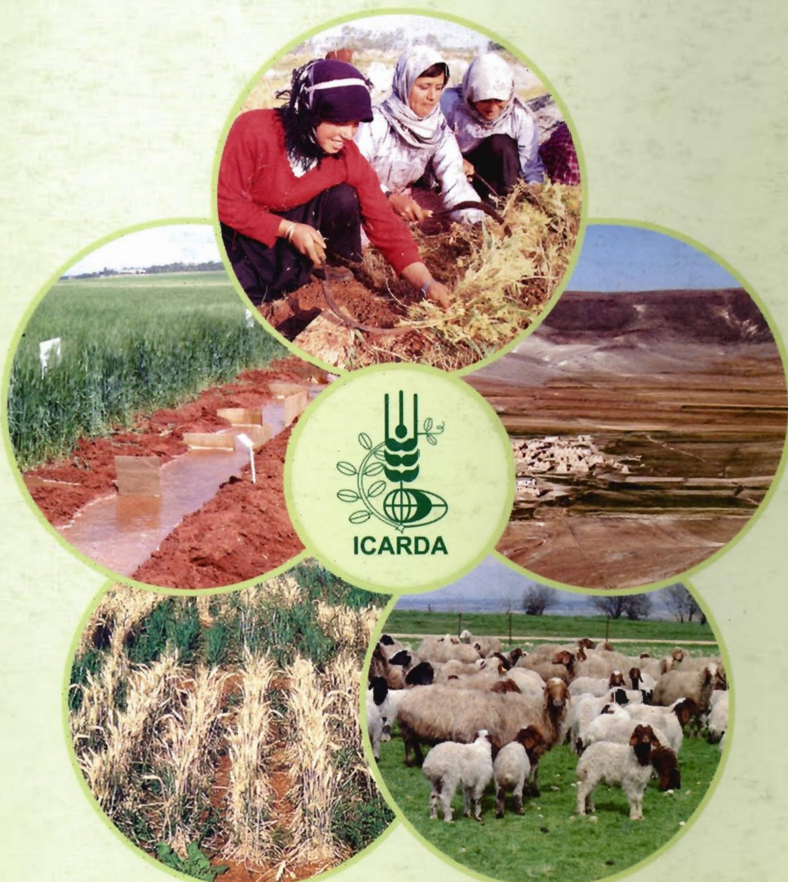
Natural Resource Management Program

Annual Report for 2002



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.

Natural Resource Management Program

Annual Report

2002

ICARDA

International Center for Agricultural Research in the Dry Areas

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 subjected 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.

Printed at ICARDA

International Center for Agricultural Research in the Dry Areas (ICARDA)
P.O. Box 5466, Aleppo, Syria
Tel.: (+963-21) 2213433, 2225112, 2225012
Fax.: (+963-21) 2213490, 2225105, 5744622
E-mail: ICARDA@CGIAR.ORG
Website: www.icarda.org

Table of Contents

Foreword

In order for the early work of the CGIAR system to achieve an even greater impact on the development of improved germplasm for enhanced productivity and resistance to pests and diseases, it was recognized that agricultural research should also focus on the environmental and socioeconomic constraints facing land users. The potential of improved germplasm was often not realized, especially for the poorest farmers, because of insufficient attention to the complexity of production systems and the pluralistic factors that have varying degrees of influence on system function. Greater attention was required on the management of the natural resources (soil, water, and biodiversity), as the poorer farmers depend more on these resources than better-off farmers.

To move towards this goal, the CGIAR began to develop concepts of Integrated Natural Resource Management (INRM) by establishing an INRM Task Force in 1999. The Task Force defined INRM as "an approach that integrates research on different types of natural resources into stakeholder-driven processes of adaptive management and innovation to improve livelihoods, agroecosystem resilience, agricultural productivity and environmental services at community, ecoregional and global scales of intervention and impact." This approach recognizes that there is the need for a new type of research.

The approach will continue to build on, and contribute to, modern advances in agricultural technology. But the research has to be grounded in local contexts and applied in ways that recognize the conditions of poor farmers. Research will be directed towards improving the adaptive capacity of stakeholders by applying and developing more participatory approaches; by following some key principles such as multi-scale analyses and interventions; and by developing and using new tools such as systems analysis, information and knowledge management and impact assessment. Key goals of the approach include better risk management, diminishing the dependence on agricultural inputs without excluding them completely, avoiding medium to long-term depletion of natural resources and greater cognizance of environmental externalities that are often neglected in classical economic analyses.

As a result of these developments, which ICARDA's NRMP has been contributing to, the program has been adjusting its goals and purpose to bring its focus into line with the system-wide INRM approach. At the same time, ICARDA has been undertaking a prioritization exercise for agricultural research and development in the Central and West Asia and North Africa (CWANA) region to ensure that its research is relevant and responsive to the demands from the region it serves.

Taking account of these developments, the goal of the NRMP has been re-defined as: *Improved well being of the people and strengthened resilience of agroecosystems in the dry areas through sustainable management of natural resources.* The program aims to contribute to this overall goal by developing and disseminating resource-conserving technologies, management practices, policy and institutional options and decision support tools, through research and capacity-building partnerships to enhance agricultural production and livelihoods in the dry areas. This is the new purpose statement of the program.

Although a detailed restructuring of the program's projects is not yet complete, the work of the program is already moving towards a more integrated mode of operation. An example of this change can be found in the report on the project on land management and soil conservation (Project 3.2). This report on the Khanasser Valley Integrated Research Site includes inputs from six other NRMP Medium Term Plan projects and also involves activities from ICARDA's Germplasm Program.

The program was dealt a tragic blow in 2002 when our dear and much-loved colleague, Dr Mustapha Bounejmate, suffered a massive heart attack and died on 9 April 2002. The entire ICARDA family was shocked and greatly saddened by the demise of a true gentleman, who was both serious and humorous while also being hard working and a wonderful ambassador for the Center. Mustapha was well liked by his fellow collaborators in the NARS and was responsible for the forage newsletter. ICARDA extends its condolences to his family, and a memorial seminar will be held in his honor in Morocco in 2003.

Richard J. Thomas
Program Director
NRMP
March 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. ICARDAis 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

Rationale

The production potential of cropping systems within a given environment depends on plant genetics and soil and crop management. Good management practices can considerably increase the efficiency with which limited available water is used. However, increasing demand for food and feed forces farmers to use non-sustainable mono-cropping of cereals with inappropriate cultural practices, resulting in decreasing yield, poor water-use efficiency, declining soil fertility, and increased pest pressure.

For production 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, mainly on research stations under controlled environments, many gaps in our knowledge still exist, especially on the sustainability of cropping systems and improved technology packages. Research findings need to be extrapolated to similar areas through predictive models and farmer participatory approaches.

Expected gains/impact: 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 result in improved living standards of rural communities. It will also result into sustainable productivity with improved water-use efficiency and improved soil fertility.

Emphasis is given to research problems in less favorable environments; evaluation of alternative crops for increasing diversification; 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

Increase 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 dryland cropping systems.
- Identify management strategies for the enhancement of soil chemical fertility in different production systems based on the elucidation of soil-nutrient dynamics.
- Assess the distribution and severity of soil micronutrient imbalances on plant growth and its implications on animal and human health.
- Train research extension and management personnel in analytical techniques 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 CWANA. We need to know what effects repeated sequences of cropping, fertilization, and management have on the pattern of productivity over time (i) to develop an understanding of physical, chemical, biological and environmental principles, which control the productivity and sustainability of cropping systems with respect to soil characteristics, water, and nutrient dynamics, (ii) to develop strategies for efficient management of soil, water, and nutrients in cropping systems.

Activity 1.1: Monitoring nutrients/organic matter/bacterial biomass and water dynamics in barley-based, long-term rotation at Tel Hadya (L13 trial)

This work has evaluated the sustainability of cropping systems through the improvement of soil quality and rain water-use efficiency. The vetch-barley rotation, in comparison with the continuous barley or fallow rotations, has consistently higher levels of soil organic carbon, organic or total N, and both labile and biomass forms of these elements. This has led to improved soil quality with reduced external N requirements for cereals. As with any long-term rotation trial, it may take several years before the effect of all cropping management becomes evident on soil chemical and physical parameters. This is especially true in Mediterranean environments where biomass inputs are low and where moisture and temperature dictate the extent of organic matter accumulation.

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

The Nile Valley and Red Sea Regional Program (NVRSRP) Resource Management Program seeks to overcome the various threats to sustainability and contribute to sustainable agricultural production in Egypt by improving the well-being of individual farming families, and increasing the overall farming system productivity with emphasis on water and land resources conservation. Therefore, the project aims to improve water productivity and to increase soil fertility in old lands and virgin areas. Long-term rotation trials at experimental stations involved crop rotations, water quality and/or quantity, mineral fertilizers, and organic manure. The program is now in its sixth season and the second rotation cycle has been completed. Results from the first two cycles are summarized below.

Soil fertility and plant nutrition

Soil fertility aspects of the trials have been studied in Sids as an example for the other sites. The soil residual contents P and K were generally improved by increasing NPK fertilizer application under both prevailing (short berseem+cotton / wheat+maize / faba bean+ tomato) and proposed crop rotations (onion+cotton / early wheat+soybean+forage pea / faba bean+ tomato). The available N showed 177% and 41% increases more than zero time and the first cycle, respectively. At the same time, the results exhibited 77% and 59% increases for available P, and 34% and 11% for available K, respectively. The results also showed dramatic increases in the soil N, P and K contents of the proposed rotation; this could be attributed to the higher amounts of NPK fertilizer applications as well as more legumes crops patterns compared to the prevailing rotations. Soil organic matter contents after 6 years of crop rotations was slightly improved (2.1%) compared to those obtained after 3 years of crop rotations (1.8%) and it was not affected by the other tested factors.

Water management and water-use efficiency

The data available for all the irrigated sites is summarized below.

Nubaria

The water-use efficiency (WUE) in kg/ha/mm increased parallel to increasing chemical fertilizer for summer crops such as corn, sunflower and tomato. Adding manure clearly enhanced WUE for all summer crops mentioned before. Manure with recommended chemical fertilizer produced 34, 5.8 and 41.4 kg/ha/mm vs. 26.6, 3.6 and 20.2 kg/ha/mm without manure for corn, sunflower and tomato, respectively, under recommended levels of irrigation. WUE decreased by 8-15% due to excess irrigation water under farmers' level. Except for tomato, the proposed rotation (berseem + tomato + nilly maize / faba bean + maize / wheat + cowpea + sunflower) gave higher WUE than the prevailing one (berseem + maize / faba bean + tomato / wheat + sunflower). For winter crops, manure provided an increase in WUE reaching 26% for wheat (e.g., manure with recommended fertilizer and irrigation levels gave 13.8 kg/ha/mm vs. 10.8 without manure for wheat).

El-Bustan

No clear variation in WUE could be attributed to water quantity. However, increased chemical fertilizer was associated with increased WUE. Adding manure increased WUE by about 27, 37, 34 and 33% for groundnut, maize, sunflower and sesame, respectively. For winter crops such as wheat, berseem and peas, WUE values increased to the highest value with the high fertilizer level. Manure increased WUE substantially (e.g., manure gave 12 kg/ha/mm vs. 9.6 without manure for peas). WUE of excess water under farmers' level and recommended level irrigations were close to each other.

El-Serw

WUE at this site increased with increasing fertilizer levels, achieving highest values.for sunflower. However, using the recommended medium level was enough to obtain the highest yield for rice and berseem. In all cultivatecrops, irrigation with drainage water caused a considerable decrease in WUE.

Sids

For the summer crops, cotton, tomato, corn and soybean, WUE values responded positively to fertilizer increase. The highest level of NPK achieved higher values of WUE compared to others. Recommended irrigation resulted in higher WUE valuesas compared to farmers' level irrigation (e.g., cotton WUE of 3.6 kg/ha/mm under recommended irrigation decreased to 3.0 kg/ha/mm under farmers' excess irrigation).

Drainage water resulted in 6.5 and 8.0 kg/ha/mm and 14.4 and 9.4 from irrigation with fresh water for tomatoes and corn, respectively.

For the winter crops, wheat, faba bean, berseem and onion, the highest WUE was obtained from recommended fertilizer level. Excess irrigation water under farmers' level resulted in obvious decline in WUE values (e.g., wheat had 11 kg/ha/mm under recommended irrigation vs. 8.8 kg/ha/mm from excess irrigation of farmers' level, and drainage water reduced WUE to 9.7 from the value of 10.4 kg/ha/mm from fresh water).

Soil characteristics

This is also studied in detail for the Sids site to use as an example for other sites. Soil salinity increased greatly to 4-13 dS/m in the sixth year compared to the zero time (0.5 dS/m in 1995/1996 season) and the first cycle data (1-4 dS/m). Continuous irrigation with drainage water greatly increased the soil salinity, compared to fresh water irrigation. Maximum soil salinity was observed under the condition of proposed rotation using the recommended level of irrigation water because of more crops having more water into the systems, and less water used for leaching fraction. The results also indicate that EC values were higher in top surface layer (0-30 cm) and decreased by increasing the soil profile depth. Soil alkalinity increased compared to the first cycle data. However, these values were less than the zero time data. This is due to an improvement of the drainage system. The results also showed a high increase of ESP values in top surface layer, especially at proposed rotation. This needs further monitoring in the long run.

Summary results after six years of trials

- The recommended irrigation regime resulted in higher yields and 25-30% water savings in trials in Sids and Nubaria, compared to farmer practice.
- In trials in rainfed areas, application of organic manure produced cereal yields equal to those produced by NP fertilization, and a wheat-legume rotation reduced weed infestation in wheat, compared to the continuous wheat system. It also increased water-use efficiency (WUE). Mean values for barley in barley-barley rotation (0.38 kg grain/m^3 water) were low, compared to those for barley in rotation with fallow, lentil, or forage pea (0.81, 0.73, and 0.72 kg grain/m^3 water, respectively).
- A mole drain system (at 1.5 m depth filled with cotton wood perpendicular to lateral field drains) decreased the water table at El-Serw research station (salt affected soils) from 61 cm to 100 cm, resulting in increased crop productivity, particularly of rice.

- In the El-Bustan area (sandy soil), stable yield was maintained with the proposed crop rotation (groundnut once in three years). The prevailing practice (groundnut every year) reduced yields considerably. Moreover, the proposed rotation was more effective in reducing root-knot nematode.

Testing of promising research results in farmers' fields

- Producing and applying composite manure (fermented) at LTT sites and farmers' fields, especially in the newly reclaimed area to:
  - Utilize farm residues
  - Increase soil fertility and crop productivity
  - Reduce salinity and alkalinity hazards
  - Minimize nematodes problems
  - Control weeds
- Planting wheat on furrows followed by maize and/or sunflower to:
  - Better control irrigation
  - Save water by applying recommended levels Zero-tillage application for:
  - Optimum planting dates for summer crops
  - More intensive cropping system
  - Reduced operating costs

Recommendations made during the planning meeting for 2002/03 are following:

- Crop diversification should be considered with respect to soil health and productivity, together with with crop rotations.
- Farmers should be involved in LTT to give their opinions and learn from sustainable management of resources on the best possible crop rotations.
- Farmers should participate in the new phase with the INRM approach; Technology Transfer Trials (TTT) should be conducted with farmer's participation. The observed 30% water saving with the recommended irrigation practices should be linked with its use in the other areas for overall economic benefits.
- Salinity buildup under the use of drainage water alone in the first 6 years (two cycles) should be considered a threat to sustainability, and necessary measures should be applied in farmers' fields with similar outcomes.
- Increased Nematode infestation under prevailing crop rotation applied by farmers with inclusion of host crops (groundnut, potatoes etc.) may harm other crops in future. For the sustainability of the production systems, this issue should be considered carefully.

Activity 1.5: Crop diversification, rotations, soil, and crop management for improved water- and input-use efficiency in Central Asia

The Central Asian countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) are in transition from centrally planned to market-driven economies. Also, a decline in living standards, has disrupted input supplies and imports, including food and feed products. Although the agricultural potential of the region is significant (the total area of 400 million ha of which about 75% is suitable for agriculture), yields and production levels are currently well below those in the rest of the world; therefore, food security has become an issue and the countries are attempting to diversify their agriculture. 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 inputs (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 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 and Uzbekistan).

Crop diversification

The recommendations on appropriate technologies for crop diversification are in the process of being developed. There are ample opportunities for crop diversification in rainfed fallow-spring wheat systems in northern Kazakhstan. In a trial in 2002, chickpea yield was 1.28 t/ha, lentil 1.16 t/ha, buckwheat 1.58 t/ha, dry pea 1.94 t/ha, millet 1.58 t/ha, mustard 1.57 t/ha, rapeseed 1.42 t/ha and redhead 0.86 t/ha. Spring wheat yield was 17.5, 17.5 and 10% higher after chickpea, dry pea and lentil, respectively, compared to continuous wheat yield, which was 1.94 t/ha. The chickpea, lentil, dry pea, and buckwheat crops are ready for wide adoption to improve the economics of farming and sustainability of the production system. In the rainfed agriculture of southern Kazakhstan and in Kyrgyzstan, safflower (0.85 t/ha), lentil (0.89 t/ha), and chickpea (0.99 t/ha) are alternative to wheat crops with much higher returns. In these areas, there are opportunities to reduce the summer fallow area and replace it partially with these alternative crops. Safflower provides not just high seed yields, but also on-farm processing provides edible oil and additional employment. In southeast Kazakhstan, farmers observed that safflower can be grown on marginal lands, allowing increased land use and also ensuring high income from vegetable oil. This is important not only for the farmer, but also for national interests of the country, as Kazakhstan is a large importer of vegetable oil.

In irrigated agriculture of south Kazakhstan and Kyrgyzstan, low market prices for grain production of wheat and barley made these widespread crops least economical. Sugar beet, maize, safflower, dry pea, common bean and chickpea are good alternatives to wheat production. In irrigated wheat-cotton systems in Uzbekistan, Tajikistan and Turkmenistan, double cropping is giving good opportunities for diversified production with higher farmers' incomes. The crops for double cropping are : mungbean (mash), soybean, maize, buckwheat, cotton and common bean.

In terms of the adoption of the alternative crops chickpea was grown already on large areas in northern Kazakhstan in 2002. In the Dvurechniy farm of Akmola region, 'Yubileyniy,' a Russian chickpea variety was planted on 1145 ha of stubble land and produced 1 t/ha grain yield. In many farms, chickpea was grown on smaller areas. The total area was around 3000 ha. This was the result of seed production in 2001, from the farm of the Grain Research Institute that produced 5 tons of lentils, 10 tons of field pea, and 2 tons of chickpea seeds.

In south Kazakhstan, safflower was planted on an area of 70,000-100,000 ha (mostly rainfed), and soybean was planted with irrigation on 2000 ha. In Kyrgyzstan, common bean *(Phaseolus vulgaris)* was planted on 2500 ha. In Uzbekistan, chickpea was planted on 3000 ha, mungbean on 5000 ha, common bean on 1000 ha, groundnut on 1000 ha. Double cropping with cotton after harvest of winter wheat was done on 5000 ha in Surkhadarya province. In Tajikistan, the following crop areas were occupied for double cropping: cotton 5000 ha, buckwheat 3000 ha, tobacco 1000 ha, rice 1000 ha. In Turkmenistan, mungbean (mash) was grown on 500 ha.

Soil tillage with conservation approach

Conservation tillage is a generally adopted practice in northern Kazakhstan. There are opportunities to reduce depth of the fall tillage both for fallow-wheat, and continuous wheat crop when combined with proper soil fertility management. Deep tillage provided 2.08 t/ha wheat yields, while reduced tillage gave 2.29 t/ha and minimum tillage 2.22 t/ha as the average of the last 2 years.

As to the mean outputs of the 2001 and 2002 seasons in the semi-arid rainfed agriculture of southern Kazakhstan, conservation tillage at a depth of 20-22 cm (1.32 t/ha barley and 1.08 t/ha proso millet) and at a depth of 10-12 cm (1.19 t/ha barley and 1.10 t/ha proso millet) gave comparable yields with plowing at the depth of 20-22 cm (1.21 t/ha barley and 1.19 t/ha proso millet). Zero-tillage at the same experiment provided mean yields of 0.94 t/ha and 1.03 t/ha for barley and proso millet, respectively.

Although conservation tillage and no-till didn't show much advantage in terms of crop yields, it demonstrated many advantages in conservation of energy and labor resources. Fuel consumption for plowing, conservation tillage, and no-tillage amounted to 37.8, 24.6, and 7.4 liters/ha, respectively. Labor productivity on conservation tillage and no-tillage compared to plowing was improved by 129% and 282%, respectively. Zero-tillage provided promising results also in rainfed trials in Uzbekistan as compared to plowing and conservation tillage practices.

In irrigated agriculture of Turkmenistan, Tajikistan and Uzbekistan there are data indicating the possibility of introducing minimum and zero tillage in the wheat-cotton systems. For example, in Uzbekistan a seedbed preparation with minimum tillage with rotary cultivator, broadcasting into the cotton stubble with shallow cultivation and no-till direct drilling into cotton stubble provided higher or the same winter wheat yields (3.64, 4.09 and 3.71 t/ha, respectively) compared to traditional deep moldboard plowing at 2-22 cm (3.79 t/ha) in the year 2002.

With respect to larger-scale testing in northern Kazakhstan, minimum tillage for spring wheat (no primary tillage and direct planting into stubble) was applied on 10,000 ha. In southeastern Kazakhstan, minimum tillage was applied on 1000 ha. In southern Kazakhstan, minimum tillage was applied on 200 ha. In Kyrgyzstan, conservation tillage was applied on 50 ha. In Tajikistan, no-till broadcasting of wheat seeds into growing cotton was applied on 2000 ha. In Turkmenistan, replacement of plowing by disking for seedbed preparation prior to sowing of winter wheat was applied on 100 ha. In Uzbekistan, broadcasting of wheat seeds by cultivators into growing cotton was applied on 2000 ha.

Activity 1.7: Trials on soil and crop management in dryland areas of Iran

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.

Weather conditions of the region were better in the 2001/2002 season, seasonal rainfall being 208, 308, 330, 350, 382, 383, 414, 627 and 667 mm in Ardebil, Urumieh, Shirvan, Ghamloo, Maragheh, Zanjan, Sararoud, Ilam, and Gachsaran, respectively, compared with the three previous consecutive dry years, which affected the rainfed crop production substantially. However, rain started late in general and there was also a late drought in May, which reduced yields, particularly for cereals.

Long-term crop rotation for sustainability

These studies were established to investigate the effects of the introduction of annual food and feed legumes and oilseed crops into the fallow-wheat rotation on the productivity, soil physical and chemical quality, and to assess the profitability of crop sequences compared with fallow-cereal rotation.

In Gachsaran, with relatively higher rainfall, wheat yields after chickpea, lentil, vetch, rapeseed, safflower, sunflower, and medic were higher than wheat after fallow and much higher than continuous cereals - either wheat after wheat or wheat after spring barley. Thus, introducing legumes and oil crops as a replacement for common fallow areas or as break crops for unsustainable continuous cereal systems is a promising option for sustainable production system. In Zanjan, although the trial was in the second year, wheat yield after legumes and after oilseeds were very close to wheat after fallow and much higher than continuous wheat yield (Table 1).

These results are similar to ICARDA's and other NARS research results with respect to long-term crop rotation trials. Thus, the replacement of fallow with diversified crops shows promise for increasing overall cropping system productivity and for sustaining the productivity compared to continuous cereal cropping with its higher probability of diseases, pest incidences, and inefficient use of fertilizers, particularly nitrogen. Dissemination of these technologies is a priority of the Ministry of Agriculture in Iran.

Table 1. Yields of wheat and alternative crops in different rotations, 2001/2002.

Rotations	Wheat and other crops grain yield and medic dry forage yield (t/ha)			
	Gachsaran (7th yr)		Zanjan (2nd yr)	
	Wheat	Other crops	Wheat	Other crops
W/CH	3.546	1.368	1.422	0.553
W/L	3.603	1.575	1.356	0.318
W/V	3.627	2.046	-	-
W/W	2.888	1.862	1.021	1.150
W/RS	3.602	930	-	-
W/F	3.329	-	1.561	-
W/SF	3.453	1.186	1.278	0.696
W/SB	2.830	2.621	-	-
W/FF	-	-	1.453	-
W/SNF	3.543	1.189	1.364	0.563
W/M	3.589	8.437	-	-
LSD 5%	0.276	-	0.198	-

W: wheat, CH: chickpea, L: lentil, V: vetch, RS: rape seed, RF: recommended fallow, SF: safflower, SB: spring barley, FF: farmers' fallow, SNF: sunflower, M: medic (annual alfalfa).

Soil management with resource conservation approach

Different tillage implements with different timing and stubble management were studied in cereal/fallow, cereal/legume, and continuous cereal systems in Maragheh dryland areas. The lowest yield was under the conventional tillage in all rotations (Table 2). This is important to demonstrate increased energy consumption with deep tillage, more exposure of soil to solar radiation and higher C and N mineralization.

Table 2. Effect of conventional and conservation tillage on wheat yield (t/ha) in different rotations, Maragheh, 2001-02.

Tillage practices	Fallow/wheat		Wheat/wheat		Chickpea/wheat	
	F	W	W	W	Ch	W
Moldboard plough +disc harrow + planter (conventional tillage)	-	1.55	0.34	1.21	0.555	1.57
Chisel plough +disc harrow+ planter (Conservation sillage)	-	2.18	0.40	1.61	0.62	1.89
Sweep planter (Minimum tillage)	-	1.66	0.36	1.44	0.587	1.96
Removing stubble +planter (No-tillage)	-	2.08	0.47	1.58	0.90	2.03
Spreading stubble + planter (No tillage)	-	2.00	0.55	1.91	0.91	2.08
LSD 5%	-	0.42	0.18	0.41	0.19	0.34

Yields obtained with conservation tillage with chisel, sweep (ducks-foot) cultivator and no-tillage with stubble removed or with residue cover proved to be better than the traditional deep plowing with higher energy-use efficiency under Maragheh conditions, which are representative of other dryland areas with similar soil types. It is important to see the positive effects of conservation and no-tillage systems under continuous crop production to be able to make timely planting for earlier crop growth in the cold highland conditions.

Soil fertility and fertilizer use in crop production

The effect of fertilizer placement on dryland wheat yields

The number of models of commercial cereal drills available in Iran has increased over the past 10 years. Most of the current equipment does not have the capacity to apply N fertilizer in bands below the seed rows. With these drills, fertilizer application is restricted to placing a limited amount of nitrogen with the seed as starter fertilizer, and surface broadcasting the bulk of the crop's N-fertilizer requirement. The main purpose of fertilizer placement is to achieve greater fertilizer-use efficiency and is most effective when nutrients are more readily available in close proximity to plant roots. Thus, a study was conducted in Maragheh research station for 3 years and in farmers' fields for 2 years on a clay loam soil (fine mixed, mesic, Vertic Calcixerepts) to determine fertilizer placement effectiveness at different depths of soil with dryland wheat. For this purpose, a modified cereal drill for dryland conditions, Kesht Gostar, was used, which mixes fertilizer with seed, and places the fertilizer 3, 6, or 9 cm below the seed. One third of the fertilizer is mixed with seed and 2/3 of it is placed 3, 6 or 9 cm below seed. Overall results showed that the fertilizer placement at 6 cm or 9 cm below the seed gave significantly higher yields (1.9 t/ha) compared with 1.3 t/ha of the check plots, where seed and fertilizer were placed together with seed. There were more fertile spikes per unit area with fertilizer placed 9 cm below the seed, with a significant correlation (r =0.76) between spike numbers and grain yield. There is a risk of damage from fertilizer mixed with seeds if there are low moisture contents in the seedbed causing high osmotic pressure. To increase farmers' awareness of placement technology, the trial was conducted in two more locations in farmers' fields. Fertilizer placement of 9 cm below the seed increased mean grain yield about 20 % compared to the control plots, confirming the on-station results.

Wheat production under supplemental irrigation in dryland areas

As in previous years, supplemental irrigation improved wheat yields by 298% with the variety 'Alamut' (from 1.61 t/ha under rainfed to 4.81 t/ha under 100% water application) and 600% for the variety 'Sabalan' (0.63 to 3.79 t/ha) in Maragheh (382 mm of total rainfall) and 143% for variety cross 'Alborz' (2.80 to 4.01 t/ha) in Sararoud stations (414 mm). At both sites, on average, irrigation at 66% of the full irrigation produced about 97% of the yield (87% for 'Alamut,' and 97% for 'Sabalan' in Maragheh and 107% in Sararoud) compared with that of the 100% water application. However, even 33% of full irrigation produced about 80% of the yield (71% for 'Alamut,' and 85% for 'Sabalan' in Maragheh and 82% in Sararoud).

Thus, in the highlands with relatively lower evaporative demand, there is no need to irrigate at a rate equivalent to 100% of the water requirement of wheat. This water saving has the potential to increase the area under irrigation by 34% or more with less variable yield compared with the rainfed crops.

Alternatively, the saved water could be utilized for other agricultural sectors or for human consumption. The other important output of the project was the observed N-fertilizer use under different water regimes. In general for three years, wheat has responded to the levels of 0-30 kg N/ha under rainfed, 30-60 kg N/ha under 33% irrigation, 60-90 kg N/ha under 66% irrigation and around 90 kg/ha under 100% irrigation regimes. This compares with the farmers' practices of using about 125-150 kg N/ha when irrigation was applied. This work has been conducted in collaboration with MTP Project 3.1 (Water Management) and a final report is under preparation with journal articles to follow.

Activity 1.8: ***Assessment of oilseeds as alternative crops in cropping systems in Iran***

National production of edible oil is insufficient to meet the demand. Thus, increasing the area of oil crops utilizing fallow land is very important. In spite of a relatively dry year in Kermanshah, some of the rapeseed varieties like 'Goldrush' and 'Taparoo' gave a good yield of more than 2.8 t/ha. Some other varieties also gave more than 2 t/ha. The selected high yielding varieties were tested in farmers' fields and promising ones were released for commercial use and farmers planted about 50,000 ha to rapeseed crops. Out of 19 safflower lines some gave yeilds between 1-1.5 t/ha under very dry conditions. The best lines were tested for hull and oil content. In case of sunflower, out of 14 varieties/lines, 'Azargul' and 'Armavirsky' gave very good yields. A comprehensive national research plan for oilseed crops has been developed and implemented in various regions of Iran.

Output 2: Validated cropping systems simulation models for spatial extrapolation

Rationale

Under the harsh and variable climatic conditions in WANA, the likely consequences of management measures on the long-term productivity of a particular rainfed crop or a rotation are 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 the system performance. Geographic information systems (GIS) are the tools for mapping any soil and crop outputs for a wide region. 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.

Activity 2.1: ***Agricultural Production Systems Simulator (APSIM) cropping systems simulation model tested for wheat and barley under supplemental irrigation and nitrogen applications, and for lentil and chickpea under supplemental irrigation and different sowing dates***

A PhD thesis, under preparation jointly with Hohenheim University, aimed to (i) contribute to the assessment of the ecological and economical limits to cropping-system intensification in Mediterranean-type environments, (ii) analyze the sustainability and productivity of different rotations (cereals and legumes) in the longterm using APSIM, (iii) investigate the impact of changes in soil organic matter status on the economical and ecological system performance in the longterm using agricultural systems modeling with APSIM simulation model.

As a first output, we describe the adaptation of the APSIM cropping system model to a site in northwest Syria and a test of the model's capability to simulate the influence of environmental and managerial factors on the productivity of wheat. The APSIM software encompasses a library of modules, each describing specific processes of the crop-soil-weather system, which can be flexibly combined to represent various cropping systems. The model is designed to predict and evaluate the dynamics of soil conditions and crop production while allowing management interventions through tillage, irrigation, or fertilization as well as choice, timing and sequencing of crops.

The objectives of this study were to obtain a sufficiently detailed data set to derive the input-parameters needed by APSIM and to test whether the model sensibly mimics the results of single-season experimentation. This evaluation is a prerequisite for the application of APSIM in a scenario analysis. Outcomes provide the basis for the extrapolation over multiple seasons and the examination of hypothetical cereal-legume rotations. To achieve this, similar studies were conducted with chickpea and lentil.

The cropping systems model APSIM was adjusted to simulate durum wheat (cv. 'Cham3') grown in a semi-arid environment of northwest Syria. The results of this seasonal analysis provide the basis for the extrapolation to multiple seasons and the examination of hypothetical rotations. The model performed well for yield, biomass production and crop-N content under different conditions. Water balances were satisfactorily simulated when water demand by evapotranspiration was equal to water supply as in the rainfed treatment. Under conditions where the water supply was greater than the demand, the simulated soil water dynamics require improvement.

Output 3: Technologies and strategies for efficient water use in dry area cropping systems

Rationale

Testing relevant soil, water, and crop management practices in farmers' fields with their participation together with extension personnel is of vital importance to increase the adoption rate of improved technologies. Some technologies have been tested in farmers' fields for more efficient water use under mostly low rainfall conditions. Different management options for optimizing soil water use were tested in collaboration with ICARDA in the region.

Activity 3.1: Management options for optimizing crop yield and soil water use in semi-arid regions of Morocco

Bread wheat planting pattern

Results of the season 2001/02 showed that the average yields (1.86 t/ha in weed free and 1.51 t/ha in weedy plots of research station; 1.65 t/ha in weed free and 1.08 t/ha in weedy plots of farmers' fields) were satisfactory even with a total rainfall of only 308 mm with an irregular distribution (long-term average of the region is 390 mm).

At both sites, narrow row spacing (12 cm) combined with optimum seed rate (400 seeds/ m^2) increased the grain yield (2.00 t/ha in weed free and 1.80 in weedy plots of research station; 2.06 and 1.24 t/ha in farmers' fields, respectively) and total biomass significantly compared with the other treatments, particularly weedy plots sown with broadcasting seeds at lower rate of 200 seeds/m^2 (1.92 t/ha in weed free and 1.470 t/ha in weedy plots of research station; 1.36 and 0.89 t/ha in farmers' fields, respectively). In terms of weed competition, an average yield increase of 23% in the station and 54% in the farmers' fields was the result of higher weed infestation observed in farmers' fields, which is related to overall soil and cropping systems management.

Rainwater-use efficiency for grain showed the same trend as grain yield with the same treatment (7.0 kg/ha/mm in weed free and 6.3 in weedy plots at experimental station only). Water-use efficiency was lowest when row spacing increased to 24 cm combined with a lower seed rate of 200 seeds/m^2 (5.4 kg/ha/mm in weed free and 4.4 in weedy plots).

Thus, under rainfed conditions in dryland areas, sowing geometry has a strong interaction with weed infestation, so wheat production per unit area and its water-use efficiency can be improved by reducing evaporation losses through controlling the weed infestation through the use of narrower row spacing combined with optimum seed rate as a strategy to be applied in farmers' fields with their participation from planning to implementation. This is particularly important in the dry areas wheremoisture deficit occurs frequently through the growing season.

Season displacement, tillage, and weed management effects on water use and water-use efficiency of chickpea in dryland region of Morocco

Advancing the date of planting associated with weed control and P-fertilizer on chickpea could improve water-use efficiency and the crop productivity in farmers' field conditions. Overall average grain yields for winter and spring-sown chickpea were 2.1 and. 1.35 t/ha, respectively. The higher crop yield compared to last season was due to the optimum rainfall distribution through out the season of 2001/2002. Grain yield varied from 1.8 to 2.5 t/ha for winter-sown chickpea. For spring planting, it varied from 1.2 to 1.5 t/ha as a result of different P-fertilizer and weed control treatments. Yield advantage of winter planting vs. spring planting was 57% as average overall treatments for grain yield.

For winter-sown chickpea, grain yield increases with respect to P-0 and P-60 applications were 5.5 and 13.6% for low rate (1 kg a.i/ha) and higher rate (2 kg a.i/ha) of herbicide use, respectively. For spring-sown crop, grain yield increase was 8.3 and 7.1% for low rate and higher rate of herbicide use, respectively.

Both rates of herbicide use gave good control of annual broadleaves. Late emerging weeds were more prevalent in spring-sown chickpea crop, and they were controlled effectively. Grain yield increases were 27% for winter planting and 16% for spring planting by applying the higher rate herbicide. Most yield gains were due to herbicide use in both planting seasons, especially when spring seasons were relatively wet.

Activity 3.2: Conservation (no-till and minimum) tillage as an alternative to conventional tillage in dryland cropping systems in Central Anatolia, Turkey

A study on no- and minimum tillage as an alternative to conventiona dryland fallow/wheat and annual cropping systems in Central Anatolia showed that no-tillage can be more efficient than conventional deep tillage systems, especially when followed by minimum tillage.

No-tillage and reduced tillage systems were assessed in terms of financial and water economies, crop yields, and weed, pest and disease control. Conventional fallow-wheat/barley systems with the application of conventional deep tillage and successive operations and chemical fallow were compared with chickpea-wheat/barley cropping systems with minimum and zero-tillage. Weeds (mainly *Bromus tectorum* L.) were a problem especially in continuous wheat plots whether direct or normal seeded. Chemical and tilled fallow did not differ in moisture storage for the following wheat crop. There were no statistical differences between zero tillage and conventional tillage plots for three types of cropping systems at the time of wheat planting. There were statistical differences between fallow and planted plots. At 10-30 cm depth, no till continuous wheat and no-till chickpea had statistically more moisture thtraditional continuous wheat and traditional (minimum) chickpea. Stand establishment was significantly better with zero tillage the chickpea/wheat system and an insignificantly higher plant number was observed with zero tillage compared with continuous cropping. Although higher seed yield was obtained with no till wheat after fallow compared with conventional, there were no statistical differences in seed yield between management systems except for chickpea/wheat in which zero tillage provided statistically higher yields. In contrast to last year's extreme drought, this production season was unusually wet and produced unusual problems particularly in terms of weeds in all cropping systems. In drought and wet seasons no tillage systems performed satisfactorily. This means that they can replace the traditional and minimum tillage systems in the dryland plateau.

Activity 3.3: ***Different management options including improved cultivars to be tested and evaluated as on-farm trials for optimizing soil water and other input use efficiency in CWANA***

On-farm trials/demonstrations in Iran

These trials follow the results of previous on-farm trials conducted in several locations in Iran over three consecutive extremely dry years. On-farm demonstration plots have been held on about 3500 ha in four provinces with improved management practices to compare against the farmers' practices for wheat. The grain yield increases with the improved practices were 23% in Kurdistan, 46% in Kermanshah, 64% in Azerbaijan, 89% in Gachsaran, compared with the farmers' practices. Thus, the Ministry of Agriculture has decided to apply this action plan on about 50,000 ha area in the same provinces. This output was a result of on-the-job training activities conducted since 1995 for identifying the problems and planning of technology testing of promising management practices obtained through adaptive research in close collaboration with ICARDA.

Output 4: Management strategies for the enhancement of soil fertility in cropping systems

Rationale

While drought is the major constraint to crop production in the WANA region, nutrient deficiencies are also limiting factors. Invariably, most soils have insufficient N to meet crop needs, and N is needed either as fertilizer or from biological fixation for economic yields. Similarly, soils are usually low in P availability and low P fertilizer-use efficiency. Thus, P fertilizer use is 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.

Activity 4.1: Effective phosphate fertilizer use (funded mainly by IMPHOS)

Field trials in rainfed areas of Pakistan (NARC, Islamabad) showed that P fertilizer was highly effective and economic for increasing wheat yields. Banding of fertilizer was twice as effective as broadcasting. While soil analysis can indi cate deficiency levels of P, criteria were also developed for plant analysis.
In the Çukurova region of Turkey (Çukurova University), crop growth responses to applied P were shown for corn, with wide variation in sensitivity between genotypes. However, such differences were not attributed to the extent of mycorrhizal infection. Evidence of P accumulation from fertilization was also shown. The work is now being extended to the GAP region of Turkey.
In Jordan (JUST, Irbid), soil analysis surveys showed that most areas of the northern part of the country were low in available P; however, drought is often so severe as to render fertilization uneconomical due to crop failure. This and other research in Jordan highlighted the need for fertilizer P use, especially in years of normal rainfall.

In Morocco (INRA, Settat), a series of on-station trials established the importance of providing P fertilization for N-fixing forage legumes where test levels were in the deficiency range. Major differences were evident in the response of various cultivars to applied P. The next phase of P fertilization will involve on-farm testing.

In a greenhouse trial (at Tel Hadya), with barley and chickpea, it was shown that crop response to P fertilization was influenced by both soil depth and available moisture. At any moisture level, soil depth had a major influence. Thus, shallow soils pose a major limitation to effective P fertilizer use in the region. While nothing can be done to change soil depth, where financial resources are limited, farmers should give preference to deeper soils for fertilizer application.

Activity 4.2: Nitrogen and carbon in a long-term barley-based rotation trial.

A previous wheat-based rotation trial had shown that legumes, notably medic and vetch, could result in a buildup of soil organic matter as well as total soil N, in addition to improving soil aggregation. Biomass and labile N and C were sensitive indicators of these trends. This on-going barley-based trial is providing confirmation of these trends. However, several years may be necessary to identify the maximum amount of carbon that can be sequestered by legume-based cropping systems. This year will see additional measurements of soil physical properties such as aggregate stability, infiltration, and permeability.

Activity 4.3: Fertilizer use and fertility characterization across Syria's rain fall zones

Any research activity on soil fertility and fertilizer use has to be in tune with conditions in farmers' fields and farmers' practices. If research is to have impact, it should be reflected in such practices. Therefore, a survey was conducted related to farmers' responses to soil analysis and fertilizer use.
Given the importance of soil organic matter and the significance of carbon sequestration to mitigate global warming, measurements of C were also taken to determine and take into account spatial variability and soil depth. Estimates of the amount of soil carbon in each rainfall zone have been made. Reflecting the relationship with crop growth and rainfall, there was a consistent increase in soil organic matter concentration and content (reflecting soil depth) with increasing rainfall. This is probably due to increased primary productivity and root biomass and increased cropping intensity. Concentrations of organic matter (OM) in the top 0-20 cm of soil were lowest (1.56%) in the driest zone (< 250 mm annual rainfall) and highest (2.14%) in the favorable rainfall zone (> 400 mm). Values for intermediate zones were inconsistent. The effect of rainfall on OM was clearer when total soil profile OM was considered. Thus, profile OM was about 60 t/ha in the driest zone and 180 t/ha in the favorable zone.

In the coming year, the survey will be completed and compiled. A clear picture will emerge of the status of soil fertility and fertilizer use across the rainfall zones in northern Syria and an indication of differences due to irrigation. This will have implications in terms of transferring technology and information to farmers.

Activity 4.4: Soil and plant analysis

Reliable and meaningful analyses are fundamental to making rational decisions about nutrient deficiencies and fertilizer requirements. Thus, efforts to up-grade laboratory performance and maintain quality output continued. The most tangible output was a survey of laboratories in CGIAR centers worldwide, highlighting avenues for improvement. The Soil Laboratory plays a major role for ICARDA and assists NARS technicians and technicians and scientists (see output 6).

Output 5: Micronutrients in soils and plants

Rationale

Micronutrients, needed in only small quantities by plants, are essential to crop production. Such nutrients include iron, zinc, manganese, copper, and boron. Soil conditions in WANA, especially as they are mainly calcareous, are conducive 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.

Activity 5.1: Geographical distribution of soil and plant micronutrients

A database of soil test data is being established from soil samples from Syria and elsewhere in the region. This is essentially an ongoing activity in which information on micronutrients is gradually being built up from samples, which come from various parts of the region. A review of micronutrients in Mediterranean-type environments is being prepared in collaboration with NARC, Pakistan. This is fundamental for assessing the extent of deficiency while bringing together all available literature on the subject from the WANA region.

Activity 5.2: ***Experimentation on zinc deficiency***

Previous work had shown the need for Zn supplementation for forage legumes such as vetch. Results of greenhouse and field trials with lathyrism have shown that the nerve-damaging toxin B-ODAP (3-(N-oxalyl)-L-2,3-diaminopropionic acid) could be reduced by varietal selection and to a lesser extent by addition of Zn. Two greenhouse experiments have been completed as well as two field trials at Tel Hadya. The evidence so far indicates that in addition to increased crop yields where soil zinc is deficient, the application of Zn can substantially reduce the concentrations of the toxin in *Lathyrus* seeds.

Output 6: Strengthened capacity of NARS

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 of productive and sustainable technologies to resource users are of vital importance for the use of sustainable natural resources.

A major aspect of capacity building in the region is the publication of training materials. In 2002, a second edition of the Soil Lab Analysis Manual was produced in English (demand from NARS far exceeded the supply-500 copies) and also a Russian version for Central Asia. This has been distributed to all soil labs in CAC. The Arabic translation is now complete and will be published in 2003. Other training-related publications produced during the year included a journal article on soil laboratories in the CGIAR system.

In formal courses for technicians and scientists from the region, a module on soil fertility was presented at the JICA Course on water-use efficiency at Tel Hadya, while lectures on fertilizer use, soil quality, and soil evaluation were presented at the CIHEAM advanced course in "Soil Degradation" in Rabat, Morocco (Oct. 16 - Nov. 1, 2002).

Given adequate resources, future plans will involve exchanges of soil and plant samples with soil laboratories in Syria and in the region. A training course on Soil Laboratory Analysis is scheduled for Tashkent (June 2002) and possibly Afghanistan.

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

Examples of such activities include:

- Transfer of technology through on-farm trials in CAC, Egypt, Iran, Morocco and Turkey.
- Contribution on agronomic management of cropping systems including soil fertility to JICA/ICARDA training course on Improving Water-Use efficiency, e.g., agronomy and soil fertility (April 7 - June 6, 2002).
- Exchange of knowledge at field visits (e.g., Iran, Turkey, Egypt).
- Review of NARS-related papers.
- Workshop/meetings, and editing of the Proceedings.

Conclusions

The project on the agronomic management of cropping systems is one of the most diverse in ICARDA. This aspect of cropping systems, whether termed agronomy or soil nutrient management, has always been a major component of ICARDA's research strategy. It cuts across all the major cereal/legume crops of the institution's mandate. As a multidisciplinary endeavor, cropping systems research has been one of the most productive in terms of publication outputs ranging from primary refereed journal articles to books and proceedings and training materials. In its present form, the project has been in transition from center-based experimentation to research in outreach with the national programs. On-station research includes: long-term cereal/forage legume growing, conservation tillage practices with residue management, soil fertility and cropping systems management, validation of crop growth models and assessment of new crops such as oilseeds, medicinal plants etc.

At the NARS level, the project is heavily involved in Central Asia on crop diversification and conservation tillage in CAC; long-term resource management, evaluation and monitoring in Egypt; natural resource management in Iran; and at a broader level, the project embraces Sub-Saharan Africa, in addition to WANA, through the Optimizing Soil Water Use (OSWU) project as part of Center-wide Soil, Water and Nutrient Management Program (SWNMP).

An inherent problem with such a large and diverse project is the difficulty of packaging the output in terms of technology transfer to the national programs. The contribution of the project to science is reflected well in the refereed papers produced and papers published in conferences/workshops proceedings. Transfer of management practices that are site-specific to an agro-ecologically diverse region is a major challenge. However, the strong need for transferring technologies, which are already developed, should involve participation of farmers in adaptive on-farm research. This will be directed through a shift from classical agronomy to overall systems productivity concerned with efficient input use such as water, fertilizers, energy and pesticide, conserving natural resources and studying systems dynamics in a multidisciplinary approach.

In addition, institutionalization of on-farm adaptive research with farmers' participation for increased production, while conserving natural resources, will be a major emphasis. The use of crop, soil, and water simulation models allow the integration of existing knowledge to facilitate decision making at different levels, and to develop recommendation packages. Further, in combination with GIS, it permits the extrapolation of the site-specific information coming from benchmark sites to wider regions, where experiments are prohibitively expensive to be conducted everywhere in the region.

The project has evolved from mandate crops to novel alternatives, from traditional to conservation tillage practices and has assured an environmental component in addition to the production aspects. The project will continue to address issues of sustainable agriculture, mainly through the global challenge programs, and to meet the new biophysical and socioeconomic obstacles that will inevitably arise.

APPENDIX: STAFF LIST, COLLABORATORS, DONORS, PUBLICATIONS

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 Management, Soil Laboratory, Science editor, and coordinator for CRP with IAEA, Vienna, and fertilizer P project with IMPHOS, Morocco.

Atef Haddad (NPO): Assists in agronomic management trials for cropping systems as necessary, produces oilseeds as requested by NARS, and advises in overall weed control.

Haitham Halimeh (GS): Assists in agronomic management trials for cropping systems as necessary, conducts farm surveys for identification of biophysical problems for working on solutions.

Samir Masri (GS): Soil sampling and conduct fertility research as necessary.

George Stephan (GS): Supervises Soil Laboratory.

Shireen Badour (GS): Assists in Soil Laboratory analysis.

Students

Carina Moeller: First 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.

- Soil fertility trends; systems modeling; use of N: Pakistan, Turkey, Morocco; University of Reading, UK; International Atomic Energy Agency (IAEA), Austria.
- 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 and Yemen; Wageningen University.
- Soil chemistry: International Atomic Energy Agency (IAEA); IMPHOS; International Fertilizer Association (IFA).
- Linkage to the Systemwide Program on Soil Water and Nutrient Management (SP-SWNM) with CIAT, IBSRAM, TSBF: Optimizing Soil Water Use (OSWU), with ICRISAT.
- Participation in Inter-Center Working Group for Climate Change (IWG-CC) with the lead on the project on "Carbon and Nitrogen Dynamics in Long-term Trials".

Donors

Unrestricted core funds. Collaboration with NARS in Egypt in long-term trials and farm monitoring supported by EC; support to consortium on Optimizing Soil Water Use 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

Adary, A., A. Hachum, T. Oweis, and M. Pala. 2002. Wheat Productivity under Supplemental Irrigation in Northern Iraq. On-Farm Water Husbandry Research Report Series, No. 2. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria.

Karajeh, F., J. Ryan, and C. Studer (Ed.) 2002. On-farm soil and water management in Central Asia. Proceedings of an international workshop, 17 - 19 May, Tashkent, Uzbekistan. ICARDA, Aleppo, Syria. 164p.

Ryan, J., G. Estefan, and A. Rashid (2nd Ed). 2002. Soil and plant analysis laboratory manual, ICARDA, Aleppo, Syria/NARC, Islamabad. 172p.

Ryan, J. (Ed). 2002. International Desert Development Conference proceedings (Cairo, Aug. 22 - 27, 1999), ICARDA, Aleppo, Syria. 682p.

