maintains a strong Genetic Resources Unit and participates in the "System-wide Genetic Resource Program."

ICARDA is responding to the urgent need for higher productivity using less water by substantially increasing its research investment on improved and sustainable water-use efficiency at the farm level. The Center leads the work in this field and contributes to the "CGIAR Systemwide Program on Water Management," coordinated by the International Water Management Institute (IWMI). In this program, on-farm water management is integrated in an overall water-basin perspective. The following projects are in operation under this theme:

Project 3.1. Water Resource Conservation and Management for Agricultural Production in Dry Areas

Project 3.2. Land Management and Soil Conservation to Sustain Rural Livelihoods of Dry Areas

Project 3.3. Agrobiodiversity Collection and Conservation for Sustainable Production

Project 3.4. Agroecological Characterization for Agricultural Research, Crop Management, and Development Planning

Theme 4. Socioeconomics and Policy

Socioeconomic and policy research provides gender, market, cultural and end-user perspectives that can help in promoting the adoption of new technologies and enhance the impact and benefits of ICARDA's research. Particular emphasis is placed on participatory research methods for problem identification, technology evaluation and selection that complement the formal analytical methods already in use. The strategy is to build upon the knowledge, perspectives, and innovative capacities of farmers and local communities in finding solutions to production and resource-management problems.

As part of its new strategy, ICARDA is devoting increased attention to natural resource management, especially water, formal methods of resource and environmental economics, and farmers' participatory research to understand how resource degradation, productivity, and conservation are related. Operational guidelines on resource use for farmers, pastoralists, extensionists and policy makers are being identified. Development of local institutions will be investigated and institutional innovations that mitigate natural resource degradation and enhance collective action will be promoted.

The following projects are in operation under this theme:
Project 4.1. Socioeconomics of Natural Resource Management in Dry Areas
Project 4.2. Socioeconomics of Agricultural Production Systems in Dry Areas
Project 4.3. Policy and Public Management Research in West Asia and North Africa

Theme 5. Institutional Strengthening

ICARDA has a strong program of technical assistance to National Agricultural Research Systems' (NARS) seed-production efforts. While supporting this essential activity, the Center emphasizes the needs of the informal seed sector to stimulate improvements that are not adequately met by existing services. These include partnerships with government agencies, farming communities and NGOs, and opening up the possibility of new initiatives by the private sector.
The following project is in operation under this theme:
Project 5.1. Strengthening National Seed Systems in Central and West Asia and North Africa

Training

Training is an integral part of ICARDA's research projects. The Center's research partnerships with NARS are strengthened implicitly by colleague-to-colleague training. Increasingly, the Center is out-sourcing its training activities to make the best use of the expertise that is becoming more readily available in NARS. Training focuses on improved quality and effectiveness, and on achieving multiplier effects through training the NARS trainers. ICARDA encourages greater participation of women scientists from NARS in its training programs.

PROJECT 2.2: AGRONOMIC MANAGEMENT OF CROPPING SYSTEMS FOR SUSTAINABLE PRODUCTION IN DRY AREAS

Project rationale

The production potential of cropping systems within a given environment depends on plant genetics and soil and crop management. Good management practices like use of adequate fertilizers, weeding and suitable crop rotations can considerably increase water-use efficiency and yield. However, increasing demand for food and feed forces farmers to use non-sustainable monocropping of cereals with improper cultural practices, which result in decreasing crop yield and poor water-use efficiency, declining soil fertility, and increased pest pressure.

If production is to be sustained in the long term, attention must be paid to appropriate soil management. While there have been some achievements in this area of research over the last decade, the research has been mainly conducted on research stations under controlled environments. Therefore, research findings need to be tested in other similar areas through predictive models and farmer participatory approaches in order to understand the sustainability of the proposed cropping systems and improved technology packages. This is the purpose of this project.

The project is expected to lead to improved soil and crop management with efficient use of crop rotations that will increase productivity and productive capacity of soils in the long term and ultimately result in improved livelihoods of rural communities.

Emphasis is given to research problems in less favorable environments including: evaluation of alternative crops for increasing diversification and characterization of cropping systems in time and space through generalization of site-specific, long-term trials to wider areas using crop models in combination with GIS technology; nutrient dynamics in order to improve nutrient-use efficiency; and the participation of farmers in adaptive research on problem-oriented technologies.

Overall project objective

Increased agricultural production through improved soil, water and crop management options with sustainable crop rotations that maintain the natural resource base.

Specific objectives

- Develop and validate sustainable and resource-efficient crop rotations that optimize production and maintain the productive potential of the soil.

- Assess the potential of new crops and their role in cropping systems.
- Develop and test efficient water capture and utilization techniques in dry land cropping systems.
- Identify management strategies for the enhancement of soil chemical fertility in different production systems, based on the elucidation of soil-nutrient dynamics.
- Train research extension and management personnel in analytical techniques, in soil and cropping system management, and in the development and transfer of productive and sustainable technologies to resource users.

Outputs

Output 1: Management principles for crop type, crop rotation, input use and husbandry practices, with respect to rotational output, resource-use efficiency and long-term soil and crop productivity

Rationale

Yield stability and sustainability are recognized as issues of fundamental importance, particularly in fragile environments of Central and West Asia and North Africa (CWANA). We need to know what effects repeated sequences of cropping, fertilization and management have on the pattern of productivity over time in order to a) develop an understanding of physical, chemical, biological and environmental principles which underlie and control the productivity and sustainability of cropping systems with respect to soil characteristics and water and nutrient dynamics, and b) develop strategies for efficient management of soil, water and nutrients in cropping systems.

Activity 1.3: Monitoring of farmers' management practices in their crop rotations for effects on productivity, soil physical and chemical fertility, and pest and disease incidence (Egypt)

Objectives

The main objective under this activity is to monitor socioeconomic conditions, production systems and local resource management and compare the data with long-term trials conducted at research stations with different agroecologies to synthesize the recommendations.

Research progress

A total of 82 farmers were surveyed and their fields were monitored in the 2002/03 season for the following:

Sources of water

There are many sources of water for irrigation, varying from one location to another for the sampled farmers as follows:

- The Nile and underground water in El Bustan (reclaimed sandy soils);
- The Nile is the main source of irrigation in Sugar Beet (reclaimed Calcareous Soils);
- The Nile (fresh and drainage water) and underground water in Sids;
- Fresh and drainage water from the Nile in El-Serw; and
- Underground water and rainfall in North Sinai.

Water management

The irrigation systems used by farmers during the study period can be grouped in three categories:

- 53% of farms used flood, 32% of farms used sprinkler, 15% of farms used sprinkler + drip +ground water in El-Bustan;
- 75% of farms irrigated by gravity and the rest used pumps in Sugar Beet;
- In North Sinai, the farmers constructed wells, water catchments (harraba) and tanks. There was an increase in the number of harraba and tanks in the study period.

Cropping patterns

In winter, wheat, pea, potato and clover are the major crops in El-Bustan; wheat, berseem and faba bean in Sugar Beet; wheat and berseem in Sids and El-Serw; wheat and barley in North Sinai-with some introduction of lentil and pea mostly in rainy seasons.

Fertility management methods

The methods farmers used to maintain soil fertility in the study area were as follows:

- Deep plowing (53%), manuring (37%), soil amendments (42%), cultivating legume crops (58%) and use of more fertilizer (10%) in El-Bustan;
- Fertilizer use, sub-soiling, sulphur application, crop residues, leveling and crop rotations in Sugar Beet;
- Sub-soiling, gypsum, manuring, leaching, fertilizer application and repeated plowing as compared to sub-soiling and manuring only in 2001/02 winter season in Sids;
- Sub-soiling and manuring in El-Serw; and
- Rainfall (90%) and manure and fertilizer applications (10%) in North Sinai.

Use of manure

There was a general tendency to apply more manure in El-Bustan and more manure at the expense of chemical fertilizers in Sugar Beet. Sixty-seven per cent of the farmers added manure in Sids, while the farmers in El-Serw did not use manure during the period of the study, except in the last season (winter 2001/2002) when most farmers added manure for wheat and potato. There was, in general, no increase in manure use during the period of the study in North Sinai.

Type of manure used

About 31% of farmers used cattle manure mixed with soil, 47% used chicken manure and 10% used both types in El-Bustan; about 56% of farmers used cattle manure and 11% used chicken manure in Sugar Beet; most of the farmers used cattle manure and few used chicken manure in El-Serw; and all the famers used cattle manure in North Sinai.

Results

Evolution of soil characteristics

Seventy-nine per cent of the farmers reported positive changes in soil, i.e., no salinity in their farms in El Bustan; 85% reported changes in soil texture, 80% reported changes in color and 63% reported changes in both color and soil texture in Sugar Beet; 80% reported that there were no changes in soil fertility in Sids; all the farmers reported that there were positive changes in their soils in El-Serw; and most of the farmers reported that there were positive changes in their soils in rainy seasons in North Sinai.

Evolution of crop yields

Yields of wheat, pea and clover were increased in all villages, while for potato there was no increase in yield in El Bustan; wheat yields were increased in all villages (except in Dawood with no change) and faba bean yield was increased in all villages (except in Yahia with a decrease) in Sugar Beet; the yield of wheat ranged between 6.6 and 7.1 t/ha and that of berseem ranged between 14.3 and 16.6 t/ha in Sids; the yield of wheat ranged between 5.5 and 7.8 t/ha and that of berseem ranged between 35 and 40 t/ha dry matter in El-Serw; and the yield of barley ranged between 0.12 and 0.71 t/ha and that of wheat ranged between 0.11 and 0.71 t/ha in North Sinai.

Conclusion

- Farmers have improved water management using sprinklers and drip systems for saving water.
- There has been an introduction of lentils and peas in rainfed areas.

- Most of the farmers in all regions, except in Sids, reported positive changes in soil characteristics.
- Manure application, fertilizer use, sub-soiling, sulphur application, crop residues, leveling and crop rotations were the methods mostly used for soil fertility improvement, whereas only sub-soiling and manuring were used in the previous years.
- Manure use increased at the expense of chemical fertilizer use, which is environmentally friendly management.
- Wheat yields in general increased during the period of the study across different sites.

Activity 1.4: ***Long-term trials on water quantity and quality, manure, fertilizer rates and rotations (Egypt)***

Objectives

- Identify, over an extended period of time, sustainable and unsustainable production practices and the social and economic driving factors.
- Develop suitable and economically viable farming systems in the three major production zones, namely, the old irrigated lands, newly reclaimed desert lands, and rainfed areas.
- Formulate agronomic recommendations to extension staff and farmers that increase crop productivity and conserve soil and water resources.

The long-term trials are now in the 7th year and in the 3rd crop cycle. Although the results require an extended period to be verified, some of the available data so far indicates that there is cause for concern over the way farmers are managing their water and land resources. The outputs of 2002/03 can be summarized for each site with respect to crop rotations, fertility management, quantity and quality of applied water as follows:

Nubaria

Winter crop yields were significantly higher under the prevailing rotation (berseem + maize / faba bean + tomato / wheat + sunflower) compared to the proposed rotation (berseem + tomato + nilly maize / faba bean + maize / wheat + cowpea + sunflower) (3.15 vs. 2.85 t/ha for faba bean grain, 4.1 vs. 3.90 t/ha for wheat grain and 14.3 vs. 6.10 t/ha for berseem dry matter) because of less crop intensity in the prevailing rotation. But overall systems productivity is higher under the proposed rotation, which is a more intensive system with higher land use ratio.

Manure application increased all the winter crop yields in both rotation systems with mean yields of 3.15 vs. 2.80 t/ha in faba bean, 4.15 vs. 3.9 t/ha in wheat and

10.7 vs. 9.9 t/ha in berseem. There was no significant difference in winter crop yields with respect to different amount of water applications, thus recommended low level of water application is saving about 30% water to be used in other areas. Fertilizer application increased the winter crop yields significantly over the control by applying medium levels of fertilizer on faba bean (3.45 vs. 2.15 t/ha) and berseem (11.55 vs. 8.55 t/ha) and by the highest level of fertilizer on wheat (5.15 vs. 2.85 t/ha). However, medium levels of fertilizer application in wheat provided 4.75 t/ha grain yield, which is close to that of highest fertilizer application. Thus, fertilizer-use efficiency is improved by legumes grown in the rotation-and even in the wheat crop after two legume crops e.g. faba bean and berseem.

El-Bustan

Yields of winter crops were similar in the prevailing rotation (wheat + groundnut / wheat + groundnut / berseem + groundnut) and in the proposed one (berseem + groundnut / wheat + groundnut / pea + sunflower + maize) (1.84 vs. 1.81 t/ha for wheat grain; 13.96 vs. 13.74 t/ha berseem dry matter). Manure application significantly increased all the winter crop yields in both rotation systems with mean yields of 2.20 vs. 1.45 t/ha in wheat grain, and 15.10 vs. 12.65 t/ha in berseem dry matter. There was no significant difference in winter crop yields (1.82 vs. 1.83 t/ha for wheat and 12.85 vs. 12.45 t/ha for berseem) with respect to different amounts of water applications, just like in Nubaria. Fertilizer application increased winter crop yields significantly over the control, with high levels of fertilizer in wheat (2.17 vs. 1.45 t/ha) and berseem (14.68 vs. 11.24 t/ha). In the sandy soils of El-Bustan (unlike with the calcareous soils of Nubaria) it is more difficult to improve soil fertility; therefore, using legume crops in the rotation did not lead to reductions in fertilizer use.

Peas were grown only in rotation two. There was significant pod yield increase with manure application over the control (3.03 vs. 2.50 t/ha), and similar yields under both water quantities (2.82 t/ha by recommended level vs. 2.70 t/ha by farmers level, which is 30% more water). There was also significant pod yield increase with high level of fertilizer application over the low level application (3.24 vs. 2.54 t/ha).

El-Serw

Mean yields of winter crops were: 3.37 t/ha for wheat grain in the rotation (wheat + rice / faba bean + maize / berseem + rice); 19.11 t/ha for berseem dry matter in the proposed rotation 1, which is very wet (berseem + rice / berseem + rice / berseem + rice); and 2.04 t/ha for faba bean grain in proposed rotation 2, which is dry (faba bean + rice / sugar beet + sunflower / berseem + cotton). Fresh water application provided significantly higher yields compared with the drainage water on faba bean (2.33 vs. 1.75 t/ha), wheat (3.83 vs. 2.91 t/ha) and berseem (19.76 vs. 18.46 t/ha). Fertilizer application increased the winter crop yields significantly over the control with all levels of fertilizer. The highest yield was achieved by applying a high level of NPK on faba bean (2.40 vs. 1.67 t/ha), wheat (4.68 vs. 1.62 t/ha), and berseem (2.48 vs.15.78 t/ha). There may be a leaching effect due to excessive use of water for rice grown even once in three years.

Sids
The plan of work for the long term trial in this site was postponed due to the construction of a tile drainage system for the entire area of Beba district. The area of LTT was under cover crops of wheat in winter and maize in summer.

North Sinai (Rainfed)
The amount of precipitation at El-Barth area reached about 264 mm during the winter season of 2002/2003. This amount of rainfall allowed harvesting of tested crops in early May 2003. Significant increases in barley, wheat and peas yields were obtained by applying chemical (N+P) and organic fertilizers over the control (0.62 vs. 0.45 t/ha for both wheat and peas; 0.57 vs. 0.41 t/ha for barley), while no response of lentil to the fertilizer application was observed-about 0.32 t/ha of mean lentil grain yield. Barley showed significant increases in grain yield under barley/fallow, barley/lentil and barley/peas rotations (0.52, 0.47 and 0.53 t/ha, respectively) compared to monoculture of barley (0.4 t/ha).

Conclusions
- Application of manure increased crop productivity and water-use efficiency in the trial sites.
- Medium levels of NPK produced the highest yield in general-higher fertilizer-use efficiency.
- Application of farmer and recommended water irrigation levels showed no effects on productivity of studied crops at all locations. There was higher water-use efficiency under recommended water applications.
- At El-Serw (an area with salinity problems), fresh water application provided significantly higher yields compared with the drainage water because of salinity.

Activity 1.5: ***Testing of crop rotations and crop management practices for improved water-and input-use efficiency in CAC***

Objective

The immediate objective of the cropping systems management component of the project is the testing and dissemination of soil and crop management technologies that improve water and input (nutrient, energy, chemical etc.) use efficiency through a multidisciplinary ICARDA research team in cooperation with national research scientists in the region.

Field experiments with respect to crop diversification and tillage components were conducted in the rainfed semi-arid areas in the spring wheat-based cropping system (northern Kazakhstan), in the rainfed dry areas in the winter wheat-based cropping system (southern Kazakhstan, Kyrgyzstan and Uzbekistan) and in the irrigated cropping system (Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan).

Research progress

The recommendations on appropriate technologies for crop diversification are being developed with ample opportunities for crop diversification in rainfed areas of Central Asia. In the rainfed agriculture of southern Kazakhstan, wheat yield obtained after fallow was 3.21 t/ha. However, wheat grain yield was 3.13 t/ha after alfalfa and 3.02 t/ha after chickpea. Thus, there was higher land-use efficiency with alternative crop production (1.82 t/ha chickpea, 4.13 t/ha of alfalfa dry matter) than leaving the land bare for one year.

In Kyrgyzstan, dry pea (2.72 t/ha) and chickpea (2.26 t/ha) are alternatives to fallow, which provided only 3-9% higher wheat yield compared to the alternative crops with much higher economical efficiency. Safflower was not found to be a good preceding crop for wheat, but it could be more economical when it succeeds wheat in the production systems.

In Gallaaral sloping area of Uzbekistan, several crops were tried as alternatives to winter wheat in rainfed conditions where wheat yield was 1.97 t/ha. The yield of alternative crops was comparable to wheat: 1.06 t/ha for lentil, 0.99 t/ha for chickpea, 1.94 t/ha for fodder pea, and 1.69 t/ha for sunflower.

In 2002/2003 growing season, the crop diversification strategy was most widely adopted in Kazakhstan. The area under oilseed crops (including safflower) almost tripled in one year, exceeding 200,000 ha in southern Kazakhstan. The increase of food legumes dry pea and chickpea was also quite remarkable. This is explained

by the fact that during consecutive three years in Kazakhstan, wheat production was in surplus, causing marketing problems. On the other hand, Kazakhstan has been importing considerable amounts of edible oil. The adoption of alternative crops was observed also in Kyrgyzstan, with an increase in planted area under sugar beet, soybean, safflower and common bean. In rainfed agriculture of Uzbekistan, it was mainly the planted area of safflower that increased.
In irrigated agriculture based on wheat production (southern Kazakhstan and Kyrgyzstan), crop diversification was promoted through increase of sown area under soybean, sugar beet and maize. Kazakhstan also increased area under cotton as farmers found it a profitable crop under liberalized prices on inputs and outputs.

In irrigated agriculture based on cotton-wheat rotations (Uzbekistan, Tajikistan and Turkmenistan), crop diversification has been possible only through double cropping as the sown area under strategic crops (cotton and wheat) has been controlled by the government. The most commonly used crops for double cropping are maize, mungbean, common bean, sesame, and sunflower. The limiting factor is availability of water for irrigation as alternative crops are competing with cotton, a strategic crop supported by the government.

Conclusions

In rainfed agriculture of southern Kazakhstan the most profitable preceding crops for winter wheat in both dry and wet years were alfalfa and chickpea as compared to summer fallow, which has been the recommended practice. In rainfed agriculture of Kyrgyzstan, food legumes (dry pea and chickpea) can be recommended to replace the traditional fallow practice to provide higher land-use efficiency and total productivity for higher incomes to farmers. In the irrigated wheat based system (Kyrgyzstan), sugar beet; maize, dry pea and safflower can be good alternatives to winter wheat as they provide higher incomes. Dry pea, in addition to being a profitable crop, increased the grain yield of consecutive wheat. In cotton-wheat based irrigated cropping systems (Uzbekistan and Tajikistan) double cropping after harvest of winter wheat provides great opportunity for income raising and more sustainable agriculture. The alternative crops tried for double cropping provided higher incomes than wheat. Such crops include mungbean, common bean, soybean, rice, melon, sesame and maize. During the year, with the delayed harvest of winter wheat, it was not worth planting cotton for double cropping.

Activity 1.6: ***Soil and crop management practices tested in farmers' fields in different agroecologies of Iran***

Rationale

Iran had previously put emphasis on irrigated agriculture despite the fact that the rainfed dry areas cover about 75% of the arable land. However, the collaboration with ICARDA has created the awareness of the importance of dryland farming. Therefore, the Dryland Agricultural Research Institute (DARI) was established in 1993 in collaboration with ICARDA to generate improved soil, water and crop management practices for Iran's drylands, to test promising technologies in farmers' fields, to disseminate the appropriate technologies to larger areas with farmers' participation, and to study the socioeconomic constraints and opportunities for dryland farming.

Research progress

Weather conditions of the region were similar to the average or slightly below average in rainfall amount in 2002/2003 season (except Shirvan-Khorasan, which had rainfall above the average) with seasonal rainfall being 274.6, 287.7, 381.9, 351, 371.5, 424.8, 474, and 378.7 mm in Ardebil, Shirvan, Ghamloo, Maragheh, Zanjan, Sararoud, Ilam and Gachsaran, respectively. However, rain started late and temperatures were lower than normal in spring, thus crop growth was affected negatively and maturity delayed. Because of terminal stress at later growth stages the expected rainfed crop yields, particularly cereals, under normal weather conditions could not be achieved.

Last year, long-term crop rotations, conservation soil management, soil fertility and fertilizer use, importance of supplemental irrigation for improving the rainfed cropping system for sustainable production were reported and this year emphasis is put on the on-farm applications of recommended practices for the rainfed production system. A detailed agronomy report, prepared in collaboration with DARI, is under review.

In the 2002-2003 season the work was conducted in the following areas: East Azerbaijan: 8000 ha; West Azerbaijan: 400 ha; Kermanshah: 70,000 ha; Lorestan: 1000 ha; Kurdistan: 1700 ha; Gechsaran: 4500 ha. The results are given in Table 1 below. Yield increase ranged from none to 97% depending on the adoption of technologies by farmers. However, Kermanshah, with the largest area, has not yet provided the results so there is no clear picture on yield increase across the country.

Table 1. Effect of the recommended package on wheat yield compared to farmers' practices in Iran during 2002-2003.

Provinces and technologies	Site 1	Site 2	Site 3	Site 4	Site 5
East Azerbaijan					
Recommended package (SD=0.21)					
Recommended package	3.46	3.12	3.07	-	-
Farmers' practice (SD=0.20)	1.96	1.58	1.87		
Yield increase%	76	97	64		
West Azerbaijan					
Recommended package (SD=0.59)	2.85	1.94	1.75	-	-
Farmers' practice (SD=0.08)	1.78	1.78	1.64	-	-
Yield increase%	60	9	7	-	-
Lorestan					
Recommended package (SD=0.30)	1.76	1.85	1.30	1.44	1.70
Farmers' practice (SD=0.52)	1.42	1.57	0.61	1.25	1.35
Yield increase%	24	18	112	16	27
Kordestan					
Recommended package (SD=0.53)	1.40	0.80	1.85	2.80	1.60
Farmers' practice(SD=0.38)	1.49	0.73	1.12	1.97	1.35
Yield increase%	-6	9	65	42	18
Gechsaran					
Recommended package (SD=0.61)	2.36	1.50	-	-	-
Farmers' practice	1.73	-	-	-	-
Yield increase%	36	-	-	-	-
Kermanshah					
Recommended package (SD=)					
Farmers' practice (SD=)					
Yield increase%					

Activity 1.8: ***Assessment of alternative crops (e.g., oil seeds, herbal plants like cumin) for diversification of cropping systems in CWANA***

Rationale

The cropping system in WANA is based on cereals, mainly wheat and barley, but with small areas of oats, rye and triticale in some countries (FAO, 1995). This system is closely integrated with livestock production, mainly sheep and goats. There is increasing concern about the deterioration of crop/livestock systems because of high-pressure put on these systems by the ever-rising demand for food and feed. Continuous cereal systems are increasing parallel to the increasing demand for human and animal consumption in WANA. The importance of food and forage legumes for nutritious food and feed, their contribution to subsequent cereal productivity through biologically fixed-N and by breaking disease and pest cycles, and their effect on conserving farming resources and promoting sustainable agriculture with increased cereal yield, improved water-use efficiency and soil physical parameters, has been documented earlier by several researchers. However, there is a need to diversify the cropping systems with other alternative cash crops such as medicinal and oilseed crops for risk management and cash needs of the farmers.

Safflower testing at Tel Hadya

Thirty-two selected safflower lines (8 registered cultivars and other promising lines) were tested at Tel Hadya Research Station of ICARDA. The results are given in Table 2.

Table 2. Mean yield components of selected safflower varieties and their variability at Tel Hadya during 2002/2003.

Yield components	Mean	Range	SEM (+/-)	LSD (0.05)	CV (%)
Grain, t/ha	1.52	0.92-1.98	0.17	0.46	22
P. height, cm	84.5	63.8-97.5	3.78	10.61	8.9
Oil, %	31.5	25.8-46.1	0.70	1.95	4.4
Oil, t/ha	0.48	272-698	0.06	0.15	23

Safflower is a promising alternative crop in dry areas because it has drought tolerant characteristics, provides reasonable grain yield and an economic oil production per unit area. However, it reduces the yields of cereals if planted after it in the field because of its high water extraction even from deeper soil layers. It should, therefore, be followed by a shallow-root crop such as lentil, forage or cumin before cereals are grown in the field.

Introduction of alternative crops at Tel Hadya

In addition to safflower, we have examined Coriander, Nigella, Anis and Cumin at Tel Hadya conditions for productivity as part of crop diversification and risk management in dry areas. These crops are grown in Syria mostly under supplemental irrigation but rainfed options need to be considered. Yields of 0.49 t/ha of Coriander, 0.5 t/ha of Nigella, 0.33 t/ha of Anis and 0.3-0.5 t/ha of Cumin were obtained under Tel Hadya conditions.

Cumin production in Khanasser

Rationale

Cumin has become the major cash crop in rainfed production systems of Khanasser Valley because of its good market price. The crop is usually grown in drier areas (250-400 mm of annual precipitation) and is planted in different soils (deep, shallow, poor and fertile soils). Cumin can be introduced into 2- or 3-course rotations preceded by cereal crops, since it is considered as fallow in crop rotation with low water use through a shallow root system. Its introduction is resulting in changes in land use, increasing incomes, and is changing local labor patterns and opportunities.

Objectives

Integrated, interdisciplinary research is needed to address the main economic and agronomic issues in cumin production, namely its sustainability, profitability, and risks, especially due to fluctuating prices, diseases, and drought.

Research progress

Economic assessment of cumin production was completed in 2003. Enterprise budgets to assess its profitability were completed and are now being analyzed. The role of cumin in reducing economic risk against vulnerability and enhancing livelihoods has been assessed using various livelihoods assessment methods. Marketing is being assessed through a market study to be completed in mid-2004. Farmer participatory research on cumin has been successfully started with the establishment of a farmer interest group.

Sowing date, sowing method and seed rate, fertilizer use, weed control and diseases and pests were the major issues raised by farmers. We, therefore, studied sowing date, seed rate and fertilizer use at three villages (Herbakieh, Hweir El-Hos and Jib Jasem) under rainfed conditions. Weed control was studied at Breda and Tel Hadya research stations of ICARDA. Hweir El-Hos and Jib Jasim villages could not be harvested for yields because the field preparations by farmers did not match with the experimental plot drills –the fields were stony and rough, the plot drill could not be used. Herbakieh was the only location harvested to a reasonable degree, though the plot drill could not work due to improper field preparations by the farmers. Planting in mid-January provided significantly higher mean seed yields (330 kg/ha) compared with the mean yield (160 kg/ha) of mid-February planting. Optimum seed rate was 25 kg/ha, providing highest and significant yield (345 kg/ha) compared with the yield (245 kg/ha) of 20 kg/ha seed rate for January planting. Yields were 170 and 130 kg/ha, respectively, in February planting. Yields from seed rates above 25 kg/ha were not significantly different from each other. There was a significant effect of N-fertilizer on the cumin yield (225 kg/ha) with 30 kg N/ha compared to the yield (145 kg/ha) of plots with no fertilizer. Addition of phosphorus fertilizer did not affect seed yield. Thus, N-fertilizer is necessary to improve cumin yield at Khanasser conditions; however, the economics of it use should be considered.

Cumin production and experiments were evaluated by a farmer interest group (14 farmers) before harvesting. According to most of the farmers, earlier (January) planting was better than later (February) planting. However, they did not see any differences caused by fertilizer use or seed rate mainly because it is difficult to observe such differences in the field for such small plants. Farmers commented that cumin-cereal rotation was better than fallow-cereal rotation as they believe that cumin acts as fallow because of its low moisture use. Only two farmers used herbicides and the rest used family labor for weeding. Four farmers stated that they lacked knowledge on growing cumin and they wanted to see the success of their neighbors first. However, Fusarium wilt was seen a problem and seed treatment is required.

Conclusions

Marketing is seen as the main economic problem, particularly due to fluctuating prices. The most important managerial factors influencing cumin production are planting date, crop rotation, seed rate, weeding (particularly the cost), and fertilizer use. Lack of agronomic knowledge on growing cumin led to crop failure in many cases. Major bottlenecks to the adoption of cumin include lack of disposable income to start production, unavailability of fertilizers and machinery, insufficient knowledge on agronomic management and marketing.

Activity 1.9: ***Use of Phosphogypsum to improve soil properties and effective rainwater use under barley/fallow and continuous barley production systems in Syria***

Rationale

Phosphogypsum (PG), a residue of the phosphorus fertilizer industry, is available in large quantities in Syria. PG is a soil conditioner that can improve the physical and chemical characteristics of soils.

Objectives

The experiment was designed in consultation with different farmers of Khanasser Valley to evaluate the possible use of PG as a soil conditioner, to:

- Assess the effect of PG addition on soil properties and barley production.
- Assess the effect of PG addition to soil on fluoride content, radioactivity and nutrient contents in barley products.
- Assess the effect of PG addition on soil chemical and physical properties and its radioactivity.
- Assess site-specific effects of PG on barley response.
- Determine the cost/benefit of using PG as a soil conditioner.
- Compare PG with P-fertilizer application on barley production.

Research progress

Eight experiments were conducted at different locations in the Khanasser Valley, and 2 PG rates (20 and 40 t/ha) and one phosphate fertilizer rate (50 kg P_2O_5/ha) were applied at each site. The results of the second year show that PG application had positive effects on the total biomass and grain yield of barley compared to the control. This was similar to the first year results, though to a lesser extent (see Table 3):

- Both rates of PG application increased the crop plant height by 33% under barley after fallow and 16-28% under continuous barley, compared with the control plots. The 40 t/ha PG also increased the crop chlorophyll content by 26%, and the number of tillers increased by 56% compared to the control.
- Under continuous barley, comparison between the effects of 40 t/ha PG and the P-fertilizer applications show that PG resulted in only slightly better crop response:3% higher for biomass and 6% higher for barley grain yield.
- Under barley-fallow system, PG applications increased both the barley biomass and grain yield by 46-48%, compared to the control plots. There was no P-fertilizer application under barley-fallow systems.

Table 3. Effect of phosphogypsum (PG) application on barley yields (mean of 8 locations) in Khanasser during 2002/2003.

Treatments	Barley total biomass (kg/ha)	Barley grain yield (kg/ha)	Grain yield increase over the control (%)
Barley/fallow	Average (SD)	Average (SD)	Average
Control	4, 740 (2, 095)	2, 245 (820)	0
P_2O_5 (50 kg/ha)	-	-	-
PG (20 t/ha)	6, 900 (2, 300)	3, 285 (980)	+ 46
PG (40 t/ha)	6, 970 (2, 640)	3, 315 (1095)	+ 48
Barley/barley			
Control	3, 400 (2, 110)	1, 630 (975)	0
P_2O_5 (50 kg/ha)	4, 955 (1, 675)	2, 245 (580)	+ 37
PG (20 t/ha)	4, 620 (2, 125)	2, 170 (895)	+ 33
PG (40 t/ha)	5, 075 (2, 790)	2, 325 (1010)	+ 43

Application of PG had a negligible effect on radioactivity of the soil, whereas the radioactivity of the plant was below detection limit (= 2 Bq/kg DM). The fluoride concentration in the top 15 cm soil increased from 112 µg/g with no PG to 164 and 208 µg/g in soils receiving 20 and 40 t/ha PG, respectively. However, the concentration of fluoride in normal soils ranged between 150-400 µg/g. The concentration of fluoride in plants also increased in hay and grain from 9.9 and 7.9 µg/g DM with no PG to 15.2 and 13.4 µg/g DM in plants receiving 40 t/ha PG, respectively, which is below the permissible concentration of 30 µg/g DM.

A participatory technology evaluation was organized to evaluate farmers' perceptions on the impact of PG on barley growth, and to identify technological, economic, and other problems related to PG application. All the participating farmers evaluated PG as very effective for increasing barley yield, especially under a barley/fallow system. All the farmers were willing to apply PG if the transport costs do not exceed 100 SL/ton. They also suggested that PG should be tried on wheat, cumin and vetch.

Conclusions

The results of the first two years show that PG is a promising option for the dry, marginal conditions of Khanasser Valley. However, the experiment will be repeated for another year, to see whether the effects of PG on barley yield are lasting. The carry-over effects and radioactive residues still need to be verified before widespread dissemination of this technology is recommended.

Output 2: Conservation tillage systems for nutrient-, water- and energy-use efficiency and C sequestration

Rationale

Drought is a major limiting factor to crop production in WANA. Cropping is possible in less than 10% of this vast area, with most of the region being arid to hyper-arid. Agriculture is primarily based on rainfed cropping during the relatively cooler late fall to early spring. The rainfall range for rainfed cropping is generally between about 200 to 600 mm annually. While irrigation is practiced in arid areas and is increasing within normally rainfed areas, concerns about sustainability arise due to limited surface sources and declining water tables. Dryland crops are mainly wheat, food legumes (such as lentil, chickpea, faba-beans), and forage legumes (such as vetch, medics, and *lathyrus*). The raising of livestock, mainly sheep and goats is integrated in the farming system.

Crop rotation has been a strategy against the vagaries of climate. The use of non-cropped fallow ensures acceptable yields in most years, while legumes alternated with cereals help to reduce disease buildup and provide up to 85% of the cereal yield obtained after fallow, which actually leaves the land unused for more than 14 months. Since most of the region's soils are inherently low in nutrients, especially phosphorus, fertilizer use is now common. With increasing land-use pressure, fallow has disappeared in all but the drier areas (<250 mm/year).

In order to assess the sustainability of the various farming system changes, ICARDA initiated a series of long-term trials in the mid-1980s. An intrinsic concern in such trials is the assessment of conservation tillage in relation to conventional systems, not only because of yields and energy savings but also because of moisture conservation. Along with conservation tillage (shallow tillage by ducks-foot cultivator) is the issue of cereal residue management within a cereal/legume rotation.

Activity 2.1: Conservation tillage and no-till practices tested in Central Asia

Objectives

The immediate objective of the conservation tillage component of the project is the testing and dissemination of soil management technologies that improve water and input (nutrient, energy, chemical etc.) use efficiency through a multidisciplinary ICARDA research team in cooperation with national research scientists.

Field experiments on tillage components were conducted in the rainfed semi-arid areas in spring wheat-based cropping system (northern Kazakhstan), in the rainfed dry areas in winter wheat-based cropping system (southern Kazakhstan, Kyrgyzstan and Uzbekistan) and in the irrigated cropping system (Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan).

Research progress

In southeastern Kazakhstan, under favorable weather conditions, the grain yield of both spring barley (1.22 t/ha) and proso-millet (1.00 t/ha) was the best after mold-board plowing in the fall. The conservation tillage treatments reduced grain yield of barley by 7% and yield of millet by 16-18%. Zero tillage caused more dramatic reduction of crop yield against plowing-23% in barley and 33% in millet. Major reasons for yield reduction were more compacted soil, less moisture accumulation, and higher weed infestation.

In southern Kazakhstan, winter wheat grain yields were also better under plowing—2.06 t/ha without fertilizers and 3.21 t/ha with application of 30 kg NP/ha. The grain yields after conservation tillage were 12-14% lower, and after zero tillage they were 10% lower. On average during three years (2001-2003) the winter wheat grain yield reduction on both conservation tillage and zero tillage was between 6 and 9%. However, these reductions were covered by energy saving through lower consumption of diesel and less labor time needed per unit area cultivation by zero-primary tillage as shown in Table 4.

Table 4. Economic efficiency of tillage methods for different crops in southern Kazakhstan in 2003 (Tenge per 1 ha-1US$=148 kzt).

Tillage	Wheat	Barley	Safflower
Deep plowing (conventional tillage)	20,460	18,160	20,300
Shallow cultivation (conservation tillage)	17,500	17,500	21,300
Zero tillage (no primary tillage)	23,000	21,800	25,900

In other rainfed trials in Kazakhstan, Kyrgyzstan and Uzbekistan, similar results were obtained. The most striking result was obtained in Uzbekistan when planting was done with the cultivator-drill imported from Kazakhstan, which is capable of planting directly into standing stubble. The yield under this treatment was the same as in the best treatment of plowing after harvest of wheat (1.69 t/ha, which is 36% higher than that the other tillage equipments used at harvest).

In irrigated agriculture, two soil tillage methods tested in the cotton-wheat rotation gave the same results in Tajikistan (Yavan). In the control (plowing), the wheat grain yield was 4.8 t/ha, while broadcasting wheat into growing cotton provided 4.6 t/ha. In this case, cost of tillage saved was $56 per ha. Similar results were obtained with the same treatments in Uzbekistan (5.66 t/ha vs. 5.55 t/ha, respectively). The deep chiseling of high gypsum containing soil in Dangara of Tajikistan provided higher grain yield (by 12%) than that after deep plowing, yet the cost of tillage by chisel is lower (14 l/ha less fuel) than that of plowing. In Turkmenistan, the tillage equipments did not provide any differences in winter wheat yields but chisel, as in Tajikistan, saved substantial amounts of energy.

Conclusion

It can be anticipated that there will be more rapid adoption of conservation tillage in the rainfed agriculture areas of south Kazakhstan and Kyrgyzstan where the economic transition has been accompanied with more profound reforms including lack of control of sown area and liberalized trade with inputs and outputs. In irrigated agriculture, the fact that sowing wheat by broadcasting into standing cotton stubble under shallow cultivation gives the same yields as deep plowing is an important output for the farmers and the economies of the countries in terms of saving energy and reducing labor needs.

Activity 2.4: Assessment of compost use with tillage and residue management practices on productivity and carbon sequestration in wheat, barley and vetch rotations

Objectives

As some legume rotations can increase organic carbon under Mediterranean rainfed conditions, and given the current importance of C sequestration in relation to global warming, this relatively recent multi-year trial sought to examine the influence of rotation/tillage/residues from crops or compost on soil organic matter and associated N and C fractions.

Research progress

The long-term trial was conducted between 1996 and 2003 (planned up to 2008 and beyond) with the following treatments:

Tillage:

- Deep, moldboard plow (25-30 cm) and shallow (10-15 cm) after cereals (conventional tillage)
- Shallow, "ducks foot" cultivator, 10-15 cm every year after legumes (conservation tillage)

Rotations:

- Two-course: barley, vetch + oats
- Four-course: barley, vetch + oats, wheat, vetch + oats

Straw management/compost application:

1. Burned, all cereal straw + stubble (SBurn)
2. Stubble (10-15 cm height) incorporated (SInc)
3. Stubble + chopped straw incorporated (SCInc)
4. Same as No. 3 + 10 t DM compost per ha every 2 years (SCInc+C2Yr)
5. Same as No. 4, but compost every 4 years (SCInc+C4Yr)

The soil is very fine 55% clay montmorillonitic, thermic, Chronic Calcixerert (pH, 8.2) with high CaCO3 (23-35% at 1.5 m) and cation exchange capacity of 52 cmol/kg.

Seasonal rainfall ranged from 260 mm (1999/2000) to 492 mm (2002/2003). Organic matter (OM), total nitrogen, labile biomass carbon and nitrogen were measured in the soil to see the effects of the above mentioned management factors on soil quality parameters.

The following results were observed:

- Despite seven years of the rotation x tillage x straw management trial, there were no obvious differences in crop yields due to the treatments-whether tillage system, rotation, or straw management. But less energy was used with conservation tillage for similar yield levels, providing a substantial economic benefit to farmers compared with deep tillage which may result in land degradation. However, the effects on soil properties were clear as given below.
- Concentrations of OM were significantly higher in the top 0-15 cm with the shallow ducks foot cultivation compared to the deeper moldboard plowing, regardless of treatments. The mean OM in the top 30 cm of soil was 36.7 t/ha under ducksfoot cultivation compared with 31.4 t/ha of moldboard plowing. This difference mainly came from the top 10 cm of the soil with18.2 t/ha and 12.7 t/ha, respectively. Between 10 and 20 cm there was slightly higher OM under ducks foot. But the difference was reversed at the 20-30 cm soil depth, as 7.6 t/ha vs. 8.5 t/ha was obtained with moldboard.
- Highest OM values were observed with the compost addition every 2 years (2.0-2.5%), followed by the compost application every 4 years (1.6-1.9%). This is reflected in OM at the 30 cm top soil, 41.4 t/ha under ducks foot vs. 38.7 t/ha under moldboard for the compost addition every 2 years and 34.9 t/ha vs. 28.9 t/ha for the compost addition every 4 years, respectively. Distribution between the top soil layers was similar to that of tillage differences.
- The other straw treatments, burning, incorporation of stubble, and incorporating stubble and chopped straw, all had a similar effect on soil OM distribution.
- The moldboard plow resulted in uniform distribution of OM to 30 cm (about

1.0%) for all treatments, except the compost addition every 2 years, which had consistently higher OM levels.

- Total N values followed the same pattern as OM, with all treatments under the shallow cultivation being higher than the deeper moldboard plowing, and the compost addition showing marked increases in N values in the 0-15 cm layer.
- Representing the sum of both nitrate and ammonium fractions, mineral N content and distribution with soil depth was less distinct than either OM or total N in response to treatments. However, the shallow cultivation tended to have higher values in the 0-15 cm layer and lower values at depth.
- An effect of tillage type was evident again, especially with the compost treatment, where C and N values were double those with deep tillage.
- In contrast to other C and N fractions, biomass C was consistently higher with deep tillage combined with straw and compost incorporation. However, labile N was higher at deep, compared to shallow tillage.
- As shown in Table 5, there was a significant yield increase by compost application but it was not directly related to yield increases because of the confounding effect of years with different climatic conditions. There is a need for longer time to develop such relations between soil quality parameters and crop yield. However, the same level of yield under conventional deep tillage and conservation shallow tillage is showing itself as higher energy saving for economic as well as environmental benefit under conservation tillage systems.

Table 5. Mean barley grain yield (kg/ha) in rotation with vetch at Tel Hadya during 1998-2003.

Tillage	Straw management/compost application					
	SBurn	SInc	SCInc	SCInc+C2Yr	SCInc+C4Yr	Mean
Ducksfoot	3.936	3.929	4.121	4.351	4.406	4.148
Moldboard	4.227	4.204	4.142	4.315	4.520	4.282
SE (/-)		0.1380 (Interaction is not significant)				0.1113 (NS)
Mean	4.081	4.066	4.131	4.333	4.463	
SE (/-)			0.136 (Significant at $p<0.05$)			

Conclusions

It can be concluded from the seven-year results that while no discernible yield trends have emerged from the trial, some clear differences were evident in terms of soil organic matter. Differences were apparent between the effects of shallow and deep tillage, and compost addition had a marked effect. Although total N followed a similar trend to organic matter, the pattern for labile and biomass N and C was less consistent. By the end of the trial in 2008, it is expected that the soil differences will be accentuated and reflected in yield differences as well.

Other treatment effects were minor, but are likely to be accentuated with time. Effects on bulk, density and moisture were less consistent. Thus, conservation tillage and compost addition can help the buildup of soil organic matter, and thus soil quality, and reduce energy inputs. The impact of rotations, tillage and residues on crop yield will take longer to be established.

Output 3: Management strategies for the enhancement of soil fertility (macro- and micro-nutrients) in cropping systems

Rationale

While drought is the dominant crop production constraint in the WANA region, nutrient deficiencies are also major limiting factors. Most soils have insufficient N and P to meet crop needs. Thus, N is needed either as fertilizer or from biological fixation for economic yields. P fertilizer use is also necessary. Fortunately, soil potassium is generally adequate in the region.

Sustainable crop production is not possible without an adequate and rational fertilization program that considers soil nutrients as well as the crop nutrient needs. Organic matter and soil quality parameters are intrinsically connected with fertilization and plant nutrition. Micronutrients, though needed in small quantities by plants, are essential for crop production. They include iron, zinc, manganese, copper, and boron. Soil conditions in WANA, especially as they are mainly calcareous, are prone to deficiency mainly because of precipitation reactions of metal cations. Though not as significant as N and P, micronutrients are now recognized as major limiting factors in some areas and for some crops. Deficiencies can be rectified by fertilization or by crop breeding for nutrient-use efficiency. Some elements such as B can also be in excess and reduce crop growth. Micronutrients such as Zn and Fe also have implications for human health. This aspect of the project will be integrated in the "Biofortification" Challenge Program.

Output 4: Validated cropping systems simulation models for the spatial extrapolation and generalization of site-specific results through use of GIS

Rationale

Under the climatic conditions in CWANA, the likely consequences of management measures on the long-term productivity of a particular rainfed crop or a rotation is difficult to assess because of the overlaying effect of rainfall variability. In such risky environments, crop simulation models are possible alternative tools to quantify impacts of alternative management strategies on system performance. Geographic information systems (GIS) are the tools for mapping any soil and crop outputs for a large area. Crop simulation models help to extrapolate results of site-specific research with respect to crop choice in improved rotations, planting date, water and N-fertilizer management. Other decision support tools could be used to disseminate the information to farmers in ways that help them to easily understand the problems and solutions and to create awareness among decision makers.

Activity 4.1: ***Identification, testing and evaluation of cropping systems simulation***

Evaluation of CropSyst performance for wheat production under various supplemental irrigation regimes in a semi-arid environment of Turkey

Rationale

Central Anatolia is a typical rainfed area with about 10 million hectares of cultivated land where wheat is the major crop. Annual rainfall varies from 250 to 500 mm, and is usually less than wheat water requirement. For this reason, wheat yield in Central Anatolia ranges between 0.9 and 2.5 t/ha with an average of less than 2.0 t/ha, which is less than the potential yield. Effective use of water through appropriate policies will ensure a more water and food secure world.

Supplemental irrigation, i.e. supplementation of deficits with minimum quantities of water, is one way to increase productivity. To improve the actual yield values, it is necessary to integrate various supplemental irrigation regimes into a comprehensive cropping system approach. The most important considerations in good supplemental irrigation management are when and how much water to apply. However, this is a laborious and expensive task to be undertaken solely by conventional field experimentation. Cropping systems simulation models need to be considered to fill the gap.

Objective

The objective of this study was to compare the performance of CropSyst model when simulating yield and water use of wheat in a semi-arid climate, using supplemental irrigation to out-scale the findings for larger areas.

Research progress

The data used for model validation was obtained from a field experiment conducted at the Ankara Research Institute of Rural Services during 1998/99, 1999/00, 2000/01 and 2001/02 seasons in collaboration with ICARDA. The experiment was not specifically designed to provide data for validation of

CropSyst, but the yield data was sufficient for testing the performance of the model outputs.

Calibration: Observed yields, evapotranspiration (ET) values and phenological calendar were compared with model predictions. Model calibration consisted of slight adjustments to crop input parameters to reflect reasonable simulations. Crop input parameters used in the calibration were either taken from the CropSyst manual (Stockle & Nelson, 1994), or set to the values observed in the experiments. These adjustments were around values that were either typical for the crop species or known from previous experiences with the model. Data from two years representing the best season during the experimental period (1998/99 and 2000/01) were used for this purpose.

Validation: Validation of the model for Ankara conditions was done using 16 of the 32 combinations of treatments and growing seasons in the experiment (2 main, 4 sub-treatments of supplemental irrigation, 4 growing seasons). Soil characteristics, initial conditions of available soil moisture, nitrogen and organic matter and daily weather data were input into the CropSyst as observed in the experiments. Then the simulations were run using the crop calibrated as mentioned above.

Model simulations: Calibration of CropSyst was done by biomass, grain yield and ET simulations throughout the two growing seasons (1998/99 and 2000/2001). The experimental data points collected were plotted against the daily-simulated data for each treatment.

For Biomass, simulated/observed data pairs were close to the 1:1 line of perfect agreement as could be seen from the statistical analysis (Table 6) confirming that CropSyst predicts wheat biomass reasonably well. Average simulated biomass was close to observed values with root mean square errors (RMSE) representing 15.1%, of the observed average. Wilmott indices of agreement between observed vs. simulated biomass were 0.83, reasonably close to 1 (perfect agreement).
For grain yields, simulated/observed data pairs were close to the 1:1 line. The predicted grain yield was similar to observed yields points out of 16 observations. Grain yield results show a RMSE representing 10.8% of the average observed grain yield and a high Wilmot index of agreement (0.93).

