Foreword

In 1997 the former Pasture, Forage and Livestock Program and the Farm Resource Management Program were merged to create the Natural Resource Management Program (NRMP). Prior to this date separate annual reports and other ICARDA documents were the main vehicle used to report on research progress to ICARDA's collaborators.

Since then topics related to Natural Resource Management have continued to be published via the Social Science Papers Series, Caravan, the Integrated Natural Resource Management Technical Report Series and the ICARDA Corporate annual report. Occasional publications are also produced on specific topics such as water harvesting, on-farm soil and water management in Central Asia, etc.

The CGIAR requires that the international centers develop Medium Term Plans to cover 5-year periods. However these are usually up-dated annually and are organized around projects with project logframes that themselves feed into an overall logframe for the CGIAR system. The reporting requirements for the Medium Term Plan are brief and are insufficient for a more general audience and especially our collaborating scientists with the NARS and Advanced Research Organizations or AROs.

In 2001 the NRMP decided to establish a more detailed annual report that is a progress report of work completed or near completion that has achieved significant milestones and that should be shared with a wider audience.

Here we present the first of these progress reports for work conducted prior to 2001 and post-1995 when ICARDA published the last of its reports from the Farm Resource Management Program. The report is organized by the Medium Term Plan project structure but as the work on the NRMP becomes more integrated reports will be based on combinations of activities from the separate projects.

We hope that this progress report will be of use to our collaborators and other scientists from the NARS and AROs.

Richard Thomas
Director, NRMP
ICARDA

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

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

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

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 the Agricultural Productive Capacity 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

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. Strengthening National Seed Systems

The following project is in operation under this theme:
Project 5.1. Strengthening National Seed Systems in West Asia and North Africa

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

Rationale

The production potential of cropping systems within a given environment depends on plant genetics and management of soil and crops. No matter how good new crop cultivars might be, they will not achieve their potential and or bring appreciable increases in yields unless they are well managed. Good management practices can considerably increase the efficiency with which the limited amount of water available from rainfall is used. Therefore, more production can be gained if crops are well established and adequately fertilized, weeds are controlled, and use is made of crop rotations. Increasing demand for food and feed forces farmers to use non-sustainable mono-cropping of cereals with improper cultural practices, resulting decreasing crop yield and water use efficiency, declining soil fertility, increased pest pressure.

If production is to be sustained in the long term, attention must be paid to the appropriate management of soil. They have been some achievements in this area of research for the last decade. However, they have been conducted mainly on research stations under controlled environments. Transfer of the improved technology packages to farmers is of vital importance. Participation of farmers in adaptive research is crucial for research to be relevant to problems and needs of the producers in sustaining overall agricultural production. Many gaps in our knowledge still exist, especially the sustainability of cropping systems or improved technology packages. Yet, research findings need to be extrapolated to other similar areas through predictive models.

Expected gains/impact: Improved soil and crop management with efficient use of crop rotations will increase productivity and productive capacity of soils for the long term resulting in improved living standards of the small farmers, too. It will also help in sustaining productivity with improved water use efficiency as well as sustaining soil fertility.

Emphasis is given to research problems in less favorable environments; evaluation of alternative crops for increasing diversification in production; 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; soil micronutrient imbalances impacting on plant growth and animal and human health; and to participation of farmers in adaptive research on problem-oriented technologies. Hence, there is a need to develop alternative crop options in the best possible rotation with each other that will help overcome the food deficit, conserve natural resources, and improve livelihood of the poor farmers.

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:

- Sustainable and resource-efficient crop rotations that optimize production and maintain the productive potential of the soil.
- Potential of new crops and their role in cropping systems.
- Techniques for more efficient water capture and utilization in dryland crop ping systems developed and tested in a watershed context.
- Identify management strategies for 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 animal and human health.
- Appropriate research extension and management personnel trained in stan dardized analytical techniques, in soil and cropping system management, and in the development and transfer to resource users of productive and sustainable technologies.

Outputs

Output 1: **Management principles for choice of crop, 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 with the objectives such as, a) to develop an understanding of physical, chemical, biological and environmental principles, which underlie and control the productivity and sustainability of cropping systems with respect to soil characteristics and water and nutrient dynamics, b) to develop strategies for efficient management of soil, water and nutrients in cropping systems.

Five activities out of eleven have been summarized for management principles for choice of crops in crop rotations with input use, soil and crop management practices with respect to rotational output, resource use-efficiency and long-term soil and crop productivity. The vetch/cereal rotation, by comparison with the continuous cereal or fallow/cereal rotations, has consistently higher levels of organic carbon, organic or total N, and both labile and biomass forms of these elements as the trend is expected to be accentuated with time. In line with positive outputs from the ICARDA research, anticipatory long-term trials and monitoring have been established in Egypt five years ago with several positive outputs on these issues.