Ryan, J., G. Estephan, and A. Rashid. 2002. Soil and plant analysis manual (in Russian). ICARDA, Tashkent. 122p.

Chapters in books

Ryan, J. 2002. Available soil nutrients and fertilizer use in relation to crop produc tion in the Mediterranean area. p. 213-246. In K. R. Krishna (Ed.) Soil Fertility and Crop Production. Science Publishers, Inc., Enfield, New Hampshire, USA.

Journal articles

Daroub, S. H., A. Gerakis, T. Ritchie, D. Friesen, and J. Ryan. 2002. Development and testing of a soil-plant phosphorus simulation model. Agricultural Systems (in press).

Eberbach, P.L., and M. Pala. 2002. Crop row spacing and its influence on transpiration and soil evaporation in winter grown wheat in northern Syria. (Accepted in Plant and Soil).

Ryan, J., and A. Rashid. 2002. Dynamics of soil phosphorus. Soil Science Encyclopedia. (online/hard copy).

Ryan, J. 2002. Methods of fertilizer application. Soil Science Encyclopedia. (online/hard copy).

Ryan, J. 2002. Dryland and semi-arid research institutions. Encyclopedia of Water Science. (online/hard copy).

Ryan, J., P. Smithson, B. Mamdac, and J. Uponimi. 2002. Role of international research center soil laboratories in agriculture. Commun. Soil Sci. Plant Anal. 33: (15-18): 3213-3225.

Ryan, J., S. Masri, M. Pala, and M. Bounejmate. 2002. Barley-based rotations in a typical Mediterranean agroecosystem: crop production trends and soil quality. Options Mediterrenees (in press).

Ryan, J. 2002. Phosphorus fertilizer use in dryland agriculture: the perspective from Syria. In: J. Lynch, J. Scheppers, and I. Unver (Ed.). "Innovative Soil-Plant Systems for Sustainable Agricultural Practices" OECD.

Abstracts

Aw-Hassan, A., and J. Ryan. 2002. Dryland resources management network in West Asia: land degradation and livelihoods. Agron. Abstr. (online). (Indianapolis, Indiana).

Baum, M., A. de Kathen, J. Ryan, and T. Blake*. 2002. Current status of bio-safety development in West Asia and North Africa. Agron. Abstr. (online). (Indianapolis, Indiana).

Mrabet, R., A. El-Brahli, J. Ryan*, S. Lahlou, and F. Bessam. 2002. No-till system: departure from traditional agricultural systems in semiarid Morocco. Agron. Abstr. (online). (Indianapolis, Indiana).

Pala, M., T. Oweis, and J. Ryan. 2002. Agronomic practices for improving water-use efficiency in drought-prone Mediterranean-type agriculture. Agron. Abstr. (online). (Indianapolis, Indiana).

Pala, M., and J. Ryan. 2002. Conservation tillage systems in West Asia. Agron. Abstr. (online). (Indianapolis, Indiana).

Pala, M., and J. Ryan. 2002. No-till planting and minimum tillage vs. traditional deep tillage for sustainable crop production in dry areas of WANA. Agron. Abstr. (online). (Indianapolis, Indiana).

Pala, M., T. Oweis, and J. Ryan. 2002. Agronomic practices for improving water-use efficiency in drought-prone Mediterranean-type agriculture. Agron. Abstr. (online). (Indianapolis, Indiana).

Pala, M. and T. Oweis. 2002. Strategies for improving water-use efficiency in the dry areas. OECD/Agriculture Workshop on 'Innovative soil/plant systems for sustainable agricultural Systems', Izmir, Turkey. June 3-7. Abstr. p.8 (in print as proceedings).

Rashid, A., M. A. Chaudhry, and J. Ryan*. 2002. Challenges and strategies of dryland agriculture in Pakistan. Agron. Abstr. (online). (Indianapolis, Indiana).

Rashid, A., M. Chaudhry, and J. Ryan. 2002. Fertilizer use in Pakistan's dryland agriculture: requirements, constraints, and options. Agron. Abstr. (online). (Indianapolis, Indiana).

Ryan, J. 2002. Twenty five years of nitrogen research at ICARDA: Achievements and future challenges. Agron. Abstr. (online) (Indianapolis, Indiana).

Ryan, J., S. Masri, and E. De Pauw. 2002. Assessment of soil carbon in Syria and potential for sequestration through crop management. International Soil Science Congress. Bangkok, Thailand. Symposium 45: Abstr. 1304.

Ryan, J., 2002. Phosphorus fertilizer use in dryland agriculture - the perspective from Syria. OECD/Agriculture Workshop on 'Innovative soil/plant systems for sustainable agricultural Systems'. Izmir, Turkey. June 3-7. Abstr. p.45 (in print as proceedings).

Suleimenov, M., M. Pala, J. Kaskarbaev, F. Khasanova and L. Martynova. 2002. Developments in tillage and cropping systems in Central Asia. Agron. Abstr. (online). (Indianapolis, Indiana).

Yau, S.K., M. Bounejmate, J. Ryan, and A. Nassar. 2002. Sustainable barley-legumes rotations for semi-arid areas of Lebanon. Agron. Abstr. (online). (Indianapolis, Indiana).

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

(Note: As a result of the tragic loss of M. Bounejmate, the report for this project is incomplete. A replacement is expected to join ICARDA in June 2003)

Goal: Sustainable system productivity, maintenance of soil fertility, and improved small ruminant feed and nutrition by increased use of sown pasture and forage crops in farming systems

Indicator: Increased production of forage and pasture and its utilization in live stock production systems

Purpose: Development of options for adoption by farmers of forage and pasture species in crop rotations or to rehabilitate native pastures

Indicator: Area grown to annual pastures and forage legumes in crop rotations or to rehabilitate native pastures

Output 1: Identification of species and selection of adapted cultivars of pasture and forage species (in cooperation with Projects 1.6 and 3.3)

Indicators: Cultivars released to NARS
On-farm testing by farmers of selected cultivars

Milestones

2003:

- 100 medicinal plant species collected and conserved
- Assessment of the biodiversity of the Khanasser Valley Integrated Research Site in Syria published
- One cultivar of range species selected
- Draft Report written and database of technology for restoring degraded pas ture in Khanasser developed
- Seedlings of introduced new fodder shrubs and perennial grasses in Syrian Steppe produced
- Rangeland germplasm including perennial grasses established in Turkey (GAP) Syria, and Talelah project with FAO
- NARS trained on taxonomy of forage legumes
- Seeds of medicinal plants that were collected from Lebanon and Syria

planted in a seed nursery

- Annual legumes paper published
- Biodiversity of Turkey completed (with 2.4)

2004:

- Significant diversity of forage and range species native to CWANA collected and conserved in genebank and/or nursery
- At least one cultivar of forage crop released by NARS
- A CD-ROM including photos and descriptions of major useful forage and range species for CWANA produced and distributed
- A list of herbaria specimens of major useful forage and range species collected in CWANA published

2005:

- Adapted range germplasm tested by NARS
- 1000 kg of new forage germplasm and 10 kg of range species distributed to NARS
- A list of major medicinal plants native in CWANA published
- Four NARS scientists trained in collection and selection of forage and pasture species

2006:

- Rangeland germplasm screening trials evaluated and recommendations published

Output 2: Forage and pasture seed production technologies developed for small farmers

Indicators: Small-scale farm machinery adapted or developed for pasture seed collection and production On-farm demonstrations and published manual.

Milestones

2003:

- A low-cost technology for harvesting *Artemisia* species tested on-farm
- Ten farmers grow and produce vetch seed in new areas of Lebanon

2004:

- Solutions to overcome shortage in forage seed in Pakistan, Central Asia and the Caucasus identified
- A low-cost technology for harvesting *Salsola* species developed

2005:

- A low-cost technology for harvesting seed of *Atriplex* species adopted by NARS

- A low-cost technology for harvesting *Salsola* species adopted by NARS
- At least four NARS scientists trained in seed production

2006:

- Final report on machinery development and testing

Output 3: Demonstration 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

Indicator: On-farm trials

Milestones

2003:

- Results on plant productivity from the long-term trials in Lebanon and Syria published

2004:

- Results on plant productivity from the long-term trial at Tel Hadya published
- At least four NARS scientists trained in rotation trials

2005:

- At least 10 field days organized to promote use of forage crops

2006:

- Results of farmer participation trials in forage/barley rotation published

Output 4: Management recommendations that provide the highest economic output at a minimum cost from pasture and forage legume rotation treatments

Indicator: Recommendations utilized by NARS in extension and demonstration programs

Milestones

2003:

- The potential use of wastewater to irrigate forage crops assessed
- Rotation trials analyzed for economic ranking of treatments
- The environmental role of fodder shrubs and their contribution to animal feeding determined
- Two NARS scientists trained in management of feed resources
- Two issues of Dryland Newsletter produced

2004:

- The potential use of drainage water to irrigate forage crops and range species assessed
- The potential use of forage and pasture crops as hay, grazing or mature seed and straw to suit land use and market opportunities assessed
- Two NARS scientists trained in management of feed resources
- Two issues of Dryland Newsletter produced

2005:

- Carbon sequestration in the different rotations assessed
- Two NARS scientists trained in management of feed resources
- Exchange of information and germplasm of oat and vetch between NARS of North Africa
- Two issues of Dryland Newsletter produced

2006:

- Two issues of Dryland Newsletter produced
- Two NARS scientists trained in management of feed resources

Duration: 10 years

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, rural and urban consumers.

Staff list

Rafik Makboul:	Research Assistant
Amin Khatib Salkini:	Research Associate
Mohamed Bader Idlebi:	Research Assistant
Adel Nasser:	Research Assistant

Collaborators

- Pasture/forage rotation trials with cereals: American University of Beirut/Agricultural Research and Extension Center, Lebanon; Syrian Ministry of Agriculture and Agrarian Reform; Aleppo University, Syria.
- Forage and pasture management: NARS of Algeria, Egypt, Iraq, Jordan, Lebanon, Libya, Morocco, Pakistan, Syria, Tunisia, Turkey, Caucasus and Central Asia; USDA-ARS; GL-CRSP (Global Livestock Collaborative Research Support Program.
- Pasture rehabilitation and vetch in Turkey: South Eastern Anatolia Project;

Field Crops Research Institute, Ankara.
- Feed resources in Central Asia and the Caucasus: National programs of Armenia, Azerbaijan, Georgia, Kyrgyzstan, Kazakhstan, Turkmenistan and Uzbekistan; ILRI.

Financing plan
Unrestricted core funds. Financing from Barani Village Development Project in Pakistan and GAP Project in Turkey; Dryland Pasture, Forage & Range Network Newsletter co-sponsored by FAO; restricted funding from USDA-ARS for research on medicinal plants in Tunisia; support from FAO for the Oat & Vetch Network in the Maghreb. Anticipated funding for collaborative research on integrated crop livestock systems in WANA from IFAD and the Arab Fund and in Central Asia and the Caucasus from IFAD.

PROJECT 2.4: REHABILITATION AND IMPROVED MANAGEMENT OF PASTURES AND RANGELANDS IN DRY AREAS[1]

Project rationale

Small ruminant flocks in the CWANA region generate incomes for the poor and can be a cushion against stressful climatic periods, especially the drought. Due to increases in population and environmental degradation, feed resources for small ruminants from natural pastures are decreasing. Rangelands in semi-arid zones and uncultivable marginal lands in the rainfed cropping zones supply low-cost forage outside the spring growing season or when cereal-crop stubbles are not available. The goal of this project is to rehabilitate natural pastures and rangelands for livestock grazing in the marginal dry areas.

Rationale

The experimental sites are located in new Obisan, old Obisan, and Dalpoh in Aleppo steppe syria. These sites are traditionally used as a Bedouin campground. Extreme overgrazing and the shrub collection has depleted all perennial and woody shrubs from the site and the surrounding area. The local flocks used to come in spring (from the end of February until the end of April or early May) to graze the annual growth of sparse vegetation.

Average rainfall on the sites is about 150-170 mm in the rainy season. The top soil surface layer is often crusted and resistant to water infiltration and often results in germination failure. The soil seed stock is totally depleted and germination conditions are extremely difficult.

The native vegetation *Artemisia herba-alba / Noaea mucronata,* a perennial range type has been completely degraded. The remaining dominant species are two geophytic plants, *Poa bulbosa* (Graminaceae) and *Carex stenophylla* (Cyperaceae), with a total vegetation cover not exceeding 5-10% and an aboveground biomass of 200-250 kg DM/ha year in an average to good year. A black small moss has spread over the top crusted layer and covers many places.

Progress of research

Species used (all native from the area) and seeding rate are *Atriplex halimus* (24kg/ha cleaned seeds), *Atriplex leucoclada* (30 kg/ha, seeds not de-hulled),

---

[1] There was a change of staff in this project as a result of the resignation of Dr B. Norton. Dr J. Tiedeman joined the staff in September 2002. This report is, therefore, only a partial representation of the project's activities.

Artemisia herba-alba (30 kg/ha, seeds not de-hulled), and *Salsola vermiculata* (25 kg/ha, seeds not de-hulled). The seeds were freshly harvested at the Maragha and Odame range stations and used immediately for the reseeding operation, which started 24 October 1998 and was completed on 1 January 1999, according to seed availability and harvest date. Each species was seeded into the pits by pitting machine automatically. A total area of 87 ha was planted. In 2001-2002, a total of 188 mm annual precipitation was received at Adamy, southeast of Khanasser, where the average is 180 mm (Figure 1).

Among the species, *Salsola vermiculata* had the best emergence in the first year in terms of number of seedlings, followed by *Artemisia herba-alba and Atriplex halimus* (Table 1). There was a significant difference in the survival rate after five years of evaluation of the three species. The survival rate of all reseeded species has decreased by 70%. The major decrease took place in the third year. *Salsola vermiculata* decreased to 3% by 2002. It appears that the drought years 1999 and 2000 impacted on survival in 2001

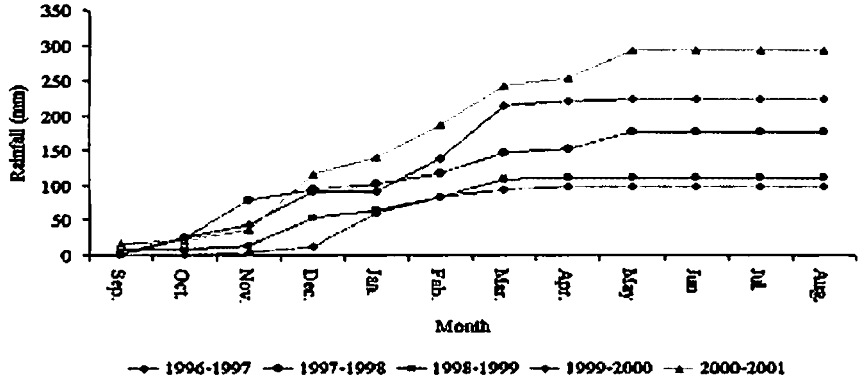


Fig. 1. Amount of rainfall (mm) during 1997-2001, as recorded at Adamy nursery station.

Table 1. Five years survival rate of three range species reseeded by pitting machine (expressed in number of emerging seedlings in a 100×20-cm quadrat) in Obissan range station, Aleppo steppe.

	Salsola vermiculata	*Artemisia herba-alba*	*Atriplex halimus*
April 1998	30.4	18.4	0.6
July 1998	24	15.2	0.3
July 1999	2.8	5.7	0.1
July 2000	2.3	5.1	0.1
July 2001	2.8	4.8	0.1
July 2002	3	4.7	0.1

Rangeland management and rehabilitation: an integrated approach to sustainable land management in dry areas, Khanasser Valley project

Rationale

The geographical information system (GIS) was used to identify the potential for rangeland improvement and biodiversity in Al Huss and Shbiet mountains in Khanasser area, Aleppo province, Syria.The Khanasser Valley is a typical watershed in the transitional zone between rainfed agriculture and rangelands in Syria, and covers an area of approximately 200 km^2. The study area is characteristic of arid and semi-arid regions of the Middle East, ranging from sedentary farming to nomadic herding.

Progress of research

Vegetation types: Two main types that represent the vegetation of Al Huss and Shbiet were identified

1. Degraded vegetation type composed mainly of annuals and occasional shrub plants on abandoned barley fields in Shbiet.The recent ban on cultivation and cropping has left large areas of bare soil or of areas covered by annual species. Fifty years of intense barley cultivation has resulted in resource degradation. Dominant species in the annual vegetation type are grasses *(Koeleria phleoides, Schismus arabicus, Carex stenophylla, Poa bulbosa, Bromus sp. Stipa capensis, Eremopyrum confusum, Hordeum glaucum)* and broad-leaf annuals *(Helianthemum salicifolium, Erodium glaucophyllum, Ziziphora tenuior, Plantago ovata, Micropus bombycinus, Matthiola longipetala, Centaurea pallescens, Malva aegyptica, Torularia torulosa, Salsola volkensii, etc.)*. Most of the species are unpalatable or of low palatability and the grazing value is relatively low.
2. Very degraded steppe vegetation composed mainly of shrubs or shrub-like species in slopes and footslope.This type is composed mainly of *Noaea mucronata, Artemisia herba-alba, Astragalus spinosus* and very rare *Salsola vermiculata.*

Life form: Annuals compose most of the life forms followed by perennial herbs and lowest for shrubs and dwarf shrubs (Figure 2). For more complete description of vegetation survey results refer to the Khanasser Project Annual Report.

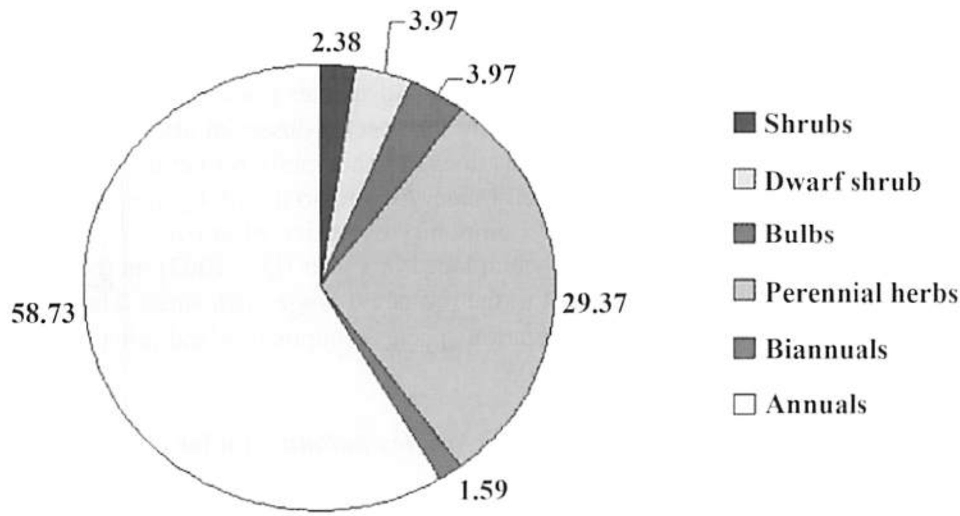


Fig. 2. Percentage of life forms in the study area.

Table 2. Aerial biomass of protected (Pr.) and plant density of protected (Pr.) and not protected (Npr.) rangeland after four years of protection at Al Huss and Shbiet, Khanasser, Aleppo Province, April 2002.

	Aerial biomass kg DW/ha and plant density, April 2002		
	Biomass (Pr.)	Density (Pr.)	Density (Npr.)
Al-Quraa	1588	6000	2635
Mgherat	2518	5200	5129
South-Om-Myal	3076	3906	2494
North-Om-Myal	5210	4165	3670
Serdah	1930	4024	1859
Khullat	2203	6188	2965
Average	2754	4914	3125

Species composition: The protection in Al Huss and Shbiet Mountains gave a new chance for many species to regenerate. Hundreds of plant species were listed in the northwestern slope of Al Huss and Shbiet including trees (even the rare *Pistacia atlantica*), fodder shrubs and perennial grasses.

Grazing: The dominant plant species of grazed sites (not protected) are annual grasses with low grazing value. The spring biomass was 2754 kg DW/ha in the protected rangeland.

Conclusion
These data on the protected range are a baseline of information useful in determining the potential of the range production and species present after rest. Data collected from grazed range includes only the species observed after most of the vegetation is removed by grazing. This does not accurately reflect the species composition or productivity of grazed range. A comparison of 4 years of protected range to grazed range would require temporary exclusion of grazing for data collection. Temporary cages have been placed this year (Dec 2002) on the unprotected range outside and next to the protected range enclosures. The effect of 4 years rest (no grazing) on vegetation species composition and range productivity will be evaluated in 2003.

Intercropping of barley and saltbush (*Atriplex halimus*) under on-farm conditions in Khanasser area

Rationale
In the low rainfall areas of the West Asia and North Africa (WANA) region where soil is very poor, barley is the most dominant crop. Since productivity is low and rainfall unreliable, the barley crop is rarely harvested for grain but used for grazing. When there is a good rainy season (one year in 5 or 10), or when underground water is available for supplemental irrigation, the crop is harvested for grain, and the stubble is grazed by small ruminants.

Crop residues are becoming the major livestock feed source in the dry areas of the WANA region. The most important crop residue is barley straw, which is usually grazed as stubble in the summer months. Stubble grazing contributes about 25 percent of the annual requirements of sheep and goats in Syria and Jordan over a period of 90 to 120 days. However, the quality of the stubble diet is low. These feeds are generally considered inadequate and low in nutritive value. A new system that produces high quality fodder without jeopardizing the grain production is needed.

Alley-cropping is well known in the subtropics, especially in the form of maize between hedgerows of *Leucaena leucocephala*, a legume, but its application to sustain farming in the Mediterranean basin is relatively new, especially in the drier domain of the marginal zone.

Objectives

- 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.
- Test the hypothesis that barley production is depressed when plants are growing close to the shrubs.

Progress of research

ICARDA is testing a new system where barley is grown in combination with wide-spaced hedgerows of drought-tolerant fodder shrubs. The shrub used in this study is *Atriplex halimus*, (saltbush), a native to West Asia and North Africa. This system provides farmers profit and subsistence requirements from the same piece of land.

This study is being carried out in Khanasser Valley, 70 km southeast of Aleppo in northwest Syria with average annual rainfall of 200-250 mm. Farmers' fields, each 1-4 ha, have been planted with *Atriplex halimus* in rows 10 m apart, 500 shrubs/ha. By the time they are ready for grazing in the second year after planting, the shrubs occupy about 10% of the field, calculated from their canopy cover. Several farmers have participated in the study over the past 4 years.

Quantity and quality of feed

Preliminary results of mean values presented in Table 3 show that yield of both barley grain and straw is enhanced in the intercropped alleys, and this higher yield compensates 10.6% more for the reduction in cropping area. Average total barley yield was 1313 kg/ha on the control fields, and 1614 kg/ha on fields with shrub hedgerows, calculated on the assumption that the shrubs exclude barley from 10% of the field. The shrub foliage adds, on average, an additional 23.6% biomass to the yield from barley in the intercropped field.

Table 3. Production of barley and shrub foliage (kg/ha) and rate of sheep live weight gain (g/head/day) on pure barley fields compared to fields with hedgerows of *Atriplex halimus* in 2001-2002 season (means of 2 trials).

	Pure barley field	Barley between hedgerows	Total field (10% shrub)%	%Change on a field basis
Barley grain	626	698	628	.27
Barley straw	687	916	824	20.08
Total barley yield	1313	1614	1452	10.6
Shrub foliage	-	-	171	
Shrub plus barley	1313	-	1623	23.6
Live-weight gain	89		108	21.9

Data from individual years show marked differences in barley yield, probably due to variation in rainfall. The growing season rainfall of 205 mm in 2001/2002 was associated with a barley yield of about 650 kg/ha, nearly the average yield for the normal years. From interviews, farmers believe the intercropping technology may have its greatest value as a means to alleviate drought stress. Farmers are most interested in what the shrub foliage can do for sheep grazing on barley stubble after harvest.

Sheep grazing intercropped barley stubble in summer have access to the protein-rich *Atriplex* leaves, and daily weight gain on shrub fields was almost 22% higher than on stands of barley stubble alone (Table 3). However, some of that extra weight gain may be associated with water retention to compensate for the higher salt content in the shrub-supplemented diet. *Atriplex halimus* is a halophytic species commonly known as saltbush. Sodium content in *Atriplex* leaves sampled from 3 trial sites in Khanasser Valley in 1999 averaged 11.6%, with a range from 9.5 to 13.2%. Potassium content averaged 3.3% in the same leaves. Intake of shrub foliage, calculated from shrub utilization estimates, ranged from 46 to over 500 g DW/head/day.

Perhaps one of the best indications that barley/shrub intercropping has promise on marginal lands in West Asia is that farmers who no longer participate in the research have kept the *Atriplex* hedgerows intact. One farmer decided to conserve his intercropped field for autumn feed instead of grazing it in summer, as was done according to the research protocol. Another farmer rented his post-harvest intercropped field to a livestock producer for a higher price than his neighbor could obtain for a field of barley stubble alone. Presumably the presence of the shrubs among the barley stubble conferred a premium to the value of the field for grazing, most likely equivalent to a protein supplement.

Influence of hedgerows on soil moisture, barley production and soil water content

The hypothesis that barley production is depressed when plants are growing close to the shrubs was tested during the 2002 data-collection season and will be continued in the next season. There appears to be no visual evidence of competition between the shrub plants and barley.

Two sites in an intercropped field and two sites in a pure barley field were selected for the study. For each site in an intercropped field the biomass of barley was sampled in May before harvest using quadrates with long axes parallel to hedgerows and from one hedgerow to the next. A comparable layout of sample sites in the pure barley field for control was conducted.

For the soil water content, sampling was along a gradient across a strip of barley from one shrub hedgerow to the next. Samples were adjacent to lines used for barley biomass. Soils were sampled at depths of 5-10cm, 20-25 cm, and 50-55 cm. Sampling was conducted in mid-March, mid-April and mid-May. Soil samples were taken approximately from the same locations at each date.
A comparable layout of the sample site in a pure barley field for control was conducted.

Conclusion

Preliminary results from the first season (Table 3) showed no significant differences in barley production sampled from one hedgerow to the next. However, there were significant differences among all samples between hedgerow and the control treatment. The first meter from the hedgerow was affected negatively by the presence of the hedgerow. On the other hand, the central area (4 m) between the two hedgerows showed the highest productivity. The results match those of the soil water content (Table 4) where there is a significant difference in the soil moisture between hedgerow and the control treatment when sampled at the end of the season (just before harvesting) at (-55) cm depths. Soil water content showed no differences when sampled on the top 5 cm over the three sampling dates. The work on soil moisture will continue in the next season.

Table 4. Soil water content under barley grown between *Atriplex halimus* hedgerows in Khanasser area, 2002.

Soil depth	Sampling date	Distance from hedgerow/m			Control
		1 m	3 m	5 m	
-5 cm	March	9.04$^{a(1)}$	9.51^{a}	8.95^{a}	9.67^{a}
	April	6.70^{a}	6.99^{a}	6.73^{a}	5.79^{a}
	May	5.19^{ab}	5.54^{a}	5.54^{a}	4.49^{b}
-25 cm	March	9.74^{a}	10.32^{a}	9.85^{a}	9.80^{a}
	April	7.88^{a}	8.40^{a}	8.03^{a}	8.33^{a}
	May	6.70^{a}	7.50^{a}	7.25^{a}	6.96^{a}
-55 cm	March	8.63^{b}	10.29^{a}	10.40^{a}	7.13^{b}
	April	8.24^{a}	7.50^{a}	9.23^{a}	6.63^{b}
	May	7.31^{b}	8.40^{a}	8.54^{a}	6.10^{c}

(1) Values followed by different letters at the same row are significantly different at .05 levels.

APPENDIX

Staff list

Fahim Ghassali:	NPO-Range
Nabil Battikha:	Research Assistant II
Elias Khoudary:	Research Assistant I
Ali Rajab:	Research Technician

Publications

Draft reports in 2002 to be published in 2003

- *Report on rangeland monitoring in Syria:* Influence of land use on the rangeland vegetation of Abdel Aziz Mountain in northeastern Syria.
- *Report on rangeland monitoring in Turkey:* Biodiversity of Kuyulu, southeastern Turkey for GIS analysis of satellite imagery of the Kuyulu, rangelands of GAP, Turkey, funded by the GAP, Southeastern Anatolia Project (GAP), Turkey.
- *Report on rangeland monitoring in Turkey*: Land use vegetation map of Kuyulu, southeastern Turkey for range rehabilitation and management. A report on this activity, which is based on GIS analysis of satellite imagery of the Kuyulu rangelands of GAP, Turkey, funded by the GAP, Southeastern Anatolia Project (GAP), Turkey.
- *Report on range productivity in Syria:* Seasonal profile of range vegetation production in Aleppo province. The productivity of rangeland vegetation has been documented on a monthly basis at five sites in the Aleppo steppe of northern Syria. Data have been collected for the past 5 years, representing a range of good and poor seasons.
- *Report on rangeland rehabilitation in Syria:* Direct-seeding techniques for establishing fodder shrubs on rangeland tested in selected sites. A direct-seeding trial was initiated in 1997. Plant survival of the seeded species has been monitored since 1998, although no data were collected in 2001.
- Inventory and survey of range resources in Aleppo and Hama Provinces: The vegetation, soil and socioeconomic survey was completed in 2001-2002, 116 sites were surveyed for range vegetation characteristics in Aleppo and Hama provinces, northern Syria. The survey was conducted as part of the second phase of the Arid Margins of Syria project supported by the Swiss Development Corporation. A final report on this project will be produced in 2003.

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

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

Rationale

Human population growth and increased rural to urban migration in WANA is prompting a progressive expansion of markets with a growing unsatisfied demand for animal products, particularly meat and milk products. These trends open promising opportunities for small-scale resource-poor producers in need of production orientation to target market opportunities. Production orientation on the basis of market demands and trends is even more critical in Central Asia where the dissolution of the Soviet markets led to production stagnation and farmers' frustration as the traditional products such as wool and pelts face marketing difficulties.

Efforts to improve productivity of production systems by past research gave little attention to markets, which is reflected in low adoption of technological interventions and lack of appropriate information for adequate production on the basis of demand opportunities. By identifying the peculiarities of markets and the existing relationships with production systems, this output aims at identifying constraints and areas for intervention as well as identifying market opportunities to better target production.

Objective

To assess markets for small ruminant products and their interrelationships with production systems, and to identify market opportunities.

Activity 1.1: Analysis of markets and market opportunities for small ruminant products, identifying niches where small ruminants have a comparative advantage in CWANA

1.1.1. Research on markets associated with milk production systems in northern Syria

Consumer preferences with regard to sheep milk derivatives

The preferences of consumers for type and quality of sheep milk derivatives (SMD) were assessed by a survey in three different locations in northern Syria. The survey involved 628 consumers randomly selected on the streets, during the hours when people buy food (9 am to 2 pm) and at clinics and governmental offices in Aleppo, El Bab and Sufire. The objective was to identify key aspects to be considered in improving the transformation of milk derivatives. Reflecting the fact that shopping for food is a male business in Syria, the majority of interviewed people were males (77.5%) in the age range 17-60 years (median 34 years).

Main preferences in buying milk derivative

A set of 13 criteria was checked to assess the key considerations for buying milk products. The top four considerations that accounted for more than 1/3 of the responses regarding each type of product are shown in Table 1. In general, consumers gave high preference to cleanness of products as the Table shows.

Table 1. Top four considerations given by consumers in buying milk derivatives.

Product	1st rank	2nd rank	3rd rank	4th rank	Cumulative percent	Total responses
Salty cheese	B	A	J	E	84	
	34%	24%	16%	10%		1845
Sweet cheese	J	B	C	G (A)	70	
	22%	19%	15%	14% (13%)		
String cheese	F	J	G	C (B and A)13%	68	
	21%	19%	15%	(13 and 12%)		
Yogurt	K	E	J	B	87	1789
	29%	27%	16%	15%		
Ghee	H	L	E	B (J)	77	993
	35%	17%	16%	9% (8%)		

A) White color; B) produced from pure sheep milk; C) cheese with low humidity; D) low price; E) good flavor; F) cheese without holes; G) cheese with uniform shape; H) good smell; I) brand name or provider; J) clean production; K) firm consistency (yogurt); L) possibility to pay the product in installments; and M) cream color.

Cheese
In general, respondents had fewer considerations before buying salty cheese than sweet and string cheese, which is reflected in the lower cumulative percentage for the top four considerations. Cleanness of the product was among the top four considerations in buying cheese; however, it received higher priority in selecting sweet and string cheese as compared to salty cheese.

Purity of the product (pure as opposed to mixed sheep milk) received higher priority in buying salty and sweet cheese as compared to string cheese.Consumers were not attached to particular brands for any kind of cheese as far as the product meets the preferences, particularly with regard to sweet and string cheese.

Yogurt
Sheep milk yogurt was the most affordable and preferred product, in spite of its high fat content. Also, consumers had well-defined preferences particularly considering firm consistency (K) and good flavor (E). If these factors were satisfied the next consideration was cleanness of product (J). As much as 15% of the consumers preferred yogurt made out of unaltered sheep milk.

As in the case of cheese, consumers were not attached to a particular brand, though they were aware of different yogurt brands. However, the percentage of respondents expressing preferences for particular brands of yogurt was higher (5%) than in the case of cheese (<3%).

Ghee
Due to its high price, ghee is purchased only occasionally and by fewer people. Unlike other products, good smell and the possibility to pay for the product in installments ranked high.

Price
In comparing last and current production seasons, the majority of people (69-80%) considered that prices were reasonable and affordable, particularly in the case of yogurt (80%); however, majority of the respondents (76%) felt that ghee was expensive.

Attitude to product improvement
Consumers were asked whether they would accept improvements in quality considering that increase in price will be unavoidable. Of 561 persons, 93% answered that they would pay more if this involves quality improvement. The maximum premium that consumers were willing to pay varied with the type of the

product. The maximum additional amount which respondents were willing to pay was SL200 per kg for ghee and SL30 per kg for either yogurt or cheese, the latter representing as much as 40% of the cheese market price. This should be an incentive to the farmers to improve quality.

About 68% of the consumers (out of 628 responses) favored written information on the products including name and address of producers, date of production, expiry date, and nutritional facts. The reasons: quality and the expectation of more responsibility in producing safe and clean products. Storage of products was another important consideration in relation to quality.

Production diversification

Nearly 70% of consumers were fully satisfied with traditional products, while the remaining 30% showed interest in new products. The demand for new products, such as flavored sheep milk yogurt and ice cream, is still low, though health-oriented consumers have increased interest in low fat products, in particular yogurt.

Conclusions

- The encouraging news is that consumers are ready to pay more for products of improved quality.
- Cleanness is rated highly in cheese and yogurt buying, thus efforts to improve milk collection, management and transformation are justified.
- Consumers are particularly attached to salty and sweet cheese made out sheep milk. Thus, maximum retention of value will be achieved by avoiding mixing with other milk. This information could be useful for processing enterprises and farmers.
- Firmness, good flavor and cleanness were desirable characteristics for yogurt, this reflecting the use of a good starter. Efforts should be concentrated in this direction to achieve maximum benefits.

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 intensive change. Rapid population growth, 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.

Consequently, there are dramatic changes in the nature and conditions of livestock production systems in the search for secure livelihoods, and new production strategies and production diversification. There is a 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 by appropriate technological interventions and orientation.

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.

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

2.1.1. Local knowledge in milk transformation in Syria: applied dairy technology at household levels

Milk transformation into derivatives is practiced in West Asia as an additional means to generate income and contributes substantially to the income of many rural families. ICARDA initiated research efforts to assess the main constraints associated with this important process in the production chain, identify and characterize the type of transformation technologies and also identify areas for technological intervention leading to production improvement. In September 2001-February 2002, a baseline survey on applied dairy technology in Syria was conducted in northern Syria to describe local knowledge in processing dairy products and identify areas of required technological intervention to secure better quality products and income. The survey was conducted in the most traditional milk production areas including Aleppo, Idleb, Hama, Homs, Al Raqqa, Al Hassakeh, Der Zour, Damascus, Dara, Sweida, Knitra and Khamishil. A total of 219 farmers were interviewed.

Targeted farmers were those having flocks with more than 45 ewes. The average herd size contained 218 milking ewes (range 45-3,000 milking ewes). According to the farmers, the average milk yield was 715 g/ewe/day with a maximum of 2,000 g/ewe/day and a minimum of 250 g/ewe/day.

Gender
The management of the herd is a family shared responsibility. While women are responsible for the feeding of animals, milking and milk processing, males are involved in shepherding, management of the flock and buying and selling of products.

Milk collection and associated problems
Milk in Syria is collected from February to late August, in view of a rather extended lambing season. The peak season is in April-May. Milking is a labor-intensive activity done by tying the animals together somewhere in the field followed by hand milking. The animal and udder are not cleaned, nor do the operators wash their hands prior to milking. Thus, milk is often contaminated by dirt, from the ground, animals and the operator. None of the interviewed farmers used a milking parlor and fed their animals during milking. Bacteria loads are unknown, though assumed to be high due to the management conditions, and should be the subject of close monitoring.

Mastitis is common (80% of respondents) but only discovered when the animals are feverish and when there are milk clots. Farmers were well aware of diseases such as FMD, brucellosis, mange and sheep pox. Most farmers, 172 out 219 (79%), were aware of the transfer of diseases from animals to humans and an alarming proportion, 45 out 219 (21%), expressed that their families acquired brucellosis in the past.

Cheese processing and derivatives
Three types of cheese are processed in Syria: Jibneh msanara, Mishallaleh and Haloumi. The first two are produced locally on the farm, while Haloumi is produced commercially. Of the interviewed farmers, 92% processed cheese. Cheese is made out of raw milk and set for renneting straight after milking. The cheese for home consumption is cooked and brined 24 hours after milking. The cheese while that for selling is only cooked and brined by the consumer, whom it reaches 24-36 hours after it is made. Thus, the product probably undergoes maturing processes by the time it reaches the consumer.

Cheese is produced with common kitchen tools/utensils adapted to the processing of dairy products. The tools are what farmers can find in local markets and not necessarily suitable for hygienic and efficient processing. The processing is manual and done by bare hands and differs little in the different regions of the study.

The main byproduct derived from whey in cheese processing is Karisheh (ricotta). Karisheh is mainly processed for home consumption as reported by 73% of the interviewed farmers and, if family supply needs are satisfied, the surplus whey is thrown or fed to animals.

Laban processing
All farmers process Laban, the Syrian cultured milk, defined often as local yogurt. Laban is the easiest product to process, easily available and with good demand. During its processing, the raw milk is cooked and set with a portion of Laban from the day before, which is a source of contamination.

Derivations of Laban include Labneh, a drained Laban, though this product is also made from other byproducts such as buttermilk. Labneh is sold fresh as condensed Laban with added salt or formed into small balls and stored in oil with the addition of some spices. This product is mainly made for home consumption-only a few (5 out of 219) of the respondents made Labneh for the market.

Samneh or Ghee is the most labor-intensive product that was processed by 93% of the interviewed farmers. Most farmers (74%) make Samneh by churning Laban in a washing machine or by shaking it in animal skins. Few farmers process Samneh from cultured cream. Other derivatives such as Schinglish, Doberkeh, Jameed and Kishik are regional products only made for home consumption.

Processing constraints
Only 1/4 of farmers agreed that they faced problems in milk processing and only 1/3 considered positively the improvement of product quality. All products are usually consumed after some kind of heat treatment or long storage in brine, which has the effect of destroying bacteria. Furthermore, some of the products have very low humidity, which prevents bacteria from surviving. All interviewed farmers indicated that Laban is the only heat-treated product prior to processing, while other products are heat treated/cooked in the final stage of processing or after processing-Samneh is heat-treated during the melting of butter or cheese and cooked just prior to storage. Thus, all products are relatively safe for consumption, though the main disadvantage of a later heat treatment is that undesirable bacteria could develop and affect the flavor and quality of the final product. Three categories of problems associated with the collection and processing of milk were identified, namely i) hard labor, ii) cost of fodder, lack of fodder and diseases, and iii) lack of medicines, lack of finance, marketing, and milk spoilage, lack of electricity and lack of processing knowledge. A clear definition of what they meant by hard labor was not provided. Farmers claimed that improvement in milk collection and processing could be achieved with availability of electricity, water and the centralized milk collection.

Conclusions

Milk processing follows techniques that reflect well-developed local knowledge serving the livelihood of people. The main problem, often not perceived by farmers, is bacteria contamination during milk collection and contaminated starters during processing. Reduction of harmful bacteria and improvement of the useful load require interventions in milk collection and post-milking management, heating/cooling treatment and control of starters. At farm production level, priority should go to improved hygiene and heat treatment of milk to reduce bacteria loads. If some level of industrialization could be promoted via associative work, then several other issues could be considered. Thus efforts in promoting associative production and community action for collection and transformation are justified. Little is known about bacteria loads during collection and transformation and its effects on milk quality. There is then a need to quantify these aspects and research to overcome problems.

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, access by farmers is limited, particularly to systems evolving to different levels of intensification and entrepreneurial organization to satisfy the increasing demand of animal products by growing markets. Many technologies were not adopted due to the lack of a market orientation and an adaptive process to evaluate not only suitability but also their behavior under specific production constraints with active end-user participation.

An adaptive interdisciplinary mechanism to link strategic/basic research outputs to farm production with the direct involvement of farmers and extension agents is, therefore, justified. The available technologies to improve production in a given place may not be suitable in another, or may require modifications. When the modifications are straightforward, they could be worked out on-farm on the basis of the prevailing constraints, but some may require more complex approaches. Thus, on-farm adaptive research could be a powerful mechanism to identify candidate cases for strategic research intervention.

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 the behavior of the technologies being tested.

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.

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

3.1.1. On-farm testing of technologies to improve small ruminant productivity in West Asia

Production monitoring of farms applying improved technologies in northern Syria

Starting in 2000, a research on-farm network was organized in northern Syria in order to i) identify constraints and understand the processes involved, and ii) identify and apply candidate technologies to improve productivity. The monitoring of production performance has been implemented since the start of the adaptive research work in an on-farm research network that includes 16 farms from 4 villages located in two contrasting regions, El Bab and Khanasser. El Bab is a traditional milk producing area with adequate rainfall that allows the cropping of barley and wheat, whereas Khanasser is a more marginal area with low rainfall (Table 2) that poses difficulties for milk production, an important commodity that contributes substantially to the livelihood of farmers in the region. A total of 1,146 animals were individually monitored in the 16 participant farms.

Table 2. Locations, villages, ecological zones, number of farms and farm characteristics in ICARDA's on-farm network of northern Syria.

Location	Villages	Ecological zone (rainfall, mm)	Farms	Average flock size of animals	Total number in ewes,%	Average increase
El-Bab	Burshaya	2 (250-300)	4	71	285	19
El-Bab	Zamkeh	2 (250-300)	4	73	293	0
El-Bab	Kherbeh	3 (200-250)	4	44	174	7
Khanasser	Rasm Hamad	4 (150-200)	4	99	394	23
Averages or totals			16	72	1,146	12

Sheep population changes

Farmers increased the number of ewes per flock by 12%, on average. The largest increase occurred in Khanasser. The increase reflects past restocking strategies during good years. Weather conditions in 2001 and 2002 were desirable and prompted a flock size increase, particularly in marginal areas such as Khanasser.

However, as the systems intensify, as in El-Bab, flock sizes remain more stable. The increasing numbers need due consideration, as keeping more animals results in increased feeding costs and, consequently, selling animals when prices are low. The project is proposing to direct efforts to keeping a flock size affordable to feed, particularly keeping the most productive sheep by culling the unproductive ones. To this end, in two consecutive seasons, a simple recording system was implemented to enable farmers evaluate the performance of individual animals for culling purposes.

Sheep movement, grazing management, supplementation frequency and feeds used

El-Bab farms have shown less mobility and a clear trend toward more intensification of production. Results from the socioeconomic monitoring of production strongly suggest that milk production as a result of increased demand determines more stability if systems could intensify production. In a more marginal area with more dependency on flock migration and little chances for intensification the problem is to sustain production. This is further limited by flock size, as only larger flocks with larger yields will allow absorbing moving and feeding costs more evenly. Interestingly, in this area it was mainly small-flock farmers who turned to trade or to fattening systems, virtually abandoning the raising of breeding flocks. Table 3 provides a summary of the details of movements and grazing of flocks.

Table 3. Sheep movements and grazing management in the monitored farms.

Village	Movement of flocks	General details of grazing management
Burshaya	Flock did not move and are orienting to intensive production	Some farmers used spring barley to graze it green or failed barley to graze during the spring. All animals were grazed on stubble during the summer for 146 days
Zmakeh	Two farmers moved the flocks only 5-10 km away for a short period (42 days). All the other farmers are orienting to intensive production	With no fallow nor green barley, flocks grazed mountains in spring and stubble in summer for 144 days, two of the farmers moved nearby to graze on cotton residues
Kherbeh	Flocks did not move and are orienting to intensive production	Green barley, though in reduced area, as well as failed barley was used in spring. Stubble was used for 156 days in summer
Rasm Hamad (Khanasser)	Flocks were moved to distant locations (150 km away) as early as June	With no fallow land, flocks grazed on mountains* in spring and then moved north in June for grazing on cotton and vegetable grazing

**Desirable grazing ranges due to the good years in 2001 and 2002. Otherwise spring grazing could be extremely limited.*

The average duration of hand feeding was 5.72 months. Sheep were hand-fed for longer periods in Burshaya (6.75 months) and Zamkeh (6.63 months), reflecting intensive production. In Rasm Hamad and Kherbeh the average was 4.75 months. As indicated in Table 3, flocks from Rasm Hamad remained away from the village for a longer time and those from Kherbeh used fallow lands for grazing. The most widely used supplements were barley grain (94%), wheat bran (97%), and cotton seed cake (100%). Roughages used included barley straw (94%), wheat straw (38%), lentil straw (25%), faba bean straw (19%), and vetch straw (19%).

Reproductive performance

Reproductive performance was desirable in all villages and fertility was definitely higher than in former years, reflecting an improvement due to changes in management. Average fertility in farms that did not apply improved technologies (70%) was lower than those applying improved management (83%) in 2001. In the current year, with the exception of one flock in Burshaya having 80% fertility, all flocks performed with above 83% fertility. Culling rate was higher in El Bab villages and about a half in Rasm Hamad; in addition, farmers in this location sold less and kept more lambs to increase the flock size (Table 4). The twinning rate was higher than in farms using improved management in the previous year (3.7%).

Table 4. Average reproductive performance in the monitored flocks.

Village	Fertility%	Twinning %	Lam crop %	Culling %	Adult mortality%	Sold%	Lambs kept%	ADG g/day
Burshaya	87.5	8.5	116	16.3	4.3	73	16.3	205
Zamkeh	89.3	2.8	96	17.5	1	61	29.5	204
Kherbeh	94.5	4.8	115	15.3	6.3	45	31.3	169
Rasm Hamed	91.8	4	107	8.0	1	47	43.3	179
Mean all	91	5	109	14	3	56	30	189

Lamb crop: number of lambs born per 100 ewes present at mating (lamb crop %). Milk production: milk produced per lambed ewe. ADG: Average daily gain during the suckling period.

Lamb mortality ranging 4.3-7.3 in El Bab was slightly better than in farms with improved management in 2001. In contrast, lamb mortality in Khanasser was similar to that on farms with traditional management in that year. Lamb growth in El Bab, with the exception of Kherbeh, was excellent. Deficient management is still evident in Kherbeh, which had the highest adult mortality, highest lamb mortality and lowest lamb growth rates in El Bab group.

Milk and milking

The milk season was extended over several months. Figure 1 shows the percentage distribution of farms milking during the year with peaks during the period March-June. Figure 1 depicts a case of production out-of-season that seems to be followed in northern Syria, an aspect that will be targeted in the future considering the high prices of milk products outside the peaks of production.

Production of milk is shown in Table 5. With the exception of Burshaya, which had two farmers producing about 100 kg per ewe, the production levels of El Bab with better conditions and more days of milking twice in the day, was more variable (CV=27%) than Khanasser (CV=14%).

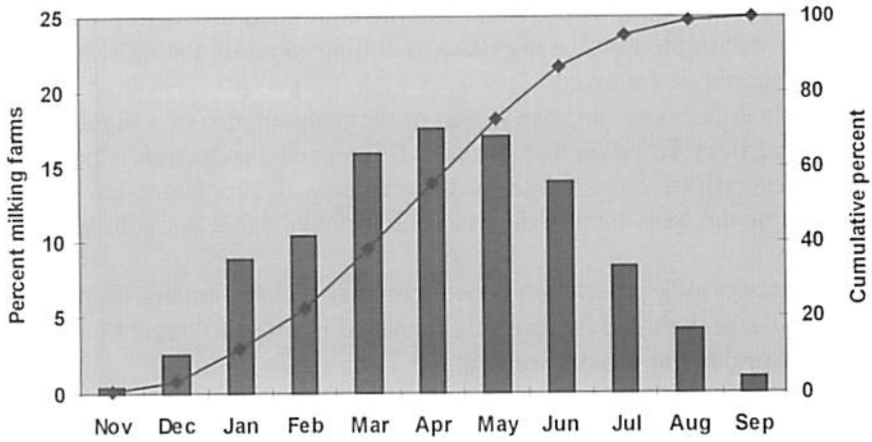


Fig. 1. Distribution of milking farms through the year in the project area, northern Syria.

Table 5. Milk production of the monitored flocks.

Village	Milk yield	Milking duration Kg/ewe (days)	Once a day milking (days)	Twice a day milking (days)
Burshaya	83	249	73	176
Zamkeh	60	258	80	178
Kherbeh	65	240	51	189
Rasm Hamad	77	259	12	134
Mean all	71	236	77	159

Introduction of participatory methods

In September 2002, the project organized a workshop on participatory research to introduce this methodology in the on-farm work as a tool for new developments in 2003. Three workshops were conducted under this new approach to help analyze the information of socioeconomic studies and to shift the focus to a community action plan.

Conclusions

- Most farms increased the production performance of their flocks; however, milk production levels are still low in El Bab where farms have more stable flocks, in spite of more intensive milking. In these farms the improved environments allow for an improved genotype. This was targeted in the project, but the results are yet to be seen in the progeny of improved rams that will start production in 2003. Linked to the continued use of improved animal selection within the flock, a high rate of culling to retain the most productive females should be followed.