The cumulative ET results at harvest also show most data pairs close to the 1:1 line, with a trend to under-prediction, although overestimation also occurred. The statistical analysis confirmed that CropSyst predicted ET reasonably well.

The RMSE values were 12.76% of the average observed ET and the Wilmot index of agreement (0.85) was reasonably close to 1.

Table 6. Summary of statistical results comparing simulated with observed data.

Data form	n	Slope	Const.	r^2	Observed mean (t/ha)	Simulated mean (t/ha)	RMSE (t/ha)	RMSE/ observed mean	d
Biomass	16	0.62	3.63	0.51	9.99	9.78	1.51	0.15	0.83
Grain yield	16	1.06	-0.05	0.80	4.43	4.64	0.48	0.11	0.93
ET	16	0.85	19.67	0.83	452.1*	404.7*	57.68*	0.13	0.85

**ET values are in mm*

Conclusions

For the CropSyst model, except the rainfed treatment, all other irrigated treatments plus precipitation provide enough water to support evapotranspiration and fully irrigated yields. For this reason, it is not possible to obtain any effect of deficit irrigation from the model. The data shows slight responses for various deficit irrigation treatments, but not very significant. During the field experiment, it was observed that irrigation at sowing had a significant effect on grain yield, but not on the straw yield of 'Bezostia' wheat cultivars. Also, irrigation during the spring and early summer had a significant influence on both grain and straw yields. The statistical analysis confirmed that CropSyst predicted wheat biomass reasonably well. The reason for the over- and under-predicted data is because of the slight response of the model for spring and early summer deficit irrigation treatments. Grain yield and ET at harvest were predicted very closely for rainfed and full supplemental irrigation, but not for deficit irrigation treatments. Cropssyst model gives satisfactory results for rainfed and full irrigation conditions, but the subtle detail between irrigation strategies is hard to reproduce.

Activity 4.4: Decision tree for technical options for land management based on efficient rainwater use under different environmental conditions in Morocco

Rationale

Because of complexity of soil and crop management practices for sustainable production systems, it is evident that developing recommendations for optimizing soil water use is not an easy task. However, a simple decision tree for the choice of agronomic management options could be possible to optimize rainwater-use on the basis of crop water requirements and at the relative risk of occurrence of climatic and edaphic drought, which is based on the actual rainfall infiltrating into the soil and on the relative amount of plant available water (PAW).

Edaphic drought will be high as the PAW is low, and if the runoff potential is high, or both. Therefore, if a high risk of climatic or edaphic drought exists, soil and crop management practices should be implemented to deal with such problems to optimize soil water use. Therefore, such decision trees should be validated in a participatory approach to be able to advise farmers for their maximum benefits.

Objectives

Validation of the decision tree (DT) reported by Van Duivenbooden et al. (2000) in 'Netherlands Journal of Agricultural Science 48: 213-236' using a farmers survey in different agroecologies of Morocco.

Methodology

A pre-validation of the DT was done with researchers from the Aridoculture Center to obtain agreement on the options and technologies. The validation was implemented during three workshops with farmers and extension agents. Seven groups of farmers from representative areas of the three agricultural systems (wheat-based, barley-based and rangeland systems) of the Chaouia region contributed to the workshops. During the workshops, extension agents as well as farmers discussed and evaluated the different alternatives presented. The workshops were held at three local extension agencies, which are representative of different edaphic and climatic conditions of dry areas of the Chaouia region shown in Table 7 below.

Table 7. A decision tree for climatic and edaphic drought risk conditions with respect to rainfall crop water requirement satisfaction.

Rainfall crop water requirement satisfaction	Climatic drought risk	Edaphic drought risk	
		Plant available water	Runoff potential
1 Sufficient	Low	High	Low
2 Sufficient	Low	Low	Low
3 Sufficient	Low	High	High
4 Sufficient	High	High or Low	Low
5 Sufficient	High	High or low	High
6 Insufficient	High	High or Low	Low
7 Insufficient	High	High or Low	High

Group 1: Possible options of technologies identified were: replace fallow, diversfy crops in rotation, apply adequate fertilizers, minimum tillage for energy-use efficiency, graze, and bale or incorporate residues as needed.

Validation: As wheat is the pivotal crop of the system, the best rotation is wheat/row crops (lentil, chickpea, pigeon pea, corn, some oil crops, onion).

However, wheat/fallow is prefered by farmers because row crops are labor intensive. Fertilization is based on soil test calibration for the majority of farmers, a practice that has been disseminated for the last 5 years. Split application of fertilizer is also practiced to manage drought. In addition, farmers use herbicides for weed control, and many are now practicing minimum tillage. Farmers are aware about water losses due to multiple passes of tillage implements. The participants mentioned the importance of organic residues in maintaining the soil structure. However, the straw is baled to avoid social problems, fire etc. In small farms and during very dry years they graze whatever is left in the field after baling, due to the high prices of barley grain. Deep ploughing to remove rocks (depierrage) is practiced by farmers to increase the soil water storage capacity.

Group 2: Use low water requiring crops, apply adequate amount of macro- and micronutrients to stimulate crop growth, use deep rooted crops for more water extraction (safflower) or pigeon pea, along with climatic range, leave residue on the surface for increasing soil water storage, correct soil physical factors limiting root development (tillage, sub-soiling, etc.), increase soil water holding capacity by adding manure if available (theoretically feasible but not practical in most cases).

Validation: Low water requiring crops (short-cycle and early-maturing varieties) are grown. Safflower was grown for few seasons but disappeared because of market problems. Sub-soiling is used to break the hard pan and extract rocks from the field. In light soils, the roller is used to compact the soil surface in order to ensure better seed germination. Minimum tillage is the most widely used practice. Otherwise, everything else is similar to the preceding case.

Group 3: Correct surface sealing problems (proper tillage with chisel, cultivator; leave crop residue on the surface, optimum sowing date, plant perpendicular to slope, plant with narrow row spacing, fertilize in adequate amount, apply weed control in time, etc.), use deep ploughing or sub-soiling to reduce the effect of low permeability layers in the soil.

Validation: The importance of leaving crop residues on the surface is recognised by the farmers. However, to avoid social problems the residues are baled or grazed. Narrow spacing is already imposed by commercial drills because most of them are set to 11-12 cm row space. Perpendicular planting to the slope is well known, largely used in the region when sowing is done with drills.

Group 4: Timely tillage with proper implement and adequate fertilizer amounts to ensure optimal physical and chemical soil conditions favoring root development and access of the plant to stored water; apply supplemental irrigation from tanks or reservoirs as available (water harvesting from areas with high runoff potential in the landscape).

> ***Validation:*** In deep soils, the cropping system is different from that in shallow soils. Fallow is mostly practiced in deep soils, whereas in shallow soils food legumes come after wheat. Durum wheat, a high water-requiring crop, is never planted in shallow soils. Farmers plant generally bread wheat or barley. Supplemental irrigation is used when water is available either from wells or reservoirs.

Group 5: Timely tillage with proper implement and adequate fertilizer amounts to ensure optimal physical and chemical soil conditions favoring root development and plant access to stored water; apply supplemental irrigation from tanks or reservoirs as available (water harvesting from areas with high runoff potential in the landscape); take advantage of runoff to increase locally the amount of water infiltrating into the root zone during rainy periods (water collection, zai, demi-lunes, strip farming etc.).

> ***Validation:*** Most water-harvesting techniques are known to the farmers, but these techniques are not well mastered and practiced. Farmers showed interest in using demi-lunes combined with olive trees or shrubs, and strip farming. However, demonstration trials should be undertaken in the region. The chisel implement is now used instead of the offset disc to improve water infiltration in the soil profile.

Group 6: Timely tillage with proper implement and adequate fertilizer amounts to ensure optimal physical and chemical soil conditions favoring root development and plant access to stored water; apply supplemental irrigation from tanks or reservoirs as available (water harvesting from areas with high runoff potential in the landscape).

> ***Validation:*** Under these conditions, we have the barley and rangeland agricultural systems. In these areas, crops when planted receive minimum inputs, because of the high risk of drought. Planting time is determined by the first significant rain. The most used implement is the offset disc; however, the chisel is sometimes used in deep soils as a primary tillage. No or very little fertilizers, no chemicals are used, and barley is the most common crop under these

systems. Farmers increase seeding rate because they do not focus on tillers that might be lost. In Settat area, which is representative of the intermediate system, triticale was mentioned as an interesting crop under dry conditions. However, it is not planted on a large scale because of marketing problems.

Group 7: Timely tillage with proper implements and adequate fertilizer amounts to ensure optimal physical and chemical soil conditions favoring root development and plant access to stored water; apply supplemental irrigation from tanks or reservoirs as available (water harvesting from areas with high runoff potential in the landscape); take advantage of runoff to increase locally the amount of water infiltrating into the root zone during rainy periods (water collection, zai, demi-lunes, strip farming, etc.).

Validation: Under these conditions, we have the barley and rangeland agricultural systems. In these areas, crops when planted receive minimum inputs, because of the high risk of drought. Planting time is determined by the first significant rain. The most used implement is the offset disc; however, the chisel is sometimes used in deep soils as a primary tillage. No or very little fertilizers, no chemicals are used, and barley is the most common crop under these systems. Whenever chemical weeding is practiced it is first applied on bread wheat. Barley planted under such conditions is dual purpose material-grazed at tillering and left to grow for grain. When the year is very dry it is all grazed. Farmers do know about forage mixtures (cereals/vetch) but cannot find legume seeds locally. Most of water harvesting techniques is known to farmers, but these techniques are not well mastered and practiced. Farmers showed interest in using the demi-lunes combined with olive trees or shrubs, and strip farming. However, demonstration trials should be undertaken in the region. Livestock is tightly integrated to cereals and rangeland has to be improved in terms of biomass production and management.

Conclusions

The workshops held to validate the proposed technological options for such dry areas showed that farmers have a clear perception of their environment and farming systems, know what they need to do to improve their work, adopt practices and techniques that optimize production and are open to technological changes.

The workshops highlighted also the complexity of the farming systems and the strong integration of crop and livestock in these areas. It was also stressed that institutional and organizational insufficiencies are the major constraints to technology use and adoption. Farmers know about the work done by research and extension in their region. They also know about low water demanding crops (triticale), water-harvesting techniques, no or minimum tillage, forage mixtures, and that crop residues improve soil characteristics and water storage in soils. However, inputs such as seeds and materials such as drills and varieties are not available locally. In addition, the high feed prices force farmers to collect all crop residues. Continuing to train farmers on new technologies through demonstration trials and field days and using an organizational and community approach will be useful. Most of the suggested technologies (no-till drills, improved varieties, seeds, etc.) are not easy for individual farmers to adopt, but they could be used by groups or communities (on-farm community, informal seed production, community, no-till, etc.) for more sustainable production systems to improve the livelihoods of farmers.

Output 5: Strengthened capacity of NARS

Rationale

Training of appropriate research, extension and management personnel in standardized analytical techniques, in soil and cropping system management for improved water and nutrient-use efficiency, and in the development and transfer to resource users of productive and sustainable technologies is of vital importance for the sustainability of natural resources.

Research progress

There was a continuous strengthening of the capacity of NARS researchers and extension staff through coordination meetings, field visits, participating in workshops/conferences, visits to ICARDA, common papers, and participating in headquarters and in-country training courses. Such activities included:

- An in-country training course on "use of CropSyst simulation model" held under the Iran /ICARDA project, Iran, Feb 22-26. Sixteen DARI researchers attended the course.
- Contribution to JICA-Water-Use Efficiency training course through lectures, field sampling and evaluation and final reporting with respect to agronomic management and fertility aspects (May 5-June 12).
- Mechanization and weed management practices presented in the training course on 'Experimental Station Operations Management' held on 18-29 May.
- Transfer of technology through on-farm trials in CAC, Egypt, Iran, Morocco and Turkey.
- Exchange of knowledge during field visits (e.g., Egypt, Iran, Morocco, Turkey).

- The Soil Laboratory Analysis Manual produced in Russian for Central Asia as the basis of a soil analysis workshop in Tashkent in June 2003. The Arabic translation will be published in 2004.
- Review of NARS-related papers.
- Participation in a meeting for the Water Challenge Program project preparation for Kherkeh River Basin of Iran with the involvement of ICARDA/IWMI/IRRI and NARS on 17-20 Feb in Karaj, Iran.
- Presentations on agronomic management-including weed control-during the field days for Lentil (25 May in Shillah), and for winter-sown Chickpea (8 June in Muslimiyeh-Aleppo and 9 June in Ibben-Idleb).
- Participation at the Iran/ICARDA coordination/planning meeting at Maragheh on 7-11 September to report on the achievements and discussion of new proposals for next year.
- Participation at the 7th IDDC Conference held in Tehran, Iran, on 14-17 September.
- Participation at the CAC/ICARDA regional Coordination/Planning meeting to discuss the outputs/plans of previous ADB projects on soil and water management and the new phase and to develop the 'Mountain Agriculture Project' in Yerevan, Armenia, on 26-28 September.
- Participation in Rainfed Benchmark Sites Workshop on Community-based Optimization of the Management of Scarce Water Resources in Agriculture in West Asia and North Africa, November 11-14, 2003, INRA, Morocco.

APPENDIX

Staff list

ICARDA staff

Mustafa Pala (P): Project Manager; cropping systems management; conservation tillage, crop diversification, Optimizing Soil Water Use (OSWU) Consortium within Soil, Water and Nutrient management (SWNM) Program of CGIAR.
John Ryan (P): Soil Fertility Specialist; Soil Laboratory, science editing, and Coordinator for CRP with IAEA, Vienna, and Fertilizer P project with IMPHOS, Morocco.
Atef Haddad (NPO): Assist in agronomic management trials for cropping systems as necessary, produce oilseeds as requested by NARS and advise on overall weed control.
Haitham Halimeh (GS): Assist in agronomic management trials for cropping systems as necessary, conduct farm surveys for identification of biophysical problems.
Samir Masri (GS): Soil sampling and conduct fertility research as necessary.
George Estefan (GS): Supervise Soil Laboratory.
Shireen Badour (GS): Assist in Soil Laboratory analysis.

Students

Carina Moeller (Student): Second output of a PhD thesis at the University of Hohenheim, Germany, on "Sustainable Management of a Mediterranean Type Agro-ecosystem: Results from Simulation Studies." The supervisors are Dr Joachim Sauerborn (Hohenheim University), and Dr Mustafa Pala (ICARDA).

Collaborators

- Long-term trials for resource management: Egypt, Jordan, Lebanon, Iran, Morocco, Syria, Turkey, CAC.
- Farm surveys and on-farm experimentation: Egypt, Jordan, Iran, Morocco, Syria and Turkey, CAC.
- Optimizing Soil Water Use: Jordan, Morocco, Syria, Turkey, Niger, Zimbabwe, Kenya, Burkina Faso, South Africa; and ICRISAT as co-convener.
- Testing and validation of simulation models: Egypt, Iran, Jordan, Morocco, Syria and Turkey; Washington State University, USA; Hohenheim University, Germany.

- Soils laboratory standardization: Egypt, Iran, Jordan, Lebanon, Morocco, Pakistan, Syria, Turkey, Yemen and Wageningen University.
- Soil chemistry: International Atomic Energy Agency (IAEA); IMPHOS; International Fertilizer Association (IFA).
- Linkage to the Systemwide Programme on Soil Water and Nutrient Management (SP-SWNM) with CIAT, IWMI, TSBF: Optimizing Soil Water Use (OSWU), with ICRISAT.
- Participation in the Inter-Center Working Group for Climate Change (IWG-CC) with the lead on the project on "Carbon and Nitrogen Dynamics in Long-term Trials"; Water Challenge Program on 'Water Management' and 'Land Management' projects in Kherkeh basin of Iran.

Donors

Unrestricted core funds. Collaboration with NARS in Egypt in long-term trials and farm monitoring supported by EC; consortium on Optimizing Soil Water Use supported through the SP-SWNM; collaboration with Iran financed by Iran; support for collaboration on crop diversification, soil water and nutrient management in Central Asia from Asian Development Bank.

Publications

Books

Ryan, J. (ed.). 2003. Desert and dryland development: challenges and potential in the new millennium: Proceedings of the Sixth International Conference on the Development of Dry Lands, 22-27 August 1999, Cairo, Egypt. 655p. Published by ICARDA.

Journal articles

Oweis, T., A. Hachum and M. Pala. 2003. Water productivity of lentil under s upplemental irrigation in a Mediterranean environment (Submitted to Agricultural Water Management).

Oweis, T., A. Hachum and M. Pala. 2003. Water use efficiency of winter sown chickpea under supplemental irrigation in a Mediterranean environment (Submitted to Agricultural Water Management).

Pala, M., B. Benli, A. Ilbeyi and T. Oweis. 2003. Evaluating CropSyst performance for wheat production under various supplemental irrigation regimes in a semi-arid environment (To be submitted to Agricultural Systems).

Pala, M., J. Ryan, A. Mazid, O. Abdallah and M. Nachit. 2003. Wheat farming in Syria: an approach to economic transformation and sustainability. Agriculture Sustainability and Food Systems (accepted for publication).

Conference papers

Eskandari, I., C. Asghari, R. Rahimzade, H. Siadat, A. Gaffari, M. Pala and H. Ketata. 2003. Sustainable soil management for cereal-based cropping systems in the dry highlands of northwestern Iran. Paper presented at the 7th IDDC Conference, 14-17 Sep, Tehran, Iran.

Feiziasil, V., G. Velizadeh, I. Eskandari, H. Mahmoudi, R. Rahimzadeh, A. Gaffari, H. Siadat, M. Pala and H. Ketata. 2003. Soil fertility management for sustainable cereal-based cropping systems in the dry highlands of northwestern Iran. Paper presented at the 7th IDDC Conference, 14-17 Sep, Tehran, Iran.

Ibrikci, H., J. Ryan, N. Guzel, A.C. Ulger, U. Yildiran, G. Buyuk, E. Karnez, and K. Korkmaz. 2003. Phosphorus fertilizer efficiency and mycorrhizal infection in comgenotypes. American Journal of Alternative Agriculture (submitted). This was presented as an Abstract at ASA (2002) in Minneapolis.

Moeller, C., A.M. Manschadi, M. Pala, H. Meinke and J. Sauerborn. 2003. Sustainable management of wheat-based systems in a Mediterranean environment: an analysis using a cropping systems simulator, p. 223-225, In D. Kauter, A. Kaempf, W. Claupein, W. Diepenbrock, eds. Mitteilungen der Gesellschaft fuer Pflanzenbauwissenschaften, Vol. 15. Verlag Guenther Heimbach, Stuttgart, Germany.

Rashid, A., Z.I. Awan and J. Ryan. 2003. Diagnosing phosphorus deficiency in spring wheat by plant analysis: critical concentration ranges. Paper presented to the 8th International Symposium on Soil and Plant Analysis held in Sanerset, Cape Town, South Africa, 8-17 January 2003.

Rashid, A., Z.I. Awan and J. Ryan. 2003. Diagnosing phosphorus deficiency in spring wheat by plant analysis. Proposed critical concentration ranges. Commun. Soil Sci. Plant Anal.

Rashid, A., Z.I. Awan, J. Ryan and E. Rafique. 2003. Phosphorus deficiency in rainfed wheat in Pakistan magnitude and crop responses to fertilization. European. J. Agronomy (interview).

Ryan, J. and S. Masri. 2003. Crop response to available phosphorus: Soil depth and moisture interactions. Paper presented to the 8th International Symposium on Soil and Plant Analysis" held in Sanerset, Cape Town, South Africa, 8-17 January 2003.

PROJECT 2.3: IMPROVEMENT OF SOWN PASTURE AND FORAGE PRODUCTION FOR LIVESTOCK FEED IN DRY AREAS

Rationale

Rural livelihoods in the dry areas of Central and West Asia and North Africa (CWANA) are based on agro-pastoral and crop-livestock systems. Small ruminants (sheep and goats) are an integral part of the farming systems providing meat, milk, wool and manure. Shortage of livestock feed, a result of population pressures and increasing demands for livestock products, is the main constraint to livestock production. The major research and development challenge is to improve the productivity of feed resources to support the rapidly growing small ruminant population and, consequently, the livelihoods of rural families who depend on them.

In an effort to meet the increasing feed needs, farmers have replaced traditional cereal/fallow rotations with continuous cereal cultivation that is not sustainable in the long term. There is evidence that cereal yields are declining, and in some countries where annual fallow used to provide additional grazing, the loss of fallow areas reduces a valuable feed resource. Alternative cropping options are needed to meet the food/feed needs of crop-livestock farmers.

Most countries in CWANA rely on imported seed for pasture and forage crops because the pasture seed industry is underdeveloped. Lack of seed at the farm level constrains the adoption of pasture and forage technologies to increase livestock productivity and to mitigate natural resource degradation. Government seed agencies focus on food/field crop species, and seed producers are not interested in producing small volumes of seed with low profit margins and uncertain markets. Transfer of appropriate technologies for pasture seed production to the informal seed sector is needed to strengthen national capacity to produce forage seed.

The CWANA region has a number of native species that could be used as pasture/forage crops. Many of the species are currently endangered and some are threatened with extinction as a result of over-exploitation in their natural environments. There is need to assemble significant diversity of target key species and evaluate them for use as pasture/forage crops to overcome the livestock feed deficit and reverse land degradation.

Project purpose
The purpose of the project is to develop options of forage and pasture species in crop rotations for adoption by farmers or to rehabilitate native pastures.

Objectives
- Develop alternative crop systems to increase crop and livestock outputs.
- Develop sustainable forages and pastures crops seed production systems.
- Conserve and valorize local biodiversity.

The main outputs are:
1. Identified species and adapted cultivars of annual pasture and forage legumes (in cooperation with Projects 1.6 and 3.3).
2. Forage and pasture seed technologies developed for small farmers (in cooperation with the Seed Unit).
3. Demonstrations of higher and sustainable system productivity from barley in rotation with pasture or forage legumes, compared to continuous barley cropping or barley in rotation with other food legumes, clean fallow, weedy fallow, or other relevant crops.
4. Management recommendations that provide the highest economic output at a minimum cost from pasture and forage legume rotation treatments.

This report focuses on activities implemented during the reporting period to achieve outputs 2 and 3.

Research progress

Output 2: Forage and pasture seed technologies developed for small farmers (in cooperation with the ICARDA Seed Unit)

Rationale
Lack of seed at the farm level is a major constraint to the adoption of pasture/ forage-based technologies to increase livestock productivity and natural resource management in CWANA. Although pasture and forage materials that could rapidly improve farm profitability through their use in meat and milk production systems and/or re-vegetation of degraded land have been identified, lack of seed prevents the passage of these materials from the evaluation stage to on-farm testing and large-scale planting.

Forage/pasture seed production in CWANA is underdeveloped. Government agencies in charge of seed multiplication deal mainly with field crops species, and seed producers are not interested in producing small volumes of seed with low profit margins and uncertain market. As a result, most of the CWANA countries rely on imported seed for pasture/forage crops. Thus, transfer of appropriate technologies for pasture seed production to the informal seed sector is needed to strengthen national capacity to produce forage seed and to promote production, supply and utilization of selected pasture and forage materials by farmers to integrate them into the production systems. In addition, applied research is needed to provide quantitative data on the seed production and physiology of most of the native species with potential as pasture/forage crops in order to integrate them into the farming system.

Activity 2.1: Multiply seeds of adapted and promising native and indigenous species

Activity objectives

- Multiply seeds of adapted native and introduce species.
- Train national collaborators on forage seed production.
- Supply small quantities of seed of selected species for research/development.

Research progress

Seeds of adapted pasture/forage species were multiplied at Tel Hadya, Syria and Terbol, Lebanon. Small quantities of planting materials were supplied upon request to national agricultural research and extension systems (NARS) and non-governmental organizations (NGOs).

A list of germplasm sent to NARS in Syria and Turkey is given in Table 1. In Syria, seedlings and seeds of 11 species of grasses and legumes were supplied to a project funded by FAO at Palmyra to establish a botanical garden for the Syrian Steppe. Seeds of 8 *Atriplex* species were supplied to Haran University in Turkey for research, and 420 seedlings of 30 fodder shrub and grasses were given to the GAP project in Turkey for re-vegetation of degraded rangeland in Kuyulu, southeast Turkey.

In Lebanon, to enhance the adoption of pasture/forage-based technologies, the project donated 21 kg of *Trifolium subterranum* to World Vision, an NGO, and 31 of alfafa to the Lebanese Institute of Agricultural Research.

Table 1. Seeds distributed to national collaborators in Syria and Turkey.

Species	Origin
Agropyron elongatum / 1	USA
Agropyron fragile / 1	USA
Artemisia herba-alba-1	Syria
Artemisia herba-alba / 2	Spain
Atriplex canescens	Syria
Atriplex canescens / 1	USA
Atriplex halimus-2	Syria
Atriplex halimus-halimus-4	Spain
Atriplex halimus-prostrate	Syria
Atriplex halimus-spain	Spain
Atriplex halimus / 1	Syria
Atriplex halimus / 1	Tunisia
Atriplex halimus-Syria	Syria
Atriplex halimus-halimus / 3	Spain
Atriplex lentiformis / 1	USA
Atriplex leucoclada / 1	Syria
Atriplex nummularia / 1	Australia
Atriplex polycarpa / 1	USA
Atriplex torreyi / 1	USA
Atriplex undulata / 1	Australia
Bituminaria bituminosa / 1	Spain
Colutea istria / 1	Syria
Colutea istria / 2	Jordan
Coronilla glauca / 1	France
Dactylis glomerata / 1	Syria
Dactylis glomerata / 76	Turkmenistan
Eragrostis sp. / 1	USA
Festuca elatior 20	Morocco
Halothamnus subaphyllus / 1	Uzbekistan
Haloxylon aphyllum / 2	Syria
Kochia prostrata / 1	Uzbekistan
Lolium sp. 24	Morocco
Medicago noeana	Iran
Medicago polymorpha	Syria
Medicago rigidula-1919	Syria
Onobrychis aurantiaca / 1	Syria
Onobrychis sativa / 1	Turkey
Oryzopsis miliacea / 1	Syria
Panicum turgidum / 1	Sudan
Phalaris tuberosa / 1	Syria
Plantago lanceolata 72	Turkmenistan
Salsola orientalis / 1	Uzbekistan
Salsola vermiculata	Syria
Trifolium pilulare	Syria
Trifolium purpureum	Syria
Trifolium speciosum	Syria
Trifolium tomentosum	Syria
Trigonella astroites	Syria
Trigonella monantha	Syria

Brief activity conclusions

Feed-back from the NARS and NGOs indicated that seed availability is a major constraint to widespread adoption of forage-based technologies for livestock feed and mitigation of land degradation. The importance of evaluating native species for their potential as livestock feed and rangeland re-vegetation was stressed.

Output conclusions

Future activities will be focused on building the capacities of NARS and NGOs for pasture seed production, and conducting applied research on seed production and physiology of the native species.

Output 3: Demonstrations of higher and sustainable system productivity from barley in rotation with pasture or forage legumes, compared to continuous barley cropping or barley in rotation with other food legumes, clean fallow, weedy fallow, or other relevant crops

Rationale

In many dry areas of CWANA, shortage of quality feed resources is one of the major constraints to improved livestock productivity. In order to meet the feed needs of the small ruminants, farmers have replaced traditional cereal/fallow rotations with continuous cultivation, a practice that is not sustainable in the long term. There is evidence that cereal yields are declining and in some countries where annual fallows are left weedy to provide additional grazing, the loss of fallow areas reduces a valuable feed source. Alternative crop rotations are needed to maintain adequate levels of cereal crop health and grain yields, while at the same time meeting the feed needs of livestock. To this end, cropping systems research is undertaken to monitor long-term trends in cropping systems with the aim of steering policy makers and farmers away from non-sustainable and degrading practices. Land-use practices common through CWANA are compared to potential new cropping systems.

In West Asia and North Africa (WANA) rotations of cereals with fallow or food/forage legume crops depend on location and rainfall. Barley (*Hordeum vulgare*) dominates in the drier zones, and bread wheat (*Triticum aestivum*) in the more favorable areas. Two-phase rotational trials were therefore established by ICARDA to monitor long-term trends in cropping systems in three benchmark sites: Tel Hadya (northwest Syria), Hemo (northeast Syria), and Terbol (Lebanon). This report focuses on the trials in Syria.

Activity 3.1: ***Comparison of barley/legume rotations***

Activity objectives

- Determine the effect of different barley-based rotations on crop yield, soil nutrient status, and animal performance.
- Compare economic returns and biological yields of the different rotations.

Research progress

Data collection for the second phase of a long-term two-phase rotational trial started in 1993/94 at ICARDA's main research station at Tel Hadya continued for the 10^{th} year. The design was a split-plot with three replicates. Seven barley-based rotations were the main-plots and sub-plots were nitrogen fertilizer levels of 0 and 60 kg/ha. The rotations were barley rotated with: barley (BB), clean fallow (BF), lentil (*Lens culinaris*) for seed and straw (BL), medic (*Medicago spp.*) for grazing, vetch (*Vicia sativa*) for grazing (BVG), vetch harvested as hay at maturity (BVH), or vetch harvested for seed and straw (BVSS). Yields of barley grain and straw, vetch seed and straw, and vetch hay were recorded each year. Soil samples from each of the rotations were analyzed annually to determine organic carbon (OC) and total nitrogen (TN) concentrations. Data from 1993/4 to 2002/3 were analyzed to compare productivity of the rotations, and trends in barley grain and straw yields and soil OC and TN.

The year x rotation and year x fertilizer interactions affected barley grain and straw yields ($p < 0.001$). The grain and straw yields of barley grown after the legumes were higher ($p < 0.001$) than barley following barley (Table 2). Barley grown after vetch produced 85% more grain and 73% more straw than barley grown after barley. Grain yield was positively correlated ($r = 0.68$, $p = 0.031$) with time for the barley/fallow rotation.

Application of N fertilizer consistently increased grain and straw yields in all rotations over the 10-year period (Tables 2 and 3). Averaged across rotations, the increase in grain yield due to fertilization was 47%, and for straw 71%.Vetch grown after barley produced 20% more seed, and 37% more straw than lentil (Table 4). Vetch grown after barley for hay produced an average of 2.35 t DM/ha. Assuming a dry matter requirement of 3% body weight, the hay could provide feed for a flock size of 50 with an average body weight of 30 kg for 52 days.

Table 2. Yields (t DM/ha) of barley grain and straw after barley, fallow, lentil, medic and vetch, and effect of nitrogen fertilizer level on yield at Tel Hadya, northwest Syria.

	Year	Rain (mm)	Rotation[1,2] BB	BF	BL	BM	BVG	BVH	BVSS	N Fertilizer 0	60
Grain	1994	373	2.18	2.08	2.62	2.22	2.78	2.65	2.65	2.15	3.33
	1995	323	1.88	2.53	2.27	2.99	2.79	3.05	2.89	2.29	2.97
	1996	405	1.73	2.11	1.99	2.57	2.32	2.68	2.27	1.66	2.81
	1997	434	1.84	2.66	2.58	3.32	3.29	3.67	3.14	2.44	3.42
	1998	411	0.88	2.41	1.84	2.24	2.86	2.75	2.08	1.66	2.64
	1999	307	0.49	2.02	1.69	2.22	2.45	2.51	2.09	1.52	2.32
	2000	261	0.84	2.32	1.42	1.33	1.82	2.27	1.29	1.53	1.68
	2001	429	1.08	2.72	2.39	2.83	2.64	2.80	2.41	1.85	2.97
	2002	405	1.56	3.69	3.57	3.04	4.32	4.59	4.23	2.92	4.16
	2003	492	1.94	3.15	3.03	3.58	4.29	3.91	3.03	2.54	4.01
	SEM[3]				0.176 (df=54)					0.210 (df=9)	
	Mean		1.44	2.67	2.73	2.96	3.09	2.61	2.32	2.06	3.03
	SEM				0.545 (df=6)					0.094 (df=9)	
Straw											
	1994	373	2.71	4.45	3.33	4.42	3.89	3.82	3.82	2.61	4.94
	1995	323	1.86	2.72	2.18	3.43	3.15	3.15	3.33	2.34	3.37
	1996	405	2.12	2.83	2.39	3.84	3.29	3.87	3.03	1.95	4.19
	1997	434	2.20	3.14	3.01	4.53	4.71	5.31	4.11	2.78	4.94
	1998	411	0.85	2.38	1.81	2.21	2.83	2.72	2.05	1.66	2.56
	1999	307	0.69	2.49	1.86	2.81	2.89	3.16	2.45	1.70	2.97
	2000	261	0.75	1.97	1.12	1.21	1.51	1.89	1.06	1.26	1.47
	2001	429	1.08	2.72	2.39	2.83	2.64	2.80	2.41	2.08	4.18
	2002	405	1.56	3.69	3.34	3.01	4.32	4.59	4.23	3.07	5.22
	2003	492	4.86	6.22	6.31	7.25	8.33	7.43	6.03	5.12	8.16
	SEM				0.295 (df=54)					0.234 (df=9)	
	Mean		1.99	3.44	3.66	3.86	4.11	3.44	2.81	2.45	4.20
	SEM				0.718 (df=6)					0.158 (df=9)	

[1] *Two-course rotation: BB, barley/barley; BF, barley/fallow; BL, barley/lentil for seed and straw; BM, barley/medic for grazing; BVG, barley/vetch for grazing; BVH, barley/vetch for hay; BVSS, barley/vetch for seed and straw.*

[2] *Values are averages of three replicates.*

[3] *SEM: Standard error of mean*

Table 3. Effect of nitrogen fertilizer level (kg/ha) on barley grain and straw yields (t/ha) in different rotations at Tel Hadya during 1994-2003.

	[1]Grain		Straw	
Rotation	0	60	0	60
Barley/barley	0.91	1.97	1.21	2.79
Barley/fallow	1.99	3.35	2.69	4.56
Barley/lentil	1.74	2.90	1.91	3.70
Barley/medic	2.36	3.10	2.85	4.47
Barley/vetch for grazing	2.64	3.27	3.14	4.58
Barley/vetch for hay	2.60	3.57	3.18	5.04
Barley/vetch for seed and straw	2.16	3.05	2.61	4.27
[2]SEM (df=6)	0.079		0.131	
Mean	2.06	3.03	22.45	4.20
SEM (df=6)	0.076		0.179	

[1]*Values are averages of three replicates.*

[2]*SEM: Standard error of mean*

Table 4. Yields (t/ha) of seed, straw and hay of lentil and vetch in rotation with barley at Tel Hadya during 1994-2003.

Seed/straw	[1]Rotation	Mean	[2]SEM	Range
Seed	Barley/lentil	0.94	0.516	0.11-1.99
	Barley/vetch	1.13	0.429	0.19-1.96
Straw	Barley/lentil	1.56	0.617	0.22-3.15
	Barley/vetch	2.14	0.792	0.46-3.94
Hay	Barley/vetch	2.35	0.838	0.57-3.81

[1]*Values are averages of three replicates.*

[2]*SEM: Standard error of mean*

The differences in soil OC and TN concentrations among the rotations were small (Table 5). However, OC and TN concentrations of the barley/vetch for grazing rotation were significantly higher than the rest of the rotations, except the barley/vetch for seed and straw rotation. The average concentrations of soil OC and TN in the barley/vetch rotations were 2% and 5%, respectively, higher than that of the barley/barley rotation.

The OC concentration for the barley/medic (r = 0.86, p = 0.028) and barley/vetch for hay (r = 0.83, p = 0.041) rotations increased with time. The TN concentration for the barley/medic (r = 0.83, p = 0.022) and barley/vetch (r = 0.71, p = 0.074) rotations followed similar trends with time.

Table 5. Soil organic matter and total nitrogen concentrations (g/kg) at Tel Hadya.

		[1,2]Rotation						
Rotation	Year	BB	BF	BL	BM	BVG	BVH	BVSS
Organic matter	1994	10.8	10.8	10.3	8.7	11.6	9.0	11.0
	1995	13.1	13.2	13.6	9.2	13.8	11.1	11.0
	1996	11.5	11.5	10.3	8.6	11.9	9.6	10.3
	1997	12.2	12.0	12.4	9.2	12.8	10.9	11.4
	1998	9.2	10.6	10.1	12.7	11.4	na	11.4
	1999	[3]Na	na	na	na	na	na	na
	2000	12.0	12.5	10.9	15.4	12.7	na	12.8
	2001	11.1	10.8	11.3	13.1	12.3	12.8	13.9
	2002	11.6	10.2	10.0	14.4	11.7	12.3	12.0
	[4]SEM				0.48 (df=30)			
	Mean	11.5	11.3	11.1	11.4	12.4	11.0	11.7
	SEM				0.26 (df=6)			
Total Nitrogen	1994	0.80	0.80	0.75	0.65	0.83	0.66	0.79
	1995	0.83	0.86	0.93	0.63	0.90	0.76	0.79
	1996	0.78	0.77	0.72	0.61	0.81	0.67	0.69
	1997	0.69	0.69	0.74	0.57	0.78	0.63	0.73
	1998	0.61	0.65	0.62	0.80	0.72	Na	0.74
	1999	[3]na	Na	Na	na	Na	Na	Na
	2000	0.74	0.70	0.70	0.91	0.82	Na	0.83
	2001	0.75	0.71	0.76	0.90	0.82	0.85	0.92
	2002	0.74	0.73	0.66	0.95	0.80	0.86	0.84
	SEM				0.028 (df=30)			
	Mean	0.74	0.74	0.74	0.75	0.81	0.74	0.78
	SEM				0.011 (df=6)			

[1]*Two-course rotation:BB, barley/barley; BF, barley/fallow; BL, barley/lentil for seed and straw; BM, barley/medic for grazing; BVG barley/vetch for grazing; BVH, barley/vetch for hay; BVSS, barley/vetch for seed and straw.*

[2]*Values are averages of three replicates.*

[3]*Na:Data not available.*

[4]*SEM:Standard error of mean*

Brief activity conclusions

The results suggest that growing barley in rotation with vetch for either grazing or hay could improve productivity per unit area of land in crop-livestock systems than growing barley after barley or barley followed by fallow.

Activity 3.2: Comparison of wheat-based rotations

Activity objectives

- Determine the effects of different wheat-based rotations on crop yield, soil nutrient status and animal performance.
- Compare the economic returns and biological yields of the different rotations.

Research progress

Data collection continued on a trial initiated with the Syrian Ministry of Agriculture and Agrarian Reform at Himo Research Station near Kamishly in northeast Syria in 1986. The first phase of the trial ended in 1993, and a second phase was started during the 1993/94 growing season. The design was a split-plot with three replicates. Seven wheat-based rotations were the main-plots and sub-plots were nitrogen fertilizer levels of 0 and 60 kg/ha. The rotations were wheat, rotated with: wheat (WW), clean fallow (WF), lentil (*Lens culinaris*) for seed and straw (WL), medic (*Medicago* spp.) for grazing (WM), vetch (*Vicia sativa*) for grazing (WVG), vetch harvested as hay at 50% maturity (WVH), or vetch harvested for seed and straw (WVSS). Weaned Awassi lambs grazed the vetch grown after barley to estimate growth rate and live weight, whilst lactating ewes grazed the medic grown after wheat to estimate milk off-take and wool production. Yields of wheat grain and straw, vetch seed and straw, and vetch hay were recorded each year. Soil samples from each of the rotations were analyzed annually to determine OC, TN, and available phosphorus (P) concentrations. Data from 1993/4 to 2001/2 were analyzed to compare productivity of the rotations, and trends in wheat grain and straw yields and soil OC, TN and P.

The year x rotation and year x fertilizer interactions had significant effects on wheat grain and straw yields partly due to the variations in total annual rainfall. Wheat grain and straw yields in the wheat-legume rotations were significantly higher than the wheat/wheat (Table 6). Averaged across years, wheat grown after vetch gave 56% more grain, and 59% more straw than wheat grown after wheat. In general, wheat grain and straw yields tended to decline ($r = -0.28$ to 0.47; $p = 0.021-0.065$) with time in all the rotations, except the wheat/medic rotation. Fertilizer nitrogen application had minimal effect on grain and straw yield.

Vetch grown after wheat produced 17% more grain and 10% more straw than lentil (Table 7). Hay yield of vetch grown after vetch averaged 3.6 t/ha per annum. Assuming a daily dry matter requirement of 3% of the body weight, and an average body weight of 30 kg/head the hay could provide feed for a flock size of 50 for 80 days.

Differences in soil OC, TN, and P concentrations between the rotations were often small, although there were indications that planting wheat after vetch could improve the soil nutrient status (Table 8). For example, soil OC, TN, and P concentrations in the wheat/vetch rotations were about 2, 9 and 3% greater than the wheat/wheat rotations.

The introduction of forage legumes to be grazed directly by sheep not only increased the wheat grain and straw yields but also provided quality feed for lamb fattening and production of milk and wool. Table 9 shows average stocking rate, grazing days, forage-on-offer and performance of weaned lambs grazing vetch after wheat. Similar data for ewes grazing medics after wheat are presented in Table 10. Lambs grazing vetch after wheat gained 144 g per day resulting in an average live weight gain of 334 kg/ha over the 9-year period. Similarly, milk off-take and wool production of lactating Awassi ewes grazing medic pasture after wheat averaged 614 and 22.7 kg/ha, respectively.

Brief activity conclusions

The results show that, wheat grown in rotation with vetch for either grazing or hay appears to have higher potential for improving the productivity per unit area of land in crop-livestock systems than wheat grown after wheat or wheat followed by fallow.

Output conclusions

Results of the barley and wheat-based rotations suggest that planting wheat or barley in rotation with forage legumes, especially vetch, could improve the productivity of the crop-livestock systems while maintaining the natural resource base. Economic analysis to compare the different rotations systems is recommended for the future.

Table 6. Wheat grain and straw yields (t DM/ha) after common vetch, medic, fallow and wheat and the effect of nitrogen fertilizer level (N kg/ha) on yield at Kamishly, northeast Syria.

			Rotation[1,2]							N Fertilizer	
	Year	Rain (mm)	WW	WF	WL	WM	WVG	WVH	WVSS	0	60
Grain	1994	332	0.64	2.79	1.11	1.39	1.61	1.39	1.19	1.50	1.66
	1995	635	1.14	3.10	2.79	3.02	3.09	3.20	2.74	2.79	3.28
	1996	406	1.46	3.32	2.76	2.78	3.13	2.98	2.62	2.69	3.12
	1997	352	0.69	2.62	1.95	0.93	1.94	1.94	1.93	1.98	1.78
	1998	395	1.94	3.09	2.54	2.31	2.74	2.64	2.46	2.60	2.66
	1999	219	0.06	0.67	0.09	0.08	0.09	0.28	0.09	0.23	0.21
	2000	218	0.05	0.37	0.04	0.01	0.06	0.01	0.01	0.07	0.09
	2001	496	3.01	4.19	3.44	3.71	3.17	3.47	3.41	3.67	3.48
	2002	322	1.29	1.36	0.62	0.08	0.71	0.92	0.63	0.84	0.84
	[3]SEM				0.116					0.095	
	Mean		1.15	2.39	1.70	1.67	1.84	1.87	1.68	1.81	1.91
	SEM				0.055					0.032	
Straw											
	1994	332	2.42	5.26	3.17	2.91	5.26	4.03	3.53	3.34	4.10
	1995	635	2.83	4.43	4.55	5.21	4.43	4.95	4.51	4.29	5.29
	1996	406	2.91	6.01	5.19	5.22	6.01	6.47	6.32	5.49	6.31
	1997	352	2.26	5.47	5.37	3.74	5.47	5.73	5.42	4.49	5.40
	1998	395	3.17	4.78	4.29	4.09	4.78	4.29	4.45	4.12	4.64
	1999	219	0.49	1.72	0.73	0.69	1.72	1.16	0.67	0.96	0.96
	2000	218	0.79	1.10	0.79	0.70	1.10	0.86	0.81	0.87	0.89
	2001	496	5.11	5.59	5.89	6.08	5.59	5.72	6.37	5.71	6.07
	2002	322	2.45	2.89	2.47	2.88	2.86	3.43	2.99	2.92	2.98
	SEM				0.222					0.128	
	Mean		2.48	4.14	3.61	3.50	3.87	4.07	3.89	3.63	4.07
	SEM				0.074					0.043	

[1]*Two-course rotation: WW, wheat/wheat; WF, wheat/fallow; WL, wheat/lentil for seed and straw; WM, wheat/medic for grazing; WVG, wheat/vetch for grazing; WVH, wheat/vetch for hay; WVSS, wheat/vetch for seed and straw.*

[2]*Values are averages of three replicates.*

[3]*SEM: Standard error of mean*

Table 7. Yields (t/ha) of seed, straw and hay of lentil and vetch in rotation with wheat at Kamishly, northeast Syria during 1994-2002.

Seed/straw	[1]Rotation	Mean	[2]SEM	Range
Seed	Wheat/lentil	1.06	0.77	0.11-2.52
	Wheat/vetch	1.25	0.52	0.23-2.27
Straw	Wheat/lentil	2.88	1.087	0.68-4.89
	Wheat/vetch	3.29	1.282	0.69-5.40
Hay	Wheat/vetch	3.63	1.748	0.93-7.84

[1]*Values are averages of three replicates*

[2]*SEM: Standard error of mean*

Table 8. Soil organic carbon (OC, g/kg), total nitrogen (TN, g/kg) and available phosphorus (P, mg/kg) concentrations in different rotations at Kamishly, northeast Syria.

[1]Rotation	O C	TN	P
Wheat/wheat	1.99	1073	16.3
Wheat/fallow	1.67	970	14.8
Wheat/lentil	2.00	1132	14.9
Wheat/medic for grazing	2.02	1167	11.1
Wheat/vetch for grazing	1.97	1155	16.2
Wheat/vetch for hay	2.01	1175	17.6
Wheat/vetch for seed and straw	2.10	1197	16.6
[2]SEM	0.034	16.9	0.644

[1]*Values are averages of three field replicates*

[2]*SEM: Standard error of mean*

Table 9. Stocking rate (lambs per ha), grazing days, forage-on-offer (t DM/ha), daily gain (g/lamb), and live weight gain of weaned lambs grazing vetch in rotation with wheat at Kamishiy, northeast Syria.

Year	Stocking Rate	Grazing days	[1]Forage-on-offer Mean	[2]SEM	Daily gain Mean	SEM	Live weight Mean	SEM
1994-95	15	43	1.8	0.25	174	13.0	375	28.4
1995-96	20	66	2.3	0.17	131	6.1	549	31.5
1996-97	20	49	2.7	0.31	177	13.1	589	43.5
1997-98	30	43	2.7	0.47	181	1.2	398	12.9
1998-99	20	55	2.8	0.23	141	8.0	388	22.5
1999-00	20	23	0.9	0.05	151	2.5	85	6.4
2000-01	20	26	[3]Na	Na	208	7.7	180	6.8
2001-02	30	65	1.2	0.51	88	12.2	286	38.7
2002-03	30	39	3.0	0.74	87	25.9	169	51.5
Mean	24	45	2.83	1.19	144.7	42.8	23.4	3.97

[1]*Values are averages of three replications*

[2]*SEM: Standard error of mean*

[3]*Na: Data not available*

Table 10. Stocking rate (ewes per ha), grazing days, forage-on-offer (kg DM/ha), milk off-take and wool yields (kg/ha) of Awassi ewes grazing medic pasture in rotation with wheat at Kamishly, northeast Syria.

Year	Stocking rate	Grazing days	[1]Forage-on-offer Mean	[2]SEM	Milk off-take Mean	SEM	Wool Mean	SEM
1994-'95	12	127	3.2	0.49	428	28.1	22.4	3.36
1995-'96	12	149	4.7	0.45	417	22.8	28.4	3.38
1996-'97	12	122	4.0	1.01	632	48.5	21.1	2.71
1997-'98	24	65	3.9	0.89	528	75.2	17.6	0.83
1998-'99	24	127	4.1	0.83	623	57.5	25.9	1.21
1999-'00	24	46	2.3	0.20	492	71.3	21.9	1.51
2000-'01	[3]Na	Na	Na	Na	945	56.3	Na	Na
2001-'02	24	60	6.7	1.17	929	58.2	21.8	1.26
2002-'03	24	78	2.6	0.57	532	45.2	22.2	2.52
Mean	20	98	3.9	1.49	614	194.9	334	3.97

[1]*Values are averages of three replications*

[2]*SEM: Standard error of mean*

[3]*Na: Data not available*

Appendix

Staff list

Asamoah Larbi	Project Leader
Rafik Makboul	Research Assistant
Amin Khatib Salkini	Research Associate
Mohamed Bader Idlebi	Research Assistant
Adel Nasser	Research Assistant

Collaborators

- Armenian Agricultural Academy
- American University of Lebanon, Beirut, Lebanon
- Aleppo University, Syria
- Field Crops Research Institute, Ankara, Turkey
- Georgia Academy of Agricultural Sciences
- International Center for Advanced Mediterranean Agronomic Studies (CIHEAM)
- National Academy and Center of Agricultural Research, Kazakhstan
- National Agricultural Research and Extension Systems of Algeria, Egypt, Lebanon, Morocco
- Kyrgyz Agrarian Academy, Kyrgyzstan
- South Eastern Anatolia project
- Turkmen Agricultural University
- Uzbek Scientific Production Center of Agriculture, Uzbekistan

Donors

- Unrestricted core funds
- International Fund for Agricultural Development (IFAD)
- Systemwide Livestock Program
- Japan
- United State of America
- Food and Agricultural Organization

Students

Abdullah Al-Youssef, PhD Student, University of Aleppo, Syria

Users and beneficiaries

The immediate users are ICARDA's NARS partners. The ultimate beneficiaries are farmers and their families, through the sustainability of production systems and livelihoods and through provision of livestock feed, and rural and urban consumers.