Similarly, crop diversification studies have been conducted in Iran and Central Asia with associated soil and crop management practices with the outputs of legumes and oilseed crops successfully taking place either in fallow/cereal rotations or mono-cropped systems of these regions. In the region, national productions of edible oil are insufficient to meet the demand. Thus, increasing the area of oil crops utilizing fallow or continuous cereal and is very important. Thus oilseeds (mainly rapeseeds and safflowers were introduced to Iran, Lebanon and Syria with successful results with yields ranging from 0.4 to 2 t/ha associated with 30-40% oil content (not given in detail below).

Activity 1.1: Monitoring nutrients/organic matter/bacterial biomass and water dynamics in barley-based, long-term rotation.

Barley-based long-term rotation trial: Evaluate the sustainability of cropping systems through improvement of soil quality and rain water-use efficiency. Soil quality data from the barley-based trial confirmed previous trends from the wheat-based trial. Thus, here the vetch rotation, by comparison with the continious cereal or fallow rotations, has consistently higher levels of organic carbon, organic or total N, and both labile and biomass forms of these elements. With time, these trends are expected to be accentuated.

Activity 1.2: Data analysis and assessment of trends in various long-term trials in relation to soil, water, nutrient, and tillage systems.

Rainfall - and consequently soil moisture - is the dominant factor controlling crop yields in the drought-prone West Asia - North Africa (WANA) region. Not only is rainfall low (200-600 mm yr^{-1}), but it varies widely from year-to-year and within seasons. A large- plot trial was established at Tel Hadya Research farm of ICARDA in 1986 as wheat-legumes including wheat-fallow and wheat-watermelon rotations to assess the sustainable productivity of the cropping systems. There were the ancillary treatments involving nitrogen (0, 30, 60, 90 kg ha^{-1}) and variable grazing of the cereal stubble (heavy, moderate, none). While highest yields occurred in wetter years, responses were the lowest under continuous wheat and slightly lower after legumes, particularly medicago as compared with wheat after fallow and watermelon (*Citrullus vulgaris* L.). The effect of grazing was minor in relation to cereal yields.

Activity 1.3: Monitoring of farmers' management practices in their crop rotations for effects on productivity, soil physical and chemical fertility, and pest and disease incidence in Egypt (Multidisciplinary team work with strong collaboration of MTP projects 2.2, 3.1, 4.1 and 4.2).

This is being accomplished through extensive on-farm monitoring of farmer's resource inputs and management practices developed as a complementary and parallel research effort to long-term on-station trials (LTT). Farmer's practices are monitored to provide information on their management of soil and water resources in response to changing natural economic, and social circumstances. This is directly linked to biophysical measurements of changes over time in the status of natural resources on representative farmers. Participating farmers (88) were selected for the Long-Term Monitoring (LTM) activities. The background information was reported in detail report of 2001, thus the results are just summarized below for soil quality and fertility aspects as leaving the water management and socio-economic aspects to MTP projects 3.1, 4.1,and 4.2. Detailed results could be obtained from the annual report for Natural Resource Management Component in Egypt prepared by the Project team.

- The team found that farmers on the newly reclaimed land have started to introduce new crops into their summer rotations. These include vegetables, in addition to groundnut in sandy soils, and cotton in addition to maize and tomato in the calcareous soils. On the old land, medicinal plants have replaced faba bean. Farmers close to the coast in north Sinai have expanded their fruit tree plantations and vegetable production using underground water. Manuring, subsoiling, and the planting of legume crops were the soil fertility enhancing methods preferred by most of the farmers sampled the newly reclaimed land, whereas manure and residue incorporation were preferred by the old land farmers. However, on the old land of Sids, where alkalinity is a problem, sub soiling and gypsum application are practiced. It was found that most farmers on the old land were not sensitive to price increase of chemical fertilizers.
- About 80% of most farmers reported positive changes in their soil properties and crop performances at all locations.
- Adding manure was the best method to improve the soil fertility status in newly reclaimed irrigated and also rainfed areas. However, about 75% of the farmers did not have sufficient manure in the newly reclaimed areas, which should be considered to be obtained from the old land areas. But most farmers in rainfed areas of north Sinai had self-sufficiency in manure, which is used mostly in fruit trees.

- Development of drainage systems in salt effected northern Delta, El-Serw area has improved the systems productivity and lowered the watertable under the hazardous level.
- In all locations, most participating farmers overused nitrogen fertilizers. Nitrogen-use efficiency values for wheat in farmers' fields in Sids and Nubaria was about half that recorded in LTT research plots; but values were higher where manure was applied.
- WUE values for wheat in farmers' fields at Sids and Nubaria were low compared with those in LTT plots, attributed to differences in overall management.
- Monitoring inlet water (canal or well) and field drain water in farmers' fields at Sids, El-Serw, and Nubaria found increased nitrate content in drain water. The team recorded mean inlet and outlet values of 1.6 and 12.1 mg NO_3/liter, respectively, in Nubaria, indicating considerable leaching loss and water pollution.