- An area that deserves attention is that of the maintenance of a highly productive flock based on a stable size. If intensive production is possible and farmers can afford to overcome feed shortages with supplementation, which seems to be the case, then flock size could remain stable but with high productivity.
- Out-of-season milk production is common, particularly among farmers in El Bab. This aspect should be carefully managed in order to target out-of-season excellent prices and unsatisfied demand.

3.1.2. Diseases causing abortions in small ruminants in northern Syria: survey in preparation for an epidemiological analysis

Brucellosis causes economic losses due to animal reproduction problems and is a threat to human health. It is a widespread disease in the Mediterranean region. In northern Syria, a traditional milk sheep production region, cases of abortions in animals and the presence of brucellosis among humans are often reported by milk producers; however, little quantified information is available on the incidence and severity of the disease.

The present work was planned to assess whether diseases causing abortions in small ruminants are common and represent a production risk and a threat to human health in northern Syria, focusing on ICARDA's on-farm research network at El Bab district, Aleppo province. A targeted survey was conducted in July-September 2002 to cover key aspects of flock management, animal health, public health, awareness of zoonotic diseases, the incidence of abortions and cases of brucellosis. Villages located in Al Ra'ai, Arimah, Kabbasine and Tadef areas were randomly chosen. In each village 3-5 farms having more than 10 milking ewes were then interviewed, totaling 214 farms. The survey was the preamble to an epidemiological serological study to take place at the end of 2002 and early 2003.

Type of farms and farmers

The surveyed farms (n=214) consisted mainly of small ruminant production systems (94%). There were less goats than sheep and few cattle. Most systems were sedentary (79%) and semi-sedentary (20%), while only 2 farmers (1%) practiced nomadism.

The majority of the farms consisted of less than 50 animals (45%), and almost half of the flocks contained 50-200 animals. For most of the interviewed farmers (71%), the contribution of dairy production to total farm income ranged from 20 to 80%. Only few farmers (8%) had no income from dairy production.

Flock management

Most of the farmers (69%) tend their animals by themselves, and a considerable number (32%) employ labor. Also, a considerable number of farmers (56%) were in contact with flocks of other farmers, while nearly 30% did not have any contact. Contact with infected flocks is a means to acquire the disease particularly if manipulation of aborted animals and milking are involved.

Rams for reproduction include the farmer's own animals (52%) and shared rams (48%). In addition, the introduction of animals from outside the flock (45%) was nearly the same as the use of shared rams. These two aspects are important in the dynamics of transmission of brucellosis. In practice, the merging of flocks in the field is very common and occurs more often than the times reported by farmers. This is an important factor in matters of disease control.

Rams are maintained with ewes year-round. Though mating occurs at any time, it usually peaks during July-August. The permanent presence of rams introduces another factor in the spread of disease if the rams are infected.

Reproduction season in 2001

A little more than half of farmers interviewed (59%) reported that they had some ewes that aborted, while slightly less (41%) did not observe abortions. The causes for abortions include nutritional reasons; a combination of high twining rates-89% of the flocks were reported to have twin cases-and inadequate nutrition or infectious diseases. The rates of twins, abortions and neonatal mortality were 6.3, 6.7 and 7.1%, respectively.

Management of aborted fetus, animals and facilities

Most farmers (87%) discarded the fetus immediately and others left the dead animals around for up to one day. Such a condition represents a serious source of infection to other animals such as dogs and cats, as well as children. There is, therefore, a need to include other farm animals in the epidemiological assessment to evaluate relationships with disease prevalence.

Apparently, aborted animals are not treated-although half of the respondents (51%) indicated that they treat their animals. Isolation of aborted ewes for a certain period and injections with antibiotics or vitamins are among the most common practices. Almost all farmers (94%) do not apply any preventive treatment for abortions.

The frequency with which animal facilities are cleaned is an important factor in relation to the spread of diseases. Just about 60% of the farmers cleaned the facilities in the dry season and fewer (26%) in the rainy season because of mud.

Farmers' awareness of animal and public health

Awareness of reproduction problems was evenly divided among farms (48% aware vs. 52% not aware). Farmers were more concerned about abortions (52%) than neonatal deaths (21%) and infertility (12%). However, they pay little attention to past history of abortions in culling and replacing animals (0.5%) as opposed to other diseases (59%) and age (39%). Little attention was also placed on milk quality and quantity (1%) in matters of culling or replacement of animals.

Most farmers (84%) were unaware of animal brucellosis, though most acknowledged the disease among humans. In consuming milk products, most farmers declared having treated the products with heat, though this does not apply to milk transformation. Cases of brucellosis seem to be widespread, in fact, a total of 66 out of 211 farms (31%) had had at least one person with brucellosis. In relation to the population sampled, there were 135 out of 3132 (4.3%) people that acquired the disease at least once.

Conclusions

- Abortions are frequent in the region, the causes are not known. The higher than expected rate of human brucellosis observed suggests that infectious diseases, including brucellosis, could explain this situation. The epidemiological assessment, based on a serosurvey originally planned for brucellosis, should then be expanded to include other common infectious diseases such as Chlamidiosis and Toxoplasmosis.
- Farmers do not handle adequately the disposal of aborted materials and tissues. This probably results in broader contamination involving other animals. In addition, the cleaning frequency of animal facilities is low considering the brucellosis prevalence estimates for the region. The epidemiological assessment should take into account these facts.
- The lack of awareness regarding animal brucellosis suggests a need to focus on this subject in the on-farm community.
- Careful observations need to be taken with regard to flock size, number of males in the flock, and traditions observed in sharing rams to find out potential relationships.

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. Under 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 aimed to capture and maximize profits are justified.

Objective

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

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***

ICARDA is exploring the utilization in small ruminant systems of agricultural and agroindustrial byproducts available in the Mediterranean region of WANA. Important byproducts include conventional feedstuffs such as cotton seed cake and wheat bran and less conventional products such as tomato pulp, orange pulp, crude olive cake and molasses. The main purpose is to identify the potentials and limitations of these byproducts and the means to integrate them in the feeding systems, targeting not only feed shortages but also reduced feeding costs.

6.1.1. Rapid assessment of the utilization of agricultural and industrial byproducts and feed blocks in El-Bab area

On-farm research activities in El-Bab demonstrated that farmers are using different levels of supplementation in the feeding of their animals. A rapid assessment based on a local survey on the use of byproducts in this supplementation was conducted during the workshop organized by ICARDA for farmers and extension agents in Qabasin, El-Bab, on June 23-24, 2002. Eight agriculture extension staff and 20 farmers participated and responded to a brief targeted questionnaire. Farmers had an average of 50 animals, with a range of 10-100 sheep.

Conclusions

- Sugar beet pulp is the more known byproduct used by farmers and known by extension agents.
- Though well known by extensionists, tomato pulp and burgul derivatives are byproducts relatively unknown by farmers, as only half of the respondents were familiar with them. Crude olive cake, starch byproducts, soybean cake, sesame cake, citrus pulp, molasses, sunflower cake and byproducts of the beer industry are little known or unknown by farmers and extensionists. Some of these products are widely available in the region and ICARDA has recently been studying their incorporation in animal diets.
- Most of the farmers mentioned the lack of availability of byproducts (75%) and the lack of knowledge on their use (70%) as the main limitations in the use of agricultural and industrial byproducts in sheep feeding. Conservation and storing were issues of less concern.
- Few farmers (5%) and few extension agents use feed blocks in the feeding of their flocks. However, almost all interviewed farmers (90%) were willing to participate in trials on feed-block manufacturing and utilization. Most farmers (above 80%) felt that feed blocks are a good means of combining agricultural, industrial byproducts and urea to prepare diets that could eventually replace expensive concentrates used in the supplementation of their flocks.
- The majority of farmers (90%) considered that the main limitations to feed-block utilization were the lack of information on the process of feed blocks and the ingredients to be used. Farmers (80-90%) felt that the best means to introduce feed blocks is by trials in the field along with field demonstration days as opposed to other methods of training. Extension agents were more supportive of direct on-farm application of feed-block technology than other methods.

6.1.2. The use of urea to improve the feeding value of straw

Straw is one of the most important livestock feed resources in West Asia, though its quality, particularly in the case of wheat straw, is not necessarily optimal. The effects of ammoniation of straw in the improvement of digestibility, nitrogen content and voluntary intake of the treated straw are known and are being successfully utilized by smallholders in several parts of the world. This technique was also introduced in Syria in the past, but was not adopted by farmers. The momentum exists now to reconsider the utilization of ammoniated straw in West Asia, as this technique could suit production systems undergoing different degrees of intensification. The production context has the conditions for the consideration of cost-reduced diets with potential to generate increased production of meat and milk.

Straw treatment with urea

Successful treatment was obtained by mixing chopped wheat and barley straw with an equal weight of water containing 3% urea in large black heavy-gauge polythene bags. The urea-treated straw was sealed in bags and left for a period of four to eight weeks. The higher the ambient temperature, the shorter the time needed for obtaining a desirable product. Once the bags were opened, the straw was laid out in the shade to free ammonia and moisture. Treated straw could be used immediately. Evidence that the reaction has taken place is a change in color of the fibrous material that turns light brown; there is also a strong ammonia smell when the straw is uncovered. Dark yellow or brown may result if the stacks are exposed to high temperatures.

Table 6 summarizes the results of the analysis of the value of conventional feedstuffs used in sheep feeding in Syria and that of treated straw in the trial.

Treatment of wheat straw with urea induced an improvement of digestible protein, DMD and ME of 27%, 19% and 13%, respectively. The effect of wheat ammonia-tion was remarkable in producing a better product than barley straw and relatively similar to ammoniated barley straw.

Trial with animals for a preliminary evaluation of the use of urea treated straw

Table 7 summarizes the results of a trial of feeding 8-9 castrated males with diets containing untreated and treated wheat straw, and with supplementation with local byproducts used in sheep feeding in Syria.

Table 6. Feeding value of often used feedstuffs in Syria and treated straw.

Feedstuff	DM%	Ash%	CP%	Digestibility *in vitro*		MEMJ/kg
				DMD%	DOMD%	
CSM	94.5	4.7	26.9	67.0	63.6	9.5
Barley grain	94.5	2.5	10.3	79.2	76.4	11.5
Wheat bran	94.7	5.3	15.9	74.7	72.9	10.9
Wheat urea treated straw	94.4	10.2	8.4	52.6	45.2	6.8
Wheat untreated straw	94.6	9.6	3.7	44.1	40.1	6.0
Barley urea treated straw	93.8	8.5	8.2	52.5	50.0	7.5
Barley untreated straw	92.5	9.2	4.1	41.4	40.3	6.1

GSM: Cottonseed meal

The level of supplementation was the same for both diets. The treated straw improved the level of intake of untreated straw by 29% and thus generated more CP (272 vs. 246 g/sheep/day) and more ME (19 vs. 16 MJ/sheep/day), as if a richer concentrate was added. In 21 days of the trial, the animals recorded weight gains above 200 g/day under both diets. The average gain under treated straw was 18% higher than under untreated straw, probably due to the higher ME received.

Conclusion

Wheat straw is not as widely used in animal feeding as barley straw, and its feed value could be improved by urea treatment. Furthermore, urea treated straw could be used in animal feeding as a concentrate and eventually could replace expensive components of fattening or milk production diets. Fattening trials and trials with milking ewes should be organized with sufficient number of animals to evaluate the economic feasibility of the use of this feedstuff.

6.1.3. Utilization of tomato pulp in sheep feeding

This product is widely available in the region, particularly during July-August a period when livestock consume low quality fodder of dry pastures and stubble. Direct utilization of tomato pulp leads to loss of nutrients because of its high water content. This was studied by ICARDA through drying, ensiling and integrating it in feed blocks. In this report an experiment using ensiled tomato pulp is reported.

Table 7. Effects of feeding animals with urea-treated wheat straw.

	Urea treated straw and supplement	Straw and supplement
Sheep heads	9	8
Date	28 July - 17 August (21 days)	
Feed intake (DM kg/sheep/day)		
Urea treated wheat straw (ad libitum)	678	0
Wheat straw (ad libitum)	0	526
Concentrate feeds (CSM, BG and WB)[1]	1,234	1,234
Minerals/salt/vitamins	20	20
Total feed intake	1,912	1,760
ME supplied (MJ sheep/day)		
ME by straw	4.75	2.84
ME by concentrate	13.45	13.45
Total ME (MJ/sheep/day)	18.20	16.29
Total CP supplied (g/sheep/day)	271	246
CP: ME ratio (g MJ)	14.89	15.10
Live weight (kg)		
Initial	43.86	44.84
Final	49.26	49.50
Daily LW gain (g)	260	220

[1]CSM 35%, BG 49% and WB 16%. CSM: Cottonseed meal; BG: barley grain; WG: wheat grain.

For reference, the nutritive value of fresh tomato pulp along with that of other byproducts used in the experiments described below is given in Table 8. Note that fresh pulp has high humidity content (80%) such that the quantity of valuable nutrients is diluted. However, as dried material, it has desirable levels of protein and ME, in addition to high DMD.

Ensiling tomato pulp

Tomato pulp was ensiled alone (TP) or in a mix with different proportions of chopped straw (S), crude olive cake (COC) or wheat bran (WB), and with an additive (A) consisting of a mix of molasses (2%[1]), soybean flour (2%[1]) and urea (1%[1]).

Heavy-duty polyethylene bags were filled with the mix and sealed after expelling the air above the packed material. The sealed bags were then placed in 40-liter plastic barrels and tightly closed. The bags were opened after fermentation periods of 4, 8 or 12 weeks. The aroma, color, taste, texture and pH were recorded and samples of silage for analysis taken for evaluation of chemical composition and in vitro digestibility, the remaining of the ensiled materials were used in a feeding trial.

[1] relative TP

Table 9 provides the evaluations of quality assessed subjectively by scores assigned to aroma, taste, color, texture and PH, and Table 10 shows the results of the chemical analysis and *in vitro* digestibility. The additives (mix of molasses, urea and soybean flour) substantially increased the protein content of TP fresh 22% and ensiled alone 20.2% to 25.5%. While inclusion of COC improved the protein content, the DMD decreased by half.

DMD of ensiled TP (59%) was lower than fresh TP (65%) and was improved by the addition of WB and WB and additives. Maximum DMD was achieved in the mixes 90TP/10WB and TP75/WB25, 66 and 69%, respectively. The added value in the TP75/WB25 mix was due to a slight increase in ME.
The excellent scores (regarding aroma, taste, color, texture and pH) obtained in ensiling with COC were matched with poor protein and DMD levels.

Conclusions

- The addition of additives provided a better performance of TP ensiled. The addition of WB may not induce a higher protein value as the additives alone, but increases DMD and ME performance.
- Ensiling tomato pulp alone (with a good grade, CP 20%, DMD 65% and ME 8 MJ) or with wheat bran mix 90/10 (grade good, CP 21%, DMD 66% and ME 9 MJ) produces a desirable material for animal feeding.

Table 8. Nutritive value of fresh tomato pulp, July 2001.

Feedstuff	DM	Ash	ADF	CP	DMD	DOMD	ME
	(%)						MJ/kg
Tomato pulp fresh (mean of 5 samples)	92	6.0	42	22	65	61	9
Wheat straw	93	11.0	51	3	38	32	4
Solvent extracted Crude olive cake	93	16.0	60	4	8	5	1
Tomato pulp silage	90.4	5.5	51.5	22.3	56.9	53.9	8.1
Barley grain	94.6	1.8	13.0	11.6	76.4	74.0	11.1
CSM	95.7	5.2	31.3	25.9	58.3	51.8	7.8
Wheat bran	95.5	6.2	11.4	16.7	62.3	58.7	8.8
Barley straw urea treated	93.7	9.2	52.0	9.9	48.1	45.3	6.8

Table 9. Subjective evaluation of quality and pH of silage made from tomato pulp (TP) alone or mixed with straw (S), crude olive cake (COC), wheat bran (WB) with or without additives (A)[4].

Materials	Ratios	4 weeks pH	4 weeks Sense score[1]	4 weeks Total score[2]	4 weeks Grade[3]	8 weeks pH	8 weeks Sense score	8 weeks Total score	8 weeks Grade	12 weeks pH	12 weeks Sense score	12 weeks Total score	12 weeks Grade
Tomato pulp silage	100	4.8	32	52	Fair	4.9	38	58	Fair	4.6	40	70	Good
TP/S	75/25	5.0	30	40	Fair	4.9	40	50	Fair	4.7	38	58	Fair
TP/S	50/50	5.2	30	32	Fair	5.1	36	41	Fair	5.0	37	47	Fair
TP/COC	75/25	4.8	35	55	Fair	4.7	39	59	Fair	4.4	40	95	Excellent
TP/COC	50/50	4.8	35	55	Fair	4.6	39	69	Good	4.3	39	94	Excellent
TP/A I	100	7.7	13	13	Poor	6.3	24	24	Poor	5.8	31	31	Poor
TP/S/A	90/10	8.1	19	19	Poor	8.0	21	21	Poor	7.7	27	27	Poor
TP/S/A	80/20	8.2	28	28	Poor	8.1	21	21	Poor	8.0	27	27	Poor
TP/S/A	75/25	8.2	28	28	Poor	8.0	23	27	Poor	8.1	28	28	Poor
TP/COC/A	90/10	7.7	19	19	Poor	7.5	31	31	Fair	7.0	29	29	Poor
TP/COC/A	80/20	5.6	33	33	Poor	7.3	35	35	Fair	7.3	35	35	Poor
TP/COC/A	75/25	4.8	35	55	Poor	7.2	37	37	Fair	6.1	37	37	Poor
TP/S/COC	90/5/5	4.8	35	55	Fair	5.3	37	37	Fair	5.0	39	49	Fair
TP/S/COC/A	90/5/5	7.4	15	15	Poor	7.7	24	24	Poor	6.8	28	28	Poor
TP/S/COC	75/12.5/12.5	4.9	35	45	Fair	8.0	40	42	Fair	4.9	40	50	Fair
TP/S/COC/A	75/12.5/12.5	8.1	22	22	Poor	8.1	24	24	Poor	7.9	28	28	Poor
TP/S/C	50/25/25	5.1	35	40	Fair	5.1	36	41	Fair	5.0	39	49	Fair
TP/S/COC/A	50/25/25	7.7	26	26	Poor	5.2	26	26	Poor	8.0	32	32	Poor
TP/WB	90/10	5.0	33	43	Fair	5.0	40	50	Fair	4.6	40	70	Good
TP/WB/A	90/10	7.6	19	19	Poor	7.8	24	24	Fair	6.2	32	32	Poor
TP/WB	75/25	4.6	33	63	Good	4.9	37	47	Fair	4.9	40	50	Fair
TP/WB/A	75/25	7.9	17	17	Poor	7.8	24	24	Fair	7.5	30	30	Poor

Fresh tomato pH = 4.13. [1]Sense score is a composite score that ranged 0-40, obtained by adding individual scores for aroma, taste, color and texture, each judged on 0-10 scale. [2]Total score: pH score + sense score. pH scores in parenthesis for given values of pH: pH< 4.1 (60), pH 4.2-4.4 (55), pH 4.5 (40), pH 4.6 (30), pH 4.7-4.8 (20), pH 4.9-5.0 (10), pH 5.1 (5), pH 5.2 (2), pH> 5.2 (0). [3]Grades were taken in relation to total scores: (100-81) Excellent, (80-61) Good, (60-31) Fair, and (30-0) Poor. [4]Additives: (2%) molasses, (2%) urea and (1%) Soybean flour.

Evaluation of intake of ensiled tomato pulp

A feed evaluation trial involving four 8-month-old castrated sheep to assess voluntary feed intake and *in vivo* digestibility was conducted for a period of 28 days. The animals were fed only on ensiled pulp or mixed with other feedstuffs. For the trial, only selected silage combinations depending on their availability in large amounts were chosen. The ensiled material along with barley straw was fed ad libitum. The results, including weight changes during the trial, are presented in Table 11.

Table 10. Chemical composition and digestibility of silage made from tomato pulp (TP) alone or mixed with straw (S), crude olive cake (COC), wheat bran (WB) with or without additives (A)[1].

Materials	Ratios	Incubation periods											
		4 weeks				8 weeks				12 weeks			
		CP	Digestibility		ME	CP	Digestibility		ME	CP	Digestibility		ME
			DMD	DOMD			DMD	DOMD			DMD	DOMD	
		--------%-------			MJ/kg	--------%-------			MJ/kg	-------%-------			MJ/kg
Tomato pulp silage	100	21.9	67.4	62.2	9	21.2	57.2	53.2	8	20.2	59.0	53.4	8
TP/S	75/25	7.5	47.0	44.2	7	8.2	47.2	43.6	7	7.4	51.1	43.5	7
TP/S	50/50	5.7	46.8	40.8	6	5.8	41.3	37.7	6	6.2	51.1	41.4	6
TP/COC	75/25	11.1	33.7	27.5	4	13.0	29.8	25.6	4	10.6	28.2	24.2	4
TP/COC	50/50	8.5	27.8	24.3	4	8.9	22.2	19.9	3	10.1	32.8	25.3	4
TP/A	1100	25.2	55.0	50.9	8	26.3	52.4	47.7	7	25.5	60.3	50.2	8
TP/S/A	90/10	15.0	50.9	48.4	7	17.6	47.4	44.3	7	17.3	62.5	52.0	8
TP/S/A	80/20	12.8	52.2	46.2	7	NA	47.1	40.1	6	14.5	61.9	51.4	8
TP/S/A	75/25	13.6	44.2	43.9	7	12.0	45.3	40.9	6	12.5	57.5	50.4	8
TP/COC/A	90/10	19.9	42.3	41.0	6	20.8	38.3	36.1	5	20.6	35.8	32.4	5
TP/COC/A	80/20	20.4	35.7	31.2	5	22.6	30.8	28.6	4	19.4	33.3	26.9	4
TP/COC/A	75/25	25.8	52.6	50.3	8	22.3	34.5	29.6	4	17.8	34.5	31.8	5
TP/S/COC	90/5/5	16.4	53.8	48.8	7	13.0	40.6	36.6	6	11.7	46.4	40.4	6
TP/S/COC/A	90/5/5	18.4	43.0	39.2	6	15.6	43.3	36.7	6	17.2	47.3	40.7	6
TP/S/COC	75/12.5/12.5	13.3	39.0	38.2	6	9.8	37.0	30.1	5	11.7	41.5	35.7	5
TP/S/COC/A	75/12.5/12.5	14.5	42.1	38.9	6	12.1	39.2	34.1	5	13.3	45.0	37.8	6
TP/S/C	50/25/25	9.2	36.2	31.2	5	8.6	35.1	31.6	5	8.3	37.6	33.1	5
TP/S/COC/A	50/25/25	12.6	42.1	38.3	6	11.9	38.2	34.5	5	11.2	39.3	33.4	5
TP/WB	90/10	22.0	63.9	61.3	9	20.9	63.7	61.7	9	20.5	65.6	60.1	9
TP/WB/A	90/10	24.9	66.8	64.0	10	19.1	61.8	56.2	8	22.8	55.9	54.2	8
TP/WB	75/25	20.9	67.4	64.8	10	20.0	69.3	64.7	10	21.2	69.0	64.5	10
TP/WB/A	75/25	22.2	62.1	60.0	9	20.6	60.7	59.2	9	19.1	61.5	58.2	9

[1]*Additives: (2%) molasses, (2%) urea and (1%) Soya bean flour. NA not available*

TP/COC 75/25 and TP/COC 50/50 were rated as excellent materials (Table 9). However, only TP/COC 75/25 recorded the highest consumption of ensiled material (388 g/d) with a poor weight change. In both cases the consumption of straw was quite depressed that reflected in the two lowest total consumptions. In spite of a desirable DMD, protein level and a relatively high consumption, TP90/WB10 induced a poor weight change (97 g/d).

The mean intake of tomato pulp silage was 0.365 kg/day and that of straw 0.478 kg/day, with a total consumption of 0.843 g/d, this level induced the largest live weight change in comparison to other treatments (138 g/d), though it was far below the potential of the breed.

Table 11. Voluntary feed intake (VFI), digestibility (*in vivo*) and weight changes of sheep fed on silage made of tomato pulp alone or mixed (January 2001) (Mean of 4 sheep).

Treatments	VF			*In vivo* digestibility		Live weight		Live-weight changes
	Silage	Straw	Total	DMD	DOMD	Initial	Final	
	------DM g/d-----			--------%--------		------kg-------		------g/d ±SE-----
TP	365	478	843	58.2	53.7	25.6	29.4	138 ± 6.3
TP/S (75/25)[1]	372	447	819	52.2	47.6	25.2	28.6	123 ±10.3
TP/S (50/50)	312	405	717	51.5	45.4	26.3	28.4	80 ±10.0
TP/COC (75/25)	388	320	708	44.1	39.4	25.7	29.1	120 ±13.5
TP/COC (50/50)	309	335	644	39.5	34.2	25.1	27.1	73 ± 8.5
TP/WB (90/10)	374	454	828	61.2	NA	NA	55.7	97 ± 8.8

[1]In parenthesis ratios of tomato pulp and other feedstuffs. Consumption rates of ensiled products ranged 309-388 g/d.

Testing tomato pulp as a substitute of concentrates in feed diets: substituting barley grain by tomato pulp silage

Conventional ingredients of supplements and concentrates in Syria include CSC, barley grain and wheat bran. These ingredients are costly and farmers are hesitant to use them because of the associated economic implications. Ensiled tomato pulp has the potential to replace grains because of a higher level of protein though the levels of energy are slightly lower (Table 8). An exploratory trial was conducted to check whether this replacement is feasible. Four diets were used based on successive proportions of tomato pulp silage replacing barley grains on eight 9-month-old castrated sheep during 30 days. A mixture of salt, minerals and vitamins were provided at the rate of 20g/animal/day. The diets along with results in relation to chemical analysis, individual intake and weight change are summarized in Table 12.

Conclusion

The *in vivo* digestibility slightly improved when barley grain was replaced by tomato pulp silage. Likewise, the progressive replacement of barley grain by tomato pulp silage paralleled a slight increase in daily weight gain. The substitution potential, however, was somewhat confounded by the use of urea treated straw. Replacing barley grains by tomato pulp silage would imply a net reduction of feeding costs; however, a complete economic analysis linked to a large test with sheep in high production rate stages is required to confirm this assessment.

Table 12. Feeding tomato pulp silage to replace levels of barley grain in the diet (values are the average of 8 sheep).

Ingredients, feeding value and weight changes	Diets			
	1	2	3	4
Feed intake (DM g/day/sheep)				
Tomato pulp silage	0	150	200	275
Barley grain	210	110	75	0
CSM	370	378	380	376
Wheat bran	360	360	355	368
Barley straw urea treated	345	325	350	352
Salt-minerals-vitamins	20	20	20	20
Total feed intake	1300	1300	1400	1400
Energy and protein contributions				
ME (MJ) supplied by tomato pulp silage	0	1.22	1.62	2.23
ME (MJ) supplied by barley grain	2.33	1.22	0.83	0
Total ME supplied by ration (MJ/sheep/day)	10.7	10.8	10.9	10.8
Total CP supplied by ration (g/sheep/day)	214	236	246	255
CP: ME ratio supplied (g MJ)	20.0	22.7	23.1	23.9
In vivo digestibility (%)				
DMD	67.5	67.9	68.8	69.7
DOMD	66.6	66.7	67.5	68.1
ME (MJ kg)	10.0	10.0	10.1	10.2
Live weight changes				
Initial	34.54	34.10	34.70	34.86
Final	39.19	38.96	39.83	40.41
Daily live weight gains	0.155	0.162	0.171	0.185

6.1.4. Test of the use of fodder shrub-molasses based feed blocks, voluntary feed intake and possibilities for substitution of expensive supplements

The expected utilization of fodder shrubs is through direct grazing, sometimes limited because of the presence of anti-nutritional compounds. Alternative ways of using this fodder material have been proposed by ICARDA, particularly to look for the sustainability of the management and use of shrubs once planted to rehabilitate degraded ranges. It has been demonstrated in former trials at ICARDA that the leaves of shrubs integrate well in feed blocks when molasses are included in its elaboration. On this basis, in January-May 2002 an exploratory trial was conducted to test the substitution feasibility of traditional ingredients used in fattening sheep in Syria by leaves of *Atriplex halimus* and *Salsola vermiculata*. The leaves of these plants were mixed in feed blocks with molasses, urea, salt, minerals, vitamins and binders (quick lime, plaster of Paris and

Bentonite). Details of the feed blocks, chemical composition and *in vitro* digestibility are provided in Table 13.

Table 14 provides information on the nutritive value of leaves of shrubs and feedstuffs commonly used in sheep feed in Syria. The excellent DMD, CP and ME values of leaves of shrub-based blocks is contrasted with that of leaves alone.

Table 13. Composition and *in vitro* digestibility analysis of fodder Shrubs-Molasses feed blocks.

Feed block	*Atriplex/Salsola* (1)	*Atriplex* (2)
Ingredients, %		
Atriplex	25	50
Salsola	25	0
Molasses	32	32
Urea	5	5
Salt-minerals-vitamins	1	1
Quick lime	4	4
Plaster of Paris	4	4
Bentonite	4	4
Hardiness[1]	G	G
Compactness[2]	G	G
Chemical composition, % DM basis		
DM	94.8	93.3
Ash	32.2	33.4
ADF	12.6	12.5
CP	25.5	25.2
Digestibility *in vitro*, % DM basis		
DMD	72.7	73.4
DOMD	65.8	66.7
ME (MJ kg)	9.9	10.0

[1]Hardiness: Soft (S), Medium (M) and Good (G). [2]Compactness: Null (N), Medium (M) and Good (G)

Feed blocks 1 and 2 were used in fattening diets for 15 Awassi 9-month old castrated sheep, having an initial weight of 28 kg. Five different rations were formed (Table 15) and applied in a crossover design in five stages of 21 days each. In each stage, three animals were allocated to the five diets, in the following stage the animals were shifted to another diet such that at the end of the trial all animals shifted to the five diets with no repetition.

The five rations were formulated to supply approximately the same amount of ME (12.9 MJ) by using different proportions of feed blocks, CSM, barley grains and urea treated wheat straw.

Table 14. Feed values of leaves of shrubs and composition of common ingredients in fattening diets on DM Basis.

Feedstuffs	DM	Ash	ADF	CP	Digestibility *in vitro*		ME
					DMD	DOMD	
	----------------------------		%		----------------------------		MJ/KG
Atriplex halimus	94.5	26.2	19.7	11.1	59.5	52.1	7.8
Salsola vermiculata	3.1	20.4	18.9	12.0	57.1	50.4	7.6
Barley grain	94.6	1.8	13.0	11.6	76.4	74.0	11.1
CSM	95.7	5.2	31.3	25.9	58.3	51.8	7.8
Wheat straw urea treated	93.3	10.5	52.1	8.6	48.9	45.9	6.9

The mix of traditional ingredients promoted 189 g/d of weight change. Similar and even higher weights were promoted by substituting CSM and barley grain by cheaper feed blocks and some urea treated straw. It is recognized that the trial design was not the most efficient as the growth promoted by a given diet was confounded with the growth rate of the animal. Thus, the condition of animals during the shifts to consecutive diets were affected not only by the previous diet but also by the growth stage of the animal.

Conclusion

The main result of this trial is that it confirms the technical possibility of replacing CSM by fodder shrub-molasses feed blocks in sheep feeding. The elaboration of feed blocks is simple and allows for incorporating feeds, such as leaves of shrubs, otherwise difficult to use. While economic analysis of this technique is to be followed, in former evaluations the total costs of shrub-molasses feed blocks were lower than mixes of barley grains and CSM, thus suggesting also an economic benefit of the replacement.

6.1.5. Mulberry leaves as a livestock feed resource in dry areas

The genus *Morus* has different species distributed widely in different ecologies of the world including many of the dry areas. The leaves of these plants have been utilized mainly for the production of the silk worm. Although the leaves are not included among the conventional sources of fodder, their use by farmers is not uncommon but not generalized. In recent years, several organizations in the world, such as FAO, have been promoting the use of mulberry leaves in the improvement of feeding systems because of the high nutritional value and successful experiences in their utilization. The high nutritive value of the leaves is such that they could be used as concentrates, replacing costly feedstuffs, to support production of meat and milk.

Table 15. Dry matter feed intake, digestibility *in vivo* and live weight changes of Awassi sheep (mean of 15 sheep), January-May 2002.

Ration	1	2	3	4	5
Feed intake (DM g/day/sheep)					
Feed block 1	0	358	475	0	0
Feed block 2	0	0	0	375	462
CSM	592	130	0	130	0
Barley grain	505	455	435	471	465
Wheat straw urea treated	394	435	476	420	495
Salt-minerals-vitamins	20	20	20	20	20
Total feed intake	1500	1400	1400	1400	1400
Energy and protein contributions					
ME (MJ) supplied by fodder shrubs FB	0	3.54	4.70	3.75	4.62
ME (MJ) supplied by CSM	4.62	1.01	0	1.01	0
Total ME (MJ) supplied by ration	12.9	12.6	12.8	12.9	13.2
Total CP supplied by ration (g/sheep/day)	246	215	213	219	213
CP: ME ratio supplied (g MJ)	19.1	17.1	16.6	17.0	16.1
Digestibility *in vivo*, %					
DMD	74.6	75.1	74.9	78.6	77.3
DOMD	73.2	73.8	72.6	76.9	75.8
ME (MJ kg)	11.0	11.1	10.9	11.5	11.4
Live weight, kg					
Initial	27.28	27.90	27.32	27.49	27.75
Final	32.95	33.75	33.02	33.43	33.81
Daily live weight gains	0.189	0.195	0.190	0.198	0.202

ICARDA initiated research on Mulberry trees in Uzbekistan and in West Asia to widen the options to access nutrients for the feeding of animals in critical periods of the year when the contribution of fodder from rangelands and cropping areas reduces substantially.

In Uzbekistan, the production of silk uses the leaves produced in the spring and thereafter the trees are unutilized for the remaining of the year particularly at the start of the fall when a second crop is still possible. In this particular period all other sources of fodder are nearly depleted by summer grazing of rangelands and stubbles and costs of feeding become expensive.

The target of these experiments includes the evaluation of the nutritional value of mulberry foliage and the possible seasonal differences through the year and its incorporation as a supplement to reduce feeding costs.

Nutritive value

Table 16 provides a summary of the chemical composition and nutritive value of mulberry leaves collected during the year around Tel Hadya, ICARDA, to evaluate seasonal variation in fresh material. In this location, the mulberry species produce red as well as white fruits. The mean differences in the two types of trees collected are minimal, as indicated in Table 16, with similar CP, DMD and ME levels, 18%, 61-62% and 9MJ, respectively. Note that the average CP and DMD levels of mulberry foliage were very similar to those of vetch hay, an excellent fodder that could be produced in West Asia for animal feeding.

Table 16. Chemical composition and digestibility (*in vitro*) of mulberry foliage collected at Tel Hadya, ICARDA, April-November 2001.

Harvesting date	DM %	Ash %	ADF %	NDF %	CP %	*In vitro* digestibility DMD %	DOMD %	ME MJ/kg
Foliage of trees with red fruits								
April	92.9	11.3	15.5	24.8	22.6	78.6	71.1	10.7
May	92.6	14.6	18.2	18.2	20.0	76.3	69.2	10.4
June	92.0	19.1	21.9	24.1	17.2	79.9	60.1	9.0
July	92.7	16.4	17.8	26.0	19.8	71.6	62.1	9.3
August	92.7	17.9	19.6	30.7	18.4	73.6	61.0	9.2
September	92.6	20.1	20.6	26.8	17.8	67.8	57.0	8.6
October	92.4	17.5	19.5	27.6	16.5	68.2	59.5	8.9
November	93.0	22.1	21.1	26.2	12.0	65.4	55.8	8.4
Mean	92.6	17.4	19.3	25.6	18.0	72.7	62.0	9.3
Foliage of trees with white fruits								
April	92.5	12.3	17.3	28.1	21.8	80.3	70.6	10.6
May	91.4	17.6	19.3	23.8	21.6	76.1	64.8	9.7
June	92.1	16.8	19.6	27.8	17.9	74.4	63.5	9.5
July	92.2	19.3	19.9	25.8	18.6	75.4	62.6	9.4
August	92.4	12.8	22.1	24.9	15.7	73.4	59.9	9.0
September	92.3	19.6	20.8	27.8	17.3	71.5	59.5	8.9
October	92.0	19.2	20.2	28.7	17.8	72.6	57.6	9.1
November	92.4	20.9	21.8	25.1	14.4	66.8	52.4	8.5
Mean	92.2	17.3	20.1	26.5	18.1	73.8	61.4	9.2

Besides DM, leaves of both types of trees showed seasonal variation in chemical composition (ash, ADF, NDF and CP), and in DMD. While the values of ash, ADF and NDF increased overtime as fall approached, those of CP and DMD decreased. ME changes are less pronounced, but followed a similar trend to that of CP and DMD.

Evaluation with animals
Mulberry foliage was harvested in October-November 2000, in the period when it would not be utilized for silkworm feeding and when critical fodder deficits are confronted, and used in a 60-day feeding trial with 10 mature castrated rams. Animals were fed *ad lib* with dry mulberry leaves and wheat straw. At this stage, mulberry foliage contained 13% CP, 54% DMOD and 8 MJ/kg of ME. The results of the trial are shown in Table 17.

Consumption of mulberry and straw averaged 566 and 940 g/d, respectively suggesting that the nearly 0.6 kg of mulberry leaves induced a high consumption of straw known to have low nutritional value. The mulberry consumed supplied about 74 g of protein, which would be equivalent to the supply of 0.3 kg of CSM (at a cost of SL 2.1), suggesting promising replacing potentials.

The mature castrated rams increased weight at a rate of 100 g/d. As in the experiments in Uzbekistan, it is expected that mulberry leaves could eventually promote similar growth rates to those of vetch or concentrates based on costly byproducts that are used in fattening systems.

Conclusion
The results show that mulberry leaves could be incorporated into the diet of small ruminants in the dry areas at the start of the fall without disrupting silkworm production. The nutritional value of this feedstuff is excellent and could replace concentrate ingredients or function as a concentrate itself.

Table 17. Weight changes Caused by feeding Awassi sheep with mulberry foliage and wheat straw, October-December 2000.

Feeding period 23 Oct. - 23 Dec (60 days)		Feeding period 23 Oct. - 23 Dec (60 days)	
Feed VFI (DM g/day):		Chemical composition % (wheat straw):	
Mulberry foliage[1]	566	CP	3
Wheat straw	940	DOMD (*In vitro*)	32
		ME (MJ kg)	5
Chemical composition % (mulberry foliage)			
ADF	23	Digestibility % (*In vivo*) of mulberry foliage and straw:	
NDF	25	DMD	62
CP	13	DOMD	54
DOMD (*In vitro*)	57	ME (MJ kg)	8
ME (MJ kg)	9		
		Live weight change	
Chemical composition % (wheat straw):		Initial LW (kg)	52
ADF	45	Final LW (kg)	58
NDF	58	Daily LW changes (g)	100

[1] *Mulberry foliage (mixtures of red and white mulberry fruits trees).*

APPENDIX: STAFF LIST, TRAINING, LABORATORY, RESEARCH COLLABORATORS, FINANCIAL SUPPORT AND PUBLICATIONS

Staff list

Luis Iniguez (P):	Project Manager
Monika Zaklouta (RA):	Animal Laboratory Manager
Muhi El Din Hilali (GS):	Milk Technologist and Animal Research Facility Manager, started his work at ICARDA in January 2001
Safouh Rihawi (RA):	Animal Nutrition Scientist
Adnan Termanini (NPO):	On-farm Research Scientist
Azusa Fukuki (RA):	Economist, Market Researcher
Sota Kobayashi (PhD):	Veterinarian, JICA Volunteer Program
Tsuyoshi Takahashi (RA):	Animal Nutritionist, JICA Volunteer Program
Inger Waldhauer (RA):	Junior Professional Officer (DANIDA program), milk transformation research
Birgitte Hartwell (RA):	Junior Professional Officer (DANIDA program), research on production systems
Mohamed Haylani (GS):	Lab Technician
Sahar Sabouni (GS):	Lab Technician
Ahmed Sawas (GS):	Technician

Training activities

Training staff in research methodologies for updating and improving research performance

- Monika Zaklouta, manager of the animal laboratory at the Dairy Science Laboratory of Animal Reproduction under Dr Milo Wiltbank, University of Wisconsin, Madison, on 8-24 February, in protocols for progesterone assessment, animal nutrition and milk technology.
- Muhi El Din Hilali at the Milk Processing Plant of Çukurova University, Adana, Turkey on February 12-19, to be exposed to management of milk processing plants and technologies.
- Inger Waldhauer, Azusa Fukuki, and Adnan Termanini visited the GAP project area and Çukurova University, Turkey, on 12-22 March to learn from the milk transformation experiences of the private sector.
- Dr Turkan Keceli, food technologist from Çukurova University, Turkey, was invited on 2-12 March to ICARDA to meet with staff to discuss and review procedures for elaboration of fresh and semi-fresh cheese and ice cream.

- Dr Werner Stur was contracted on 9-17 September to conduct the workshop "Participatory Approaches for Improving the Effectiveness of On-farm Research in Small Ruminant Production". Staff under Project 2.5 and two Central Asian scientists attended this event jointly organized by project 2.5 and the Projects 4.1 and 4.2 under Dr Aden Aw-Hassan.
- Mohamed Haylani, ICARDA's technician in the area of feed evaluation at the Nutrition Laboratory of the Macaulay Institute, Aberdeen, UK, under Dr Robert Orskov, for the period of one month (14 November-15 December) to upgrade his skills in feed evaluation techniques and exposing him to new analytical developments.

On 1-7 December, Dr Harinder Makkar, a senior scientist from the International Atomic Energy Agency, was invited to ICARDA to work with Monika Zaklouta and review the Gas Production Test protocols and introduce a protocol for bacterial kinetics analysis.

Central Asian scientists trained as part of the IFAD-funded project

NARS scientists trained for short periods (1-2 months) at ICARDA or other centers.

Scientist	NARS	Topic	Period	Place
Alisher Atakurbanov	Uzbekistan	Biometrical data analysis	April-June	ICARDA
Antonina Vasilyieva	Uzbekistan	Feed evaluation and lab management	May-June	ICARDA
		Feed evaluation techniques	Nov-Dec	Macaulay UK
A. Ilias	Turkmenistan	Socioeconomics and data	March-April	ICARDA
E. Gaziyants	Uzbekistan	Discussions on socioeconomics	March -April	ICARDA
Modashev	Kazakhstan	Discussions on socioeconomics	March -April	ICARDA
Berik Arungazyiev	Kazakhstan	Feeding systems and animal production	May -June	ICARDA
Madina Mussaeva	Kazakhstan	Socioeconomics and data analysis	March-April and Nov-Dec	ICARDA
Tolib Mukimov	Uzbekistan	Participatory research	September	ICARDA
Turusbekov Sagyundyk	Kyrgyzstan	Socioeconomics and data analysis	March-April	ICARDA
		Participatory research	September	ICARDA

Training workshops in Central Asia.

Place and Country	Topic	Participants: host country	Participants: remaining countries	Lecturers and periods
Konya, Turkey	Basis and techniques in animal epidemiology	-	6	University of Konya, Turkey under the coordination of Prof. Ersin Istanbulluoglu. January 2002
Bishkek, Kyrgyzstan	Range and grazing management techniques	10	4	Ben Norton (ICARDA), May 2002

A total of 40 scientists (10 per country) were trained in English in Kazakhstan, Kyrgyzstan, Uzbekistan and Turkmenistan.

Turkish scientists trained at ICARDA under the GAP-ICARDA project

In April, Adnan Termanini, staff under Project 2.5, trained 15 GAP scientists in a two-day course organized in the GAP project area, Turkey, on computerized management of survey data.

On 26-28 June, Dr Safouh Rihawi, ICARDA's animal nutritionist, trained GAP scientists in Urfa, Turkey, on feed block elaboration and use.

Other training

Three on-farm training workshops about milk transformation aimed at improving farmer's skills in the subject, conducted by Muhi El Din Hilali and Inger Waldhauer, both staff under Project 2.5. Main topics included pasteurization in cheese elaboration; elaboration of safe yogurt with freeze-dried starters and starter management; and Jameed (a new product) elaboration. The workshop places and dates are listed below.

- Nurata, Uzbekistan on 15-19 April
- Khanasser, Syria on 27-30 May
- El Bab, Syria on 23-26 September

A workshop on "How to Succeed in Sheep Production" was organized by ICARDA on 23-24 June for extension officers and farmers in Kabasin, El Bab, Syria, to discuss the approaches followed at ICARDA's on-farm adaptive research work and technologies associated with flock production (Adnan Termanini and Safouh Rihawi), milk collection and transformation (Muhi El Din Hilali). A total of 30 participants (extension agents and farmers) attended this event.

Sarah Caddy from UK was hosted by the project on internship for three months (September 8-December 3) and worked under Dr Sota Kobayashi in veterinary research issues.

Animal Research Laboratory

Samples analyzed

A total of 7,288 samples from other ICARDA dependencies as well as NARS and on-farm activities were processed in the year. The samples included feedstuffs such as cereals and legume plants (straw and grain), forages, shrubs, plant residues, cotton seed cake, olive cake pulp and leaves, whole olives, silages, as well as milk and cheese from the milk processing plant. The table below shows the distribution of the different analyses provided by the Animal Nutrition Laboratory

Analysis performed at Orita's Animal Laboratory.

Type of analysis	Number of samples
Dry matter/ Ash	906
Crude protein/ N	2,615
ADF/Lignin	797
NDF	535
Gas production test	208
Fat	88
IVDMD	669
Milk NIR	1,470
Total	7,288

New equipment

During 2002 the animal research laboratory was equipped with modern equipment. This includes a new Kjeldahl distillation unit, an automatic Soxhlet unit, a Lactostar milk analyzer, a vacuum packager for cheese, and equipment for the quality control of dairy products.

Research collaboration

- The Macaulay Land Use Research Institute (UK) through Dr Robert Orskov and the Animal Production and Health Division of FAO-Rome, through Dr Manuel Sanchez in the area of feeding strategies for the dry areas and the framework of a research activity in exploiting adaptive traits of sheep for improving feeding systems for CWANA.
- The International Atomic Energy Agency (IAEA), through Dr Harinder Makkar in the area of feed evaluation with a specific interaction in a training workshop in Central Asia.
- ILRI and IPGRI the project in the characterization of breeds of small ruminants in Central Asia and the Caucasus.
- DANIDA through two JPO's 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), to develop joint research activities 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 and the Land Tenure Center in market evaluations.
- The University of California, Davis, through the Global Livestock-Collaborative Research Support Program (GL-CRSP) in Central Asia.
- NARS from 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 Jordan Cooperative Corporation (JCC) in the areas of milk transformation and processing.

Financial support

- Government of Japan
- International Fund for Agricultural Development (IFAD)
- System-wide Livestock
- System-wide Genetic Resources Program

Publications

Refereed publications

Iniguez, L. 2002. Goats in resource poor systems in the dry environments of West Asia Central Asia and the Inter-Andean Valleys. Small Ruminant Research (Submitted).

Non-refereed publications

Iñiguez, L. 2002. Improvement of small ruminant productivity in the dry areas. Abstract and presentation at the Meeting of the FAO/CIHEAM Cooperative Research Network on Sheep and Goats Genetic Resources Sub-Network. Istituto Zootecnico e Caseario per la Sardegna, Sassari, Italy, 9-11 May 2002.

Iñiguez, L. 2002. Goats in harsh conditions. Abstract and paper presented at EAAP meeting, Cairo, Cairo, September 2-6, 2002.

Iñiguez, L. 2002. Multipurpose sheep in the dry areas of West Asia. Abstract and paper presented at EAAP meeting, Cairo, Cairo, September 2-6, 2002.

Iñiguez, L., M. Suleimenov, S. Yusupov, M. Kineev, S. Kheremov, A. Ajibekov, D. Thomas. 2002. Livestock production in Central Asia: constraints, improvement needs, and research opportunities. Abstract and paper presented at ASA, Symposium-Agricultural Development in Central Asia, Indianapolis, USA, November 11-14, 2002.

ICARDA's research on livestock production in Central Asia. Poster presented in ICARDA's stand at the American Society of Agronomy, Indianapolis, USA, November 11-14, 2002.

Training materials

Ten posters on training materials for on-farm research in northern Syria were published

1. Maintaining sheep health
2. Selection of the sheep flock
3. Strategic feeding of ewes
4. Animal scores for assessing the body condition of ewes
5. Hygienic collection and management of milk for processing
6. Caring for new born lambs is looking after your future capital
7. Lambing
8. Preparing ewes for the lambing season
9. A good ram, the base for building a good flock
10. Sheep feeding and health care management

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

Rationale
Water resources in the dry areas are very limited. The annual supply per capita 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. Over 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 resources for agriculture are decreasing, food demand is increasing. 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.

In the dry areas covered by ICARDA's mandate, activities are aimed at optimizing supplemental irrigation in rainfed areas, promoting water harvesting in drier environments, increasing water-use efficiency in irrigation, sustainable utilization of marginal water and building the capacity of NARS in water resources management.

Objective
Water resources in the dry areas that are potentially available for agriculture efficiently and sustainably utilized for improved and stabilized agricultural production.

Immediate objectives
- Rainwater in the drier areas properly managed through water harvesting in sustainable and integrated production systems to improve agricultural production and reduce degradation or desertification.
- In rainfed areas, limited water resources are utilized efficiently and effectively in conjunction with rainfall through supplemental irrigation for improved and stabilized agricultural production.
- On-farm water-use efficiency in irrigated dry areas is maximized through the adoption of optimal combination of management strategies, practices and inputs both in qualitative and quantitative manner.
- Unconventional water resources, in particular saline waters and sewage effluents, are managed properly for improved potential in agriculture through new technologies that ensure safety and sustainability.
- Ground water resources in rainfed areas, in particular shallow aquifers, are optimally and sustainably used (quantity and quality) in irrigation.

- Clients of on-farm water management are well trained on issues related to conducting needed research and transfer of technologies.

Research Progress

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

Micro-catchment water harvesting for improved vegetative cover in the Syrian drier environments (*Badia*)

Background

ICARDA responded to CGIAR priorities and vision for international agricultural research (CGIAR 1994) and took an initiative for strategic research aimed at developing techniques and approaches for the optimization of dryland on-farm water husbandry. The ICARDA initiative was based on four research themes i) water in present land-use systems: indigenous knowledge, and end-user perceptions and participation, ii) water resource and capture potential, iii) options for water utilization, iv) dissemination, development and impact. In order to address the declining water-biomass situation, a research plan was prepared and implemented in the WANA region in collaboration with NARS.