Publications

Refereed publications

Yau, S. K., Bounejmate, M., Ryan, J., Baalbaki, R., Nassar, A. and Maacaroun, R. 2003. Barley-legumes rotations for semi-arid areas of Lebanon. European Journal of Agronomy 19:599-610.

Books

Khatib, A. 2003. Manual of identification of annual forage legumes: a simple key. NRMP, ICARDA, Aleppo, Syria.

Training activities

During 2003, the project continued to enhance the capacities of national counter parts as follows:

- A training course on "Taxonomic Keys of Annual Forage Legumes" was organized for two senior scientists from the Easton Anatolia Project (GAP) in Turkey, Dr Beybin Hacikamilogin from Haran University and Dr Ismail Gul from Dicle University, on 18-22 May 2003.
- Twelve agricultural engineers from the Syrian Ministry of Agriculture Station at Sweida were trained on how to establish a herbarium on July 9. Another group of 10 were trained on the same subject on July 13.

Training staff

Amin Khatib

PROJECT 2.4: REHABILITATION AND IMPROVED MANAGEMENT OF RANGELANDS IN DRY AREAS

Project rationale

Small ruminant flocks in the Central Asia and North Africa (CWANA) region are a source of livelihoods for the poor. However, increased degradation of natural resources, especially rangelands, is putting pressure on herders who now have to find alternative means of sustaining their flocks. In addition to forage during the spring growing season, rangelands in the semi-arid zones and in the margins of the rainfed-cropping zone supply low-cost forage during other critical seasons, such as when cereal crop stubble is not available.

Rangelands also provide households with fuel derived from shrubs that are harvested in significant numbers. Rangeland vegetation covers such vast land areas in CWANA that reversing degradation and increasing range plant biomass can contribute to enhanced carbon sequestration. The mission of this project is to improve the welfare of rangeland inhabitants in dry areas of developing countries, while preserving and enhancing the rangeland ecosystem.

Project purpose

The project aims to develop rehabilitation and management measures for rangelands which are sustainable, socially and environmentally acceptable and contribute significantly to increasing the supplies of feed for small ruminants and fuel wood in dry areas.

Specific objectives and outputs

- Develop management plans for rangelands.
- Develop low-cost techniques for land rehabilitation.
- Make an inventory of useful plant and vegetation resources.
- Assess methods of introducing fodder shrubs into rangelands.

Activity 1: ***Restoring production and ecological integrity to high-potential low-lying areas in the Syrian steppe***

Rangelands in the Middle East are in fragile zones, typically dominated by harsh environmental conditions. Rainfall is low and erratic, soils are shallow and poor, temperatures and evaporation rates are high. However, despite the long-term stability of the climate through the centuries, productivity and biodiversity decreased mostly during the first half of the last century. The reduced contribution of rangelands to livestock feed is mainly due to the tremendous increase in animal population. Other factors include the loss of traditional management tools, excessive harvesting of shrubs for fuel, changes in land tenure and conversion of rangeland to cropland.

About 50% of the soils in Syria are arid. Without irrigation these soils are not suitable to grow small grain crops (e.g. wheat and barley) in most years. Under the prevailing climatic conditions in Syria, these soils occur where the annual average of the rainfall drops below 200 mm. Computations for the water requirements of barley, a major rainfed crop in the steppe area, indicate that a minimum of 250 mm is needed to grow the crop. In the mid-1980s rainfed agriculture was expanded in the country to include large areas within the steppe, where Aridisols prevail. Rainfed agriculture in the Syrian steppe expanded from 36, 000 ha in 1982 to 218, 000 ha in 1985 and reaching 552, 000 ha in 1990. (Ilaiwi 1992).

Because of low and fluctuating rainfall patterns, attempts to cultivate the steppe areas have often been unsuccessful, except under irrigation. Consequently, many areas of rangeland that were opened to agriculture were abandoned and now have low vegetative cover and are, thus, subject to erosion (El-shorbagy 1998). Recurrent droughts and the unreliable rainfall results in large fluctuations in forage production.

Government policy in the Syrian steppe prohibits cultivation below the 200 mm rainfall isohyet mainly because when the high-potential low-lying basins are cultivated for barley, the fields are exposed to wind erosion in summer and autumn following the crop harvest. Since the implementation of this law in 1995, the areas on which formerly barley was grown have become infested with weedy annual plants, and are still vulnerable to erosion. The steppe communities that depended on these high-potential areas are under threat from declining productivity of the natural resources and instability of household incomes, and many households perceive emigration to the cropping zone as their only long-term option (Wachholtz 1996).

Perennial vegetation composed of a suitable mix of species should produce as much or more annual biomass than a barley crop, with less year-to-year fluctuation. Establishment costs for perennial vegetation is less than barley if direct seeding is feasible, since it would not need to be replanted annually. A combination of direct seeding and the planting of shrub seedlings may be necessary to enable the establishment of some species. Perennial vegetation should permit more water infiltration than can occur on cultivated ground, and be able to extract water from a greater volume of soil than a barley crop, thus extending growth into the summer and autumn seasons. Such vegetation, if properly managed, lasts very long.

Activity objectives

- Improve the productivity of the high-potential low-lying wadi basins in the arid zone of Syria for use by pastoral people on a sustainable basis.
- Test the value and acceptability of multi-purpose perennial vegetation as an alternative land use to either barley cultivation or land abandonment.
- Mitigate soil erosion and ecological deterioration.

Site selection

Three sites were selected in the provinces of Aleppo, Hama and Homs. The sites are located in the Syrian steppe where barley cultivation was practiced before 1995. Location of each site (Table 1) was recorded using the Global Positioning System (GPS).

An area of six hectares was selected and two separate experiments were conducted at each site.

- Different species planted as seedling transplants (transplanting experiment).
- Different species seeded directly with different sowing methods (seeding experiment).

1. Transplanting experiment: Eighteen species of different shrubs and grass seedlings were selected from both the ICARDA nursery and the steppe directorate materials (Table 2) and transplanted in January 2003 in furrows (500/shrub/ha at 10 meters apart, and 2 meters between seedlings within each furrow). A split-plot design was applied with two replications. Water harvesting structures were constructed after transplanting in half the area as the main plot. Survival and vigor of seedlings was observed in the first season. Biomass of transplants and volunteer vegetation between the rows will be measured next season.
2. Direct seeding experiment: Seedlings of *Atriplex halimus* were transplanted January 2003 from the steppe directorate nurseries in furrows of 10 meters apart and 2 meters between seedlings in each furrow to duplicate the shrub plantation environment used in the area. Rangeland species were planted between the *Atriplex* rows by two methods: 1) broadcasting seed, and 2) seeding in small pits designed to catch and hold precipitation on the site.

Preleminary results

Native vegetation

The native vegetation of the three sites was recorded and classified. Plant species were classified into four categories according to their abundance in each site (dominant, less dominant, few and rare).

Numbers of species recorded at the three sites were 33, 40 and 49 species, for Obissan, Wadi al Azib and Al Dao, respectively. The plant community of Obissan and Wadi al Azib was similar with *Poa bulbosa* present as the dominant species on both sites, while *Aizoon hispanicum* dominated at Al Dao site indicating soil salinity. Sheep do not like to feed on many of the species found at the three sites or can only be grazed when dry, (i.e. *Anabasis or Achillea sp*). Many species present are classified as medicinal plants.

Residual dry matter, June 2003
The amount of residual dry matter (RDM) from standing native vegetation at the end of the dry season was measured as an indication of site productivity. Native vegetation between the rows of the seedling experiment was estimated by direct clipping and weighing early in June using quadrate size 1 X 1 m for sampling the three sites. There was large variation between the three sites and within each site. Average dry matter was the highest in Wadi Al Azib site of the Hama steppe (797±192 kg/ha) while dry matter in AL Dao and Obissan sites was 362±367 and 578±382 kg/ha, respectively.

Plant vigor
Transplants were scored in June 2003 for the three sites (1 is the lowest and 10 highest). The plants displayed good vigor and very little dieback. Generally the highest score for plant vigor was for *Atriplex* species, which is adapted to the Syrian steppe. Grasses were dormant which may have been a reason for their lower rating. Vigor will be measured again in spring during active growth of all species.

Plant survival
The number of seedling from each species was counted for seedling survival in June 2003. Since the grasses were dormant in summer, survival was difficult to verify. Although the shrub *Salsola orientalis* from Uzbekistan had the lowest survival rate, shrubs overall had a success rate of nearly 90% (Table 2).

Activity 2: Intercropping barley between forage-shrub hedgerows

In the low rainfall areas of CWANA where the soils lack adequate nutrients for plant growth, barley is the most dominant crop, but productivity is low. As a result, the crop is rarely harvested: instead it is used for grazing. When the rains are adequate, or if the farmer uses supplimetal irrigation, the crop is harvested for grain and the straw is grazed as stubble. Barley straw is the most important crop residue used as feed, usually grazed in summer. Stubble grazing over a period of 90 to 120 days contributes about 25% of the annual feed requirements of sheep and goats in Syria and Jordan. However, the stubble has low nutritive value. There is, therefore, a need to introduce a new system of producing high quality fodder without jeopardizing grain production. A combination of cereal crops with wide-spaced hedgerows of drought-tolerant fodder shrubs can be one option. Fodder shrubs established in widely spaced rows (10-15 meters) within barley fields could help to improve the feed quantity and quality in marginal dry areas. They could also help to protect the soils from degradation. The stubble, in addition to being a source of metabolizable energy (ME) for sheep grazing, also provides nitrogen to the soil. This system could provide the following adavantages:

- The shrubs have a deeper rooting system using moisture not available to barley.
- Microclimate is changed reducing wind speed and erosion, lowering evapotranspiration, and moderating temperature extremes.
- Runoff is reduced when planted on the contour.
- The shrub is left to recover from previous defoliation while the cereal is growing (October to April); the over-browsing hazard is thus limited.
- The combination of energy-rich and protein-poor stubble is complemented by the energy-poor but nitrogen-rich shrubs.

Activity objectives

The objective of this work is to test the hypothesis that both quantity and quality of feed for small ruminants grazing on barley stubble can be improved by growing rows of shrubs (saltbush) within farmers' barley fields in the marginal areas of Aleppo steppe.

Results

Barley grain was measured at only two sites as farmers in the other sites planted different crops between the rows of *Atriplex*. In Kurbatieh, the barley grain production was similar between treatments, at 946 kg/ha and 968 kg/ha with and without *Atriplex* strips, respectively, but higher with *Atriplex* in Rashadyeh at 988 kg/ha compared to 620 kg/ha for barley alone. The flexibility of the system offers a wide range of options for the farmers. For instance, some farmers planted cumin, wheat, or even vetch between *Atriplex* as an alternative to barley depending on the market and the price of the crop.

Participatory technology evaluation (PTE)

During the spring of 2003, a field day was held in Khanasser to evaluate the intercropping technology with local farmers. The event provided a platform for farmers to interact with scientists and to see the technological and management options.

Objectives of the PTE

- Demonstrate, evaluate and discuss the role of saltbush (*Atriplex halimus*) when associated with barley and other field crops.
- Identify the factors that help expand the technology.
- Define the problems and new issues that farmers see as the focus for future research.

Farmer conclusions

Atriplex has multiple benefits. It is nutritious and palatable to sheep, protects the soil from wind erosion, provides green pastures in dry seasons, grows on salty soil, saves feed and increases soil fertility. The disadvantages are that it increases field rats and weeds. The obstacles to expansion of the region are the cost of cultivation, cost of protection, the fact that farmers have no experience in growing it, no information on where to get seedlings and lack of money to cover cultivation costs. It is planted on small scale, proportional to the owner's flock size. It can't be used as a cash crop by farmers with no sheep, it is only for herders. No one was willing to grow *Atriplex* if there without subsidy for fencing or plowing, or if no technical advice was provided. However, of the more than 9000 *Atriplex* seedlings planted during the last five years, none were removed by the farmers. This is an indication that the shrubs will be maintained for a long time if farmers are provided assistance during establishment. An alternative to intercropping may be to plant *Atriplex* to mark field boundaries, while providing an alternative source of feed at the same time.

References

El-Shorbagy, M. A. 1998. Impact of development programs on deterioration of rangeland resources in some African and Middle Eastern Countries. Chapter 5; In: Squires, V.R. & Sidahmed Hrsg (1998): Drylands: Sustainable Use of Rangelands into the Twenty-First Century; edit., A., p. 45-70, Rome.

Ilaiwi, M.1992. Soil of the Syrian Arab Republic. In Options Mediterraneennes. Serie B, n.34

Wachholtz, R.1996. Socio-economics of Bedouin farming systems in dry areas of Northern Syria. Stuttgart-Hohenhiem: Wissenschaftsverlag Vauk Kiel KG, Germany.

Table 1. Location of the three sites for range restoration in Syria.

Province	Site	Longitude	Latitude	Altitude
Homs	Al Dao	37, 55, 09.5	34, 31, 55.8	538
Hama	Wadi Al Azib	37, 36, 22.5	35, 22, 09.4	500
Aleppo	Obissan	37, 32, 19.7	35, 35, 43.5	312

Table 2. Vigor and percentage of survival for different species transplanted at three sites.

		Vigor (1-10)			% Survival		
Species	Origin	Palmyra	Hama	Aleppo	Palmyra	Hama	Aleppo
Artemisia herba-alba / 1	Ain Zarqa	4.0	8.0	6.5	95	99	87
Atriplex halimus-halimus / 3	Spain (Alhama)	7.5	6.8	5.8	100	97	87
Atriplex lentiformis / 1	USA (Maricopa)	8.0	7.5	6.5	98	96	93
Atriplex leucoclada / 1	T4 (Syria)	7.5	7.8	7.0	99	91	75
Atriplex torreyi / 1	USA	6.5	7.3	7.0	94	96	97
Oryzopsis miliacea / 1	Tel Hadya	6.0	8.0	6.0	98	94	95
Salsola orientalis / 1	Uzbekistan (Samarkand)	4.5	5.5	4.5	60	76	72
Agropyron elongatum	USA	5.5	7.3	5.8	97	97	94
Phalaris tuberosa	Syria	5.5	6.8	3.3	95	97	88
Festuca elatior	Morocco	4.5	6.0	4.0	94	99	94
Dactylis glomerata	Syria	6.0	7.5	4.0	78	95	95
Atriplex halimus	Tunisia	8.0	7.0	5.8	97	95	87
Atriplex halimus	Syrian Steppe(Deir-Ezzor)	3.5	8.0	6.5	46	99	98
Atriplex canescens	USA	4.5	8.5	6.5	76	95	94
Salsola vermiculata / 1	Maragha	7.5	7.0	6.5	97	96	97
Haloxylon aphyllum	Aleppo Steppe	6.0	7.5	6.0	95	96	83
Atriplex halimus (prostrate)	Aleppo Steppe	7.5	7.8	6.3	87	94	98
Atriplex halimus (erect)	Aleppo Steppe	7.5	7.5	7.5	95	100	95

APPENDIX

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Syria: British Embassy, Damascus

North Africa: Swiss Agency for Development and Cooperation (SDC)

Users and beneficiaries

Pastoralists and agropastoralists who live in the arid zone, NARS

Publications

Non-refereed

Tiedeman, James A. 2003. Grazing management for sustainable production of common use rangeland. Proceedings: Seminar on the Development of Feeding systems for Better Livestock Productivity, Asian Productivity Organization. 18-23 October 2003. Iran.

Training activities

GIS and Remote Sensing For Rangeland Management, Oujda, Morocco, 15-22 Dec 2003

Training staff

Mahyou, H.	(Laboratoire SIG et Télédétection, INRA Oujda)
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Maghreb Agropastoral Project Phase II Planning and Training Workshop, April 6-9, 2003, Settat Morocco

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(All country coordinators participated as trainers)

PROJECT 2.5: IMPROVEMENT OF SMALL RUMINANT PRODUCTION IN THE DRY AREAS

Project rationale

Over a wide range of dry agroecological niches, small ruminant production in the regions of West Asia and North Africa (WANA), and Central Asia and the Caucasus (CAC) contributes significantly to the livelihood of small-scale and resource-poor producers. However, the associated production systems are usually managed with low inputs and investment that translates into low productivity. A common limiting factor in all regions is feed scarcity, which is likely to be exacerbated by global climate changes. To counteract this problem, farmers attempt to integrate cropping and livestock enterprises, making use of crop residues and non-conventional sources of feed.

In CAC, this problem was exacerbated by the economic reforms that caused the disintegration of large production units into smallholdings, of markets and production support services including research and technology transfer. With a lack of markets for traditional products, i.e. pelts and wool, production stagnates and poverty increases. Since these regions have increasing population growth rates with expanded urban areas and markets, there is an increasing demand for livestock products which offers opportunities for productivity and income improvement, provided that appropriate production strategies are implemented, systems are diversified and production is re-orientated.

There is a need for market-oriented research to help farmers overcome production problems, increase productivity and re-orient/diversify production. Knowledge is needed about market opportunities and the current production system features for the better targeting of these opportunities. The development of suitable feeding strategies to make the best use of available feed in cropping areas is also required. This includes the integration of agroindustrial byproducts and non-conventional feeds into the feeding systems and adequate production strategies including the restoring of sustainable grazing systems wherever appropriate. Production strategies should be explored in anticipation of global changes that will impact these areas in critical usually dry periods. Thus, research on the ability of the breeds to produce under drought conditions is important and will address an equally important problem of management of animal genetic resources.

Project purpose

The project aims to improve the productivity of small ruminant production systems and add value to small ruminant products in the dry areas to increase farmers' incomes with a market-oriented and natural resource management approach, in partnership with NARS and producers.

Socioeconomic issues

Output 1: Assessment of markets and market opportunities for small ruminant products, identifying niches where small ruminants have a comparative advantage for a better orientation of the production systems

No activities reported but see 2.1.1.

Output 2: Characterization of small ruminant production systems and constraint analysis for better understanding of the processes involved and for improved targeting of research

Rationale

The production environments of CWANA are undergoing rapid and dynamic changes. Population increase, increased rural to urban migration, expansion of markets, acute water scarcity and increased drought vulnerability of degraded ranges, are, among others, factors that impose new challenges, opportunities and constraints. This translates into dramatic changes in the nature and condition of livestock production systems in the search for secure livelihoods and often leads to new production strategies and production diversification. There is, therefore, need to assess the new changes, trends and associated constraints in order to understand the nature of the process involved and better identify the areas where production improvement could be achieved through appropriate technological interventions and orientation.

Activity 2.1. Conduct constraint analysis and characterization of small ruminant production systems

Activity objective

To characterize small ruminant production systems, assess the constraints to production and identify appropriate areas of intervention for better targeting of small ruminant productivity improvement.

2.1.1. Constrains and opportunities of lamb fattening systems in Syria

A comprehensive rapid appraisal study of lamb fattening systems in seven provinces in Syria was initiated to identify the opportunities and constraints of fattening systems for improved income-generation and production diversification for livestock farmers.

Typologies of fattening systems

Five major fattening production systems of Awassi lambs were identified.
Salient production aspects: batch size, feeding and production constraints

Systems identified	Main features
1.Intensive fattening of lambs 3 to 12 months	- Situated around sheep markets in urban or peri-urban areas - High turnover of lambs - High number of lambs per batch - Intensive feeding often in closed padlocks - Middlemen and moneylenders are often engaged in these systems
2.Intensive fattening of culled ewes and older rams	- Specialized fatteners engage in fattening of older culled ewes and older rams (<12 months) for consumption by the army and for targeting celebrations such as like Eid and Ramadan
3.Semi-intensive fattening of lambs 3-12 months	- Often situated in peri-urban areas or in the desert with close access to main roads - Systems based on intensive feeding and assess to open areas (walking is the most common exercise). These systems have very little grazing incorporated - Depending on area, moneylenders from bigger cities are often involved in these systems
4.Semi-extensive fattening of lambs 3 to 6 months	- Opportunistic fattening in terms of fattening own lambs if prices are favorable - Typically systems engaged in by Bedouins to sell excess lambs with added value - Lambs are reared with their mothers, feed concentrates and grazed until the age of 6 months - System is based on seasonal lambing, mostly occurring from December to March
5.Alternative fattening bought cheap at markets	-Intensive fattening of sick lambs and culled ewes

The average number of lambs in a fattening batch was 268 (ranging 70-1000) and the average number of batches for fattening per year was 2.7. Depending on the province and distance to major markets, fatteners engage in different types of fattening: a) as a sole business activity and/or b) to sell excess lambs for added value. Some farmers buy all the lambs at once to constitute a batch and others buy additional lambs to add to their own lambs to constitute a profitable batch size. The existing fattening systems rely heavily on concentrates, especially barley, wheat bran, legume straw and cotton seed cake, usually at a high cost according to availability and climate (drought or wet year).

Main constraints in most fattening systems included: 1) feeding costs and 2) health problems of lambs. A clear need to reduce feeding costs and develop low-cost and effective strategies to minimize health problems was identified.

Marketing and income aspects

Fattened lambs are mainly sold as live animals in the many urban and peri-urban markets around the country through middlemen, who in turn resell the lambs to local markets or to bigger entrepreneurs that market in the Gulf areas. Fatteners prefer to target bigger markets for two reasons: 1) live animals are weighed on scales and not estimated by eye assessment, and 2) the presence of major takers for export to the Gulf states where the highest returns are made.

Farmers engaged in fattening manage their livelihood on the basis of a mix of opportunities for income generation. Although farmers expressed that their income from fattening was either high or medium, 56% had an alternative income source besides fattening. Alternative income was mostly generated from agricultural related activities such as cropping, transport of animals and feeds and selling of feedstuffs.

Conclusions

- Intensive fattening is profitable, fits well with other income generating activities and offers an interesting option for poor producers.
- Feeding costs and health problems are key constraints addressed by farmers. While reduction of feeding costs would be easier to achieve provided that a large variety of feed resources is available in a given place, the minimization of health problems could be beyond solely research.
- There is a need to assess the inter-relationships between middlemen and fatteners, the informal lending systems and other elements governing lamb marketing in and out the country.

2.1.2. *Characterization of cotton crop residue (CCR) utilization, a feed resource used by sheep producers in Syria*

Due to the scarcity of feed, Syrian farmers are intensively interacting with cropping areas and use CCR as a source of fodder in their feeding strategies. Little is known about the features of this utilization.

During October-November 2002, livestock producers (n=52) in cotton production areas of Aleppo, Idleb, Hama and Homs provinces were interviewed to learn about CCR utilization by small ruminants and the perceptions of farmers regarding CCR-Aleppo (56%), Idleb (25%), Hama (13%) and Homs (6%).

CCR integrates the feeding calendar

CCR grazing integrates the annual feeding calendar of farmers. The majority of farmers (86%) use CCR fields after the grazing of stubble. Most of these farmers (92%) indicated that the CCR grazing period lasts for 35-60 days, after which they return with their flocks to their villages to feed the animals on straw, grains and concentrates including CSM and wheat bran. It was revealed that during CCR grazing period, 85% of the ewes in the flocks were in their last period of pregnancy and 15% were still under mating.

The value of CCR perceived by farmers

The general agreement was that CCR are nutritious, improve productivity, make the flock healthier and are of low cost.

Farmers (73%) estimated that CCR grazing contributes to about 30% of the feeding of animals during this period and that this contribution saves 90% of total feeding costs. While the majority (85%) of farmers did not provide supplements to their animals during CCR grazing, some (15%) provided a small amount of supplement consisting of barley grain and wheat bran. This supplementation takes place according to the availability of CCR. Interestingly, 90% of livestock owners had experienced that the results of CCR grazing could be improved by supplementation with combinations of ingredients such as CSM, grains, wheat bran, sugar beet pulp, cotton seeds and dried bread.

In collecting the perceptions of landowners, it was clear that a mutually beneficial relationship is established through grazing their CCR with flock owners. Most (87%) of landowners expressed that this activity provides additional income, and allows lower collecting costs of the residues from fields.

Features of the grazing management

Cotton crop owners and flock owners develop an agreement, as indicated by most users of CCR (92%), in consideration of the rent price, the number of sheep in the flock and the time when grazing starts. The rent price of CCR fields that averaged SL3,500 (US$70), is negotiated on the basis of the following factors (in order of importance):

1) Quantity and quality of CCR (quantities of green bursting and leaves),
2) Availability of CCR areas,
3) Number of flocks moved to the CCR areas, and
4) Availability of other crop residues for grazing.

Factors affecting grazing grazing of CCR include:

1) High rent price (in 90% of the cases), particularly if large numbers of flocks were moved to CCR areas for grazing, affects usage of CCR grazing.
2) If the crop was sprayed by chemical or irrigated by salty water, farmer's do not use CCR fields even if they are offered free (65% of respondents).
3) If the CCR fields are small or the distance from the camping site to the fields is excessively long (15% of respondents), farmers may not use CCR grazing.

From the point of view of landowners, CCR fields could be excluded from grazing, 1) particularly if exorbitant rent is asked (76% of the cases), 2) because of fear of contamination by weed seeds (15% of the cases) or 3) simply the difficulty to access the fields (9% of the cases).

The most preferred number of sheep to be grazed per ha for a period of 30 days is 90, as indicated by the majority of the livestock owners (86%). The remaining residues (stems and dried bursting balls) are collected after the end of grazing and burnt (100%). While most farmers (92%) indicated that at the end of grazing the remaining CCR have no feeding value, some (8%) expressed that the feeding value can be improved by chopping the residues.

While most farmers (90%) preferred to graze their animals in the mornings and the evenings, the remaining farmers preferred to graze them at night (65%) or at noon (45%). Most farmers (76%) claimed that their animals grazing on CCR gained weight at a rate of approximately 3 kg/month while some farmers (10%) claimed that the animals maintained their weight. Most of the interviewed owners (87%) claimed no health problems during grazing.

Farmers' information validated by field observations identified the following list of parts of plants and grasses from the most to the least palatable in a CCR field:

1) Green, soft and notorious (highly palatable),
2) Flowers (highly palatable),
3) Green leaves, bursting ball with seed fibers and small branches (palatable),
4) Grasses under the cotton crop, highly notorious, and
5) Stems, big branches, dried leaves and dried bursting balls (usually not eaten by sheep).

Most flock (62%) owners usually move to CCR areas on the basis of experience in previous years, about 24% move to these areas by searching and only a small fraction (14%) on information collected from friends and relatives.

Farmers do not experience serious difficulties during CCR grazing, except those associated with long distance travel and regular health problems.

Conclusions

- CCR grazing can be considered as an integral part of a large number of small ruminant production systems in Syria that mutually benefits livestock farmers and landowners.
- CCR is perceived as an excellent source of fodder by farmers who claim that sheep eventually increase weight and do not have health problems.
- It remains to be explored whether the use of chemicals in the cropping cycle has an effect on the quality of the meat and milk products.

Output conclusions

- Increased market demand and feed scarcity are forcing Syrian farmers to develop innovative ways: in the first case to re-orient production and then to change production system features.
- Fattening is a diversification option that targets the increased demand for lamb meat in West Asia and has the potential to benefit poor farmers provided that capital is available to them. The high costs of feed and animal health problems are critical constraints faced by farmers that require research consideration. Equally important aspects include identification of appropriate local and regional arrangements that could affect the trade, interrelationships among farmers, intermediaries and traders and community action to target investment opportunities.
- Moved by the need to feed their animals and out of their own initiative, farmers have developed solid knowledge on the integration of grazing of crop residues such as cotton into their feeding systems. Cotton crop residues have excellent fodder quality that fit well into the feeding system.

On-farm research

Output 3: Testing of technologies to improve small ruminant productivity and farmers' income integrated in adaptive market-oriented research

Rationale

Suitable technologies are available to improve animal productivity in the dry areas; however, farmers have limited access particularly to systems evolving to different levels of intensification and entrepreneurial organization. Many technologies failed to be adopted due to the lack of a market orientation and an adaptive process to evaluate not only their suitability but also their behavior under specific production constraints with active end-user participation. The technologies which improve production in a given place may not be suitable in another place and may require modifications. These modifications could be straightforward and could be worked out on-farm on the basis of the prevailing constraints, but some may require more complex approaches. An adaptive interdisciplinary mechanism to link strategic/basic research outputs to farm production with the direct involvement of farmers and extension agents is, therefore, necessary.

Due to the peculiarities of dry areas, priority is placed on technologies oriented to improve the feeding systems and flock management. Research in animal diseases in the area of small ruminant production in the dry areas has been limited and also requires attention. A key aspect is the monitoring of production that helps researchers to understand better the very nature of production bottlenecks, missed opportunities and also the behavior of the technologies being tested.

Activity 3.1. Organization of on-farm adaptive research networks for technology testing and production monitoring, with active participation of farmers in CWANA

Activity objective

Low-cost, productivity-increasing and resource-conserving technologies for small ruminant production systems are on-farm tested with the simultaneous participation of researchers, farmers and extension agents, and production is monitored to identify key constraints and assess on-farm behavior of technologies.

3.1.1. Participatory research tools in implementing technologies to improve sheep management in northern Syria

Participatory research tools are being adopted by the project to improve effectiveness in community-based research and technology testing. To this end, the village of Kherbet El-Dib[1] was selected to target strategic feeding of ewes during late pregnancy. The village depends mainly on barley crop and sheep production.

Problem diagnosis and priority setting

A multidisciplinary team from ICARDA and the extension service visited the village in October 2002 to discuss with the community aspects of the production systems. Farmers identified the main constrains to production, and agreed that low income from sheep production impacted negatively on their livelihoods. They recognized that this was the result of low productivity as a consequence of the following factors: shortage of feed, reduction of natural grazing land, low milk yields, low lamb growth rates, low lamb birth weight, abortion, some abnormally born lambs, disease and parasite problems and low fertility. After organizing these factors in four categories-health, genetic, nutrition and administration-farmers agreed that sheep nutrition was a factor that needed urgent attention.

Furthermore, farmers indicated that the main reasons for deficient nutrition included high feeding costs and/or low purchasing power. On the possibilty to reduce feeding costs, all farmers agreed that such a task is rather difficult and concluded that it will be worthwhile to experiment trials addressing the issue. The community members then agreed to conduct a participatory feeding trial in partnership with ICARDA researchers to economically compare two feeding regimes, the traditional and strategic feeding at late pregnancy suggested by ICARDA as a technological option.

The trial

Four farmers were selected by the community to participate in a trial of strategic feeding of pregnant ewes during late gestation to contrast with the traditional feeding of pregnant ewes under which each farmer fed his/her flock following their own selection of feeds. Traditional feeding does not provide a balanced diet (minerals are not supplied regularly, vitamins are not used and feeds may change according to market availability), in addition, farmers could end up feeding more or less than what is actually needed by the ewes with implications on cost and production.

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[1] *Located in Zone 3 (with ~200 mm rainfall per year), El Bab area of Aleppo district, an important area of sheep milk production in Northern Syria.*

Farmers weighed their 168 ewes and randomly divided them into two groups (treatments): the first to follow the traditional feeding and the second to follow strategic feeding. Only 81 lambed ewes that received the traditional (n=47) or the strategic ration (n=82) for 50-70 days during late pregnancy were monitored. The suggested diet was formulated to contain 9.7 MJ (ME) and 140 g/kg of CP and prepared by farmers under the supervision of the extension officer and ICARDA in accordance to feed requirements of pregnant ewes for which purpose farmers were timely trained. The feeding trial lasted for 50-70 days. All ewes were weighed at the start of the trial in October and 24 hours after lambing, and all lambs weighed at birth and at weaning. Bulk milk production of each treatment group was measured daily for 123 days only in the morning during suckling time and twice a day after weaning.

Flock feed intake during late pregnancy (last 60 days of pregnancy) was measured under both treatments and the associated costs recorded and expressed on per head basis (Table 1). One farmer (flock I) overfed his ewes with implications on costs, while the rest underfed their ewes. The strategic average feeding cost was 37 SL per ewe over the traditional feeding.

Table 1. Total feeding costs in Syrian Lira per treatment per flock and per head.

Flock	Strategic feeding	Traditional feeding
I	429	505
II	440	350
III	424	376
IV	414	327
Mean	426.7	389.5

All ewes under strategic feeding increased their weight, accumulating reserves for lactation ($P<0.05$) (Table 2). The farmer overfeeding his animals (I) benefited from weight increases; however, the benefit obtained was less than that promoted by strategic feeding, although the difference was not significant ($P>0.05$). This was because he used an unbalanced ration, thus the implications of the traditional feeding reflected on cost and production. The underfeeding under the traditional system implied in Table 1 was reflected in losses of weight in flocks II-IV ($P<0.05$).

Table 2. Mean body weight changes (kg) taken as the difference in weight at the start of the trial 60 days before and after lambing.

Flock	Suggested	Traditional
I	6.5a	4.5a
II	1.6a	-2.5a
III	5.6a	0.0b
IV	1.6a	-0.8a
Overall[1]	3.3a	-0.8b

[1] Least square estimates adjusted by the initial weight as a covariate and flocks and treatments as fixed effects. In the analysis the flock effect was significant (P<0.05)
Only means with different accompanying letters in each row differ (P<0.05)

Though in each flock heavier lambs were produced by strategic feeding as opposed to traditional feeding, reflecting known effects of timely feeding during late pregnancy, these differences were not significant (P>0.05). In general, strategic feeding resulted into 0.3 more kg of lamb birth weight over the traditional system (P<0.05). After lambing, lambs coped well with any initial difference in body weight such that at weaning lambs of both groups did not differ. Moreover, all lambs survived till weaning in both groups.

In spite of the significant differences shown in ewe weight changes, farmers did not see significant improvements in production with regard to lamb production till weaning. This was mainly because the flocks usually receive extra feeding which was sufficient to equate the weights of the growing lambs. However, farmers observed important differences in bulk milk productivity. In fact, an increase of 12.5 kg of milk production per ewe fed was obtained due to strategic feeding.

The net average revenue per ewe due to the technological intervention was 218 SL per ewe (range 42-504 SL/ewe) at an extra cost of 37 SL per ewe. Farmers of flocks I and III were among those that achieved the largest revenue per ewe. The average income was 218 SL/ewe, thus in an average flock of 50 ewes the application of this technology could generate 10,875 SL (approximately US$217).

Conclusions

- Participatory research tools facilitated a better understanding of the farmer's problems and processes affecting production and identification of researchable issues. Farmers contributed substantially to the research process while finding out practical solutions to their own problems.
- Strategic feeding for improving productivity is a concept that was easily introduced in the farm environment. Farmers were able to understand the benefits and the economic implications directly.

- The application of strategic feeding during the last third of the pregnancy period has a positive impact on milk productivity and thus income.

3.1.2. Participatory research tools used in an experiment using vetch grazing for lactating ewes

Grazing in zone 2 (250-300 mm of rainfall) in Syria is limited because of shortage of rangelands and shortage or lack of fallow land for spring grazing in view of continuous barley cropping. Vetch (*Vicia sativa*) can be grown in this area in rotation with barley and provides spring grazing opportunities during April and May for lactating ewes.

A participatory trial was conducted with farmers to economically compare milk production and live-weight changes of milking ewes under traditional feeding and under the feeding on vetch at green stage. The trial was conducted on the farm of Mameq Shikho who owned 59 mature ewes. The farmer and ICARDA research team selected 28 weaned ewes and randomly allocated them into 2 groups, each consisting of 14 ewes. The first group was solely grazed on vetch on a fenced vetch field of 0.8 ha and the second was fed traditionally on concentrates and straw in addition to limited mountain grazing. Vetch grazing started on 2 April 2003 and lasted 47 days at a stocking rate of 17.5 ewes/ha. Farmers recorded milk production, feed costs and any other associated costs incurred in both treatments.

Ewes fed on vetch gained 4.1 kg on average as opposed to only 1.5 kg/head in the case of the traditional feeding (Table 3). Thus, as expected the ewes recovered more rapidly from gestation and lactation.

Table 3. Effects of the treatments on weight changes of ewes.

Treatment	Start weight, kg	End weight, kg	Difference, kg	Daily gain, g
Traditional	43.6	45.1	1.5	31
Vetch grazing	45.3	49.4	4.1	83.5
Significance	(ns)	p=0.057	p=0.018	p=0.018

Individual ewe milk (milk control) records were taken four times during the experiment on 29 March and April 4, 10 and 23. Farmers weighed the milk in the presence of ICARDA scientists. Total milk production exceeded 12 kg per ewe due to solely vetch grazing in addition to a higher content of fat, an important component in milk processing (Table 4). Milk production was the main component of revenues obtained.

Table 4. Milk production and composition per treatment.

Treatment	Milk production		Milk composition (g/kg)						
	Total[1] kg/ewe	Daily g/ewe	Fat	Total solids	SnF	Crude protein	Lactose	DM	Ash
Vetch grazing	45.5	968	53.1	169.4	116.4	59 1	50.3	164.3	55.0
Traditional Feeding	34.2	727	60.3	175.5	115.2	61.0	47.2	175.1	48.9
Probability		0.012	0.025	Ns	ns	Ns	ns	0.021	0.028

[1] *During 47 days.*
ns: P>0.05.
SnF: non-fat solids

The application of vetch grazing led to a revenue of 4674 SL per plot of 0.8 ha or 5842.5 SL/ha, that is, 34% more than the traditional feeding that costs SL 4400. Notice that the improved fertility of the field for the next crop is linked to the vetch option, which was not taken into account in the calculation of the net income obtained.

Conclusions

- Farmers can easily participate in labor-intensive research such as recording of milk production. This issue could improve research where production monitoring of animals is needed.
- The realization of the benefits of vetch grazing, a technology proposed in the past by ICARDA with low adoption rate, seems more effective if farmers participate in the entire process i.e. production of vetch, its utilization and the assessment of its impact in improving milk production.
- Further research is required to assess whether the inclusion of some level of supplementation to vetch grazing will produce larger differences in milk production. The assessment of the benefits of vetch in the next cropping systems should also be incorporated in a more complex participatory design.

Output conclusions

The application of participatory tools in technology testing facilitates the introduction of technological changes to the farm environment. However, the participation of farmers during the analysis of results and economics requires careful consideration. Livestock production is a complex operation that involves interlinked steps such that in some cases events observed in a given moment will influence events in another period with even greater impact. These relationships should be taken into consideration during the analysis of effects in the season they are applied and also beyond the trial (i.e. the effect of grazing vetch fields in spring that could have an impact on the reproduction of ewes later in the incoming fall or on the fertility of the soil for the following year's cropping).

Failure to link these aspects may be a reason for lack of adoption of certain technologies with carry-over effects.

Milk processing and transformation

Output 4: **Assessment and testing of technologies involving transformation of primary products (i.e. to process milk into milk derivatives such as cheese and yogurt) that capitalizes on added value for farmers' income enhancement**

No activities reported.

Research on genetic diversity

Output 5: **Production and genetic characterization of small ruminant breeds in CWANA, along with characterization of their production and market environments**

No activities reported.

Output 6: **Assessment of the biological and economic feasibility of the utilization of feeding/management strategies to improve small ruminant feeding systems and target better market opportunities in West Asia**

Rationale

Small ruminant production in WANA is evolving under a declining contribution of rangelands to the animal diets, because of overgrazing and degradation, in contrast to an increased demand for animal products, mainly milk and meat, by expanded markets. In this production context, livestock production systems are progressively intensifying, relying more on interactions with the cropping zone and the use of supplements and concentrates that have implications for feeding costs. Therefore, technological options for farmers to access valuable nutrients to feed their animals at low cost are urgently needed. This requires the exploration of non-conventional sources of feeding and suitable feeding strategies. Intensive production also requires adequate management practices with regard to reproduction to produce in periods of better opportunities. Out-of-season production, for instance, can tap on seasonal niches paying more for demanded products otherwise produced in fixed periods of the year. To this end, the potentials of the breed and new managerial strategies to capture and maximize profits are justified.

Activity 6.1. ***Studies on the biological and economic feasibility of the use of non-conventional feedstuffs and byproducts in small ruminant feeding systems in West Asia***

Activity objectives

To develop and assess technologies that involve the utilization of non-conventional feedstuffs and byproducts for improved feeding systems; improved management for out-of-season production, and utilization of adaptive traits for improved productivity.

6.1.1. The use of CCR by farmers and exploring possibilities for improving its feeding value

During the fall (October-November) of 2002, a series of trials on cotton crop residue (CCR) were conducted at ICARDA to observe feed intake and to estimate the effect of grazing CCR on the weight of animals.

Intake

Seven random samples each consisting of 18 plants/m^2 were collected for chemical composition analysis. Results of this analysis are reported in Table 5. Consistent with farmers' perceptions, dried material and stems were the least nutritious parts of the residues, while green parts and tops offered reasonable amounts per ha as well as more nutrients. Though in smaller quantities, the underneath grasses complemented the CCR diet.

Table 5. Yield (kg/ha) and chemical composition of CCR (mean of 7 samples).

Plant parts and grasses	Yield kg/ha	Ash	ADF	CP %DM	DMD	DOMD	ME MJ per kg
Bursting ball (green)	1280	4.21	34.19	12.87	54.92	52.84	7.93
Tops, leaves and small branches	22, 000	16.84	15.18	9.79	54.52	47.31	7.10
Bursting ball (dry)	3400	11.58	47.75	5.09	24.49	19.95	2.99
Stems	4900	4.50	56.31	3.88	35.07	28.80	4.32
Grasses (underneath)	1500	20.53	25.76	9.57	55.08	41.47	6.22

[1]*sample = 18 plants/m^2*

Moreover, twelve Awassi wethers (mean live weight 48 kg) were used in a feeding trial at ICARDA's sheep facility to estimate intake. The animals were fed ad libitum for 35 days on collected CCR from the sampled cotton fields. The feeding material included tops, flowers, leaves, small branches and green bursting balls with seed fiber.

The results of voluntary feed intake, digestibility and weight changes confirmed the chemical analysis conducted in the samples and showed a rather high level of intake per head and slight positive weight gain (113g/day/head) over the 35 days of the trial, which also validated the perception by farmers of an increase in weight when animals graze on CCR. The CCR had a high feeding value (CP 9% and ME 7.5 M, calculated from Table 5) and, considering the DM content, it was consumed at a rate of 3.6% of body weight.

Recordings on grazing flocks

From October to November 2002, six grazing flocks were monitored in three different locations in northern Syria, in locations 15 km away from Tel Hadya, during periods of 17 to 35 days. Agreements were made with farmers to tag a sub-sample of animals and for the monitoring of changes of weight in the tagged animals. Goats where included in the monitoring because of the incidence of this species in the flocks. The animals were kept by farmers under the usual management conditions and on solely CCR grazing. The locations, animals and grazing periods with results of changes in weights are shown in Table 6.

Table 6. Live weight (LW) changes of small ruminants grazing on CCR at different locations in Aleppo province (October-November 2002).

Grazing location sand species	Number of animals	Grazing period (days)	Live weight (kg) Initial (SE)	Final (SE)	Total gain, kg	Daily weight gain per head (g)	Origin of flock
Sheep							
Barkohum	22	35	36.9 (7.86)	42.7 (10.36)	5.8	166	Hama
Barkohum	15	28	40.5 (10.48)	43.3 (10.83)	2.8	100	Homs
Barkohum	15	28	44.4 (11.45)	49.0 (18.49)	4.6	164	Hama
Barkohum	17	28	45.5 (11.02)	48.7 (13.51)	3.2	114	Aleppo
Tel el Nabaris	19	27	48.7 (12.17)	52.7 (13.34)	4.0	148	Aleppo
Zetain	20	17	51.7 (11.57)	53.9 (12.34)	2.2	129	Aleppo
Mean	18	27	44.6	48.4	3.8	141	
Goats							
Barkohum	3	35	32.6 (18.85)	38.6 (26.54)	6.0	171	Hama
Tel el Nabaris	34	23	44.0 (8.13)	47.3 (8.25)	3.3	143	Aleppo
Zetain	5	17	54.7 (24.48)	56.8 (25.37)	2.1	124	Aleppo
Mean	14	25	43.8	47.5	3.7	148	

In parenthesis SE.

In all cases, animals were moved from stubble grazing fields or from vegetable residues or sugar beet residues in different locations in Aleppo, Hama or Homs provinces. All monitored sheep and goats showed weight gains increasing at a rate of 141 g/head/day and 148 g/head/day, respectively, which confirms the farmers' perceptions and preferences and the results in Table 5.

Improving the feeding of CCR

During November 2002-January 2003, the remaining parts of CCR in fields near ICARDA were collected, after being grazed by sheep. This material included mainly woody parts, bursting balls, cobs, dried leaves and big branches. The residues were chopped by machine (3-4 cm), treated with urea (10%) and molasses (20%) and ensiled for 35 days.

The results of the chemical analysis of treated and untreated samples are provided in Table 7. Treated residues increased their CP levels five times more than the untreated CCR, likewise DMD levels of treated residues improved by 60% and ME by 85% more than the untreated CCR. This result suggests that there is potential to significantly improve CCR grazing with the provision of combinations of urea-molasses during grazing.

Table 7. Effects of treating different crop residues with urea and molasses on feed quality.

	DM	Ash	ADF	CP	DMD	DOMD	ME
Treatments	-----	-----	-----	-----% DM	-----	-----	----MJ kg----
CCR	93.71	8.06	51.11	5.18	28.32	23.32	3.50
CCR treated[1]	90.49	8.16	39.39	25.99	45.33	43.24	6.49

[1] *additives (10% urea and 20% molasses)*

Conclusions

- The analysis of the nutritive value of CCR validates farmers' perceptions. Furthermore, a grazing trial conducted with farmers revealed that in all cases animals gained weight during an average of 27 days of observation in the field.
- Ensiling residues with urea and molasses notably improves the feeding value of this product suggesting that a molasses-urea block administered to sheep during grazing CCR could enhance its feeding value and thus the productivity of sheep.

6.1.2 Studies of udder morphology of Awassi ewes in search of predictors to identify highly producing animals

Different Awassi genotypes are being evaluated at ICARDA's experimental flock for several traits related to milk production, including the actual recording of milk production, udder linear measurements and exploring for aids to rapid identification of highly producing animals in the flock.

Ewes are evaluated on the 70th day of lactation during the normal milk season occurring after the lambs are born in January. At this time milk production is recorded and the linear measurements taken approximately 7 hours after morning milking. The linear measurements involved are shown in Figure 1.

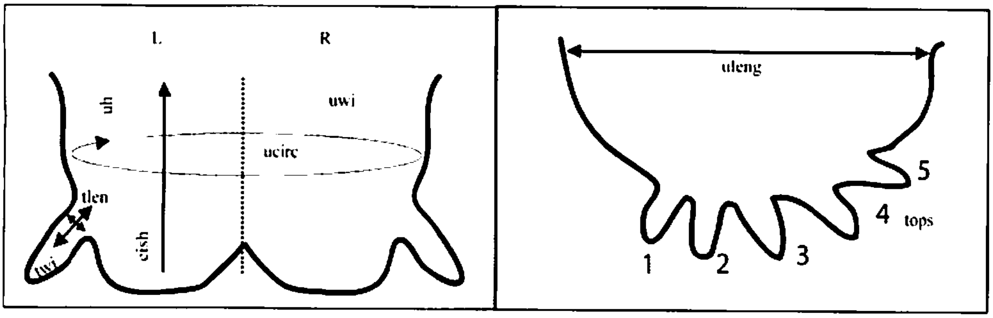

Figure 1. Different udder linear measurements (left and right frames) and five categories associated to different teat types.

Table 8 summarizes the raw averages of this evaluation in a line of Syrian Awassi sheep (S), Turkish Awassi (T) and the compounded reciprocal crosses of these two genotypes (SxT).

Table 8. Different udder linear measurements (in cm) and teat scores of Awassi sheep at day 70 of the lactation period.