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

The NVRSRP Resource Management Program seeks to overcome the various threats to sustainability and to contribute to sustainable agricultural production in Egypt. By improving well-being of individual farming families, increasing the overall farming system, with emphasis on water and land resources conservation in an environmentally sustainable way. Therefore, the project aims to improve water productivity and increase soil production potential in old lands and virgin areas. Long-term rotation trials were at experimental stations under full researcher control involved crop rotations, water quality and /or quantity and mineral fertilizers, as well as organic manure. The program is now in their fifth season and trials in the second rotation cycle.

- The recommended irrigation regime resulted in higher yields and 25-30% water savings at Sids and Nubaria, compared to farmer's practice.
- 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 of wheat, compared to the continuous wheat system. It also increased water-use efficiency.
- A mole drain system (at 1.5 m depth filled with cotton wood perpendicular to lateral field drains) decreased the watertable 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.
- Producing and applying composite manure (fermented) at trial 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, and control weeds.
- Planting wheat on furrows followed by maize and/or sunflower to test/achieve: better control of irrigation, save water by applying recommended levels, and zero-tillage application for: optimum planting dates for summer crops, more intensive cropping system, and reduced operating costs.
- Mole drains in salt-affected clay soils to increase drainage efficiency.

Activity 1.5: Crop diversification, rotations, soil, and crop management practices for improved water and input use efficiency in CAC.

To assist the Central Asian countries in achieving sustainable increases in the productivity of crop and livestock systems, the On-Farm Soil and Water Management Project was initiated. The project's goals are to provide food security, economic growth, environmental sustainability, and poverty alleviation in the region. The Asian Development Bank is funding the project for the years 2000 to 2003. The project's activities are organized under four themes: (i) application of technologies that improve water and nutrient use efficiency; (ii) alleviation of salinization in irrigated areas; (iii) utilization of marginal water sources; and (iv) human resource development.

A multidisciplinary ICARDA research team in cooperation with national research scientist in the region developed pilot research activities addressing the themes. Research activities were identified according to the specific needs and problems of each country. All the technologies and practices developed and tested by the pilot projects will be adapted for transfer to farms with similar conditions. Farmers in both rainfed and irrigated areas are the primary beneficiaries of this program, as the program will improve the sustainability and productivity of agriculture. Successful implementation of the results will also benefit the environment. Eventually, the whole population of the region will benefit from the project's effects on food security and on the development of viable agro-economic, and social systems. The following sections present progress made in 2001 growing season with respect to agronomic management of the cropping systems within the Component One on "Development of improved strategies for on-farm soil,

water, and crop management (water management, irrigation methods, fertility, tillage, crop diversification) in the lowland farming systems (irrigated and rainfed) of all the CA countries and highland and mountainous areas of Tajikistan.
Field experiments with respect to Component One were laid out 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 Kazakstan, Kyrgyzstan and Uzbekistan) and in the irrigated cropping system (Kyrgyzstan and Uzbekistan). Detailed results could be obtained from the annual report for ADB-funded Soil and Water Management Project for Central Asia.

Activity 1.6: Trials on crop rotation, tillage, sowing date, crop varieties, fertilizer use, weed control, and supplemental irrigation in dryland areas of Iran.

The Dryland Agricultural Research Institute (DARI), established in 1993 to generate appropriate technologies for Iran drylands, involved development and testing of improved crop, soil and water management practices, including supplemental irrigation and mechanization and studies on the socioeconomic constraints to dryland farming.

The three consecutive dry seasons have given an opportunity to show the potential impact of improved soil and crop management practices together with improved varieties. Cereal yield for the improved technology, recorded in on-farm large plots (> 1 ha) generally were 50-200 % higher as compared to yield of similar crops using farmer, unimproved practice. Total crop failure in farmers' fields was not uncommon. Summary of some activities are given below and detailed information can be obtained from the Annual Report for the Planning Meeting between ICARDA/Iran.

Long-term Crop Rotation Studies (7th year)
These studies were established to investigate the introduction of annual food and feed legumes and oilseed crops into the fallow-wheat rotation on productivity and soil physical and chemical quality, and to assess the profitability of crop sequences compared with fallow-cereal rotation (Maragheh, Herke-Sanandaj, Gachsaran and Sararoud-Kermanshah and Zanjan). Fallow was not more productive than wheat following other crops to be considered replacing fallow even though the season of 2000/01 was extremely dry and affected the overall crop yields as in the last two years.

Wheat Production under Supplemental Irrigation in Dryland Areas (2nd year)
Supplementary irrigation improved wheat yields by more than 300% under very dry conditions of Maragheh (0.95 to 3.4 t/ha) and Urumieh. In both sites as an average, irrigation at 66% of the full irrigation provided about 84% of the yield (86% in Maragheh and 82% in Urumieh) compared with that of the 100% water application. Under relatively better conditions of Sararoud, 86% of yield was obtained by 33% irrigation level and 66% irrigation provided 96% of the yield obtained by 100% irrigation. With the two-year results, it could be seen how much water could be saved for such a small reduction in yield by applying deficit supplementary irrigation where water could be used for other crops or for larger areas.