Syria is one of the WANA countries facing water scarcity problems. About half of the total area of the country is located in drier environments (*Badia*), where rain-fall is the only source of freshwater and it is not adequate to support cropped-based agriculture. Groundwater as a source of freshwater is very limited and restricted to a few locations. Semi-desert conditions prevail throughout this area. Potentially, it is grazing land, which hosts most of the country's nomadic herders and the sheep population.

Natural vegetation is a source of feed for livestock, which is a major source of livelihood for the population. Consecutive droughts and low rainfall negatively affected the vegetative cover. Increasing animal population and overgrazing further deteriorated the vegetative cover. This has resulted in declining livelihoods and degraded lands. The deteriorating situation demands effective measures. Presently, the *Badia* provides feed for not more than three to four months per year. Improvement of vegetative cover in the *Badia* is absolutely necessary to combat land degradation and to improve the livelihood of the population.

Rehabilitation of the range in the *Badia* could be possible through re-vegetation with the help of appropriate water-harvesting techniques and grazing management. Water-harvesting techniques have also potential to conserve the soil and water *in-situ* and reduce the soil losses by reducing flow velocities, thus increasing flow time and infiltration. There is a pressing need to develop cost-effective and environmentally friendly interventions to enhance the rainwater productivity and reduce/halt the on-going desertification process. ICARDA entered in an agreement (1996) with Directorate of Irrigation and Water Use (DIWU), Ministry of Agriculture and Agrarian Reform (MAAR), Syria, to provide technological support and scientific guidance to developing research set up at its Mehasseh Research Center (MRC) for the required studies. This research, aimed at developing the appropriate micro-catchment water harvesting technologies for sustainable biomass production that suit Syria's drier environment *(Badia)*, was carried out from 1996 to 2001. Data were collected for three rainfall seasons, 1997/98 - 1999/2000, and results were analyzed and interpreted. The objectives of this research were to:

- Assess water capturing potential through development of rainfall-runoff relationships in the area.
- Develop and test water-harvesting techniques for improved vegetative cover that is suitable for the *Badia* environment.

Methodology

Three experimental sites, one for runoff plots and two for water harvesting, were chosen at the MRC. For the rainfall-runoff experiment, 36 runoff plots of four different sizes (5x5, 5x10, 5x15 and 5x20 m) on three different ground slopes (5, 7 and 12%), and with three replicates of each were developed at Experimental Site I (ES-I). Each plot was furnished with one or more runoff collecting tanks, and one automatic and two manual rain gauges were installed to record rainfall. Rainfall and runoff data were collected for various storms. Runoff coefficients for each case were computed from the water collected in the tanks and the total rainfall for that event.

To test the water-harvesting potential, two experimental sites, i.e., ES-II and ES-III, were developed. Experimental Site II was provided with 540 manually developed semicircular bunds. Treatments at this site included semicircles of three sizes (2, 4 and 6-m diameter) on two ground slopes of 2% and 5%. It provided micro-catchment areas of 6, 16 and 30 m^2. The layout arrangement included 90 micro-catchments of each size and slope. *Atriplex Halimus* and *Salsola vermiculata* fodder shrubs were planted on these micro-catchments. One rain gauge was installed in order to collect precipitation data. Neutron probe access tubes were installed to register the soil-moisture changes in the micro-catchments. Experimental Site III was provided with mechanically built contour bunds on an area of about 5.4 ha. The treatments included 8, 16 and 24-m spacing between the bunds on two ground slopes of 4% and 6%. Transverse bunds created 216, 108 and 72 micro-catchments of 8, 16 and 24 m spacing, respectively, on each ground slope. A total of 792 micro-catchments were developed with drainage areas of 40, 80 and 120 m². Each micro-catchment was planted with two shrubs. *Atriplex Halimus* and *Salsola vermiculata* were again planted on these micro-catchments.

Micro-catchment areas for one shrub were estimated as 20, 40 and 60 m². A manual rain gauge and neutron probe access tubes were installed to record rainfall and soil moisture changes.

Rainfall data were collected and analyzed according to the requirements of the experiments. Event rainfall data was used to relate rainfall with runoff events. Annual rainfall was required to relate the shrub survival and growth with the rainfall. Shrub growth was measured in May and October every year, at the end and start of the rainfall seasons, respectively. Results were compiled by averaging the biomass growth of shrubs for each treatment.

Results

Observed rainfall data showed annual rainfall for years 1997/98, 1998/99 and 1999/2000 as 174, 36 and 42 mm, respectively. Very little rainfall occurred in the second and third year. These years can be regarded as a drought period. During the first year of the study, three runoff events were observed at ES-I. In subsequent low rainfall years no runoff events were generated. These data were not adequate to develop appropriate relationships between rainfall and runoff considering the different rainfall intensities and antecedent moisture conditions.

However, variation of runoff coefficients in relation to micro-catchment area and ground slope could be registered for prevailing rainfall-runoff events. The results showed positive trends and should be further evaluated when more data are available.

Comparison of the performance of semicircular bunds with the control case without bunds showed improvement in soil-moisture storage by about 100% on 2% slope and about 300% on 5% slope. It also indicated an increase in the shrubs survival rate by about 6 times on 2% slope and 45 times on 5% slope. During the drought period, the shrubs' survival rate on 5% slope was more than 90%, compared to 2% for the control case. The interventions also improved the shrub growth rate by about two to three times during this period. Comparing the results between treatments, 4-m diameter semicircular bunds, having high growth rates, showed a comparative advantage. The results also indicated that the intervention performed better on a relatively steeper slope.

Comparing the performance of contour bunds with a control case showed improvement in soil-moisture storage by about 100% on 4% slope and about 300 to 400% on 6% slope. It also indicated an increase in the shrub survival rate by about 2 times on 4% slope and 3 times on 6% slope. The shrub survival rate on 6% slope was raised from 31% to 90% during the drought-affected period. Data on shrub growth in relation to bund spacing did not show considerable comparative advantage; therefore, smaller spacing (8 m) should be preferred over larger sizes in order to maximize production from a unit area.

Conclusions

- Because of the low rainfall conditions, the runoff plot experiments did not generate a good database and need to be continued till accumulation of a reasonable record to establish appropriate relationships between runoff and rainfall for various intensities and antecedent conditions.
- The micro-catchment water-harvesting systems performed very well on tested slopes between 2% and 6% as compared with a control case without water harvesting. The results indicated a higher marginal advantage for relatively steeper slopes.
- The tested technology emerged as a tool to harvest 2 to 3 times more water as compared with the control case under drought conditions.
- The tested technology proved that a shrub survival rate of about 90% could be achieved, even during two consecutive drought years, when shrub survival was very low under control conditions. This result is of practical importance, with water harvesting emerging as a useful system for drought alleviation in dry areas like the Syrian *Badia*.
- Cost comparison and implementation show that construction of contour bunds with machinery is cost effective and saves on time. However, for small areas and locations where cheap or family labor is available, manually constructed semicircular bunds could be a preferred option.
- It is very encouraging that on the basis of results from this study, the Government of Syrian Arab Republic has already initiated implementation of a program of water harvesting on larger areas of similar environment. However, publicity is needed for scaling out. An appropriate policy and farmers-based field trials in zones with various socioeconomic conditions could be useful for widespread adoption of water harvesting techniques by end-users.

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

Optimization of wheat supplemental irrigation in the north-west of Iran

Background

Rainfed cropping in Iranian highlands coincides with the relatively cool, rainy winter season, usually from October to May. Cereal yields are low and variable in response to inadequate and erratic seasonal rainfall and associated management factors such as late sowing (or late germination). In an area where water is limited, small amounts of supplemental irrigation water can make up for the deficits in seasonal rain and potentially produce satisfactory yields.

This field study (1999-2002), on deep clay silty soil, was conducted in north-west of Iran. The experiment was conducted in three cropping seasons (1999-2002) at Maragheh, main station of the Dryland Agricultural Research Institute (DARI), in the north-west of Iran (37° 15' N; 46°15'E; elev.1725m), with a mean annual rainfall of 298 mm(1996-2002). The trial included four supplemental irrigation (SI) levels (rainfed, 1/3, 2/3 and full irrigation) combined with N rates (0, 30, 60, 90 and 120 kg ha-1) on one rainfed wheat variety, 'Sabalan'.

Over the study period, growing season rainfall was 281 mm (1999-2000), 228 mm (2000- 2001), 382 mm (2001-2002). The first season's rainfall was below the long-term average, with the first rain on 31 October - 1 November; subsequent rain was well distributed until April, when the last significant rainfall occurred. However, 15.5 mm rainfall in May cannot make a substantial contribution to crop yield. The second season's rainfall was below the long-term average (298 mm). Thus, the first rainfall (17.4 mm) on 23-25 October was the main source of moisture for the crops from germination to growth during autumn. The rainfall in the third year was above the usual amount; however, the first season's rainfall was very late (5 November), thus the rainfed treatment could not successfully take the crop from germination to growth. However, 49.5 mm rainfall in May made a substantial contribution to crop yield, except rainfed treatments, in addition to the cooler weather in spring. Rainfall is inversely related to seasonal temperatures.

Results

The analysis of variance showed that during the three seasons of the study there were significant effects due to the primary factors and their interactions. However, the effects were more consistently expressed for grain, straw, biological yields, and harvest index, 1000KW, high and kernel number per spike. Differences due to year, irrigation and nitrogen were highly significant for all variables, except N rates on kernel number per spike. In addition, the interaction of N with year were non significant, except on 1000KW. Similarly, there were significant interactions between water level with N and water level with year for all variables, except the interaction of water with N on the harvest index. There were significant interactions between irrigation, N and year on grain yield, harvest index, high and 1000KW.

Yields of rainfed wheat varied with seasonal rainfall and its distribution, with all main factors having significant effects. A delay in the seed germination from October (SI treatment) to November (check treatment) consistently reduced yields. With irrigation, crop responses were generally significant up to 60 kg N-ha-1. An addition of only limited irrigation (1/3 of full irrigation) significantly increased yields and obtained maximum water-use efficiency. Use efficiency for both water and N was greatly increased by SI.

As the main production factor in dryland cropping is water, whether from rainfall or added as SI, the interaction involving water, year and nitrogen are depicted. The use of SI increased crop yields in each season, but the effect varied with the season. Thus the highest yields were in season 3 (2001-2002) and the lowest yields in season 2 (2000-2001).Yields from rainfall plots alone were poorly related to seasonal rainfall.

Regardless of season, the pattern of response to SI was similar, with the addition of the first increment of water having the greatest effect. Although increases occurred at the 2/3 SI and full SI levels, based on water-use efficiency, there was no significant additional increase with 2/3 and full supplemental irrigation.

The response to N was conditioned by water levels. As expected, the lowest response to N was under rainfed conditions, with no increase yields beyond the 30 kg N/ha in dry years or delayed first effective rainfall in autumn. The highest level (more than 90 kg N/ha) tended to decrease yields. As the N application rate increased, the effect on yield was limited by water especially at 1/3 SI level, the lowest irrigation rate. Responses to N were not limited by available water at the 2/3 SI level, as they were similar to those at full irrigation. Under any soil water condition, delay in seed germination in autumn, on rainfed treatments, reduced the extent of a yield response to added N. SI, nitrogen and their interaction affected water-use efficiency (WUE).

The rain + irr-WUE, irr-WUE and Nitrogen-use efficiency (NUE) were calculated for treatments averaged over the three seasons. Over the three seasons, NUE increased from 7.47 to 12.67 kg/ha. The rain + irr-WUE over three seasons increased from 1.76 to 7.9 kg/ha/mm by applying 60 kg N/ha and the irr-WUE over three seasons increased from 24.1 to 31.6 kg/ha/mm with lowest SI rate (1/3 of full SI).

Conclusions

- Wheat rainfed yields can be substantially increased and stabilized with minimal SI and fertilizer inputs, together with higher yield potential.
- The most dramatic implication of this study is the substantial savings in irrigation water with little associated loss in yield. In most cases, applying 1/3 of full irrigation with 60 kg N/ha quadrupled yield compared with rainfed conditions.
- Nitrogen application helps increase yields and water-use efficiency only when associated with adequate SI.

Output 3: Water management packages for sustainable optimisization of on-farm WUE particularly in irrigated areas

Water-use efficiency of winter-sown chickpea under supplemental irrigation in a Mediterranean environment

Chickpea is one of the major legume crops in West Asia and North Africa (WANA) region. It has a considerable importance as food, feed and fodder. Traditionally, chickpea is grown as a rainfed crop in the WANA region where rainfall is highly variable and often not sufficient. In the Mediterranean environment of WANA, chickpea is traditionally sown in spring (March - April), about the end of the rainy season in the region. Consequently, chickpea planted in spring largely depends on residual moisture. As the season progresses, the crop is exposed to increasing moisture deficit and heat, which results in low and variable yields, thus discouraging farmers from investing inputs in its production.

Limited supplemental irrigation (SI) can play a major role in boosting and stabilizing the productivity of both the spring-sown and winter-sown chickpea. With the development of improved chickpea cultivars, tolerant to biotic and abiotoc stresses, it becomes feasible to advance its sowing date. Weighted against spring sowing, winter sowing provides higher and more stable productivity, increased biological nitrogen fixation and better effect on a subsequent cereal crop. Winter sowing can be extended to areas which are too dry for spring sowing of chickpea.

No work has been reported on the effect of different managed levels of irrigation on yield and water-use efficiency of winter-sown chickpea. Therefore, the present study aimed towards investigating the effect of different levels of SI on yield and water-use efficiency of winter-sown chickpea.

An experiment was carried out in five cropping seasons (1996-2001) at ICARDA's main station, Tel Hadya, Aleppo, northern Syria, with mean annual rainfall of 330 mm. The rainfall was variable during the four growing seasons in total: 365 mm (1996/1997), 408 (1997/1998), 305 mm (1998/1999), and 383 mm (2000/2001). A cold tolerant chickpea cultivar with improved resistance to Ascochyta blight, 'Ghab 2' (ILC 3297), was grown in rotation with wheat. The experiment included three sowing dates (late November, mid-January, and late February) and four levels of SI (full SI, 2/3 SI, 1/3 SI, and rainfed). Table 1 presents a summary of the data generated. The plots were replicated three times in a split-plot design with date of sowing as the main plots. The soil water content was monitored at approximately regular time intervals using a neutron probe. Crop evapotranspiration was determined for each subplot during each time interval, from sowing to harvest, using the soil-water balance equation. Water-use efficiency was determined as the ratio of crop yield per unit area to seasonal evapotranspiration.

Table 1. Basic data from the experiment on winter-sown chickpea (1997-2001).

Season	Rainfall	Sowing dates	1/3 SI	2/3 SI	Full SI
	(mm)		----------------	mm	----------------
1997-98	408	Dec. 1, 1997	58	117	175
		Jan. 13, 1998	93	185	278
		Feb 23, 1998	79	159	238
1998-99	305	Nov. 23, 1998	67	133	200
		Jan. 5, 1999	95	190	285
		Feb. 21, 1999	108	217	325
1999-00	222	Nov. 22, 1999	94	187	281
		Jan. 16, 2000	74	149	223
		Feb. 20, 2000	71	142	213
2000-01	383	Nov. 28, 2000	85	171	256
		Jan. 10, 2001	60	120	180
		Feb. 22, 2001	87	173	260

The results showed that yield of chickpea per unit area increases with earliness of sowing and with the increase in amount of SI. However, water-use efficiency decreases with the earliness of sowing due to the relatively large increase in the amount of evapotranspiration with the advancement of sowing.

Furthermore, the results indicated that the 2/3 SI level gives the optimum water-use efficiency for SI in chickpea. The analysis of the results also included the development of anonlinear mathematical model relating winter sowing chickpea yield and water-use efficiency with supplied water and sowing date.

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

Salinity tolerance screening of legumes and forages

Background

Due to the scarcity of water resources in the region, agriculture is likely to be forced to use more and more marginal quality water for irrigation. Marginal quality water could include treated sewage effluent, recycled drainage water, or brackish groundwater. These water resources often have a high chloride content. The main management issues involved in using saline water are the control of soil salinity by adequate leaching and drainage, and the selection of crops adapted to the salinity level of the soil. Numerous studies have been conducted on the management and identification of varieties of saline tolerant crops such as cotton or cereals. But very little attention has been given to legumes and forages, which are known to have low tolerance to salinity.

However, food and forage legumes improve soil health and could reduce crop pests and diseases when grown in rotation. They are also important protein sources. The objective of the project was to identify legume and forage genotypes that are tolerant to salinity and to develop an understanding of the mechanisms that affect this tolerance.

Methodology

During the 1999-2001 seasons, 200 lentil and 205 chickpea varieties were screened for salinity tolerance in plastic dishes in the laboratory (in vitro). The seeds were tested at four salinity levels: 0.5 (control), 4, 7, and 10 dS/m. Groundwater with an EC of 0.5 dS/m was mixed with NaCl until the required salinity level was obtained. The experiments were conducted in two phases: seeds that were pre-soaked for 24 hours in groundwater (F1) and dry seeds (F2). The lentil seeds were also treated with X-ray (96 KV, 200 mas, 1 sec shot, 5 sec interval). The screening tests of the X-rayed seeds are referred to as F1X and F2X. After the initial screening, 20 to 40 varieties that performed well in the laboratory were tested in the greenhouse. Five seeds were put in plastic pots filled with approximately 3 kg sand. Every other day 40 ml water of the selected EC-level was added.

To understand the mechanisms and effects of salinity, six genotypes of each chickpea and vetch with different tolerance to salinity were examined in the greenhouse during the 2001-2002 season. The seeds were planted in plastic pots filled with sand. Samples of water with three different salinity levels (2, 4, 6 dS/m) were obtained by adding a mixture of NaCl and CaCl2 in a 3:1 ratio to the water. No salt was added to the control (0.5 dS/m). Two inoculums of Rhizobium strain were added immediately to the genotypes. Fertilizer solutions were added to the pots.

Results

Lentil

Average germination of the 200 lentil varieties varied between 3% for the dry seeds (F2) at an EC of 10 dS/m to 59% for the pre-soaked seeds (F1) at an EC of 0.5 dS/m. The pre-soaking improved germination and shoot growth, especially at the higher salinity levels. The effect of the X-ray treatment on the lentils varied per variety. On average, the X-ray had no positive effect on the germination and shoot growth of the pre-soaked seeds. The X-rayed dry seeds (F2X) performed better than the dry seeds without X-ray treatment (F2). Even for the more resistant varieties, shoot growth became severely impaired at ECs of 4 dS/m and higher. The lentil varieties that occurred in more than one top 10 of the four screening tests, in order of salinity tolerance, are: 8010, 8008, 7686, 7520, 2815, 2501, 4402, 7554, and 3597.

For the Phase I greenhouse study (F1G), seven varieties from the top 10, and 14 varieties ranking between 11 and 70 were selected. At an EC of 7 dS/m only eight varieties survived, 1712, 2501, 2815, 4402, 7521, 7522, 7553, and 7620. Variety 7521 was also the only surviving variety at and EC of 10 dS/m. The greenhouse study for the dry seeds (F2G) included eight varieties from the top 10 and 11 varieties that ranked between 11 and 60 during the in vitro screening of the dry seeds (F2). After 62 days all varieties had died at the highest three salinity levels. On day 71, four of the 19 varieties had also died at an EC of 0.5 dS/m. Of the six tested varieties that were identified as saline tolerant varieties during the initial screening, varieties 2501, 2815, 3597, 4402, and 7686 survived.

Chickpea

Germination of the 205 chickpea varieties varied between 40% for the dry seeds (F2) at an EC of 10 dS/m to 84% for the pre-soaked seeds (F1) at an EC of 0.5 dS/m (Table 3). As with the lentils, the pre-soaking improved germination and shoot growth at the higher salinity levels. Without pre-soaking (F2) there was almost no shoot growth at the two highest salinity levels. The varieties ranked in the top 20 of both the F1 and the F2 screening test were: F.87-59, F.97-158, F.97-259, F.97-205, F.98-128. Of the 40 varieties that were tested in the greenhouse, 97-266, 98-100, 98-107, 98-131, 98-162, 98-169 performed the best.

The greenhouse study during the 2001-2002 season included the following varieties: F.98-74, F.87-59, F.87-85, F.97-265, ICCV2, and ILC3279. As the duration of salinity stress increased, a significant reduction in seedling growth and shoot-root ratio was observed. At day 55 and 65, the growth parameters for all varieties were inhibited at 6 dS/m except for F.87-85. Increasing levels of salinity adversely affected both root and shoot length of the chickpea seedling. Salinity had a significant effect on the leaf area, but its effect was not strong and decreased with time for the most saline treatment. Dry matter accumulation for shoots, leaves and stems developed regularly, the effect of salinity was most severe for F.97-265. All varieties were affected with time at salinity levels 4 and 6 dS/m. Water content was reduced with increasing salinity level. At 6 dS/m, the reduction values were higher in F.97-265 (100% at 50% of flowering) than in F.87-59 (24% at 50% flowering and 66% at 100% of flowering). There was no significant effect of salinity on plastochron. Flower and pod numbers and pod weights of all chickpea varieties were reduced at a salinity level of 6 dS/m. At 2 dS/m none of the components was significantly reduced, as compared with the control. Chickpea cultivars F.98-74, F.87-59 and ILC 3279 were found to have higher salt tolerance and produced more dry matter than F.97-265.

Vetch

In vitro screening of 20 vetch genotypes indicated that salinity had a more negative effect on the germination of the vetches than on the germination of the chickpea genotypes. At the highest EC level only *Vicia ervilia* 2520 and *Vicia sativa* 2064 obtained 100% germination. For the greenhouse study V.E.2520, V.S.2604, V.S.2560, V.S.2003, *Vicia hybrida* 2555, and *Vicia Narbonensis* 2561 were selected. At 25 and 35 days after sowing, the inhibitory effect of salinity at 6 dS/m had a greater effect on the shoot and root lengths, and dry weights of V.N.2561, V.E.2520 and V.S.2560 than on V.H.2604 and V.H.2555. No reduction in shoot and root dry weights for V.S.2560 and V.H.2555 was observed at 25 days. At 35 days V.N.2561 and V.E.2520 changed their response and no reduction on shoot and root dry weights was observed. After 35 days all vetch genotypes succumbed to the salinity stresses.

Conclusions

The *in vitro* screening of 200 lentil and 205 chickpea varieties indicated that the chickpea varieties were more saline tolerant than the lentil varieties.

Pre-soaking of the seeds in water with a very low salt content (EC 0.5 dS/m) substantially improved emergence, shoot growth, and survival of the species at the higher salinity levels.

The observed effects of salinity on seedling growth were a function of both salt level and time of exposure. The length of the phenological stages of the chickpea genotypes showed no clear effect of salinity. Salinity as high as 2 dS/m can reduce seedling shoot dry weight and salinity at 6 dS/m can reduce seedling survival (plant stand) in all varieties. During early seedling, the symptoms of salinity were similar to those of water stress, as observed by the leaf water potential, water content, and pod number and weights. The six chickpea varieties studied displayed distinct variation in salinity tolerance during growth. A comparison of the effects of salinity on growth of 6 varieties indicates that varieties F.98-74, F.87-59 and ILC 3279 seemed to be more salt tolerant than F.97-265, F.87-85 and ICCV2. Vetch had a more severe reaction to salinity than chickpea, as confirmed by growth and yield.

To better understand the different responses to salt on osmotic adjustment and water-use efficiency, additional greenhouse experiments in sand and soil will be conducted for chickpea; vetch and lentil genotypes. To test the performance of the identified salt tolerant genotypes when exposed to various other environmental stresses, the top-2 genotypes of each crop will be subsequently tested in the field.

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

Groundwater resources and use in the Jebel Al Hoss and adjacent valleys

Background

Groundwater irrigation has risen rapidly during the latter half of the last century in Syria. In arid areas renewable groundwater resources are limited. Open access to this common pool resource often leads to unsustainable use, resulting in problems with varied severity, such as falling water tables, salt water intrusion, water quality problems, and, in some cases, complete depletion. To create a better understanding of the groundwater resources and their use in northern Syria a survey was conducted in a 20 km wide transect from Tel Hadya to Khanasser Valley.

Hydrogeology

The lower aquifer is formed by upper Cretaceous deposits, including Conacien, Santonien and Campanien formations. This aquifer is highly productive with well

yields of up to 30 L/s. Mineralization and temperatures are high, with conductivities up to 20 dS/m and temperatures ranging between 30 to 42 °C. The temperature conforms to earth temperature at a depth of 300 to 1000 m (assuming a geothermal gradient of 20 to 30 C/km). The high mineralization could be caused by gypsum beds, reportedly occurring in the Conacien deposits. The stable isotope composition is characteristic of Pleistocene recharge, indicating that no leakage from the upper aquifer takes place. The Maastrichtian forms an impermeable layer of 150 to 200 m, acting as the lower boundary of the upper aquifer system.
The upper aquifer is formed by Paleocene/Eocene deposits, covered by Helvetian limestone in the Qweiq Valley and adjacent areas, Miocene basalts on the Jebel Al Hoss, and Quaternary deposits in the Khanasser Valley. Except for the central part of the Qweiq Valley, the upper aquifer can be considered unconfined. The Paleocene/Eocene deposits have a low primary permeability, which is slightly enhanced by silicified limestone layers which occur more frequently in the lower Eocene deposits. Well yields are small. Fractures enhance permeability locally, which results in a high variation in well yields within short distances. On the Jebel Al Hoss, the basalt sheet constitutes an aquifer of low productivity. Infiltration rate is relatively high due to the jointed structure of the basalt. In the Khanasser Valley, Quaternary deposits form the top of the upper aquifer. The most productive layer is called rummel aswad by farmers. It consists of black or dark grey conglomerates. These conglomerates are probably alluvial deposits.

The Helvetian limestones form a productive aquifer in the northwest of the study area. Well yields are high and mineralization is generally low. Relatively shallow soils and high permeability also indicate relatively high recharge. In the center of the Qweiq Valley, the basalt conglomerate bed of Pliocene age forms the top of the aquifer. In the Qweiq depression an additional aquifer system is found. The lower boundary consists of Pliocene clays. The aquifer itself is an alteration of permeable and impermeable layers of Quaternary age. Local Quaternary aquifers are found in valleys, most notably in Quneitrat Valley, Bagat/Rabai'a and Seyaleh, where they form far more productive aquifers than the underlying Eocene sediments.

Irrigation water use

In winter, supplemental irrigation is applied to wheat. Barley is often rainfed, and is provided with less water than wheat when irrigated. Farmers that have sufficient water irrigate cotton and vegetables in summer. Cotton is the dominant summer crop in the Qweiq Valley and the Helvetian aquifer. On the Jebel Al Hoss and adjacent valleys we generally find small plots of irrigated vegetables and less cotton. Irrigation water requirements, computed using long-term climate data from the Breda station, are 400 mm for wheat and 1280 mm for cotton. Summer vegetables require less water, but often more than one crop is grown during the summer season. Previous investigations have found that the farmers in this region tend to over-irrigate. Therefore, winter irrigation was estimated as 400 mm, and summer irrigation as 1500 mm for cotton and 1000 mm for vegetables. LandSat TM images were used to estimate the irrigated summer and winter area. Of the 1770 km^2 study area, 17% was irrigated in winter and 11% was irrigated in summer.

Groundwater balance
For the water balance, the catchment formed by the Qweiq Valley and the part of the Jebel Al-Hoss that drains toward the Harayek depression were considered. Groundwater recharge on the Jebel Al-Hoss, estimated using a chloride mass-balance method, was approximately 7%. Irrigation return flow was assumed to be 10%. Of the 135 wells that were visited during the field survey in the fall of 2001, 13 wells accessed the Cretaceous aquifer. Most of the deep wells were found in the vicinity of Breda. Because of the high yields, deep wells usually irrigate a larger area than the wells that tap the upper aquifer system. It was estimated that approximately 30% of the area was irrigated by deep wells. The irrigation in the Qweiq Valley is assumed to be supplied by the surface water from the Qweiq. The outflow towards the Harayek depression was estimated from the groundwater contours, assuming a hydraulic conductivity of 0.5 m/d. The resulting groundwater balance has a deficit of 44.2 million m^3. Assuming an effective porosity of limestone of 3%, this would result in an average drop in water level of 2.2 m/yr.

Conclusion
The computed groundwater balance was based on a number of bold assumptions. Obviously, a long-term monitoring program could improve the accuracy of the estimates. However, a 1.7 m/yr drop in groundwater level during the last 18 years at Tel Hadya, just east of the Qweiq Valley, and observations of the farmers, confirm the general results. Implementation of strategies for using the scarce water resources more efficiently, combined with a program to control groundwater use, are required to ensure the livelihoods of the farmers in this area.

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

JICA-supported water-use efficiency training course
From April 7 to June 6, 2002, a training course on the "Management of Water

Resources and Improvement of Water-Use Efficiency in the Dry Areas" was jointly organized and sponsored by ICARDA, JICA, and the Syrian Government. Scientists and staff from various projects and units at ICARDA contributed to the course. The purpose of the course was to provide participants from Central and West Asia and North Africa (CWANA) with necessary practical and theoretical information to improve water-use efficiency in agriculture, and to increase their capability to support sustainable agricultural production.

Twenty-three young researchers attended the course from 17 different countries in CWANA. The trainees received lectures on integrated natural resource management, water harvesting, supplemental irrigation, on-farm water management, agronomy, plant water relations, hydrology and modeling, GIS and remote sensing, agro meteorology, soil conservation and land management, socioeconomics, experimental design and analysis, and scientific writing and presenting. Some of the lectures included laboratory and practical sessions. The trainees also gave short presentations on their own research and water resources issues in their respective countries.

The trainees visited three Syrian research stations and several Syrian farmers. They also had the chance to attend two international workshops, one on "Desertification and Rehabilitation of Degraded Drylands", and another on "Agriculture and Human Welfare in West Asia and North Africa."
The last three weeks of the course were devoted to research projects and final presentations. The trainees could choose between three research topics

- Irrigation and water-use efficiency
- Hydrology and soil conservation
- Agronomy

The trainees of the irrigation group computed all water-use efficiency aspects of an irrigation trial at Tel Hadya. They analyzed the effect of sowing dates, fertilizer and irrigation water amounts for the wheat crop. The hydrology and soil conservation group analyzed livelihood strategies and land degradation dynamics in the J'deideh watershed in Khanasser Valley. They diagnosed major problems with the farmers in the watershed (used a GPS to map the area) and assessed options for improvement. The agronomy group learned to work with the CropSyst model. They used the simulation model and data from a wheat trial at Tel Hadya to assess the effect of soil depth and various agronomic practices.

The presentations of the research projects showed the enthusiasm and motivation of these young researchers. The presentations were very well prepared and were followed by interesting discussions. It was obvious that the trainees had expanded their knowledge and experience in various aspects of agricultural water management. The trainees had also gained valuable experience in conducting problem solving research, in working efficiently and effectively together in diverse groups, and in preparing and presenting a scientific presentation and report.

Staff list

- A. Bruggeman, A. Ajmi (AP), T. Oweis: P Staff
- A. Akhtar, A. Karimov (CA): RA Staff
- P. Hayek, A. Hamwieh, A. Haj Dibo, I. Halimeh, J. Abdullah: GS Staff
- A. Hachum: Consultant

Publications

Adary, A., A. Hachum, T. Oweis and M. Pala. 2002. Wheat productivity under supplemental irrigation in northern Iraq. On-farm Water Husbandry Research Report series No 2. ICARDA, Aleppo, Syria.

Bounejmate, M., B. Norton and A. Bruggeman. 2002. Changes suffered by the Mediterranean rangelands in the recent past: ICARDA's experience. Medias Newsletter 13: 21-30.

Karajeh, F, J. Ryan and C. Studer (Eds.). 2002. On-farm soil and water management in Central Asia. Proceedings of an international workshop, 17-19 May, 1999. ICARDA/SANIIRI. ICARDA, Aleppo, Syria.

Kijne, J.W., T. Toung, J. Bennett, B. Bouman and T. Oweis. 2002. Ensuring food security via improvement in crop water productivity. In "Challenge program on water and food" IWMI, Colombo, Sri Lanka.

Oweis, T., D. Prinz and A. Hacum. 2002. Water harvesting: indigenous knowledge for the future of the drier environments. (in Arabic). ICARDA, Aleppo, Syria.

Oweis, T., A. Ali, F. Bahadi, R. Thomas, A. Salkini, M. Pala, A. Bruggeman and P. Hayek. 2002. Sustainable management of water Resources in agriculture in Salamieh, Syria: Preliminary Study. (Prepared, in Arabic, for the Agha Khan Foundation). ICARDA, Aleppo, Syria.

Pereira, L.S, T. Oweis, A. Zairi. 2002. Irrigation management under water scarcity. Agricultural Water Management 57 (2002) 175-206.

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 2.5, 3.1, 3.2, 3.4, 4.1, 4.2
AND AEC-S

Introduction

Khanasser Valley has been selected by ICARDA as an integrated research site to address problems that are characteristic of the marginal dryland environments. The diversity and dynamics of the natural resources and livelihoods, the prevailing poverty and the relative easy accessibility made Khanasser a prime candidate. Khanasser Valley is located approximately 70 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).
The valley lies between two hill ranges: the basalt-covered hill ranges of the Jabal Al-Hass in the west and the Jabal Shbeith in the east. The northern part of the valley drains towards the Jabul salt lake and the southern part drains towards the Adami depression. These bio-physical features result in a diverse ecosystem, with several NRM-related problems.

Here we report on the activities of the second project year of KVIRS (total duration is 4 years). As ICARDA has been working for about 20 years in Khanasser Valley, the pressure from farmers to deliver quick impact was high. On the other hand, a conceptual framework for the project and an integrative approach was still lacking. During 2002, major effort was made to address these two critical issues.

Refined objectives of KVIRS

During the 'Farmer Participatory Research' (FPR) workshop (Oct. 2002), the objectives of the project were revisited. Based on insights gained during the FPR workshop and past field experiences, the objectives were reformulated:

Goals / vision of KVIRS

- Poverty alleviation and creation of job opportunities in Khanasser through delivery of livelihood supporting options and technologies.
- Sustainable management of natural resources in 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 to the analysis of natural resource degradation and the evaluation of potential resource management options that can be applied beyond Khanasser in a spectrum of dry area environments.

Indicator: Approach 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.

Integrated Natural Resources Management (INRM) Framework

INRM is an approach that aims to operationalise true integration within NRM research in order to achieve impact at the field level. It is presently being developed mainly within the CGIAR system. INRM is currently defined as: "An approach to research that aims at improving livelihoods, agro-ecosystem resilience, agricultural productivity and environmental services."

During the 4th INRM workshop at Aleppo (16-19 Sept. 2002), the INRM principles were translated into operational 'building blocks.' As part of the workshop, a full-day field trip was organized to Khanasser. The main objective was to discuss the application of the INRM approach in Khanasser Valley, and to allow the visitors to experience and observe the living conditions in a marginal environment.

About 30 workshop participants joined the field trip. The next day, the workshop participants evaluated the KVIRS approach and provided a wealth of useful feedback. The feedback and the 'building blocks' were discussed by KVIRS staff and adapted to the context of the Khanasser project. This resulted in a list of 16 'tools', which can be grouped into diagnostic, process and problem solving tools.

It is believed that when all these tools are used at the proper time and place, that research will be able to make a difference in NRM and will contribute to improved livelihoods. The 16 identified tools for KVIRS are:

Process tools
Cross-disciplinary approach
Envisioning
Farmer participatory research (FPR)
Local organizational capacity
Monitoring and evaluation (M&E) and impact assessment
Stakeholder cooperation (NARs and policy makers)
Effective communication and facilitation strategy
Capacity building
Scaling-out and scaling-up

Diagnostic tools
Multiple scales framework
Livelihood and community analysis
Analysis of policy and institutional environment
Natural resources analysis and Agroecological characterization
Holistic analysis

Tools for problem-solving and opportunity capitalizing
a. 'Plausible options' or 'best bets' (i.e. testing of alternative technologies or modifications of existing practices)
b. Decision and negotiation support tools

Most of these tools are already used in the project to some extent. Tools with which most progress was made during 2002 are reported in this chapter.

Process tools

Cross-disciplinary grouping and coordination

Interdisciplinary research is one of the cornerstones of KVIRS. However, the key challenge is how to operationalise this type of cooperation when there are a large number of issues to study and when there are more than 40 involved scientists. Interdisciplinary cooperation is not functional when everybody works with everyone on each issue. Therefore, the need for logical subgroups and a coordination structure was identified. Research can be sub-divided in numerous ways, but finally it was decided that it is best to organize along the most relevant farming enterprises at Khanasser, as this classification is most closely related to the farmers' reality (Table 1).

The extensive livestock-barley system is the traditional farming practice at Khanasser, but there are three other alternative farming enterprises, which are fast gaining popularity: intensive livestock production
system (i.e. sheep fattening), income-generating annual crops, and fruit trees.

In addition, a secondary coordination linkage was established for natural resources with multiple uses (Table 1).

Farmer participatory research (FPR) workshop at ICARDA

A training workshop on farmer participatory research methods was held at ICARDA on 20-31 October. The objectives of the workshop were to improve the capacity of KVIRS staff to conduct participatory research and to develop FPR strategies for the different technologies tested at Khanasser. The workshop was attended by 15 ICARDA staff and 5 staff of Syrian NARS. The first week was focused on understanding the FPR concept and the FPR planning cycle, while the second week was devoted on improving participatory skills and FPR support for the technology groups. The major outcomes of this training workshop were: increased awareness about farmers' perspectives and the need for participatory research, improved objectives for the project, a common-agreed role for scientists at Khanasser, a new organizational structure for interdisciplinary cooperation, improved participatory skills, and last, but not least, the initiation of truly participatory (or collaborative) research activities. The participatory planning cycle will be applied by the 4 'farm enterprise groups' (see above), and will complement the on-going contractual on-farm research.

Participatory technology evaluation (PTE) day at Khanasser

On 3 April, a participatory technology evaluation day was held at Khanasser. It provided a platform where farmers evaluated, in a participatory way, a variety of technological options. On this occasion, farmers could interact directly with scientists of ICARDA and of Syrian NARs. In total about 120 farmers participated, representing most of the social and geographical strata of Khanasser. The 'technology menu' included: livestock health and fertility, improved livestock feeding, vetch, barley breeding, *Atriplex*-barley intercropping, restoration of degraded pastures, olive production on stony hill slopes, phospho-gypsum and water harvesting for barley. This participatory exercise generated a wealth of information on constraints and opportunities for technology adoption, farmers' needs, and alternative solutions proposed by farmers themselves.

Table 1. Primary (columns) and secondary (horizontal) clustering of research topics at KVIRS.

ECO-SYSTEMS	Cross cutting research	FARMING ENTERPRISES IN KHANASSER: Intensive livestock (fattening)	Extensive livestock-barley system	Annual cash crops (e.g. wheat, cumin, capparis	Fruit trees (e.g. olive, pistachio)
	OBJECTIVE	Sustainable improvement of the enterprise	Sustainable improvement of the enterprise	Sustainable improvement of the enterprise	Sustainable improvement of the enterprise
Valley bottom	Management	Husbandry	Sheep husbandry Vetch *Atriplex* Barley varieties Intercropping	Crop husbandry	Tree husbandry Intercropping
	Economics	Analysis	Analysis	Analysis	Analysis
	Water	(Ground) water	Ground water Water harvesting in valley floor	Ground water WUE irrigation Irrigation water quality	Ground water WUE irrigation
	Soil	Manure use?	PG Manure flows Wind erosion	Wind erosion	Fertilization Wind erosion
Degraded hill slopes	Management		Grazing regimes Rehabilitation of degraded pastures	Management of medicinal plants	Tree husbandry
	Economics		Analysis	Analysis	Analysis
	Water		Water harvesting	Water harvesting Qanat	Water harvesting Qanat
	Soil		Manure flows Water erosion		Water erosion & SWC Soil fertility
Steppe (*Badia*)	Management				
	Economics		Analysis		
	Water		Water harvesting for pasture		
	Soil		Wind erosion		

Implications of the PTE day were a renewed effort on farmer-centered and demand-driven on-farm research, an enhanced cooperation and communicatio with the two development projects of Jabal Al-Hass (IFAD/UNDP), extension services and with ICARDA's Germplasm Program, and a better rapport with farmers.

Collaboration with NARs

- A Memorandum of understanding was prepared with the following NARs:
- Atomic Energy Commission of Syria (KVIRS official partner)
- Olive Bureau (Idleb)
- Rural Community Development Project at Jabal Al-Hass (supported by the UNDP)
- Directorate for Agricultural Development Project at Jabal Al-Hass (supported by IFAD and AFESD)
- Directorate of Extension (under discussion)

Diagnosis

Multi-level framework

The 'multi-level framework' was instrumental in enabling a comprehensive analysis of technologies and/or resources, to obtain interdisciplinary cooperation and to address all major issues at the right scales and with the right stakeholders (Fig.1). In KVIRS, it was used as the diagnostic backbone, to which the other diagnostic tools are linked and integrated. Although it is realised that a sub-division in different levels is a simplification of reality, it is considered as a very helpful tool to analyze complex processes and to identify interactions and dynamics.

For Khanasser Valley, we identified a number of levels which we found relevant for our context. The levels are grouped in a spatial 'pillar' and a stakeholder 'pillar', which are linked vertically and horizontally in different degrees. This tool can be used both for technologies and for natural resource use. An example of an application for olive orchards on degraded hill slopes is shown in Figure 1. This tool is not meant to list all possible influencing factors, but to prioritize issues which are (actually or potentially) constraining optimum use of technologies and/or resources by the communities. This helps to focus the KVIRS research time and resources in strategic solutions.

Land-user and livelihood characterization

A rapid rural appraisal (RRA) provided essential insights on several variables at village level across Khanasser Valley and surroundings (Mazid and Aw-Hassan, 2002). The RRA indicated that the total population in KVIRS (excluding Khanasser town) is 24,000 persons, of which about 73% are resident.

Twenty percent of the households do not own agricultural land, 6% have members working as off-farm laborers, 2% have members working as laborers in cities, and 1.4% have members working outside Syria.

Spatial levels:

Marginal drylands (Zone 4):
Can olives grow in this type of climate?
Selection of proper varieties

Khanasser Valley:
Land suitability to grow olives at stony hillslopes
Survey of orchards

(Sub)-catchment:
Competition between runoff-water use (upslope versus down slope)

Hillslope characterization

Potential use of Scytonema for runoff harvesting

Role of Qanats

Stakeholders:

Policy & Institutions:
Policy regarding state land
Credit availability for drip irrigation to reclaim land
Olive policy in Syria
Institutional analysis + services

Trading links:
Marketing channels for olives?

Community / common interest group:
Competition of common land for grazing versus orchards (incl. grazing of olives)?
Potential for communal agreed arrangements

Household:
Enterprise budgets of olives (incl. labor, guarding, water, opportunity costs of land) and water harvesting

Fit into livelihood strategy: Livelihood typology and equity issues

Motives (including state land issue)?

Local management practices, technical knowledge, knowledge sources (Afrin?) and knowledge gaps

Increasing awareness

Field:
Soil and water harvesting, water-use efficiency, tillage and effect on survival and productivity/quality of the olives and soil erosion
Tree husbandry: Pruning, varieties, soil fertility management, diagnosis unproductive trees
Use of ancient terraces and gullies
Alternative tree crops?

Fig. 1. Application of the multi-level framework for olive orchard technology at degraded hill slopes.

Severe poverty is associated with lack of sheep, debts, no or little rainfed area (2-3 ha), and no family members working as laborer. Indicators of being better-off are: large sheep flocks, sheep fattening, irrigation, owning wells and/or lorry/tractor, and family members working as laborer. It is estimated that 13% of households are very poor, 48% are poor, 33% are moderately better-off, and only 6% are well-off (Table 2).

Table 2. Average of estimated percentages of wealth classes.

Location		% Very poor household	% Poor household	% Moderate household	% Well-off household
Khanasser Valley	Mean (SD)	13.2 (13.1)	47.4 (26.6)	33.3 (26.8)	6.1 (10.6)
Jabal Al-Hass (plateau)	Mean (SD)	13.5 (20.6)	50.5 (26.1)	29.4 (26.5)	6.7 (11.2)
Badia (steppe)	Mean (SD)	7.0 (14.5)	51.4 (21.7)	33.2 (17.9)	8.2 (12.5)
Total	Mean (SD)	12.3 (15.6)	48.9 (25.4)	32.2 (25.2)	6.6 (10.9)

During the participatory technology evaluation (PTE) day, farmers listed their major agricultural problems:

- Lack of sufficient rainfall and water for irrigation.
- Financial constraints to meet customary expenses, to establish and adopt new technologies, and to purchase inputs.
- Widespread lack of information on appropriate technical knowledge.
- Shortage of varieties resistant to diseases and drought.
- Unclear land property rights and policies that discourage investments, contribute to resource use conflicts, and lack sound compensatory measures for affected groups.

Policy and institutional analysis

Policy and institutional analysis is an important component of the multi-level framework (see Fig. 1). This analysis entails three major components:

- Effect of policies and institutions on livelihood strategies and natural resources use,
- The impact of policies and institutions on the adoption of new technologies,and
- Study of options to improve existing policies and institutions.

Policies with widespread impacts on livelihoods and natural resource use include the cotton ban in Zone 4 (200-250 mm/yr) and the cultivation ban in Zone 5 (<200 mm/year).

The impact of the latter policy on livelihoods of nomads living on the fringes of the Syrian rangelands was studied during the livelihood survey (La Rovere et al., 2002). The Syrian rangelands have traditionally sustained nomadic and semi-nomadic populations whose livelihood strategies were centered on animal production, sometimes combined with forage-oriented barley cropping systems. A recent policy bans cultivation from rangelands below the 200 mm annual rainfall probability line, in order to halt the encroachment of crops into marginal land and to reduce land and vegetation degradation. This has contributed to drastic changes and diversification of local livelihood strategies.

Those who remain on the range struggle for their subsistence needs and to meet the feed demand of their livestock, as they can no longer rely on local barley as feed during the dry season and during years of drought. This has increased the need for seasonal migration of families with their flocks to wetter areas in search of animal feed. However, the main income strategy for large numbers of nomads is seasonal migration to cities for wage labor. Incomes from off-farm wages now often surpass the income from herding. The ability of households to earn off-farm income depends on family composition and the level of economic independence of the household. Off-farm incomes are increasingly invested in non-agricultural business, such as businesses or trade.

It can be concluded that banning cultivation has destabilized semi-sedentary socio-agricultural systems, accelerated migration and affected the livelihoods of those who remain on the fringes of the Syrian rangeland. However, the cultivation ban is not the only cause of these dynamics as rangeland degradation had started already before the cultivation ban.

Water resources

The objective of the water resource assessment in Khanasser Valley is to define strategies for the sustainable and more productive use of water resources in the valley.

Precipitation in the 2001/02 season was 183 mm in Qurbatiyeh, approximately 40 mm below the long-term average for the valley. The rainfall was distributed over the season as usual, with highest rainfall in December and January. A few high intensity events occurred and the maximum 15-minute intensity was 13 mm/hr (observed during a two hour storm in December at Umm-Mial). Some runoff occurred in the channels that drain the stony slopes of the Jabal Shbeith, but no major Wadi flow events took place this season.

The groundwater resource in Khanasser Valley has been assessed by using different methods:

- Groundwater level measurements, the most important diagnostic tool to assess groundwater changes, have been stepped up from 4 to 6 readings per year and more unused wells were included to fill the gaps in the piezometric maps and to minimize the distortion from pumping. A comparison of the water levels for a rectangular 48 km^2 area in the middle of the valley revealed a slight drop in water levels since the first water level measurements in May 1998, despite the ban on cotton cultivation and above-average rainfall during the 2000-2001 season (Fig. 2).

- Deep soil augering revealed dry conditions at about 5 m depth in the valley bottom. Recharge is, thus, expected to result primarily from lateral contributions from the hillslopes and from temporarily flooded areas. Results of the biannual water quality and isotope analysis indicated recent recharge and a relatively short turnover time in the alluvial Quaternary formation. The Paleogene limestone aquifer seems to have a long turnover time, indicated by the near absence of Tritium (3H). A hydraulic connection between the Paleogene and the deep Cretaceous aquifer was excluded (based on a comparison of Deuterium and Oxygen-18 levels).

- Salinity in the northern part of the Khanasser Valley is most likely the result of upconing of saline water from Jaboul Lake due to pumping, as indicated by the isotopic conformity of the water samples. In other areas the salinity of the groundwater may be due to the dissolution of lacustrine deposits in the Quaternary aquifer. In May 2002, the EC averaged 7.3 dS/m for the 48 km^2 of the central valley area.

- On a larger scale, the structure of an aquifer can only be understood with the help of geophysical methods, such as the geoelectrical soundings.
  Ten geoelectrical profiles across the valley have been studied and analyzed, using a maximum current electrode spacing of 500 m. The obtained interpretative results indicate that electrical resistivity in the valley is generally very low (3m) due to salt water. On the contrary, Jabal Al-Hass and Jabal Shbeith are characterized by high resistivity, due to the presence of basalt formations. Precise thicknesses of Quaternary and Paleogene as well as basalt formations have been determined.

- The transmissivities of the geologic formations, determined from 10 pumping tests in existing wells, are in the order of 10-4 m^2/s for the Quaternary and 10-6 m^2/s for the Paleogene aquifers.

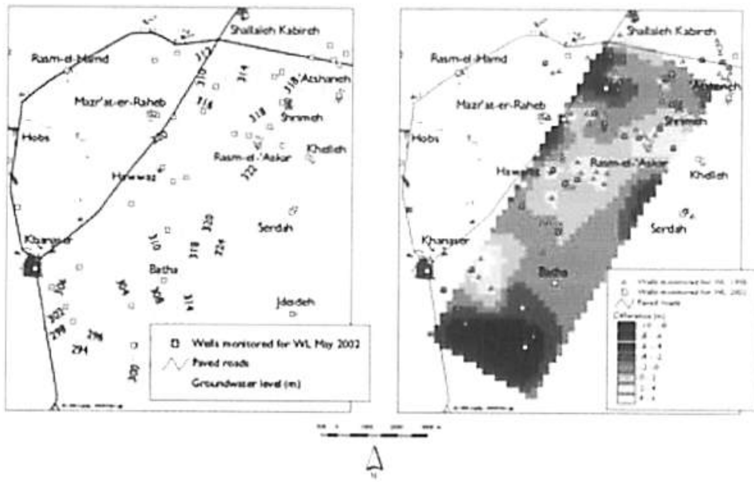


Fig.2. Water levels in May 2002 and comparative changes to 1998.