	Class	Ucirc	Uwi	Uleng	Uh		Cish		Tlen		Twi		Tpos	
					L	R	L	R	L	R	L	R	L	R
Mean	S	39.8	13.6	10.9	21.4	21.2	4.3	4.1	3.4	3.6	2.2	2.2	2.5	2.5
	S×T	39.3	13.3	10.8	20.5	20.5	4.0	3.7	3.5	3.6	2.3	2.3	2.7	2.8
	T	38.5	13.4	10.6	22.3	21.9	4.5	3.7	3.6	3.6	2.3	2.3	3.0	3.2
Min	S	20.5	9.2	5.9	15.2	14.9	1.6	1.7	2	2	1.2	1.2	2	2
	S×T	27.5	9.2	8.2	14.2	14.5	1.6	1.7	2	2.5	1.5	1.7	2	2
	T	24	10.4	8.9	18	18.2	2.4	2.1	2.8	3	1.6	1.6	2	2
Max	S	50	18.4	15	29.5	26.8	7.8	6.8	5.2	7.1	3.5	3.5	4	4
	S×T	46	15.7	13.2	24.7	24.3	7.1	5.5	5.1	5.5	3	3.2	4	5
	T	44.5	16.6	12.6	24.5	23.8	7.1	5.5	5	4.6	3.3	3	5	5
SD	S	4.63	1.8	1.7	2.7	2.5	1.2	1	0.7	0.9	0.4	0.5	0.6	0.6
	S×T	4.17	1.6	1.2	2.6	2.4	1.2	1.2	0.8	0.8	0.4	0.4	0.6	0.7
	T	5.75	1.6	1.2	2.0	1.7	1.5	1.2	0.7	0.5	0.5	0.4	0.6	0.8
CV (%)	S	12	13	15	12	12	28	25	21	24	20	21	23	23
	S×T	11	12	11	13	12	30	32	21	21	16	18	20	25
	T	15	12	11	9	8	33	31	18	14	23	19	27	24
N	S	94												
	S×T	23												
	T	16												

SD: Standard deviation.

Most of the measured traits were similar across genotypes. Larger variations were in general observed in teat length and higher variations seemed to occur in Syrian sheep.

Teats are variable in shape and small in length and width. The teats are inserted and projected in different directions, not only from the bottom of the udder but also from its sides, which makes milking difficult. The most desirable score for a teat (tpos) that will facilitate milking, particularly mechanical milking, is 3, a position slightly cranial. Teats of Awassi sheep seem close to this position and tend to be slightly vertical. T animals showed a slightly wider variation in teat type. In contrast, S and SxT animals have comparatively more type 3.

The raw means of milk production at day 70 of lactation and its composition are presented in Table 9, without correcting for lactation or age of the ewe. T ewes produced about 22% more than S ewes and 26% more than SxT ewes. Notice also in Table 9 that crosses apparently produced slightly richer milk, as macro components are higher than those of S and T ewes, a trend that should be inspected after accounting for the animal's age.

Table 9. Milk yield (g) per ewe and milk composition (%) of Awassi sheep at day 70.

Genotype and statistics		Milk yield, g	% Fat	% Protein	% Lactose	% SnF
SxS	Average	861.2	6.67	4.79	6.85	12.64
	Count	94	89	89	89	89
	Min	100[1]	3.68	3.62	5.13	9.52
	Max	1750	17.73	6.99	9.87	18.34
	Standard deviation	328.8	2.91	0.78	1.07	1.99
SxT	Average	832.6	7.27	5.05	7.25	13.36
	Count	23	20	20	20	20
	Min	0	3.82	3.90	5.56	10.29
	Max	1750	12.94	6.16	8.71	16.16
	Standard deviation	393.6	2.76	0.69	0.96	1.77
TxT	Average	1050.0	6.80	4.64	6.52	12.28
	Count	16	16	16	16	16
	Min	450	3.76	3.70	3.73	9.85
	Max	1750	12.42	6.63	9.36	17.39
	Standard deviation	433.6	2.69	0.94	1.49	2.45

[1] *Only one animal that was in milking condition in the previous milk control was measured having 100 g milk yield in day 70.*

Note:at day 70th there could be animals that were not producing milk anymore which recorded 0 production or could be producing 150 g which was considered as the lower limit to milk.

While half of the T ewes produced over a kg of milk on day 70, only 1/3 of the S and SxT animals had this production level showing the large production capacity of T ewes. Similarly almost half of the S and SxT ewes produced less than 800 g/day.

Correlation estimates among traits larger than 0.45, disregarding the sign, were included in Table 10. Udder circumference was highly correlated (r ranging 0.62-0.90) with its component udder width and udder height, and definitely more associated with width than with height. Total milk production was moderately associated with udder circumference and with the components of the latter (r ranging 0.47-0.49). The association with udder circumference and its components with milk production at day 70 (the same day the measurement were made) was higher than with total milk production. Therefore, these measurements are relatively good predictors of the milk production of the ewe and could serve to identify highly producing ewes more rapidly.

There was a very marked correlation between teat width and length. The intra-genotype estimates were very similar, except that a larger degree of association was evident in SxT and T animals. It is not clear whether this could be due to the less number of animals involved or differences associated with more milk production in ewes having T breeding.

Table 10. Correlation between udder measurements and commercial milk production at day 70.

Correlation	All	S	SxT	T
SM vs MP	0.77	0.71	0.88	0.85
SM vs Ucirc	0.49	0.48	0.52	0.71
SM vs Uwi	0.48	0.49	0.52	0.63
SM vs Uh	0.47	0.45	0.51	0.73
MP vs Ucirc	0.57	0.58	0.54	0.72
MP vs Uwi	0.60	0.59	0.62	0.79
MP vs Uh	0.60	0.58	0.66	0.64
Ucirc x Uwi	0.78	0.76	0.90	0.80
Ucirc x Uh	0.62	0.64	0.70	0.61
Uwi vs Uh	0.61	0.62	0.62	0.52
Uh vs Cish	0.54	0.51	0.58	0.74
Tlen vs Twi	0.80	0.80	0.81	0.84

Conclusions

- Udder measurements could help to assess very rapidly the milk production potential of ewes and are thus useful tools for screening of highly productive animals. Relatively high correlations (r ranging 0.57-0.6) were found between

total milk production and udder circumference, udder width and udder height.
- Considerable variation was found in milk production and in teat shape. The differences found among genotypes suggest that this difference is somehow due to genetic factors and that could be subject to selection.

Output conclusions
- Evaluations of CCR have validated the assertions made by farmers regarding feed quality and have shown the possibility to improve the feed value of this resource if treatment with urea and molasses is considered. This could significantly enhance the benefits of grazing on CCR.
- It appears that the recording of some linear measurements after weaning could be used as predictors of milk production, addressing the need to count on tools to rapidly identify highly producing dairy ewes. However, if possible, the fewer animals recording the largest linear measurement should also be milked to obtain individual observation of milk production on the observation day or following days.

APPENDIX

Staff list

Luis Iniguez:	Project Manager
Monika Zaklouta:	Animal Laboratory Manager
Muhi El Din Hilali:	Milk Technologist and Animal Research Facility Manager
Safouh Rihawi:	Animal Nutrition Scientist
Adnan Termanini:	Research Associate
Azusa Fukuki:	Research Associate, socioeconomic studies
Birgitte Hartwell:	Junior Professional Officer (DANIDA program) in the area of research on production systems
Sota Kobayashi:	Veterinarian. JICA Volunteer Program, until March 2003
Tsuyoshi Takahashi:	Animal Nutritionist. JICA Volunteer Program, until July 2003
Inger Waldhauer:	Junior Professional Officer (DANIDA program) in the area of milk transformation research, until December 2003
Mohamed Haylani:	Lab Technician
Maha Addas:	Lab Technician
Ahmed Sawas:	Technician
Ghazan Jesri:	Consultant Veterinarian

Collaborators

- ILRI in the development of a joint research project funded by IFAD on small ruminant epidemiology in WANA.
- The Macaulay Land Use Research Institute (UK) through Dr R. Orskov on feeding strategies for the dry areas and framework of a research activity in exploiting adaptive traits of sheep for improving feeding systems for CWANA, and Dr I. Wright in analyzing long-term trials of crop livestock production.
- DANIDA through two JPOs from Denmark working now at ICARDA in the area of small ruminant production in the dry areas.
- The Royal Veterinary and Agricultural University of Denmark (KVL), in developing a collaborative research plan in the area of animal production and health.
- The University of Wisconsin, Madison, through Dr Dave Thomas in the area of sheep breeding in Central Asia.
- NARS of Central Asia and the Caucasus, including: Kazakhstan (National Academic, Center of Agricultural Research); Kyrgyzstan (Kyrgyz Agrarian Academy); Turkmenistan (Ministry of Agriculture, Turkmen Agricultural University); Uzbekistan (Uzbek Scientific Production Center of Agriculture-USPCA), Armenia (Ministry of Agriculture and Armenian

Agricultural Academy); Azerbaijan (Ministry of Agriculture, Livestock Research Institute, Ganja); and Georgia (Georgian Academy of Agricultural Sciences and Georgian State Zootechnical-Veterinary Academy).

- NARS from 11 countries of WANA (Morocco, Algeria, Tunisia, Egypt, Jordan. Iran, Iraq, Syria, Lebanon, Turkey and Cyprus) in the study of characterization of breeds.
- The Department of Livestock Sciences, University of Natural Resources and Applied Life Science (BOKU), Vienna, Austria, through a recently-developed research collaboration on livestock production in WANA.

Donors

- Government of Japan
- International Fund for Agricultural Development (IFAD)
- CGIAR Systemwide Livestock Program
- CGIAR Systemwide Genetic Resources Program
- The Government of Austria
- Danish International Development Agency

Publications

Non-refereed publications

ICARDA. 2002. Improving incomes of small-scale producers in low rainfall areas in northern Syria.

Research Highlights. 2002. Natural Resource Management Program. 4pp. (manuscript).

Waldhauer, I. 2003. Dairy processing booklet for Syria. Natural Resource Management Program. ICARDA. 48pp. (manuscript).

Waldhauer, I and L. Iniguez. 2003. Applied dairy technology in Syria. Report on findings from a country-wide household survey. Natural Resource Management Program. ICARDA. 62 pp. (manuscript).

Training materials

Technologies to improve the production of dairy sheep. A training CD. Natural Resource Management Program. ICARDA.

Training activities

- Twenty Bedouin women trained on milk processing by ICARDA milk technology research team during a one-week workshop organized by FAO in early January in Talila, Palmyra, Syria.

- Three professionals affiliated to the Finland Agricultural Research Project in Egypt were trained in several aspects of small ruminant production for two days in early March.
- Safouh Rihawi participated as a trainer in two training courses organized by ICARDA's Agrobiodiversity Project, 1) in early March in Amman, Jordan, on utilization of agricultural by-products and feed blocks in sheep feeding (10 people from different countries attended this workshop), and 2) in late March in Sweida, Syria, on livestock management and nutrition (20 farmers of the area attended the workshop).
- Twelve farmers from the Al-Bab area participated in a training workshop held in April at ICARDA's small ruminant facility on aspects of flock management, milking and milk transformation, under the project "Improving Income of Small Scale Producers in Low Rainfall Areas in Northern Syria."
- As an activity of the ICARDA/GAP Project, Safouh Rihawi conducted a course on feeding strategies, including the use of feed blocks, straw ammoniation and strategic feeding, to cope with critical periods affecting the feeding systems in the GAP region in Urfa, Turkey. In addition, the experimental framework for the use of feed blocks and ammoniated straw in strategic feeding was established. Participants included farmers, technicians and extension officers from the GAP region.

Meetings in relation with project administration and research development

- The fourth and last Steering Committee meeting of the project "Integrated Feed and Livestock Production in the Steppes of Central Asia," was held in Tashkent, Uzbekistan, in early March. The meeting discussed the steps to be followed to secure a second phase of the project for which a proposal was presented in January.
- The First Steering Committee meeting of the project "Strengthening Institutional Capacity to Improve Marketing of Small Ruminant Products and Income Generation in Dry Areas of Latin America," was held in late September in Recife, Brazil. Research activities to be conducted in dry areas of Brazil and Mexico were launched.
- A regional conference on "Policies and Technology Options for Livestock Development in Central Asia and Caucasus" was conducted in Tashkent in early October to present the technological developments achieved during ICARDA's research work in Central Asia. This conference overlapped with the mission review for the "Integrated Feed and Livestock Production in the Steppes of Central.

PROJECT 3.1: WATER RESOURCE CONSERVATION AND MANAGEMENT FOR AGRICULTURAL PRODUCTION IN DRY AREAS

Project rationale

Water resources in the dry areas are very limited. The annual supply is about 1250 m^3 compared to the world average of 7500 m^3 per capita. Rainfall is generally low, unpredictable and variable in time and space. More than 75% of the water resources are used for agriculture, but this share is decreasing due to continuous diversion to higher priority sectors such as domestic and industrial. While water for agriculture is decreasing, the demand for food is increasing mainly because of the rapid population growth. To overcome this problem, a more efficient capture and use of the scarce water resource is needed. Research is needed to optimize the management of rainfall, fresh and marginal-water resources in the dry areas.

ICARDA's research activities on water are aimed at optimizing supplemental irrigation in rainfed areas, promoting water harvesting in drier environments, increasing water-use efficiency in irrigation, utilizing sustainable marginal-water, developing cultivars that can thrive in scarce-water conditions and building the capacity of NARS in water resources management.

Project purpose

- To develop improved technologies and management options for rainfall, conventional and non-conventional water resources in order to attain higher water-use efficiency and sustainable agricultural production.

Outputs

Output 1: Methodologies, recommendations and information available to the NARS on efficient capture, storage and utilization of rainwater through water harvesting and integrated watershed management

Activity 1.1: Evaluation of strip-crop water harvesting with drought resistant barley varieties and vetch species in Khanasser Valley, Syria.

Activity 1.2: Participatory and controlled research on micro-catchments for olive trees in Khanasser Valley, Syria.

Activity 1.3: Evaluation of water harvesting techniques for establishment of fruit trees and fodder shrubs in northern Syria.

Activity 1.4: Establishment of water-harvesting and watershed management for UNCCD pilot projects in Jordan, Lebanon, Syria, and Yemen for combating desertification in West Asia.

Activity 1.5: GIS-based modeling to support watershed management in the arid regions of Tunisia.

Activity 1.6: Community-based integrated natural resource management research in three small watersheds in the mountain terraces of Yemen.

Activity 1.7: Development of low-cost and farmer-friendly soil and water conservation structures and micro-catchments water-harvesting techniques for establishment of fodder shrubs and trees in Barani Village Development Project, Pakistan.

Activity 1.8: Review of indigenous water harvesting systems in West Asia and North Africa.

Activity 1.9: Inventory study and development of regional database on sustainable water management in West Asia (Sub-Regional Action Program (SRAP) to Combat Desertification and Drought in West Asia-TN1).

Activity 1.8: Review of indigenous water harvesting systems in West Asia and North Africa

Activity objectives

In the drier environments of WANA, rain does not supply sufficient water to grow a crop. Since time immemorial, people inhabiting these dry environments have used different techniques to efficiently collect and use rainfall and surface runoff. To improve the use and adaptation of these traditional water-harvesting practices a better understanding of these systems is necessary. To achieve this, field surveys and review studies were undertaken in nine countries in the region.

Brief activity conclusions

The studies undertaken in Egypt, Iraq, Jordan, Libya, Morocco, Pakistan, Syria, Tunisia, and Yemen revealed a wealth of indigenous water harvesting systems in the WANA region. Whereas some systems, although often under different local names, could be found in most countries, other systems were found in only a few countries. A document was developed that mapped and described these practices in the different countries. The document reviewed the current use and future perspectives of these traditional water-harvesting practices.

Activity 1.9: Inventory study and development of regional database on sustainable water management in West Asia (Sub-Regional Action Program (SRAP) to Combat Desertification and Drought in West Asia-TN1)

Activity objectives

The project had the following specific objectives:

- To conduct an inventory on the institutions, projects, personnel and findings associated with water resources use in combating desertification.
- To provide a dynamic database with information from member countries on water resources management activities accessible to all users.
- To allow all Focal Point members and stakeholders to use the database and utilize the information to develop and conduct activities within TN1 in West Asia.
- To develop projects for pilot activities on water resources within TN1.

Brief activity conclusion

The study has achieved all the expected outputs.

Output 2: Optimal strategies and practices for using limited water resources conjunctively with rainfall in rainfed agriculture

Activity 2.1: Strategic research on supplemental irrigation of wheat varieties in Syria.

Activity 2.2: Optimization of furrow irrigation systems for supplemental irri gation of wheat in northern Syria.

Activity 2.3: Development of optimal supplemental irrigation management options for lentil under Mediterranean environment.

Activity 2.4: Development of supplemental irrigation and nitrogen application recommendations for bread wheat production in the Highlands of Iran.

Activity 2.3: Development of optimal supplemental irrigation management options for lentil under Mediterranean environment

Activity objectives

In the Mediterranean region, winter-sown lentil often experiences drought stress during the reproductive growth stage, resulting in poor yields. Supplemental irrigation (SI) can stabilize the productivity of lentil. But with increasing water scarcity in the region, water-use efficiency is a major concern. An experiment was carried out at ICARDA's main station at Tel Hadya (Aleppo, northern Syria) during the cropping seasons 1996/97 to 1999/2000 to develop recommendations on sowing dates and supplemental irrigation schedules for lentil.

The experiment included three sowing dates (early: mid-November; normal: late December to mid-January; and late: late January to mid-February) and four levels of SI (full SI, 2/3 SI, 1/3 SI, and no SI, i.e. rainfed). Lentil cultivar ILL 5883 was grown in rotation with wheat, which acted as a cover crop. Soil moisture was measured using a neutron probe at 0.15-m intervals up to a depth of 1.6 m. Irrigation was applied to all plots when the full SI treatment had lost 50% of it's available moisture. The full SI plot was filled back up to field capacity, with the other treatments receiving 2/3 and 1/3 of the full irrigation amount. In all four seasons, SI was not needed before mid-March. In three seasons out of four, irrigation was only needed after the beginning of April. During the wet 1996/1997 season, only one irrigation was applied in the beginning of May for both the early and late sowing dates.

Brief activity conclusions
Biomass production increased with water application from 4.27 t/ha for the rainfed crop to 6.2 t/ha for full SI. The overall mean grain yield of 1.04 t/ha under rainfed conditions increased to 1.42 t/ha (at 1/3 SI), 1.69 t/ha (at 2/3 SI) and 1.81 t/ha (full SI). Overall mean water productivity was 0.44 kg grain/m^3 water (rainfed), 0.54 kg/m^3 (1/3 SI), 0.6 kg/m^3 (2/3 SI) and 0.58 kg/m^3 (full SI). Results indicated that a 2/3 SI level gives the optimum water productivity for both grain and biomass under SI.

Sowing date had the greatest impact on crop response under rainfed conditions. Early sowing of lentil increased biomass: 6.13 t/ha (early); 5.66 t/ha (normal); and 4.57 t/ha (late). Biomass water productivity followed a similar trend, from 2.05 kg/m^3 (early), 1.97 kg/m^3 (normal), to 1.79 kg/m^3 (late). However, the highest grain yield was obtained at the normal (1.6 t/ha) as compared to the early (1.4 t/ha) and late (1.51 t/ha) sowing dates. Grain water productivity under SI decreased with the earliness of sowing-from 0.59 kg/m^3 (late) to 0.47 kg/m^3 (early). There was a significant interaction between season and sowing date for both grain and biomass production.

Evapotranspiration (ET), computed from the soil moisture measurements during the season, was consistently lower for the rainfed lentil, compared to the irrigated treatments. The ET values for the rainfed treatments ranged from 177 mm during the dry 1999/2000 season (225 mm rain) to 285 mm during the wet 1996/1997 season (420 mm), averaged over the three sowing dates. Thus, additional moisture remained in the profile. Some of this residual soil moisture evaporates from the soil surface and from deep cracks in the root zone during the dry and hot summer, and some carries over to the following cropping season. The effective root depth of lentil is relatively shallow (0.80 m), therefore any subsequent, deep-rooted, crop will be able to benefit from this 'carryover' moisture.

Linear relationships were found to be the most suitable for relating grain yield (Y_g) and biomass yield (Y_b) to field water supply, W_{r+i} (rainwater + irrigation), with Y_g and Y_b the combined means over all sowing date treatments. The resulting production functions for grain and biomass yield, respectively, were:

$Y_g = 0.0041\ Wr{+}i{-}0.249$ ($r^2 = 0.64$)

$Y_b = 0.0142\ Wr{+}i{-}0.306$ ($r^2 = 0.74$)

Activity 2.4: Development of supplemental irrigation and nitrogen application recommendations for bread wheat production in the highlands of Iran

Activity objectives

Rainfed cropping in the highlands of WANA coincides with the severely cold winter with snow from November to April. Cereal yields are low and variable mainly as a result of inadequate and erratic seasonal rainfall and associated agronomic factors such as late sowing or late crop emergence. In an area where water is limited, small amounts of supplemental irrigation water can make up for the deficits in seasonal rain and produce satisfactory and sustainable yields. The objective of this study was to increase production of bread wheat in the rainfed areas of Iranian highlands by better management of SI and through identifying the amounts and time of application of water and nitrogen to increase the efficiency of their use.

A field study was conducted on a deep silt-clay soil in northwest Iran during 1999-2002. The study included four SI levels (rainfed, 1/3, 2/3 and full irrigation requirements) combined with different N rates (0, 30, 60, 90 and 120 kg/ha) with the wheat variety 'Sabalan.' Precipitation varied from 228 mm in 1999/2000 to 382 mm in 2001/20002.

Brief activity conclusions

Results indicated that addition of only limited irrigation (1/3 of full irrigation) significantly increased yields and maximized water-use efficiency. The distribution of rainfall throughout the season had an important effect on crop yield. A small amount of SI (40-50 mm) after planting in October could have a critical effect on crop yields by providing an adequate crop stand before the winter frost. Water-use efficiency of the rainfed crop varied from 0.15 kg/m^3 to 0.43 kg/m^3, with the lower efficiency, recorded in the wet 2001/2002 season, caused by severe drought in spring. During this season, WUE reached 2.96 kg/m^3

at the 1/3 SI treatment. With irrigation, crop responses to nitrogen were generally significant up to 60 kg N/ha. For the rainfed crops there was no increase beyond 30 kg N/ha.

Output 3: **Water management packages for sustainably optimizing on-farm water-use efficiency particularly in irrigated areas**

Activity 3.1: Research trials to improve water-use efficiency for various crops, soils, irrigation and management systems in Central Asia.

Activity 3.2: Use of automated climate stations and information technology for improving water-use efficiency.

Activity 3.2: ***Use of automated climate stations and information technology for improving water-use efficiency***

Activity objectives

On irrigated land, the decision on how much water to apply, and when, has a direct effect on crop yields and water-use efficiency. This decision depends on many factors, with soil water content being one of the most important. There is, however, no method available to measure volumetric soil water content which meets the ideals of simplicity, accuracy, ease of use, and low cost. An alternative approach is to estimate irrigation water requirements from meteorological data. The objective of this activity is to develop a generic tool for posting up-to-date irrigation advice for selected sites on the internet, based on research knowledge and data from automated weather stations.

Research progress

Software was developed to automatically dial weather stations, which are connected through a modem and telephone line. Data are automatically downloaded and daily updates of weather data are posted on the internet. A simple water-balance model, which estimates soil water content based on generic soil properties, meteorological data, and crop growth and characteristics, was selected for computing irrigation water requirements. The water balance model was evaluated using data from supplemental irrigation trials from Tel-Hadya, Syria.

Output 4: Strategies, methods and techniques for the safe and sustainable use of non-conventional water resources in agriculture

Activity 4.1: Research trials on the use of saline water and treated wastewater for irrigated agriculture in Central Asia.
Activity 4.2: Salinity tolerance screening of forage and legume varieties.
Activity 4.3: Review of cyclic strategy for the use of saline-sodic water in agriculture.

Activity 4.3: Review of cyclic strategy for the use of saline-sodic water in agriculture

Brief activity conclusions

With supplies of good-quality water decreasing due to increased municipal-industrial-agricultural-environmental competition, irrigated agriculture has to become more efficient and inventive. The use and reuse of saline and/or sodic drainage water does not only provide agriculture with an important irrigation water resource, but it also encourages the disposal of drainage water within the regions where it is generated rather than exporting this water to other regions by discharge into main irrigation canals, local streams, or rivers.

The cyclic strategy involves the use of saline-sodic and high-quality (nonsaline-nonsodic) irrigation water in crop rotations that include both moderately salt-sensitive and salt-tolerant crops. Typically, the high-quality water is used before planting and during initial growth stages of the salt-tolerant crop while saline water is mainly used after seedling establishment. Therefore, such a strategy requires a crop rotation plan that can make best use of the available high- and poor-quality waters, and takes into account the different salt sensitivities among the crops grown in the region, including the changes in salt sensitivities of crops at different stages of growth. The cyclic use of saline-sodic water may also be practiced at suitable times of the year during the growth cycle of perennial crops and trees.

The advantages of cyclic strategy when compared with other strategies such as blending of high- and poor-quality waters include:

(1) Steady-state salinity conditions in the soil profile are never reached because the quality of irrigation water changes over time,
(2) Soil salinity is kept lower over time, especially in the topsoil during seedling establishment,

(3) A broad range of crops, including those with high economic-value and moderate salt sensitivity, can be grown in rotation with salt-tolerant crops, and
(4) Conventional irrigation systems can be used.

Studies carried out under field conditions involving cyclic use of saline-sodic water have shown promise and allowed a good degree of flexibility to fit different situations as described below. One limitation of the cyclic strategy is that the drainage water must be collected and kept separate from the primary water supply, i.e., it requires storage when it cannot be used for irrigation.

The interaction between soil and irrigation water management under different levels of salinity and sodicity will continue to be a challenge for researchers and farmers. There is a need to inform the farming community that the occurrence of salinity and sodicity problems does not mark the end of being able to use the soil and/or drainage water for crop production. Thus, there would be a need to strengthen linkages among researchers working at international and national institutions, farm advisors, and farmers for quick adoption of useful research information by farmers, and transfer of research needs of farmers to researchers for their attention. These linkages will continue to be needed and fostered as the use of saline-sodic water and salt-affected soils becomes more common.

Output 5: Methods for assessing the safe utilization of renewable groundwater resources in agriculture

Activity 5.1: Assessment of groundwater resources and management in Khanasser Valley, Syria

Research progress
(See KVIRS Report.)

Output 6: Strengthened capacity of national research, extension and management personnel and greater public and governmental awareness of the importance of water conservation and management issues

Activity 6.1: Training course on planning and management of water resources for the Ministry of Irrigation, SAR, January 5-16, 2003, Aleppo, Syria.
Activity 6.2: Training course on biosaline agriculture and sustainable production

systems, 12-21 May 2003, Tashkent, Uzbekistan - in cooperation with the International Center for Biosaline Agriculture (ICBA).

Activity 6.3: Training course on management of water resources and improvement of water-use efficiency in the dry areas. May 5-June 12, 2003, Aleppo, Syria. Co-sponsored by JICA and the Syrian State Board of Planning.

Activity 6.3: Training course on management of water resources and improvement of water-use efficiency in the dry areas. May 5-June 12, 2003, Aleppo, Syria. Co-sponsored by JICA and the Syrian State Board of Planning

Brief activity conclusions

This was the second year of the training course on the "Management of Water Resources and Improvement of Water-Use Efficiency in the Dry Areas." Many ICARDA staff contributed to making this six-week course a successful learning experience for the 28 trainees from 16 different countries. Practical sessions were scheduled throughout the course, so that the trainees could directly practice and apply what they heard and discussed in the lectures.

During the first week, the trainees were introduced to the cornerstones of Integrated Natural Resource Management (INRM) by Dr Richard Thomas. The design and implementation of a wide variety of water harvesting methods and techniques for improving water-use efficiency in the dry areas was presented by Dr Theib Oweis and Dr Ahmed Hachum. A visit to ICARDA's water-harvesting research and demonstration site generated discussion and practical questions. New and old techniques for the measurement of climate parameters and theoretical aspects and use of agroclimatology were presented by Dr Eddy de Pauw and Mr Mohamed Salem.

The second week of the course introduced the trainees to various aspects of water-use efficiency and water management. Dr Theib Oweis and Dr Ahmed Hachum presented all research and practical issues related to supplemental irrigation and on-farm water management. The trainees also went to the field to learn the use of a neutron probe for soil measurements. They practiced the computation of water balances using the data from the neutron probe measurements in the computer lab. ICARDA's agronomy group took the trainees to the field for plant sampling and subsequent analysis in the agronomy lab.

Lectures on agronomic aspects of water-use efficiency in dry areas, such as crop rotations, tillage, stubble management, and soil fertility and fertilizer use were presented by Dr Mustafa Pala and Dr John Ryan. Mr Akhtar Ali explained the concepts of watershed hydrology and runoff measurements for improving water management in dry areas. Dr Adriana Bruggeman lectured on rainfall measurement and analysis and the use of Excel spreadsheets for various water management issues. Dr Murari Singh provided the trainees with a practical introduction to design and analysis for water resources experiments.

Most afternoons during the second and third week were spent in the computer lab, where the trainees received a practical introduction to scientific use of computers. Guided by the professional instructions from Mr David Abbas, the trainees also learned to work with PowerPoint for the preparation of professional presentations. Thus equipped, the trainees prepared computer presentations on the water resources and their research in their own countries. The country presentations generated a lot of interesting questions and discussions among the participants.

Week four was focused on socioeconomic issues, GIS, soil conservation and land management. Stakeholder analysis, gender aspects and participatory problem diagnosis were explained and discussed by Dr Ahmed Mazid and Dr Malika Martini. Dr Aden Aw-Hassan and Mr Hisham Salahieh instructed the trainees in the use of Excel for crop budgets and technology evaluation in the computer lab. Mr Adekunle Ibiyemi presented an overview of GIS resources and GIS applications for INRM. The nature and causes of erosion and soil and water conservation options for dry areas were explained and discussed by Dr Francis Turkelboom and Dr Zuhair Masri. Finally, a long and hot day was spent in Khanasser Valley under the guidance of Mr Alois Klewinghaus and Dr Zuhair Masri, to practice erosion surveying and design of soil conservation techniques.

Teamwork was required during the final two weeks of the course. The trainees worked in teams of two to apply their newly acquired knowledge and skills. First, they interviewed farmers in a nearby village to understand the local problems, perspectives, and economics. Using data from research experiments at Tel Hadya, they then computed the water-use efficiency of wheat for different sowing dates, fertilizer, and supplemental irrigation rates. They also conducted an economic analysis. Finally, the trainees prepared an irrigation schedule for a selected crop in their own country. It was clear from the final scientific presentations that the trainees went back home with a lot of new knowledge and skills to tackle the water problems in their countries.

APPENDIX

Staff list

- Theib Oweis: Water Management Specialist, Project Manager
- Adriana Bruggeman: Agricultural Hydrologist
- Manzoor Qadir: Marginal Water Scientist (joined October 2003)
- Assadullah Al Ajmi: (until June 2003)
- Akhtar Ali: Water Resources Engineer
- Ahmed Hachum: Irrigation and Water Management, Consultant
- Akmal Karimov: Soil and Water Management, National Professional Officer, Central Asia
- Jihad Abdullah: Research Assistant
- Ali Haj Dibo: Research Assistant
- Issam Halimeh: Research Assistant
- Ahmed Hamwieh: Research Assistant
- Pierre Hayek: Research Assistant

Students

Lawand Hussein, Geerte van der Meijden, Rhalia Abdu Majid, Biniam Constantinos Berhe

Collaborators

- NARS of CWANA
- CGIAR Centers (IWMI, ICRISAT, CIAT, IRRI, IFRI)
- CIHEAM-IAM Bari
- CIHEAM-IAM Zaragoza
- INRA-France (Greenion and Avenion)
- Purdue University, West Lafayette, Indiana
- Noragric, Agricultural University of Norway
- Vrije Universiteit, Amsterdam, The Netherlands
- Wageningen University, Wageningen, The Netherlands

Donors

- ADB, AFESD, IFAD, BMZ, GM-UNCCD, OPEC, IDRC, IFAD, JICA, USAID

Users and beneficiaries

Farmers and NARS of CWANA

Publications

Refereed publications

Tavakkoli, A.R and Theib Y. Oweis. 2003. The role of supplemental irrigation and nitrogen in producing bread wheat in the highlands of Iran. Agricultural Water Management.

Oweis, T. Y. and Hachum, A. Y. 2003. Farming where there's no water. LEISA Magazine, June 2003.

Oweis, T. Y. and Hachum, A. Y. 2003. Water-use efficiency of winter-sown chickpea under supplemental irrigation in a Mediterranean environment. Agricultural Water Management (in press).

Books

Rossi, G., Cancelliere, A., Pereira, L.S., Oweis, T., Shatanawi, M. and Zairi, A. (eds.). 2003. Tools for drought mitigation in Mediterranean regions. p. 259-272. Kluwer Academic Publishers, Dordrect, The Netherlands.

Chapter in Books

El-Beltagy, A. and Oweis, T. 2003. Sustainable management of scarce water resources in dry areas. In UN book on fresh water. UN, New York.

Oweis, T., Rodrigues, P.N. and Pereira, L.S. 2003. Simulation of supplemental irrigation strategies for wheat in near east to cope with water scarcity. Tools for Drought Mitigation in Mediterranean regions p. 259-272. Rossi, G. Cancelliere, A. Pereira, L.S. Oweis, T. Shatanawi, M. Zairi, A. (eds.).

Oweis, T.Y., and Hachum, A.Y. ICARDA, Aleppo (Syria) University of Mosul, Mosul (Iraq). 2003. Improving water productivity in the dry areas of West Asia and North Africa. Water Productivity in Agriculture: Limits and Opportunities for Improvement p. 179-198. Comprehensive Assessment of Water Management in Agriculture Series. Kijne, J.W. Barker, R. Molden, D. (eds.).

Oweis, T.Y. and Hachum, A.Y. 2002. New approaches to manage scarce water resources in agriculture. Proceedings of Second International Agronomy Congress on Balancing Food and Environment Security- A Continuing Challenge. Vol. 2. New Delhi, India, Nov. 26-30, 2002.

Non-refereed

Bruggeman, A. and Oweis, T. 2003. ICARDA's water program. Water Co-operation in Syria. Proceedings of the Seminar. Damascus, 28-29 January 2003. Abstract.

Bruggeman, A., Hamdy, A., Touchan, H., Karajeh, F. and Oweis, T. 2003. Screening of some chickpea genotypes for salinity tolerance in a Mediterranean environment. Options Mediterraneennes.

ICARDA-UNCCD. 2003. SRAP-TN1 report. Inventory study and regional database on sustainable water management in West Asia (SRAP-TN1). ICARDA, Aleppo, Syria.

Karajeh, F., Hamdy, A., Bruggeman, A., Touchan, H. and Oweis, T. 2003. In vitro salinity tolerance screening of some legumes and forages cultivars. Options Mediterraneennes.

Oweis, T. and Kobori, I. ICARDA, Aleppo (Syria) United Nations University, Tokyo (Japan). 2003. Indigenous water management knowledge: from traditional to modern technology. Sustainable development and management of dry lands in the 21st century: Abstracts Seventh International Conference on Development of Dry Lands. 14-17 Sept 2003, Tehran, Iran. p. 61. ICARDA, Aleppo, Syria. ICARDA Japan Abstract.

Qadir, M., Oweis, T. and Bruggeman, A. ICARDA, Aleppo (Syria). 2003. Agricultural management of saline-sodic waters through cyclic application with good-quality waters. Proceedings of the International Workshop on Sustainable Strategies for Irrigation in Salt-prone Mediterranean Regions: A System Approach. 8-10 December 2003, Cairo, Egypt. p. 349-357. ISBN 1 903741 08 4 (CD-ROM edition). ISBN 1 903741 07 6 (Printed edition). R. Ragab (ed). Centre for Ecology & Hydrology, Wallingford, UK.

Tavakkoli, R., Oweis, T., Pala, M., Abdol-Rahmani, B., Maleki, A.H., Gaffari, A., Rahimzadehand, R. and Ketata, H. ICARDA, Aleppo (Syria) Dryland Agricultural Research Center, Maragheh (Iran). 2003. Evaluation of supplemental irrigation and nitrogen rates for winter wheat (var. Sabalan) in rainfed conditions. Sustainable development and management of dry lands in the 21st century: abstracts Seventh International Conference on Development of Dry Lands. 14-17 Sept 2003, Tehran, Iran. p. 133. (En). ICARDA, Aleppo, Syria. ICARDA Iran Poster Abstract.

Other Products

Bruggeman et al. 2003. Management of water resources and improvement of water-use efficiency in the dry areas. Training materials, CD-ROM. ICARDA, Aleppo, Syria.

Training activities

See output 6.

PROJECT 3.2: KHANASSER VALLEY INTEGRATED RESEARCH SITE (KVIRS) 'AN INTEGRATED APPROACH TO SUSTAINABLE LAND MANAGEMENT IN DRY AREAS'

COORDINATED BY PROJECT 3.2, WITH CONTRIBUTIONS FROM PROJECTS 2.2, 2.3, 2.4, 2.5, 3.1, 3.2, 3.4, 4.1, 4.2, AECS AND BONN UNIVERSITY

Introduction

The Khanasser Valley has been selected by ICARDA as an integrated research site to address problems that are characteristic of marginal dryland environments of CWANA. The occurrence of natural resources degradation, the diversity and dynamics of livelihoods, the prevailing poverty and the relative easy accessibility were the main factors in the choice of Khanasser as a benchmark site. Khanasser Valley is located approximately 80 km southeast of Aleppo city, and the study area covers 453 km^2. The agricultural area and the natural rangelands of the steppe meet in the valley (200 mm/year is considered the boundary between the two areas).

Here we report on the activities of the third year of the KVIRS project, which is funded by BMZ, Germany (total duration is 4 years). During 2003, the major focus was on farmer participatory research with several farmer interest groups. The INRM framework was further operationalised.

Objectives of KVIRS

Goal/vision of KVIRS

Livelihood improvement of land users and sustainable management of natural resources in the marginal dry areas.

Purpose/mission of KVIRS

- To develop environmental-friendly "adoptable" agricultural technologies and approaches for Khanasser (either improvement of existing technologies or adoption of new options).
  Indicator: Some farmers start to adopt and/or adapt technologies without any kind of subsidy.

- To develop an integrated and transferable approach that can be applied beyond Khanasser in a spectrum of dry area environments for:

- The analysis of natural resource dynamics (degradation and rehabilitation).
- The evaluation of potential resource management options.
- The operationalisation of the integrated natural resources management (INRM) framework.
- Indicator: Approaches available by the end of the project.
- For livelihood needs, which are outside the mandate of ICARDA, the project will try to facilitate linkages between villagers (or farmer groups) and government and development agencies.
  Indicator: Effective linkages established.

The results of 2003 will be discussed along the major pillars of the operationalised INRM strategy: process tools, diagnosis and problem solving (Turkelboom et al., 2003).

Process tools

Farmer-researcher communication
One of the findings during 2002 was that the communication between researchers and farmers was not optimal. Short visits by scientists do not always allow thorough discussions with farmers, which leaves the scientist often ignorant about real farmer concerns and opinions, while farmers often do not understand the reasons for certain activities and measurements. As a result, an extra ICARDA staff was recruited, whose main role is to facilitate a better two-way communication between researchers and farmers. As part of the selection process, Khanasser farmers were able to interview two pre-selected candidates and air their opinions about them. Their most important selection criteria was that the person, who would come to live with them, would behave as an equal and be able to understand their conditions and problems.

The selected facilitator was trained during a workshop and coached during regular meetings with scientists. He is now full-time based at Harbakiyeh village, and his residence also serves as a meeting place with farmers and as a guesthouse for visiting researchers. The Khanasser farmers have accepted him and he is now a trusted person in the community. There is a weekly meeting with the facilitator and scientists during which farmers' feedback and new assignments for the facilitator are discussed. Interesting issues are shared with the complete Khanasser e-mailing list via the 'Voices of Khanasser.' This arrangement has greatly improved cooperation between scientists and Khanasser farmers.

Farmer participatory research (FPR)
FPR is expected to increase the impact of our research by improving the relevance of the technology for users, reducing the research lag (development phase), shortening the adoption lag (early adoption), increasing adoption speed, increasing farmer knowledge and empowering farmers. Collaboration with farmers occurs through 'farmers interest groups' (FIG). These are informal groups of male farmers with similar production interests. These groups are mobilised to diagnose production constraints and opportunities, select options for further research or extension, try new options on their farm, and, monitor and evaluate the technology. ICARDA teams who join these meetings usually contain a facilitator, technical experts, a translator, a reporter, and a process observer. The expectation is that these meetings will increase informal contacts and collaboration between FIG members.

Participatory technology evaluation (PTE) is an essential part of FPR. Objectives of PTE days are to let interested farmers observe and evaluate different technologies under farmer conditions. The aim is to find out how the tested technologies can be better used, adopted and improved by farmers, and how the research work can increasingly be enhanced and owned by farmers. Over the last two years, skills to plan, conduct and facilitate participatory evaluation exercises have increased significantly at ICARDA. PTE days also strengthened the collaboration between different research disciplines within ICARDA's programs. For next year, it is expected that most ICARDA technology groups can run their own participatory meetings with minimal external help. However, involvement of farmers at planning and monitoring stages still needs to be strengthened.

Institutionalisation of FPR
Based on a recommendation of the social science project, a workshop focused on institutionalizing participatory research and on ways to strengthen the capacities of rural communities for development was organized on 25-27 March 2003. This workshop was a follow up to a training course on FPR methods conducted during the previous year (October 2002), and was attended by ICARDA NRM staff and NARS partners involved in Khanasser. The workshop increased the awareness and knowledge among participants of participatory research, and developed steps for institutionalizing participatory methods in research.

Diagnosis

Land user livelihoods characterization

Rationale

In order to identify and evaluate alternative farming and non-farming opportunities for local land users and alternative policy options, it is essential to have a better understanding of the diversity of rural livelihood strategies. Therefore, ICARDA carried out a study on livelihood strategies in Khanasser Valley.

Objectives

The objectives of the study were to characterize the diversity and dynamics of livelihood strategies in Khanasser Valley, to evaluate the relative contributions of different sources of livelihoods, to identify potential opportunities and constraints for the different livelihood groups, and to assess the relationship between livelihoods and natural and other resources. It is hoped that the identified household types will give a representative picture of the situation in the whole transition zone of Syria.

Research progress

The survey allowed characterizing households into types, based on their livelihood activities:

- The 'Laborers-Farmers' (LF): Earnings from off-farm labor wages, plus some crops sales.
- The 'Laborers-Herders' (LH): Earnings mainly from off-farm waged labor (plus livestock).
- The 'Agriculturists-Laborers' (AL): Earnings from crops, livestock (particularly sheep fattening), as well as from off-farm labor.
- The 'Agriculturists' (AG): Earnings from crops and livestock, particularly sheep fattening.
- The 'Pastoralists-Laborers' (PL): Earnings from extensive livestock and off-farm labor.
- The 'Pastoralists' (PA): Earnings mostly from livestock production.

Table 1. Average per capita earnings (SP) from different sources for the households.

	Laborers		Agriculturists		Pastoralists	
	LF	LH	AG	AL	PL	PA
Crop production	1376	461	7380	2225	0	0
Animal production	1007	1699	9158	2981	21879	16203
Sheep fattening	0	0	15422	12174	762	3232
Total animal production	1007	1699	24580	15155	22641	19435
Total earnings by off-farm labor	3030	6886	104	6767	3981	2000
Average annual earnings	15413	9046	32064	24147	26622	21435
Average annual earnings / day (in US$) #	0.82	0.48	1.72	1.30	1.43	1.15
Persons / household	9.17	6.64	6.75	11.29	10.43	11.00
Land owned (ha) / capita	0.75	0.56	1.12	1.00	0.00	0.00
Total land owned (ha) / household	6.83	3.73	7.55	11.26	0.00	0.00

The increasingly dominant household type is that of the 'agriculturists-laborers.' These combine on-farm cropping, extensive and intensive animal production, with off-farm labor (locally and overseas, as well as in farming and non-farming work). None of the de-facto landless households seems to have obvious opportunities to improve their livelihoods. The 'laborers-herders,' who rely nearly entirely on waged labor, are highly dependent on volatile and dwindling labor opportunities. The current importance of farming (specifically earnings from crop sales, Table 1) for livelihoods in this marginal area is limited and decreasing. In fact, it does not exceed for most households 10% of their total earnings. Contribution of off-farm wages to livelihoods is shown in Figure 1. The labor pyramid vividly illustrates that the bulk of labor earnings are from seasonal migration abroad (~55%), followed by national migration (~30%) and local off-farm activities (~15%). The share of labor earnings from within and outside agriculture are more or less the same.

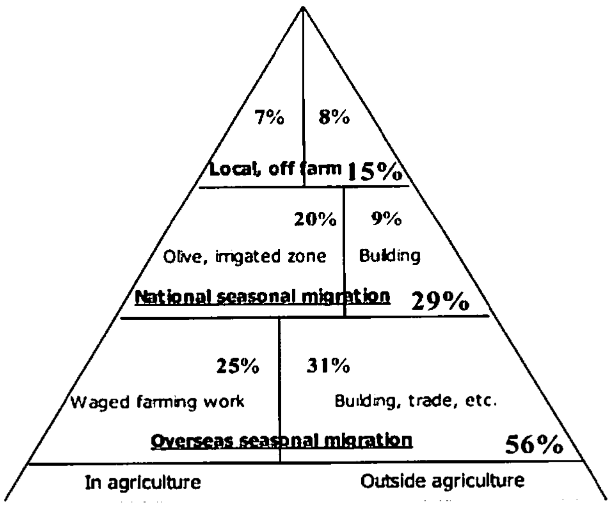

Figure 1. Contributions of different labor sources to household incomes over total off-farm labour income in Khanasser (average of all interviewed families).

The prevailing trends and bottlenecks for households in Khanasser Valley are:

- Increasing family size, increased scarcity of local jobs, and more migration.
- Increased living costs, which result in higher needs for cash and credit for most households.
- Reduction of herd sizes, caused by dwindling feed resources, a cultivation ban for the Zone 5 rangelands, and the shifting intensive fattening of sheep.
- Land fragmentation, land degradation and declines in farm productivity.
- Decreasing groundwater quantity and quality, and increasing costs to purchase water.
- Diversification of household activities driven by the dynamic response of local people to increasing uncertainty of the socioeconomic and ecological environment.
- Significant improvements in education and schooling and infrastructure (transport, electricity, and in nutrition).

The per capita disposable income in this dry area falls in most cases below 2 US$/day. For the 'laborers,' the capita income is even less than 1 US$/day. This geographic diversity of income is also significant, for instance only some KVIRS communities fall significantly below 1 $/day, while others are well above it.A strong demand of Khanasser farmers is for easier availability of credit to reduce livelihood risks. They would like the use of credit for starting small-scale enterprises or to invest in promising technologies, which are difficult to adopt without sources of credit. The demand for credit is a priority for households that have no substantial off-farm income (i.e. the pure 'agriculturists') or those facing high production costs, particularly for buying feed (i.e. all 'pastoralists').

Conclusion
The study clearly shows that rural households at Khanasser Valley cannot be considered as a homogeneous group. Consequently, strategies for the development of new technologies and options should take this differentiation into consideration.

Policy, institutions, and marketing analysis

Rationale
Policy analysis is an integral part of the study of livelihoods and technologies at KVIRS. Looking at these levels of analysis ensures that the proposed solutions are also sound in social and institutional terms.

Objectives
The main objective is to identify options for policies and a more "enabling" institutional environment to improve livelihoods and sustainable natural resources management.

Research progress
Research on policy, markets and institutions has so far focused on identifying and describing the key issues that need to be simulated to monitor their impacts on livelihoods or on natural resources use in marginal dry areas such as Khanasser. They consist of:

- Land tenure and land use patterns that play crucial roles in people's livelihoods. The land tenure types in the Khanasser area are private, reform land and state land. Assigned reform land is predominant in the North of the valley, different land tenure types are present in the central part of the valley, while the rangeland is entirely state land, particularly south of the cultivation ban line. According to the law there is a limitation of the land size owned for all land tenure types. This means that individuals are not allowed to own more than a certain amount of land. This differs among precipitation zones, between irrigated, rainfed, and fruit trees areas, and between lands planted with annual crops (*'amiri'*) and trees (*'mulk'*).

- Collapse or opening of (export) markets for fattened animals and for alternative cash crops (especially cumin) and export-oriented medicinal plants.
- Dissemination of those management options anticipated as being profitable, acceptable and sustainable.
- Alternative new policies, or amending existing ones, which can have a potential to reverse current negative trends and to contribute to livelihoods and resource conservation. In particular, the policies and institutions that are relevant for the marginal cultivated areas and the *Badia* (Zone 4 and 5) are being explored, such as:
  - Amendment of current policies, such as the cultivation ban for the *Badia*, restoring natural pastures, regulated grazing, irrigation ban in Zone 4, and regulations on using wells and digging new ones.
  - Evaluation of subsidies for agricultural inputs, such as animal feed, seeds of new promising crop varieties, fertilizers, fuel, irrigation and drinking water.
  - Credit provision to support technology adoption.