Soil Management Studies
Different tillage implements with different timing and stubble management were studied in cereal fallow systems. Minimum tillage with chisel or "ducks foot" cultivator proved to be the same as the traditional deep plowing in continuous cropping systems (Yield range of 0.7-1.0 t/ha in Maragheh under very dry conditions, and 1.3-1.5 t/ha in Sararoud-Kermanshah with relatively more favorable conditions). However, under cereal/fallow cropping systems, timely deep plowing by moldboard or chisel (20 cm) in Fall or early Spring followed by ducks-foot cultivator at the beginning of early Summer when the rainfall cease to create an isolation layer on the soil surface for reducing the evaporative losses of soil moisture is the best for yield increase (yield ranges of 1.0-1.8 t/ha) compared with improper late tillage, which is a major practice of farmers (yield ranges of 0.3-0.7 t/ha) under very dry conditions in farmers' fields of Maragheh region.

Nutrition Studies in Crop Production:
Under this title crop responses to fertilizer application and different sowing dates and methods and seed rates were studied. Determination of micronutrients as well as macronutrients in soil of dryland areas of Iran (1st year) as a survey work in farmers' fields was conducted in Maragheh, Gamloo-Sanandaj and Sararoud-Kermanshah regions.

Critical levels of Fe, Mn, Zn, Cu, and B are 5, 5, 0.65, 0.8, and 0.7 ppm, respectively. Thus, there is a deficiency of Fe, Zn, Cu and B in several farmers' fields of Maragheh and Sanandaj to be considered for productivity increase in these regions soil sampling and application of these micronutrients should occur where deficiency is found.

Responses to fertilizer and seed rate were negligible because of the long drought period in the season. Response to nitrogen fertilizer was even negative. However, row spacing of 36 cm for chickpea was better 18 cm and 54 cm (0.57 t/ha) in Maragheh area.

On-farm testing of fertilizer application have shown that fertilizer placed at 9 cm under the seed provided significantly higher yield (1.33 t/ha) compared with fertilizer applied to the same depth together with seeds (1.2 t/ha) and farmers' practice with broadcasting the same amount of fertilizer (0.7 t/ha) in wheat yield. Similarly fertilizer placement at 9 cm below seed level provided 1.66 t/ha as compared to 1.33 t/ha from mixed application of seed and fertilizers in barley at Maragheh farmers' fields.

Output 2: Validated cropping systems simulation models for the spatial extrapolation and generalization of site-specific results through use of GIS.

Rationale

Crop simulation models are possible alternative tools for such kind of studies provided with preliminary calibrations. Geographic Information Systems (GIS) are the tools for mapping any soil and crop outputs for a wide region to direct research and development projects for the welfare of the farmers. Therefore, the objective of using crop simulation models is to identify techniques for the spatial extrapolation and generalization of results of agronomic experiments in use. Crop simulation models extrapolate the site-specific research results to wider areas with the appropriate crop parameters established to be tested and calibrated for given experimental fields.

A Ph.D. thesis under preparation jointly with Hohenheim University aiming at (i) contribute to the objective 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 long-term using APSIM (Agricultural Production Systems Simulator), to (iii) investigate the impact of changes in soil organic matter status on the economical and ecological system performance in the long-term via agricultural systems modeling with APSIM simulation model. However, there is a need to test cropping systems simulation models for validation in larger areas with respect to different agro-ecologies as combined with GIS.

Activity 2.1: ***CropSyst simulation model was tested on wheat and promising results were obtained, yet further tests are needed for the new version of the model, not only on wheat but also for other crops in order to identify appropriate management options and to quantify production risks.***

CropSyst simulation model has been tested with the previously published data set in Washington State University in consultation with its developer. Results showed that new version of the model could be used as good as that of the previous version. Yet it is in windows environment with more user-friendly feature having salinity module and integrated with weather generator and GIS systems. There is a need to test cropping systems simulation models for validation in larger areas with respect to different agro-ecologies.

Activity 2.2: ***APSIM cropping systems simulation model was tested for wheat and barley under supplemental irrigation and nitrogen applications and for lentil and chickpea under supplemental irrigation and sowing date for a Ph.D. study by Ms. Carina Moeller.***

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 together with them and extension personnel is of vital importance to increase the adoption rate. 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 in semi-arid regions of Morocco: a) Effect of planting pattern on yield and water use efficiency of bread wheat in semi arid regions, b) Season displacement, tillage and weed management effects on water use and water use efficiency of chickpea have been studied.

Under rainfed conditions in dryland areas, wheat production and its water-use efficiency can be improved as reducing the weed infestation by using narrower row spacing. Advancing the date of planting associated with weed control and application of phosphorus on chickpea could improve water-use efficiency and the crop productivity. A study on 'no- and minimum tillage as an alternative to conventional in dryland fallow/wheat and annual cropping systems in Central Anatolia, Turkey showed that no-tillage can be more efficient compared with the conventional deep tillage systems followed by minimum tillage as well. Improved soil and crop management practices applied on farmers' fields in Iran could bring the yield levels of wheat crop to about 2 t/ha from nil or 0.4 t/ha under very extreme dry conditions.