Obviously, the groundwater situation in Khanasser Valley is worrisome. The upper aquifer system receives little recharge. The groundwater table has gone down substantially during the last two decades, and still shows a downward trend. The majority of the irrigation wells tap groundwater that is too saline to be used for several purposes. Along the hill ranges in the northeast and west, the water quality is good, but extremely limited, especially in summer.

Farmers have recently adopted sprinkler and drip irrigation systems. In a dry area as Khanasser Valley, a little water supplied at the right time, can make the difference between harvesting a crop or abandoning the crop for grazing by sheep. Therefore, understanding of the irrigation practices in the valley and implementation of effective salinity control measures and improved water-use efficiency are critical.

Soil resources

Water erosion

A reconnaissance soil erosion survey was conducted in Khanasser Valley near Yakhour (a village in the northwest of Syria, where olive orchards are the dominant land use). The survey is mainly based on field observations and complemented by analyzing IKONOS satellite images. In selected subcatchments (i.e. Jedeideh, Rashadieh, Yakhour) detailed surveys were conducted. Soil erosion features/damages, land use and agricultural practices were recorded by using a GPS-receiver, and the field data were downloaded to GIS. Topographical maps and terrain models were prepared to visualize the erosion patterns and to analyze their relationship to the topographical situation. In cooperation with the Atomic Energy Commission of Syria (AECS), a Caesium-137 study was started to gain more detailed information about soil displacement by erosion during the last 40-45 years.

The first results show that rills are the dominant soil erosion forms, both in the subcatchments of Khanasser Valley and at the steep slopes of Yakhour. Several causes for the erosion damages could be detected:
Overgrazing of the slopes by sheep and goats (mainly in Khanasser Valley).
Lack of maintenance of ancient terrace structures (Khanasser Valley).
Inappropriate agricultural practices (especially up and down tillage).
Uncontrolled runon of surface water from roads, tracks, and (animal) paths.
Also, Wadi bank erosion plays a role in the deterioration of agricultural land in both study areas.

Wind erosion
Evidence of wind erosion is widespread in the region. To quantify the extent of windblown dust and to assess the factors that affect the susceptibility to wind erosion, a four-year study was carried out in Khanasser Valley.

In the valley floor, cultivation of rainfed barley using conventional tillage had spread over the past decades due to mechanization, reducing the area of natural grazing land. After harvest, the stubble is grazed leaving the land bare and vulnerable to wind erosion during the following hot and dry summer months. BSNE (Big Spring Number Eight) samplers were used to measure the horizontal flux of airborne dust between 0 and 100 cm above the surface. Samplers were installed during the summer months of 1998 till 2001 at two locations in Khanasser Valley: i.e. on rainfed, grazed barley fields in the valley, and on natural grazing land on the plateau.

The results of four seasons of wind erosion showed that there is substantial movement of windblown material, and that the quantity of airborne materials transported by the wind was related to soil management, wind velocity, and soil surface conditions. The nature of the windblown material was assessed in detail:

- The airborne mass consisted of light soil constituents, such as organic matter, clay, and silt. The blown mass was composed of 50 to 83% suspension particles; the coarser mode or saltation particles (0.1-0.5 μm diameter) varied between 15 and 33%, and the creep-size particles ranged between 1 and 17%. The grain-size distribution of sediments transported above a wind-eroded surface was strongly influenced by the grain size and structure of the surface material. Fine-grained disturbed soils with a high percentage of clay yielded a higher percentage of fine airborne particles for an equal amount of horizontal soil movement, compared to disturbed soils with lower clay content.

- Nutrient and organic matter content of the airborne sediments exceeded the amounts in the parent soils, indicating that wind erosion contributes to nutrient depletion of the source areas.

The mass flux of wind-eroded airborne material from cropland was markedly higher than from degraded grazing land. In addition, the percentage of suspension was always higher at the cropland sites in the valley floor than at the natural grazing land on the plateau. This indicates that due to heavy sheep grazing of the barley stubble, the soil surface in the valley is more disturbed and more susceptible to wind erosion of the finer fractions.

The observed relationships between eroded soil mass and soil-erodibility indices showed that improved land management, especially an improvement of the soil organic matter status, could reduce wind erosion hazards in the Khanasser Valley.

The vegetation of Al-Hass and Shbeith mountains

The objective of the vegetation resource assessment survey in Khanasser Valley is to define strategies for the sustainable and more productive use of pasture resources in the valley. The species survey showed that the flora of Al-Hass and Shbeith contain 198 species, belonging to 40 families and 153 genera. Annual and biennial species are dominant as far as their number is concerned (116 species), followed by perennials (57 species), semi-shrubs (16 species), trees (8 species) and one species of shrub (*Anagyris foetida*). Fifty-five species (29%) are common to the Mediterranean botanical region, 46 species (25%) are common to Irano-Turanian region, and also 46 species (25%) are transitional (i.e. they occur in both Mediterranean and Irano-Turanian regions). This is adequate evidence to classify the study area under the Mediterranian-Irano-Turanian region.

The climax vegetation of the region was probably dry steppe-forest, based on the following observations:

- The botanical geographical aspect of the species identified.
- The identification of eight arboreal species (recorded in the area for the first time): *Pistacia atlantica*, *P. khinjuk*, *Crataegus azarolus*, *Prunus microcarpa*, *P. prostrata*, *Rhamnus palaestina*, *Zizyphus louts* and *Ficus carica* var. *caprificus*.
- The finding of the association of *Crataegus azarolus* at many sites.

The climax vegetation was probably destroyed by cutting, ploughing and heavy grazing, which removed the trees layer and replaced the valuable semi-shrubs fodder by less palatable or spiny species. In some sites around settlements, the vegetation was reduced through overgrazing into an extremely poor *Peganum harmala-Carex stenophlla* community, with no ability to sustain livestock.

Comparison between fenced and non-fenced grazed vegetation showed that protection for a few years does not result in regeneration of the species of the previous dry steppe-forest vegetation and its potential productivity. Therefore, reintroduction of climax species may be necessary to rehabilitate the region. Such activity should involve planting arboreal, semi-shrubs and annual species to assure continuous forage vegetation over the year. Species that should be planted in the area are:

- Trees: *Pistacia atlantica*, *Pyrus syriaca*, *Crataegus* and *Rhus coriaria*
- Semi-shrubs: *Kochia prostrata*, *Salsola vermiculata* and species of *Atriplex*
- Annuals: *Kochia scoparia*, *Avena barbata* and other species of the Leguminosae family

Agro-ecological similarity analysis

For the purpose of future outscaling of the expected research results of the Khanasser Valley integrated research site, the extrapolation domain needs to be defined from an agroecological and socioeconomic perspective. A first step is to define areas with a climate similar to Khanasser. According to the UNESCO classification of the arid zones, Khanasser Valley is located in the 'arid, cool winter and warm summer' agroclimatic zone. Using the UNESCO map of arid zones (1979) as reference, the same climate occurs in approximately 4.4% of CWANA, or about 12% of all arid areas in CWANA (Fig.3). This assessment of the climatic extrapolation domain is a first assessment. By using topography-guided spatial interpolation methods and a denser meteorological database, it will be possible to improve the spatial extent of Figure 3, to revise the area estimates for the different agroclimatic zones, and to assess similarity in a more quantified way.

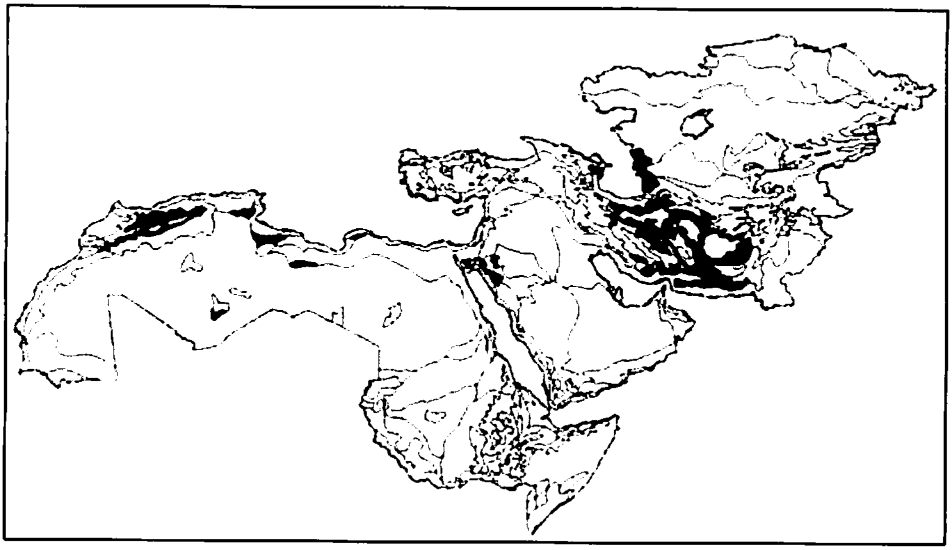


Fig. 3. Areas with similar agroclimatic conditions to Khanasser Valley.

Technology development and evaluation

Farmers perceived the following 'best-bet' technologies (or technologies worthwhile to invest in) during the PTE day:

- Crops: Vetch, olive trees, cumin, barley and other income generating crops (e.g. capers).
- Livestock: Sheep fattening, improved animal health and reproduction (rams)
- Resource management: Particularly those aimed at better water availability and use

In addition, there was an overwhelming demand for new ways to overcome financial constraints, namely through facilitated and more widely accessible and flexible credit.

Extensive livestock-barley system

In total, five technologies are being tested to improve the dominant and traditional extensive livestock-barley farming system in Khanasser Valley. Three of them are reported here. The two others are: vetch and participatory breeding of barley varieties (by the Germplasm Program).

Phosphogypsum (PG) as soil conditioner to improve barley yields
PG is a residue product of the phosphorus fertilizer industry, and is available in large quantities in Syria. PG is known as a soil conditioner, which can improve the physical and chemical characteristics of soils. The objective of this experiment is to test the effect of PG on physical and chemical soil properties and on barley yields in Khanasser Valley. 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/ha) were applied at each site.

The first year result shows that adding PG significantly increased the total biomass and grain yield of barley compared to the control (see Table 3). PG application also significantly increased the crop chlorophyll content by about 28%, plant height by 20-36%, and number of tillers by 63-78%, compared with the control plots.Comparison between the effects of the 40 t/ha PG and the P fertilizer applications shows that PG resulted in a better crop response: 40% higher for biomass and 36% higher for barley grain yield (Table 3). This would indicate that the benefit of PG is not only caused by the additional phosphorus, but that also the soil physical conditions are improved. This would be especially beneficial for the early crop growth. Soil moisture measurements in spring indicated that there was about 1.3 to 3.5% more soil water in the top 60 cm soil profile, which was beneficial during the flowering and grain filling periods. The experiment will be repeated for another three years, to see whether the effects of PG on barley yield are lasting.

Table 3. Effect of phosphogypsum (PG) application on barley yields (N=8).

Treatments	Barley grain yield (kg/ha)	Grain yield increase over the control (%)	Barley total biomass (kg/ha)
	Average (SD)	Average	Average (SD)
Control	629 (135)	0	1,325 (137)
P2O5 (50 kg/ha)	773 (179)	+ 24	1,581 (350)
PG (20 ton/ha)	932 (290)	+ 47	1,968 (398)
PG (40 ton/ha)	1,055 (366)	+ 66	2,219 (430)

Barley-vetch strip-crop water harvesting
To improve grain yields in areas where rainfall is not sufficient during the majority of the years, a strip-crop water-harvesting system, with selected varieties of barley and vetch grown in rotation, is being tested in Qurbatiyeh. Crops are planted in a 2m wide strip along the contour. In between the cultivated strips, strips are left bare (i.e. runoff strips). Part of the rainfall that falls on the runoff strips is expected to flow as surface runoff down the slope into the planted strips. In this way, extra water is provided to the crop.

Four different cultivated/runoff area ratios were tested: 1:0, 1:1, 1:2, and 1:3. Fertilizer is applied to half of the plots. Four drought-tolerant barley ('Arta', 'Harmal', 'Rihan', 'Zambaka') and vetch genotypes (*Vicia hybrida, Vicia dasycarpa, Vicia narbonensis, Vicia sativa*) were selected.
The first season (2000/01) was wet (318 mm) and yields were high, but there was no clear effect of water harvesting. As *V. hybrida* did not perform well in 2000/01, it was replaced by *Lathyrus sativus* in 2001/02. The 2001/02 season received below-average rainfall (182 mm) and the effect of the water-harvesting system improved. As a consequence, the average barley grain yield was 19% higher on the plots with water harvesting as compared to the plots without water harvesting. However, vetch did not benefit from the water harvesting.

***Intercropping of barley between saltbushes* (Atriplex halimus)**
The objective of this study 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) inside farmers' barley fields in the marginal areas of Khanasser.

Preliminary results of mean values show that yield of both barley grain and straw is enhanced in the intercropped alleys, and this higher yield compensates 10.6% more for the reduction in cropping area. Average total barley yield was 1,313 kg/ha on the control fields and 1,614 kg/ha on fields with shrub hedgerows (calculated on the assumption that the shrubs exclude barley from 10% of the field). The shrub foliage adds on average an additional 24% biomass to the yield from barley in the intercropped field. (More complete results and data are presented in Project 2.4.).

Annual cash crops
Some annual cash crops and medicinal plants can rapidly generate incomes, while not degrading-or in some cases actually improving-the land. While some of these can be cultivated (primarily cumin and wheat), others are wild plants which are typically harvested in pasture land by women and children.

During the last few years, cumin cultivation has experienced a great boost, driven by its good prices and relatively low water requirements. However, unstable prices and improper management have recently affected incomes from this crop. As a result, many poor farmers lack the capital to purchase the right inputs and to crop it in appropriate ways. To reduce risks in the early expansion phase at Khanasser, an evaluation of profitability, risks (particularly prices, diseases and drought) and local sustainability is being conducted.

Despite unreliable demand, we hypothesize that proper management of cumin can increase farmers' incomes without degrading the land. During 2002, cumin trials in Tel Hadya and socioeconomic comparative analysis of the profitability and international marketability of cumin under different conditions have been carried out. We now plan to work with farmer interest groups to directly assess with them this crop and to test solutions for recognized constraints in a participatory way.

For the medicinal plants, KVIRS in cooperation with the Jabal Al-Hass project, are identifying the potential options, their spatial extent and relevance, the possible beneficiary households and communities, and the marketing system.

Fruit trees

Fruit trees are not a traditional production system in Khanasser Valley. In the early 1990s, only a few olive orchards existed in the valley. Although olive is a drought-resistant tree, the low and unreliable annual rainfall (< 250 mm) and the lack of knowledge regarding orchard management, make it difficult for farmers to grow trees in this harsh environment. While lack in knowledge regarding olive husbandry can be solved by farmer field days and extension activities, potential solutions for the water shortage problem need to be tested. To manage this problem, water harvesting is being implemented in similar areas of the world. Therefore, an experiment was launched in Khanasser to study the feasibility and the effect of semicircular water-harvesting dikes on soil moisture content and olive growth. This was implemented in a 4-year-old olive grove located at the hillsides of Hobs village.

The water-harvesting system proved to be beneficial in this site although the amount of water harvested in the 2001/02 rainy season was relatively low due to low and erratic rainfall (148 mm). However, when there was some intense rain (from November to January), water content in the target area (located in the tree basin at 0.5 m from the trunk) increased at a higher rate compared to other points located higher along the slope (at 1.2 m and 4 m from the trunk) (Fig.4). In a wet year, the benefits of this water-harvesting system could be substantially higher. Therefore, to assess the benefits of this technique under Khanasser Valley conditions, it is necessary to continue this study for several years.

In addition to this experiment, a participatory research has been launched with experienced olive growers in Khanasser Valley aiming at solving the problems that farmers encounter. In addition to water harvesting, this work will focus on stone mulch and irrigation scheduling in order to provide integrated solutions for the water shortage problem.

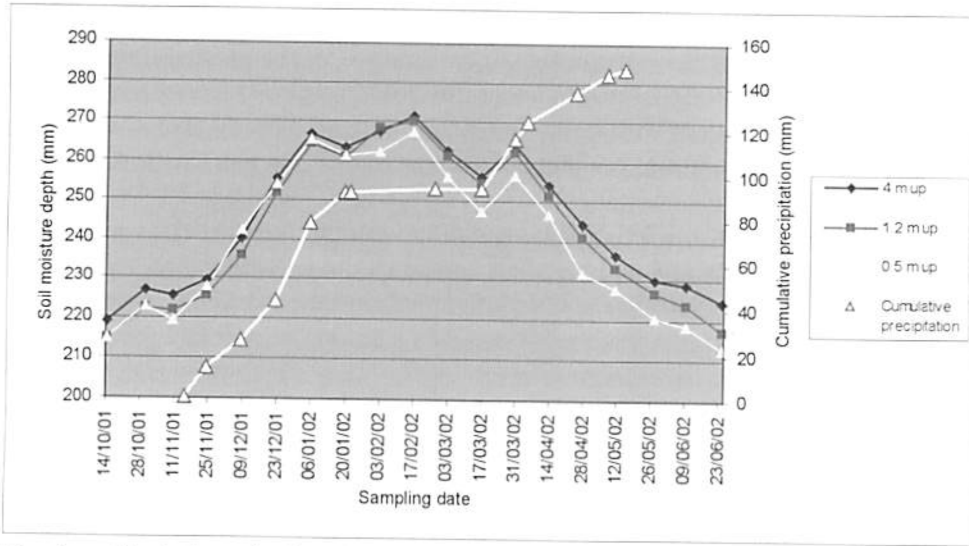


Fig. 4. Evolution of soil moisture depth and cumulative precipitation during the 2001/'02 rainy season (values are an average of four trees with water-harvesting systems).

Summary

During 2002, major progress was made towards integrating of the different sectoral research activities and towards involving different stakeholders. The 'Integrated Natural Resources Management' (INRM) approach was found to be a useful framework to guide this integrative and consultative process. The clustering of research topics in an interdisciplinary table was a major tool to clarify roles of different research partners, inside and outside ICARDA. Collaboration with Syrian NARs has been intensified and four memoranda of understanding have been prepared.

Farmer participatory research (FPR) was operationalized in 2002. The FPR training of fieldworkers was aimed at changing the perspective from supply-driven to demand-driven technology development, and to increase the participation of farmers in the research process. First steps were made in this direction and the first results are promising. The FPR work is complementing the on-going contractual on-farm research.

The 'multi-level framework' was used as the diagnostic backbone, to which the other diagnostic tools are linked and integrated. This framework integrates socioeconomic aspects and biophysical aspects.

On both 'pillars', significant progress has been made. A striking factor is the diversity of livelihood strategies and their responsiveness to new land-use restrictions and resource decline. Our understanding of the natural resources status and use has also progressed significantly, especially for ground water, hillslope vegetation and soil loss by water and wind erosion. The general picture that appears is one of unsustainable over-use and degradation of natural resources.

The extensive livestock-barley system is the traditional farming practise at Khanasser. However, alternative farming enterprises are gaining fast popularity. They are sheep fattening, annual cash crops and fruit trees. Since the beginning of the project, most emphasis has been given to find options for the traditional farming system. During 2002, research has widened to include technologies for the alternative farming enterprises as well, especially for olives, cumin and sheep fattening. The first results on phosphogypsum, *Atriplex* and water harvesting for olive trees results are promising.

References

Ellis, F. 2000. Rural livelihoods and diversity in developing countries. Oxford University Press, New York.

UNESCO. 1979. Map of the world distribution of arid regions. Map at scale 1:25,000,000 with explanatory note. UNESCO, Paris, 54 pp.

APPENDIX: STAFF LIST, COLLABORATORS, TRAINING, FINANCIAL SUPPORT AND PUBLICATIONS RELATED TO KVIRS

Staff list

ICARDA research group (including students and consultants)

Director's office

Richard Thomas
Afif Dakermanji

Agricultural economics

Aden Aw-Hassan
Roberto La Rovere
Malika Martini
Ahmed Mazid
Hisham Salahieh
George Arab

Agronomy

Mustafa Pala
Atef Haddad
Haitham Halimeh

Agroecological characterization

Eddy De-Pauw

Barley breeding

Salvatore Ceccarelli
Stefania Grando
Michel Michel

KVIRS Kasem Al-Ahmad

Livestock

Luis Iniguez
Birgitte Hartwell
Adnan Termanini

Pasture and fodder

James Tiedeman
Rafik Mabkboul
Amin Khatib
Fahim Ghassali
Nabil Battikha
Bader Idelbi
Rima Al-Tarsha (Student)

Soil conservation/land management

Francis Turkelboom (Project Coordinator)
Zuhair Masri
Wilko Schweers
Ashraf Tubeileh (Consultant)
Alois Klewinghaus
Haben Asgedom
Piero D'Alton (Consultant)
Mohamed El-Ali
Rochene Haj Abdo

Soil fertility

John Ryan

Water management

Adriana Bruggeman
Theib Oweis
Pierre Hayek
Jihad Abdullah
Ahmed Hamwieh
Ali Haj Dibo

Collaborators

Bonn University

Armin Rieser	(Coordinator) Soil and Water Management
Armin Skowronek	Soil Management Scientist
Mathias Becker	Soil Fertility Scientist

AEC-S

Fares Asfary	(Coordinator) Soil Fertility
Bolos Abu Zakhem	Hydrologist
Gamal Asfahany	Geophysist
Mohammad Al-Oudat	Rangeland Ecologist

	Salwa Kanaktry	Land Resources
	Nazir Kedkwy	Hydrologist
	Iyad Suleiman	Hydrologist
	Iyad Abu-Mady	Hydrologist
	Usama El-Dajany	Hydrologist
	Muhsen Makhloof	Soil Fertility
	Ja'afar Mohamed	Hydrologist
	Abdul-Karim Al-Razzook	Neutron Probe
JAH (UNDP)		
	Abdul-Razzak Duksy	(contact person) Director
	Younes Hawwary	Extension
	Ahmad Jaddoo'a	Medicinal Plants
	Mohammad Mokaddam	Veterinary
	Nadya Yazgy	Gender
	Mahmood Al-Asa'ad	Human Resources
JAH (IFAD)		
	Issam Zannoon	Director
	May Lubbos	(contact person) Gender
	Ahmad Mjouaz	Extension
	Hassan El-Saleh	Water Resources
Olive Bureau		
	Mufeed Khayzaran	(contact person) Director
	Mustafa M. Al-Rasheed	Pathologist
	Malek Abdeen	Soil Fertility
	Adnan Sheikh Bakry	Olive Resources
	Ahmad Al-Bashy	Pathologist
	Husam Al-Naeb	Olive Resources
Extension (Damascus)		
	Darwish El-Sheikh	(contact person) Director
	Abdallah Khabbaz	Technology Transfer
	Hasan Al-Rashy	Technology Transfer
Extension (Aleppo)		
	Ghazzan Ziadeh	(contact person) Head
	Faez Amer	Media
Agricultural Section of Sfeireh		
	Ali Swedan	Head
	Farid Fayyad	Agri. Resources
	Mahmood Al-Juma'a	Extension
	Mohamad Adib El-Ali	Extension
	Mohamad Basrawy	Extension

Training activities

PhD research of Alois Klewinghaus (University of Bonn and ICARDA) on: "Soil erosion assessment for sustainable land management in semiarid NW-Syria".

PhD research of Haben Asgedom (University of Bonn and ICARDA) on: "The effects of land use and crop management on water and nutrient availability in barley and forage legumes".

MSc research of Rima Al-Tarsha (Aleppo University) on pasture management at Khanasser Valley.

Individual non-degree training course by Ashraf Tubeileh on: "Growing olive trees in Khanasser Valley-Feasibility and potential" (July and August).

Water-use efficiency JICA/ICARDA course: 3 week field study and interdisciplinary teamwork at Khanasser sub-catchment of 6 trainees (May).

Financial support

The operational budget and costs for four staff (two PhD and two Post-Doc) are paid by BMZ, Germany.

ICARDA core and restricted budget is used to pay for ICARDA's staff time and some of the operational costs.

Publications

Non-refereed publications

La Rovere, R., Aw-Hassan, A. and Arab, G. 2002. Impact of policy and ecological changes on livelihood dynamics on the fringes of Syrian rangelands. Submitted to International Rangeland Conference, Durban, South Africa, 2003.

Masri, Z. 2002. Time-tested pitcher irrigation helps green the slopes of Khanasser Valley. Caravan No. 16, June 2002. ICARDA. p.39-40.

Masri, Z. and Zöbisch, M. 2002. Indicators of soil erodibility of dryland degradation-hazards assessments: A case study of Khanasser Valley northwestern Syria. 3rd International Symposium, 2002, Egypt.

Masri, Z., Zöbisch, M., Bruggeman, A., Hayek, P. and Kardous, M. 2002. Wind erosion in a marginal Mediterranean dryland area: a case study from the Khanasser Valley, Syria. Presentation at the Fifth International Conference on Aeolian Research and the Global Change and Terrestrial Ecosystems-Soil Erosion Network (Wind), July 22-25, 2002 at Texas Tech University, Lubbock Texas Lubbock Texas (USA).

Schweers, W., Bruggeman, A., Abu-Zhakem, B., Asfahani, J. and Kasmo, B. 2002. Assessment of groundwater resources for sustainable management in the Khanasser Valley, northwest Syria. Presented at the ACSAD/BGR Workshop on Soil and Groundwater Quality: Monitoring, Management and Protection, Amman, 23 - 25 June 2002.

Zöbisch, M. and Masri, Z. 2002. Natural restoration of degraded grazing land. 17th WCSS, Bangkok, Thailand.

Other publications

Al-Oudat, M. 2002. Flora characterization for Al-Hass and Shbeith mountains. AECS.

KVIRS. 2002. Field notes for the fieldtrip of the 4th INRM workshop, Khanasser Valley: NRM integration at work, 17 September 2002. KVIRS, ICARDA.

La Rovere, R. and Turkelboom, F. (compilers). 2002. Report of the farmers' participatory technology evaluation day (PTE) at Khanasser Valley, April 3rd 2002. KVIRS (NRMP-ICARDA & AECS).

Mazid, A. and Aw-Hassan, A. (asssited by Salahieh, H. and Arab, G.). 2002. An integrated approach to sustainable land management in dry areas: the Khanasser Valley integrated research site, socioeconomic component: Land user characterization. Research Report (draft), KVIRS, ICARDA.

Siderius, C. 2002. Water use and water harvesting in olive orchards on the stony slopes of Khanasser Valley, Syria. Erosion and Soil and Water Conservation Group, Environmental Sciences, Wageningen University.

Stür, W., La Rovere, R., Turkelboom, F. and El-Khatib, R. 2002. Report on the farmer participatory research (FPR) workshop for the Khanasser Valley integrated research site (KVIRS) held at ICARDA, 20-31 October 2002. KVIRS, ICARDA.

Tubeileh, A. 2002. Adaptability and potential of olive trees to rainfed semi-arid conditions in Syria: A case study at Khanasser Valley (Draft). KVIRS, ICARDA. pp.75.

Tubeileh, A. 2002. Effect of a water harvesting system on soil moisture in olive-tree orchards in Khanasser Valley (Draft). KVIRS, ICARDA. pp.20.

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

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.

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 region-wide 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.

Output 3: Comprehensive physical frameworks of CWANA

'Hot spot' assessment of land cover change and land degradation in CWANA using AVHRR satellite imagery

David Celis and Eddy De Pauw

Background

Land degradation is one of the most serious threats to the prosperity of rural populations in dryland areas. One of the major problems in combating land degradation in ICARDA's mandate region is a shortage of reliable basic data on the extent and severity of land degradation. An unequivocal identification of land degradation in dryland areas requires that processes related to aridity and natural climatic fluctuations are separated from human-induced negative trends. This may be easy for some forms of land degradation, e.g. water erosion, but difficult for others, such as vegetation degradation, a widespread phenomenon in West Asia and North Africa.

In a dryland region as huge and diverse as CWANA, with limited reliable ground-based resource inventories and monitoring systems, remote sensing presents a highly valuable tool to get a grip on the highly complex issue of land degradation.

Through the system of the Advanced Very High Resolution Radiometer (AVHRR) satellites, a global platform exists for the continuous space-based monitoring of the vegetation cover of the world since 1982.

Although covering a relatively short period and with rather coarse resolution (8 km), it is the only consistent dataset that permits the detection of trends in land use/land cover change at global and regional scales.

Objective

At the level of CWANA a time series of AVHRR imagery could thus be used for delineating 'hot spots' of land use/land cover change. The main advantage of the 'hot spots' approach is that it allows zooming into 'target areas' for more detailed observations through ground-based characterization and monitoring assisted by high-resolution satellite information such as Landsat. In view of the problems of the short time series, the low resolution, and the difficulties involved in distinguishing genuine trends in the land cover from short-term fluctuations in biomass as a result of year-to-year weather variations, a specific methodology has been developed.

Progress of research

Six hundred and twelve 10-daily composites of 8km-AVHRR reflectance data, covering the period from January 1982 to December 2000, were downloaded from the relevant NASA Web site for band 1 (0.58-0.68 m) and band 2 (0.725-1.1 m). No complete time series was available for the year 1994. These data consisted of separate subsets for Africa (top left: 37.9 N, -20 W; lower right -2 S, 59.9 E) and Asia (top left 59 N, 26.5 E; lower right 4.5 S, 91 E), in 16-bit unsigned format and in Goode's Homolosine Interrupted Space projection. The data were imported as layer stacks and both subsets were mosaiced to form a complete coverage of the CWANA region. The Normalized Difference Vegetation Index (NDVI) was calculated and aggregated into monthly NDVI composites in order to reduce the effects of cloud cover. Additional corrections for noise and sensor drift were made, as well as conversion to geographic projection and merger into a single CWANA dataset.

In order to convert this temporal NDVI dataset into a land use/land cover classification, two procedures were developed. The first procedure consisted of a hierarchical decision-tree (Figure 1) based on the average values of the classifiers (NDV – and NDVI ...), which take account of average weather conditions (Celis and De Pauw, 2003).

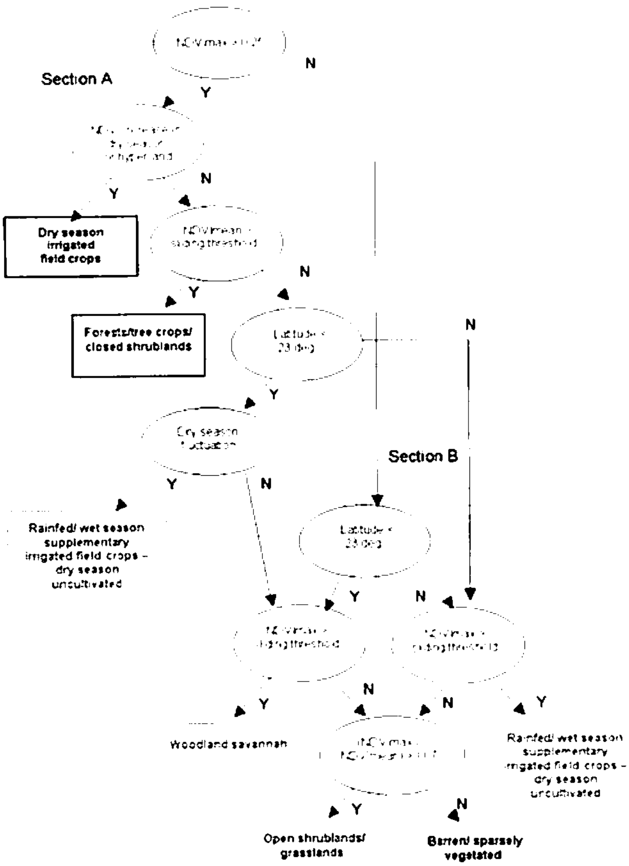


Fig. 1. Hierarchical decision-tree for land use/land cover assessment.

To account also for the fact that in any particular year the actual weather can differ substantially from the average, a second procedure was developed to adjust the NDVI thresholds of the hierarchical decision-tree for different agroclimatic zones. Using the above algorithm for land use/land cover classification, 17 annual land cover maps were produced for each year in the period 1982-1999. This dataset was further condensed into four maps, showing the majority land cover classes for the following three-year key periods: 1982-1984, 1987-1989, 1992-1994, and 1997-1999 (Figure 2).*(on the left the land cover classes for the years 1987, 1988, 1989; on the right the majority land cover class).*

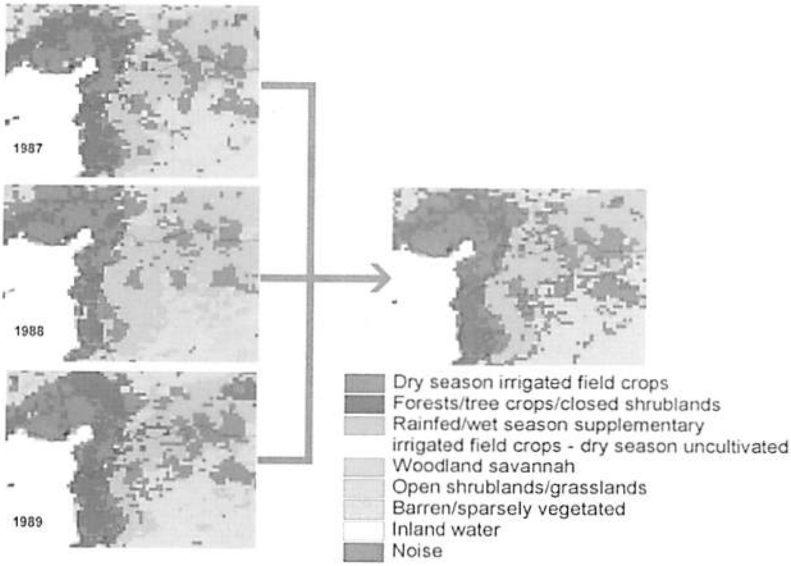


Fig. 2. Majority land-cover classes for different years, subset northwest Syria.

For each of the sampled three-year periods the majority land cover type in each pixel was retained. Depending on the value and sequence of this majority land cover type, the following kinds of change were allocated to each pixel: noise, stable land use/land cover, stable land use/land cover mosaic and change pattern (Table 1). Seventeen stable classes were recognized, as well as 66 change patterns, which were regrouped into 22 change classes and four change trends *('intensification of agriculture', 'intensification of natural vegetation', retrenchment of agriculture', and 'retrenchment of natural vegetation')*. On the basis of this hierarchical classification 'change maps' were prepared for the CWANA region (Figure 3), and areas belonging to individual change combinations, change classes and change trends were calculated.

On the basis of this exploratory assessment for CWANA, it is concluded that in terms of land area, the most dramatic changes in land cover have occurred in the Sahel, followed by North Central Asia (Figure 4).

Table 1. Change detection scheme.

4 equal classes:
A A A A; B B B B = Stable
Permanent change from one class to another:
A B B B; A A B B; A A A B; = Change
B A A A; B B A A; B B B A
Other combinations of two classes with
A = 'Grasslands/open shrublands' or 'Barren/sparsely vegetated'
C = 'Dry season irrigated field crops' or 'Rainfed/wet season supplementary irrigated field crops':
A C A A; A C C A; A A C A = Change from A to C
A C A C; C C A C; C A C A; C A A C; = Stable mosaic A/C
C A C C
Other combinations:
A A B A; A B A A; A B A B; A B B A; = Stable mosaic A/B
B B A B; B A B B; B A B A; B A A B
Three or Four classes or noise class (E):
A B C A; A B C D; A E A A; A A B E = Noise

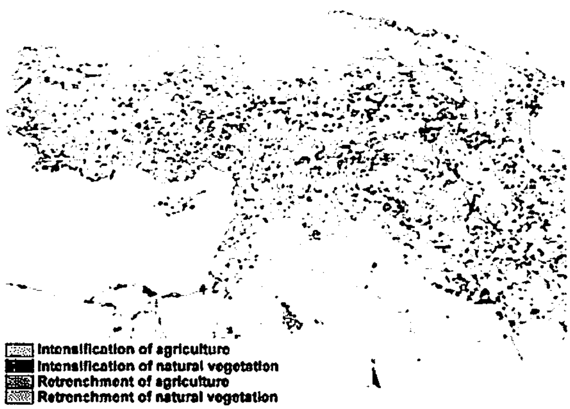


Fig. 3. Example of a 'change map' showing the spatial distribution of land cover change trends in the Near East and the Caucasus.

In the former region, approximately 75 million hectare changed from one land cover to another. In the latter, 43 million hectare changed. In relative terms, the regions where the most change occurred are the Middle East and the Sahel, where about 14% of the land cover changed. On the other hand, even in the regions with the highest change in land cover, most of the land has remained stable during the period 1982-1999.

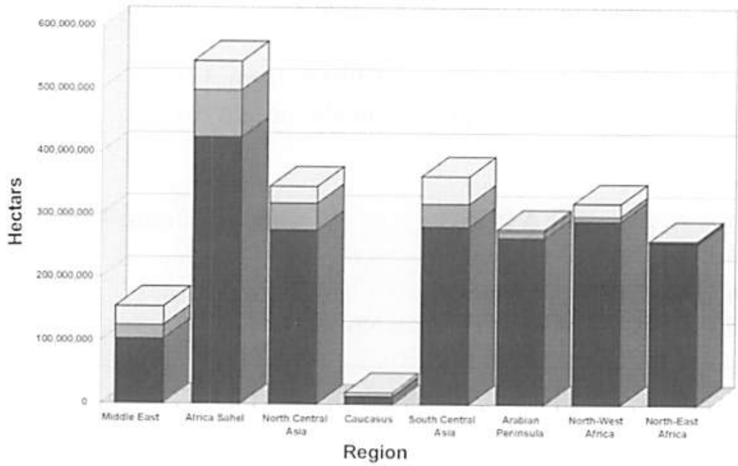


Fig. 4. Stability of land cover/land use.

At the onset of this study it was expected that within CWANA two major trends in land use/land cover change would occur: intensification of agriculture and land degradation, as indirectly evidenced by biomass decline in both natural vegetation and agriculture. However, the analysis of the 1982-2000 AVHRR time series indicates a more complex picture, with some remarkable and often unexpected trends of land use/land cover change in different subregions of CWANA. In most subregions intensification of agriculture is a major, if not the predominant trend (Figure 5). Particularly, the Near East has experienced a remarkable degree of intensification of agriculture, mainly by the conversion of rainfed into irrigated croplands. However, retrenchment of agriculture and natural vegetation, which are potential indicators of land degradation, but also intensification of natural vegetation, are other important trends throughout CWANA, with significant differences between subregions.

On a subregional basis the change trends can be quite different. The main trend in the Maghreb is an intensification of agriculture. This occurred mostly through deforestation to develop irrigated and rainfed cropland in the coastal zone, and by converting bare land into irrigated croplands inland. A second trend involves a retrenchment of agriculture, which occurred inland, where both rainfed and irrigated fields were taken out of cultivation to become barren/sparsely vegetated areas. A third, less important, trend is one of intensification of the natural vegetation. This occurred mostly as a change from bare areas to grasslands/ open shrublands in the Atlas Mountains of Algeria.The only noticeable trends in Egypt are a retrenchment of agriculture on the right bank of the Nile, and intensification of agriculture at the western edge of the Nile delta.

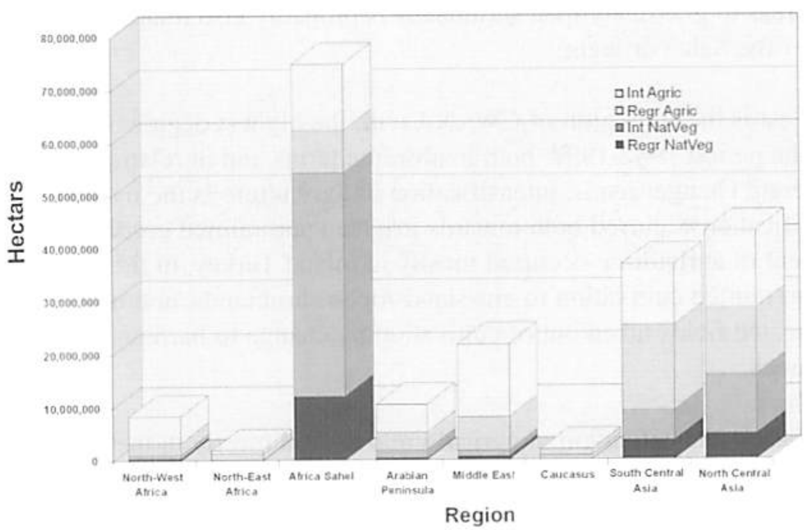


Fig. 5. Kinds of land cover/land use changes.

The major trend in the Sahel region was an intensification of natural vegetation, mainly in the form of a change from barren/sparsely vegetated areas to grasslands/open shrublands. In northern Sudan and Mauritania, the desert border shifted 100 to 150 km to the North. The Sahel experienced a drought from 1961 until 1984, followed by a period with normal rainfall. The northward shift of the desert boundary after 1984 can therefore be interpreted as a regeneration of the grasslands/open shrublands when rainfall returned to normal after the long drought cycle. In contrast with this general Sahelian trend, a retrenchment of the natural vegetation occurred in scattered areas. Intensification of agriculture occurred in southwestern Sudan and western Ethiopia, in the form of a change from rainfed field crops to tree crops or from woodland savannah to rainfed field crops. In the center of both Sudan and Ethiopia, a retrenchment of agriculture occurred, mainly in the form of a change from rainfed field crops to woodland savannah.

During the period 1982-1999, two contrasting trends of land cover change are observed in the Arabian Peninsula. A first trend of intensification of agriculture is due to the fact that since 1982 huge areas were converted into irrigated croplands, mostly in Saudi Arabia. In the same period a trend of retrenchment of agriculture is caused by the fact that large irrigated areas were also taken out of cultivation in Saudi Arabia. The observed intensification of natural vegetation at the edges of the Asir and Yemen Highlands in the form of a change from barren/sparsely vegetated areas to grassland/open shrublands is probably also related to increased rainfall after the Sahel drought.

The Near East is the subregion of CWANA with the highest degree of land cover change in the period 1982-1999, both in absolute terms and in relation to its size. Of the different change trends, intensification of agriculture is the most important one. Intensification occurred both towards irrigated and rainfed cropland. Retrenchment of agriculture occurred mostly in inland Turkey, in the form of a change from rainfed cultivation to grasslands/open shrublands, and in Iraq in the form of irrigated fields taken out of cultivation by change to barren/sparsely vegetated areas.

In the Caucasus, intensification of agriculture occurred mostly in the form of a change from rainfed fields to either tree crops or irrigated fields. A retrenchment of agriculture occurred mainly in the form of a change from irrigated fields to rainfed fields or from rainfed fields to grasslands/open shrublands.

A major trend of change in Central Asia is the intensification of agriculture, mostly in the form of a change from grasslands/open shrublands into rainfed cultivation. However, in other parts of the subregion the reverse trend, with a change from rainfed cultivation to grasslands/open shrublands has occurred. In addition, intensification of natural vegetation did occur in a major part of the region, mostly as a result of change from barren/sparsely vegetated areas to grass-lands/open shrublands. This intensification trend is very noticeable in southwest Kazakhstan near the Caspian Sea. The inverse trend, a change from grasslands/open shrublands into barren/sparsely vegetated areas, is particularly clear in central Kazakhstan.

The main trend in Southwest Asia is one of retrenchment of agriculture. This trend is particularly noticeable in Pakistan and Afghanistan, and has affected in particular the irrigated croplands. On the other hand, intensification of agriculture occurred as well throughout the region without any particular focus.

Conclusions

A general conclusion of this study is that, even after the year-to-year weather variations were compensated for, it is still difficult to understand the causes of the land use/land cover changes. An intensification of agriculture is the easiest to interpret because it is always human induced, whereas a retrenchment of agriculture can have three possible causes: long-term weather change, lack of inputs to maintain the cultivation or degradation of the natural resource base (too intensive use of natural resources). Both the intensification and the retrenchment of natural vegetation could be either human-induced or result from a longer-term change in weather. The identification of a trend towards denser natural vegetation proves the possibility of natural regeneration and puts the issue of land degradation in a more positive perspective.

The main advantage of the 'hot spots' approach is that it allows zooming into 'target areas', thus achieving considerable savings in time and financial resources. However, due to the low resolution of the imagery, there are considerable limitations to what can be seen. For this reason, a second assessment stage is necessary, in which the 'hot spots' are further characterized using ground-based observation networks complemented with high-resolution satellite imagery, such as Landsat or SPOT.

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

Agroecological zoning in northwest Iran

Eddy De Pauw, Abdolali Ghaffari, Vahid Ghassemi

Background

The dryland areas of Iran, for which the recently established Drylands Agricultural Research Institute *(DARI)* has a mandate, are characterized by considerable weather variability, as well as major abiotic stresses, in particular drought and cold. They are also very diverse in landscapes and soil patterns. The combination of these interacting factors leads to different agroecological conditions, which can be suitable for some crops, but marginal or unsuitable for others.

The intensification of crop production in these areas needs to take into consideration the agroecological diversity, and adapt cropping and land use patterns to the opportunities and constraints of each agroecological niche. In order to make proper recommendations for optimal land use, the interactions between soils, climate and crops, including fodder crops and forages, need to be studied. Such general understanding of the interactions between agroecological conditions and land use can be obtained by an integrated approach using an agroecological zones framework.

One further stage is to look not only at limitations of land, and ways to avoid them, but also at opportunities. Land suitability studies make it possible to match specific land uses to well-defined parts of landscapes. The principle of the approach is to find optimal combinations between land characteristics and requirements of different land uses. Land suitability studies can answer questions, such as "how suitable is this area for a specific crop?" Since they already have built in the principle of sustainable use, such studies are important tools for establishing sound land use recommendations.

Whereas land suitability studies are useful for planning and identifying new options for farmers, for the actual definition of an appropriate location-specific technological package, information related to the socioeconomic environment is at least as critical as a good characterization of the biophysical environment.

Objective

The objective of this study is to develop an agroecological zones framework for targeting germplasm to specific environments, formulating land use and land management recommendations, and assisting development planning.

Progress of research

Project design

In the framework of the Iran-ICARDA Collaborative Program, DARI and the Soil and Water Research Institute (SWRI), Tehran, agreed to undertake a multi-scale agroecological characterization of two basins in NW Iran. Both institutes are under the umbrella of the Agricultural Research and Extension Organization (AREO) of the Ministry of Agriculture. The institutes agreed to undertake, in a first stage, an agroecological zones study for the whole study area, covering parts of the Aras and the Daryache-Uromieh basin, followed by land evaluation studies. In a second stage, areas with special development needs or resource problems would be investigated in more detail using approaches of participatory land evaluation.

The Agroecological Characterization Project and GIS Lab at ICARDA would provide technical backstopping for this project.

Agroecological zones study

The first stage is to obtain an overview at scale 1:250,000 of the agroecological and production system diversity of the whole study area by delineation of the agroecological zones. The outcome of the study is the identification of areas with particular resource problems, or special development or conservation needs. The required activities for this study are listed in Table 2.

Table 2. Required activities for the agroecological zones study.

• Preparation of an inventory of available climate, soil, water resources, land use and farming systems data
• Analysis of satellite imagery for land cover/land use mapping and delineation of terrain units
• Creation of interpolated climate surfaces of the major parameters
• Delineation of agroecological zones by combining climate surfaces, land systems and soils in GIS
• Characterization of each agroecological zone in terms of resource components, current and potential land degradation, potential and constraints for major land uses
• Field work for validation of the established agroecological zones
• Rapid rural appraisals for identifying resource management problems in the different agroecological zones

Land evaluation studies

The agroecological zones study will be followed by land evaluation for specified land utilization types. The land evaluation study will also cover the whole survey area and will be undertaken at the same scale (1:250,000). The outcome of this study will be the identification of spatially differentiated land use options and recommendations for land use, which could lead to an initial land use plan at provincial level. The required activities for this study are listed in Table 3.

This study requires the collection of sufficient socioeconomic background information to characterize the land utilization types of the area in sufficient detail for the purpose of a small-scale land evaluation study. This may necessitate field surveys in the form of rapid rural appraisals.

Table 3. Required activities for the land evaluation studies.

- Community-level agroecological characterization incorporating traditional knowledge
- Land suitability classification for different agroecological units
- Validation and modification of the land suitability classification
- Development of land user typology
- Development of land use/management packages for different agroecological units and land user groups

Participatory agroecological characterization for technology transfer

The focus of these studies will be on areas with specific resource degradation problems or development needs, identified during the first and second stage of the study. The areas can be catchments or sub-provincial administrative units, managed by communities. Whereas in the more general studies at provincial level conventional land resource appraisal techniques are used to assist land use planning, in these studies at community level participatory techniques need to be applied for the definition of location-specific technologies and management practices and land use regulations.

The outcome of these studies should be concrete recommendations in the form of technological packages to enhance land use productivity, farmer incomes and environmental sustainability.The expected major activities for this study are listed in Table 4.

Table 4. Required activities for the land evaluation studies.

- Identification of land utilization types
- Creation of crop requirement tables
- Definition of homogeneous land units
- Matching requirements of land utilization types with land unit characteristics
- Developing land use recommendations and a recommended land use plan at provincial level

Agroecological characterization at community level requires a specific set of activities in line with the Guidelines for Participatory Agroecological Characterization in Dry Areas (De Pauw et al., 2000).

Methodology for the agroecological zones study

The methodology is based on compilation and analysis of multi-thematic layers in a GIS. Since a GIS can be composed of tens, even hundreds of different data layers, it becomes difficult to establish agroecological zones through simple overlaying procedures. For this reason, the themes are integrated in a stepwise procedure using two 'independent' biophysical frameworks, a land systems framework and an agroclimatic framework. The development of these frameworks is explained later.

Study area

The study area has been delimited on the basis of hydrological basins and sub-basins using the ArcView hydrological extension. The study area contains the following basins and sub-basins (Figure 6).