Conclusion

A substantial number of policies seem to have a paramount impact on the livelihood strategies of Khanasser people. It is important to understand the impact of these policies so that alternative policies can be formulated to replace those that have negative impacts on people's livelihoods.

Water resources

Climate

Average winter rainfall (October-May) in the Khanasser Valley, observed with a tipping bucket rain gauge at ICARDA's automatic station in Qurbatieh for the 1998/99 to 2002/03 seasons, was 215 mm. Average winter rainfall from the Government station in Khanasser town for the 1929/30 to 1978/79 seasons reported by Gruzgiprovodkhoz (1982) was 193 mm. Based on the available information we may conclude that there is a declining rainfall trend. It should be considered, however, that the quality of this last data set is not perfect, and further analysis will be conducted.

An overview of this season's precipitation (2002/03) for all monitored stations in Khanasser Valley is presented in Table 2. It was a wet season with few large storm events. The data show a clear trend with higher rainfall on the Jebel Al Hoss in the northwest and lower rainfall towards the southeast observed in Umm Mial.

Table 2. Khanasser Valley rainfall summary for the September 2002-August 2003 season.

	Lat.	Long.	Elevation	Precipitation	Max. event (Dec 19, 2002)
	UTM	UTM	m asl	mm	mm
Hweier Al Hoss	361140	3968503	560	362	53
Habs	362644	3964270	428	302	47
Rasm Askar	370894	3965276	330	291	49
Qurbatieh	365016	3955411	306	298	41
Umm Mial	372266	3958505	427	273	44

Monthly reference evapotranspiration computed with the FAO Penman-Monteith equation (Allen et al., 1998) and precipitation recorded at the new climate station in Rasm-Askar is presented in Figure 2. It should be noted that during the summer months the station is not kept under reference conditions and the evapotranspiration data will over-estimate summer irrigation requirements.

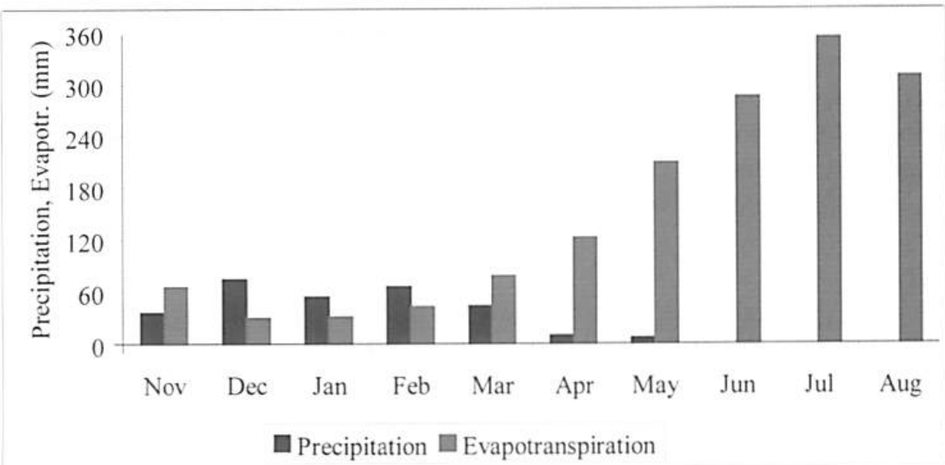

Figure 2. Total monthly precipitation and reference evapotranspiration at Rasm-Askar for the November 2002-August 2003 season.

Average monthly temperatures observed in Rasm-Askar are presented in Figure 3. Below-zero minimum daily temperatures were observed for a total of 29 days, between 16 November 2002 and 29 March 2003. But temperatures are still mild; the average of the observed below-zero minimum temperatures was -1.5 C. The coldest period occurred on 13-14 December 2002, when temperatures remained below zero for 13 hours. The coldest temperature observed was -4.6 C on 14 December 2002.

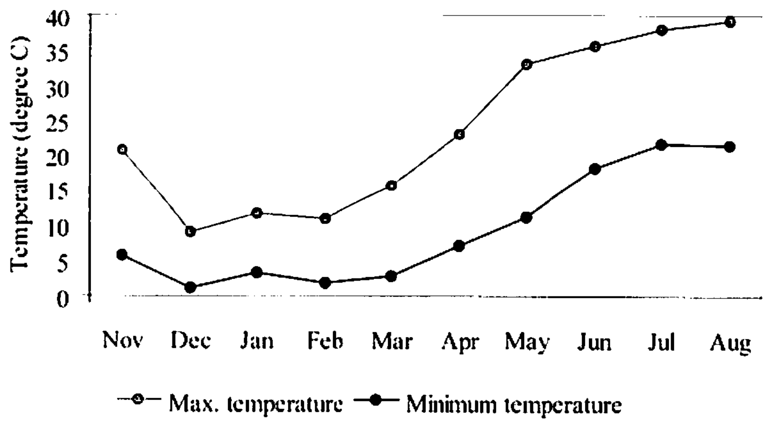

Figure 3. Average monthly daily minimum and maximum temperatures at Rasm-Askar for the November 2002-August 2003 season.

Hydrochemical and isotopic study of the groundwater

Rationale

Water is a scarce natural resource in Khanasser Valley and groundwater is especially crucial for bridging the dry season and unexpected dry spells. In order to make sustainable use of this groundwater, it is necessary to understand the nature and dynamics of the resource.

Objectives

The aim of this study is to assess the groundwater resource and its potential cycle in the Khanasser Valley.

Research progress

- The EC map of Khanasser Valley shows that the salinity is higher in the middle of the valley, between Al-Jabul salt lake and Oudamey, compared to the salinity at the recharge zones (Al-Hoss and Shbeit mountains). However, salinity increases along the pathway of the groundwater flow. The high salinity occurrence in the upper aquifer is related to a paleo-sabkha of recent quaternary age. To a limited extent, it can also be attributed to salt water intrusion around the sabkha and subsequent up-coming of the salty groundwater due to pumping.
- The piper diagram for groundwater shows that the groundwater can be classified as calcium sulphate and transforms to sodium chloride around Al-Jabul salt lake. This indicates a possible salt-water intrusion around Sebkha Jabul.

- The Deuterium and Oxygen-18 relationship shows that the Cretaceous deep aquifer is completely separated from the shallow aquifer. The shallow groundwater of Paleogene and Quaternary origin is distributed around an evaporation line of 1: 5.7 slope, indicating a limited mixing with saline lake water. In general, precipitation is enriched with stable isotopes compared to groundwater, indicating that the major part of this rainwater is discharged to the sabkha rather than to the valley's groundwater.
- The frequency distribution of Oxygen-18 content in Khanasser Valley shows that the isotope content ranges between -4 and -7 % in the shallow groundwater, between -8 to -8.5 % in the Cretaceous deep aquifer and between 3 and 3.5% in the surface water of Al-Jabul salt lake.
- The relationship between Oxygen-18 and EC values (Fig. 4) and the relationship between chloride, sulphate and Oxygen-18 reveals that water salinity is mainly due to the dissolution of evaporated aquifer minerals. The influence of the salt intrusion from the sabkha is restricted to adjacent areas. However, the salinity of the deep ground water is due only to dissolution.

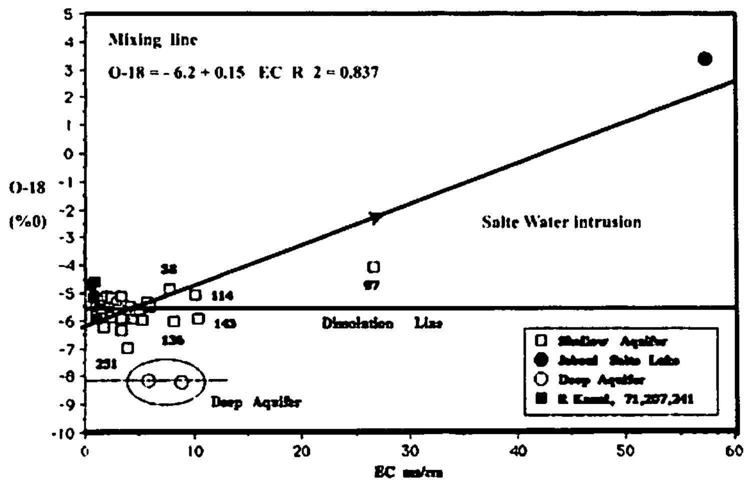

Figure 4. Oxygen-18 and EC correlation in Khanasser Valley.

- The Tritium content in the Quaternary aquifer indicates a recent recharge, while the "absence" of Tritium in Paleogene aquifer indicates a longer transit time in the aquifer.
- The initial results of groundwater dating using 14C show that the Cretaceous aquifer dating is between 8000 to 18,000 years, whereas the Quaternary and Paleogene groundwater age extends from 5000 years to recent.

Conclusions
Most of the salinity in Khanasser Valley results from dissolution of paleo-evaporites. This indicates that the main cause of salinity is of geological origin. In the Quaternary aquifer, recharge is relatively fast, but recharge for the lower aquifer is very slow due to very low transit times. Near the salt lake, upcoming of saline water due to pumping can be a problem for agriculture. In such situations, farmers would be advised to reduce the use of their pumps to an indispensable minimum for supplementary irrigation. The fact that most of the water is of calcium sulphate type, is rather positive, as plants are less sensitive to sulphate then chloride, and calcium can buffer the more harmful sodium while maintaining a better soil structure.

Water use and irrigation

Rationale
Water resources are more limited than soil resources in dry areas. Strategic use of irrigation water for increased agricultural productivity and risk minimization is of high importance to the farmers of Khanasser Valley, as well as other marginal dry areas. However, due to water scarcity, there is a challenge to manage water resources for agricultural use in the long term without decreasing the groundwater levels and salinization of soil and water.

Objectives
- Determination of resource base (water levels, aquifer properties, water balance, water quality).
- Evaluation of current water use.
- Irrigation research with farmers.
- Recommendations for sustainable water use practices.

Research progress
During the 2002/03 season, irrigation practice and water-use efficiency were assessed. Rainfall in the 2002/03 winter cropping season was 291 mm. About 4% of the cultivated area in the 245 km² watershed was irrigated. All irrigated fields were mapped and 20% of this area was monitored for water use and productivity. Crops, agronomic practices and irrigation methods were recorded for each field. Average water use values from monitored plots were used to compute total water use for every crop-irrigation method combination. Total water abstractions amounted to about 636,000 m³ or 1.3% of the average yearly rainfall in the entire watershed. The average water use for different crop-irrigation was: sprinkler-barley (949 m³ per ha), surface-barley (1447 m³ per ha), sprinkler-cumin (273 m³

per ha), sprinkler-wheat (1053 m^3 per ha), and surface-wheat (3270 m^3 per ha). On average, sprinkler-irrigated wheat had the highest irrigation water-use efficiency, defined as grain yield per unit of applied irrigation water (1.21 kg/m^3), and sprinkler-irrigated cumin the lowest (0.11 kg/m^3). Grazing affected the water-use efficiency values of barley. On average, the water use was 33% higher than the crop irrigation requirements.

Conclusions
From the study on irrigation practice and water-use efficiency the following conclusions can be drawn:

- Farmers adjusted their irrigation well to the crop requirements of a wet year.
- Most of the abstracted groundwater was used for growing wheat: about 50% of total groundwater abstractions were applied via surface irrigation to wheat with mostly marginal water and another 30% of the total water abstractions were applied via sprinkler irrigation to wheat. The remaining 20% was used for irrigation of barley (17%) and cumin (3%).
- Sprinkler-irrigated wheat had the highest water-use efficiency.
- More data are needed to quantify groundwater abstractions in a normal year.

Soil resources

Water erosion

Rationale
The assessment of soil erosion and the detection of its causes are preconditions for the development of improved land management strategies. The high spatial and temporal variability of rainfall events in semi-arid Mediterranean climates makes this a challenging task.

Objectives

- To develop a practical and reliable water erosion assessment method that can be used as a decision support tool for sustainable land management.
- To assess the extent of soil erosion within the last 45 years by using the Cs-137 redistribution technique.

Research progress
The GPS/GIS-integrated soil erosion survey in the study areas Khanasser Valley and Yakhour was continued. Digital terrain models (DTMs), and maps of soil characteristics, erosion damages, land use, ground cover, and agricultural practices were generated. Farmers' fields with different land use and with different agricultural treatments were monitored.

The developed methodology shows several positive aspects:

- On catchment-scale as well as on field-scale, the erosion survey can provide a rapid overview of type, distribution and extent of erosion damages (micro-rills, rills, gullies and sedimentation areas).
- Spatial as well as temporal distribution of erosion damages can be monitored.
- Possible causal relationships between land use, agricultural practices, ground cover, and infrastructure (terraces, village borders, roads, tracks, paths), and soil erosion can be detected.
- No need for installing measuring devices and maintenance.
- There is no interference with farmers' management.
- Practicability and accuracy of the mapping are improved in comparison to analogous work with paper maps.
- Interpretation of erosion damages is supported by quantitative analyses.
- Visualization of the erosion analyses by GIS-maps is helpful for decision support and awareness raising (e.g., at farmers days).

For the Caesium study, three representative sites were selected in Khanasser Valley (Rashadyeh at Al-Hoss mountain, Shbeit mountain and at the valley bottom). The sampling was conducted at two successive depths 0-10 and 10-20 cm. The micro scale sampling (10 m 10 m grid) at Al-Rashadyeh indicated that there is a wide spatial variability of Cs-137 concentration (i.e. indicator of soil erosion and redeposition) across the contour lines and down the slope. The data also show that there is a decreasing trend of Cs-137 concentration down the slope. However, assessment of erosion and of redeposition of Cs and soil still awaits the measurement of the reference samples.

Conclusions

Erosion damage mapping seems especially useful for developing countries which lack good topographical information (maps, aerial photos) and financial resources, and can contribute to the design of improved land management strategies. Cs mapping could help us to identify long-term trends in soil redistribution.

Nurtrient flows

Rationale

In dry areas, the efficient exploitation of water and nutrient resources is vital for the optimum use of natural resources. As most farmers in Khanasser are subsistence farmers, they hardly apply inputs on their farmland, especially to the rainfed farming systems. The traditional fallow cycle has broken down, and mono cropping is becoming common. Farm activities, such as cropping, harvesting and grazing, represent an export of nutrients from the farmland. Ploughing up and down and in shallow depths implies less chance for rainwater to infiltrate. Seeds with poor quality result in less seedling establishment and more weeds. These practices could be the main cause for the present low soil fertility in the project area. Therefore, evaluation of the available nutrient dynamics within the land use system is an important step in developing integrated nutrient and water management practices.

Objectives

- To learn about farmers' needs and strategies to cope with nutrient and water related problems.
- To assess and characterize the soil fertility status of agricultural fields.
- To develop a nutrient flow balance at farm level for households with different nutrient and water management strategies.
- To create a platform for farmers to share their observations and experiences.

Research progress

Nutrient flow: After meetings with elders in Hobs, a group of farmers who showed interest in nutrient and water management were selected and farmers' orientation day was conducted. The farmers were able to draw their village resource map and classify themselves into three categories based on soil fertility management strategies. In addition, they debated about the soil fertility problems and long-term yield trends. Their existing strategies for soil nutrient management are (in declining order): fallowing, ploughing, manure, mineral fertilizer and rotation.

Local soil classification: Farmers can classify their cropping land into four different classes according color, soil depth and yield. The classification in Serdah is more dependent on yield observations and geographical position.

Nutrients deficiency: Barley fields in Khanasser have exemplified multi-nutrient deficiencies (mainly P and Zn). These have been observed in three farms in the project area. Generally, nutrients decreased with depth. This finding rules out the argument that deep ploughing will pump nutrients to the top of the soil; but, it strengthens the possible effect of deep ploughing on soil moisture storage capacity and increasing the root zone.

Nutrient bioavailability: Resin bags were buried and incubated in the soil for the last two months of the growing season at two depths. Resin extracts nutrients from soil solutions and, therefore, is a better indicator to develop a relationship between plant nutrient uptake and bioavailability of nutrients. It was not known whether resin would be useful in dry areas. So far, results from Khanasser show that the resin can collect considerable amount of nutrients even under dry conditions. The analysis for the nutrients is not yet finished.

Soil moisture assessment: Previous studies have shown the decisive role of soil moisture during the last stages of barley growth. Preliminary studies on soil moisture along depth (0-20, 20-40 and 40-60 cm) and horizontal distances (10, 25 and 100 m) from the adjacent foot slope were conducted. The observation was possible only from the end of March 2003 to June 2003. These measurements will help to understand the interactions between the hill slopes and the farmland. Although it is premature to make sturdy points, the determinant effects of rainfall characteristics and the nature of the hill to the contribution of water to the farmland is apparent. A better picture will be gained from full season observations in 2003/4.

Conclusions

Development of an integrated nutrient management strategy requires understanding of the farming system and evaluation of existing resources and their dynamics. The participation of farmers in the process is important to increase the impact of the research, to sustain the continuity of the technologies, and to include indigenous knowledge on soil fertility management. Consideration of these experiences can be a source of deep insight into local facts and opportunities.

The relationship between nutrient management options and drought occurrence has been a main concern to farmers. Testing nutrient management options for their effect on drought tolerance is a promising research area. Therefore, a glasshouse research will be conducted to test the options under different soil moisture and drought cycles in addition to what is proposed in the working plan.

Rangeland vegetation of Al-Hoss and Shbeit mountains

Rationale

Communal rangelands are traditionally important grazing areas during the cropping season. However, their importance seems to have declined over the past decades. In order to develop more sustainable and productive strategies for use of forage and other plant resources on the hill slopes of Khanasser Valley, it is important to understand the past climax vegetation and the present dominant plant associations.

Objectives

The objective of the vegetation resource assessment survey in Khanasser Valley is to better understand the rangeland resources.

Research progress
The climax vegetation of the region was probably dry steppe forest. The dominant species of the first stratum of the climax vegetation were: *Crategus aronia, Pistacia, Prunus* and other arboreal species. High grasses as *Stipa, Avena, Lolium, Phlomis* and others formed the second stratum, while the third stratum was formed by low grass and herbs, such *as Hordeum, Bromus, Linum, Dianthus* and others.

Destruction of the climax vegetation by cutting, ploughing and heavy grazing led to degradation of the vegetation. Consequently, the tree layer was removed and the valuable semi-shrubs fodder was taken over by less palatable or spiny species. Around settlements, the vegetation is usually reduced through overgrazing and cutting into an extremely poor *Peganum harmala-Carex stenophylla* association, with no ability to sustain livestock. Based on many records made in the area, the main associations currently present are:

- *Crataegus aronia*-Grasses association.
- *Crataegus aronia-Noaea mucronata* association.
- *Anagyris foetida-Avena barbtata* association.
- *Noaea mucronata-Carex stenophylla* association.
- *Noaea mucronata-Capparis spinosa* association.
- *Peganum harmala-Carex stenophylla* association.

Conclusions
The original climax vegetation had a high potential to provide fodder for extensive livestock rearing. However, the severe degradation of rangeland vegetation reduced this potential significantly.

Khanasser range exclosure study
A study was conducted to compare the productivity of rangeland plants after five years of protection by exclosures to one season of protection under cages. This shows the effect of 4 years of protection on rangeland. It was necessary to protect the area outside the exclosure with cages for the growing season to be able to make the measurements. Cages were moved after sampling to allow grazing outside the exclosures. Comparisons made in previous years were not valid since plots outside the exclosures were harvested by grazing before samples were collected. It was not possible to measure the amount or composition of forage the animals removed. The results of four years of protection are shown in Table 3 and 4. (HS stands for highly significant, NS non significant, S for significant). Biomass increased significantly in only one of the 6 exclosures after 4 years of protection.

Table 3. Total and graminae standing crop biomass of protected and grazed range.

Site	Total productivity g/m² protected	grazed	LSD	Graminae productivity g/m² protected	grazed	LSD
N.Om mial	396	106	HS	223	46	S
Khuluh	106	31	NS	82.8	8.2	H.S
Mugherat	108	77	NS	88.2	41.4	NS
Qaraa	42	140	NS	39	83	NS
Big excl. om mial	54.3	69.4	NS	25.4	27.4	NS
Big excl. mugherat	105.6	88.2	NS	46.8	25.3	NS

Table 4. Components of Leguminosae and other families in standing crop biomass of protected and grazed range.

Site	Leguminosae productivity, g/m² protected	grazed	LSD	Other families productivity, g/m² protected	grazed	LSD
N.Om mial	58	10	NS	115	50	NS
Khuluh	11.8	1.2	NS	11.5	21.2	NS
Mugherat	10	14	NS	29.8	21.8	NS
Qaraa	0.16	5.44	S	2.9	52.2	NS
Big excl. om mial	1.24	1.60	NS	27.6	40.4	NS
Big excl. mugherat	31.7	30.9	NS	27.1	32	NS

Participatory technology development and evaluation

Approach

Rationale

The technical and management options for dry areas are quite limited. Therefore, the general strategy of KVIRS is not to test an endless list of options. Rather, we focus on best bets, and try to evaluate possible risks and opportunities at multiple levels. As an irregular climate and markets induce a significant risk for land users, a lot of emphasis is given to increasing 'adaptive capacity' of land users.

Objectives

To develop technologies suitable for the dry and marginal conditions of Khanasser that are economically viable, socially acceptable, and ecologically sound. Hence, they are expected to represent sustainable solutions for the area.

Research progress

The socioeconomic *ex-ante* assessment of agricultural technologies and management options (TMOs) was guided by a multi-level analytical framework (MLAF, see 2002 report) to assess different key aspects at different levels of analysis, from the enterprise (within farm) up to the policy levels. As part of the MLAF, a number of activities were conducted:

- The underlining SWOT analysis aims at identifying the major 'current' Strengths and Weaknesses (SW) and the foreseeable main 'future' Opportunities and Threats (OT) of different TMOs or land use or enterprises.
- A number of inter-disciplinary participatory activities were carried out (La Rovere and Turkelboom, 2002; La Rovere et al., 2003) by involving NARS stakeholders and locally established Farmer Interest Groups (FIGs).
- To better understand the actual role played by the various enterprises and their adoption, a link was made with the livelihoods study (La Rovere et al., 2003).
- The core element for economic *ex-ante* profitability assessment consists of assessing the economic feasibility of the different enterprises, by what is known as 'enterprise budgeting.' This was first done to assess the TMOs absolute profitability, and in their improved form, by comparing cases of farmers with and without the TMO and the Net Present Values. In a second stage the multi-annual Net Present Values for all technologies are being cross-compared to assess their relative profitability and opportunity cost. Finally, scenarios on their impacts on households and the regions were simulated.

Conclusions

The approach for integrated *ex-ante* assessment of agricultural technologies and management options is developing well. The final toolbox and results will be completed by mid-2004. For this report, preliminary results are reported.

Extensive barley-livestock systems

In the low rainfall areas of the Mediterranean region (200-250 mm), livestock and barley are the major elements of the farming system. Historically, most of the farmers in the area are barley growers and also livestock owners. Barley is the most dominant crop, but productivity is low. As a result, the barley crop is rarely harvested; instead it is used for grazing. In the event of good rainy-season (one in

5 or 10 years), or when underground water is available for supplemental irrigation, the crop is harvested for grain before the stubble is grazed by small ruminants.

Participatory breeding of barley (PBB)

Rationale

Decentralized selection, defined as selection in the target environment, has been used by ICARDA's barley breeding program to avoid the risk of useful lines being discarded because of their relatively poor performance at the experimental stations. Decentralized selection is a powerful methodology to fit crops to the physical (climate and management) environment. However, crop breeding based on decentralized selection can still miss its objectives if it does not utilize the farmers' knowledge of the crops and the environment, and it may fail to fit crops to the specific needs and uses of farmers communities unless it becomes participatory.

Participation of farmers in the very initial stages of breeding, when the large genetic variability created by the breeders is virtually untapped, is expected to exploit fully the potential gains from breeding for specific adaptation by adding farmers' perception of their own needs and farmers' knowledge of the crop. At ICARDA, farmers' participation has been the ultimate conceptual consequence of a positive interpretation of genotype x environment interactions, i.e. of breeding for specific adaptation. These concepts have been implemented in several participatory breeding projects.

Objectives

To test an alternative way to produce improved varieties of barley grown in marginal environments. This alternative approach is expected to introduce early-generation segregating populations into selected farmers' fields for farmer selection.

Research progress

Twelve farmers from three different villages of Khanasser Valley participated in the field selection. The detailed PBB methodology is described in the PTE 2003 report (La Rovere et al., 2003). Initial selection took place during maturity of the crop, while the final selection took place during July in Mugherat. During the last meeting, farmers had access to the result of the statistical analysis of the data. Farmers combined the two types of information to decide which entries to promote to the next year trials. Some of the farmers asked to compare the performance of lines across the three villages. This was interesting because it is considered as a typical attitude of a "professional" breeder. Farmers expressed their satisfaction with 'Zambaka,' which in most of fields outyielded the local 'Arabi aswad.' One farmer was particularly happy with 'Tadmor' (although it was not clear where he got the seed from).

During a planning meeting, farmers decided to reduce the number of villages from three to two (Mugherat and Khanasser), and to conduct the initial yield trials in other villages (un-replicated with systematic check). The lines selected during 2003 will be grown by five farmers in Mugherat and six farmers in Khanasser.

Conclusions

The participatory selection process enabled the selection of barley lines that were superior to local varieties and adapted to the local conditions. The trials will be continued over the next years to verify the findings.

Seed priming

Rationale

Since low-input farmers are unlikely to apply large amounts of fertilizer in an inherently risky environment (uncertainty of the outcome of such an investment), we hypothesize that technologies that are acceptable and adoptable by the farmers must be low-cost and largely seed-based.

One such option may be seed priming (i.e. short-term soaking of seeds in water and drying them back to store moisture before seeding). This technique has shown in other dry areas of the world to improve crop establishment, increase germination and enhance the plants' capability for water and nutrient acquisition (Harris, 1996; Harris et al., 2000). Supplementing the soaking with nutrients that limit crop production in the target regions may further increase the beneficial effects of priming (Asgedom and Becker, 2001).

Objectives

- To determine the optimum soaking periods and nutrient concentration solutions.
- To validate seed priming as an adoptable technology to Mediterranean environmental conditions.
- To evaluate effects of seed priming under different moisture levels in combination with other nutrient management options (OM and P).
- To assess the effects of seed priming to drought cycles.

Research progress

Priming technology: The optimum priming period for barley was found to be 6 hours, while 10 mMol of Zn and 50 mMol of P are the optimum concentration (Aziza, unpublished).

Drought tolerance: Nutrient primed barley seeds ('Arabi aswad') from Syria were grown in 20 cm tubes filled with calcium carbonate rich soil mixed with sand at 10°C and 85% relative humidity under phytotron conditions. The field capacity was determined by weighing. Half of the tubes were subjected to drought for two weeks while the other half were watered. At the end of four weeks all were measured (plant height, root length, dry biomass and tube weight). Seedlings from nutrient primed seeds showed better dry biomass production and water-use efficiency under phytotron conditions than water and unprimed seeds.

Conclusions

Under controlled conditions, priming seeds with water and nutrient improved the early growth of barley seedlings and water-use efficiency. Since the relationship between nutrient management options and drought occurrence has been the main concern of farmers, a detailed experiment is needed to test the effect of seed priming with water and nutrients on drought tolerance at different moisture status and in combination with other nutrient management options.

Phosphogypsum (PG) as soil conditioner to improve barley yields

Rationale

PG is a residue product of the phosphorus fertilizer industry, and is available in large quantities in Syria. It is a soil conditioner, which can improve the physical and chemical characteristics of soils.

Objectives

The experiment was designed in consultation with different farmers of Khanasser Valley to evaluate the possible use of PG as a soil conditioner, and specifically to:

- Assess the effect of PG addition on soil properties and barley production.
- Assess the effect of PG addition to soil on fluoride content, radioactivity and nutrients contents in barley products.
- Assess the effect of PG addition to soil on soil chemical and physical properties and its radioactivity.
- Assess the effect of site-specific effects of PG on barley response.
- Determine the cost benefit of using PG as a soil conditioner.
- Compare PG with the effect of P-fertilizer application to soil on barley production.

Research progress

Eight experiments were conducted at different locations in Khanasser Valley, and 2 PG rates (20 and 40 t/ha) and one phosphate fertilizer rate (50 kg P_2O_5/ha) were applied at each site. The second year result shows that the residual effect of PG application continues to have positive effects on the total biomass and grain yield of barley compared to the control. This is similar to the first year results-though to a lesser extent (Table 5):

- Both rates of PG application significantly increased the crop plant height by 33% under barley after fallow and 16-28% under continuous barley, compared with the control plots. The 40 t/ha PG also significantly increased the crop chlorophyll content (+ 26%), and the number of tillers (+ 56%) compared to the control.
- Under continuous barley system, comparison between the effects of 40 t/ha PG and the P-fertilizer applications showed that PG resulted in only slightly better crop response: 3% higher for biomass and 6% higher for barley grain yield.
- Under barley-fallow system, PG applications increased both the barley biomass and grain yield significantly by 46-48%, compared to the control plots. There was no P-fertilizer application under barley-fallow systems.

Table 5. Effect of phosphogypsum (PG) application on barley yields (N=8).

Treatments	Barley total biomass (kg/ha) Average (SD)	Barley grain yield (kg/ha) Average (SD)	Grain yield increase over the control (%) Average
Barley/fallow			
Control	4740 (2095)	2245 (820)	0
P_2O_5 (50 kg/ha)	-	-	-
PG (20 t/ha)	6900 (2300)	3285 (980)	+ 46
PG (40 t/ha)	6970 (2640)	3315 (1095)	+ 48
Barley/barley			
Control	3400 (2110)	1630 (975)	0
P_2O_5 (50 kg/ha)	4955 (1675)	2245 (580)	+37
PG (20 t/ha)	4620 (2125)	2170 (895)	+ 33
PG (40 t/ha)	5075 (2790)	2325 (1010)	+ 43

- Application of PG had negligible effect on radiation activity of the soil, whereas the radioactivity of the plants was below detection limit (= 2 Bq/kg DM). The fluoride concentration in the top 15 cm soil increased from 112 μg/g with no PG to 164 and 208 μg/g in soils receiving 20 and 40 t/ha PG, respectively. However, the concentration of fluoride in normal soils ranged between 150-400 μg/g. The concentration of fluoride in plants also increased from (μg/g DM) 9.9 in hay and 7.9 in grain with no PG to 15.2 and 13.4, respectively, in plants receiving 40 t/ha PG, which is below the permissible concentration (30 μg/g DM).

- A PTE was organized to evaluate the farmers' perception on PG's impact on barley growth, and to identify technological, economical, and other problems related to PG application. All the participating farmers evaluated the PG as being very effective for increasing barley yield, and even more positive under a barley/fallow system. They all were interested to apply PG if the transport cost were not more than 100 SL/ton. All the farmers also suggested that PG should be tried on *wheat, cumin and vetch.*

Conclusions

The results of the first two years show that PG is a promising option for the dry marginal conditions of Khanasser Valley. However, the experiment will be repeated for another year, to see whether the effects of PG on barley yield are lasting. The carry-over effects and radioactive residues still need to be verified, before widespread dissemination of this technology is recommended.

Wind erosion control

Rationale

Concern about wind erosion was expressed during a meeting with farmers from three communities of the eastern side of Khanasser Valley. Dust in the summer months is irritating and is one of the reasons for migration.

Objectives

To identify feasible ways to reduce the risk of wind erosion in the valley floor of Khanasser Valley.

Research progress

A number of control measures were reviewed by farmers, and two feasible options were selected for testing under farmer conditions, i.e. pre-summer tillage and no-tillage after growing the cumin. In Serdah, Rasm Askar, and Hawwaz villages, two sites (15x 50 m each) were established. BSNE (Big Spring Number Eight; Fryrear, 1986) samplers were used to assess dust fluxes, and detailed measurements on the soil surface were conducted to check the evolution of soil parameters that affect wind erosion.

Vetch as alternative feed source

Rationale

Seasonal variation in the quantity and quality of feed resources is one of the main constraints facing livestock owners and crop-livestock farmers in Khanasser Valley, and the dry areas of West Asia and North Africa in general. One of the technologies being tested is the planting of common vetch (*Vicia sativa*) in pure stands for either grain or straw or for grazing. The vetch can also be grown in rotation with barley to improve soil fertility, barley grain and straw yields, while meeting the livestock feed needs of the farmers. Preliminary discussions with farmers indicated that they were interested in growing vetch. Therefore, ICARDA distributed vetch seeds to 10 farmers for testing during the 2002/03 growing season. This report focuses on a field day organized to evaluate the farmers' perceptions on growing vetch.

Objectives

- To identify technological, economic, and other problems related to planting vetch.
- To define researchable issues based on farmers' needs and interests.
- To let farmers express what they want to do as a follow-up of the experiments.
- To identify farmers who would evaluate vetch next year.

Research progress

A field day was organized on 1 May 2003 to evaluate the vetch technology. Twenty-four farmers, including those who planted vetch, and those who expressed interest in planting vetch, and a team from ICARDA attended. The ICARDA team explained to the farmers that the purpose of the meeting was to evaluate the vetch with their help, and to plan together future research and development activities. Participants visited a vetch field cultivated by one of the farmers to evaluate the vetch. Farmers were asked to list the main problems they faced in growing vetch. Yields of vetch grain and straw were measured by both ICARDA staff and by farmers on eight farms.

The farmers observed that the vetch variety planted by their colleague was not pure i.e. two varieties in one field. The stand had small pods/seeds, low pod setting, but good vegetative growth suited for grazing. The major problems farmers face with vetch include weed control, ploughing methods, use of fertilizers, seeding and harvest dates, seeding rate and method, management of green grazing, use of vetch for fattening, and lack of information on soil analysis to assess its benefits. Other issues are low rainfall, storage of vetch as hay, and its mechanical harvest. Farmers showed particular interest in continuing the vetch interest group research and development activities, and suggested that livestock should be included in the activities. As expected, vetch grain yield on farms varied among farmers. Grain yield ranged from 200-1680 t/ha, and straw from 204-2500 kg/ha.

Conclusions

The results suggest that farmers are interested in improving the nutrition of their livestock by growing vetch. However, there are many constraints associated with vetch growing that need to be addressed through applied research and development activities.

Saltbush (*Atriplex halimus*) alley cropping

Rationale

Barley residues, usually grazed as stubble during the summer months, are becoming a major feed source in the dry areas of WANA. Stubble grazing is stretched over a period of 90 to 120 days and contributes about 25 percent of the annual requirements of sheep and goat in Syria and Jordan. However, stubble is generally considered inadequate and low in nutritive value. In order to produce high quality fodder without jeopardizing the grain production, there is a need to introduce a new system. A combination of cereal crops with wide-spaced hedgerows of drought-tolerant fodder shrubs is a feasible option.

One of technologies to improve the extensive barley-livestock production system in Khanasser Valley is alley cropping of barley between hedgerows of a forage shrub (*Atriplex halimus*, a crop native to West Asia and North Africa). This system provides farmers combined benefits from the same piece of land. Alley cropping technology to sustain farming in the Mediterranean basin is relatively new, especially in the drier marginal areas.

Objectives

- Demonstrate, evaluate and discuss the role of saltbush (*Atriplex halimus*) when combined with barley and other field crops.
- Identify factors that could help to expand this technology in the area.
- Define a framer-driven research agenda for *Atriplex*.

Research progress

In Khanasser Valley, several farmers have participated in the study over the past four years. Farmers' fields, each 1-4 ha, have been planted with *Atriplex halimus* in rows 10 m apart, 500 shrubs/ha. In the second year after planting, the time they are ready for grazing, the shrubs occupy about 10% of the field surface (calculated from their canopy cover). In addition to extra forage value from s altbush, saltbushes are excellent windbreakers which can reduce soil erosion. The system seems to be flexible, as a wide range of crops was planted between the *Atriplex* (i.e. barley, cumin, wheat, vetch).

Conclusions

During a PTE day, the *Atriplex* experiments were evaluated. Farmers perceived multiple benefits: it is a nutritious and palatable fodder for sheep especially during the dry season, it saves feed, it protects the soil from wind erosion, it grows on salty soil, and increase soil fertility. Few disadvantages were identified, including the risk of rats and weeds. The obstacles that limit the expansion of *Atriplex* in the region are: the cost of cultivation, cost of protection, and lack of experience to grow it and to buy the seedlings. Moreover, the size of *Atriplex* planting should be a function of the number of sheep of the household, and *Atriplex* is of little use for households without sheep. None of the farmers participating in the PTE day were ready to plant *Atriplex* unless there is subsidy for protection, ploughing and supervision. However, most of the farmers who are currently using *Atriplex* did not attend the field day because it was harvesting time, so the outcome of this field day should be viewed in this context.

What are the lessons learned from Saltbush trials with farmers? Planting of saltbush is feasible if it is at a small scale and only if the farmers have livestock. With more than 9000 seedlings of *Atriplex* planted during the last five years, not a single seedling was removed by the farmers. This is an indication that farmers are satisfied with the system and that they are utilizing and managing the saltbush in a proper way. Based upon our experience with nine farmers in Khanasser, the shrubs will remain once established; therefore, the establishment phase seems to be the most crucial one. Another way by which saltbush can be integrated with the farming system is to plant it on the field boundaries. Those boundaries are usually made by collecting stones along the border between the fields to distinguish between the different plots of land.

Range rehabilitation

Objectives

To assess the vegetation rehabilitation potential of the degraded hill slopes of Al-Hoss and Shbeit mountains.

Research progress

A study was done comparing the productivity of rangeland plants after five years of protection by exclosures to one season of protection under cages of normal grazed rangeland. This shows the effect of four years of protection of rangeland. It was necessary to protect the area outside the exclosures with cages for the growing season to be able to make the measurements. Cages were moved after sampling to allow grazing outside the exclosures. Comparisons made in previous years were not valid since plots outside the exclosures were harvested by grazing before samples were collected. It was not possible to measure the amount or composition of forage the animals removed. The results of four years of protection are shown in Tables 6 and 7. (HS stands for highly significant, NS non-significant, S for significant). Biomass increased significantly in only one of the 6 exclosures after 4 years of protection. After 4 years, the protected sites did not show any regeneration of arboreal and semi-shrubs of the original dry steppe forest vegetation. It only led to an increase in the biodiversity of annuals and a limited increase in the biomass production.

Table 6. Total and graminae standing crop biomass of protected and grazed range.

Site	Total productivity (g/m^2)			Graminae productivity (g/m^2)		
	protected	grazed	LSD	Protected	grazed	LSD
N. Um Mial	396	106	HS	223	46	S
Khuluh	106	31	NS	82.8	8.2	H.S
Mugherat	108	77	NS	88.2	41.4	NS
Qaraa	42	140	NS	39	83	NS
Big excl. Um Mial	54.3	69.4	NS	25.4	27.4	NS
Big excl. Mugherat	105.6	88.2	NS	46.8	25.3	NS

Table 7. Leguminosae and other families' components of standing crop biomass of protected and grazed range.

Site	Leguminosae productivity (g/m^2)			Other families productivity (g/m^2)		
	protected	grazed	LSD	protected	grazed	LSD
North Um Mial	58	10	NS	115	50	NS
Khuluh		11.8	1.2	NS	11.5	21.2
NS						
Mugherat	10	14	NS	29.8	21.8	NS
Qaraa		0.16	5.44	S	2.9	52.2
NS						
Big excl. Um Mial	1.24	1.60	NS	27.6	40.4	NS
Big excl. Mugherat	31.7	30.9	NS	27.1	32	NS

Considering the limited impact of exclosures, a fenced experiment at two sites (at Um-Mial and Rasm-Al-Nafel) was initiated in 2003. On these plots, climax species were planted (including arboreal, semi-shrubs, perennial grasses and annual legumes) and simple water harvesting techniques were applied. Rehabilitation of fenced areas at increased the vegetation production by twofold compared to that of the fenced non-rehabilitated areas.

Conclusions

Fencing off rangeland has only limited impact on biomass production and species regeneration. If the climax vegetation and original pasture productivity is desired, then it is necessary to re-introduce the species. However, it is important to find alternative management regimes for the common rangelands which were the cause of the degradation in the first place.

Fruit trees

Rationale

Efforts have been made to grow olive trees in low rainfall areas and marginal lands in Syria including Khanasser Valley. While only a few olive groves existed in the valley in the late 1980s, dozens of new olive plantations appeared across the valley during the last few years. Although olive is known for its high drought tolerance, the low and erratic amount of rainfall in the valley (average of 200 mm/year) is not sufficient to support this crop. The most critical period is the hot dry season that lasts from May through October, which also coincides with the most active olive growth stages. A traditional method of increasing available water to the trees in dry environments is water-harvesting (WH). This implies the collection of water from a micro-catchment in order to concentrate it to a desired place where the crops can use it. WH is of particular interest in hilly areas due to the high runoff potential and the difficult accessibility for irrigation equipment. Optimum WH design is a function of site conditions, climate, purpose and crops to be grown (Reij et al., 1988). Slope and length of the micro-catchment are of primary importance for runoff generation (Critchley and Siegert, 1991).

Objectives

- To study different micro-catchment designs for WH for dry hill slopes in northwest Syria, in order to recommend designs that are most capable of increasing soil moisture content in the root zone of olive trees.
- To determine the period for which the soil can store the harvested amounts on the hill slopes of Khanasser Valley.
- To establish participatory research on water management with some olive growers in Khanasser Valley.

Research progress
The threshold for generating runoff on hill slopes was relatively low and WH measures increased the amount of water available for olive trees. Increasing the slope resulted in an increase in the amount of water harvested in the presence of small storms, while big storms (greater than 27 mm) resulted in the same amount of runoff for the two studied slopes (8 and 15%). A large micro-catchment size (70 m^2) resulted in higher amounts of harvested water only in the presence of storms greater than 26 mm. Large micro-catchments are also recommended in dry environments to avoid tree competition for water. WH efficiency can be improved by planting the trees in deep soils or by preparing deep, large-diameter holes in the soft limestone parent material, which should be filled with soil during the planting of the tree. The larger soil volume would enable better root proliferation and higher moisture storage capacity. Furthermore, adding compost or other forms of organic matter would improve soil water-holding capacity.

The beneficial effect of water harvesting on soil moisture content remained for most of the trees until early July. It is therefore important to irrigate the trees during the dry months of August and September.

Simultaneous to this on-farm controlled research, a participatory research was launched with about 10 olive growers. Most of the farmers showed an enthusiasm for WH measures, as they implemented them spontaneously on their lands. These olive growers agreed that WH increased soil moisture content and improved tree growth.

Conclusions
Water harvesting can increase soil moisture availability for olive trees in marginal dry areas. However, a deep soil profile is needed for better moisture storage. The amount of water harvested during the rainy season was depleted from the soil by mid-June. Therefore, summer supplemental irrigation should be considered in dry areas with climate similar to that of Khanasser Valley.

Lamb fattening production systems

Rationale
Lamb fattening activities have been identified as one of the promising livelihood strategies followed by farmers in Khanasser (La Rovere et al., 2003).

Objectives
- Characterize existing fattening production systems in order to better understand the constraints, processes and factors involved.

- To identify key constraints and isolate those that could be mitigated by research and technological intervention.
- To implement technical options to target market opportunities in the farm and community environment.

Research progress

From a national survey on fattening systems, which included a small sample from Khanasser area, it was established that a diversity of lamb production systems exists (Hartwell and Iniguez, draft). The fattening systems practiced in Khanasser can be grouped in two categories:

- Intensive fattening systems of lambs, (3-12) months old, with a high turnover and high number of lambs per batch. Usually these systems are found within close proximity to sheep markets. Feeding is usually done in closed paddocks with little utilization of grazing areas. Middlemen and moneylenders are often engaged in these systems.
- Semi-intensive fattening systems of lambs, 3-12 months old, often situated in peri-urban areas or in the desert with close access to main roads. Such systems are based on intensive feeding and access to open areas. The number and turnover of lambs varies according to available funds. These systems have very little, if any, grazing incorporated. Animals are taken out on daily walks for one to two hours for exercise purposes. Depending on area, moneylenders from bigger cities are often involved in these systems.

Conclusions

One of the main constraints to the fattening systems was identified to be high cost of feeding. To overcome this constraint several options for low-cost feeding of Awassi lambs are currently being tested on-station at ICARDA. It is anticipated that on the basis of the results obtained from these trials, feasible options will be discussed, tested and evaluated in collaboration with farmers starting early 2004.

Furthermore, there is an urgent need to evaluate and identify the key policies and institutional arrangements governing the marketing of lamb in and out the country. Once the full impact of the policies is understood, a more holistic approach could be adopted and the realization of benefits could be more effective. Moreover, the inter-relationship and contracts between middlemen and fatteners are not fully understood, as well as the informal lending systems. These are crucial elements for identifying entry points for income-generation options for resource-poor armers.

Annual cash crops: cumin

Rationale

Cumin is usually grown in drier areas (250-400 mm/year) and can be cultivated in diverse soil types (deep, shallow, poor and fertile soils). It can be introduced into 2-course or 3-course rotations preceded by cereal crops. Cumin is considered equivalent to fallow as it consumes small amounts of water through its shallow root system.

Cumin is a relatively new, market-driven crop at Khanasser, which is causing significant changes in land use, influencing income and changes in local labour patterns and opportunities. Thanks to its attractive market prices, it has become the major cash crop in rainfed production systems in Khanasser Valley.

Objectives

To assess the main economic and agronomic constraints for cumin production in Khanasser Valley. They include: sustainability, profitability, and risks, especially due to fluctuating prices, diseases, and drought.

Research progress

During 2003, economic assessment and farmer participatory research on cumin successfully started with a cumin farmer interest group. The major concerns of farmers related to cumin are sowing date, sowing method, seed rate, fertilizer use, weed control and diseases and pests. The most important agronomic factors (sowing date, seed rate and fertilizer use) were selected to test them on farmers' rainfed fields in three villages (Harbakieh, Hweir El-Hos and Jib Jasem). Weed control was studied at Breda and Tel Hadya research stations of ICARDA.

Due to technical reasons, reasonable harvests could only be obtained at the Harbakieh site. The major findings are:

- Early planting resulted in a significantly higher yield: the mean seed yield for the mid-January planting was 330 kg/ha, while for mid-February it was only 160 kg/ha.
- The optimum seed rate was 25 kg/ha.
- N-fertilizer increased the cumin yield significantly at Khanasser conditions. An application of 30 kg N/ha resulted in a cumin yield of 225 kg/ha, compared to 145 kg/ha at the zero-treatment plots. Addition of phosphorus fertilizer did not affect seed yield.

Before the harvest, 14 farmers participated in the evaluation. Most of the farmers evaluated the earlier (January) planting better than the later (February) planting. They saw no difference between the different fertilizer or seed rates, which is actually difficult to observe in the field for such small plants. Farmers mostly said that cumin-cereal rotation is better than fallow-cereal rotation, as they believe that cumin uses little water, which would otherwise be lost by evaporation during fallow. Only two farmers used herbicide in cumin for weed control, while the others used hand weeding by family labor. *Fusarium wilt* was seen as a problem, and currently seed treatment is the only option. Four farmers stated that they lacked experience and wanted to see the success of neighbours first before adopting. However, marketing is seen as the main economic problem, particularly due to fluctuating prices.

Conclusions

Cumin often fails in Khanasser Valley for a number of reasons. The most important managerial factors influencing cumin production are: planting date, crop rotation, seed rate, cost of weeding, fertilizer use and the general lack of agronomic knowledge for growing cumin. Major bottlenecks for further expansion of cumin are: lack of disposable income to start the production, lack of fertilizers and machinery, lack of sufficient knowledge for agronomic management, and marketing of the cumin production.

Extrapolation domain of Khanasser research: a follow-up

Rationale

The Khanasser area is currently the most intensively studied benchmark site for ICARDA's INRM research. The technological options for resource-stressed farmers and communities developed in this area have application possibilities in the dry areas far beyond Khanasser.

Objectives

In order to assess where the technological options developed in Khanasser have potential relevance, the similarity in agroecologies and socioeconomic conditions has been mapped.

Research progress

The approach has been to use two different spatial frameworks for representing similarity in either biophysical or socioeconomic conditions. To map biophysical similarity, only climatic parameters (temperature and precipitation) have been considered. Climatic similarity was assessed through simple distance functions, comparing the monthly temperature and precipitation averages at the 'match location' (Khanasser) with those in the target region (CWANA and the northern Mediterranean), first separately, and afterwards in combination. To map similarity in production systems, a regional land use/land cover map developed previously by ICARDA (Celis and De Pauw, 2003) was used. Only those classes associated with the main production systems of Khanasser (rainfed crop production and natural rangeland management) were retained. By combining the areas of the climatic similarity indices with the relevant land use/land cover classes, the combined similarity in biophysical and socioeconomic conditions was assessed. Table 8 summarizes the areas at different levels of similarity. For more details on methodology, as well as results and limitations of the approach, refer to the report section of Project 3.4.