Activity 3.1: Different management options for optimizing soil water use in semi-arid regions of Morocco: a) Effect of planting pattern on yield and water use efficiency of bread wheat in semi arid regions, b) Season displacement, tillage and weed management effects on water use and water use efficiency of chickpea.

a) Bread wheat planting pattern for yield and water use efficiency of in semi-arid regions of Morocco:
Under dryland conditions, vegetative covering of the soil surface early in the growing season by changing row spacing in wheat crops appears attractive as a strategy that might reduce the evaporation rate and save some water for later stages where water deficit and temperature became higher. Consequently, grain yield can be improved. Results showed that, although the average yield is low, in both sites narrow row spacing increased grain yield and total biomass. However, the biomass increase observed at the experiment station is not statistically significant. Rainwater use efficiency for grain showed the same trend as grain yield. Therefore, the best planting pattern was 12-cm row spacing with 400 kernels/m² (1.8 t/ha in weed-free and 1.4 t/ha in weedy plots). However, the effect of seeding rate was not statistically significant. Broadcasting treatment gave better yield than 24 cm when combined with 400 kernels/m² and shows once more the benefit of early vegetative soil coverage. Water saving can be also achieved by decreasing weed infestation and wheat crop production can be improved and weed infestation can be reduced by narrower row space. This type of crop pattern helps by reducing evaporation and saves water for later stages where moisture deficit occurs frequently (M. Boutfirass, INRA-Settat).

b) Season displacement, tillage and weed management effects on water use and water use efficiency of chickpea in dryland region of Morocco:
The experiment was conducted as on and off-station trial to evaluate different combination of tillage and weed management systems in terms of water use, water use efficiency, yield and yield components; to determine the potential of winter vs. spring planting season in term of productivity, the pattern of water use, water use efficiency within different conservation techniques; to evaluate weed infestation and biomass production under different combination; and to determine the production costs and returns of different strategies

Advancing date of planting improved the performance of the winter sown-chickpea (5.2 t/ha) due to the prevalence of relatively more favorable thermal and moisture regime during its vegetative and, more importantly, reproductive phases, compared to conventional spring sown-chickpea (1.4 t/ha). Phosphorus fertilization is advantageous mainly in soils where available phosphorus P is low. Weed control using a pre-emergence herbicide, such as Igran, proves to be effective when environmental conditions are favorable for its absorption.

From the above, there is still a need for the studies to be carried out in different parts of the region on these agronomic options and other aspects that take full advantage of existing environments (R. Dahan, and A. El Brahli, INRA-Settat).

Activity 3.2: No-till and minimum tillage as an alternative to conventional in dryland fallow/ wheat and annual cropping systems in Central Anatolia, Turkey (OSWU)

The research has aimed to assess the no-tillage and reduced tillage systems in terms of water economy, to compare and evaluate the tillage systems in terms of crop yields, and feasibility of the systems as to production economy, weed, pest and disease control. Conventional fallow-wheat/barley system with the application of conventional deep tillage and successive operations and chemical fallow were compared chickpea-wheat/barley cropping systems with minimum and zero-tillage applications. Results showed that towards summer, minimum tillage in chickpea tended more moisture (195 mm at 80 cm depth) than zero-tillage in chickpea (120 mm) although they have similar soil moisture during the earlier periods of the growth. On the other hand, zero wheat following chickpea and continuous wheat tended to have similar water content during the season. There was a general tendency that zero till systems had almost always more moisture in the soil profile than reduced and conventional systems. Except for systems including fallow, more net benefit was obtained with zero tillage systems as a whole (M. Avci and agronomy team, CRIFC).

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 in Iran:
Another dry year gave the opportunity to show the potential impact of improved management practices together with improved varieties compared with farmers' fields. Crop development at the research stations compared with expected low yields in farmers' fields under also this year conditions is very remarkable showing the importance of improved soil and crop management practices applied

timely. Therefore, technology transfer activities should be given more emphasis then ever for increasing farmers' adoption rate of improved production techniques. DARI has started already the training activities for extension staff and conducting field days for as much farmers as possible inviting also decision-makers to create awareness of good management practices under different environments. Wheat variety registered as Azer-2 is performing excellently combined with improved management practices, which would result in around 2-t/ha-yield level while farmers would not exceed more than 0.7 t/ha where the observations made.

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

Rationale

While drought is the dominant crop constraint in the WANA region, nutrient deficiencies are also major 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.

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 use of phosphate fertilizer (funded mainly by IMPHOS).

- Field trials in rainfed areas of Pakistan (NARC, Islamabad) showed that P fertilizer was highly effective and economic in increasing wheat yields. Banding of fertilizer was twice as effective as broadcasting. While soil analysis can indicate deficiency levels of P, criteria were also developed for plant analysis.
- In the Çukurova region of Turkey (Adana 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. Evidences of P accumulation from fertilization were also shown.
- In Jordan (JUST University), 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.