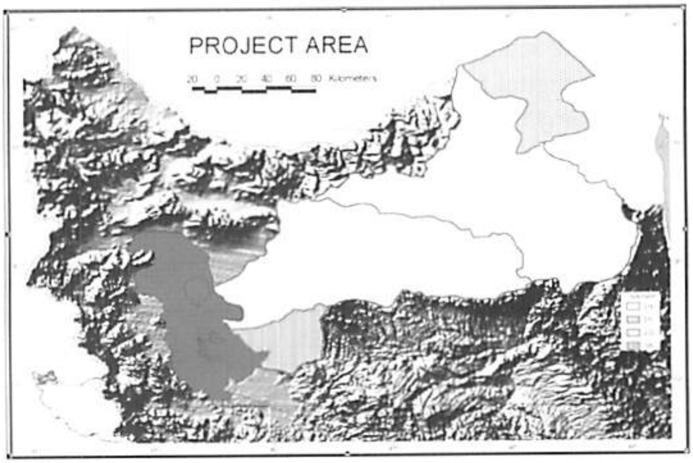


Fig. 6. Location of the study area and 4 sub-basins in NW Iran.

Basin: Aras

Sub-basins: 214 (area: 13,877 km^2) and 215 (area: 4,024 km^2)

Basin: Daryache-Uromieh

Sub-basins: 223 (area: 12,265 km^2) and 225 (area: 1,899 km^2)

The total area covered is 32,055 km^2.

Data collection, processing and generation

The study requires climatic, topographical, soil and geological data, as well as satellite imagery. As a general-purpose platform, a GIS was established for the study area.

Climatic data were compiled from a good network of synoptic and climatological stations in and around the study area. The synoptic stations provided all the elements needed for calculating water requirements (sunshine, humidity, temperature and wind) as well as frost risk, whereas the climatological stations were useful to capture better the spatial variability, particularly of precipitation. In addition, existing maps of isohyets of precipitation, temperature and evaporation (Jamab Consulting Engineer) have been digitized.

Topographical maps at scale 1:250,000, with 50 m contour interval in the plains and 100 m interval elsewhere, were compiled for the survey area and the contours were digitized. From this a digital elevation model (DEM) was developed for the study area using the TIN function in the 3-D Analyst extension of ArcView.

The Soil Map of Iran at scale 1:1,000,000 was extracted for the study area. This map was available in digital form with map units in the form of soil associations, using the Soil Taxonomy classification system, and with associated attribute tables. It is based on the interpretation of a 10x10 km grid of soil profiles, which have been described and sampled for chemical and physical analysis. In addition, soil maps and land suitability studies for irrigation, following the USBR classification system, have been produced at scale 1:50,000 for the main irrigated areas.

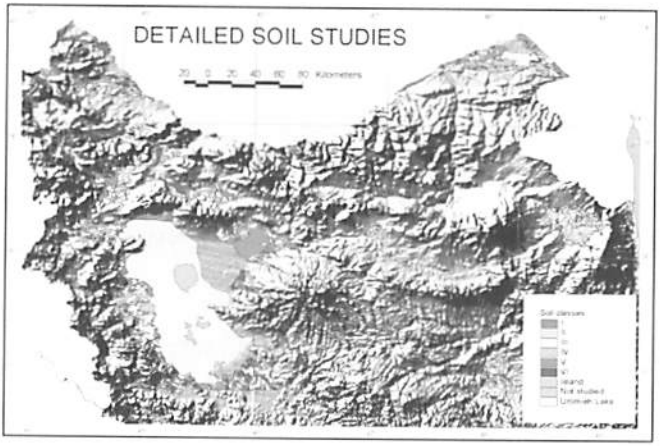


Fig. 7. Location of areas with detailed soil information.

The parts of the project area for which such detailed soils information is available, are indicated in Figure 7.

Geological maps at scale 1:250,000 cover the whole of Iran. In addition, a 1:100,000 scale map of the Maragheh area is available. Geological maps are very useful since they show the relationships between stratigraphy, lithology, soil types and landforms. All sheets covering the project area were purchased, scanned and georeferenced for use as an image layer in the GIS for the study area.

The GIS section of the SWRI compiled a land cover map in digital form. While of a general nature, it provides a good basis for understanding the spatial distribution of the production systems in the project area.

The following Landsat-7 satellite imagery in digital form was obtained for the study area from the Iranian.

Remote Sensing Center

Path-row	Date
167-33	8-Jun-1998
167-34	8-Jun-1998
168-33	19-Aug-1998
168-34	19-Aug-1998

These images represent late-spring/early-summer conditions at the end of a good growing season and are virtually cloud-free. They are very suitable for mapping of landforms and areas under irrigation. From these images a mosaic was created and radiometric correction applied.The different data processing steps are summarized in Figure 8.

Developing a land systems framework

The land systems framework emerges from the combination of data related to topography, geology and soils. The fundamental model for integrating these information sources is the 'soilscape'. This is a classical mapping approach that fits soils within landscapes and is well adapted to a wide range of mapping scales. The map delineates landscapes which are characterized in terms of soil components, and, if possible, soil patterns (Figure 9).

The first step in achieving this integration is to convert the DEM into a limited number of *landform classes*. This is achieved by using the absolute elevation and *the elevation difference*[1] as main criteria. For the study area, it was found that a very good agreement was obtained with the actual terrain by adopting the ranges for the differentiating criteria found in Table 5. In this way, 7 main landforms were recognized (Table 5; Figure 10).

[1]The elevation difference is the average difference in elevation between neighbouring grid cells of the DEM.

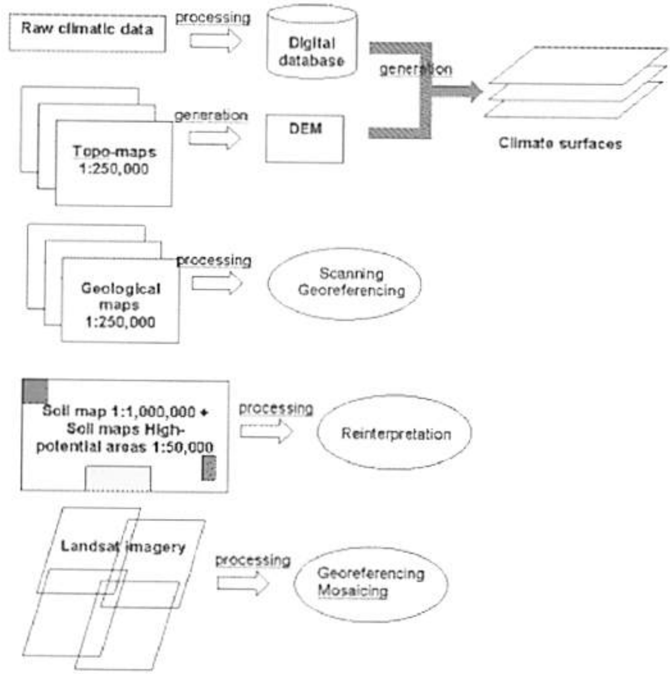
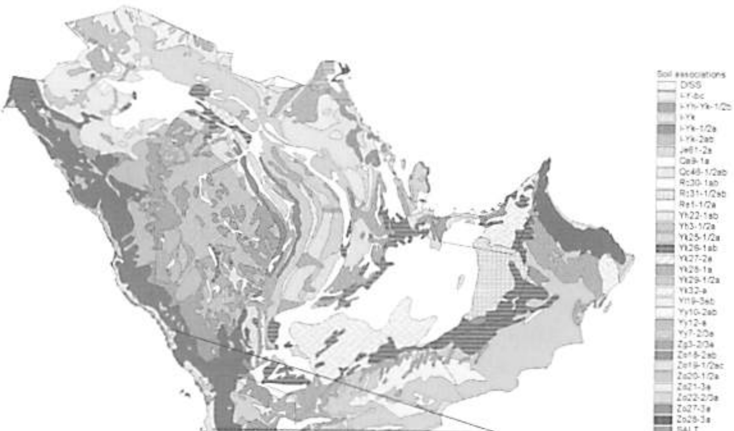


Fig. 8. Data processing.



Soil association	Soil types and proportions											
	1%	1	2%	2	3%	3	4%	4	5%	5	6%	6
Yh22-1ab	Yh	30	Qc	20	Yk	20	Jc	10	Rc	10	Z	10

Fig. 9. An example of the 'soil association' concept

Table 5. Landforms of the study area.

Landform symbol	Landform	Elevation	Elevation difference
1	Lowland plains	< 700 m	< 20 m
2	Lowland hills	< 700 m	> 20 m
3	Medium-altitude plateaux	700-1200 m	< 20 m
4	High-altitude plateaux	1200-1600 m	< 20 m
5	Very-high-altitude plateaux	> 1600 m	< 20 m
6	Medium-altitude hills and mountains	700-1600 m	> 20 m
7	High-altitude hills and mountains	> 1600 m	> 20 m

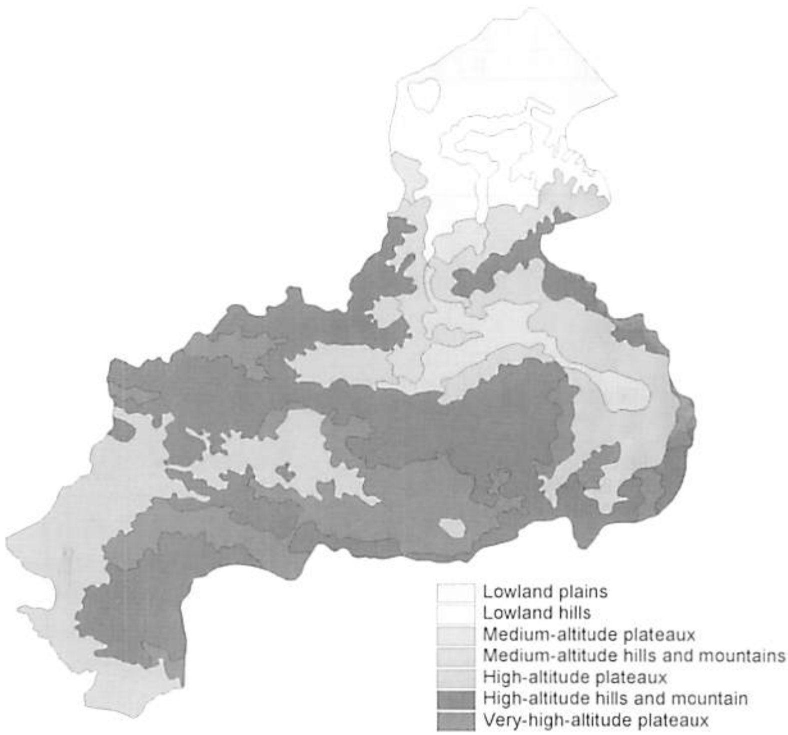


Fig. 10. Landforms of the study area.

The next step is to overlay the landforms onto the geological layer and subdivide these landforms into *land systems* on the basis of major geological substrata (e.g. recent alluvium, marls, limestones, basalts, etc.). Examples of land systems are 'Low-altitude plains on recent alluvium', 'Low-altitude plains on old terraces' etc. The land systems raster layer is then converted into a vector layer.

The third step is to characterize the soils of each land system in terms of soil associations. The soil information is obtained from the 1:1,000,000 soil maps. Since this soil information is of low resolution, Landsat imagery may sometimes (but not always) be helpful to refine the characterization of the soil associations.

In summary, the spatial entity 'land system' is characterized through an attribute table that includes the land system symbol, the geological substratum, and the relative proportions of the composing soil types (Table 6). These proportions can be indicated as either descriptive (such as '*dominant*', '*associated*' and '*inclusions*') or, if more information is available, as (approximate) percentages.

Table 6. An example of an extract from the attribute table for the land systems.

Land system	Geology	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6	Soil 7	Soil 8
		%							
LS1	Basalt			30		10			60
LS2	Marl	45	55						
LS3	Alluvium				15		35	50	

The flowchart for developing the land systems framework is shown in Figure 11.

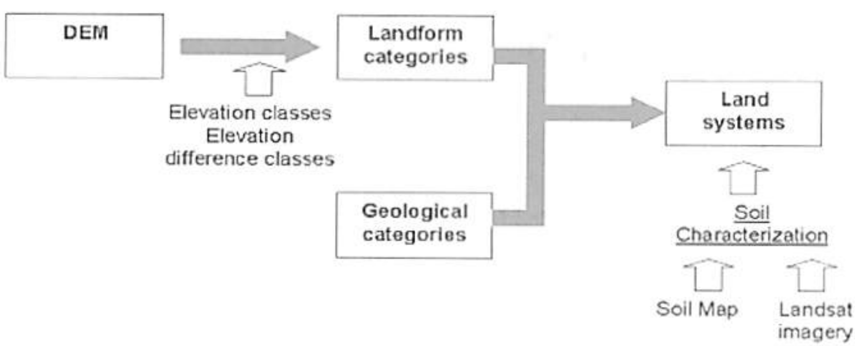


Fig. 11. Developing the land systems framework.

Developing an agroclimatic framework

The first step in developing an agroclimatic framework is to generate for the study area layers of climatic parameters e.g. monthly or annual maximum temperature, precipitation etc. The approach used for generating the basic climate surfaces is by combining a database of point climatic data with a DEM using a 'topography-guided' spatial interpolation method. The specific statistical technique is the 'thin-plate smoothing spline' method (Hutchinson, 1995) in which topography is used as a proxy variable and brought into the model as a grid. The main benefit of this approach is that DEMs are widely available and their spatial resolution is much higher than the density of climatic stations.
The approach is outlined in Figure 12.

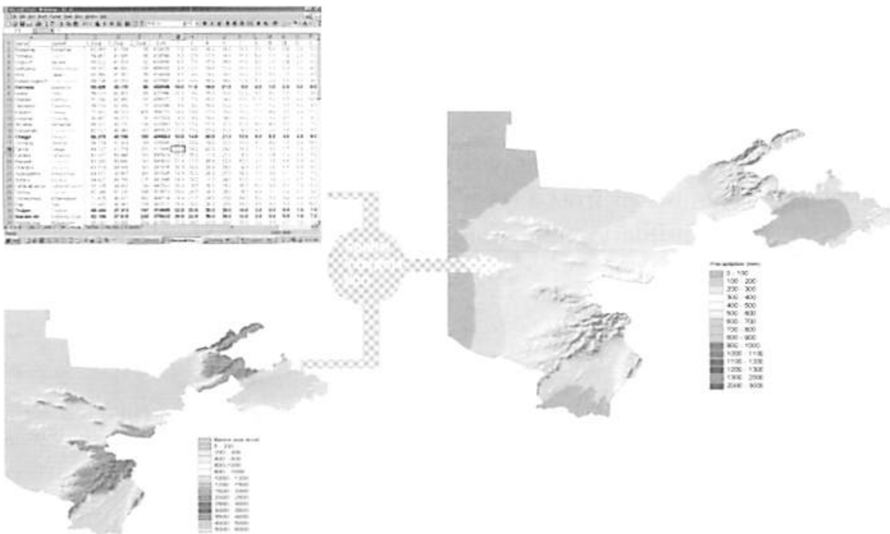


Fig. 12. Generation of basic climate surfaces.

Through formulas and models these basic layers or 'climate surfaces' can be recombined into derived climate surfaces e.g. potential evapotranspiration, length of growing period, agroclimatic zones etc. More details can be found in De Pauw (2002).

In this way a large number of climate parameter layers for the study area can be generated and stored in the GIS, and used for further analysis and interpretation. For the purpose of developing an agroclimatic framework for the study area, it is sufficient to integrate the factors that are the major determinants of climate, temperature and moisture supply, into agroclimatic zones. For the objectives of this study the UNESCO classification of arid zones (UNESCO, 1979) has been found perfectly adequate, and the agroclimatic zones have therefore been mapped in accordance with this system (Figure 13).

These agroclimatic zones can be further characterized in terms of the major climatic parameters. A non-exhaustive list of indicative parameters that can be used for the characterization of the agroclimatic zones is given in Table 7.

Table 7. Important parameters for the characterization of agroclimatic zones.

Symbol	Parameter	Units
AHU	Accumulated heat units above 0°C	Degree.days
Prec_Yr	Annual precipitation	Mm
PET_Yr	Annual potential evapotranspiration	Mm
AI	Aridity index	N.A.
LGP	Length of growing period	Days
Frost	Number of frost days	Days
NPPI	Net primary productivity index	Degree.days

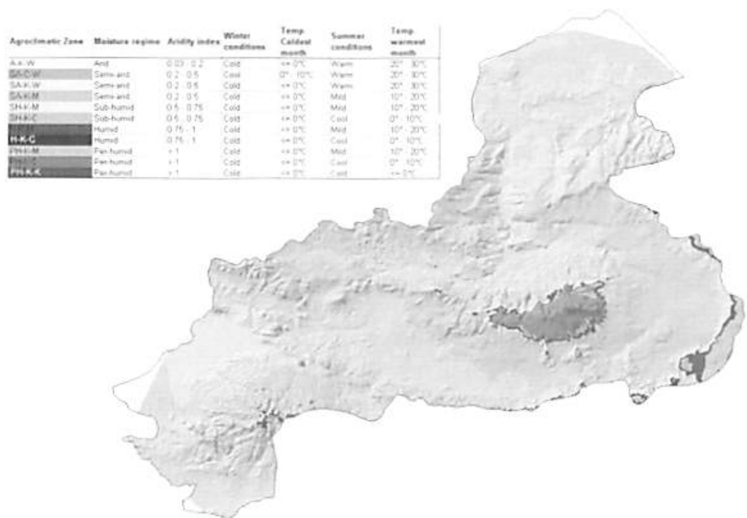


Fig. 13. Agroclimatic zones of the study area.

After conversion from raster to vector, the agroclimatic zones can be further characterized in terms of these parameters through an attribute table, containing the parameter range and the proportion of the agroclimatic zone. An example is given in Table 8.

Table 8. Example of an extract from the attribute table for the agroclimatic zones.

Agroclimatic	AHU: % in each class						
zone	2500-3000	3000-4000	4000-5000	5000-6000	6000-7000	7000-8000	8000-9000
ACZ1	60	30	10	0	0	0	0
ACZ2	0	0	0	25	38	25	12
ACZ3	0	0	55	35	12	3	0

For each parameter similar attribute tables can be developed, each of which can be joined to the agroclimatic zones theme.
The flowchart for developing the agroclimatic framework is shown in Figure14

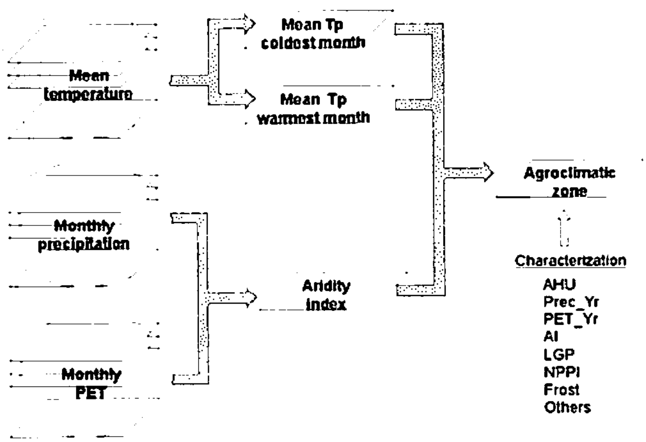


Fig. 14. Developing the agroclimatic framework.

Merging the land systems and agroclimatic framework

The two frameworks are merged by simple overlaying of the agroclimatic zones over the land systems layer using the union operation (Figure 15). The boundaries of the land systems are more accurate and, therefore, take precedence over those of the agroclimatic zones. It is recommended to remove very small 'agroecological zones' wherever these appear as artifacts of the merger procedure and not as a result of genuine differences. The generated agroecological zones will then share the attribute tables of the merged land systems and agroclimatic zones (Fig. 16).

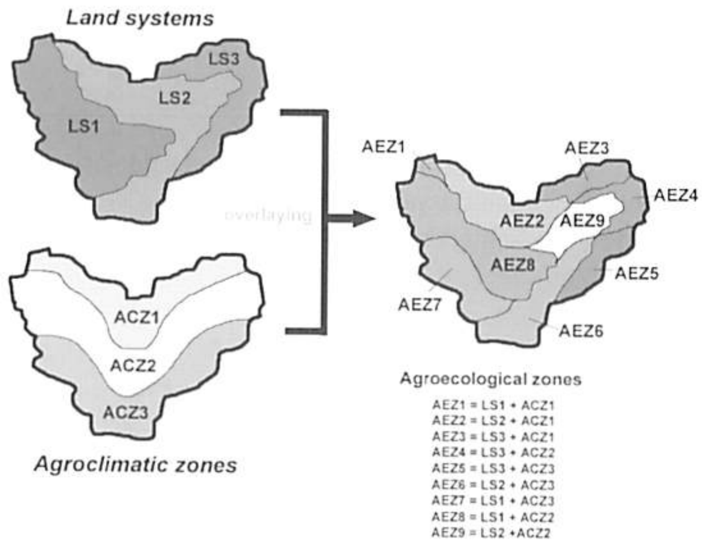


Fig. 15. Generation of agroecological zones through overlaying.

Agroecological zone	Geology	Soil 1 (%)	Soil 2 (%)	Soil 3 (%)	Soil 4 (%)	Soil 5 (%)	Soil 6 (%)	Soil 7 (%)	Soil 8 (%)	AHU 2500-3000 (%)	AHU 3000-4000 (%)	AHU 4000-5000 (%)	AHU 5000-6000 (%)	AHU 6000-7000 (%)	AHU 7000-8000 (%)	AHU 8000-9000 (%)
AEZ1	Basalt			30		10			60	60	30	10	0	0	0	0
AEZ2	Marl	45	55							60	30	10	0	0	0	0
AEZ3	Alluvium				15		35	50		60	30	10	0	0	0	0
AEZ4	Alluvium				15		35	50		0	0	0	25	38	25	12
AEZ5	Alluvium				15		35	50		0	0	55	35	12	3	0
AEZ6	Marl	45	55							0	0	55	35	12	3	0
AEZ7	Basalt			30		10			60	0	0	55	35	12	3	0
AEZ8	Basalt			30		10			60	0	0	0	25	38	25	12
AEZ9	Marl	45	55							0	0	0	25	38	25	12

Fig. 16. Sample attribute table for the agroecological zones through union of the land systems and agroclimatic zones.

Conclusions

Agroecological zones can be easily defined by the combination of terrain (DEM), climatic, soil and other data using GIS procedures. These procedures can be applied to a wide range of scales, subject to data availability at the required level of detail to be meaningful. The datasets are integrated in a stepwise procedure using two 'independent' biophysical frameworks, a land systems framework and an agroclimatic framework. Each framework is characterized separately through its own specific attributes. The merger of the two frameworks generates agroecological zones, which automatically inherit the characteristics of each framework. This approach is extremely useful to define areas that can be considered relatively homogeneous in their biophysical characteristics and can serve as a first basis for developing land use/land management recommendations.

Farming systems mapping in Syria

Katrien Descheemaeker and Eddy De Pauw

Background

A feature of farming systems research (FSA) is its high site-specificity. In order to develop, adapt and transfer agricultural technologies or practices, FSA needs to be organized in such a way that it can be assigned a spatial dimension. This requires developing a typology of farming systems that can effectively be mapped at scales relevant for particular applications.

Objective

This case study aims to map farming systems at the level of a country (Syria) by combining scattered and site-specific information from FSA, with spatial information on land use and land cover obtained from LANDSAT imagery.

Progress of research

Farming Systems Database

Information sources dealing with any particular aspect of FSA were collected and organized in a Farming Systems Database the structure of which was based on the guidelines in AGDAT (De Pauw, 1991). These guidelines provide a database structure for the description methods of Ruthenberg (1980) and Fresco and Westphal (1988).

From this database the main farming system attributes were extracted (Table 9) which allowed the description and differentiation of farming systems and the development of a typology, relevant to the Syrian situation.

Table 9. Main farming system attributes, arranged by theme.

Cropping principle	Animal husbandry	Irrigation	Spatial organization	Socioeconomics
Main crops	- Type of animal	- Water source	- Area	- Labor
Main rotations crops	- Flock size	- Water transport	- Property	- Economy
Main perennial	- Irrigation method	- Field pattern	- Income	
Cropping index		- Time		
Multiple cropping		- Area		
		- Quantity		

Typology of farming systems in Syria

On the basis of the main farming system attributes a typology was developed based on the combination of 'homogeneous' production systems (Table 10).

Homogeneous production systems are essentially the farming system categories differentiated by Ruthenberg (1980). In reality, more than one production system can be managed by the same household. In that case, the final code is a combination of two or more symbols (e.g. 35C: combination of rainfed field crops with tree crops and livestock). The production system that is in the first place in a mixed code is the main component of the farming system. The livestock production component is included in the code, where the herd comprises at least 10 sheep or goats, or where the farmers keep cattle.

Table 10. Homogeneous production systems.

Homogeneous production systems	Code
Fallow system	1
Ley system	2
Permanent rainfed system	3
Irrigation system	4
Perennial crop system	5
Horticulture system	6
Nomadism	A
Semi/partial nomadism	B
Stationary animal husbandry	C

The different farming system categories were combined with the digital land cover/land use map of Syria (De Pauw et al., 2000). Essentially this was achieved by attaching farming system category attributes to the land use units in the form of an attribute table to a GIS vector file. The rationale for this approach was that land use is indicative for farming systems, and whereas land use/land cover can be mapped, farming systems can only be given a spatial dimension by association with a spatial theme.

By applying the criteria for differentiation in Table 9, a typology of farming systems in Syria was established, which could be aggregated into 6 major groups (Table 11). The differentiation between wheat-based and barley-based systems is based on annual rainfall. Where the mean annual rainfall exceeds 325 mm, wheat is the dominant crop.

Table 11. Typology of farming systems in Syria.

Major groups of farming systems	Production system components	Without livestock	With livestock
Wheat-based farming systems	rainfed field crops	3	3C
	rainfed field crops + tree crops	35	35C
	rainfed + irrigated field crops	34	34C
	irrigated + rainfed field crops	43	43C
	field crops (rainfed + irrigated) + tree crops	345	345C
	field crops (irrigated + rainfed) + tree crops	435	435C
Barley-based farming systems	rainfed field crops		3C
	rainfed field crops + tree crops	35	35C
	rainfed + irrigated field crops	34	34C
	irrigated + rainfed field crops	43	43C
	field crops (rainfed + irrigated) + tree crops	345	345C
Tree-based farming systems	without cultivation of field crops	5	5C
	with field crops (only rainfed)	53	53C
	with field crops (rainfed + irrigated)	543	543C
Livestock-based farming systems	with field crops, without migration		C3,C1
	with field crops, with migration		B3,B1
	without cultivation of field crops		A
Farming systems with intensive irrigation	with rainfed field crops	43	43C
	only irrigated field crops	4	4C
Horticulture systems		6	

Mapping farming systems

On the basis of the above typology a simplified map of farming systems in Syria could be prepared (Figure 17).

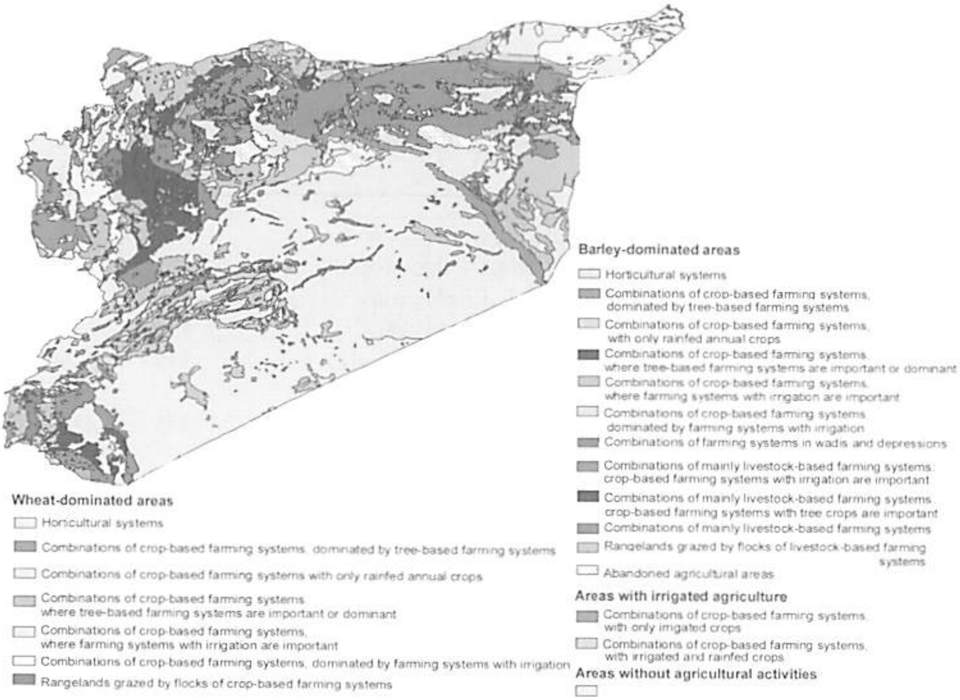


Fig. 17. Overview map of farming systems in Syria.

This map summarizes a highly complex picture. This is recognized in the legend by the term 'combinations'. Some of the combinations, identified from the publications related to FSA, are shown in Table 12. In reality there can be even more combinations.

Farming systems and rainfall zones

The rainfall zones in Syria are shown in Figure 18.

Using standard GIS operations the percentages of the main farming systems in each rainfall zone were calculated. For the purpose of this study, Zones 1a and 1b will be grouped into Zone 1. The results are summarized in Figure 19.

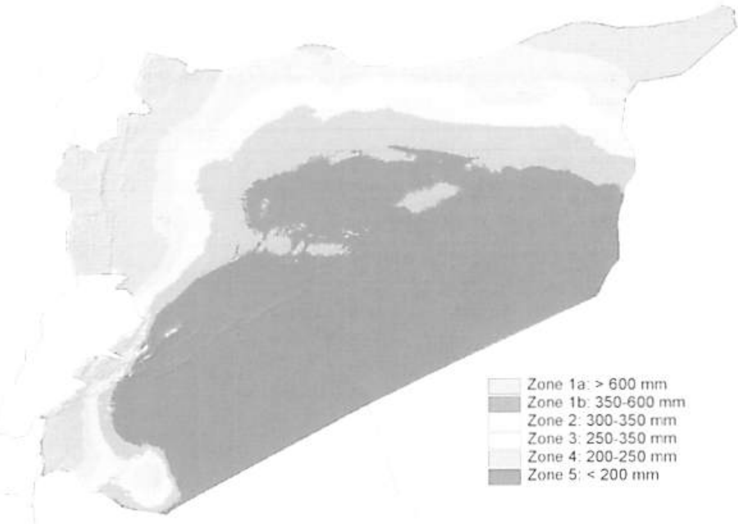


Fig. 18. Rainfall zones in Syria (Source: ICARDA GIS).

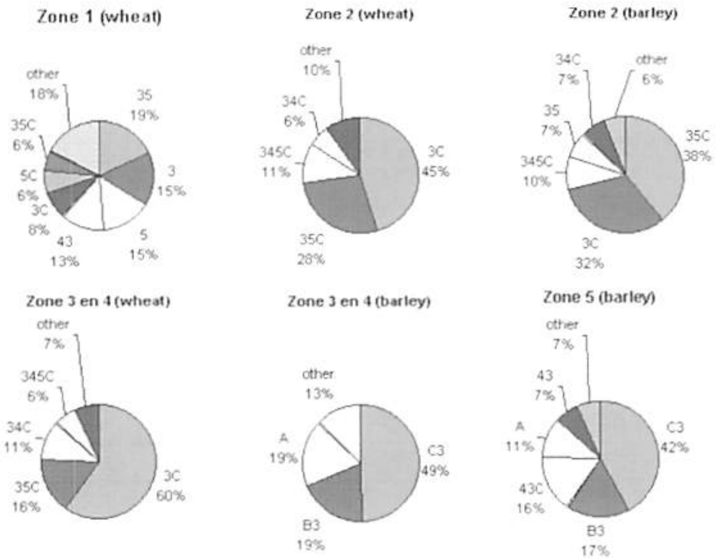


Fig. 19. Composition of rainfall zones by main farming systems.

Table 12. Relationships between farming systems categories and combinations.

Overview of the mapped combinations of farming systems and the legend groups to which they belong

(see table 1 for the explanation of the symbols)

Theme layer	Legend group	Combination
Wheat part	Horticultural systems	6
		543/6,543C
	Combinations of crop-based farming systems, dominated by tree-based farming systems	53/543,543C,34/3,53C,3C,34C
		53/53C
		5/5C
	Combinations of crop-based farming systems, with only rainfed annual crops	3C
		3/3C
	Combinations of crop-based farming systems, where tree-based farming systems are important or dominant	3C/35C
		35C/35/3C
		35/35C/3C,3
		35/35C
		35/3,35C,3C
		35C//35
	Combinations of crop-based farming systems, where farming systems with irrigation are important	35C/345C,345,35/3C
		35/435,435C/35C,3C,3
		35/345,345C/35C
		/3C,345C,35C/34C,34,345
		35/345,345C,34/3,35C 3C,34C
		/35C,345C/35,345
	Combinations of crop-based farming systems, dominated by farming systems with irrigation	34C/3C,34
		34C/34
		345C/345,34C,34
		345C/345
		345/345C,34/34C
		345/345C
		43/43C
		43/3,43C/3C
	Rangelands grazed by flocks of crop-based farming systems	435/435C
		/3C,35C,5C/34C,345C
Barley part	Horticultural systems	6
	Combinations of crop-based farming systems, dominated by tree-based farming systems	5/5C
	Combinations of crop-based farming systems, with only rainfed annual crops	3C
	Combinations of crop-based farming systems, where tree-based farming systems are important or dominant	3C/35C
		35C/35/3C
		35C//35
	Combinations of crop-based farming systems, where farming systems with irrigation are important	/35C,345C/35,345
		35C/345C,345,35/3C
		/3C,345C,35C/34C,34 345
	Combinations of crop-based farming systems, dominated by farming systems with irrigation	345C/345
		345C/345,34C,34
		34C/34
		34C/34,345C,345
		34C/3C,34
	Combinations of farming systems in wadis and depressions	C3/B3
	Combinations of mainly livestock-based farming systems, where crop-based farming systems with irrigation are important	C3/B3 A,345C/C1,B1,34C,35C
		C3/B3 A,34C/C1,B1
		C3/B3 A,34C/C1,B1,345C,35C
	Combinations of mainly livestock-based farming systems, where crop-based farming systems with tree crops are important	C3/B3 A,35C/C1,B1
	Combinations of mainly livestock-based farming systems	C3/B3 A/C1,B1
		C3/B3 A/C1,B1,35C
	Rangelands grazed by flocks of livestock-based farming systems	/A,B3,C3/B1,C1
Regions with intensive irrigation	Combinations of crop-based farming systems, with only irrigated crops	4/4C
	Combinations of crop-based farming systems, with irrigated and rainfed crops	43/43C

Zone 1

In Zone 1, the importance of farming systems with tree crops is striking. The high rainfall in this Zone makes it possible to grow trees without irri gation. Moreover, the hilly to mountainous terrain, that is widely present in Zone 1, is more suitable for perennial crops than for annual field crops. Animal husbandry is only present in a minority of the farming systems of Zone 1. Again, this can be explained by the high rainfall amounts, which make farmers less dependent on animal production than in the drier areas. In comparison with the other zones, a higher diversity of farming systems is found. This is due to the relatively favorable conditions for agriculture, which make it possible for very diverse systems to develop.

Zone 2

In Zone 2, the barley-based and wheat-based farming systems each occupy about 50% of the cultivated area. This mix is the result of the intensification of agriculture in this zone, which was dominated, until about 20 years ago, by farming systems based on barley and livestock. Along with this intensification, the area under irrigation and tree crops rose sharply, which is illustrated by the importance of these farming systems.

Although the rangelands available for animal husbandry decreased with these intensifying trends, the animal component is still important. Between 80 and 90% of the farmers have a flocks of 15 to 20 animals on average.

Zone 3 and 4

The area that comprises Zone 3 and 4 is dominated by farming systems based on livestock and barley. Wheat-based farming systems are only found on 4% of the cultivated area, because of the low rainfall amounts.
Nomads, semi-nomads and stationary livestock keepers occupy very large areas with low production potential. Fallow systems are rare in these zones. Agriculture is practiced in marginal conditions and with low input levels. The association with irrigated agriculture occurs only in a limited area, and farming systems with tree crops are rare.

Zone 5

In addition to the dominance of livestock-based farming systems, the relatively high importance of irrigated systems in Zone 5 is striking. This is explained by the extreme difficulties to conduct rainfed agriculture.
As evidenced by the Land Use/Land Cover Map of 1990 (De Pauw et al., 2003), agriculture has been abandoned in some parts of these zones.

These are former rangeland areas that were cultivated in 1987-1988, after the abolition of the cultivation prohibition and in an unusually wet growing season. In 1990, however, they were abandoned because of low rainfall amounts and in 1995 the prohibition became active again (Debaine and Jaubert, 1998).

The zones not only differ by the proportional presence of certain farming systems, but also by certain characteristics of each farming system. The more humid areas have a greater diversity in crops and rotations. Also, flock size differs according to the rainfall regime. In the drier areas, where livestock is more important, the flocks are bigger and the contribution of animal production to the total income is higher.

Conclusions

Farming systems are inherently complex, which makes their mapping problematic. Despite this problem, the mapping of farming systems is vital for a range of research applications, related e.g. to poverty mapping, drought vulnerability, agricultural technology/practice development, adaptation or transfer. A reasonable approximation can be achieved by linking attributes of farming systems that have a spatial dimension, with land use/land cover maps.

This study indicates that it is feasible to represent farming systems at particular scales, by a 'proxy' mapping procedure which links farming systems information to land use/land cover and climatic information. In this particular study the procedure has been applied at a country-level scale, but the same approach, using lower-resolution data, could be applied at a regional scale.

In many cases, particularly in marginal lands, farming systems are mixtures of different production systems. The complexity of farming systems derives in part from the kinds and relative importance of the constituent production systems, which can vary considerably both in space and time. This merely reflects the fact that farming systems are constantly evolving, and, as a result, any farming systems map can only represent a snapshot in time. For this reason, the production of a 'hard' map is unfeasible, which necessitates the acceptance of an inherent 'fuzziness' to the mapping exercise.

References

Celis, D. and E. De Pauw. 2003. Assessment of land cover/ land use in CWANA region using AVHRR imagery and agroclimatic data. NRMP Research Report. ICARDA.

Debaine, F. and R. Jaubert. 1998. Les marges arides de Syrie: la frontière des 200mm. Planification agricole et occupation du territoire. Sécheresse, 9(1): pp43-50.

De Pauw, E. 1991. AGDAT (Agricultural Environment Database). A database management system for reference agricultural resource information. FAO Projects GCP/INT/439/BEL and GCPS/RAF/270(DEN). FAO, Rome.

De Pauw, E. 2002. Agroecological characterization to upscale soil and water research in Central Asia. In Karajeh., F., Ryan, J., Studer, C. (Eds.) On-farm soil and water management in Central Asia. Proceedings of an International Workshop 17-19 May 1999, Tashkent, Uzbekistan, organized by ICARDA and SANIIRI. ICARDA. ISBN 92-9127-123-3.

De Pauw, E., Oberle, A. and Zöbisch, M. 2003. An overview of land cover and land use in Syria 1990. NRMP Research report, Natural Resources Management Programme, ICARDA, Aleppo, Syria.

Fresco, L. and Westphal, P. 1988. A hierarchical classification of farm systems. Expl. Agric., 24, 399-419.

Hutchinson, M. 1995. Interpolating mean rainfall using thin plate smoothing splines. Int. J. Geographical Information Systems 9: 385-403.

Ruthenberg, H. 1980. Farming systems in the tropics. Oxford University Press, Oxford (Third Edition).

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.

APPENDIX: STAFF LIST, TRAINING, FINANCIAL SUPPORT AND PUBLICATIONS

Staff list including students

Eddy De Pauw (P):	Agroecologist, Project Manager (Belgium)
Adekunle Ibiyemi (RA):	Senior GIS Analyst (Nigeria)
Kristof Scheldeman (RA):	JPO, Land resources assessment (Belgium)
David Celis (RA):	JPO, Remote sensing (Belgium)
Mohamed Salem (NPO):	Meteorological Technician (Syria)
Ahmed Hamoud (GS):	Meteorological Observer (Syria)
Ghazi Yassin (GS):	Meteorological Observer (Syria)
Nathalie Cools:	PhD Student (Belgium)
Vahid Ghassemi:	PhD Student (Iran)

Training activities

- June 2002: Participation in JICA training course
- 20 Sep - 4 Oct 2002: on-the-job training two Iranian scientists from DARI and SWRI

Financial support

VVOB: provision of two JPOs

Publications

Refereed publications

Cools, N., De Pauw, E. and Deckers, J. Integrating conventional land evaluation methods and farmers' soil suitability assessment: Case of Northwestern Syria. (accepted by Agriculture, Ecosystems and Environment)

De Pauw, E. Approaches to multi-scale agroecological zoning in ICARDA's mandate region (accepted for the Proceedings of the OECD Meeting on "Innovative soil-plant systems for sustainable agricultural practices", Izmir, Turkey, 3-7 June 2002.

De Pauw, E. and Zöbisch, M. 2002. Soil degradation and greenhouse effect. in R. Lal (Ed.) Encyclopedia of Soil Science, Marcel Dekker, USA. ISBN 0-8247-0634-X.

Descheemaeker, K., Cools, N., De Pauw, E. and Deckers, J. 2002. Farming systems in Syria: Towards a methodology for characterising and mapping farming systems. The Land, Vol 5.2., pp. 101-118

Thenkabail, P.S, Smith R.B. and De Pauw E. 2002. Evaluation of narrowband and broadband vegetation indices for determining optimal hyperspectral wavebands for agricultural crop characterization. Photogrammetric Engineering and Remote Sensing, Vol. 68, No.6, June 2002, pp. 607-621.

Zöbisch, M. and De Pauw, E. 2002. Soil degradation and global food security. in R. Lal (Ed.) Encyclopedia of Soil Science, Marcel Dekker, USA. ISBN 0-8247-0634-X.

Non-refereed publications

Celis, D., Scheldeman K. and De Pauw E. 2002. Challenges in regional land cover/land use mapping using low-spatial-resolution satellite imagery. (Paper presented at the 3rd International Symposium on Sustainable Agro-environmental Systems: New Technologies and Applications. 26-29 October 2002, Cairo, Egypt).

De Pauw, E. 2002. Agroecological characterization to upscale soil and water research in Central Asia. in Karajeh., F., Ryan, J., Studer, C. (Eds.) On-farm soil and water management in Central Asia. Proceedings of an International Workshop 17-19 May 1999, Tashkent, Uzbekistan, organized by ICARDA and SANIIRI, ICARDA. ISBN 92-9127-123-3.

De Pauw, E. 2002. An agroecological exploration of the Arabian Peninsula. ICARDA, Aleppo, Syria. 77 pp. ISBN 92-9127-119-5.

Other products

De Pauw, E. 2002. Agrometeorological stations and practices.

De Pauw, E. 2002. Drought early warning systems for the Middle East region (presentation at ICARDA- Drylands Symposium at ASA Meeting, Indianapolis, 11-14 November 2002).

De Pauw, E., Cools, N., Celis, D. 2002. Multi-scale agroecological characterization for natural resources management in dryland areas (abstract and poster presented at 17th World Congress of Soil Science, 14-21 August 2002).

Lecture module prepared for the Course on "Management of Water Resources and Improvement of Water Use Efficiency in the Dry Areas", April 7-June 6, ICARDA, Aleppo, Syria, jointly organized by ICARDA and JICA.

Pertziger, F. and De Pauw, E. 2002. Agroecological characterization of Central Asia (presentation at Central Asia Symposium at ASA Meeting, Indianapolis, 11-14 November 2002).

Software

F. Pertziger and E. De Pauw 2002. CLIMAP (An Excel-based software for climate surface mapping).

Ibiyemi 2002. Point Profiler. An ArcView extension to generate a data profile based on the thematic layers contained in a view.

PROJECT 4.1: SOCIOECONOMICS OF NATURAL RESOURCES MANAGEMENT IN DRY AREAS

Goal
Conservation and sustainable use of the natural resource base for improving the welfare of incurrent and future generations.

Purpose
Analysis of the social, institutional and economic factors that influence resource management and a greater understanding of resource users' perceptions and objectives that will assist in the design of proposed technical interventions and reveal where opportunities may exist for community action and cooperative management of resources.

Output 1: Market and non-market valuation of natural resources and estimation of the economic and social costs of their degradation

Planned milestones 2002
Economic modeling of ground water use and irrigation technologies in Syria completed

Achievements in 2002
A study titled "Computer Simulation Models for Sustainable Groundwater Use in Agriculture in Syria" was completed as PhD thesis of Mr Fadil Rida. This study determined the driving factors behind the expansion of groundwater exploitation for the last few decades, evaluated the profitability of irrigated cropping in water-scarce areas in selected villages in four stability zones in Syria, and analyzed the demand for groundwater and irrigation costs. Farmers' groundwater investment was modeled, probability of drilling success determined and system dynamic simulation models developed.

Contrary to the prevailing view, it was found that groundwater use in these areas has transformed sustainable traditional livestock-barley farming system into an unsustainable system. When the groundwater wells run out of water, these communities had no choice but to migrate. 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, hence irrigation costs and crop prices can play an important role in the sustainability of water use. Where the probability of drilling success was very low, investment in groundwater irrigation was unrecoverable and risky. It was also evident that due to the absence of other investment options, farmers invest in depleted natural resources. Expansion in areas allocated to high water consuming crops such as cotton have led to water depletion and are not profitable if fuel costs were to increase by 50%. Crops such as vegetables in combination with wheat can be sustainable options to high water consuming crops.

Output 2: Economic assessment of the environmental impact of resource management strategies

Planned milestones 2002: none

Output 3: Socioeconomic evaluation of potential resource management options

Planned milestones 2002

Characterization of resource users' perceptions and attitudes towards resource use, associated institutional factors and natural resource conservation technologies completed in Khanasser Valley in Syria

Achievements in 2002

An indepth household livelihoods study carried out in 2002 in Khanasser on the basis of the sustainable livelihoods framework reveals the following major changes in natural resources:

- The most often recognized (55-80% of households) changes in natural resources are the degradation of rangelands, mountain slopes, and other communal grazing areas. This is believed to have started during the end of the 1980s. Indicators are believed to be the decrease in the natural vegetation, the loss of biodiversity and wild plants, and the shorter grazing period available for animals on local pastures. Major causes are believed to be drought and declining rainfall, overgrazing, and limited expansion of crop land. Local households respond by buying more feeds to compensate for the decrease in pasture availability, reduce the size of their flock, and/or move to sheep fattening with external feed inputs. They advocate an increased role of the government in restoring the rangeland, or plan to change the grazing itineraries for their flock to adapt to dwindling resources. However, most farmers accept the trend as inevitable.

- The other major process known to affect local natural resources is the decrease in the water table and the drying out of wells. This has been noticed since as early as the 1960s as declines in level and flow of water in the cropped areas, and since the end of the 1980s in the rangeland. This is attributed to drought, less rainfall, and more rarely to the increased digging of wells. Actions to counteract this phenomenon are: reducing irrigation area and time, using improved water-use efficiency technologies, and buying drinking water. Yet, several households still plan to dig more and deeper wells.

- The third major process affecting natural resources in the area is the decrease of the fertility of soils in the cultivated areas, clearly recognized by the decrease in crop yields. Major causes are believed to be the decline in fallows and of the custom of fallowing and putting the land under pressure that leads to continuous cropping. Farmers try to buffer this process by applying fertilizers and considering restoring the winter fallows.

- Salinization of water and soils has affected some areas of northern Khanasser Valley, where about 20% of households recognize this fact as dating back to 1994. The quality of water has been declining. The causes are believed to be the proximity of the salt lake, and the fact that the wells use the water from this lake. Local farmers plan to take action by drilling the wells elsewhere, and expect irrigation channels to be brought to the villages.

Participatory technology evaluation (PTE) activities, including a plenary field day, were held at Khanasser to provide a platform where farmers evaluated in participatory ways a variety of technological options, interacted directly with scientists from ICARDA and Syrian NARs. Implications of PTE activities are a renewed effort on farmer-centered and demand-driven on-farm research, an enhanced cooperation and communication with development projects, extension services, and a better rapport with farmers. A number of cross-cutting insights were gained during the discussion with farmers across the various technology groups.

The concerns and problems faced by farmers and identified by them are:
- Costs involved in adopting new technologies, particularly for their establishment
- Lack of sufficient and reliable rainfall, and unavailability of water for irrigation
- Low fertility of several of the soils
- Financial constraints to adopt new technologies, and difficult access to credit

- Lack of information and technical knowledge, particularly on new technologies
- Lack of crops that are resistant to diseases and drought
- Susceptibility of animals to diseases, driving the need for better animal health care
- Difficult land property rights that discourage investments and create conflicts

The technologies and management options regarded as most important to them are:

- Crops: vetch, olive trees, cumin, barley, and other income generating crops (e.g. capers)
- Livestock technologies: sheep fattening, improved animal health, improved rams
- Other management strategies: particularly those aimed at 'water harvesting'

Output 4: Institutionalized multidisciplinary and participatory approaches to natural resource management research in national systems

Planned milestones 2002

- Rapid assessment of potential improvement in water management in Salamieh area, Syria
- Community collective action in mountains of Yemen evaluated

Achievements in 2002

A rapid assessment study was conducted to provide an action framework for a project (funded by the Aga Khan Foundation) aimed at halting natural resource degradation, and improving the livelihoods of the rural poor in the Salamieh district, Syria. Based on synthesis of available data, field observations, and personal interviews with individual farmers and communities, the area was characterized, constraints to sustainable development were identified, and proper technologies were suggested for testing and dissemination, with a particular emphasis on water management. The project area has variable agroclimatic and socioeconomic conditions. Livelihoods of about 50% of the population (260,680 people) depend on agriculture or agriculture-related activities. Cultivated area is 22% of the total area (20% rainfed, and 2% irrigated), and yields are low and uncertain. Wheat, barley, lentil, and fruit trees (olive, almond, pistachio, and grapes) are the main crops. Livestock is a principal component of the farming systems, but rangeland (50 % of total area) is highly degraded. Rainfall and groundwater are the main sources of water supply for agriculture.

Rainfall is low and erratic (annual rate 200-350 mm), and groundwater (once a good resource) has progressively been depleted due to over-pumping, and lack of proper water management practices. The irrigated area has been reduced by about 50% in the last 3 decades, causing a significant socioeconomic decline, and escalating migration to urban areas.