Areas with high similarity in climatic conditions within the three land use/land cover patterns (Fig. 5) are situated within plains in a narrow latitudinal range (28°N-40°N), characterized by precipitation during the colder part of the year. There are no similar environments in those parts of CWANA with summer precipitation patterns. Since the similarity indices do take account of shifts in the timing of precipitation, these findings clearly indicate that the climatic regimes with summer precipitation in CWANA are very different from the one in the Khanasser area.

Table 8. Areas with high similarity to Khanasser.

Similarity index	Approx. area in CWANA and N.Med. (km^2)	% of CWANA and N.Med.
0.9-1.0	1639	0.01
0.8-0.9	8177	0.03
0.7-0.8	16, 491	0.07
0.6-0.7	65, 338	0.65
0.5-0.6	406, 495	1.65
0.4-0.5	1, 201, 864	4.87
< 0.4	22, 960, 072	93.11

Conclusions

This study confirms findings of a previous report (De Pauw, 2002) that only a small part of the CWANA area is similar to Khanasser in terms of climate and land cover (but not land use). Environments similar to the one in Khanasser can mainly be found in Syria, Jordan, Maghreb countries and Iran.

Figure 5. Areas with highly similar climates and land use/land cover patterns.

Project conclusions and discussion

During 2003, significant progress was achieved at many different levels. As explained in the 2002 report, an integrated natural resources management (INRM) framework is used as a general guideline for the project. This entails a balanced effort towards diagnosis, problem solving and process tools, while considering the multiple level implications of the research.

Process tools

The researcher-farmer interaction has been significantly improved thanks to the starting up of focussed farmer interest group (FIG), farmer participatory research (FPR), and establishment of a field office and the placement of one permanent field staff, whose major role is to improve farmers-researcher communication. In addition, a training workshop has been organised to stimulate the institutionalisation of FPR at ICARDA and the cooperating NARES. Although the FPR and FIG models can still be improved, it can be stated that they are now becoming common approaches among ICARDA scientists.

At the research management level, fewer plenary meetings were held compared with last year. On the other hand, small, focussed and interdisciplinary meetings were very common. This is a good indication that there is a common agreement about the major direction of the project, and that the project responsibilities are now more decentralized. Next year, more attention will be given to cooperation with other NARES, dissemination strategies, knowledge management, and monitoring and evaluation.

Livelihood diagnosis

Livelihood strategies are quite diverse and can be grouped in three major categories: agriculturists, laborers and pastoralists. Despite this diversity, income levels are generally low. The per capita disposable income falls in most cases below 2 US$/day, while for the labourers the capita income is even less than 1 USS/day. The role of off-farm labour in income generation is high and it is growing, at the cost of the contribution of agriculture. The analysis also shows that most households in this dry environment do not depend on earnings from crop production for more than 10% of their total income, making off-farm labour-as well as livestock production, both fattening and extensive-as the major breadwinners. This has serious implications for our research focus. One consequence is that our research will benefit only the households who really have a stake in agriculture and who are semi-permanently settled at Khanasser Valley. Another consequence is that although we work in a generally poor area, reaching the poorest of this target group will be difficult. This group either have no or very limited natural and human resources, are absent for long periods and have limited time and interest to invest in agriculture. In other words, when selecting technologies and targeting our participatory technology research, we must make sure that the technologies and the households' livelihood strategies are compatible with each other. Gender issues, community organizations and policy impact analysis will be elaborated in 2004.

Natural resources diagnosis

Rainfall was much higher than usual, about 300 mm/year (average: 200 mm/year). This has resulted in a partial recharge of the Quaternary aquifer. However, Tritium measurements have shown that there is no significant recharge to the lower aquifers. The salinity of the ground water is caused by a paleo-sebkha of recent quaternary age, and by limited up coming of salt water intrusion around Jabul salt lake. Irrigation water is mainly used for wheat, but also for barley, cumin, vegetables and olives. On average, the water use is 33% higher than the crop irrigation requirements.

The soils are poor mainly in P and Zn. However, the soil nutrients availability is strongly dependent on the moisture levels.

The natural climax vegetation on the stony hills slopes used to be dominated by

Crategus aronia, Pistacia, Prunus and other arboreal species. Nowadays, the vegetation has been replaced with less palatable or spiny species that are indicative of land degradation especially around the settlements.

Although the natural resources are in a very degraded state, the speed of degradation seems quite slow. This in combination with the relative poverty of the area can explain why farmers do not perceive resource degradation as a pressing issue.

Participatory technology development

For the extensive livestock-barley system, several options are being explored. For barley, there are promising results for new locally adapted barley varieties (especially 'Zambaka'), nutrient priming, phospho-gypsum and pre-summer tillage to reduce wind erosion. By the end of next year, conclusive results are expected for these technologies. Three options are explored to improve forage sources. The most promising is vetch, while *Atriplex* and rangeland rehabilitation seems only possible with significant outside facilitation and/or subsidies.

Cash enterprises, such as cumin and sheep fattening, are rapidly gaining popularity in the valley despite several constraints. For fattening, the cost of the feeding is the major bottleneck. This will be the focus of research during 2004. For cumin, the first year results showed positive impact for early planting, N application and appropriate seed rates. Major bottlenecks for cumin are pests and market price instability.

Olive trees have been expanding rapidly at the western slopes of Khanasser Valley. Several farmers see it as a useful long-term investment, which fulfils mainly subsistence needs and possibly cash income. Simple water harvesting structures were found to be cheap and efficient methods to increase water availability for olive trees. Several farmers made temporary water harvesting structures in their ploughed fields, so that they concentrate the runoff from the furrows to the trees.

Khanasser Valley is of course not an end in itself. Concentrated research in a benchmark site only makes sense if the new technologies can also be disseminated to other comparable areas. Similarity analysis, based on climate and land-cover maps, indicated that similar environments as Khanasser can be found in Syria, Jordan, Maghreb and Iran.

Approach and research tools development
The second objective of the project is to develop "an integrated and transferable approach that can be applied beyond Khanasser in a spectrum of dry area environments." An operationalised INRM approach applied to dry marginal conditions will be the umbrella for this output. Major tools that are tested in KVIRS include farmer participatory research, farmer interest groups, livelihood analysis and multi-level analytical framework. Simultaneously, some more technical tools are designed, adapted or tested to the dryland conditions, such as GPS-based erosion damage survey, resin bags for measuring nutrient availability, irrigation monitoring, erosion measurements by Caesium, nutrient mapping, local soil mapping, and methods for measuring the efficiency of soil and water harvesting.

References

Allen, R.G., Pereira L.S., Raes D. and Smith M. 1998. Crop evapotranspiration. Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56. Rome.

Asgedom, H. and Becker M. 2001. Effect of seed priming with water and nutrient solutions on germination, early growth and competitiveness against weeds. 2001. In:Proceedings of the Deutscher Tropentag 2001 (University of Bonn, eds.). One world: Research for a better quality of life. Margraf Publishers, Germany.

Fryrear, D. W. 1986. A Field Dust Sampler. Journal of Soil and Water Conservation, 41(2):117-120.

Gruzgiprovodkhoz. 1982. Hydrogeological and hydrological surveys and investigations in four areas of the Syrian Arab Republic: Summary report. Volume I. Hydrology. Book 2. Tables. Georgian State Institute for Design of Water Resources. Tbilisi.

Harris, D. 1996. The effect of manure, genotype, seed priming, depth, and date of sowing on the emergence and early growth of Sorghum *bicolor* L., Moench in semi-arid Botswana. Soil and Tillage Research 40:73-88.

Harris, D., Tripathi R. S. and Joshi A. 2000. 'On-farm' seed priming to improve crop establishment and yield in direct-seeded rice In Proceedings,International Workshop on Dry-seeded Rice Technology, Bangkok, 25-28 January 2000.

PROJECT 3.4: AGROECOLOGICAL CHARACTERIZATION FOR AGRICULTURAL RESEARCH, CROP MANAGEMENT AND DEVELOPMENT PLANNING

Project rationale

To improve land use planning and environmental management of the agricultural production systems of Central and West Asia and North Africa (CWANA) through a better understanding and characterization of the specific potentials and constraints of agricultural environments.

Project objectives

- To characterize the varied agroenvironments of ICARDA's mandate region with respect to biophysical constraints of crop production and natural resources management, in support of the development, adaptation and transfer of new technologies for sustainable agricultural production.
- To assist NARS in the characterization of the diverse agroecologies and associated land use systems of CWANA through development and transfer of multi-scale approaches, methodologies and procedures for the quantitative assessment of agricultural environments

Outputs

Output 3: Comprehensive physical frameworks of CWANA

MAPPING LANDFORMS AND SOILS IN CWANA

Kristof Scheldeman and Eddy De Pauw

Introduction

As an input into the process of identification of agroecological zones in the CWANA region, reliable spatial information on soils and terrain is needed. This contribution describes the procedures used for generating (i) a landform map for CWANA, and (ii) an improved soil map. To generate the new landform map, the global Digital Elevation Model (DEM) GTOPO30 (Gesch and Larson, 1996) was used. As a basis for creating a soil map for CWANA, the already existing Digital Soil Map of the World (FAO, 1995) was checked and, where necessary, corrected, using low-resolution satellite imagery and the landform map, generated from GTOPO30.

Generating the landform map

A DEM is nowadays a prerequisite for all terrain assessments. In principle, a DEM is a dataset listing elevation against geographical position. Yet elevation does not really show a landscape. To identify landscapes, two criteria were used: absolute elevation and the degree of dissection, as expressed by the difference in elevation between adjacent high and low points.

Because the Dem GTOPO30 has a resolution of only 1 km, there is no real concept of 'slope.' However, the calculation of the parameter 'range' indicating relief intensity is more reliable. The range or relief intensity can be defined as *the median difference between the highest and lowest point within the terrain per specified distance, which is expressed in m/km.*

When working in a huge study area as CWANA and coarse resolution data in geographical coordinate system are used to calculate the relief intensity, the estimates can be considered to produce significant underestimates of the true relief intensity (Xiaoyang Zhang et al., 1999). To calculate accurate relief intensities, one must consider the latitude-longitude position of all the pixels and make projection adjustments for every pixel.

In order to make a latitude/longitude correction for the relief intensity the following procedure was developed.

In IDRISI GIS software a relationship was established between row and latitude through linear regression, using seven control points:

Latitude = -0.0083*Row + 55.402 (r^2=0.9)

The latitude map was transformed from degrees to radians: Rad = degrees* /180

For each pixel on the new latitude map three corrected distance layers (X, Y and diagonally) were created in relation to their latitude position (original pixel size of GTOPO30 DEM is 926 m)

Xew = R*0.000145444cos(lat) *(between 528-926 m)*
Ysn = *926 m* for all pixels (original GTOP30 value remains unchanged)
Pxy = R*arcos(sin(lat)*sin(lat + 0.000145444) + cos(lat)*cos(lat + 0.000145444)* cos 0.000145444) (*between 1066- 1310 m*)]
with R= 6371100 m (radius of the Earth)

All layers were subsequently merged to one dataset in ER Mapper software to be able to move the neighbor cells towards the central cell position and make calculations between the central pixel and its neighbors.

To calculate the relief intensity value (difference in altitude in m/km) between the central pixel and its upper-left neighbor, the following formula was used:
$ABS(I_1-I_2)*1000/I_3$

with I_1 = altitude central pixel, I_2 = altitude upper-left neighbor pixel and I_3 = lat/long corrected diagonal distance

This calculation was repeated for the other seven neighbor pixels.

For each pixel the maximum relief intensity value was selected using the function $MAX(I_1,..,I_8)$

After obtaining the latitude-adjusted relief intensity, the range values were classified in terrain classes as show in Table 1.

Table 1. Preliminary terrain classes.

Terrain class	Range value
Plain	0-50 m
Low hills	50-100 m
Steep hills	100-300 m
Medium-gradient mountains	300-600 m
High-gradient mountains	> 600 m

For creating the final terrain map, the range values were combined with altitude information from GTOPO30, in order to create three sub-classes within the terrain class 'plain.' Depending on its altitude, the terrain class 'plain' could be differentiated in three new terrain classes:

- plain (altitude < 800 m),
- middle plateau (altitude between 800-1500 m), and
- high plateau (altitude > 1500 m).

This resulted in the following classes for the final terrain map (Table 2):

[2]Based on zone et al., 1999

Table 2. Final terrain classes.

Terrain class	Range value
Low-altitude plain (altitude < 800 m)	0-50 m
Medium-altitude plains (altitude 800-1500 m)	0-50 m
High-elevation plateau (altitude > 1500 m)	0-50 m
Low hills	50-100 m
Steep hills	100-300 m
Medium-gradient mountains	300-600 m
High-gradient mountains	> 600 m

Results

The map in Figure 1 shows that the most mountainous areas are situated in the east of the study area. Areas with plateau above 1500 m are mostly located in Ethiopia and Iran, whereas vast areas of Saudi Arabia, Algeria and the central part of Turkey, could be classified as plateau between 800 and 1500 m.

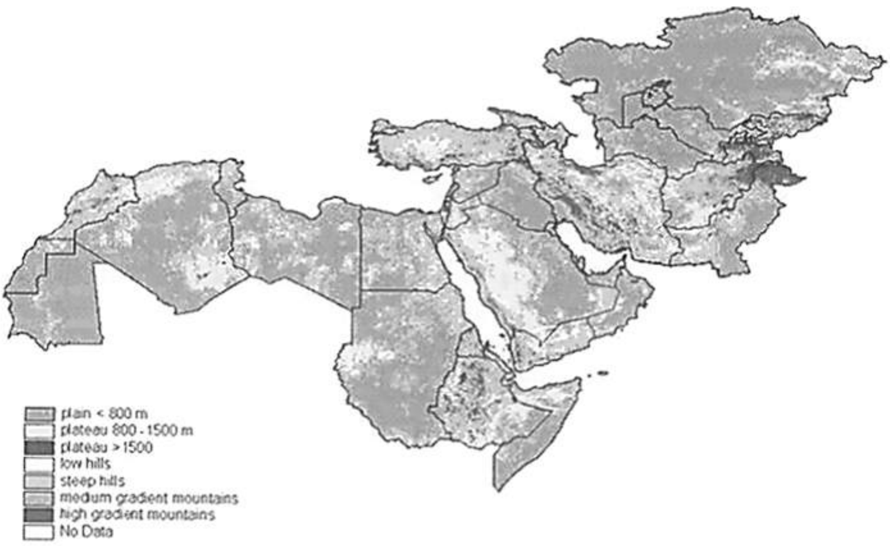

Figure 1. Terrain Map of CWANA

Soil Map of CWANA

The information sources used to prepare a CWANA soil map are the Digital Soil Map of the World (SMW) at scale 1:5, 000, 000 (FAO, 1995), the global DEM GTOPO30, and the September 2000 RGB-741 false color mosaic of the low-resolution satellite platform "Moderate Resolution Imaging Spectro-radiometer" (MODIS)-Fig. 2.

Within the GIS group at ICARDA, the SMW is used as a comprehensive and trusted layer of regional soil information for CWANA. Despite its continuing pre-eminence as a data source, it is worth recalling that the SMW was compiled in the 1960s and early 1970s from national soil maps, and assembled, before the advent of GIS, using manual techniques. In view of the advances made in digital cartography since then, and changes that may have occurred in particular soil types, like specific saline soils and shifting sands, there are questions about how up-to-date the SMW remains. For this reason a method was tested to use satellite imagery to improve the quality of the FAO soil map without the need of additional time-consuming fieldwork.

Since the beginning of the year 2000 MODIS is producing low spatial resolution imagery for use by the scientific community. Despite the low spatial resolution (500 m pixel) of the MODIS images, they have the potential to serve as a valuable source of information to distinguish soil and geological features in the non-vegetated parts of ICARDA's mandate region.

Figure 2. MODIS mosaic for CWANA (RGB 741 composite).

To evaluate this potential, different combinations of spectral bands were tested in false color composites. The 741 combination, which contains information of the infrared (band 7), near-infrared (band 4) and blue (band 1) reflectance resulted in being the best combination for the visual analysis of soil characteristics. Several pedogenetic features as sand dunes, rocky areas, basaltic plateaus, wadis, and even areas with vertic properties and salt affected areas could be delineated or detected in a more accurate way.

Using MODIS imagery for updating the FAO SMW makes it an even more valuable source of soil information for regional applications, such as land suitability classification or agroecological zoning. In addition to the MODIS imagery, the terrain map was used as an information source for the updating process of the FAO soil map.

The following specific improvements could be made to the SMW, especially in the non-vegetated parts of CWANA:

- Better delineation of alluvial areas (flat areas on the terrain map, e.g. the. Nile valley)
- Better delineation and detection of sand dunes (strong yellow color on the 741 MODIS mosaic)
- Better delineation and detection of saline soils (light blue color on the 741 MODIS mosaic)
- Better delineation of Vertisols (dark brown color on the 741 MODIS mosaic and flat on the terrain map)
- Better delineation of Calcaric Fluvisols following the wadi structures on the MODIS image
- Better delineation of rocky areas (basalt, sandstone, granite, . . .) with the MODIS information and the terrain map
- Better differentiation of Cambisols from valley soils using the terrain map

Because of the fairly poor digitizing of the country boundaries in the original SMW, the country boundaries were also updated and delineated more correctly, using the Digital Chart of the World spatial database (ESRI, 1993).

Conclusions

A landform map for CWANA was obtained from the global DEM GTOPO30 by a simple classification, applying straightforward criteria of elevation and 'ruggedness,' as defined by the elevation difference between neighboring pixels. To assess the relief intensity in m/km, a latitude-based correction was applied.

With the updated FAO soil map for CWANA a better delineation and more complete detection of the soil units was possible. No changes were made to the non-spatial database of the original map of 1974 (FAO, 1974). The final result is a more accurate soil map that can be used in its own right for future regional studies in ICARDA's mandate region.

Both layers (landforms and updated soil map) will be very useful as input layers for the definition of agroecological zones.

HOT SPOT ASSESSMENT OF DROUGHT RISK IN THE CWANA REGION BASED ON AVHRR IMAGERY

David Celis and Eddy De Pauw

Introduction

Drought is 'a deficiency of precipitation from expected or "normal" that, when extended over a season or longer period of time, is insufficient to meet demands' (Knutson et al., 1998). This definition implies that drought is inherent to climates with pronounced precipitation variability.

In contrast with other parts of the world, the CWANA region is not covered by a dense network of meteorological stations, although there are exceptions for particular countries. Up to now it has not been possible to compile a homogeneous time series of meteorological data for the entire region, which would allow mapping drought risk at a scale of relevance to agricultural planning.

In a study reported last year (Celis and De Pauw, 2003a), remote sensing was used for the detection of large-scale (regional to sub-continental) land use change trends during the period 1982-1999. The same low-resolution platform of the NOAA Advanced Very High Resolution Radiometer (AVHRR) satellites can be used to compensate for the lack of meteorological data in the region, and allows identifying the 'hot spots' of drought risk by mapping the inter-annual variations in vegetation spectral signature, as expressed through the Normalized Difference Vegetation Index (NDVI).

Methodology

The same dataset of 10-daily composites of 8km-AVHRR reflectance data, covering the period January 1982 to December 2000 (with 1994 missing), was used for this study. The steps of pre-processing the imagery, generating monthly NDVI composites, assigning land use/land cover classes for each year of data, and identifying change classes, were exactly the same as in the first study, and have been described earlier (Celis and De Pauw, 2003a). However, whereas the first study focused on the areas that had experienced changes in land use/land cover during the period 1982-2000, the current study focuses on areas where no such changes could be detected.

Drought risk is directly linked to the inter-annual variability in precipitation, but is not synonymous with *drought vulnerability*, which is a much more complex phenomenon, involving both climatic and socioeconomic dimensions.

As illustrated in Fig. 3, which is derived from a small dataset of meteorological stations in Syria and Turkey (Celis and De Pauw, 2003b), the maximum NDVI ($NDVI_{max}$) is positively correlated with annual precipitation. Whereas no extensive climatological analysis has been carried out covering the whole of CWANA, it can be safely assumed that in dryland regions inter-annual variations of the $NDVI_{max}$ are related to fluctuations in climatic conditions, especially precipitation.

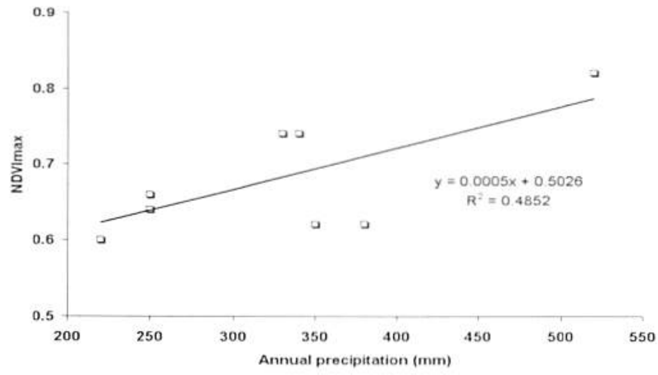

Figure 3. Averaged relationship between $NDVI_{max}$ and annual precipitation for 6 locations in Northern Syria and Southern Turkey.

A simple indicator of drought risk, derived from remote sensing, is the coefficient of variation (CV) of NDVImax. These values were calculated from the mean and standard deviation of NDVImax for the 17 years with NDVI data. To avoid the influence of changing land cover over time, only CV-values for pixels with stable land cover over time were retained. This is illustrated in Fig. 4 (left), showing the window for Syria, with the areas where land cover change has occurred during the period 1982-2000, marked in gray. In order to reduce noise and smoothen the map, a 3 3 median filter was applied.

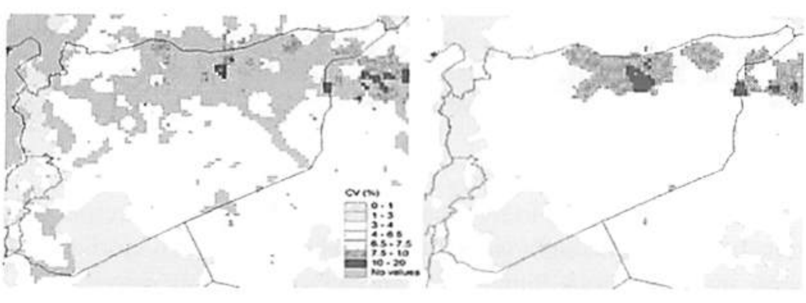

Figure 4. CV-values in Syria for stable pixels (left) and after 25 interpolation iterations (right).

The missing pixels were filled up using an iterative interpolation technique. In subsequent iterations, pixels without CV-values (in grey) were replaced by the average of those neighbouring pixels, which had a CV-value (with a minimum of 2 neighbors), until all pixels obtained a CV-value. Fig. 4 (right) illustrates the result for Syria. For the whole CWANA region only East Pakistan remained without values after 25 iterations.

Results

An example of a regional map obtained according to the above methodology is shown in Figure 5. A full coverage of CWANA has been established according to this methodology.

Figure 5. Spatial distribution of drought risk in the Middle East.

These maps need to be interpreted with considerable caution. To start with, they aim to identify areas with a significantly higher risk of drought than their surroundings. The adopted 'hot spot' approach therefore implies that the results need to be interpreted in a *relative*, rather than absolute sense.

Secondly, the CV values refer to fluctuations in biomass, as expressed by the combined spectral signature of live vegetation, represented in this study by $NDVI_{max}$. These CV values are to be considered impact indicators, in terms of vegetation response to climatic fluctuations. They are therefore not directly comparable to *causal* indicators, such as the (higher) fluctuations in precipitation. This explains to some extent the fairly low CV values in most areas. Another reason for these low values is the 8-km resolution of the original AVHRR reflectance data. Due to this low resolution, and the associated lack of pixel homogeneity in terms of land cover/land use, the fluctuations of NDVI are dampened.

Conclusions

Even within the limits of the methodology and data used, it is clear that there are 'hot spots' of drought risk, as inferred from the fluctuations in the vegetation biomass. Focusing on these areas with higher-resolution satellite imagery, such as Landsat, may be an economical way to identify the land use/land cover patterns in the 'hot spots.' By combining this information with time series of climatic data from selected stations, a better understanding of the observed fluctuations may be obtained.

Output 4: Case studies and methodologies for multi-scale agroecological characterization

HOW SIMILAR ARE THE CWANA AND NORTHERN MEDITERRANEAN REGIONS TO KHANASSER?

Eddy De Pauw

Introduction

The Khanasser area is currently the most important benchmark site for ICARDA's INRM research. The technological options for resource-stressed farmers and communities developed in this area have application possibilities in the dry areas far beyond Khanasser. A first approach to an *ex-ante* analysis of where else these technological options have potential relevance is by looking at similarity in agroecologies and socioeconomic conditions.

In a preliminary assessment (De Pauw, 2002) it was estimated that Khanasser was climatically representative for about 4% of CWANA. This first analysis was based on a low-resolution dataset, represented by the UNESCO Map of Arid Zones (1979) and did not attempt to look at similarity in socioeconomic conditions. In this study, a more comprehensive approach is outlined. It works with higher-resolution datasets, deals with both biophysical and socioeconomic factors, and assesses similarity in the whole of CWANA and the northern Mediterranean.

General approach

The general approach was to use two different spatial frameworks for representing similarity in either biophysical or socioeconomic conditions. Similarity in biophysical conditions was assessed using temperature and precipitation as indicators and similarity indices for quantification, and is explained in the next section. The outcomes of this analysis are maps, which show similarity of the CWANA and northern Mediterranean region with Khanasser, in either temperature, precipitation, or both.

The best way to assess similarity in socioeconomic conditions at the scale of CWANA and the northern Mediterranean, is by mapping farming systems. A first attempt at mapping farming systems at global level has been published recently (Dixon et al., 2000). While highly informative and with a sound mapping legend, the mapping component is spatially tentative and could not be used for mapping farming systems at the regional scale. For this reason a land use/land cover map for CWANA and the northern Mediterranean has been used as a proxy for farming systems. The method is discussed further on.

Methodology for climatic similarity assessment

In climatic similarity analysis, the value of a climatic parameter or index at one location (the 'match' location) is compared with other ('target') locations in order to quantify the degree of similarity in climatic conditions. In this particular case the climatic pattern of Khanasser town has been used as representing the match location. The target area is CWANA and the northern Mediterranean.

The model used to assess similarity is a very simple distance function:

$$S = I_{1(\Delta t)} * I_{2(\Delta p)}$$

The functions I_1 and I_2 are similarity indices for respectively air temperature and precipitation. They model the drop in similarity under increasing dissimilarity for air temperature Δ_t and precipitation Δ_p, respectively, as

$$I_1 = e^{(-\frac{\Delta_t}{\sigma_t})} \text{ and } I_2 = e^{(\frac{\Delta_p}{i0.\sigma_p})},$$

with σ_t [$^{o}C^{-1}$] and σ_p [mm^{-1}] user-defined calibration constants (Fig. 6).

Data input was in the form of climatic grids (12 mean monthly precipitation and average temperature surfaces) with 1-km resolution for both match and target areas. The dissimilarity in temperature Δ_t is computed as follows:

$$\Delta_t = \sqrt{\frac{\sum_{i=1}^{12}(t_{i+s} - T_i)^2}{12}},$$

where i is month number, t is mean monthly air temperature in the target point, T is mean monthly air temperature in the matching point (^{o}C), s is a phase shift in month numbering.

The phase minimizes the deviation in temperature between match and target location and is obtained by shifting the temperature array until the covariance:

$$Cov(\overline{Tm},\overline{T}) = \sum_{i=1}^{12}(Tm_i - \overline{Tm}) \cdot (T_i - \overline{T})$$

reaches a maximum. This way the seasonal pattern in different geographic locations can be synchronized. In a climatically homogeneous region the phase is 0. The maximum possible phase is 11.
The same phase (s) was then applied to calculate the dissimilarity in precipitatio pattern (Δ_p):

$$\Delta_p = \sqrt{\frac{\sum_{i=1}^{12}(p_{i+s} - P_i)^2}{12}},$$

where p is monthly precipitation in each target point, P monthly precipitation in the match point.

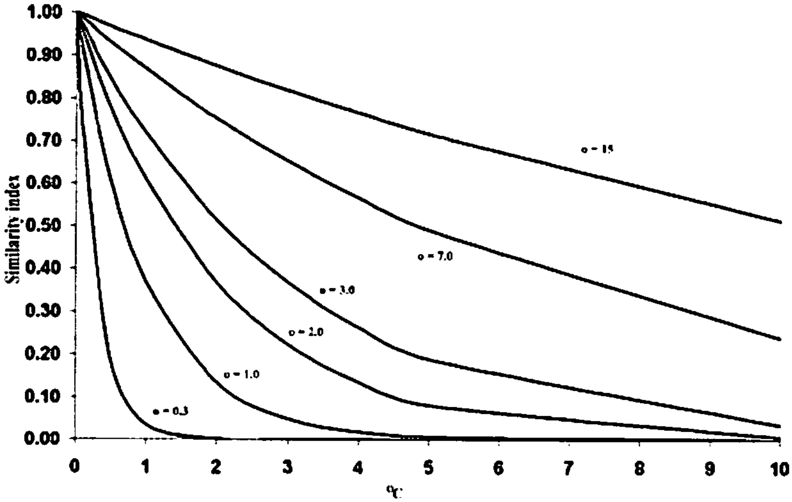

Figure 6. Use of calibration factors to adjust sensitivity to a climatic parameter.

In this study the calibration factor for air temperature t is set to 7.0 and for precipitation p to 3.0. The former corresponds to a similarity drop by 25% under $\Delta t = 2^{o}C$ and of about 50% under $\sigma_t = 5^{o}C$, the latter to a drop of 50% under $\Delta_p = 20$ mm and of about 80% under $\Delta_p = 50$ mm.

Methodology for production systems similarity assessment

A regional Land Use/Land Cover map developed previously by ICARDA (Celis and De Pauw, 2003) was used to assess similarity in production systems (Fig. 7).

The land use/land cover map recognizes the following categories:
- Dry-season irrigated field crops
- Rainfed field crops/dry-season uncultivated
- Open shrublands/grasslands
- Forests/closed shrublands/tree crops
- Woodland savanna
- Barren/sparsely vegetated
- Inland water
- Urban/built-up areas

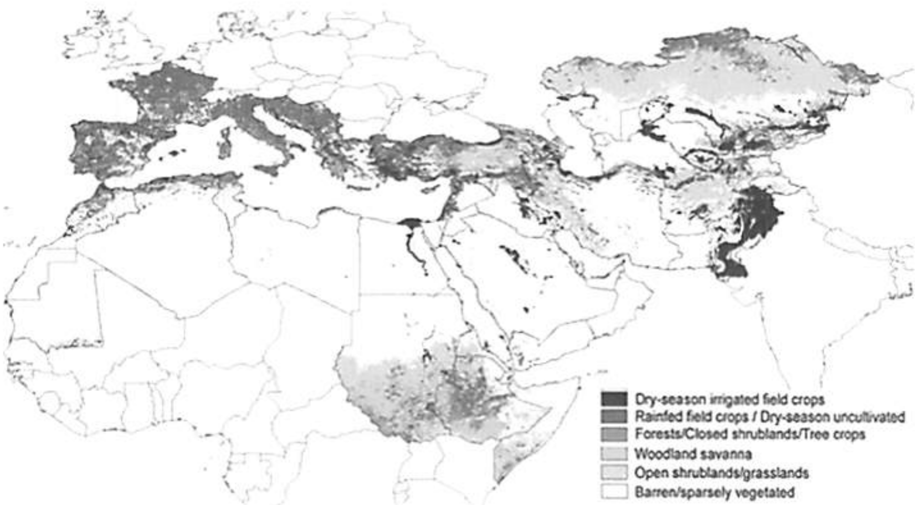

Figure 7. Major land use/land cover types in the CWANA and northern Mediterranean regions.

In the Khanasser area, two major production systems meet: rainfed crop production (of crops with low water requirement, e.g. barley) and natural range management. The rangelands are in different conditions, but are mostly overgrazed. These production systems can be associated with the following land use/land cover types:
- Rainfed field crops/dry-season uncultivated (R)
- Open shrublands/grasslands (G)
- Barren/sparsely vegetated (S)

Areas that are under one of these land use/land cover types can be obtained in the GIS by simple filtering.

The process of assessing similarity in production systems involves major simplifications. The main simplifications concern the inherent complexity of production systems, which cannot be represented at sub-continental scale, and the wide range of mixtures that are possible within the spatial limits imposed by the resolution of the Land Use/Land Cover Map (1 km^2). Mapping production systems through a land use/land cover 'proxy' thus has to be seen as a 'hot spot' approach: at local level the picture remains fairly blurred but at the regional level one obtains a good sense of which areas are very dissimilar and which ones are similar.

Combining climatic and production systems similarity

In GIS a straightforward combination of the climatic and land use/land cover variables can be made through the calculation:

I1 x I2 x OR(R, G, S) in which OR is a logical operator.

Results

Using the model for climatic similarity, Khanasser as the match location, and CWANA and the northern Mediterranean as the target regions, similarity maps have been produced for temperature (Fig. 8), and for precipitation (Fig. 9). The similarity map for both precipitation and temperature (Fig. 10) is obtained by multiplying the two similarity indices following Liebig's Law of the Minimum. Only the areas with a high similarity, indicated by a combined similarity index larger than 0.4, are shown.

Table 3 summarizes the areas at different levels of similarity. They confirm the findings of the previous assessment (De Pauw, 2002) that only a small part of the CWANA area is similar to Khanasser.

Areas with high similarity in climatic conditions within the three land use/land cover patterns (Fig. 11) are situated within plains in a narrow latitudinal range (28°N-40°N), characterized by precipitation during the colder part of the year. There are no similar environments in those parts of CWANA with summer precipitation patterns. Since the similarity indices do take account of shifts in the timing of precipitation, these findings clearly indicate that the climatic regimes with summer precipitation in CWANA are very different from the Khanasser area.

Table 3. **Areas with high similarity to Khanasser.**

Similarity Index	Temperature	Precipitation	Variable Temperature and precipitation	Climate and production systems
0-0.1	6.18	6.81	36.80	
0.1-0.2	15.45	7.33	30.63	
0.2-0.3	19.68	7.88	16.33	
0.3-0.4	17.86	10.22	8.74	93.11
0.4-0.5	14.38	35.29	5.28	4.87
0.5-0.6	10.52	20.93	1.80	1.65
0.6-0.7	8.43	8.15	0.30	0.26
0.7-0.8	5.21	3.05	0.08	0.07
0.8-0.9	1.95	0.32	0.04	0.03
0.9-1.0	0.34	0.03	0.01	0.01

Note: total area of CWANA and the Northern Mediterranean is 24, 660, 075 km²

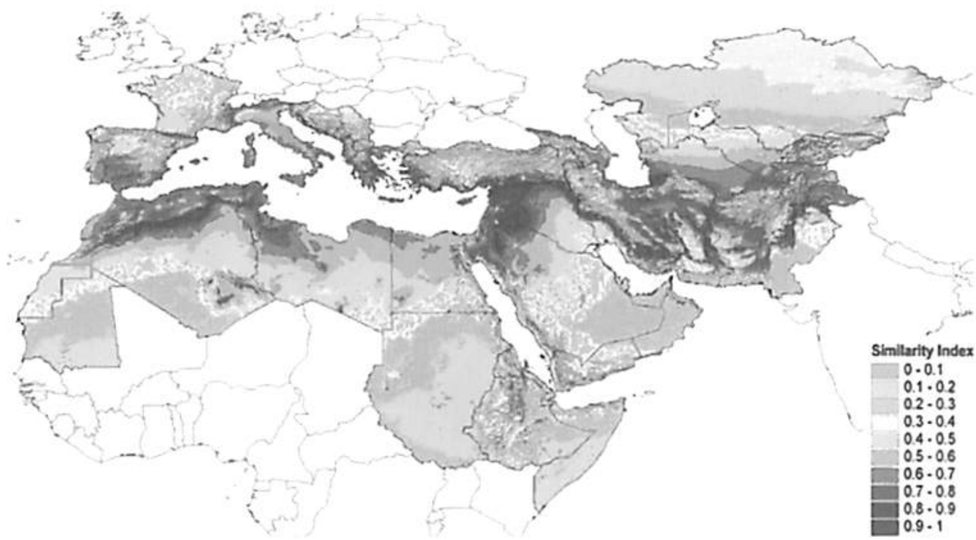

Figure 8. Temperature similarity index.

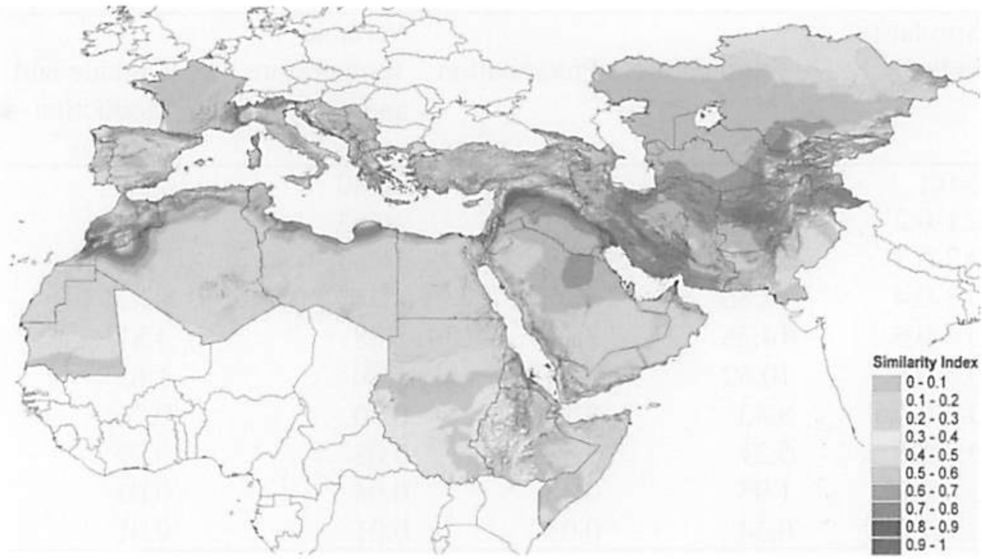

Figure 9. Precipitation similarity index.

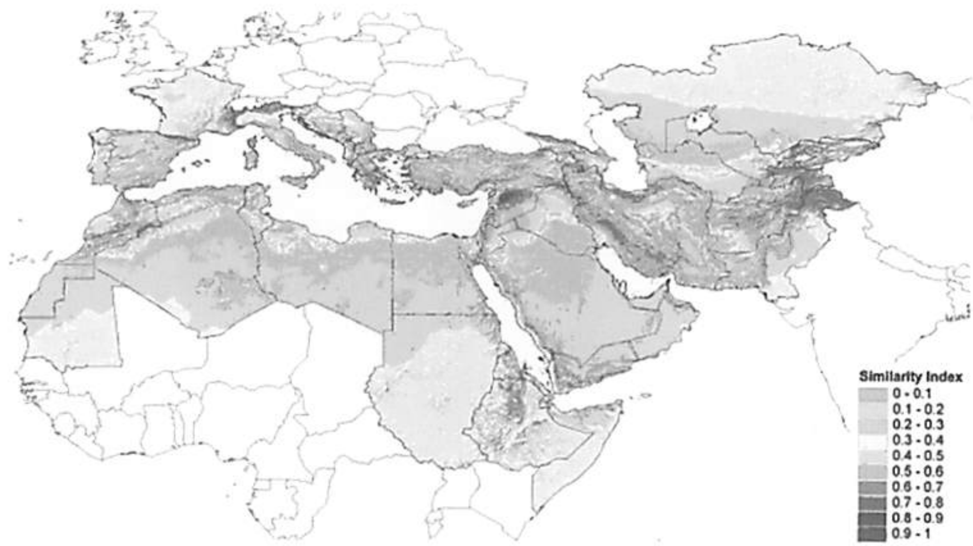

Figure 10. Similarity in temperature and precipitation.

Figure 11. Areas with highly similar climates and land use/land cover patterns.

AGROECOLOGICAL CHARACTERIZATION OF THE AGROBIODIVERSITY SITES IN SYRIA

Kristof Scheldeman and Eddy De Pauw

Introduction

The West Asia region is considered one of the major centers of plant diversity and endemism in the world. It encompasses an area of mega-diversity for major food crops and pastures species and contains wild relatives including those of wheat, barley, lentils and many fruit trees. The diversity of many of these species and their wild relatives is seriously decreasing due to rapid degradation of their natural habitats, intensification and expansion of cultivation and overgrazing and replacement of local varieties by imported ones.

Aware of the importance of the agrobiodiversity for present and future generations, the Global Environmental Facility (GEF), managed by UNDP, has funded a regional project aiming at the promotion of *in-situ* and on-farm conservation and sustainable use of the landraces and wild relatives of cereals, food and feed legumes, Allium and fruit tree species originating from Jordan, Lebanon, the Palestinian Authority and Syria. The activities are mostly concentrated in project sites that cover the diversity of ecosystems and predominant farming systems, ranging from highly degraded rangelands to intensive farming. In each country the project is executed by an organization representing a national agricultural research system. In Syria the General Commission for Scientific Agricultural Research (GCSAR) implements the project.

As part of its activities aimed towards the strengthening of the scientific basis for *in-situ* conservation of agrobiodiversity in Syria, the GCSAR requested ICARDA to undertake a land resources inventory study of the designated agrobiodiversity conservation areas in Hafe and Sweida.

Methodology

The Hafe study area covers about 73 km^2 on the western slopes of the coastal mountains in northwest Syria. The Sweida study area is located in the south of Syria, on the slopes of the Jebel El Arab, close to the Jordan frontier. With an area of about 768 km^2, it is much larger than the Hafe study area. Each study area contains monitoring areas, in which detailed collection was carried out of wild relatives of the target species (wheat, barley, lentil, vetch, medics, clover, and fruit trees such as wild olive, almond, fig, pear, apricot, peach, pistachio etc.), as well as detailed botanical and resource surveys, and research on land use dynamics and socioeconomic aspects. However, these activities on monitoring sites preceded the land resources study, which started on 1 September 2002 and was completed six months later.

Database development

The first step in the land resource assessment was the acquisition and preparation of the digital database. Existing 1:50, 000 topographical maps and soil maps were scanned and georeferenced in order to serve as primary terrain and soil data layers in the GIS. A digital elevation model (DEM) derived from the ASTER-satellite product (resolution 30 m) was acquired for Hafe. No similar image could be obtained for the Sweida area from the NASA. Landsat and ASTER images were acquired and preprocessed to create land cover maps for the areas.

Field work

For the characterization of the land resources, field surveys were carried out. Transects were used for soil auger and profile observations and sampling for analysis in the Soil and Water Laboratory at ICARDA, where physical and chemical characteristics, such as texture, organic carbon, pH, EC, $CaCO_3$ content etc., were determined. During the fieldwork ground truth information on soils characteristics, land cover, land use and degradation processes was collected. Internationally accepted methods for environmental data classification (CORINE for land cover mapping and the FAO soil classification system for soil mapping) were used to ensure compatibility with other data sets in the other country projects. For the Hafe study area nine soil profiles were described and ten for Sweida. The full soil profile description was done according to the FAO Guidelines for soil profile description (FAO, 1990).

Analysis

Terrain

DEM information for the Hafe area was obtained through ASTER satellite imagery, processed by NASA. However, for the Sweida area no ASTER-derived DEM could be obtained and the less detailed information from the digital DEM of the world (GTOPO30) had to be used to delimit terrain characteristics. The spatial resolution for the Aster DEM is 30 m, whereas for the GTOPO30 global DEM the resolution is 1000 m. From the DEMs the slope was calculated to create for both areas a slope map. For Hafe the DEM's resolution was adequate to calculate the actual slope in degrees. For Sweida, no real slope map could be prepared given the 1-km resolution. Instead of the Range filter script in ArcView, the 'relative elevation difference' was used to obtain a reasonable approximation of the dissection of the terrain. Both parameters altitude and slope were classified, and combined into a terrain map. For Hafe study area 15 terrain types were defined, whereas for the Sweida area 8 terrain types were defined.

Soils and land systems
Based on the field work and analysis of the reference profiles, soil maps were prepared for both study areas. Two different scales were used for Hafe (1:65, 000) and for Sweida (1:175, 000) in view of the difference in size between the two areas, and the higher degree of homogeneity in the Sweida study area. The soil maps were represented as maps of soil associations. Soil association maps show patterns of soil occurrence, instead of the location of individual soils, and are characterized by the recurrence of a limited number of specific soil types within particular land systems in different proportions.

Land systems were delineated by combining field observations, local soil maps and satellite image interpretations. They are characterized by a homogenous landscape with the same geological background, similar topographic characteristics and a specific soil association. Each soil map was linked to a spatial soil database, which allows users to derive information of the soil characteristics for the different land systems.

Climatic conditions
Climatic conditions at both sites were assessed through climate diagrams for representative sites and climatic maps. The climate diagrams summarized precipitation, temperature, growing period and water balance conditions at a location representative for each study area. The representative location for the Hafe area was Bereen, and for Sweida area it was Sweida itself. Climatic data for Sweida were obtained from the FAOCLIM2 database (FAO, 2001). For Bereen the climatic data were extracted from the climate surfaces for Syria (De Pauw et al., 2001) using the Point-Profiler extension of ArcView (Ibiyemi, 2002), and imported into the CLIMCHART software (De Pauw and Pertziger, 2001) for generation of climate diagrams. The climatic maps were created through 'topography-guided' spatial interpolation (Hutchinson, 1995), using the GTOPO30 global digital elevation model (Gesch and Larson, 1996) extracted for Syria, in combination with a database of point climatic data, extracted from FAOCLIM2, through the software ANUSPLIN 4.1 (Hutchinson, 2000). For each site maps of Agroclimatic Zones were created by combination of individual layers for annual precipitation, potential evapotranspiration, maximum and minimum temperature according to the UNESCO classification system (UNESCO, 1979).

Land cover/land use
A general analysis of the land cover was conducted through a supervised classification on Landsat imagery, using the CORINE Level 2 classification and IDRISI 3.2 software. Spectral information from different 'training sites' was used to define the land cover/use types. Six types of land cover/use could be separated statistically for the Hafe region, whereas in Sweida eight types of land cover/use could be distinguished. In addition, in both study areas a more detailed survey, based on intensive fieldwork, was done to obtain a land cover/use map using the CORINE Level 3 classification.

Because the supervised classification method is an automatic classification process, which uses only ground truth information from the training sites, the CORINE II land cover maps are less accurate than the CORINE III land cover maps, which were prepared entirely of the basis of fieldwork. Nevertheless because the CORINE II maps are processed for an area bigger than the study area boundaries, they also give an idea of the land cover/use in the area surrounding the Hafe and Sweida study areas and allow situating the study areas in a wider geographical context.

The land cover/use CORINE III maps were created with the GIS ArcView software and are in vector format. They are linked with a spatial database, which contains for every mapping unit information on land cover/use (with a maximum combination of three kinds of land cover/use for every mapping unit), their
coverage (in percent), the occurrence of small landscape elements (e.g. hedges, terraces, wadis, big trees, and land reclamation) and a biodiversity rating which depends on the amount and the kind of natural vegetation present.

Biodiversity rating
The biodiversity rating is a tool to evaluate the importance of biological diversity for the mapping units. The following relative scale was used (Table 4):
1= none, 2 = very low, 3 = low, 4 = medium, 5 = high, 6 = very high biological diversity.

Table 4. Relationship between land cover/use types (CORINE Level 3) and biodiversity ratings.

Land cover/use (CORINE III)	Biodiversity rating	Land cover/use (CORINE III)	Biodiversity rating
Continuous urban fabric	1	Agro-forestry areas	4
Discontinuous urban fabric	1	Broad-leaved forest	6
Industrial or commercial units	1	Coniferous forest	4
Road and rail networks and associated land	1	Mixed forest	6
Airports	1	Natural grassland	6
Mineral extraction site	1	Maquis (high shrub)	6
Construction site	1	Garrigue (low shrub)	6
Green urban areas	2	Transitional woodland scrub	5
Sport and leisure facilities	1	Bare rock	2
Non-irrigated arable land	1	Sparsely vegetated areas	2
Permanently irrigated land	1	Burnt areas	1
Vineyards	1	Inland marshes	6
Fruit trees and berry plantations	1	Salt marshes	6
Olive groves	1	Salines	3
Pastures	1	Water courses l	1
Annual crops associated with permanent crops	2	Water bodies	1
Complex cultivation pattern	1	Mixture fruit + vines in equal quantities	1
Land principally occupied by agriculture with significant areas of natural vegetation	4	Mixture fruit + olive in equal quantities	1

This rating system uses physiognomic classes and is, therefore, particularly suitable at landscape level for rapid visual assessment and mapping purposes. Obviously, it is not intended as a replacement for detailed botanical surveys at sampling sites, but can be used to target the surveys and ensure that the sampling is representative. Because the rating system is linked to a detailed land use/land cover classification, the rating is objective and reproducible. At the same time the reliance of the rating scale on visual observations provides a reality check. The rating scale can also be developed in a participatory manner to ensure that local values are incorporated. The combination of visual observations and remote sensing makes accurate mapping possible.