- In Morocco (INRA, Settat), a series on on-station trials established the importance of providing P fertilization for N-fixing forage legumes where test levels were in the deficiency range.
- 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. Thus, critical soil test levels should be interpreted in this context.

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, lead to 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 reflections of these trends. The on-going barley-based trial is providing confirmation of these trends.

Activity 4.3: Fertilizer use and fertility characterization across Syria's rainfall 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 analyses. Given the importance of soil organic matter and the significance of carbon sequestration to mitigate global warming, measurements of C were taken to reflect spatial variability and soil depth. Rough estimates of the amount of soil carbon in each rainfall zone have been made.

Activity 4.4: Soil and plant analysis improvement.

Reliable and meaningful analyses are fundamental to making rational decisions about nutrient deficiencies and fertilizer requirements. Thus, efforts continued to up-grade laboratory performance and maintain quality output. The most tangible output was a survey of laboratories in CGIAR centers worldwide, highlighting avenues for improvement.

Output 5: Micronutrients in Soils and Plants

Rationale

Micronutrients, though needed in small quantities by plants are essential to crop production. Such nutrients include iron, zinc, manganese, copper, and boron. Soil conditions in WANA, especially being calcareous, are conductive to deficiency, mainly because of precipitation reactions of metal cations. Though not as significant as N and P, micronutrients are now recognized as being major limiting factors in some areas and for some crops. Deficiencies can be rectified by fertilization or be 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.

Activity 5.1: Geographical distribution of micronutrient problems.

A database of soil test data is being established from soil samples from Syria and elsewhere in the region: A review on micronutrients in Mediterranean-type environments is being prepared, brining together all available literature on the subject from WANA.

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 ß-ODAP could be reduced by varietal selection and to a lesser extent by addition of Zn.

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 to resource users of productive and sustainable technologies are of vital importance for use of sustainable natural resources. The following activities are highlighted.

- Finalized soil lab analysis manual for printing in 2001. The English language version will be translated to Russian in 2002, while the Arabic version is ready, with a French to follow.
- Dr. John Ryan, as Associate Editor and reviewer of International and regional journals, plays a key role in upgrading published scientific output of WANA scientists.
- Fertilizer application guide is being prepared for farmer use in WANA.

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

- Analytical methods of soil, plant and water analysis in Tajikistan
- Transfer of technology through on-farm trials in Iran
- Contribution to training courses, e.g., agronomy and soil fertility
- Exchange of knowledge at field visits (e.g., Iran, Turkey, Egypt)
- Review NARS-related papers
- Review of Soils/Plant Analysis Labs in CGIAR centers
- Workshop/meetings, and editing of the Proceedings.

Appendix 1: Staff list, Collaborators, Donors, Publications

Staff list

1. 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): **Assist in agronomic management trials for cropping systems as necessary, produce oilseeds as requested by NARSs, and advise in overall weed control.**

Haitham Halimeh (GS): **Assist in agronomic management trials for cropping systems as necessary, conduct 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): **Supervise Soil Laboratory.**

Shireen Badour (GS): **Assist in Soil Laboratory analysis.**

2. Students

Carina Moeller (Student): **prepare a Ph.D. 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: Algeria, Egypt, Jordan, Lebanon, Iran, Morocco, Syria, Turkey, CAC;
- Farm surveys and on-farm experimentation: Algeria, Egypt, Jordan, Iran, Morocco, Syria and Turkey, CAC;
- Optimizing Soil Water Use: Egypt, Jordan, Iran, Morocco, Syria, Turkey, Niger, Zimbabwe, Mali, Kenya, Burkina Faso, South Africa; and ICRISAT as co-convener.
- Soil fertility trends; systems modeling; use of ^{15}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 Programme 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.

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

Rationale

Many livestock in the Central and West Asia and North Africa (CWANA) region are suffering from chronic under-nutrition. These shortages are reflected in low animal productivity, severe rates of lamb and adult mortality, and reduced income for farmers. In Central Asia, the transition to non-centralized economies resulted in the disruption of winter-feeding systems and rotational seasonal grazing, generating severe feed shortages in particular during winter. Large feed deficits are projected by 2020 in CWANA.

A generation ago, a large proportion of the feed needs of the small ruminant population were provided by rangelands. Nowadays, however, crop encroachment, fuel wood collection, overgrazing and general mismanagement have led to a decreasing contribution of rangeland to animal feeding. In many CWANA countries, this contribution has declined from around 70% in the 1950s to only 10-40% at present. Given the fact that the current livestock population cannot be maintained on the rangelands throughout the year, and given the need to reduce grazing pressure, alternative sources of feed must be found.

There are also increasing pressures on the resource base for traditional livestock raising in CWANA. To meet increasing demands for food and feed, farmers are using more erosive crop rotations and non-sustainable cultural practices. The cereal/fallow rotation has turned to continuous cereal monoculture. Rainfed barley cropping has extended to marginal land. This has generated serious problems associated with declining soil fertility, cereal yield depression, increased pest pressure, loss of biodiversity, and lack of feed has been exacerbated.