An integrated resource management strategy and 'research for development' framework were built up, specifying short- and long-term interventions for three distinguished agroecological areas (rainfed, transitional, and steppe). The short-term development program included micro-catchment water harvesting, sprinkler and drip systems, plastic greenhouses and supply of improved seed varieties at pilot sites. This program would not require elaborative research and therefore, it could be implemented immediately with potential direct benefits to the farmers. The long-term development program included groundwater assessment and management, macro-catchment surface water harvesting, design of a suitable cropping pattern for each agroecological zone, and assessment of adoption and impacts of the interventions. Implementation of these interventions would require adaptive research, and benefits accruals and impact would a take longer time.

A multidisciplinary community-based integrated natural resources management research is being conducted in the three watersheds in the mountains of Yemen. Characterization of the natural resources, production systems and livelihoods is now completed. Experiments/demonstrations are made on farmer identified and selected problems in the three small watersheds, each with 7 to 12 communities, through a project supported by the International Development Research Center (IDRC), Canada. Participatory rural appraisals (PRA) were conducted to identify problems and suggest possible research and development interventions. Land information databases, which include biophysical and socioeconomic data, are being developed.

Surveys and discussions with farmers have revealed that water scarcity is the most critical issue in the study areas. Communities have developed complex water management structures based on 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. 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 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.

Water productivity in the watersheds could be improved in various ways. More surface runoff could be caught in small reservoirs. This water could be used for supplemental irrigation at critical times. Earthen irrigation channels, which guide water over long distances along the terraced slopes, could be improved to reduce leakage. Crop selection is an important issue. Due to the uncertainty of the water resources and the traditional water sharing system, water is not always given to the highest value crop. There is also potential for the use of drip irrigation for high value crops grown in plastic tunnels. All water management options need to be carefully planned and discussed with the farmers, so that downstream farmers will not be adversely affected by improved water-use efficiency upstream.

The development of cisterns for domestic and agricultural use could have an enormous impact on livelihoods in these communities. Availability of domestic water is a major problem, and women spend much of their time fetching water. However, farmers need technical help and advice on the design of cisterns, and on the optimal use of water for agriculture. Improved access to development loans through community organizations and farmer visits to areas where such systems are used could improve adoption.

The CB-INRM approach requires that agricultural research institutions adapt long-term perspective 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.

Implications for 2003 and beyond
The mountain terraces project described above will seek further funding from IDRC. The project needs to link with development programs in order to improve the livelihoods of the people.

Output 5: Knowledge of NARS social scientists on socioeconomic research in NRM enhanced

Planned milestones 2002
On-the-job individual training and training workshops

Achievements in 2002
- Participatory training courses were conducted for the Livestock Project, the Barani Village Development Project (Pakistan), and the Khanasser Project (Integrated Research Site in Syria representing the Dry Margins of CWANA) with support from this project. Two consultants have successfully executed these participatory training courses.
- Management of water resources and improvement of water-use efficiency in the dry areas ICARDA/JICA/Syria, 7 April-6 June 2002.
- In-country short-term training courses on monitoring on-farm trials and demonstration fields - Iran ICARDA/Iran, 25-30 May 2002.
- Individual Training: About 10 individuals from Central Asia, Syria, and Yemen were trained on socioeconomics research.
- The work of two MSc students is in progress.

SUCCESSFUL CASES OF RESEARCH AND DEVELOPMENT INTERFACES IN IMPROVING THE LIVELIHOODS OF THE POOR

Abdul Bari Salkini

Abstract

Technical backstopping provided by ICARDA has significantly contributed to improving the design and implementation efficacy of many natural resource management and rural development projects in CWANA. In Egypt and Pakistan in particular, the research for development programs conducted by the development projects, in collaboration with ICARDA and with the effective participation of the farming communities, have been successful in sustaining fragile natural resource bases, and improving the livelihoods of rural poor in marginal drylands of the two countries. Technologies were tested and promoted for improving water-use efficiency of erratic rainfall, substantially increasing rainfed agricultural production.

Considerable amounts of scarce and valuable rainwater runoffs (which used to be lost to evaporation and/ or to the sea) were conserved for domestic and agricultural uses. Degraded rangelands were rehabilitated, and livestock production and cropping systems were improved, diversified, and intensified, generating higher productivity and farm income. New employment opportunities and economic enterprises were developed for local community members, including rural women. Most importantly, ICARDA backstopping to these projects has substantially contributed to human resource development and capacity building of project scientists, managers, and farming communities. New expertise in resource conservation and sustainable development, and in monitoring and evaluation was built up through extensive on-job training and formal (in-country and overseas) training and study tours.

MATROUH RESOURCE MANAGEMENT PROJECT, EGYPT

Background

In Egypt, Bedouin communities in the Northwest Coast (NWC) have developed indigenous knowledge, skills, and resource management practices, maintaining for ages ecologically balanced pastoral systems in a harsh semi-desert environment. They have also developed drought-coping strategies, traditions, and a lifestyle that sustained their livelihoods, and maintained equity and social peace between and within the Bedouin tribes. However, the settlement of the Bedouins and rural development projects implemented in the last few decades on marginal dryland have transformed the traditional pastoral systems to sedentary agriculture.

This transition, urbanization, the aggressive intrusion of the tourism industry and the drive for modernizing the Bedouin lifestyle have aggravated the human and livestock pressure on a resource base essentially known for its fragility. Vast areas of rich biodiversity and natural vegetation were badly damaged by tourist constructions, overgrazed, or cultivated. Biodiversity was substantially eroded, and natural habitats and ecological systems deteriorated, creating a cycle of resource degradation and poverty. Recently, new developments on upper catchment areas have reduced rainwater runoffs to old well-developed areas downstream, causing conflicts and threatening social peace between and within the tribal population.

ICARDA was contracted (1996-2001) to provide technical assistance to Matrouh Resource Management Project (MRMP), established to break the degradation cycle and promote technologies for sustainable resource management and poverty alleviation on a vast area (about 20,000 km^2) in the western part of the NWC.

The project (1995-2002), co-financed at US$ 29.6 million by the World Bank, the Government of Egypt (GOE), and beneficiaries, was a rural development project with a strong adaptive research and technology transfer base. The project, with technical assistance from ICARDA and effective participation of Bedouin communities, has employed holistic, multi-disciplinary approaches to achieve its objectives. This report summarizes ICARDA's experience in providing technical assistance to resource conservation and development endeavors, adaptive research and technology transfer for agricultural production and livelihood improvement. It also briefly presents project achievements, and the lessons learned from this innovative involvement by ICARDA in rural development projects.

Constraints to rural development

The project was confronted by a number of biophysical, socioeconomic, policy and institutional constraints of a long-standing nature. Resource scarcity, land degradation and poverty were the main constraints. Rainfall, the principal source of water, is low and highly erratic, with annual long-term averages of about 145 mm at the coast and declines rapidly as one moves in-land.

However, the rain falls mainly in few heavy storms, and this, together with the existing topography and physiography, provided suitable conditions for the implementation of water-harvesting technologies. The scarcity of arable land (< 10 % of the total area), poor and eroded soils, and highly degraded rangelands are other major physical constraints. Crop yields are very low, averaging 700 kg/ha for barley and 50 kg/tree for fig (two major crops in the NWC). Crop and livestock yields are highly variable, with little potential for improvement. Lack of crop diversity and income sources, poverty, and scarcity of employment and economic opportunities are also major constraints, as well as the many problems related to credit, marketing, land tenure, health, illiteracy, lack of information and vocational experience.

Objectives

The project was established to achieve the following objectives:

- Promote new managerial and operational models and participatory methodological approaches to research and development.
- Enhance resource supply and the efficient use of water, soil, range, and biodiversity.
- Introduce and disseminate improved germplasm and production practices for crop, range, and livestock improvement.
- Create new on-and-off-farm employment and economic opportunities.
- Strengthen social aspects of the Bedouin tribal communities.
- Improve and develop human resources through capacity building of project staff and beneficiaries, including rural women.
- Monitor and evaluate project performance, adoption, and impact on the resource base and on the livelihoods and welfare of project beneficiaries.

Research and development (R&D) programs

Project objectives were achieved through a multidisciplinary teamwork approach that integrated the following R&D components:

- Development and conservation of natural resources (water, soil, and vegetation)
- Adaptive research program for improving crop, horticulture, range and livestock
- Extension and social development program
- Rural credit program
- Training and human resource development program
- Project management, including monitoring and evaluation
- The technical assistance program

Technical assistance delivery

To assist the project in achieving its objectives, 51 ICARDA scientists and consultants from 18 nationalities provided more than 4000 person/days of on-site technical backstopping for all the R&D programs mentioned above. Training and human resource development was given particular emphasis by MRMP and the TA component. In addition to extensive on-the-job training provided by all TA scientists, ICARDA facilitated over 1500 person/days of overseas training (for staff, farmers, and herders), carried out in 12 countries. On-job training has contributed effectively to upgrading staff and farmers' skills and capacities, and to speeding up the implementation of the project activities. Overseas training, particularly the study tours, has effectively enhanced the adoption of new technologies tested by the project, such as micro-water harvesting systems (semicircular, contour ridges), Atriplex and spineless cactus, barley-legume rotations and barley-vetch mixtures, and fodder shrub interplanting on barley.

Achievements and impact

The dedication of project personnel, the efficient technical assistance of ICARDA, and the effective participation of local communities have resulted in impressive achievements and impacts that have been recognized nationally and internationally. The project success has been reflected in the positive response received from the Government of Egypt and international funding agencies (WB, IFAD, and GEF) by extending the project for a second 5-year phase, with a prospected funding of US$ 50 million.

Water and Soil R&D Program was assigned US$ 12 million (41 % of the total budget). The program has focused on:

- Investigating runoff coefficients (principal value for designing water management structures) on a variety of land topography and physiography;
- Improving the design of water harvesting structures (cisterns, concrete reservoirs, and dikes) for higher harvesting and storage capacity and cost-effectiveness;
- Introducing, testing and disseminating micro-water harvesting technologies, such as the semicircular bunds, the small basins, and contour ridges; and
- Introducing the integrated watershed management approach to sustainable resource management, conducting relevant studies on 53 watersheds with integrated planning completed on 11 watersheds.

Water harvesting structures, established by the project, added over 1.2 m^3 of rainwater (>50 % of the total available before the project) conserved and stored in over 8000 cisterns, and used mainly for domestic purposes and livestock, and partly for farming when water surplus is available. Roughly, 4500 small dikes (earth, stone, and cemented stone) were established to provide badly needed water to about 2000 ha of orchards. Soils were also conserved on more than 5000 hectares by reseeding and engineering structures. Monitoring and evaluation (M&E) studies showed that roughly 58 % of the total (17500) households benefited from the cistern structures, and 47 % benefited from dikes.

Rangeland rehabilitation.
Highly degraded rangeland constituted about 48 % of the total project area. The productivity of these ranges was very low, averaging 20 feed units (FU) per hectare (FU is 1 kg of barley grain equivalent). Location-specific technologies were tested and implemented, based on the specific biophysical and socioeconomic conditions of the locations. These technologies were:

- Fenced and non-fenced fodder shrub plantations, Acacia, *Atriplex*, and other species;
- Introducing new range plant species, such as the spineless cactus;
- Interplanting fodder shrubs on barley plots;
- Improved seedling production practices in the nurseries;
- Direct reseeding of annual and perennial fodder species; and
- Reseeding of barley-vetch mixtures.

Farmers were encouraged and supported to establish family-based, seed production enterprises to collect and reproduce seeds of indigenous and exotic range species, and to establish private nurseries. Private nurseries were established by 16 farmers with support from the project, and a botanic garden established in Matrouh Adaptive Research Center. Some 25 threatened range species were revived and conserved, more than 10 million fodder shrubs and trees were planted on about 10,000 ha, and over 1500 ha were reseeded by shrubs and by barley-vetch mixtures. More than 13.5 million FU were produced, reducing the total feed gap in project area (FU 145 million) by about 10 %.

M&E studies have shown that about 67 % of rangeland holders benefited from range rehabilitation activities. Of these, 45 % increased their income by 25-50 % due to savings on purchases of feed concentrates.

Cropping systems improvement.
The R&D program for improving cropping systems was based on germplasm improvement, agronomic practices, and diversification and intensification of the system. Tested and promoted technologies have focused on:

- A small genetic and agronomic package for improving barley production. The package consisted of a new variety ('Giza 126' developed by the NVRSRP), two crossed cultivations before and after sowing, a seed rate of 25-30 kg, and a small amount of phosphorous fertilizer;
- ICARDA participatory breeding approach to barley improvement;
- Barley-food and feed legumes rotation;
- Barley-vetch mixtures;
- Fodder shrub interplanting on barley fields; and
- Introducing legumes and vegetables for cropping diversity and higher intensity.

M&E studies have shown that about 53 % of barley producers have increased yield by 20-100 %, on over 27,300 ha of crop area. Case studies revealed that barley yield was increased by 93 % (from about 700 kg/ha to about 1380 kg/ha) and net income was increased by 105 % (from 500 EL/ha to 1025 EL/ha).

Horticulture improvement.

The R&D program for horticulture improvement was also based on introducing new germplasm, agronomic practices, and availing more water supply to fruit orchards. Tested and promoted technologies have focused on:

- Introducing new species (almond, date palm, and pomegranate);
- Introducing new varieties of figs (for drying), olives, and grapes;
- Cultural practices, particularly pruning, fertilization, supplemental irrigation, harvest, and post-harvest handling and processing; and
- Increasing water supply by improved water harvesting techniques, such as dike constructions and micro-water harvesting technologies (semicirculars, small basins).

M&E studies revealed that about 62 % of fruit producers increased yield by 25-200 %, on more than 14,700 ha of orchards. Case studies showed that yield was increased by 60 % on average for fig and olive (50 to 80 kg/tree, and 30 to 50 kg/tree, respectively). The average farm income increased by 52 % (57,000 EL/farm to 86,550 EL/farm). It should be noted, however, that these are very high values of net income in Egypt; and for our case studies, they represent the income of extended families.

Livestock improvement.

Technologies tested and promoted for livestock improvement focused on:

- Genetic improvement using shared rams, and cross-breeding with Shami goats;
- Nutrition improvement using fattening early-weaned lambs, introducing urea-treated straw, and olive-pulp cakes;
- Health improvement by enhancing veterinary services provided to the flocks; and
- Introducing new improved chicken breeds.

M&E studies showed that about 49 % of breeders benefited (directly or indirectly) from livestock improvement activities. The majority (65 %) of technology adopters increased livestock productivity by about 25 %, only 8 % realized 50 % increase or more, but about 12 % of technology adopters could not have any increase in livestock productivity.

Women in development.
Great achievements were realized by this important program in terms of literacy, training on food processing and handicraft making, and enhancing environmental and health awareness of rural women. However, ICARDA contribution to this program was limited to training and capacity building of staff to conduct gender studies, and gender mainstreaming of activities.

BARANI VILLAGE DEVELOPMENT PROJECT, PAKISTAN

Background
ICARDA was contracted by the funding agency (IFAD) to provide technical assistance (TA) to the research component of the Barani Village Development Project (BVDP) in Pakistan. BVDP is a six-year (1999-2005) rural development project with a strong adaptive research base that aims to sustain the resource base and alleviate rural poverty in Barani area in the Punjab region. The challenge, however, is great. With virtually all arable land and water resources being used, the pressure on the natural resource base has increased and environmental problems have reached a critical level.

The project area represents the agroclimatic and socioeconomic variability in Barani region. Rainfall is highly spatially variable (450-800 mm annually, winter and monsoon). About 83 % of the population is rural. The average farm size is 5.6 ha, of which 2.5 ha are arable land (only 1 % of farmers own more than 10 ha). Rainfed wheat, mustard, oilseeds, lentil and chickpea are grown in the Rabi season, and maize, sorghum, millet, groundnut, and pulses in the Kharif season.

Yields are generally low and highly fluctuate (1 t/ha for wheat, 0.7 t/ha for groundnuts, and 0.4 t/ha for chickpea). Livestock is an important component of the farming system, and all farmers own livestock (average 4 cattle, 1 buffalo, 3 sheep, and 4 goats). Feed resources are scarce, large ruminants are fed on some farm produced fodder and crop residues, and small ruminants are fed almost entirely on degraded rangeland (about 40 % of the project area).

Constraints
The Barani area is generally characterized by low and erratic rainfall and crop yields, a high risk to farm production, and poor natural resources and population. Other major constraints are related to land fragmentation and soil erosion and salinity, inadequate water management practices, degraded rangelands and forests, depleted biodiversity, inefficient agricultural research and extension systems, and inadequate use of inputs-certified seed, for example, is 14 % for wheat, and 9 % for maize.

Project objectives

The main objectives of the project are to contribute to:

- The establishment and institutionalization of community organizations;
- Increased agricultural production and income;
- Improved status of women in a culturally accepted manner, including provision of support to income generating activities;
- Improved living conditions of the target population through provision of social infrastructure (water supply, link roads, health centers, etc.); and
- Increased opportunities for off-farm and on-farm employment.

R&D programs

Project objectives should be achieved through integrated programs for community and women development; soil conservation; on-farm water management; applied research; extension; livestock improvement; and enterprise development.

Technical assistance delivery

ICARDA's technical assistance has mainly focused on (i) availing to the project proven technologies developed in similar agroecologies in CWANA region; and (ii) providing technical and managerial backstopping to the research component, including training and human resource development. ICARDA is delivering the technical backstopping through its National Project Office (NPO) and in collaboration with the national research institutes involved in the project; namely, Soil and Water Conservation Institute (SAWCRI); Barani Agricultural Research Institute; Barani Livestock Production Institute; Forest Research Institute, and the National Agricultural Research Center. These institutes, with backstopping from ICARDA, aim to (i) improve water and land use management; and (ii) improve integrated production systems. Most of the research work has been implemented on-farm, on three integrated research sites (IRS) in different agroclimatic and socioeconomic conditions.

Technologies tested

Major technologies tested at the IRS, with TA of ICARDA for improved resource management and agricultural production are related to:

- **Cropping systems improvement:** testing and promoting new germplasm and agronomic practices to increase crop productivity, diversity, and cropping intensities; develop location-specific crop improvement packages.
- **Soil and water conservation and development:** improved design of earth dikes and their spillways (stone-outlets on earth dikes) to regulate water flow and distribution; test planting one row of fruit and/ or fodder shrub and tree at the dike's upstream side as windbreaks, and to improve water-use efficiency and add to farm income; soil conservation by growing fruit plants in the

eroded gully areas using micro-water harvesting techniques and/or supplemental irrigation.

- **Rangeland rehabilitation:** test and disseminate reseeding of several indigenous species of fodder shrubs and trees, and feed block technology.

Achievements

Within three years of project implementation, promising results have so far been obtained in most R&D areas, above; but, it is too early to evaluate and report. However, the recommendations below should be taken into consideration to enhance activity implementation and achievements.

Research and technology transfer

- Improve the design of the on-farm trial and demonstration programs at the IRS, especially these of water and soil conservation, and rangeland rehabilitation.
- Introduce, test, and provide for farmers several technical options of water-harvesting techniques and plants.
- Special emphasis should be on research and technology transfer for improved water-use efficiency.
- Gender issues and women perspectives should be considered in the assessment of the promoted technologies.
- Encourage establishment of family, or community-based seed production enterprises and a proper mechanism for producing and trading the feed block technology.
- Consider the possibility of injecting research of a long-term dimension and initiate monitoring and evaluation research to investigate sustainability of project impacts on the natural resource base and poverty.

Institutional and capacity building

- The strict official government regulations hindering the overseas training program should be relaxed to facilitate implementation of this important program.
- In-country formal and on-job training for project personnel and farming com munities should be supported for enlargement and wider coverage.
- Regular consultation meetings with farmers' communities should be organized to identify ways for community management of water resources and rangeland.
- The R&D work conducted on the IRS should be highlighted and communicated to farmers through extension pamphlets, and mass media.
- More effective collaboration and integration between the stakeholders of the project (research institutes, extension, NGOs, farmers' organizations) is needed for efficient use of the community-based participatory approaches adopted by the project.

R&D projects: conclusions/lessons learned

The MRMP has been recognized nationally and internationally as a successful resource management and rural development project that has a strong adaptive research and technology transfer base. The project has proceeded well towards achieving its goal of promoting and adopting sustainable resource management practices, biodiversity enhancement, and poverty alleviation in a semi-desert environment of the poor Bedouin population. The World Bank, the funding agency of the project, has considered MRMP as one of its most successful, pioneer resource and rural development projects that could be copied elsewhere in the dry areas.

The role of ICARDA's technical support for project implementation, especially in the realms of developing new methodological approaches and in integrating the themes of resource management and improved agricultural production with human resource and social development, has been well recognized and acknowledged in many local, national, and international events and documents.

Factors behind the success

The following factors were mainly responsible for the success of the project:

- Employment of an innovative management model and participatory approaches, where all implementing agencies (research, extension, and resource development) were integrated and operated under one authority, the project coordination unit. Decentralized management was facilitated through five sub-regional support centers established to connect the project decision-making mechanism to the local communities. Also, effective community participation was ensured through grouping of the project beneficiaries into 38 Local Communities (LC). Each had to develop its own R&D plans that were contracted for implementation with LC members.
- Three participatory R&D approaches were used for implementing project activities. The integrated watershed management approach to resource conservation and development recognized the whole of a watershed as the physical development unit; the farming system approach considered the whole of the farm as the agricultural development unit; and, the community action planning approach dealt with each of the 38 local communities as a consolidated social development unit.

- The keen interest of the Government of Egypt and the World Bank to develop the area, the Bedouins to improve their livelihoods, and ICARDA to maintain its image as a Center of excellence.
- Availability of sufficient budgets, human and physical resources for effective

activity implementation.

- The build-up of an efficient monitoring and evaluation system that assisted the project management in follow up and evaluation of project performance, adoption of technologies by project beneficiaries and its biophysical and socioeconomic impact.

Research-Development Continuum.

ICARDA and other sister international agriculture research centers (IARCs) are advancing ahead towards more involvement and partnership in promoting the research-development continuum. It could be concluded from Matrouh lessons that development projects could be an appropriate vehicle for injecting the research agenda of IARCs into development sites for the following reasons:

- These projects usually cover a large area, thus facilitating multi-location research programs under variable biophysical and socioeconomic environments.
- They are multi-purpose, targeting the sustainability of natural resources/agri-cultural production improvement/and social development enabling researching on, within and between these themes.
- They integrate research/extension/development work, creating a conducive environment for technology transfer, and assessment of real potential for adoption and impact.
- They are well funded with good physical and human resources.
- Have a long-term dimension (mostly over 5 years, with extension potential for multi-phases), enabling strategic research on sustainability of adoption and impact.

What needs to be done?

It is an area of new concepts and role of agricultural research in rural development. Therefore, it requires IARCs to:

- Have innovativeness, courage, and creativity to build up new research philosophy, school of thinking, and new expertise to deal with new tasks and challenges.
- Develop a technical and managerial capacity to inject the centers' research agenda in development sites. Difficult questions arise in this respect: what kind of research and for what purposes? Where, and at what scale? What designs and methods to use, and who will do what, and how?
- It is recommended to establish a Research/Development Coordination Unit in the Center to coordinate internal and external efforts to answer the questions above and other questions, and to assist in the managerial and logistical aspects of technical assistance delivery to development projects.

PROJECT 4.2: SOCIOECONOMICS OF AGRICULTURAL PRODUCTION SYSTEMS IN DRY AREAS

Goal

Sustainable improvement of agricultural productivity and the welfare of poor people in dry areas through the identification of problems and the development, transfer and adoption of viable options

Purpose

A better understanding of the economic and social dimensions of rural poverty through micro-economic and social analysis of farm households and rural poverty and improved targeting of technology transfer efforts

Output 1: Production problems of resource-poor farmers identified and their production systems characterized

Planned milestones 2002

Production problems diagnosis and characterization of farm and households typologies completed in the dry land farming systems in Central Asia using data already collected

Achievements in 2002

A production systems characterization study covering four countries in Central Asia (Kazakhstan, Uzbekistan, Turkmenistan, and Kyrgyzstan) was conducted as an integral part of IFAD supported Livestock and Forage Improvement Project for Central Asia in collaboration with the Livestock Project (MTP Project 2.5). The study used formal and informal methods to gather information on livestock production systems, production practices and problems faced by producers and perceptions about introduced technologies. Surveys on livestock production (focusing on small ruminants) were conducted in the Central Asian countries (Kazakhstan, Uzbekistan, Turkmenistan and Kyrgyzstan). The surveys covered more than 2300 interviewees in the four countries and included different types of producers, intermediaries (middlemen) and consumers. The study used formal and informal methods to gather information on livestock production systems, production practices and problems faced by producers and perceptions about introduced technologies.

The study established specific farm types including household farms, small private farms, and agricultural cooperatives. Agricultural Cooperatives (AC) can be state or non-state farms. There are different forms of AC based on the legal basis of their establishment. ACs can have a large land area-up to 3000 ha in sample households in Kazakhstan. Small private farms consist of holdings of 2-3 families which acquired their land as a share of state collective farms, and who jointly produce, process and market their produce. Small private farms have relatively small areas of agricultural land of about 4-120 ha. Household (private subsidiary) farms are based on private ownership.

Official statistics demonstrate that, although average stock of animals per household is not significant, these farms hold the bulk of the livestock. For example, in Uzbekistan they hold over 80% of cattle and about 70% of the whole population of sheep and goats of the country. Household (HH) farms consisted of single household units with small land of about 0.06 -1 ha, with average holding of less than a hectare. These farm types differ in their resource endowments (cultivable and range lands), livestock ownership, feeding practices, expenditures, production problems (such as diseases, machinery availability and access to finance), and production orientation.

Producers' perceptions on new technologies (such as fodder production, early weaning, winter-feeding, and production of sheep milk derivatives) were also described. The information in this study will be essential for planning a client-oriented adaptive-research in livestock production in these countries.

In all the countries, private farms predominate livestock production. Some of the household farms operate independently of the cooperative farms (Shirkats) while others operate within the Shirkat and depend on the latter. The cooperative farms or Shirkats play an important role in supplying inputs, services and expertise to small farms and provide market linkages to small household farms and individual private farms. However, improving feed availability at critical times of the year (such as pregnancy and lambing periods) should be an important research topic in the future. Other constraints were, lack of farm machinery, credit and marketing related problems. Farmers also complained about the incidence of different types of diseases. They welcomed the idea of producing and marketing sheep milk, which provides an opportunity to increase farm income.

In Kyrgyzstan, the main constraint is insufficient agricultural machinery. Farmers believe that acquiring machinery will lead to improved productivity. As farmers indicated, cooperatives or available extension offices do not have sufficient machinery to enable timely field preparations, which results in significant yield declines and harvest losses. Shortage of fodder was also considered as a major constraint related to improper grazing and limited hay-making land area. Because of the lack of fodder, severe losses occur during the lambing period. Animal diseases that often lead to economic losses were also stressed as important problems.

In countries where the reform process has been slow, such as Uzbekistan and Turkmenistan, the high interdependence between the agricultural cooperatives *(Shirkats)* and private (small-scale and medium) farms has to be understood and taken into consideration for further reforms in this sector. Many households are still dependent on the cooperative farms for employment, input supply, product sales; and the cooperatives rely on the households for labor and supply of production. In some cases there are contractual arrangements between cooperative farms and producers. Agricultural cooperatives provide veterinary services, supply inputs (fuel, lubricants, machinery), and provide the infrastructure through which state-subsidized food stuff (flour, rice, sugar, and winter clothes) are transferred to poor rural communities. Therefore, the role of agricultural cooperatives as service provider was strengthened, while their production role was fully transferred to individual producers.

Implications for 2003 and beyond

The study provided vital training to the Central Asian teams and was able to bring young and enthusiastic scientists into the system, but the deficiency in social science research capacity in these countries in so huge that expectations had to be lowered. Human capacity building for long-term training and full-time research staff support stationed there will be required in the future to improve research outputs and ensure high quality of research.

Output 2: Rural households and their livelihood strategies characterized and the circumstances that constrain or enhance the adoption of technologies and management practices identified

Achievements in 2002

- A rural rapid appraisal (RRA) was conducted in an integrated research site, the Khanasser Valley, in Syria, as the first step towards understanding rural people's livelihoods, their strategies and constraints. A 'Livelihoods Framework' was the basic approach used. Participatory Poverty Assessment (PPA) was incorporated into the RRA using key informants and group discussions. Community-perceived poverty was identified using PPA methods. Off-farm employment is an important livelihood option, involving about 86% of households. New enterprises (including sheep fattening and olive and cumin production) have emerged as ways of diversifying income and seeking higher returns, whilst the more environmentally sustainable alley-cropping technology of growing drought-tolerant *Atriplex* shrubs with barley has not been readily accepted. Villages were classified into groups with dominant livelihoods using cluster analysis. Different options for improving rural livelihoods are presented. The variables used in the cluster analysis were overlaid using GIS, in order to select representative case study villages in which the impacts of these options on the livelihoods of the people are now being investigated as the next step in this study. In addition, participatory evaluation of new technical options is part of on-going integrated natural resource management research. A poster paper of this study was submitted to the 25th International Conference of Agricultural Economists, 16-22 August, Durban, South Africa.

- A comprehensive report of this survey titled "Socioeconomic Assessment of Rural Communities in the Dry Areas: Survey Results of Khanasser Valley in Syria" is completed and used as an important reference of the study area by all participating researchers. The study is an integral part of several social science studies aimed to understand rural livelihoods using in-depth livelihood surveys, analysis of social organizations, enterprise budgets, price monitoring, and ex ante analysis of different options and their impact on different communities. This study has already had an impact at the research level as it led to the identification and characterization of rural livelihoods used for detailed in-depth livelihood surveys. The characterization, using GIS, also led to the establishment of specific villages representing different livelihood situations as the main research focus. The understanding provided by these studies allows the development of appropriate interventions and the identification of policy and institutional changes necessary for the adoption of these interventions.

- A rapid survey of the community in a steppe of Syria near Khanasser Valley was conducted that aimed at understanding rural livelihood strategies. Syrian rangelands have traditionally sustained nomadic and semi-nomadic populations whose livelihood strategies were centered on animal production, sometimes combined with forage-oriented barley cropping systems. A recent policy-aimed at halting the encroachment of crops onto marginal land and reducing environmental deterioration-has banned cultivation from rangeland below a 200 mm rainfall probability line. This has contributed to drastic changes and diversification of local livelihood strategies. Seasonal migration to cities for wage labor-traditionally uncommon within most local nomadic societies-has become the main income strategy for large numbers of former nomads. Those who remain on the range struggle for subsistence, and struggle to meet the feed demand of their livestock. They can no longer rely on local barley as

feed in the dry season and in years of drought. This study shows how different groups of households have responded to policy and ecological changes.
It represents the first step in integrated research, which should lead to policy recommendations and technology options for sustainable and enhanced livelihoods in marginal rural dry areas.

- A study assessing the socioeconomic factors influencing the incidence of lathyrism (a crippling disease) as a result of the consumption of grass pea (*Lathyrus Sativus*) was conducted. The study found out that despite being the least preferred legume for human consumption, farmers in Ethiopia widely consume grass pea in several local preparations and the low-income farmers consume it more frequently than the middle-income farmers. There are two main reasons for the consumption of grass pea. First, farmers cannot produce the preferred legumes, chickpea and lentils, in sufficient quantities due to insects and disease problems. Grass pea is more readily available because of its better tolerance to insects and diseases. Second, low-income farmers cannot afford to buy preferred legumes because of their relatively high prices. The health hazard associated with the consumption of grass pea still exists in the rural areas. It is highly associated with drought periods when the food security situation of the rural population deteriorates. Lathyrism mainly affects poorer households which have greater household food insecurity, own fewer assets such as land and livestock, and have lower income than unaffected households. Poor households will continue to depend on grass peas as source of protein for years to come. Therefore, effective educational and public awareness programs are required to inform rural people about the health hazards associated with different consumption patterns of grass pea. There is a need for the development of simple and standardized detoxification techniques and their popularization as part of the agricultural extension program. Simple guidelines for the use of such techniques that can reduce the neurotoxin substance in local preparations of grass pea to safe levels are urgently needed. Development of new varieties with low and acceptable level of â-ODAP content should continue. Such varieties would have a positive impact in reducing costs of food processing and preparation by reducing the time of soaking and cooking. This would also save protein, vitamins and other nutrient losses due to rigorous processing usually done for reducing the neurotoxin substance of grass pea. Above all, the development of varieties with low level of â-ODAP will reduce the incidence of lathyrism and social and economic costs to poor rural households.
- A detailed report titled "Socioeconomic Factors Affecting Grass Pea Consumption and the Distribution of Lathyrism in Ethiopia" by Legesse Dadi,

Hailemariam Teklewold, Aden Aw-Hassan, Ali Abdel Moniem and Geltu Bejiga, was submitted as a *Social Science Paper*, ICARDA, forthcoming.

- A study on poverty, food systems and nutritional wellbeing of children in three production systems in Syria is in progress. The study employed both qualitative and quantitative methods. These include informal interviews and observations, seasonal calendars, food card sorting exercises, participatory socioeconomic evaluation, community level socioeconomic characterization, food frequency questionnaires and anthropometry. The villages studied belong to three livelihood groups (barley/livestock/wage labor; olive/fruit tree and wage labor and irrigated group). The households were purposively selected in the different villages based on presence of children less than 10 years of age. A total of 207 households were interviewed and 541 children of the interviewed households were measured in 5 villages. Data collection for this study was completed in November 2001. Data entry was conducted through the period of data collection and was completed by February 2002. Data cleanup was conducted in early 2002. Analysis of growth data was completed in March and a draft of a growth assessment paper was completed. Two other papers, one on assessment of the Socioeconomic factors influencing child nutrition and another on the food intake pattern of the studied households, are in progress. Analysis of the entire dataset in which comparison of each level of data will be made using multiple regression analysis is underway. A PhD dissertation outline for Ms. Shibani Ghosh was finalized by a committee. Compilation of the dissertation is in progress.

The main findings of this analysis, thus far, are that rural Syrian children are more stunted and underweight than urban children. Urban children not only have low levels of stunting, wasting and are underweight, but in many cases they are overweight. Wasting levels in the rural children are low and thus the levels of underweight observed in the rural children can be explained by a linear growth. Within the rural context, poor growth was observed in both high and low rainfall areas and differences occurred within the same agricultural stability zone. The groups with high levels of poor growth and under weight were more resource poor, dependent completely on wage labor and were located in marginal areas. These were households with barley/livestock/wage labor as the livelihood base and close to the steppe with high land degradation and poor rainfall, and those with livelihoods dependent on olive and fruit trees in mountainous areas of the Afrin valley with poor soils despite a higher rainfall. However, the irrigation-based group and the olive tree-based group were part of the same agricultural zone but the fact that the former was much better off indicates that factors other than zonal differences such as other natural resource constraints and poor access to means of acquiring livelihood assets are likely to affect the agricultural household welfare and growth status of the children.

- A study on the impact of Lysine fortified wheat flour on the nutritional status of rural families in North West Syria is in progress. The study is in 2 phases. Phase 1 involves a dietary and socioeconomic evaluation of families living in the Khanasser Valley, whereas phase 2 involves examining the effect of lysine-fortified wheat flour on the nutritional status of families predominantly dependent on wheat. The main objectives of Phase 1 were: To evaluate the dietary status of families in the marginal areas of northwest Syria, evaluate their socioeconomic status and test the stability of lysine in thin-Arabic bread. The main objectives of Phase 2 are to estimate the functional improvement of protein status on the provision of lysine fortified flour to adults and children; to study the growth pattern of children in Khanasser families with fortified diets as compared to non-fortified diets and to observe other health consequences of fortification to the target population, for example the occurrences of diarrhea or respiratory diseases.

Data collection in Phase 1 of the study was started in March 2002 and completed in May 2002. A quantitative evaluation was conducted on the dietary and socioeconomic status of households belonging to Khanasser Valley. The main criterion for selection of villages was the utilization of home-baked bread at the household level. In the region of Khanasser, after conducting rural appraisals, a total of 17 villages (out of 35 which are part of the region) were found to use home-baked bread. Eleven villages were too small to beincluded. A community characterization was conducted in the remaining 6 villages. One village was dropped as villagers were not cooperative, and two other villages could not be included due to the high level of migration through the year for wage labor and sheep grazing. Thus, out of six villages, three villages were chosen and data collection was conducted in a total of 107 households. The data was entered and cleaned in June-July 2002. A nutrient database was set up at the University of Massachusetts using USDA nutrient database and Middle East food composition tables. Analysis of food data to determine nutrient value per adult per household was conducted in September 2002. Corrections to the food and nutrient composition data base had to be made on completion of the analysis and final results were available and reported in November 2002. A report was submitted to INF on values of lysine in Khanasser diets. Khanasser diets were found to be limited in good quality protein with a level of 41-mg/g protein of lysine, which is much lower than the current requirement of 50 mg lysine/g protein.

Socioeconomic data entry is completed. Data clean up is currently underway. Examining the relation between the nutrient availability per household (and nutritional content of the diets) and the socioeconomic characteristics of the households will be key analyses that will be conducted. Factors affecting the availability of animal protein will be analyzed. One of the main findings of the preliminary analysis conducted was that the Khanasser diets were found to have sufficient calories and protein. However, the protein was predominantly cereal in origin (65% cereal protein- Figure 1).

A study on the characterization of the livelihoods of rural communities in the Mountains of Yemen is in progress. The study highlighted the following major points:

a. In the survey, the poorest households were described as having very 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 that crop-based technologies will not take the poorest households out of poverty. Other asset-building interventions, such as enabling the poor to acquire livestock, would be more appropriate.

b. Surveys and discussions with farmers have revealed that water scarcity is the most critical issue in the study areas. 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 scarce 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 adequate labour for the repair and maintenance of these water systems. 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 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.

c. Water productivity in the watersheds could be improved in various ways. More surface runoff could be caught in small reservoirs. This water could be used for supplemental irrigation at critical times. Earthen irrigation channels, which guide water over long distances along the terraced slopes, could be improved to reduce leakage. Crop selection is an important issue. Due to the uncertainty of the water resources and the traditional water sharing system, water is not always given to the highest value crop. There is also potential for the use of drip irrigation for high value crops grown in plastic tunnels. All water management options need to be carefully planned and discussed with the farmers, so that downstream farmers will not be adversely affected by improved water-use efficiency upstream.

d. The development of cisterns for domestic and agricultural use could have an enormous impact on livelihoods in these communities. Availability of domestic water is a major problem, and women spend much of their time fetching water. However, farmers need technical help and advice on the design of cisterns, and on the optimal use of water for agriculture. Improved access to development loans through community organizations, and farmer visits to areas where such systems are used could improve adoption.

e. Livestock is one of the most important sources of livelihood for the communities in the research sites. The RRA determined that feed constraint is the most important problem facing livestock producers. Children, mainly girls, spend a lot of time and effort herding sheep and goats on degraded mountain slopes. Cows are handfed, mainly by women. Farmers graze their animals on farm residues, fodder crops, and forage collected by women from different places. This subsistence practice limits the productivity of livestock. Researchers, therefore, must develop innovative and practical ways to improve livestock feed, reduce the cost of feed, and increase livestock productivity. Assessing market opportunities and farmers' ability to take advantage of these opportunities is an integral part of the livestock improvement program.

f. 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.

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.

Output 3: Quality of farmer participation in agricultural research improved

Planned milestones 2002

- Analysis of the institutional implications of farmer participatory research completed in Jordan
- Study on the effects of farmers' socioeconomic characteristics (including gender) on the quality and outcomes of farmer participatory research completed in Yemen and Syria

Achievements in 2002

A study on the institutionalization of participatory research in Jordan was conducted. As a first step, the study assessed the current institutional structure of plant breeding research in Jordan and made an attempt to identify the opportunities and constraints to the adoption of participatory plant breeding in the country. The study was carried out using personal interviews with 21 scientists (five of whom are PhD holders), in addition to meetings with the Director General of the National Center for Agricultural Research and Technology Transfer (NCARTT) and the Director of Extension. The PhD holders have between 6 and 10 years experience in research. It is important to note here that only 2 of the 5 PhD holders are working at NCARTT, while the other 3 scientists work at the Jordanian University. Most master degree holders have between 11 and 15 years experience working in research. About 67% of the scientists spent between 25 and 50% of their time working on-station (laboratory and office work), and 33% were working on their on-farm trials also as 25-50% of their total working time. Also, about 52% of the scientists spend sometime working on PPB, and the remaining 48% work only on classical on-farm trials.

Participatory plant breeding (PPB) was initiated and introduced by ICARDA to NCARTT. This approach is relatively new to many researchers. About 57% of the scientists were aware of the approach but 43% had never heard about it. Their definitions of participatory breeding approach were diversified. The level of understanding of the approach was mixed, but it seems that by and large there is a good basis for further development. Some of them understood the approach very well, while others need more information. Most researchers perceived that the opportunities offered by the approach are great, and perceived that less time and efforts are needed to produce varieties suitable to different environments with the participation of the concerned farmers. Also, researchers perceived that through farmer participation, research would reach the farmers' goals and the adoption potential would be higher. Scientists anticipate substantial benefits from the approach although it is too early to assess real changes due to the short time of the project in Jordan. There was no formal training course given to NCARTT scientists about the PPB approach, they learned by participating in the project. However, five of them attended a participatory course organized by the Biodiversity Project and run by the principle barley breeder, Dr Salvatore Ceccarelli, who is the main driver of the participatory plant breeding at ICARDA.

There are certainly difficulties with multi-institution projects, and it was clear from this investigation that clear mechanisms to cooperate between different institutions, such as universities and NCARTT should be part of the institutional framework that would make PPB work easier for collaborating scientists. Certainly, this project has highlighted the difficulties that arise when multiple institutions are involved in one project. If Jordan has to use its human resources efficiently, mechanisms and norms from inter-institution collaboration must be established. The researchers listed many problems that they face which are commonly found in developing countries' NARS where budgets and infrastructure facilities are limited. These difficulties included: research facilities at the headquarters are lacking in the other research stations, research inputs that are not provided at the right time except for special projects, etc. However, the main difficulties in implementing PPB perceived by researchers were:

- Lack of scientific information on PPB, as only few scientists read the approach in the literature,
- Lack of cooperation between scientists and extension agents. This requires much greater involvement of extension staff in participatory research if it has to be truly institutionalized.

Finally, after having interviewed the Director General of NCARTT, and the Director of Extension about the Participatory Barley Breeding project, they both expressed their willingness to institutionalize the approach within their institution, and have strongly recommended that ICARDA should organize workshops and conferences for their staff to become more acquainted with the approach. They have also expressed their willingness to expand the approach to other crops.

As part of a participatory plant-breeding program in Yemen, a socioeconomic study was initiated. During March 2001, participatory rural appraisal was conducted in 2 villages (Beit al-Wali and Al-Ashmor) in the Kuhlan Affar area (North of Sana'a) and 2 villages (Balasan and Yarim) in the intermountain plains near Dhamar City. The aim of this investigation was to understand the socioeconomic and gender aspects of farmers varietal selection strategies. In the northern mountains of Kuhlan Affar region, barley and lentils are the main crops grown in addition to sorghum, wheat, peas, maize, and alfalfa. In this area all farmers consult each other in order to set a period where they graze their land at the same time. In the intermountain plateau, near Dhamar, farmers grow mainly potatoes (where irrigation is possible), sorghum, wheat, barley, peas, lentil, maize, alfalfa, vegetables, and some fruit trees. However, the main crops are wheat and barley and are grown under rainfed conditions.

Group meetings were held with men and women together and separately, and the decision-making process in relation to the selection of varieties was discussed. Men and women selected new varieties separately.
Barley is one of the most important crops for the livelihoods of rural people in the dry mountain areas of Yemen. It is widely used for making bread called *"Malug"*

or *"Gahin"*. Barley grains are used as a drink called "coffee from barley". It is also used to make *"khamir"* bread made of maize flour mixed with barley, and is also used to make soup and cake. Barley grains are used as medicine for relieving kidney problems. Milk and barley are cooked together can be served anytime of the day as a meal called *"Zawm"*. Other types of bread and food called "Chiza" and "Mathani" are made of barley. For animal nutrition, barley grains are fed to ewes after lambing, and to sheep in general. Straw is fed to animals and as building material, and other uses. Lentil is a high value cash crop.

The main selection criterion of barley and lentil varieties by farmers in the mountain area (Kuhlan Affar region) was the length of growth period, apparently due to the very short rainy season (2 months). However, there were gender differences in selection. Men farmers based their selection mainly on market prices. Thus, grain size was the most important selection criteria. Women think more about food and animal feed characteristics, which made both grain and straw important in their selection. Also, on small terraced fields in the mountains, smallholder farmers made group decisions concerning rotation, and they practically selected the same varieties of barley.

In the intermountain plateau (Dhamar region), the collaborating farmers (women and men) selected short-growing, early-maturing varieties to utilize the short (two months) rainy season. In addition, frost affects the varieties with longer growing cycle. Both women and men base their selection on the growth period. However, few farmers who have a source of irrigation select varieties with large grains. The color of the grain is not of great importance for both men and women farmers as bread is actually made of a dark grain, which is considered of good quality.

Women's decision and knowledge.

In this study, most women selected the same varieties as their male relatives (husbands, brothers and fathers). This shows that they were very much influenced by their male relatives. This selection agreement between men and women was due to the perception that disagreement will not lead to a recommendation of a variety for large-scale adoption, but agreement would. So, women voted with their male relatives rather than selecting according to their personal preferences. As the project has later explained the objective of the selection more clearly, it is expected that women will select more independently in the following years.

Although women have participated in the PPB in Yemen, they have never heard about the performance of the different varieties in the different locations because they know only the two or three local varieties grown in Yemen. Men of these households have expressed their willingness to allow their wives and daughters to participate in field trips organized by the scientists and extension agents involved in the project in order to enable them learn about the performance of the different varieties in different agroecological conditions.

Participatory training courses were conducted for the Livestock Project, the Barani Village Development Project (Pakistan), and the Khanasser Project. Two consultants have successfully executed these participatory training courses.

Implications for 2003 and beyond

The resources allocated for social sciences research in these participatory projects were inadequate and the social science role was limited to the level of adviser to biological sciences and NARS. There are very few skilled social scientists from NARS participating in these projects. In the future, there should be a better balance between NARS social and biological scientists, and social scientists should be able to address farmers' learning process and information dissemination questions as well as the livelihoods of the rural communities beyond the immediate crop under investigation. This will provide greater incentives for social scientists to be involved in such projects. This, however, requires clear budget allocations for the social science component.

Output 4: Documented adoption and feedback of user evaluations into the technology generation process

Planned milestones 2002

Adoption of chickpea technology in Syria assessed

Achievements in 2002

1. The milestone was not achieved because of the delay in the release of new chickpea varieties. The Ministry of Agriculture has accepted the new chickpeas varieties for official release in this year, and the Chickpea improvement program initiated a small-seed package program with farmer participation. This program is expected to speed up the adoption of new varieties. This project is also participating in monitoring the diffusion of new chickpeas varieties. Other achievements are given below.
2. **Analysis of seed tracer study**. The five-year data of farmer-to-farmer diffusion of seeds of new barley varieties was analyzed. The initial 52 farmers who received seeds from ICARDA and those who obtained new variety seeds from them either directly or through other farmers in the following years were

surveyed every year form 1994/95 and until 1998/99 season. In the first year, the initial 52 farmers were interviewed using a designed questionnaire. In the following year, 45 new growers who received new varieties from the former group were included in the survey so a total of 97 farmers were interviewed. This number reached 149 farmers in the third year, 186 in the fourth and 206 farmers in the fifth and last year. The farmers in the sample were visited in their villages once every year at the end of the planting season. The aim of this study was determine the diffusion of varieties by tracing the seeds of new varieties. The initial group of farmers who received seeds of new varieties from ICARDA in the first year were located in 24 villages. This started off the informal seed distribution process that we traced in this study. Main findings were that:

- Small farmers tend to sell all their barley production directly at harvest time in one big lot to cover their expenses and debts. Few farmers, who were convinced of the value of new varieties, indicated that they tend to sell all of their production at harvest. They did not keep any seeds for future planting if they did not plan to grow barley the following year due to lack of land or rotation, since they could not guarantee safe storage due to rats and insects damage. This means that many farmers rely on outside sources for seeds on an annual basis.
- In the 5th year of this seed tracer study, about 27% of the seeds cultivated by the sample farmers were new varieties. This is much higher than what the formal seed system can provide. About half the farmers (49%) used their own seeds saved from the previous season and 37% of them pur chased from neighbors, indicating the importance of farmer-to-farmer seed distribution, on commercial basis, in the diffusion of new varieties. Some 14% of the farmers received seeds from ICARDA's breeding program.
- Out of the 52 original farmers who received the seeds of new varieties from ICARDA, only five (coded as F11, F14, F25, F36, and F44) have become the basis for networks with significant number of seed transactions. In total, 156 seed transactions were reported for the four years excluding the first year that ICARDA provided the seeds. About 70% of these trans actions took place within these five networks. The five main seed suppliers directly accounted for 42% of the total seed transactions. These five and another two second generation seed suppliers directly accounted for more than half (53%) of the seed transactions. This indicates that there is strong propensity for the concentration of seed trade at the local level. This may be based on experience on the part of suppliers,

trust, reputation and the fact that these original farmers and their associates have linkages with agricultural research organization (ICARDA). Any attempts to strengthen local systems should build upon established networks. The names of the farmers forming these networks were provided to the barley breeding program upon request. The program is currently experimenting local seed systems and this information will be essential for this effort.

3. A study was conducted in 12 districts in Bangladesh (Jessore, Norail, Jhenaidah, Magura, Faridpur, Rajbari, Kushtia, Maherpur, Chuadanga, Pabna, Natore and Comilla) to assess the adoption and the profitability of Bangladesh Agricultural Research Institute (BARI) lentil varieties. Using multi-stage sampling techniques data were collected from two categories of farmers: participants of extension program (125) and non-participants (125), during rabi season, 2001-2002. The study revealed that the cultivation of BARI lentil varieties has increased. 'Barimasur-4' was the most frequently adopted variety. Only 49% farmers cultivated local varieties within the sample farmers. Modern production practices were more likely to be adopted by participating farmers. Some non-participating farmers also adopted modern production techniques. The results of this study indicate that local lentil varieties could be replaced by 'Barimasur-3' and 'Barimasur-4' lentil varieties. The adoption of new lentil varieties increased the farm income by Taka 5378 or about US$ 95 (1 US Dollar = 56.32900 Bangladeshi Taka).