Human intervention

Landsat images from 1990 were compared with the more recent Landsat images from 1999 (Hafe) and 2000 (Sweida) to detect changes. The changes were marked with spots. By using this method, only major changes in land cover or land use could be detected.

Results

Landform maps

The landform map for Hafe (Figure 12) is based on the combination of elevation and slope criteria. As indicated earlier, the landform map for Sweida was prepared by combining elevation and range criteria.

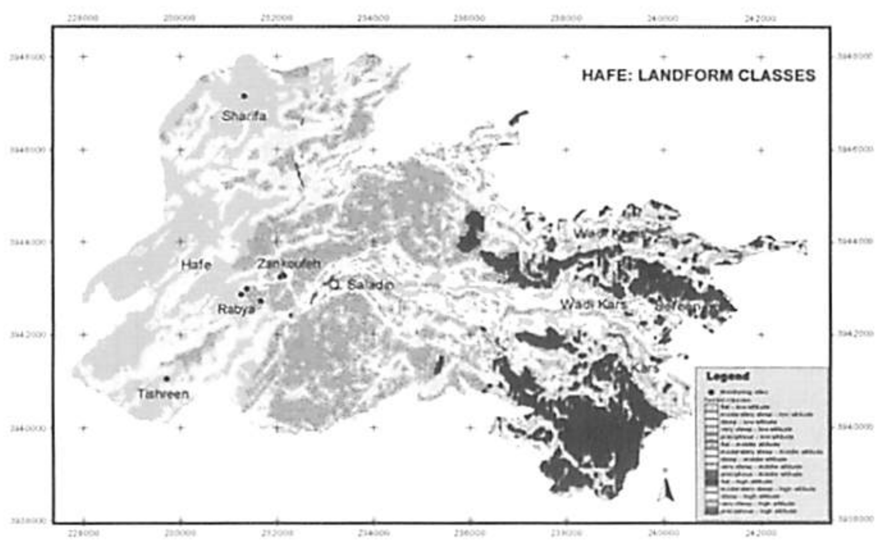

Figure 12. Landform map of Hafe.

Soil maps

The soil association map for Sweida is shown in Figure 13. As explained earlier, the soil map for Hafe has been made by the same method.

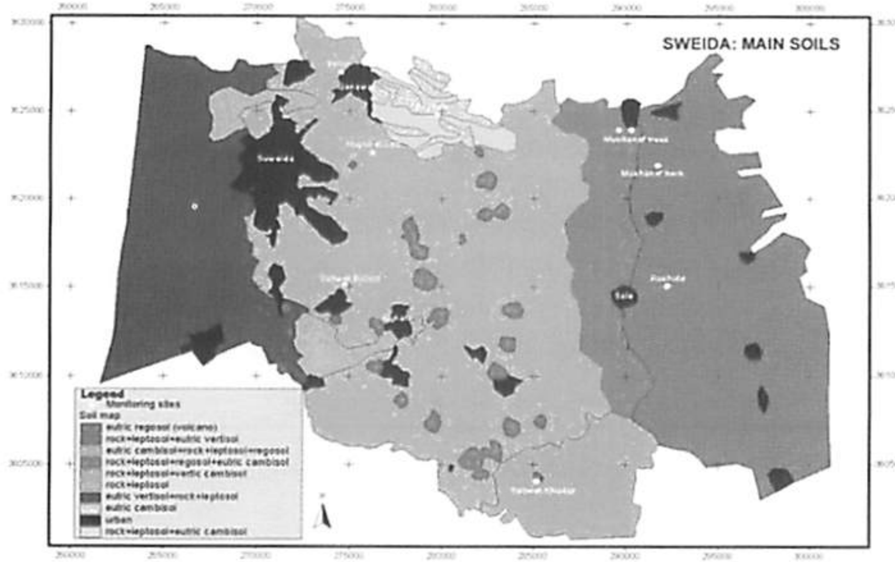

Figure 13. Soil map of Sweida.

Climatic maps

In spite of its small size, the Hafe area contains three agroclimatic zones:

- SH-C-W: sub-humid, cool winter, warm summer
- H-C-W: humid, cool winter, warm summer
- PH-C-W: per-humid, cool winter, warm summer

These divisions are determined by a strong precipitation gradient in the area.

The Sweida area, although much larger, contains only two agroclimatic zones:

- *A-C-W*: arid, cool winter, warm summer
- *SA-C-W*: semi-arid, cool winter, warm summer

The strongly contrasting climatic conditions in Hafe and Sweida are illustrated in Figure 14.

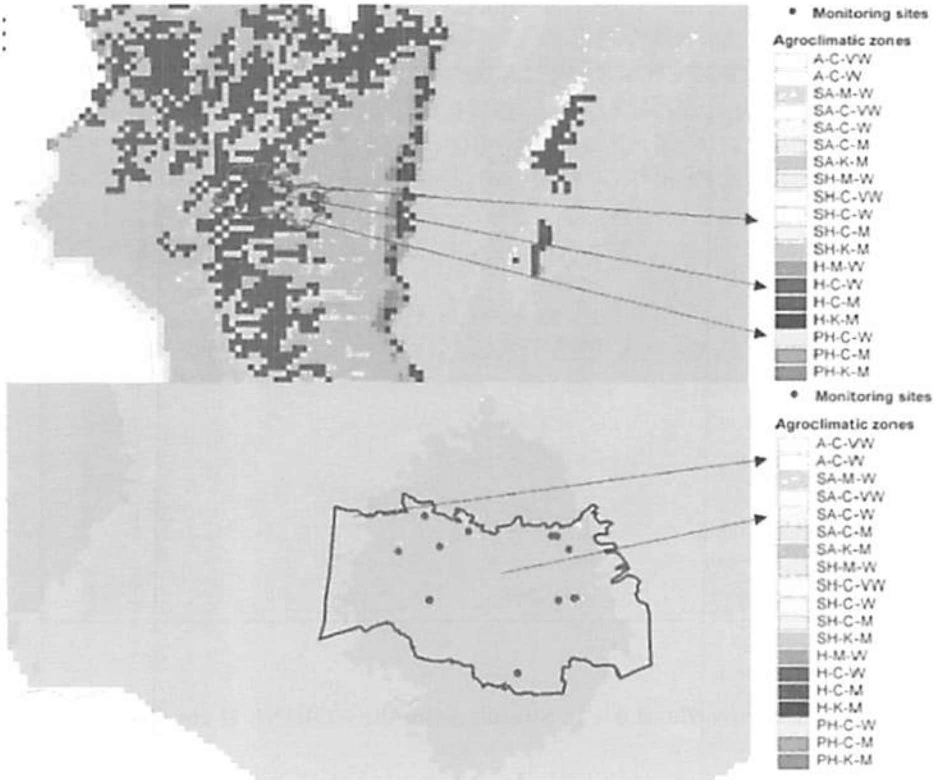

Figure 14. Agroclimatic zones in Hafe (top) and Sweida (bottom).

Land use/land cover and biodiversity ratings

The different approaches to land use/land cover map using either the CORINE Level 2 or CORINE Level 3 are illustrated for the Sweida area in the following figures.

As indicated in the methodology section, the CORINE II map (Figure 15) can be developed quickly by supervised classification of medium-resolution satellite imagery (Landsat, ASTER etc.), but the legend is not detailed and the degree of accuracy is not as high as a map based on visual observations. The CORINE III map (Figure 16) has a finer classification and the accuracy is higher, being based on visual observations, but so is the expense and time needed.

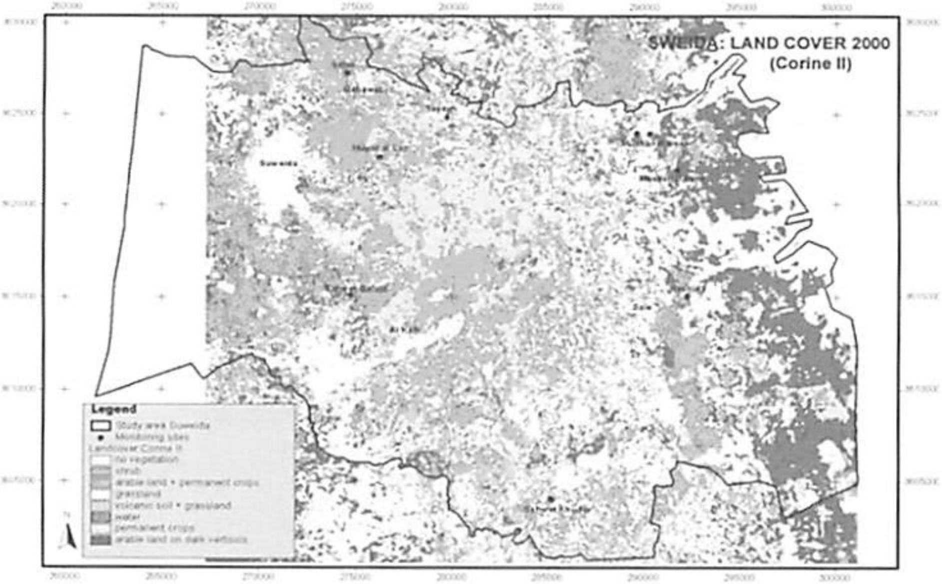

Figure 15. Land cover/land use in Sweida using the CORINE II classification.

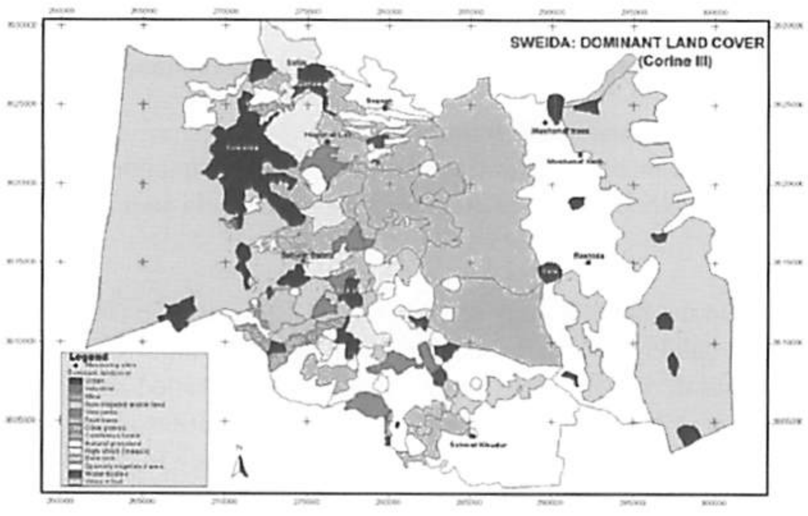

Figure 16. Land cover/land use in Sweida using the CORINE III classification.

As explained in the methodology section, the biodiversity rating map (Figure 17) is a by-product of the CORINE III land use/land cover mapping.

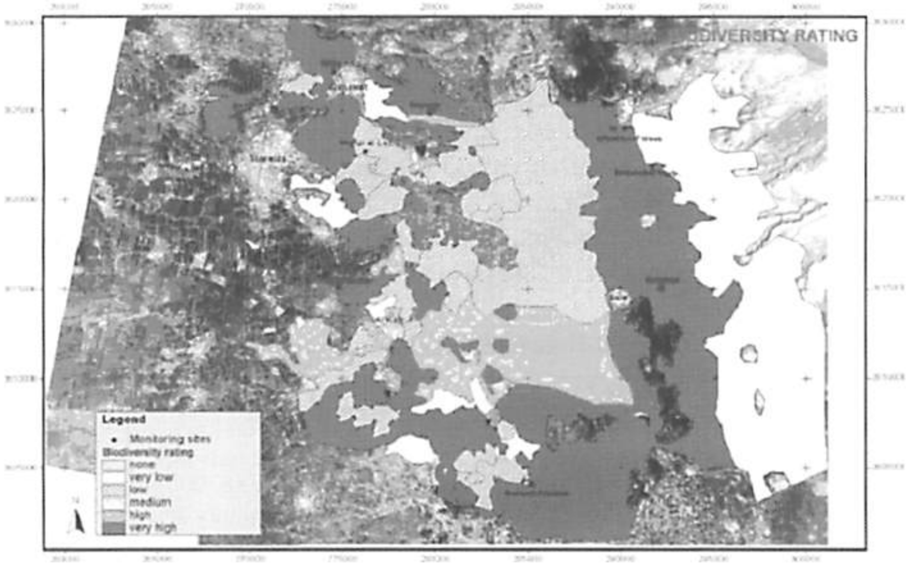

Figure 17. Biodiversity rating for the Sweida area.

Synthesis and conclusions

Table 5 summarizes the major similarities and differences between the two study areas. Although the Hafe study area is much smaller, its ecological diversity is larger than in the Sweida area. This is attributed to a stronger climatic gradient and the high ruggedness of the terrain, with steep gorge-like valleys.

With the exception of the temperature regime, which, at a regional scale, is fairly similar, the two areas have very contrasting moisture regimes, terrain and soil characteristics, as well as land cover patterns. The kinds of human influence are also different, with terracing the main land-shaping factor in the Hafe area, and de-stoning the main land intervention in the Sweida area.

Both study areas still contain 30-40% of the land with a very high biodiversity rating and conservation value. The challenges to their biodiversity are, however, different. The de-stoning operations in the Sweida area continue to transform natural rangelands into agricultural lands on a substantial scale and, at first glance, this appears a major trend that needs careful regulation in order to safeguard the few remaining biodiversity havens.

In the Hafe area the comparison of satellite images between 1990 and 1999 does not show much deforestation, if any. With the exception of isolated quarry operations, no major changes in land use/land cover patterns could be detected, which in one way is positive and in another way misleading. Within the agricultural areas much land has converted from field crops to fruit tree crops, but this cannot be assessed from the Landsat except through a detailed (and expensive) study. Probably the main but stealthy threat in the Hafe area is the extension of sub-urbanization and natural growth of village as a result of high population growth in the coastal plains. This natural growth is likely to entail the fragmentation of the remaining natural habitats through new road and housing construction. Zoning regulations are vital to prevent this encroachment into the remaining habitats.

Table 5. Comparison between Hafe and Sweida study area.

Characteristics	Hafe	Sweida
Size study area	73 km^2	768 km^2
Parent material	Marl (west) & limestone (east)	Basalt rock
Altitude	200-1000 m	600-2000 m
Slope	mainly very steep slopes, very dissected by wadis	mainly steep slopes and plateaus
Zonal Soils	Luvisols	Vertisols
Climate	Per-humid to sub-humid, cool winter, warm summer	Semi-arid to arid, cool winter, warm summer
Land use and human interventions	small-scale plots, frequent use of terraces	large-scale plots, frequent stone removal
Land cover	mainly high shrub, olive and fruit orchardsand fruit	natural grassland, arable land orchards
Biodiversity rating	40% of study area with very high rating	30% of study area with very high rating

By explaining the environmental diversity in the selected pilot areas, this study aims to link up with the other national components (in Jordan, Lebanon and the West Bank) and make a regional comparison possible. This regional comparison is currently underway and will be reported in the 2004 Annual Report. As such it will be of value for future biodiversity management, habitat conservation, land use planning and public awareness at national and regional level.

References

Celis, D. and E. De Pauw. 2003(a). 'Hot spot' assessment of land cover change and land degradation in CWANA using AVHRR satellite imagery. 2002 Annual report. Natural Resources Management Program, ICARDA, Aleppo, Syria, pp. 95-101.

Celis, D. and E. De Pauw. 2003(b). 'Hot spot' assessment of land cover change and drought risk in the CWANA region based on AVHRR imagery and agroclimatic data. Research Report, Natural Resources Management Program, ICARDA, Aleppo, Syria.

Celis, D. and E. De Pauw. 2003(c). Assessment of land cover/ land use in the CWANA region using AVHRR imagery and agroclimatic data. Research Report. Natural Resources Management Program, ICARDA, Aleppo, Syria.

De Pauw, E. 2002. Climatic extrapolation domain of Khanassir research. First approximation. Technical Note. 3 pp. NRMP, ICARDA, Aleppo, Syria.

De Pauw, E. and Pertziger F. 2001. CLIMCHART. Excel software for generation of climate diagrams. ICARDA, Aleppo.

Dixon, J., A. Gulliver and D. Gibbon. 2001. Farming Systems and Poverty. FAO and World Bank, Rome and Washington D.C., 412 pp. ISBN 92-5-104627-1.

ESRI (Environmental Systems Research Institute). 1993. Digital Chart of the World. ESRI, Redlands, California, USA.

FAO (Food and Agriculture Organization of the United Nations). 1974. FAO-UNESCO soil map of the world. Vol I: Legend. Unesco, Paris.

FAO. 1988. FAO-Unesco Soil Map of the World: Revised Legend. World Soil Resources Report 60. Food and Agriculture Organization of the United Nations, Rome.

FAO. 1990. Guidelines for soil profile description. Food and Agriculture Organization of the United Nations, Rome.

FAO. 2001. FAOCLIM, a CD ROM with world-wide climatic data. Food and Agriculture Organization of the United Nations, Rome. URL: http://www.fao.org/sd/2001/EN1102_en.htm

Gesch, D.B. and Larson K.S. 1996. Techniques for development of global 1-kilometer digital elevation models. In: Pecora Thirteen, Human interactions with the environment.

Hutchinson, M.F. 1995. Interpolating mean rainfall using thin plate smoothing splines. International Journal of Geographical Information Systems, 9: 385-403.

Hutchinson, M.F. 2000. ANUSPLIN version 4.1. User Guide. Center for Resource and Environmental Studies, Australian National University, Canberra. URL: http://cres.anu.edu.au

Ibiyemi, A. 2002. Point Profiler. An ArcView extension to extract multi-layer information for a specific point. ICARDA, Aleppo

Knutson, C., Hayes, M. and Phillips, T. 1998. How to reduce drought. Western Drought Coordination Council, Colorado, USA.
Document available on-line from URL: http://enso.unl.edu/ndmc ha-1ndbook ha-1ndbook.htm

UNESCO. 1979. Map of the world distribution of arid regions. Map at scale 1:25.000.000 with explanatory note. UNESCO, Paris, 54 pp. ISBN 92-3-101484-6.

Zhang, X., Drake A.N., Wainwright J. and Mulligan M. 1999. Comparison of slope estimates from low resolution DEMs: scaling issues and a fractal method for their solution. In Earth Surface Processes and Landforms 24, 763-779 (1999).

ANNEX

Refereed publications

Cools, N., De Pauw, E. and Deckers, J. 2003. Integrating conventional land evaluation methods and farmers' soil suitability assessment: Case of Northwestern Syria. Agriculture, Ecosystems and Environment 95 (2003) 327-342.

De Pauw, E. 2003. Approaches to multi-scale agroecological zoning in ICARDA's mandate region in: Proceedings of the OECD Meeting on "Innovative soil-plant systems for sustainable agricultural practices," Izmir, Turkey, 3-7 June 2002, pp. 29-48.

Accepted for publication

De Pauw, E. Agricultural drought monitoring in the Middle East. Accepted as book chapter in V.K.Boken, A.P. Cracknell, and R.L. Heathcote(Eds.)- Agricultural Drought: Global Monitoring and Prediction. To be published in 2004 by Oxford University Press.

De Pauw, E. Drought. Early Warning Systems for the Near East. Accepted for a special ASA publication on Dryland Challenges.

Ryan, John; Eddy De Pauw, Humberto Gomez, and Rachid Mrabet. Drylands of the Mediterranean Zone: Biophysical Resources and Cropping Systems. Accepted as book chapter for publication by ASA.

De Pauw, E. Management of dryland and desert areas. Accepted for publication by on-line Encyclopedia for Life Support Systems (UNESCO-EOLSS Publishers).

Other publications

Cools, N. 2003. Multi-scale participatory land resource assessment in northwest Syria. Ph.D. Thesis, Katholieke Universiteit, Leuven, Belgium, 345 pp.

De Pauw, E. Six frequently asked questions about drought. Caravan, October 2003, ICARDA, Aleppo, Syria, pp.6-7.

Scheldeman, K. and E. De Pauw. 2003. Agroecological characterization of the agrobiodiversity conservation areas in Syria. GEF-UNDP-ICARDA Agrobiodiversity Project. Technical Report. 94 pp.

Training manuals

Ibiyemi, A.G., K. Scheldeman and E. De Pauw. 2003. GIS for natural resources management and agrobiodiversity assessment: ArcView GIS, GPS, Spatial Analyst and IDRISI. Training Manual with hands-on exercises. ICARDA, Aleppo.

Software

Abed, H., E. De Pauw, Z. Abdul Hadi. 2003. ICARDA Meteorological Database System. . On-line Intranet/Internet-based Client/Server database system for meteorological data.

Training activities

- February-March 2003: 2-week training course "Use of GIS and Remote Sensing for Natural Resources Management" for ICARDA staff and GCSAR staff
- March 2003: 3-day micro-course on use of GIS and GPS for Khanassir researchers
- May 2003: 1-week GIS training course in Beirut, Lebanon
- June 2003: Participation in JICA training course
- December 2003: 2-week on-the-job GIS/Remote Sensing training two range ecologists from IRA Medenine, Tunisia

Staff list including students

- Dr Eddy De Pauw: Agroecologist (Belgium)
- Mr Adekunle Ibiyemi: Senior GIS Analyst (Nigeria)
- Mr Kristof Scheldeman: JPO Land resources assessment (Belgium)
- Mr Mohamed Salem: meteorological technician (Syria)
- Mr Ahmed Hamoud: meteorological observer (Syria)
- Mr Ghazi Yassin: meteorological observer (Syria)
- Ms Nathalie Cools: PhD student (Belgium)
- Mr Vahid Ghassemi: PhD student (Iran)

Financial support

ICARDA Core

PROJECT 4.1: SOCIOECONOMICS OF NATURAL RESOURCES MANAGEMENT IN DRY AREAS

Project rationale

Conservation and sustainable use of the natural resource base for agricultural and livestock production in CWANA is an important goal of ICARDA. This can not be achieved without appropriate analysis of the social, institutional and economic factors that influence resource management and an understanding of resource users' perceptions, goals and limitations. This understanding enables the design of technical interventions, reveals where opportunities may exist for community action and cooperative management of resources, and identifies where policy and institutional changes are needed to achieve that goal. This project aims to conduct the necessary social, economic, institutional and policy analysis to help achieve that goal.

Project purpose

The purpose of this project is to analyze the social, institutional and economic factors that influence resource management and resource users' perceptions, with the aim of assisting in the design of policy, institutional and technical interventions.

Outputs

Output 1: Market and non-market valuation of natural resources and estimation of the economic and social costs of their degradation

Rationale

Water scarcity is getting worse in CWANA with the growth of the population and increased development needs. Agriculture is the largest user of fresh water. Research on the economic, institutional and policy issues affecting agricultural water management is essential for developing interventions that bring about more efficient, sustainable and equitable use of scarce water resources.

Activity 1: Analysis of the economics of groundwater use in Syria

Activity objectives

Compare the relative profitability of alternative agricultural uses of groundwater from shallow aquifers in dry areas of Syria and identify the main driving forces of groundwater exploitation.

Research progress

This study was conducted to evaluate the profitability of irrigated cropping in water-scarce areas in five villages in four stability zones in Syria, and to determine the driving factors of the expansion of groundwater use. Furthermore, demand for groundwater and irrigation cost function was analyzed. Farmers' groundwater investment was modeled, the probability of drilling success was determined, and a system dynamic simulation model was developed. Contrary to the conventional proposition, it was found that groundwater use in these areas has transformed sustainable traditional livestock-barley farming system to non-sustainable groundwater-irrigated systems and led to out-migration in the medium term. Procurement prices of wheat and cotton, low fuel cost, and open access to groundwater constituted the driving forces for expansion. It was also found that, demand for water for high water consuming crops was elastic and hence irrigation cost and crop prices can play an important role in the water use sustainability. Investment in groundwater irrigation was unrecoverable and risky where the probability of drilling success was only 0.07. Expansion in areas allocated to high water consuming crops such as cotton have led to water depletion and are not profitable at 50% higher fuel cost than the current cost. Crops such as vegetables in combination with wheat can be sustainable options to high water consuming crops.

Brief activity conclusions

This research was carried out as a PhD thesis and was part of an inter-disciplinary research project. The findings of the study are very revealing in terms of the effects of water management policies of Syria in the past few decades. Syrian authorities have recently implemented programs requiring that farmers use water-saving technologies as a measure to reduce excessive water use in agriculture. But policy gaps still persist. The results of this study will contribute to the formulation of policies for agricultural water management in Syria. The results of the study will be disseminated through seminars involving various organizations.

Output 3: Socioeconomic evaluation of potential resource management options.

Rationale

Policy and institutional factors influence land management and affect livelihoods. Therefore, it is essential to identify and analyze the linkages between policy and institutional factors, natural resources management and rural livelihoods, and develop institutional and policy options that complement technological options.

Activity 1: ***Analysis of policies affecting land use and terrace maintenance in Yemen***

Activity objective
Identify policy gaps that affect the adoption of sustainable terrace farming and the livelihoods of rural communities in the Yemeni Mountains.

Research progress
The policy and institutional factors affecting terrace maintenance were analyzed. The study used interviews with farmers, officials from government departments and other institutions such banks and development programs. The aim was to assess how much rural communities in mountains actually are aware of and access the resources that are, in principle, available and which can be utilized for terrace maintenance and for building their livelihood assets. The results of the study are briefly summarized below.

Agricultural policy support, mainly through diesel subsidy, has largely benefited irrigated agriculture and large farmers, with no tangible benefits to the farmers in the mountain terraces who mainly depend on rainfed crops and seasonal springs. Similarly, agricultural policy support targeted at the development of large spate irrigated systems benefited spate systems in the flat downstream areas and had no impact on mountain terraces. The subsidized wheat imports which mainly benefit large urban consumers have negatively affected the production of rainfed cereal crops, thus, reducing the profitability of rainfed farming on mountain terraces where cereal rainfed faming is dominant. This in turn has negatively affected the returns to investment in terrace reconstruction and rehabilitation. On the other hand, this policy may have also helped poor rural households to access cheaper staple foods like wheat. It is quite likely that the negative price effect on food production and employment outweighs any positive effect on food security for rural mountain households.

Yemen has three main institutions which provide financial capital to rural communities, namely: the Cooperative and Agricultural Credit Bank (CACB), the Agricultural and Fisheries Production Fund (AFPPF) and the Social Fund for Development (SFD). These institutions have different programs and credit facilities which seem ideal for addressing the issues of poverty, technology access and land improvement including terrace rehabilitation in the Yemeni mountains. But, the study revealed that small farmers' access to the opportunities offered by these institutions is negligible. This is because, firstly, for all three institutions, there has been a bias in favor of large loans and irrigation rather than soil and water conservation in the upper-catchment areas, like the mountain terraces.

Thus, they provide incentives for irrigated agriculture. Secondly, the CACB loans during the 1990-2000 were neither pro-poor nor pro-rainfed. There were relatively few borrowers who were certainly not the poorest who depend on rainfed agriculture and inhabit the mountains. Thirdly, the relatively small number of projects supported by the AFPPF is not consistent with the poverty level in different governorates. Fourthly, Local Directorates of the Ministry of Agriculture believe that the SFD lack the willingness and the capacity to implement programs that benefit the rural mountain farmers. And finally, there is a lack of awareness among rural communities in the study areas about the existence of these programs and the ways in which they can benefit.

Some of the institutional and technological options that could increase the accessibility of the credit services for rural communities' conservation of mountain terraces are discussed below:

Building community-based organizations: Various community groups, including extension groups, savings and credit associations, and water users associations, need to be formed to realize greater community-coordination in acquiring credits and other services from institutions. These local organizations can perform collective action such as maintenance and rebuilding of terraces and other land improvement activities and can form the basis for self-governing rural-financial services. There is strong community cohesion and cooperative activities including those traditionally used for runoff water diversion and use for irrigation, which can be harnessed for establishing these community-based organizations.

Rural financial services: Creating savings and credit associations at the village level as grass roots micro-finance intermediaries, capable of accessing funds from CACB, AFPPF and SFD or from other financial institutions is essential. The lack of rural credit institutions to reach the rural poor and particularly those who live in the mountains requires a restructuring of these institutions. These institutions should include the development of community capacity as their goal. This may not be easy, but the three micro-watersheds where this project is conducted offer an opportunity where such grassroots organizations can be formed as pilot case and lessons learned applied in the rest of the country.

Focus on water and land conservation: The study found out that water shortage is the single most important problem that these rural communities face. Addressing this problem is fundamental to the welfare and stability of these communities. Hence, community-based organizations and micro-credit groups as well as other development schemes should make water as their initial priority focus. Water harvesting and storage structures already exist and are used in all three sites but the efficiency of these can be improved. Farmers also have ideas on how to invest more in this and they developed proposals on these projects. Similarly, soil conservation through terraces maintenance is another important activity that rural credit can actively seek to support.

Extension and technology transfer: It is unlikely that the traditional technology transfer will adequately serve the complex agricultural systems in the mountains of Yemen. Agricultural research and extension need to address this serious issue. Farmers in these areas grow a number of crop types each suitable for different conditions, even in relatively small micro-watersheds, and a failure to understand the local crop types, their uses and niches in the season and along the altitude gradient is a sure failure for technology transfer in these terraced mountain lands. The limited number of functional climate stations in Yemen hampers the characterization of these complex environments. The project's provision of rain gauges and min-max thermometers to farmers at different elevations in the watershed is only a small start. As demonstrated in this project, researchers need to learn a lot from these communities before passing on recommendations. Presently identified technology transfer opportunities for rainfed crops would include improved seeds for sorghum, wheat, barley and legumes. AFPPF facilities program would be vital to enabling poor farmers to get access to important inputs like improved seeds and fertilizers. Potato farmers could receive advice on improved practices to improve their yields. Farmers with over-age coffee plots could be advised on rehabilitation and poor farmers would be assisted to replant through compensation for the loss of production and additional labor requirements.

Marketing: Farmers need better marketing of their cash crops, particularly potatoes and coffee through marketing associations, in order to achieve bargaining power with traders and to establish market linkages. Assistance should, therefore, be provided to form marketing associations to access credit from CACB or partial grants from AFPPF for the construction of potato stores which could enable them to sell their potatoes at much higher prices and to store their seed under optimum conditions, for export potatoes. Training can also be provided, in a simple manual, including the practice of grading to obtain better prices.

Income diversification: This could be facilitated by access to credit from CACB and/or partial grant from AFPPF as well as technical support, and could include acquisition of livestock and high yielding new crop varieties and better crop management technologies for higher income and greater food security.

Brief activity conclusions
This activity revealed the gap between policies and rural support programs and the actual utilization of these by rural mountain communities in Yemen. Larger and more resourceful farmers in the irrigated and spade systems have greater access than the poor relatively less resourceful farmers in the mountain communities. Closer linkage between research and development is needed to demonstrate development models that accelerate impact in these mountain systems.

Activity 2: ***Analysis of the policy and institutional factors that influence land use in Khanasser Integrated Research Site, Syria***

Activity objectives
Determine how farmers responded to recent policy changes. These policy changes influence land use and rural livelihoods.

Research progress
Research on policy has so far focused on identifying and describing the key policies that impact on marginal dry areas such as Khanasser. These policies affect livelihoods or natural resources use. Policy changes are also linked to the impacts of changes in markets and institutions. Several policy changes that affect land use and rural livelihoods include 1) irregular management of exports of fattened animals and inputs for market-oriented agricultural production, 2) weak extension and lack of support for technology diffusion and adoption of improved management options, 3) banning of cultivation of barley in the rangelands with the aim of restoring natural pastures, 4) banning irrigation of cotton, and prohibiting digging wells and excessive groundwater abstraction, and 5) lack of credit facilities for small and poor farmers to build their assets.

A market study for Khanasser in Sfhiere (started in 2002) is on-going by means of collection of weekly prices of commodities and labour.

Conclusions
The effect of recent policy changes on rural livelihoods and resources is significant and farmers have made their own coping strategies including seasonal and permanent out-migration and off-farm employment. This activity will measure and document the effects of these policies on poor rural households and on resource management in the marginal areas (such as Khanasser). This work will be part of the bio-economic modeling that will be completed next year.

Output conclusions

As is clear from the above results, policy plays a major role in determining resources management practices, adoption of new resource-saving options and remains a strong factor than can bring about more efficient, equitable and sustainable resource use. Policy gaps persist in many countries in CWANA region. There are, nonetheless, positive signals from governments in changing some of the old policies, and in certain cases specific measures are implemented. However, there has been no research on the effects of these new policy changes which could provide valuable feed back to policy makers. Natural resources management policies have an impact on the poor and on the poverty-resource degradation cycle. Therefore, policy research on natural resources management is an area which will receive greater attention in the future.

Output 4. Institutionalized multidisciplinary and participatory approaches to natural resource management research in national systems

Rationale

The use and popularity of the application of FPR is based on its expected benefits in terms of increased research impact. This is based on the presumption that farmer (or client) participation in the research process can provide inputs that can improve the relevance of research outputs (technological options), reducing the research lag (development phase), reducing the adoption lag (early adoption), increasing adoption speed, increasing farmer knowledge, and empowering farmers. This output aims at supporting other researchers in strengthening farmer participatory research methods.

Activity 1: Training of NARS participants in water management course

Activity objectives

Develop procedures for participatory research methods and identify opportunities and constraints to community collective management of natural resources.

Research progress

The social scientists participated and led in many cases the implementation of participatory technology evaluation (PTE) days in the Khanasser Valley Integrated Research Site, Syria, where farmers were invited to the experimental/ demonstration sites and asked to make their assessment of the performance of the technologies. The technologies included water harvesting on slopes grown with olives, production of vetch, alley cropping of *Atriplex* with barley, cumin production practices, and phosphogypsum application of barley, and participatory barley breeding.

Participatory research on some technologies such as olive orchards with water harvesting is continuing, and farmer adoption is increasing. Research is needed on the agronomic management, land tenure, marketability aspects, and on their impact on improving livelihoods. Participatory research on improved cumin production, is also well on its way. Substantial progress should be made in providing answers to the several agronomic questions farmers have been raising in order to reduce the risks of failing yields. Participatory barley breeding to identify new drought tolerant varieties has been successfully transferred by the barley breeding project to Khanasser from other areas of Syria where this approach has been developed in the past. The challenge now is, in methodological terms, how the PBB model and the farmer participatory research of KVIRS can complement and learn from each other.

Atriplex alley cropping research shows a dichotomy between the documented positive ecological benefits of this technology, and the still unclear prospects for wide adoption. While some farmers apparently regard it positively, there is hardly any spontaneous adoption. Research should urgently focus on adoption aspects and on the role of extension. Participatory research on vetch is new in KVIRS. Vetch's apparent successes cannot be fully judged as they were achieved in fairly good rainfall years. Better vetch varieties and other economic uses of vetch - particularly for feeding livestock-need to be researched. Farmers asked for different varieties to evaluate and wanted that animal feeding trials be included in these experiments. Phosphogypsum technology is also in the very early stages of its participatory testing. Main issues that need to be understood include the institutional and economic aspects that may constrain the actual application and adoption of this technology, in spite of its proven agronomic success in the field.

To further strengthen the capacity of NRM staff and partners in conducting participatory research, a workshop was organized on 25-27 March 2003 for interdisciplinary teams involved in Khanasser and national partners. It focused on institutionalizing participatory research and building the capacities of rural communities for development. This workshop, facilitated by a consultant, was a follow-up on trainings in the previous year (October 2002) on FPR methods for Khanasser Valley Integrated Research Site, which was executed as a recommendation of the social science project. The objectives of the workshop were improved understanding of FPR (increased awareness and understanding of NARS partners in farmer participatory research and clarified roles in the research program); development of FPR impact assessment criteria (shared experiences in the participatory research approach and shared understanding of what are the expected impacts of participatory research in Khanasser and how these can be measured); and institutionalization of the FPR approach (an assessment of the requirements for institutionalizing participatory research at ICARDA and NARS partners).

Conclusions
Over the last two years, skills to plan, conduct and facilitate participatory evaluation exercises have increased significantly at ICARDA. The steps followed so far include: working with a group of farmers through farmer interest groups (FIG), farmer selection and agreement with the process, data recording and final assessment, there is a resident staff in Khanasser who provides weekly information about farmers' views and developments in the study area. One intern has been assigned to monitor and evaluate the process. However, the researchers raised a concern on the cost of participatory research. This is a serious concern that has to be considered. Proper documentation of the process will help to estimate the cost of the approach. For next year, it is expected that most technology groups can run their own participatory meetings with minimal external help. However, there is need for increased involvement of farmers at planning and monitoring stages and activating farmer interest groups. PTE days also strengthened the collaboration between different research disciplines, for instance between GP and NRMP scientists.

Output conclusions
The interest in and capacity to conduct participatory research at ICARDA and NARS partners is increasing. A major concern, however, is the cost of the approach. This requires a detailed documentation of the process that will help account for all research inputs used in the process, but also careful documentation is needed on how farmer participation has affected the research design, researchable variables, whether it reduced research lag, or generated other learning spillovers for farmers and researchers, and how the process speeded up the diffusion of technologies in the target population, or successfully led to sustainable collective action.

Output 5: Knowledge of NARS social scientists on the socioeconomic research in natural resource management enhanced

Activity 1: Training of NARS participants in water management course

Activity objective
To conduct a water management course with participants from CWANA countries. This is a three-year project aimed at strengthening the capacity of national programs.

Research progress

The social science project contributed to this course by introducing the trainees to the social, economic, and policy issues related to water management. Concepts on technology evaluation and farmer participation in technology development were also addressed. Most of the participants were young researchers involved in water research but none of them was working full time as a social scientist so the social science training given was essential and allowed them to appreciate these aspects. Later when the trainees conducted small field research projects they used the concepts of farmer interviews and participatory aspects in problem diagnosis indicating the value of the exposure to young researchers of such concepts as part of their basic training.

Brief activity conclusions

The capacity building of NARS in the socioeconomic aspects of resource management will continue to be an important activity. However, the maximum impact could be achieved through training of students and researchers conducting research activities as part of their of MSc or PhD thesis or as part of research activity in special projects. This will generate more practical training in the application of the methods and research outputs. This strategy will be followed in the future.

APPENDIX

Staff List

Aden Aw-Hassan (Project Manager)-50%
Roberto La Rovere (20%)
George Arab (Research Assistant)-20%
Hala Khawam (Research Assistant)-20%

Collaborators

- University of Çukorova Turkey
- National research programs of CWANA including Egypt, Iran, Jordan, Kazakhstan, Kyrgyz Republic, Pakistan, Syria, Turkmenistan, Turkey, Uzbekistan and Yemen
- University of Vermont, USA
- Kiel University, Germany

Donors

- Core budget project 4.1
- GTZ through the Kiel University, Germany
- CIAT supported the participatory capacity workshop
- Swiss Development Corporation through the Swiss Embassy in Damascus
- IDRC, Cairo office for the Yemen Mountain Terraces Project
- Asian Development Bank, through the Water Management Project in Central Asia
- The World Bank

Students

Fadil Rida (completed PhD thesis)

Users and beneficiaries

The users of this research are farmers who get information on the tradeoffs of benefits and costs of alternative resource management practices, researchers who develop and use farmer participatory research methods, research managers who get information on the effects of research interventions on resource management, and policy makers who get information on the effects of policies and institutional arrangements on resource management and, hence, help in the design of policies and institutional innovations.

Publications

Non-refereed (e.g. meetings, proceedings, posters, abstract)

Rida, Fadil. 2003. Computer simulation models for sustainable groundwater use in agriculture in Syria. PhD Thesis. Department of Agricultural Economics, Institute of Natural and Applied Sciences, University of Cukarva, Adana, Turkey.

Training activities

- The project contributed to a water management course.
- The project contributed to the training of staff of the Ministry of Environment, Syria, as part of the implementation of National Action Plan for Combating desertification.

PROJECT 4.2: SOCIOECONOMICS OF AGRICULTURAL PRODUCTION SYSTEMS IN DRY AREAS

Rationale

Sustainable improvement of the welfare of poor people in dry areas, through the proper identification of problems and the development, transfer and adoption of viable options, can be achieved only if there is a full understanding of the economic and social dimensions of rural poverty. This can be accomplished though micro-economic and social (including gender) analysis of farm households and rural poverty. Such understanding allows proper design and adaptation of land use options and superior practices and enhances their diffusion in the farming communities. In addition, it enables the identification of policy and institutional changes that remove the constraints that limit rural peoples' abilities to improve their livelihoods and to fully utilize those options and practices.

Project purpose

- Efficient and effective identification of research problems within farming systems.
- Appropriate solutions and recommendation domains for identified problems.
- Improved targeting of research and technology transfer efforts towards the rural poor.
- Improved adoption rates of appropriate new technologies.
- Measured impact of technology use on productivity, poverty alleviation, and the environment (disaggregated by population group, including gender).
- Human resources for problem identification, technology evaluation, and impact assessment increased within NARS partners.

Progress of research by output

Output 1: Production problems of resource-poor farmers identified and their production systems characterized

Rationale

Understanding the production systems, constrainers and livelihoods strategies in a proper diagnosis using rural appraisal and participatory methods that involve rural households themselves provides valuable information that guide research and project the viability of different interventions in improving the livelihoods or rural communities in the dry areas.

Activity 1.1: ***Rapid rural appraisal of livelihood strategies and options in Khanasser Valley***

Activity objectives

- The objective of the study is to document perceived poverty levels and current rural livelihood strategies, and to explore potential options for improving livelihoods in ICARDA's integrated research site, Syria, which has agro-economic conditions similar to most of marginal environments in CWANA region.

Research progress

Following a livelihoods approach, villages in the target area were characterized using key variables, including population density, production orientation, land use, property rights, services and livelihood strategies. Data were collected using Rapid Rural Appraisal, through semi-structured surveys and conversational interviewing of key informants in each village.

People's perceived poverty criteria and well-being categories were determined (Table 1). Cluster analysis was performed on village-level data to classify homogeneous communities in relation to their dominant livelihood strategy. The variables were then overlaid using GIS, and representative case study communities were selected.

Well-being and poverty indicators. Were classified as: natural (sheep, land, water), physical (farming equipment), financial (sheep fattening, straw trade, owning wells, having cash, not having debts), and human capital (workers, migrants). Using these indicators, about 13% of households were classified as 'very poor,' 48% as 'poor,' 33% as 'moderately well-off,' and 6% as 'well-off.'

Classification of communities using cluster analysis. Three clusters of villages with broadly similar livelihood strategies were identified (Table 2). Within these clusters, specific villages were selected to represent different livelihood categories. The first group is characterized with the prevalence of agricultural production based strategies. Group II are households with more off-farm labor and with sheep fattening which is an important economic activity for 15% of households. Group III has also more off-farm labor and migration as the main livelihoods strategies. Off-farm employment-in agriculture, locally or in more favorable areas, in cities, and outside the country is an important livelihood strategy. About 53% of households have members who work as off-farm wage laborers, 20% as laborers in cities, and 13% outside Syria.

Table 1. People's perceived indicators of well-being in Khanasser.

Capital	Very poor	Poor	Moderately poor	Well-of
Natural	No sheep Landless or small land area (1-3 ha)	Few sheep (1-5 head) Small land area (2-5 ha)	Medium sheep flock (20-50 head) Medium land area (15-25 ha)	Large sheep flock Large land area Own well and have irrigation.
Human	No off-farm work Sick Unable to work	Only one laborer	More laborers Members working outside Syria	Government employment
Financial	In debt	No cash	No debt Enough cash to run business Own sheep fattening Work in straw trade	No debt Have fattening sheep work Sell drinking water
Physical				Own lorry and/or tractor

Table 2. Cluster of villages with similar livelihoods in Khanasser.

Cluster of villages	No. of villages	Main characteristics	Dominant livelihood strategies
Group I	4	Relatively large land areas; large rangelands for grazing; good asphalt road; few households with members working as off-farm labor	Agricultural production
Group II	15	Small land area; small rangelands; fewer public services (electricity, school, etc.)	Off-farm work; sheep fattening
Group III	12	High population density; smaller land area; better infrastructure	Off-farm work

Options for improving the livelihoods of the poor. With 28, 000 sheep and about 1,300 goats in the valley, and about 70% of households owning livestock, sheep production has an important livelihood function. The productivity of the dominant barley/livestock system can be improved by drought tolerant barley varieties; alley-cropping of drought resistant *Atriplex* shrubs with barley or vetch; improved flock management; small-scale facilities to process quality dairy products. New crops cash such as cumin can generate high income but can be risky due to yield and price variations. Groundwater in the valley is generally high in salinity, which makes it unsuitable for drinking. In the villages along the hill ranges, water quality is good, but well yields are low. Most people pay for drinking water, which is drought by tractor-pulled tankers from government water points and private wells. Irrigation of crops is limited. Water-harvesting techniques for olive trees can make use of barren hill slopes, arrest soil erosion and increase farm income while with minimum labor demand. Value-added enterprises such as sheep fattening can have significant impact but institutional innovations, such as micro-credit, would be the key to enable the poor to engage in this profitable enterprise; other value-added enterprises, such as production of medicinal plants and mushrooms can also be profitable. Conservation and eco-tourism has also a potential, given the traditional beehive houses, ancient subsurface water channels (*qanats*), and nearby salty lake, with its wildlife and unique ecosystem.

Brief activity conclusions

The livelihood strategies of rural people in the dry areas, like those in Khanasser, are dynamic. People find new ways to augment their income. Farmers' acceptance of practices with long-term environmental and economic benefits, like alley cropping (*Atriplex* with barley), is uncertain. Detailed analysis of households' typologies and their livelihoods, and *ex-ante* assessment of these options are in progress.

Output 2. Rural households and their livelihood strategies characterized and the circumstances that constrain or enhance the adoption of technologies and management practices identified

Activity 2.1: Rapid rural appraisal of livelihood strategies and options in three micro watersheds in Yemeni Mountains

Activity objectives

The objective of the study is to document perceived poverty levels and current rural livelihood strategies, and to identify major factors influencing rural livelihoods options in remote mountain communities in Yemen. The activity is an integral part of community-based NRM research aimed at improving rural livelihoods and reducing degradation of mountain terraces in Yemen.

Research progress

Participatory poverty assessment was applied to determine the perceived livelihood categories of rural households and the criteria that local people use to describe the level of well-being of different households. Key informants were asked to classify farmers in each village into one of four categories: very poor, poor, moderately well off and well off, and then asked to identify the criteria that are typically used to classify households in to these different well-being categories. These categories and their characteristics are given in Table 3.

Farmers described the poorest households as those having few assets and mainly working for others, or sharecropping with other land users. The poorest households with no or very small productive agricultural land depend less on agriculture as a source of livelihood and more on their wage labor and on non-agricultural income. This means asset-building interventions, such as enabling the poor to acquire livestock, would be the first step since they will not directly benefit from production technologies. The sources of income for different income categories (from the lower to the top quartiles) is given in Figure 1. This shows that household incomes in the communities of Yemeni mountains are quite variable with the poor having the least diverse income sources, hence being the most vulnerable. The results show that the poorest of the poor had no meaningful assets. Policies and institutional innovations that can allow building assets are needed. In addition, high payoff agricultural technologies are essential for the poor with limited agricultural assets. Further analysis of the survey data will be reported in the next annual report.

Water scarcity is the most critical issue in the study areas and women spend much of their time fetching water. Communities have developed complex water management structures built through local knowledge. These include networks of channels that carry harvested surface runoff to distant fields in rainy seasons, and seasonal springs with a network of diversion channels that carry water to small reservoirs and cisterns. This supports the limited irrigated agriculture. High value crops, such as coffee, *qat* and vegetables, are irrigated with this precious water. Cisterns are used to store essential runoff, mainly for domestic consumption. Water sharing mechanisms are based on traditional institutional arrangements, which are working well. However, several limitations were identified. Population growth, increased interest in off-farm employment, and male out-migration strain traditional institutional arrangements, which no longer provide adequately for the repair and maintenance of these water systems.

Table 3. Well-being criteria used in the classification of communities of Al Qimma Watershed.