CWANA harbors a riche flora with a high number of indigenous species that could be used as forage and pasture plants. The continuous and accelerating overexploitation of these native plants in their natural habitats have led to destruction of the natural stocks in the wild. Many of them are endangered and some are threatened with extinction. These represent a "gold mine" with huge potential to reverse land degradation in fragile environments, especially as local species and ecotypes have proven to be far better adapted to local conditions than introduced cultivars.

Hence, there is a need to develop alternative sources of feed that will help overcome the feed deficit, preserve natural resources and avoid large migrations of people from the countryside to the cities.

Objectives

The purpose of Project 2.3 is the development of options for adoption by farmers of forage and pasture species in crop rotations or to rehabilitate native pastures. Specific objectives include:

Development of Alternative Crop Rotations

In many dry areas, small ruminant production is the major economic output. With increasing land-use pressure, farmers have replaced traditional cereal/fallow rotations with continuous cereal cultivation. This practice is, in the long-term, unsustainable. There is evidence that cereal yields are declining and in some countries, where annual fallows are left weedy to provide additional grazing, the loss of fallow areas reduces a valuable feed source. Alternative crop rotations are needed that maintain adequate levels of cereal crop health and grain yields, while at the same time meeting feed requirements.

To this end research is undertaken to monitor long-term trends in cropping systems with the aim of steering policy makers and farmers away from non-sustainable and degrading practices. Land-uses common throughout CWANA are compared to potential new cropping systems. As high and sustainable yields may be obtained by growing cereals in rotation with forage legumes, efforts are devoted to promote the use of forage legumes, primarily vetch, as alternatives to continuous cereal cultivation. Different methods of utilization of forage legumes (direct grazing *vs* hay-making *vs* harvesting at maturity for conserved feed) are also tested.

Development of Sustainable Seed Production Systems

Lack of seed at the farmers' level is still one of the important constraints to increased livestock productivity in CWANA. Research effort has resulted in the identification of adapted forage and pasture material that would rapidly improve farm profitability through their use in meat and milk production. Lack of seed production, however, prevents the passage of promising, locally-adapted material from the evaluation stage to on-farm testing or broad-scale planting.

Forage and pasture seed production in CWANA is insufficiently developed. Governmental organizations for seed multiplication deal mainly with field crop species and seed producers are not interested in producing small volumes of seed with low profit margins and for uncertain market. Most of the CWANA countries are still relying on imported seed for pasture and forage crops.
Thus, there is a need to develop new concepts and techniques in forage and pasture seed production. Transfer of appropriate and practical knowledge for forage

and pasture seed production to the informal seed sector is a priority. The Project is also investing in the development and on-farm testing of machinery to feasibly introduce the pasture and forage legumes into productive farming systems, and in the development of human resources to promote forage and pasture seed production in CWANA.

Conservation and Valorization of Local Biodiversity
Another objective of the Project is to conserve threatened species, assemble significant diversity of target key species and evaluate them for use as forage or pasture crops to overcome the feed deficit and reverse land degradation. Considering that new production systems are emerging, there is a need to develop adapted cultivars to the different ecological niches and market opportunities prevailing in CWANA.

Output 1: Identification of Species and Selection of Adapted Cultivars of Pasture and Forage Species

Activity 1.1 Collect Native Forage, Pasture and Range Species

Efforts to gather forage, pasture and range species were continued and new accessions were acquired (Table 1). Importantly, the first accessions of cactus *(Opuntia ficus-indica)* were established *in situ* at Tel Hadya. ICARDA with its global mandate for agricultural research in dry areas is unequalled qualified to adapt a global mandate for *Opuntia* research. This valuable multipurpose resource suitable to reduce the effects of the climate variability, could be ideally combined with the other vegetal and animal genetic resources, and with technologies for the dry regions, in order to improve the livelihood of rural populations.

Currently, important and unique germplasm gathered from the CWANA region is conserved at ICARDA either *in situ* in a germplasm garden which was established in 1998, or *ex situ* as seeds held in a cold-storage facility. Some of this germplasm constitute a gold mine that could be exploited to help reverse land degradation in fragile arid and semi-arid environments (Table 2).

Efforts are also devoted to the establishment of reference herbaria. This year Identification was made and herbaria specimens established for about 100 species native to Lebanon (Appendix 1). This was undertaken in collaboration with the Lebanese team within the context of the GEF Agrobiodiversity Project. Also, collecting native species in Kuyulu Rangeland, in the GAP region, southeast Turkey, was completed in May 2001 (Appendix 2).

Assessing the biodiversity of the Khanasser Valley Integrated Research Site was continued. Plant diversity and biomass was measured at six sites: Al Qura'a and Megherat at the eastern foot of Al-Huss's mountain, South Im-Myal, North Im-Myal, Serdah and Khullat at the foot of Shbeith's mountain. In each site a 10mx10m plot was fenced as a "protected plots", and three plots around the fence were chosen as "grazed plots".