Implications for 2003 and beyond

The lentil study in Bangladesh was extended to cover more detailed information about the socioeconomic characteristics of the adopters of new lentil varieties using the livelihoods framework in order to be able to assess how new varieties affected rural poverty. This aspect of the research will be completed in 2003.

Output 5: Quantified *ex ante* and *ex post* impact of new technologies and information for research priority setting and planning

Planned milestones 2002

The impact of farmer participatory research in one project assessed

Achievements in 2002

A study aiming at assessing the benefits and costs of ICARDA's participatory barley breeding approach as compared to the conventional (centralized) breeding approach; both at the farmer level and as returns to research was conducted. This is a response to the increasing application of participatory approaches by scientists to their research to better understand clients' needs and to design agricultural technologies that fit the complexity of poor people's livelihoods. The methods used include economic methods of measuring benefits from adoption, and from "process impacts" which occur because of the participation itself rather than because of the technologies developed. We calculated the opportunity costs of farmers' time in research and analyzed the change in research costs due to the breeding approach.

Our results show that there are potentially significant increases to Syrian agriculture from participatory barley breeding. Findings indicate that the infrastructure and personnel constitute the largest share of the breeding budget. The given breeding approach (e.g. conventional, decentralized, participatory) or breeding method used (bulk, pedigree) affects the operational costs which represent a relatively small share of the total breeding budget. Moving from conventional breeding to participatory breeding affects the allocation of the total operational costs, and the biggest change is due to the decentralization of breeding (moving from station to on-farm). Adding participatory trials 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. Participatory research increases farmer's skills and implies some economic benefits from learning.

Farmers' views about the participatory research process were documented and the feedback was given to breeders. Farmers were interested in conducting participatory research in other crops like cumin and research on cumin has been initiated. Farmers also wanted to conduct animal feeding trials on different varieties. This aspect has also been added to the research. Participation in research increases farmers' skills and implies some economic benefits from learning. Paper of the study was submitted to the *25th International Conference of Agricultural Economists*, 16-22 August, Durban, South Africa.

A study titled "Impact of ICARDA Research on Australian Agriculture", by John P. Brennan, Aden Aw-Hassan, Kathryn J. Quade and Thomas L. Nordblom, was published as Economic Research Report No. 11, New South Wales Agriculture 2002, Waga Waga, Australia. This study details the impact of ICARDA's germplasm research on Australia agriculture. There were relatively strong links with ICARDA for the five main mandate crops. In barley, durum wheat, Kabuli chickpea, faba bean and lentil there are both strong links and a substantial Australian industry to provide the necessary conditions for a significant benefit flowing back to Australia from germplasm obtained from ICARDA. In particular, the Australian faba bean and lentil industries have relied heavily on germplasm from ICARDA.

The average estimated net gain to Australia as a result of the overall research effort at ICARDA is A$13.7 million per year (in 2001 Australian dollars) over the period to 2022. Most of those gains are achieved in the faba bean and lentil industries. Producers receive most of the welfare gains in Australia, amounting to A$12.6 million of the total. On the other hand, Australian consumers of these crops will make gains of approximately A$1.1 million per year. Consumer gains in Australia are relatively small because domestic consumption of several of the ICARDA mandate crops is modest.

This study also led to the completion of a paper titled "Role of Spillovers in Enhancing the Benefits of the International Agricultural Research System" by John P. Brennan*, Aden Aw-Hassan and Thomas L. Nordblom, and that was submitted to the Food Policy Journal. A second paper titled "Quantifying Spillover Benefits to Australia from ICARDA's Research on Kabuli Chickpeas," by John P. Brennan, Kathryn J. Quade, Aden Aw-Hassan and Thomas L. Nordblom, was submitted to the *Australian Journal of Agricultural Economics.*

A publication titled "Impact of Modern Agricultural Technologies on Durum Wheat Production in Syria" by Ahmed Mazid, Richard Tutwiler, Malika A. Martini, and Hassan Al-Ahmed was submitted as Social Science Paper No. 11 (in print). The study, using multivariate analysis based on survey data, estimates an increase of 1.66 million tons (1 ton = 1000 kg) of durum wheat as a result of modern agricultural technology on wheat production in Syria. This is equivalent to an increase in national income of about 17.4 billion Syrian Lira annually (US$348 million at the exchange rate of 1 US$ = 50 SL). About 34% of this increase is due to the impact of the use of improved varieties, 24% to fertilizer, 23% to irrigation, and 19% to improvement in land and crop management practices.

Output 6: Evaluation of the economics of livestock production in the low rainfall areas of CWANA

Planned milestones 2002

- Analysis of data already collected on livestock production systems in Central Asian countries completed
- Analysis of the economics of livestock production in the changing agricultural systems in WANA completed

Achievements in 2002

As part of the activity reported in output 1 of this report, surveys which were completed for producers, middlemen, processing companies and consumers were implemented in 4 Central Asian countries (Kazakhstan, Kyrgyzstan, Turkmenistan, and Uzbekistan) and analyzed. The aim of the surveys was to assess the marketing problems of livestock production in the changing environment. The study found that access to markets as well as the functioning of markets of different products was highly variable in the surveyed communities. This variability mainly depended on the degree of privatization of large agricultural cooperatives and proximity to main urban centers and food processing facilities. In many situations there is lack of properly functioning markets, for example for wool and pelts, and farmers rely on barter trade or in-kind exchange of goods. Agricultural cooperative farms also use live animals and meat as payments to the farm workers. The unavailability of middleman is recognized as a problem for marketing live animals, pelts and wool. Other market problems included transportation costs. Other preliminary findings include:

In Kazakhstan, for example, the share of processing companies in the milk and dairy products market is about 80%, which obviously underlines their importance. Some farmers have access to large meat and milk-processing enterprises, for example, in Almaty region that can be considered as both wholesalers and retailers. However, there is potential that these processing companies, in the face of poorly developed alternative markets, limited capacity of internal market, and lack of direct access of producers to internal and external markets, tend to set the prices due to their advantage. There are indications that processing and middlemen take a big share of the consumer price of the animal products leaving a much smaller share for the producers. Transportation costs were also important factors affecting the producers' share. Middlemen lack the necessary freezers to store the products and hence products have to be sold in a short period.

In Kyrgyzstan, farmers identified three main problems associated with marketing: transportation, low prices for animal products and low purchasing power of consumers. In one district (Kemin) the distance to the central market is far, about 50 km, and in another district (Kochkor) the central market is located closer at 15-25 km. Because of the transportation difficulties, farmers are forced to sell their livestock products, particularly live animals, to middlemen at the prices regulated by the later. As a rule, middlemen buy directly from the settlement where farmers receive farm gate prices that are substantially lower than market prices. The share of different products marketed through middlemen was: 100% for wool and pelts, 60% for meat and 55% for both live animals and dairy products.

In Uzbekistan, individual traders and retailer shops dominate the milk market. Processing companies are less developed. Farmers are aware of the potential for sheep milking. There is local experience in sheep milking, and to 29% of respondents in Uzbekistan sheep milking technology is viewed positively. Livestock products were marketed predominantly through retailers (78%), and less through wholesalers (16%) and processing enterprises (6%).

The analysis of the data and full report will be completed in 2002 and final results will be reported in the 2003 report.

Characterization of sheep production systems in Syria.
A formal survey was conducted in 2002 to identify sheep production systems in Syria after three dry years and banning of barley cultivation in the Syrian steppe in 1995. The survey covered seven provinces where 90% of the national flock is located. One village was selected from each zone (zones 3, 4 and 5) in the seven provinces with the exception of one province (Deir Al Zour) which lies in one zone (5), and two villages were selected: one in irrigated and the other in non-irrigated system. A total of 262 sheep producers were selected from 20 villages for the survey, an additional 20 lamb fatteners were randomly selected from the main fattening centers in Syria. A formal single interview survey was conducted using a questionnaire to collect data on sheep production, inputs, outputs and marketing.

A cluster analysis was used to identify homogeneous groups or clusters of production systems. The variables used to characterize the sheep production systems were: market oriented production, feed sources, labor, and movement. Cluster analysis grouped the sheep breeding producers into five main clusters: 1) irrigated mixed crop-livestock production system with an average of 290 sheep, farm size 5.6 ha and 2.4 ha irrigated; 2) intensive production system with 67 sheep, farm size 7.6 ha and 1.5 ha irrigated; 3) rainfed mixed crop-livestock production system with 427 sheep, farm size 14.7 ha and 1 ha irrigated; 4) mixed crop-livestock production system with 148 sheep, farm size 5 ha and 0.6 ha irrigated; 5) extensive sheep production system with 352 sheep, farm size 1.2 ha mostly under trees; and 6) industry fattening production system with 851 sheep with 0.2 ha under trees. The analysis indicated that the trend of sheep production is toward intensification and industrialization of the production. Complete results of this study will be reported in next year's report.

A desk study of small ruminant production in WANA is completed. The study synthesizes current information about small ruminant production, consumption and trade in the WANA region and raises critical questions concerning the improvement of this important sector. Such questions relate to factors that affect regional trade in small ruminants, influencing the income of millions who depend on them. The study highlights the diverse dependence of the economy of different WANA countries on small production. The poorer countries of WANA are net exporters and their rural communities rely on earnings from small ruminants. The WANA net exporters have lost market share within the region. High production costs, unilateral decisions on banning imports on health grounds and lack of investment in marketing could explain the loss of the market share, while preference due to developed taste of small ruminant meat with the populations from the region, considerations for religious festivities, proximity and traditional trade links are in favor of imports from WANA countries.

Different policy measures are needed in order to improve the performance of the sector and increase the returns from livestock for many rural poor in the poorest countries of WANA. At the national level, policy changes are needed to stimulate the adoption of productivity-enhancing practices, to increase investment in the vast rangelands (upon which many livestock producers rely) and to reduce the risk of environmental degradation. Productivity-enhancing technologies are the key to competitiveness in the market place. Without productivity improvements, producers may not only lose traditional export markets, they may also lose their domestic markets against more competitive producers.

Research is needed on livestock marketing and the role credit plays in livestock improvement. Such research could provide guidelines for policy action. Certainly, in exporting countries, policy action is needed to reassure importing countries that livestock production meets required standards, minimizing human health risks. At the regional level, common policies and coordinated efforts on health-related regulations on livestock trade are essential. Without such polices, small-ruminant producers in WANA may fail to compete in the regional and global markets. This would have negative impacts on the livelihoods of poor, rural communities, particularly in livestock-exporting countries. A manuscript on the study has been prepared for publication and ready for submission.

Output 7: Strengthened research capacity of NARS

Planned milestones 2002

- Socioeconomic training (including on-the job individual and group training and training workshops) organized for NARS in collaborating projects each year
- Contributions to the courses organized by other projects

Achievements in 2002

- Participatory training courses were conducted for the Livestock Project, the Barani Village Development Project (Pakistan), and the Khanasser Project (Integrated Research Site in Syria representing the Dry Margins of CWANA) with support from this project. Two consultants have successfully executed these participatory training courses.
- Management of water resources and improvement of water-use efficiency in the dry areas ICARDA/JICA/Syria, 7 April-6 June 2002.
- In-country short-term training courses on monitoring on-farm trials and demonstration fields - Iran ICARDA/Iran, 25-30 May 2002.
- Individual training: about 10 individuals were trained on socioeconomics research, from Central Asia, Syria, and Yemen.
- The work of 2 MSc students in progress.

Publications and research reports

Aw-Hassan, Aden A., Ahmed Mazid, Roberto La Rovere. 2002. Challenged livelihoods in the dry areas: the case of Khanasser Valley in Syria. Poster paper submitted to the 25th International Conference of Agricultural Economists, 16-22 August, Durban, South Africa.

Aw-Hassan, Aden A., Adriana Bruggeman, Abdul Rashid Yassin Ebrahim. 2002.The Yemeni Mountain Terraces Project: Institutionalizing Community-Based Integrated Natural Resources Management Research. Caravan, no. 16, June 2002, ICARDA, Aleppo, Syria.

Aw-Hassan, A. and K. Shideed 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 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.

Brennan, John P., Aden Aw-Hassan and Thomas L. Nordblom. 2002. Role of spillovers in enhancing the benefits of the international agricultural research system". Paper submitted to the Food Policy Journal.

Brennan, John P., Kathryn J. Quade, Aden Aw-Hassan and Thomas L. Nordblom 2002. Quantifying spillover benefits to Australia from ICARDA's research on Kabuli chickpeas", submitted to the Australian Journal of Agricultural Economics.

La Rovere, Roberto, Aden Aw-Hassan, George Arab. 2003. Impact of policy and ecological changes on livelihood dynamics on the fringes of Syrian rangelands. Poster Paper submitted to the VII International Rangelands Conference, 26 July-1 August 2003, Durban, South Africa.

Legesse Dadi, Hailemariam Teklewold, Aden Aw-Hassan, Ali Abdel Moniem and Geletu Bejiga. 2002. The Socioeconomic factors affecting grass pea consumption and the distribution of lathyrism in Ethiopia. Paper submitted as a Social Science Paper, ICARDA (Forthcoming).

Lilja, Nina, Aden Aw-Hassan, Hisham Salahieh, Salvatore Cecarelli, Stefania Grando and Jacqueline Ashby. 2002. Benefits and costs of participatory barley breeding in Syria. Paper submitted to the 25th International Conference of Agricultural Economists, 16-22 August, Durban, South Africa.

Martini, Malika A., Elizabeth Bailey, Gwyn E. Jones, and Patricia Goldey. 2003. Agricultural intensification and female labor in farm production in northwest Syria in Trade Policy and Economic Integration in the Middle East and North Africa: Economic Boundaries in Flux (Hassan Hakimian and Jeffrey B Nugent, eds.) London: Routledge Curzon, London, forthcoming (2003).

Martini, Malika A., Patricia Goldey, Gwyn E. Jones and Elizabeth Bailey. 2003. Towards a feminization of agricultural labor in northwest Syria. Journal of Peasant Studies London (30/2).

Mazid, Ahmed, Richard Tutwiler, Malika A. Martini and Hassan Al-Ahmed. 2002. Impact of modern agricultural technologies on durum wheat production in Syria. Social Science Paper No. 11, ICARDA, Aleppo, Syria (In Print).

Mazid, Ahmed and Aden Aw-Hassan. Socioeconomic assessment of rural communities in the dry areas. Survey results of Khanasser Valley in Syria (Research Report).

SOCIOECONOMIC FACTORS AFFECTING LATHYRISM IN ETHIOPIA

Legesse Dadi[1], *Hailemariam Teklewold*[1], *Aden Aw-Hassan*[2], *Ali Abdel Moniem*[2] *and Geltu Bejiga*[3]

Rationale

Grass pea is one of the important legumes in Ethiopia cultivated by small-scale farmers for food. It grows in areas with adverse environmental conditions such as moisture stress, poor soil fertility and water logging (Asfaw, 2000 unpublished report). Despite its nutritional value and good yield under adverse environmental conditions, it contains a neurotoxic element which is a health hazard if an excess amount is consumed. The health risk of grass pea consumption is greatest when people face serious limitations of access to food and, thus, they consume it for a longer period. Over-consumption of grass pea (usually more than 30% of the diet) for a prolonged period of time, 3-4 months, causes lathyrism (Redda et al., 1994; Wuletaw et al., 1997); a crippling disorder resulting in an irreversible paralysis of both legs, particularly in young males. The neurotoxin element that causes lathyrism has been identified as a water-soluble non-protein amino acid known as B-N-Oxalyl- B-diamonipropionic (â-ODAP) (Berhanu et al., 1997; Ghirma et al., 1997).

Since the late 1980s, studies on the production and consumption of grass pea and prevalence rates of lathyrism were conducted in Ethiopia. Most of these studies, with the exception of few, including nutritional and epidemiological surveys in the Dembia and Fogera districts (Redda et al., 1993), were based on secondary data. Hence, field studies on grass pea production, processing and consumption have not been conducted. At present, with the exception of research aimed at developing varieties with acceptable â-ODAP contents and yield, the research on grass pea and lathyrism (chemistry, neurology, nutrition, epidemiology, processing etc.) is limited. Moreover, the social and economic impact of lathyrism on the victims, their households and communities at large has received little attention. Farmers' indigenous knowledge about grass pea toxicity and their attitude towards its consumption have not been adequately assessed. Strategies to reduce the toxic effects of grass pea consumption and, thus, minimize the risk of lathyrism hazards have not been examined and evaluated.

---

[1] Ethiopian Agricultural Research Organization, Debre Zeit Research Center, P.O Box 32, Debre Zeit, Ethiopia

[2] ICARDA, P.O Box. 5466, Aleppo Syria

[3] Ethiopian Agricultural Research Organization, P. O. Box 2003, Addis Ababa Ethiopia

This study aims to address this gap and document indigenous community knowledge and farmers' perceptions of the toxic compound and their strategies to reduce it. The study also attempts to assess the distribution of lathyrism and the socioeconomic conditions most likely to result in lathyrism in the study areas.

Study description

The study was conducted in Fogera wereda (district) in south Gonder, Jama wereda in South Wello, Bichana wereda in east Gojam and Ada-Liben, Ginbichu and Akaki weredas in east Shewa zone from March to July 2000. These weredas were selected on the basis of grass pea production and their accessibility during the dry season. Two peasant associations (PAs) were randomly selected from the selected weredas. Sample farmers were selected using a systematic random sampling technique. A sample size of 302 farmers, 100 farmers from each zone, were selected and interviewed.

Past studies have shown that the lathyrism prevalence rate in Ethiopia ranges from 1 to 7 persons per 1000 persons. Given this information, the chance of selecting sufficient number of lathyrism patients would be slim if the random sampling method was employed. Therefore, all lathyrism patients (88) mentioned by sample farmers were listed and interviewed.

Initially, a rapid rural appraisal was used to assess grass pea production and consumption. A semi-structured interview of individuals and key informants, and focus group discussions were held to understand the different farming systems and identify target areas. This method was also used to identify household members to be interviewed with respect to different activities, and to formulate a targeted questionnaire for different gender groups.

The information was collected from both men and women. The formal interviews were planned and implemented in such a way that female enumerators interviewed women and males interviewed men. The data were collected using a standard questionnaire initially prepared in English and later translated into local languages. The questionnaire was pre-tested and modified accordingly. Female and male enumerators were recruited from secondary school graduates. The researchers trained enumerators on the purpose of the survey and on interviewing techniques. In addition to primary data, secondary data was gathered from different sources.

Farmers' knowledge of lathyrism and grass pea consumption
Sample farmers, as well as patients, were asked about the relation between grass pea and lathyrism. Most of them knew that grass pea consumption causes lathyrism. All farmers in south Wello, and most of them in south Gondar (97%) and in east Gojam (89%) knew that grass pea contains a toxic compound which affects human health. It is only in east Shewa zone where the majority (91%) of women reported that they were not aware of the effect of grass pea on human health.

Although many farmers knew the effect of grass pea on human health, many of them (women who were interviewed) did not know whether the onset and severity of lathyrism had a direct relationship with the amount and period of grass pea consumption. The perceptions of the communities about the causes of lathyrism varied in different areas. Some of the local perceptions are given below:

- In Fogera wereda, farmers think that lathyrism is caused by exposure to vapor emissions during grass pea cooking. Stepping on ground exposed to water used for cooking grass pea is considered dangerous.
- In south Wello, most of the farmers believe that consuming grass pea with milk and meat causes lathyrism.
- Walking in grass pea field and exposure to vapor emissions from wetted grass pea straw and using grass pea straw as bedding material, particularly when it gets wet, is thought to be dangerous.
- Across the study area, farmers believe that consumption of grass pea in a raw form with milk is more toxic and dangerous to human health.

In general, farmers know the association of lathyrus and grass pea consumption and it is the least preferred legume for human consumption. Despite this, most households in rural areas and low-income urban dwellers consume grass pea. This is because grass pea has two advantages over other preferred legumes that make it a critical element in the food security of the poor. First, it outperforms chickpea and lentils under adverse environmental conditions (i.e. moisture stress and diseases) and, as respondents indicated, preferred legumes are not produced in sufficient quantities due to insects and disease problems. Secondly, grass pea is the cheapest legume and most households can afford it compared to the preferred legumes. Hence, in spite of its association with lathyrism and its low preference, grass pea provides the poor with a better food security option in terms of availability and prices, particularly in dry years. Therefore, in spite of the health hazard, the poor households will continue to rely on grass pea for their food security. Grass pea is consumed in different forms such as sauce made of spiced powder

(Shiro-wot); sauce made of dehulled split *(Kik-wot)*; boiled grain *(Nifro)*; roasted grain *(Kollo)*; and as bread made of grass pea mixed with other grains *(kitta)*, particularly by poor households during periods of acute food shortage. The shiro-wot was the most widely consumed form of grass pea across the study areas.

The quantity and forms in which grass pea is consumed vary by region and income group. The highest per capita consumption was reported in east Gojam zone followed by south Gondar. Consumption of grass pea as grain boiled *(nifro)* or roasted *(kollo)* is more prevalent in south Wello and south Gondar. The low-income groups in rural areas commonly consume *kitta*, *kollo* and *nifro* made from grass pea alone, or in mixtures with other crops.

Strategies for reducing the toxic effects of grass pea consumption
Some farmers stated their wish to refrain from consuming grass pea, which is not a viable option for most households in view of widespread poverty in rural areas. Only 2-5% of the farmers, who can afford to purchase preferred legumes, refrained from consuming grass pea in any form. Farmers apply other strategies to reduce the toxic compound of grass pea in order to minimize its potential health hazard. These strategies include blending or mixing grass pea with other food crops (for example, in one to one ratio with other legumes) to reduce the quantity consumed in any one meal (Table 1), and different processing and preparation methods such as soaking, washing, roasting, and boiling. Since the neorotoxic substance in grass pea is volatile and water-soluble (Srivastav and Khokhar, 1996; Girma et al., 1997) these indigenous processing methods can reduce its content in the food.

Table 1. Percentage of interviewed farmers who make shiro from grass pea alone and grass pea mixture with chickpea, faba bean and field pea, by zone.

Type of legume mixed with grass pea	South Wello	South Gondar	East Gojam	East Shewa	All locations
Grass pea alone	22.9	75.2	90.4	41.4	55.6
Other legumes	1.9	0	1.0	9.9	3.9
Grass pea and faba bean mix	69.5	0	3.8	19.7	23.2
Grass pea and field pea mix	3.8	0	1.9	14.5	6.1
Grass pea and chickpea mix	1.9	24.8	2.9	14.5	11.2
Reason					
Reduce toxicity	67.5	22.2	0	2.1	37.9
Better taste	23.8	77.8	100.0	55.3	45.3
Consume more of cheap legume	0	0	0	27.7	8.1

Farmers in south Wello, who perceive the volatility of the toxic compound, thinly and evenly drop water by hand on lightly toasted grass pea to make the toxic compound evaporate with water. They avoid exposing themselves to the vapor coming out of the toasted grain. Likewise, women in south Gondar tend to avoid exposure to vapors coming out of a pot at the time of *nifro* cooking and carefully dispose drained water in places where people would not step in it.

Another strategy to reduce the effects of the neurotoxic substance of grass pea is to replace the traditional varieties with modern ones that have zero or safe levels. But, at present, such varieties are not available. Researchers are working to develop grass pea varieties with acceptable â-ODAP content. Some promising lines have already been identified and are being tested for their performance and level of â-ODAP under different environments. Yet, the promising lines are not officially released and tested under different environments on farmers' fields.

The development of grass pea varieties with acceptable levels of â-ODAP and yield would have positive impact in reducing costs of food processing and preparation by reducing the time of soaking and cooking. This would also reduce the losses of protein, vitamins and other nutrients due to rigorous processing aimed at reducing toxic effects of grass pea. In addition, this would also reduce the incidence of lathyrism and its economic and social costs.

Prevelance of lathyrisim

The prevalence rates of lathyrism were estimated from randomly sampled peasant associations known for their production and consumption of grass pea (Table 2). The highest prevalence rate of 8.7 per 1000 persons was recorded at Shina, followed by 5.9 per 1000 persons at Sifatira in Fogera wereda of South Gondor. The prevalence rate of lathyrism at Shina was found to be higher than what Redda et al. (1993) documented. The prevalence in the peasant associations in south Wello and east Gojam ranged from about 3 to 5 per 1000 persons. But no incidence of lathyrism was reported in the sampled associations in East Shewa.

Table 2. The prevalence rate (no. per 1000 persons) of lathyrism in surveyed peasant associations.

South Gondor (Fogera Wereda)		South Wello (Jama wereda)		East Gojam (Bichana wereda)		East Shewa (Ada wereda)	
Shina	Sifatira	Yedo	EjertiFelegeslam	Yetenbina	weyna	Yera	Bechako
8.7	5.9	4.1	5.28	3.03	4.56	0	0

Source: Estimated from survey data

Other studies reported that the distribution of lathyrism is fairly widespread. Brehanu (1991) estimated prevalence rates in east Gojam and west Gojam, Gondar and west Shewa at 0.9, 3.4, 4.7 and 2.3 per 1000 persons, respectively. Getahun and Redda (1997) reported prevalence rates ranging from 0.6 to 2.9 persons per 1000 persons in the northern part of Ethiopia. In another study, Redda et al. (1994) documented the highest prevalence rate in Yilmana- Densa (7.5 persons/1000 persons), a wereda of west Gojam followed by Fogera in south Gondar (6.2 persons/1000 persons) and in Dambia in north Gondar (6.2 persons/1000 persons). They linked the prevelance of lathyrism in different parts of the country with grass pea production.

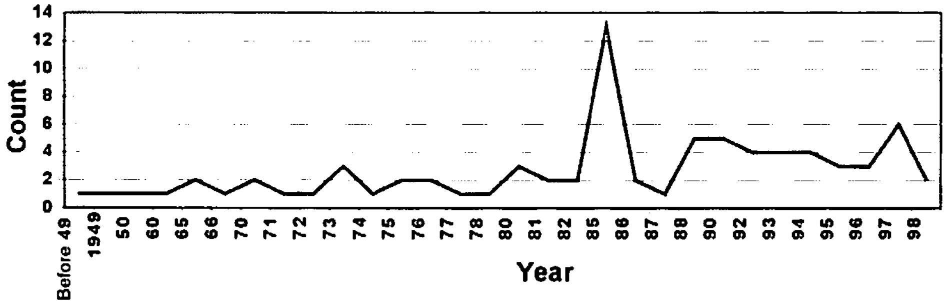


Fig. 1. The incidence of lathyrism over time in surveyed households.

However, more importantly, Redda et al. (1994) noted that lathyrism reaches epidemic proportions in times of famines caused by drought. This is because grass pea is a drought tolerant crop, and as a result many people depend on it for their food security, resulting in the consumption of larger quantities during times of famine when main crops are destroyed by drought (Redda et al., 1993). The incidence of lathyrism in the surveyed farmers over the years is depicted in Figure 1. The highest lathyrism incidence was reported in 1985, which was a very dry year. After the 1985 drought, the disease still sporadically occurred in the study areas and affected 3-6 persons per year. High incidence rates were reported in 1988, 1990 and 1997. In south Wello, the rate of lathyrism incidence was high after the 1995 drought, the highest in 1997. In 2001 and 2002, there was famine due to severe drought and many people died. Thus, the incidence of lathyrism is expected to be high among the poor in rural areas.

The incidence of lathyrism by sex and age

Out of 302 households interviewed in south Gondar, south Wello and east Gojam, 88 households were affected by lathyrism. This group was asked additional information about the age at onset of the disease and information on other social and economic indicators to assess the role that these play in the incidence of lathyrism as well as how they are affected by it. The results from three zones indicate that the disease affected males more than females. The proportion of males affected by the disease in south Wello, south Gondar and east Gojam ranged from 70 to 91% of the total affected. The average ages of male patients at the time of the onset of the lathyrism were 8, 15 and 10 years in south Wello, south Gondar and east Gojam, respectively. The average age of female patients at the time of onset of the disease ranged from 12 years in east Gojam to 23 years in south Gondar. These findings are in agreement with the results of Getahun and Redda (1997) for Estie wereda in south Gondar. Lathyrism affected young persons and such age groups of people are economically active, have a long planning horizon and the disease causes a permanent loss of critical manpower for farm households in the rural areas.

Socioeconomic characteristics of lathyrism affected and unaffected households

About half of the lathyrism patients (53%) were involved in farming for their livelihoods and many of them (43%) were dependent on the support of their family members (Figure 2). Few of them shifted to less physically demanding activities like church service, begging, handcraft, and herding after the onset of the disease.

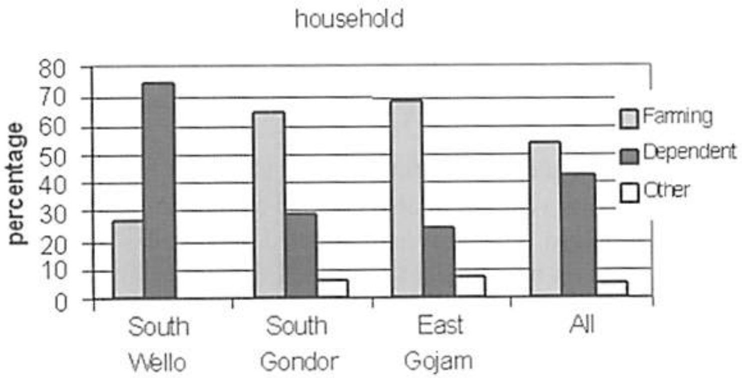


Fig. 2. Sources of livelihood for lathyrism-affected households.

The lathyrism-affected households earned substantially less income than the unaffected in all the study zones. The difference in gross income between the two groups ranged from 700 birr per household in south Wello to over 900 birr per household in south Gondar. Furthermore, affected households had few assets as compared to unaffected households (Table 3). For instance, they owned significantly smaller farm size, and significantly lower (1.75) tropical livestock units (TLU) compared with 3.33 owned by unaffected households. The ownership of assets like oxen, critical for traction in crop production, has important economic implications. Unaffected households disproportionately share out their land because of their physical disability.

Affected households pointed out that they have no access to credit because of their poverty and lack of assets for collateral. Non-agriculture related credits are rarely available in the study areas. But, when they are available, credit suppliers consider lathyrism patients as non-credit worthy due to their physical disability and socioeconomic status.

Table 3. Average farm size (ha) and tenure arrangement for affected and unaffected households.

	Income	Total farm size	Cultivated area	Grass pea area	Share & rent in	Share & rent out	Cows	Oxen	Poultry	TLU
South Wellow										
Affected	2178	1.2 (30)	1.12 (30)	0.32 (18)	0.75 (1)	0.85 (12)	1.00 (14)	1.33 (12)	2.50 (14)	1.79 (30)
Unaffected	2878	1.33 (69)	1.23 (69)	0.27 (50)	0 58 (18)	0.75 (14)	1.10 (41)	1.45 (49)	2.62 (50)	2.97 (69)
t-value	1.45	1.21	1.09	0.97	0.53	0.65	2.08***	0 67	0 29	2.5***
South Gondar										
Affected	2230	0.98 (33)	0.88 (33)	0.37 (31)	0.27 (6)	0.51 (13)	1.21 (14)	1.24 (17)	5.24 (21)	1.52 (33)
Unaffected	3165	1.43 (67)	1.37 (67)	0.43 (65)	0.52 (32)	0.73 (9)	1.78 (45)	1.81 (59)	5 63 (51)	3.75 (67)
t-value	1.97**	3 83***	4.7***	3.22***	3.59***	1.36	2.38***	3.89***	0.29	4.78***
East Gojan										
Affected	3581	1.42 (25)	1.42 (25)	0.32 (22)	0.55 (5)	0 94 (6)	1.22 (9)	1.42 (19)	2.50 (2)	1.99 (25)
Unaffected	4420	1.65 (77)	1.65 (77)	0.36 (60)	0.77 (45)	1.03 (4)	1.29 (55)	1.66 (67)	2.10 (10)	3.28 (77)
t-value	1.98***	1.53	1 53	0.84	1 32	0.3	0 37	1.52	0.48	3.01***
All locations										
Affected	2606	1.18 (88)	1.11 (88)	0 34 (71)	0 43 (12)	0.73 (31)	1.14 (37)	1.33 (48)	4 05 (37)	1.75 (88)
Unaffected	3529	1.48 (213)	1.42 (213)	0.36 (175)	0 65 (95)	0.78 (27)	1.39 (141)	1.65 (175)	3 95 (111)	3.33 (213)
t-value	3.33***	3.92***	4.15***	0.63	1.67*	0.53	2.62***	3.71***	0.13	6.4***

***, ** and * indicate statistical differences at1% and 10% significance levels

The quality and type of accommodation and the ability of households to feed their members throughout the year could also be used as indicators of the wealth status or poverty of a household. The lathyrism affected households are worse off than unaffected ones based on housing and food security (Table 4). A significantly higher proportion of unaffected households had tin-roofed houses compared to affected households in two (south Wello and east Gojam) of the three zones surveyed. This was also true for the food security aspect of the two groups. For example, in east Gojam, where only 29% of lathyrism affected households had sufficient food supplies for the whole year compared to 58% in the unaffected households, the difference in food security was highly significant ($p < 0.01$). The food security differences can also explain their patterns of food consumption, particularly the consumption of specific forms of grass peas *(kollo and nifro)* and other food legumes.

The two groups differ, particularly in south Wello, in terms of how they consume grass pea. The proportion of lathyrism affected households who consume grass pea as kollo and nifro is higher than that of unaffected households. However, there is no significant variation between the two groups in the other zones (south Gondar and east Gojam) in terms of proportions of farmers consuming grass pea as *Kollo* and *nifro*.

Table 4. Wealth status, food security indicators and food legumes consumption patterns of lathyrism affected and unaffected households.

Zone	Proportion of farmers				Average household consumption of:			
	Owning tinroofed house	Self sufficiency in food	Consuming *Kollo*	Consuming *nifro*	Faba bean	Chickpea	Grasspea	Lentil
	%				kg/head			
South Wello								
Affected (30)	3.6	3.3	80.0	66.7	5.63	0.08	17.4	0.00
Affected (69)	23.8	16.7	47.8	31.9	12.2	0.81	18.84	0.40
Total sample	17.6	12.5	57.6	42.4				
t-value	5.48***	3.35**	8.86***	10.36***	3.05***	1.57*	0.47	1.91**
Chi-square	0.24	0.18	0.29	0.31				
South Gondor								
Affected (33)	0.00	30.8	87.9	21.2	0.00	1.40	30.22	0.42
Affected (67)	1.50	46.0	88.1	14.9	0.00	7.66	25.01	3.74
Total sample	1.10	41.6	88.0	17.0				
t-value	0.466	1.77	0.00	0.62	-	3.19***	1.18	2.88***
Chi-square	0.10	0.14	0.00	0.08				
East Gojam								
Affected (25)	52.0	29.2	44.0	0	1.64	18.45	41.56	0.00
Affected (77)	74.0	57.9	41.6	0	4.22	19.90	35.56	0.24
Total sample	68.6	51.0	42.2	0				
t-value	4.25**	6.02***	0.05	0	3.06***	0.25	1.16	1.55*
Chi-square	0.10	0.24	0.02	0				
All locations								
Affected (88)					2.39	5.80	29.08	0.16
Affected (213)					5.48	9.87	26.79	1.39
Total sample								
t-value					3.55***	1.91**	0.83	3.16***
Chi-square								

*, ** *and* *** *indicate statistical difference at 10%, 5% and 1% significance level, numbers in parenthesis are observations.*

The amount of grass pea consumed by lathyrism-affected households was higher, though not significantly, than the quantity of grass pea consumed by unaffected households. The quantities of chickpea, lentils and faba bean consumed by the two groups were different and the differences are statistically significant in six out of seven comparisons made (Table 4).

Most unaffected households do not consume grass pea alone, whereas this is common for the lathyrism affected households, indicating unaffected households' greater capacity to purchase other legumes to blend with grass pea for consumption.

Conclusions

Despite being the least preferred legume for human consumption, low-income farmers in Ethiopia widely consume grass pea in several local preparations such as *shiro*, *nifro*, *kollo*, and *kitta*, while middle-income farmers consume it only as shiro. There are two main reasons for the consumption of grass pea. First, farmers cannot produce the preferred legumes, chickpea and lentils, in sufficient quantities due to insects and disease problems. Grass pea is more readily available because of its better tolerance to insects and diseases. Second, low-income farmers cannot afford to buy preferred legumes because of their relatively high prices.

The health hazard associated with the consumption of grass pea still exists in the rural areas. It is highly associated with drought periods when the food security situation of the rural population deteriorates. Lathyrism mainly affected poorer households who have greater household food insecurity, own fewer assests such as land and livestock, and had lower income than unaffected households. Poor households will continue to depend on grass peas as source of protein for years to come. Therefore, effective educational and public awareness programs are required to inform rural people about the health hazards associated with different consumption patterns of grass pea. There is a need for the development of simple and standardized detoxification techniques and their popularization as part of agricultural extension programs. Simple guidelines for the use of such techniques that can reduce the neurotoxin substance in local preparations of grass pea down to safe levels are urgently needed.

Current efforts in developing new varieties with low and acceptable level of â-ODAP content should continue. Some promising lines have already been identified and are being tested for their performance and level of â-ODAP under different environments. Such varieties would have a positive impact in reducing costs of food processing and preparation by reducing the time of soaking and cooking. This would also save protein, vitamins and other nutrient losses due to rigorous processing usually done for reducing the neurotoxin substance of grass pea. Above all, the development of varieties with low level of â-ODAP will reduce the incidence of lathyrism and social and economic costs to poor rural households. Grass pea lines found to be â-ODAP free or with acceptable â-ODAP content should be evaluated under different environments and farmers' conditions prior to their official release and promotion for wider use. Some findings are available on â-ODAP contents of grass pea grown by farmers in different parts of the country.

The determination of â-ODAP contents of landraces should continue.
Finally, it should be noted that there is little effort to support and rehabilitate lathyrism affected patients and their households. The lathyrism affected persons are overlooked, lose their social status and become even more vulnerable. Therefore, NGOs and concerned governmental organizations should give due attention to this section of the community and develop suitable income generating schemes for lathyrism affected households.

References

Berhanu, M., Abegaz, Gezachew Alemayehu and Yirgalem Yigzaw. 1997. Analysis of B-N-Oxalyl -L-ç-B-Diaminopropionic acid in milk. Pages 59-62 *in* Lathyrus and lathyrism: A Decade of Progress. Proceedings of International Conference (Redda Tekle Haimanote and F. Lambein, eds.), Addis Ababa, Ethiopia, November 1995. University of Ghent, Belgium.

Getahun, Haileyesus and Redda Tekle Haimanote. 1997. Psychological assessment of lathyrism patients in rural Estie sub-district of south Gondar administration zone, northern Ethiopia. Pages 35-37 *in* Lathyrus and lathyrism: A Decade of Progress. Proceedings of International Conference (Redda Tekle Haimanote and F. Lambein, eds.), Ababa, Ethiopia, November 1995. University of Ghent, Belgium.

Ghirma, Moges. , Abebaw Belay, Theodros Solomon and G. Johansson. 1997. Towards â-ODAP selective flow injection determinations in grass pea using glutamate oxidize reactors. Pages 63-67 *in* Lathyrus and lathyrism: A Decade of Progress. Proceedings of International Conference (Redda Tekle Haimanote and F. Lambein, eds.), Addis Ababa, Ethiopia, November 1995. University of Ghent, Belgium.

Girma Akililu, G. Johansson and B. M. Nair. 1997. Effect of processing on the content of -N-Oxalyl-L- - -diamonipropionic (â-ODAP) in grass pea *(Lathyrus sativus.)* seeds and flour. In Lathyrus and Lathyrism: A Decade of Progress. Proceedings of International Conference (Redda Tekle Haimanote and F. Lambein, eds.), Addis Ababa, Ethiopia, November 1995. University of Ghert, Belgium.

Redda Tekle haimanote, Yemane Kidane, Elizabeth Wuhib, A. Kassina, Yohannes Endeshaw, Tadesse Alemu and P. S. Spencer. 1994. The epidemiology of lathyrism in Ethiopia. Pages 1-9 *in* Nutrition, Neurotoxin & Lathyrism: The ß-ODAP Challenge. Proceedings of the Second International Lathyrus/Lathyrism Conference (Berhanu M. Abegaz, Redda T.-Haimanot, V. S. Palmer and P. S. Spencer, eds.),Ethiopia. New York: The Third World Medical Research Foundation.

Redda Tekle haimanote, Berhanu M. Abegaz, Elizabeth Wuhib, Angelina Kassina, Yemane Kidane, Naod Kebede, Tadesse Alemu and Peter. S. Spencer. 1993. Pattern of *Lathyrus sativus* (grass pea) consumption and Beta-N-Oxalil-a-ß-Diaminoprionic acid (â -ODAP) content of food samples in the lathyrism endemic region of northwest Ethiopia. *Nutrition Research*, 13: 1113-1126.

Wuletaw Tadesse, Wollelie Melesse and Yohannes Degago. 1997. Identification of alternative crops for grass pea production in the Fogera Plains of the Gondar region. Pages 63-67 *in* Lathyrus and lathyrism: A Decade of Progress. Proceedings of International Conference (Redda Tekle Haimanote and F. Lambein, eds.), Addis Ababa, Ethiopia, November 1995. University of Ghent, Belgium.

PROJECT 4.3: POLICY AND PUBLIC MANAGEMENT RESEARCH IN THE DRY AREAS OF CENTRAL AND WEST ASIA AND NORTH AFRICA

Goal

Improved policy and public management that promotes sustainable production systems and livelihood strategies in the dry areas of CWANA

Indicator: Policy and public management options adopted by policy-makers

Purpose

Influence reforms of national and regional policies and institutions to promote agricultural investments and management decisions in dry areas with respect to efficiency, equity and environmental sustainability

Indicators:-Governments and research institutions have clearly defined tools to evaluate the welfare and resource management consequences of different policy, institutional and public management options in the dry areas

- Improved information base to guide national policy formulation

- Research findings are included in the design of rural development policies, policy reforms and public management systems

Output 1: Identification of the policy and property rights environments under which rural producers and communities make their decisions and characterize the incentive and disincentive structures that shape their resource management, production and livelihood strategies

Indicators:-Two synthesis documents and 6 monographs analyzing the current policy environment in WANA and discussing the implications of policy reforms in terms of welfare changes and sustainability in the region.

-Two synthesis documents and 8 monographs analyzing property rights policies and their effects on land improvements, productivity, and incomes in the low rainfall areas of WANA

Summary of activities in 2002

- IFAD review of the M&M project
- IFPRI review of the Policy and Property rights component
- Chapter writing

- Development of concept notes
- Data management

Major achievements (milestones) in 2002

- Finished cleaning, organizing, and consolidating datasets from M&M household and community surveys.
- Two chapters in Morocco have been completed.
- Ngaido, T., F. Nassif, and M. Boughlala. The development of legal and institutional frameworks in Morocco.
- Ngaido, T., M. Boughlala, and M. Bendaoud. Effects of land reform policies in the low rainfall areas of Morocco.
- Hazell, P., T. Ngaido and N. Chaherli. 2002. Policy and institutional options for agricultural growth, poverty alleviation and environmental sustainability in the dry areas of the Mashreq and Maghreb countries. Paper prepared for the workshop on Agriculture, Environment and Human Welfare in West Asia and North Africa, ICARDA, Aleppo, 5-7 May 2002.

Concept notes and proposals

- Grant ($51,000) from the World Bank's Sustainable Resource Management Group to carry out a study on "Land Tenure, Institutions, and Conflict Management Issues in Sustainable Use of Arid Lands in the Middle East and North Africa."
- Six reviews of the legal and institutional frameworks governing forest and water resources management for Jordan, Morocco and Tunisia have been completed.
- Concept note for the M&M project: Developing Sustainable Livelihoods of Agropastoral Communities of West Asia and North Africa was submitted to IFAD.
- Consultant for Food and Agriculture Organization of the United Nations (FAO) to develop the sector note on land tenure in Morocco and Tunisia 5-12 June 2002.
- Contributed to the development of the Proposal on "Empowering the poor under volatile environments in the Near East and North Africa region," which has received funding of $661,000 to work in three countries (Morocco, Sudan and Tunisia) and evaluate the policy and institutional environment under which projects empowering the poor are implemented. This project focuses on policy processes.
- Contributed to the development of the CGIAR candidate "Challenge Program" entitled "Desertification, Poverty, and Agriculture: Building Livelihoods, Saving Lands (DPA)" and attended the Aleppo workshop 4-9 August 2002.

Outreach activities

- Gave a presentation on "Access to land and water for the poor" at the "Towards Integrated Land and Water Management" panel organized during the Environmentally and Socially Sustainable Development (ESSD) week. 8 April 2002.
- Resource person at the Regional Workshop in Land Issues in Africa, 29 April-2 May, Kampala, Uganda organized by the World Bank and co-authored the paper on rangelands (see above).
- Gave a presentation at the Workshop on Agriculture, Environment and Human Welfare in West Asia and North Africa, ICARDA, Aleppo, 5-7 May 2002.
- Attended the First meeting of the Steering Committee of Future Harvest Consortium to Rebuild Agriculture in Afghanistan, ICARDA, Aleppo, Syria, 7-8 August 2002.
- Participated in the "Land Transition" meeting to draft the research plan for the jointly sponsored IGBP and IHDP "land-related" research. Bilthoven, The Netherlands, 12-15 October.
- Gave a presentation at the "Uniting Sciences: Solutions for the Global Community" 2002 ASA-CSSA-SSSA Annual Meetings Indianapolis, Indiana, 10-14 November 2002.

Output 2: Evaluation of the effects of policy, property rights and technological options on sustainable resource management and livelihood strategies of farming and herding communities in the dry areas

Indicators:
- *Three studies identifying the feasibility of policy, property rights and technological options in selected communities in Morocco, Tunisia and Syria*
- *Five community studies describing the model building and evaluation of selected policy, property rights and technological options in communities in-Algeria, Iraq, Jordan, Lebanon, and Libya*
- *Effects of property rights on land improvement, technology use and livelihood strategies in 16 selected communities in Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria and Tunisia*

Summary of activities in 2002

- Improving the community models for Jordan and Algeria
- Building a community model for Tunisia

Major achievements (milestones) in 2002

- The community model in Algeria is now multi-periodic to account for the dynamics of the production systems.
- In Jordan, the model has been improved and is more dynamic.
- In Tunisia, 40 households have been interviewed in the Zoghmar community and the model has been built.
- A grant of 100,000 Euro to work on a model at the regional level has been provided.
- Alary, V., El-Mourid, M., Lecomte, P., Nefzaoui, A., Waterhouse, A., Wright, I.A., Gibon, A. 2002. Assessment of livestock and farming systems in harsh environments - Approaches adopted by farmers through management practices. Contribution to the 53rd EAAP, annual meeting. Cairo, 1-4 September 2002.
- Alary, V., El-Mourid, M. 2002. Contribution de la recherche agricole aux PMEAs des zones arides: de l'intensification au développement durable. Atelier FAO/ICARDA " Eléments de politiques pour faciliter l'accès des PMEAs en zones arides dans les pays de l'UMA aux technologies adaptées ", Tunis, Hammamet, 31 October-2 November 2002, 26p.
- 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.
- 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 Community in Central Tunisia (Mashreq and Maghreb project).

Output 3: Identification and evaluation of property rights and local institutional options for sustainable management of rangeland resources in Jordan, Morocco, and Tunisia

Indicators: Three synthesis reports evaluating the likely welfare effects of different rangeland management institutional options on subgroups within the community (gainers and losers under each option) and the importance of institutional and market-based feed access options for sustaining production and livelihood strategies produced.

Summary of activities in 2002

- Synthesis report for the Rangeland management option workshop held in Tunisia in may 2001
- Organize datasets from Jordan, Morocco, Tunisia and Syria
- Develop a framework for institutional options for rangeland management
- Edit rangeland papers

Major achievements (milestones) in 2002

- Organized household survey results for range management options for Jordan, Morocco and Tunisia.
- Grant ($15,000) from the World Bank to develop a framework for rangeland management options for the World Bank.
- Paper: Ngaido, T. and N. McCarthy. 2002. Managing externalities and improving pastoral production and livelihood strategies. Paper prepared for the Regional Workshop on Land Issues in Africa, Kampala, Uganda, 29 April-2 May 2002.
- Chapter on rangeland management: Ngaido, T., A. Herzenni, A. Laamari, and M. Boughlala. Effects of institutional options for managing rangelands in Morocco.
- Ngaido, T., Nancy McCarthy and Monica Di Gregorio. International Conference on Policy and Institutional Options for the Management of Rangelands in Dry Areas: Workshop Summary Paper. CAPRi Working Paper 23. Washington DC: IFPRI. 2002.

Output 4: Assessment of women's resource access and use, and household livelihood strategies in selected sites in Syria

Indicators: Report of the rapid rural appraisal (RRA) and focus groups of selected communities Synthesis reports on women asset building strategies and access to productive resources and identification of the women's constraints in conducting their activities.

Summary of activities in 2002

- Household surveys and data management
- Dr John Fitz Simons visits ICARDA to refine data analysis framework and HH data base

Major achievements (milestones) in 2002

- Writing of the progress report for CIDA.
- Completion of cleaning and organization of HH level databases.
- Identification of potential research themes and potential publication outlets.
- Literature review related to potential research themes.
- Meeting with officials from the World Food Program (WFP) and UNICEF to share information and discuss about issues related to rural development projects targeting women implemented by UNICEF and WFP in Syria.
- Meetings with extension officers from Hulu Abd (Raqaa province) to discuss the policy implications of findings of the study.

Output 5: **Updates of ICARDA commodities, resources and system trends for more effective research targeting and priority assessment**

Indicators: *Brief on barley production in West Asia and North Africa*
Brief on Wheat production in West Asia and North Africa

No major activities in 2002 under this output.

Staff list

Abdul Bari Salkini:	Agricultural Economics and Liaison Scientist
Ahmed Mazid:	Economist
Celine Dutilly-Diane:	JPO Socioeconomist
Malika Martini:	Agricultural Economist
Markus Buerli:	JPO Socioeconomist
Roberto La Rovere:	Researcher in Economics
Shibani Ghosh:	Research Fellow-Nutrition
Farouk Shomo:	NPO-Economist
Akmal Karimov:	NPO-Uzbekistan
Salahieh Hisham:	Research Assistant II
Arab George:	Research Assistant II
Khawam Hala:	Research Technician

ICARDA-01/500/March 2005