Well-being categories	Assets	Sources of income
Al Qimmah		
Very poor	Landless	Agricultural wage labor, non-agricultural wage labor in towns
Poor	Small land, some have sheep and goat, some have small shops	Agriculture (own farm), sharecrop ping, off farm work: Ag and non-agricultural wage labor in towns, trade and remittances
Moderate	Land, some own livestock, some have cars, mills and shops	Agriculture (own farm), sharecropping, off farm work: Gov. jobs, non-agricultural wage labor in towns, trade and remittances
Well off	Most own large land holdings (over 2 Ha). Most own livestock, some own cars, mills and shops	Agriculture (own farm), off farm work (government jobs), non-agricultural wage labor in towns, trade and remittances
Annaqilain		
Poor	Land: less than 1 Ha; crops: cereals and forage; cows (0), Goat (1-2); Sheep (1-2); intermittent wage labor in Yemen	
Moderate	Land: 1-2.6 Ha; crops: cereals, vegetables and *qat*; 1-2 cows, 3-4 goats; 3-4 sheep; private car or mill or small shop; steady job as government employee; 1 household member working outside Yemen	
Well off	Land: More than 1-2.6 Ha; crops: cereals, forage, vegetables and *qat*; have more than 2 cows, or greater than 4 goat, or more than 4 sheep, private car or mill or small shop, steady work in owned businesses and trade, more than 2 household members are working outside Yemen	
Yasqum		
Very poor and poor	Majority of families are landless, some families depend on agriculture with low and irregular returns, and other families depend mainly on non-agricultural income with low returns. In general, the incomes of these families hardly cover their basic needs	
Moderate	Families depend in addition to agriculture on income from skilled labor, trade, and business in towns or abroad with adequate returns	
Well off	Some families who are large landowners derive high income from cash crops, other families are involved locally in non-agricultural activities such as businesses, other families receive high remittances from family member(s) working abroad	

Source: PRA Survey

Farmers cited help for water system improvements as their first priority. Interest-free loans for developing water resources are available, but farmers are neither fully aware of the service nor effectively organized to access these loans. There is a big gap between the resources available for community development in different national and provincial institutions on one hand and the information available and organizational capacity at the local level on the other. Development of community organizations that can increase awareness about available resources and reduce the related transaction costs is critical to improve the welfare of these rural communities. Such organizations could also serve as liaison for research and extension.

The role of women is critical in the mountain communities. In terms of labor, women's contribution to sustainable livelihood is substantially higher than that of the men. Women handle most the jobs related to livestock, including herding (mainly girls), rearing, feeding, collecting feed from fields and wadis, milking, and cleaning animal yards. Women and girls account for about 88% of this labor, while boys provide the remaining 12%. Women are responsible for preparing animal dung for fuel, fetching fuel wood and water, taking care the children, and handling all domestic work. Women and girls also contribute about 31% of the labor supply for crop production and terrace repair. Groups of women travel long distances carrying collected fodder, wood, and water over steep slopes. Research and development interventions should address the drudgery that is a regular and obvious aspect of women's subsistence.

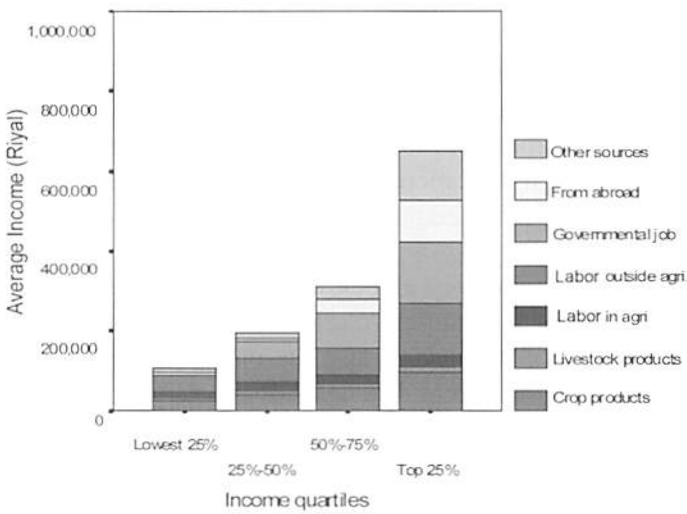

Figure 1. Income quartiles of rural households in the Yemeni Mountains (average of samples from three sites).

Brief activity conclusions
The CB-INRM approach requires that agricultural research institutions adapt a long-term approach to allow effective client-responsive research, but with agricultural research already seriously under-funded it is hard to see how such institutional change might occur. This project, however, is contributing to institutional evolution toward an impact-oriented, client-responsive agricultural research system in Yemen. The enthusiasm of Yemen's Agricultural Research and Extension Authority (AREA) researchers is already making a mark on their selected watersheds. It is important to note that successful CB-INRM research requires the support of a well-funded and managed research system. This project provides AREA the opportunity to experience and evaluate CB-INRM approaches, and judge their value in improving the livelihoods of the rural poor.

Activity 2.2: Analysis of the prevalence of malnutrition in three livelihood systems in northwest Syria

Activity objectives
The objective of this activity was to analyze the nutritional status of rural households in the dry areas of Syria and determine the socioeconomic factors influencing access to nutritious foods, with the aim of sensitizing this critical dimension of rural poverty which may be overlooked due to relatively moderate average income levels in the national data.

Research progress
Two nutritional studies are in progress. The first study has examined differences in nutritional status of children from three distinct rural livelihood groups in the Khanasser Valley and Afrin area of Aleppo province, North West Syria. This was followed by a more indepth nutritional and socioeconomic evaluation in the Khanasser Valley and a fortification trial examining the impact of improvement of protein quality of diets via the addition of lysine.

The first study covered families with below 10 years in irrigated barley/livestock and olive/fruit tree system. A purposive selection of households with children under 10 years of age was conducted; 207 households were interviewed; and 740 children were measured. Different data collection tools were used: informal interviews, seasonal calendars, participatory characterization of households, food frequency questionnaires, and anthropometric evaluations. Prevalence of stunting, underweight, and wasting was calculated and compared to the international reference (CDC/WHO) and a group of children from a middle class neighborhood school in Aleppo city.

Stunting was most prevalent in the barley/livestock group. More girls than boys were stunted in this group. Prevalence of underweight children was highest in the barley/livestock group, and lowest in the irrigation group. Prevalence of wasting was very low in the barley/livestock/ and olive groups, and was not found the irrigation group.

The second study focused on rural households within in the marginal environment of Khanasser Valley only and covered 98 households in three villages. Selection was based on baking of homemade bread.

In this study a seven-day food inventory was administered to households in three villages of Khanasser Valley (n=98). Household intake and waste were recorded on two occasions one week apart, household sizes and exact number of individuals consuming each meal was averaged over the week, converted to adult portion sizes, and used to estimate per capita adult male availability of kcal and nutrients. This was due to the common platter system, which does not allow easy reporting of individual food intake. Average energy (Kcal) per adult male equivalent was 2650+/-806.04. Average lysine mg/g protein available was 41.9-mg/g protein, which is lower than the current FAO/WHO requirements.

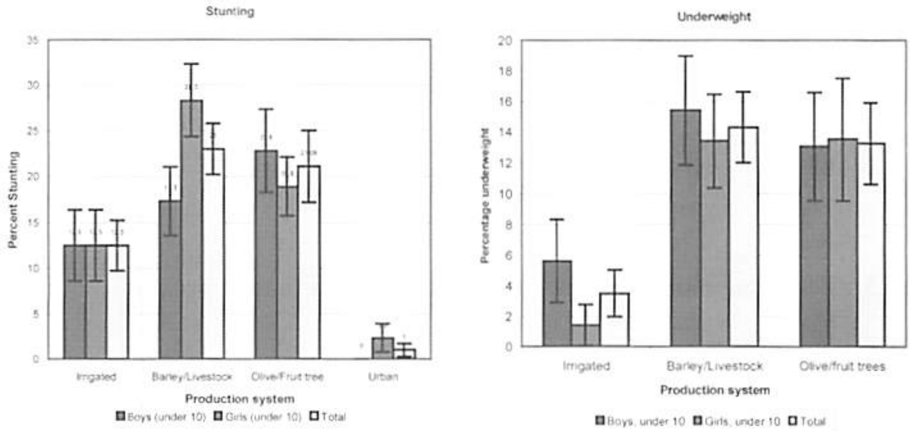

Figure 2. Percentage of children under 10 who are moderately to severely stunted in different production systems of north west Syria in comparison to urban children.

Figure 3 describes the percent contribution of different food groups to total protein available in diets of Khanasser (barley/livestock group) during spring season (period of high milk availability). We find that on average, 65% of the total protein consumed by Khanasser families is from cereals. The other major source of protein is animals (predominantly milk and milk protein). This was during the spring season, period of high milk availability.

Brief activity conclusions

Cereals, mainly wheat bread, which are deficient in the essential amino acids, lysine, is the main source of protein diet (65%) for surveyed households. There is significant child malnutrition in the surveyed households as measured by stunting, underweight and wasted under 10 years with the barley/livestock system being the most affected. The incidence of children underweight followed similar patterns. Although basically poverty is the dominant cause of malnutrition, further analysis of the socioeconomic factors influencing malnutrition is in progress. The results of the final analysis will provide policy recommendations to reduce the incidence of malnutrition among vulnerable rural populations.

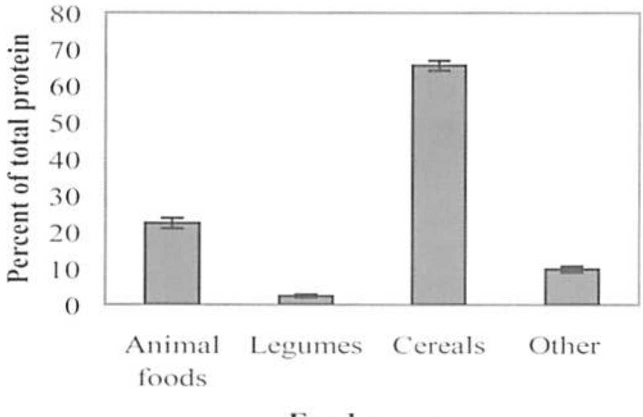

Figure 3. Percentage contribution of major food groups to total protein.

Output conclusions

The research on livelihoods is increasingly gaining importance as a way of understanding poverty in its multi-dimensionality and developing successful options to improve rural welfare. It provides a useful framework to address different issues that influence rural well-being. The project will continue to devote more resources to this and link it with impact assessment activity.

Output 3: Quality of farmer participation in agricultural research improved

Rationale

The use and popularity of the application of FPR is based on its expected benefits in terms of increased research impact. This is achieved through improving the relevance of research, reducing the research lag (development phase), reducing the adoption lag (early adoption), increasing adoption speed, increasing farmer knowledge, and empowering farmers by enhancing their capabilities. The development of participatory research approach through a learning process will enable NRM staff to internalize the process as a routine tool in their research and produce transferable methods to share with other practitioners and national programs.

Activity 3.1: ***Development of participatory research approach for Khanasser Integrated NRM research site in collaboration with the scientists involved***

Activity objectives
To strengthen the capacity of natural resources management staff in farmer participatory research with the aim of increasing the relevance of research and its impact in rural communities in Khanasser Valley.

Research progress
Following the trainings in the previous year (October 2002) on FPR methods for Khanasser Valley integrated research site, a workshop was organized on 25-27 March 2003 for interdisciplinary teams involved in Khanasser and national partners. The workshop, facilitated by a consultant Yorck van Korff, focused on institutionalizing participatory research and building the capacities of rural communities for development.

The concept of working with a group of farmers, Farmers Interest Groups (FIG), is established as a way of involving farmers in research. Procedures were developed for the selection of these farmers, agreements with farmers on the FPR process, data recording and final assessment. A permanent research assistant is stationed in Khanasser to monitor and record important observations and changes in the community and farmers concerns. The most important points of this monitoring are circulated every Sunday in the "Voices of Khanasser" notes. One intern has been assigned to support this monitoring and evaluation process.

Participatory technology evaluation sessions were held for different technologies. These include olive orchards with water harvesting, improved cumin production, *Atriplex*-barley alley cropping, production of vetch for livestock feeding and the application of phosphogypsum on barley. Research on agronomic management, land tenure, marketability aspects, and on their impact on improving livelihoods and effects on risk are needed. Participatory barley breeding to identify new better-suited varieties is successfully spreading in Khanasser. The challenge now is how the PBB model and the farmer participatory research of KVIRS can complement and learn from each other.

There is increasing spontaneous adoption of olives, but there is hardly any of *Atriplex* alley cropping in spite of the documented positive benefits. Still some farmers have positive views about this technology. Research should urgently focus on adoption aspects and on the role of extension should be promoted.

Brief activity conclusions

Over the last two years, skills to plan, conduct and facilitate participatory evaluation exercises have increased significantly. For next year, it is expected that most technology groups can run their own participatory meetings with minimal external help. However, involvement of farmers at planning and monitoring stages, and activating farmer interest groups still need to be strengthened. Participatory technology evaluation (PTE) days also strengthened the collaboration between different research disciplines, for instance between GP and NRMP scientists.

Output conclusions

The main goal of this output last year was to support capacity building of NRMP researchers. This was achieved partly by staff training and partly by supporting the groups in discussions of methods, farmer field days, etc. The goal is that FPR methods become routine part of NRM research methods.

Output 4: Documented adoption, and feedback of user evaluations into the technology generation process and quantified *ex ante* and *ex post* impact of new technologies and information for research priority setting and planning

Rationale

Proper assessment of the use of agricultural research innovations by intended beneficiaries and the impacts of these on a variety of important economic, social and environmental indicators are essential for research planning, learning from experience and accountability.

Activity 4.1: Benefits and costs of participatory barley breeding in Syria

Activity objectives

The objective of this impact study is to measure the benefits and costs of a decentralized, participatory barley breeding approach as compared to the conventional approach to barley breeding.

Research progress

Secondary production and price data were collected from Syrian statistics, ICARDA economic studies, and breeding program annual and financial reports. The primary sources of data included interviews with ICARDA breeders and household surveys of 193 barley farmers in 2001-2002. The decentralized participatory breeding begun when the initial 208 barley lines were planted on farmers' fields in nine villages throughout Syria in 1997. Program benefits were estimated, ex ante, by economic surplus model comparing conventional and participatory breeding. Program cost structure was analyzed *ex post*, and costs of conventional and decentralized breeding were constructed for comparison. Farmer level benefits were measured, *ex post*, by comparing adoption benefits and changes in human capital between participation and non-participating farmers. We also calculated the opportunity cost of farmers' time in research.

One of the main expected outcomes from decentralized participatory breeding is the reduction in research lag. Table 4 illustrates why for conventional breeding it takes 12 years from the time research commences for a cultivar to be developed where as this research lag for participatory research is 8 years.

The average speed of adoption of released modern barley varieties in Syria is 3%, and adoption ceiling of 25% because of their limited capacity to adapt to the different conditions of the marginal environments which are characteristic of area where barley is grown. We assume the same 3% speed of adoption under the participatory breeding scenario, but higher adoption ceiling; farmers involved in participatory research reported 60% adoption ceiling.

The economic surplus model was used to calculate the discounted benefits induced by the new barley cultivars in Syrian agriculture for two different scenarios: conventional and decentralized participatory breeding. The results indicate that farmer participatory research could almost double the benefits from research (from $mill. 22.0 to 42.0) due to reduced research lag, and further 30% can be achieved due to higher adoption levels. These are *ex ante* estimations of potential benefit of participatory barley breeding and realizing these benefits partially depends on the functioning extension and seed systems-as without them autonomous diffusion may be slow.

The shift from conventional centralized breeding to participatory breeding affects the allocation of the total operational costs, with relatively small share of the total breeding budget, and the biggest change is due to the decentralization of breeding (moving from station to on-farm). Participatory breeding increases the operational costs slightly, but relative change in total cost structure is insignificant. Opportunity cost of farmers' time varies according to their participation intensity, and represents a sizeable amount.

Table 4. A comparison of the conventional and the participatory breeding approaches.

	CONVENTIONAL		DECENTRALIZED PPB
Y1		Cross	
Y2		Initial increase	
Y3	Breeder initial trial		Farmer initial trials
Y4	Breeder preliminary trail		Farmer advanced trials
Y5	Breeder advanced trial		Farmer elite trials
Y6	On-farm trial/year 1		Farmer scale trials/year 1
Y7	On-farm trial/year 2		Farmer scale trials/year 1
Y8	On-farm trial/year 3		
Y9	Large scale trials/year 1		3-4 year reduction in research lag
Y10	Large scale trials/year 2		

Brief activity conclusions
ICARDA-led participatory barley breeding can yield significant economic benefits to Syrian agriculture. In addition, there could be substantial benefits from increased farmers' skills through learning and farmer-to-farmer transfer of knowledge through the participatory research process.

Output conclusions
The impact assessment work will continue to gain importance in this project and greater resources will be required to develop and operationalize methods for assessing the impacts of NRM research, including economic, environmental, social and process impacts such increased capacity of rural communities.

Output 6: Evaluation of the economics of livestock production in the low rainfall areas of CWANA

Rationale

Livestock, particularly small ruminants, is one of the most important assets for poor people in the dry areas. Livestock systems are changing due to environmental policy and market changes which are affecting rural livelihoods. Special attention is therefore given to economics of small ruminants with the aim of identifying major constraints and impacts.

Activity 6.1: Analysis of the productivity of sheep production systems in Syria

Activity objectives

This activity aimed to characterize sheep production systems in Syria and evaluate their economic efficiency, and draw research and policy implications.

Research progress

A single-visit survey was conducted between June and September 2002, using a designed questionnaire, for data collection from sheep producers in three agricultural stability zones (Zones 3, 4 and 5) in seven provinces (Aleppo, Damascus, Hama, Homs, Raqa, Hassakeh, and Dair-Ezzor) with about 90% of Syrian sheep. Nearly 15% of the producers (262) were selected and interviewed. The locations of surveyed communities are shown in Figure 4.

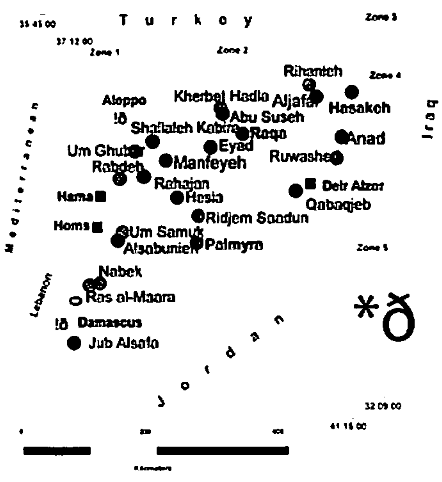

Figure 4. Location of sample villages visited during the survey May-September 2002.

Cluster analysis was used to identify sheep production systems. The variables used to group farmers in clusters, are flock size, feed sources, labor, movement, and farm size. Five clusters were identified: 1) Extensive; 2) Rainfed mixed crop-livestock; 3) Irrigated mixed crop-livestock; 4) Intensive; 5) Barley grazing. The general characteristics of the five clusters are illustrated in Table 1.

The annual reproductive rate (ARR), fertility, litter size, fecundity, lambing rate and weaning rate were used to estimate sheep productivity. Total factor productivity (TFP) was used to estimate the production efficiency. TFP is defined as a ratio of total output to total inputs. In this study we used the index number approach to measure the productivity. The intensive sheep production system reached the best performance among different sheep production systems. This performance is explained by the highest fertility, litter size, lambing, weaning, and twinning rates and the lowest abortion rate reached by intensive system.

Table 5. Summary statistics of five sheep producer types in Syria.

Cluster Variables	Extensive mixed	Rainfed mixed	Irrigated	Intensive	Barley grazing
No. of households	161	50	24	14	11
Family labor (persons)	7.1	7.9	8.0	11.6	8.0
Flock size	67	148	290	352	427
Farm size	7.6	5.0	5.7	1.2	14.7
Farm size/flock size ratio	0.11	0.03	0.02	0.003	0.03
Days away from base	88	102	123	142	214
Days hand-feeding	198	229	234	244	166
Days in native pasture*	36	26	53	29	53
Days on crop residues	127	106	73	87	141
Livestock income**	127	335	514	948	1101

**Native pasture days mean the numbers of the days spent in the grazing area and producers can use hand feeding while they are staying there.*
*** Livestock income in 1000 Syrian Pound; 1 US$ = 52 Syrian pound.*

Table 6. Performance indicators for different sheep production systems.

Production system	Fertility	Litter size	Fecundity	Lambing	Weaning rate	Twinning rate	Abortion rate	ARR* rate
Extensive	0.60	1.05	0.63	65	57	1.97	4.7	1.44
Rainfed mixed	0.56	1.04	0.59	61	54	2.49	4.9	1.44
Irrigated mixed	0.57	1.06	0.61	64	56	2.63	5.4	1.45
Intensive	0.63	1.06	0.65	66	63	3.38	1.5	1.53
Barley grazing	0.60	1.03	0.61	64	58	0.43	4.8	1.45

**Annual Reproductive Rate.*

The results show that intensive system reached the highest TFP followed by irrigated mixed crop-livestock system. In the third place was barley grazing sheep system followed by rainfed sheep system and at the last place extensive sheep system with (Table 7). The highest TFP for Intensive and Barley grazing production systems was explained by the type of the products, where in these systems lambs are the main products, while in the other three systems dairy products are the main products.

Table 7. Total Factor Productivity for different sheep production systems (TFP).

Production system	Output index	Input index	TFP
Extensive	36.195	167.645	0.216
Rainfed mixed crop-livestock	39.735	143.375	0.277
Irrigated mixed crop-livestock	35.868	102.737	0.349
Intensive	47.180	133.737	0.353
Barley grazing	45.504	146.332	0.311

Brief activity conclusions

Results obtained in this study showed that reproductive performance is very poor comparing with results from other sources. TFP obtained in this study was low comparing with other studies. Low performance rates and low TFP indicated that research is needed to increase the productivity and improve the reproductive performance by solving the problems facing the producers. Further analysis to draw research and policy implication is in progress.

Output conclusions

This work will continue with further analysis before conclusion is drawn.

Output 7: Strengthened research capacity of NARS: Socioeconomics training (including on-the job individual and group training and training workshops) organized for NARS in collaborating projects

Rationale

The capacity of many national programs in socioeconomic research in agriculture in CWANA research is generally low. Efforts are needed for different types of training including students, on-the job training through research, special skill training and workshops. Training in socioeconomics needs to be done in some cases in collaboration with other disciplines to sustain inter-disciplinary research capacity.

Training activities

- Training workshop in Iran on "Monitoring and assessing the adoption and impact of improved production technology in the rainfed areas of Iran" held in Tabriz during 19-23 October 2003.
- Contribution to the rangeland training course for GEF Project, held in Amman, Jordan during 3-6 March 2003.
- Contributions to ICARDA/JICA training course on "Management of water resources and improvement of water-use efficiency in the dry areas" held in ICARDA-Aleppo during 5 May-12 June 2003.
- Support provided to training courses carried out by other projects in ICARDA.
- Two MSc Students, registered in the Agricultural Economics Department in Aleppo University under the supervision of Drs Noureddin Mona, Ahmed Mazid, and Aden Aw-Hassan, have completed their fieldwork and have started the analysis of their data.
- Training course on "Farm Surveys and Data Analysis" at ICARDA headquarters held in December 2003 in Syria.

Output conclusions

The demand for training will continue. However, the strategy on training is shifting from general training to student training and project-based task oriented training that contributes to research output. Requests for non-task oriented training shall be discouraged.

APPENDIX

Staff list

Aden Aw-Hassan
Abdul Bari Salkini
Ahmed Mazid
Malika Martini
Roberto La Rovere
Hala Khawam
George Arab (50%)
Hisham Salahieh
Farouk Shomo
Shibani Ghosh

Collaboration

This project is implemented in collaboration with other ICARDA projects:

- Project 1.1 Barley Enhancement
- Project 1.2 Durum Wheat Enhancement
- Project 1.5 Food Legume Enhancement
- Project 1.6 Forage Legume Enhancement
- Project 2.2 Agronomic Management of Cropping Systems
- Project 2.5 Small Ruminant Production
- Project 3.2 Land Management and Soil Conservation

Students

- Haitham Al Ashkar (Impact of M&M promoted technologies in Syria)
- Hamoud Haj Hamoud (Impact of IPM on wheat in Syria)

Users and beneficiaries

- Research managers
- Policy makers
- Farmers in the dry areas

Publications

Refereed publications

Abdelali-Martini, Malika, Patricia Goldey, Gwyn E. Jones and Elizabeth Bailey. 2003. Towards a Feminization of Agricultural Labour in Northwest Syria. Journal of Peasant Studies, London (30/2).

Aw-Hassan, Aden; Ahmed Mazid, Roberto La Rovere, and Adriana Bruggeman. Challenged Livelihoods in the Dry Areas: The Case of Khanasser Valley in

Syria. A background paper to a poster presented at the 25th International Conference of Agricultural Economists, 16-22 August, Durban, South Africa.
Brennan, John P., Aden Aw-Hassan and Thomas L. Nordblom. 2003. Role of spillovers in enhancing the benefits of the international agricultural research system. Paper submitted to the Food Policy Journal xx (2003). In press.
Ghosh, S., Aw-Hassan A., Pellett P.L. Growth status of children in North West Syria: a comparison of three rural livelihood groups. Paper submitted to the Ecology of Food and Nutrition xx (2003) In press.
La Rovere, R., Aw-Hassan, A., Arab, G., 2002. Impact of policy and ecological changes on livelihood dynamics on the fringes of Syrian rangelands. African Journal of Range & Forage Science, Vol. 20 (2). Presented at VIIth International Rangeland Conference, Durban, South Africa, July 26th-August 1st
Lilja, N. and A. Aw-Hassan. 2003. Benefits and costs of participatory barley breeding in Syria. A background paper to a poster presented at the 25th International Conference of IAAE Durban, South Africa 16-22 August 2003.
Pala, M., J. Ryan, A. Mazid, O. Abdallah, and M. Nachit. . 2003. Wheat farming in Syria: an approach to economic transformation and sustainability. Article submitted to the American Journal of Alternative Agriculture. (Accepted).
Pala, M., J. Ryan, A. Mazid, and M. Nachit. 2003. Wheat farming in Syria: an approach to economic transformation and sustainability, accepted by the American Journal of Alternative Agriculture
Smriga, M., Ghosh S. Scrimshaw N., Pellett P.L. Lysine fortification of wheat reduces trait anxiety and lessens stress in poor Middle East communities. Paper to be submitted to Science xx (2003).

Chapter in books

Abdelali-Martini, Malika, Elizabeth Bailey, Gwyn E. Jones, and Patricia Goldey. 2003. Agricultural Intensification and Female Labour in Farm Production in North-west Syria in Trade Policy and Economic Integration in the Middle East and North Africa: Economic Boundaries in Flux, editors: Hassan Hakimian and Jeffrey B Nugent, London: RoutledgeCurzon, London.
Aw-Hassan, A. and K. Shideed. 2003. In collaboration with S. Ceccarelli, W. Erskine, S. Grando and R. Tutwiler. 2003. The impact of international and national investment in barley germplasm improvement in the developing countries. Pages 241-256 in Crop Variety Improvement and Its Effect on Productivity: The Impact of International Agricultural Research. (Evenson, R.E. and D. Gollin eds.). CABI Publishing, Wallingford, UK.
Aw-Hassan, A. and K. Shideed. 2003. In collaboration with A. Sarker, R. Tutwiler, and W. Erskine. 2003. Economic impact of international and national

lentil improvement research in developing countries. Pages 275-291 in Crop Variety Improvement and its Effect on Productivity: The Impact of International Agricultural Research. (Evenson, R.E. and D. Gollin eds.). CABI Publishing, Wallingford, UK.

Aw-Hassan, A. and Malika Abdelali-Martini. 2003. Changing demands in social science research in international agricultural research: the experience at ICARDA. International Conference on Social Research in the CGIAR 11-14 September 2002, Cali, Columbia. The Title of the Book to be anounced.

Non refereed publications

Abdelali-Martini, Malika, Aden Aw-Hassan and Gwyn Jones. 2003. Social Network Organization of Women's Labor gangs in Northwest Syria and their Impact on the Livelihoods of Rural Households. Paper presented at the Second International Conference of the Middle East Economic Association (MEEA) in cooperation with the Centre for Economics and Ethics (C3ED) at the University of Versailles, 2-3 June 2003. France.

Aw-Hassan, A., Farouk Shomo and Luis Iniguez. 2003. Small ruminant production trends and prospects in West Asia and North Africa. Paper resented in the 7th IDDC meeting Iran Sept 14-17, 2003.

Aw-Hassan, A., A. Mazid, , R. La Rovere, and A. Bruggeman. 2003. Challenged livelihoods in the dry areas: the case of Khanasser Valley in Syria, XXVth Conference of the International Association of Agricultural Economists, Durban, South Africa, August 16th-23rd, 2003

Aw-Hassan, A. and Farouk Shomo. 2003. Current and future demand and supply of sheep meat in West Asia and North Africa. Paper prepared to be presented in the First International Congress of Livestock, Dairy and Meat Processing Industry and Marketing, 4-7 December 2003. Antalya, Turkey.

Belaid. A, M. Solh, and A. Mazid. 2003. Setting agricultural research priorities for Central and West Asia and North Africa Region. ICARDA, Aleppo, Syria.

Ghosh, S., Pellett P.L. Scrimshaw N. and Aw-Hassan, A. Impact of lysine fortified wheat flour on nutritional status of rural families in North West Syria. Poster submitted to Experimental Biology 2004, American Society of Nutritional Sciences.

Mazid, A., A. Aw-Hassan, and H. Salahieh. 2002. Barley Seed Tracer Study: Farmer- to- Farmer Seed Distribution. (Ready for publication).

Salkini, A. 2003. Integrated Watershed Planning Approach: Theory and Application in Matrouh Project, paper submitted and presented to the Regional Workshop " Management and Rationalization of Water Resources in Agriculture," Damascus, 28-29 April 2003.

Salkini, A. 2003. Partnership in securing livelihoods of Bedouin communities. Poster paper presented to the Global Forum for Agricultural Research (GFAR 2003), Dakar, Senegal, 22 -24 May 2003.

Salkini, A., El-Naggar, S., and R. Thomas 2003. Integrated research and technology transfer for sustainable development of semi-desert areas in northwest Egypt. Paper submitted and presented at the 7th IDDC International Conference on Sustainable Drylands Development and Management in the 21st Century, 14-17 September 2003, Tehran, Iran.

Salkini, A. and G. El-Hariri. 2003. Basic concepts and methods of monitoring and evaluation of agricultural research and development projects. Training manual prepared for in-country training workshop on Monitoring and Assessing the Adoption and Impact of Improved Production Technology in Rainfed Areas of Iran, 19-23 October 2003, Tabriz, Iran.

Salkini, A, and G. El-Hariri. 2003. Long-term monitoring and evaluation system to assess sustainability of adoption and impact of new agricultural technologies. Training manual prepared for in-country training workshop on Monitoring and Assessing the Adoption and Impact of Improved Production Technology in the Rainfed Areas of Iran, 19-23 October 2003, Tabriz, Iran.

Thomson, E.F., Malika Abdelali-Martini and Richard N. Tutwiler, 2003. Sheep Management Practices in Iraq, Jordan and Syria: The Case of Reproduction and Fertility. Integrated Natural Resource Management, Technical Research Report Series No 2, International Center for Agricultural Research in the Dry Areas (ICARDA) Aleppo, Syria.

Turkelboom, Francis; Masri, Z., Bruggeman, A., Tubeileh, A., La Rovere, R. 2003. Integrating fruit orchards in a dry agro-pastoral system: the case of the degraded hillslopes in Khanasser Valley (Syria), "Sustainability Of Dehesas, Montados And Other Agrosilvopastoral Systems," Caceres, Spain, 21st- 24th.

Turkelboom, F., La Rovere, R., Hagmann, J., El-Khatib, R., Jazeh, K. 2002. Putting INRM into action: 4th INRM Workshop, ICARDA, Aleppo, Syria, September 16-19, 2002, Consultative Group on International Agricultural Research (CGIAR), Task Force on Integrated Natural Resource Management.

Turkelboom, F., Thomas, R., La Rovere, R., Aw-Hassan, A. 2003. An integrated natural resources management (INRM) framework for coping with land degradation in dry areas. Ecosystem-based assessment of soil degradation to facilitate land users' and land owners' prompt actions (Adana, Turkey, 2-6 June 2003).

ICARDA published research reports

Ghosh, S. and Aw-Hassan, A. Poverty, food systems and nutritional well being of the child. In ICARDA NRMP annual report 1996-2001 pp 223-233.

La Rovere, R., Aw-Hassan, A., Turkelboom, F. 2003. Livelihoods in transition in the marginal dry areas of Syria: a study on households and resource use in Khanasser Valley Integrated Research Site. ICARDA-KVIRS Research Report.
La Rovere, R., Turkelboom, F., Tubeilch, A. 2003. Report on farmers' participatory technology evaluation days (PTE), within 'an integrated approach to sustainable land management in dry areas' Khanasser Valley Integrated Research Site (KVIRS). ICARDA-NRMP and Atomic Energy Commission of Syria (AECS).
Mazid, A., A. Aw-Hassan, and H. Salahieh. 2002. Analysis of farmers' performance criteria for new barley varieties and their diffusion through farmer-to-farmer seed distribution. NRMP Annual Report 1996-2001. pp. 234-243.
Mazid, A., Aden Aw-Hassan. 2002. A rapid rural appraisal of the Khanasser Valley Integrated Research Site. ICARDA-KVIRS Research Report. (in 2003).
Mazid, A R. Tutwiler, H. Al-Ahmed, M. A. .Martini, and F. Maya. 2003. Impact of modern agricultural technologies on durum wheat production in Syria. INRM Technical Research Report Series No. 3. ICARDA. Aleppo, Syria.
Thomas, R., Aw-Hassan, A., Salkini, A., La Rovere, R. 2003. Improving rural livelihoods, and stimulating economically sustainable growth. Consultation Workshop for the CWANA Region on the Proposed International Assessment of the Role of Agricultural Science and Technology in Reducing Hunger, 25-26 February 2003, Cairo, Egypt. ICARDA, World Bank, Department of Agriculture and Land Reclamation, Egypt. See also: www.agassessment.org
Thomson, E.F., Malika Abdelali-Martini and Richard N. Tutwiler. 2003. Sheep management practices in Iraq, Jordan and Syria: The Case of Reproduction and Fertility. Integrated Natural Resource Management, Technical Research Report Series No 2, International Center for Agricultural Research in the Dry Areas (ICARDA) Aleppo, Syria.

PROJECT 4.3: POLICY AND PUBLIC MANAGEMENT RESEARCH IN WEST ASIA AND NORTH AFRICA

Background
This project is a component of the larger Mashreq and Maghreb (M&M) project described under GRP-5.

Objectives and rationale
The objectives are to evaluate the effectiveness of existing property rights systems and local organizations and their impact on the management of cropland. Focusing on the community, household, plot and crop levels, the project is assessing alternative institutional rangeland management and market-based options that could increase access to feed. In addition, the project is analyzing the role of women in resource management and household livelihood strategies.

Progress in 2003

Research activities and findings

Effects of property rights on input uses and profits
Governments of the Mashreq (Iraq, Jordan, Lebanon and Syria) and Maghreb (Algeria, Libya, Morocco, and Tunisia) countries have introduced different tenure options to address efficiency, equity, and sustainability issues on croplands. These options include private ownership rights, agrarian reform rights and collective use-rights. Each of these options has had different impacts on the management of croplands and farmers' welfare.

In Morocco, the government recognized customary private ownership rights (Mulk) and collective tribal rights, which accounted for 76% and 18% of croplands in 1996, respectively, while in the El Brouj district, where the research was conducted, these rights represented 53% and 43% of cropped lands. In Tunisia, where the government opted for privatizing all land rights and granting titles, privately owned lands accounted for 90% and collective lands 4%.

Our findings in Morocco confirm the general hypothesis that farmers would demand less complementary inputs and use less mechanization on the fields when they operate under incomplete land rights (perpetual collective use-rights) than on the fields where they operate under complete land rights (private ownership). Farmers relied on family and hired labor as main inputs on fields under incomplete land rights while on fields under complete land rights, they used less family and hired labor and more mechanization and complementary inputs. As a result of these different strategies, profit margins per hectare from appropriated and inherited collective lands were much lower than profit margins from rented fields and bought and inherited private fields.

In Tunisia, there were no clear differences between complete and incomplete land rights for input demands except for common property. Farmers used significantly less complementary inputs and hired labor on titled, inherited and divided collective rights, inherited state lands and purchased state lands than on rented fields. However, farmers used more complementary inputs, family labor and significantly more hired labor on purchased and inherited land under extreme indivision than on rented fields. Moreover, there were no significant differences on profit margins between land rights. Differences were evident between crops. Vegetable fields gained higher profit margins per hectare than cereal fields.

Two main conclusions emerged from the studies: Firstly, privatization policies reduce the differential effects of land rights in Tunisia because farmers have similar opportunities for gaining access to credit and investing. The main difference between farms was the extent to which farmers adopted new technologies and diversified their production systems.

Secondly, the maintenance of collective land rights in the croplands may have been a good strategy in the 1920s, under low population pressures and availability of land resources, but now that they need to improve the productivity of their lands because of lack of additional land for expansion, there is a need to grant full ownership to holders.

Rangeland management options

On rangelands, government also introduced different management options including tenure reforms (state ownership, privatization of collective rights, and collective rights) and institutional reorganization of pastoral communities (state management, cooperatives, and co-management) to improve the management of collective pastures. Yet, there has been very limited quantification of the effects of introduced options on pastoral production systems, costs and benefits of livestock production associated with these options. Are tenure reforms of common resources and institutional reorganizations associated with higher payoffs than customary management systems or production strategies?

Effects of management options in Morocco

Morocco is an interesting example for the management of common pastures because it is the sole example in the region where the government recognized collective tribal rights in 1919 and granted to tribes the possibility to delimit and title their collective lands in the name of their tribes. These different measures granted common property to tribes and as such limited state interventions for enhancing the management of common pastures to instituting pastoral perimeters in the 1970s and tribal cooperatives in 1980s.

Our study focused on evaluating the effects of these different options. Data collection was carried out in three areas: 1) High Atlas where customary institutions continue to effectively manage collective spring pastures, 2) Middle Atlas where most of the pastoral perimeters were implemented, and 3) Oriental where pastoral cooperatives were introduced. Our key findings included:

- Under customary management (High Atlas), increasing the size of the herd by an additional unit had positive but not significant effects on gross income, feed expenditures, and profit margins per TLU. Time spent on the range and quality of range were the most significant determinants for gross income and profit margins. None of the explanatory variables had significant effects on feed expenditures.
- Under "pastoral perimeter" management system, increasing the size of the herd by an additional unit led to significant decreases of gross income and feed expenditures per TLU but had positive and not significant effects on profit margins, though the effects on feed expenditures were lower. Moreover, being a member of a pastoral cooperative, growing forages and giving parts of herds under breeding contracts reduced feed expenditures significantly. On the contrary, spending more time on the range, hiring herders and taking additional livestock under breeding contracts increased feed expenditures significantly.
- Under the "tribal cooperative" management system, increasing the size of the herd by an additional unit led to significant decreases of gross income, feed expenditures, and profit margins per TLU but the coefficient associated with feed expenditures was lower. Moreover, membership to ANOC had significant positive effects on gross income and profit margins.
- A comparison between the three options suggests that livestock producers operating under the tribal cooperative system have higher gross revenues and higher feeding costs per unit (TLU) than livestock producers operating under customary system. However, there were no significant differences in profit margins between livestock producers operating under the tribal cooperative system and those operating under the customary system. Livestock producers operating under the pastoral perimeter system have higher feeding costs and lower profit margins per unit than those operating under the customary system.

Two main conclusions emerged from the study. Firstly, there are incentives for livestock producers operating under "pastoral perimeter" and "tribal cooperatives" to increase the size of their herds as increasing an additional unit reduces feeding costs less than gross revenues and profit margins. This situation might be associated with the allocation of subsidized feeds to herders when they improve part of their ranges or leave it under deferred grazing. Secondly, for livestock producers operating under customary and tribal cooperative range management systems generated higher profits than those operating under pastoral perimeters.

Land tenure, institutions and conflict management issues in sustainable use of arid lands in MENA and Africa

Conflicts arise where there is no efficiency, equity and sustainability of resources allocation, access and use. They are attempts to correct inequalities or improve the efficiency of resource access and control. In such situations the major challenges are to identify the appropriate policy instruments to enhance the performance of existing or introduced institutions and to set up conflict resolution systems.

The study developed a framework for understanding conflicts over land, forest and water resources. Moreover, we analyzed the trends of natural resources management and reviewed the different legal and institutional frameworks governing the management of land, forest and water resources in three WANA countries (Jordan, Morocco and Tunisia) and three Sahelian countries (Mali, Niger and Senegal). In addition, five country case studies on conflicts over natural resources were completed in Jordan, Morocco, Tunisia, Mali, and Senegal. Except Jordan, all the five countries have been implementing different decentralization and reform policies to devolve greater managerial roles to communities.

The preliminary analysis of country case studies shows that the number of registered conflicts were higher in countries where resources were under state management, especially for forest and range resources, than countries where community collective ownership rights were recognized.

Plans for 2004

- Publish the property rights book for West Asia and North Africa
- Develop a proposal on property rights research for West Africa
- Initiate the field work for the IFAD project on "Empowering Rural Poor under Volatile Environments in the Near East and North Africa"
- Initiate the implementation of the new M&M project

- Joint IFPRI, CIRAD and IER (Mali) Regional Workshop on Food and Nutrition Security Policies for West Africa:Implementation Issues and Research Agendas, January 13-15, 2004
- Organize a regional workshop for DSG in West Africa

Research team
Peter Hazell (IFPRI)
Tidiane Ngaido (IFPRI/ICARDA)

Collaborators
- ICARDA
- Centre Regional de Recherche Agricole (CRR) de Settat, Institut National de la Recherche Agronomique (INRA), Morocco
- Haut Commisseriat pour le Developpement de la Steppe (HCDS), Algeria
- Institut National de la Recherche Agronomique de Tunisie (INRAT), Tunisia
- Ecole Nationale d'Agriculture de Mograne, Tunisia
- Ministry of Agriculture, Government of Tunisia
- National Center for Agricultural Research and Technology Transfer (NCARTT), Jordan
- Jordan University of Science and Technology, Jordan
- University of Jordan
- Ministry of Agriculture, National Program for Rangeland Rehabilitation and Development, Government of Jordan
- Agricultural Research Institute (ARIL), Lebanon
- American University, Lebanon
- IPA Agricultural Research Center, Iraq
- Agricultural Research Center, Tripoli, Libya
- Directorate of Agricultural and Scientific Research (DASR), Syria
- Syrian Ministry of Agriculture and Agrarian Reform, Syria
- Steppe Directorates in Palmyra and Aleppo, Syria
- School of Rural Planning and Development and Department of Plant Agriculture, University of Guelph, Canada

Donor support

Mashreq & Maghreb Project Phase II 1999-2002

- International Fund for Agricultural Development (IFAD), Italy
- Arab Fund for Social and Economic Development (AFSED), Kuwait
- International Development Research Center (IDRC), Egypt

Community and Household-Level Impacts of Institutional Options for Managing and Improving Rangeland Management in the Low Rainfall Areas of Jordan, Morocco, Syria, and Tunisia. 1999-2001

- CAPRi
- Ford Foundation (Cairo office)
- European Commission

Joint ICARDA-University of Guelph, Canada, project on the Increasing Role of Women in Resource Management and Household Livelihood Strategies. 1999-2001

- CGIAR-CANADA Linkage Fund

Land Tenure, Institutions, and Conflict Management Issues in Sustainable Use of Arid Lands in MENA and AFR

- World Bank grant, June 2000

CONSTRAINTS TO TECHNOLOGY TRANSFER TO SMALL AND MEDIUM AGRICULTURAL FARMS IN ARID AND SEMI-ARID AREAS OF THE MAGHREB CONDITIONS FOR IMPROVING PRODUCTIVITY IN ALGERIA, MOROCCO AND TUNISIA

Background

Objectives and program rationale

This new FEMISE project builds onto the community models that were constructed under "The Development of Integrated Crop/Livestock Production in the Low Rainfall Areas of West Asia and North Africa (M&M) project.

The main objectives of the new project are to 1) build a multi periodic and dynamic model to account for medium and long-term decisions of farming and herding households, especially investments in perennial crops, herd management and labor allocation strategies; 2) integrate off-farm activities and intra household specific characteristics, especially labor allocation between men, women and children; 3) integrate common resources to evaluate the effects of individual practices or institutional changes on the sustainability of common pastures; and 4) integrate risk management strategies and evaluate farmers' attitudes towards risk and policy interventions.

Research team

Veronique Alary (ICARDA/CIRAD)
Tidiane Ngaido (IFPRI/ICARDA)

Progress in 2003

Different activities have been implemented in the different countries:

- In Morocco (Ait Ammar Community), a second round survey of the 85 households, previously surveyed, was conducted to actualize the data and calibrate the community model. In addition, an analysis of the grazing management of the community common pastures was conducted to identify different indicators to integrate in the model
- In Algeria (Sidi Frej Community), a second round survey of the 60 households, previously surveyed, was conducted to actualize the data and calibrate the community model. In addition, a training workshop on modeling was conducted and a survey on the marketing chain between livestock and opuntia.
- In Tunisia (Zoghmar community), a second round survey of the 40 households, previously surveyed, was conducted to actualize the data and calibrate the community model. In addition, a livestock marketing survey was conducted

- In Jordan (Maikfeh Community), the main activities focused on developing a multi periodic model

Plans for 2004

- Integrating risk constraint related to market chain in the model
- In Morocco, integrating community constraint related to grazing management
- Simulation of different agricultural policy scenarios

Book chapters and conference proceedings

Alary, V., 2002. " Adaptabilité d'un outil de programmation mathématique-Intérêts et limites de l'application de l'outil sur trois terrain, l'Haryana (Inde), La Réunion et le Maghreb (Algérie, Tunisie) ". In: Grimaud, P. Les outils d'aide à la gestion des fourrages. In: Inra-Cirad / Région Réunion / AFP. Pole élevage du Cirad à la Réunion, ed. p.

Alary, V., Elloumi M., Selmi S., 2003, Module 9: Farming System Approach: Concepts, Methods and Applications- The Case of the Zoghmar Community, Tunisia, CD Rom ILRI: Partnership to improve rural livelihoods in North Africa and West Asia through strengthened teaching and research on sheep and goat production, 2003.

Elloumi, M., S. Selmi, V. Alary, H. Ben Salem, S. Bedhiaf, H. Hassen, M. Felah, S. Chouki, N. Atti et A. Nefzaoui, Technology transfer Monitoring and evaluation-A case study of Zoghmar Communauty in Central Tunisia (Mashreq and Maghreb project), CD Rom ILRI: Partnership to improve rural livelihoods in North Africa and West Asia through strengthened teaching and research on sheep and goat production, 2003.

Ngaido, T., M. El Mourid, and M&M coordinators. M&M community approach. In *Drylands challenges* edited by Dr. Srinivas Rao (forthcoming).

Ngaido, T. M. Elloumi, and M. Boughlala. Institutional Enabling environments in Maghreb Countries. Paper presented at the Regional workshop by the Inter Academy Council for the "Study on Science and Strategies for Improved Agricultural Productivity and Food Security in Africa." Rabat Morocco, February 3-5, 2003.

Ngaido, T., A Nefzaoui, F Awawdeh, M. Elloumi, and K. Abu Soui. Mobility, Access-Options, and Transaction Costs Amongst Pastoral Households in West Asia and North Africa. Paper presented at the VII International Rangelands Congress in Durban, South Africa, on 23 July-1 August 2003.

Ngaido, T. and N. McCarthy. 2003. Managing externalities and improving pastoral production and livelihood strategies. Proceedings of the Regional Workshop on Land Issues in Africa, Kampala, Uganda, April 29- May 2, 2002. World Bank, Washington DC. USA, CD-ROM.

Unpublished reports

Alary, V., M. Elloumi, S. Selmi, Modélisation communautaire dans la Communauté de Zoghmar, Tunisie- Conception et Construction du modèle, Document de travail, 52p.

Alary, V., N. Redjel, A. Zeghida, Modélisation communautaire dans la Communauté de Sidi Frej, Algeria- Conception et Construction du modèle, Document de travail, 36p.

Baccili, M. La gestion alternative des conflits sur les resources naturelles au Mali. Paper prepared for the World Bank study on "Land Tenure, Institutions, and Conflict Management Issues in Sustainable Use of Arid Lands in MENA and AFR." September 2003.

Elloumi, M. and F. Chemak: La gestion des ressources naturelles en Tunisie: Les conflits et leur mode de résolution. Paper prepared for the World Bank study on "Land Tenure, Institutions, and Conflict Management Issues in Sustainable Use of Arid Lands in MENA and AFR." September 2003.

Herzenni, A. Land, Policy, Management and Conflict in Morocco. Paper prepared for the World Bank study on "Land Tenure, Institutions, and Conflict Management Issues in Sustainable Use of Arid Lands in MENA and AFR." July 2003.

Lo, H. and O. Toure. Conflicts et gestion des conflits au Sénégal. Paper prepared for the World Bank study on "Land Tenure, Institutions, and Conflict Management Issues in Sustainable Use of Arid Lands in MENA and AFR." September 2003.

Nesheiwat, K. Land use conflicts and management in Jordan. Paper prepared for the World Bank study on "Land Tenure, Institutions, and Conflict Management Issues in Sustainable Use of Arid Lands in MENA and AFR." August 2003.

Briefs

Ngaido, Tidiane and Nancy McCarthy. 2003. Institutional options for managing rangelands. Brief prepared for CAPRI.

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