Results from this year confirmed results from previous years. In all sites, plant diversity was higher in the protected plots. The grazed area was dominated by poisonous and unpalatable species. For instance, in the North Im-Mial site, density in the protected area was three times that in grazed area, and biomass in the protected area four times that obtained in the grazed area (Table 3); in the Megherat site, density in the protected plots was two times that in the grazed plots, and biomass in the protected plots was three times that in the grazed plots (Table 4). Species recorded in April 2001 at the North Im-Mial and the Megherat sites are listed in Appendix 3.

Seed of adapted germplasm was increased and made available for national agricultural research systems. The list of germplasm sent to NARS in 2001 are given in Appendix 4.

Table 1. List of forage, pasture and range accessions received or collected in 2001.

Species	Origin
Artemisia herba - alba / 5	Kazakhstan
Astragalus alopecias Pall. */ 1*	Kazakhstan
Calligonum aphyllum (Pallas) Gurke */ 1*	Kazakhstan
Calligonum caput medusae / 2	Kazakhstan
Calligonum microcarpum / 1	Kazakhstan
Camphorosma lessingii Litw. */ 1*	Kazakhstan
Ceratoides papposa / 1	Kazakhstan
Halothamnus subaphyllus / 2	Kazakhstan
Haloxylon aphyllum / 3	Kazakhstan
Kochia prostrata Schrad. subsp *grisea / 3*	Kazakhstan
Onobrychis chorassanicae A. Grossh. */ 1*	Kazakhstan
Onobrychis ferganica (Sirjaev) Grossh. */ 1*	Kazakhstan
Salsola richteri Kaz. */ 1*	Kazakhstan
Salsola rigida Pall. */ 1*	Kazakhstan
Sameraria boissieriana / 1	Kazakhstan
Achillea filipendulina Lam. *K-4978 N 12*	Uzbekistan
Aellenia subaphylla Collenette *K-4826 N 14*	Uzbekistan
Agropyron desertorum (Fisch.) Schult. *K-4932 N 4*	Uzbekistan
Alhagi sparsifolia Shap. *K-5010 N 9*	Uzbekistan
Amaranthus ruber L. *K-5031 N 24*	Uzbekistan

(Contd....Table 1)

Astragalus eximius K-4880 N 16	Uzbekistan
Atriplex nitens Schkuhr *K-4982 N 11*	Uzbekistan
Atriplex tatarica L. *K-5030 N23*	Uzbekistan
Berberis oblonga Schueid *K-5032 N 25*	Uzbekistan
Calligonum setosum Litil. *K-5034 N 27*	Uzbekistan
Camphorosma lessingii Litw. *K-4830 N 3*	Uzbekistan
Ceratoides ewersmanniana K-4810 N 13	Uzbekistan
Climacoptera lanata (Poll.) *K-5024 N 17*	Uzbekistan
Convolvulus subhirsutus Rgi.et Schmalh *K-4949 N7*	Uzbekistan
Crataegus turkestanica Pojark. *K-4976 N 5*	Uzbekistan
Glycyrrhiza glabra L. *K-5025 N 18*	Uzbekistan
Haloxylon aphyllum (Minkue) Jljin. *K-5019 N 2*	Uzbekistan
Haloxylon persicum Bge. *K-5021 N 1*	Uzbekistan
Hypericum perforatum L. *K-4984 N 12*	Uzbekistan
Kochia prostrata (L.) Schrader *K-4805 N 15*	Uzbekistan
Lolium perenne L. *K-4937 N 6*	Uzbekistan
Peganum harmala L. *K-5033 N 26*	Uzbekistan
Prunus armeniaca L. *K-4958 N 10*	Uzbekistan
Salicornia herbacea (L.) L. *K-5027 N 20*	Uzbekistan
Salsola richteri Kaz. *K-4979 N 8*	Uzbekistan
Sorghum cernuum (Ard.) Host *K-5029 N 22*	Uzbekistan
Suaeda crophylla Pall. *K-5028 N 21*	Uzbekistan
Suaeda heterophylla (Kar. & Kir.) Bunge ex Boiss. *K-5026 N 19*	Uzbekistan
Pisum sp.	Uzbekistan
Opuntia ficus indica	Tunisia, collected Damascus
Opuntia ficus indica	Damascus-Deer El-Hajar
Opuntia ficus indica	Tunisia, collected Jordan
Festuca arundinacea cvs Mylena, Madra, Bariane, Centurion, and Lunibelle	France

Table 2. A selection from the list of perennial species growing in ICARDA's germplasm garden.

Species	Source of germplasm	Species	Source of germplasm
Artemisia herba-alba	Spain, Syria, etc.	*Melica ciliata*	Turkmenistan
Atriplex canescens	U.S.A.	*Melica persica*	Turkmenistan
Atriplex cordobensis	Bolivia	*Onobrychis aurantiaca*	Syria
Atriplex glauca	Australia	*Onobrychis ptolemaica*	Syria
Atriplex halimus	Jordan, Tunisia	*Onobrychis sativa*	Turkey
Atriplex leucoclada	Jordan, Syria	*Opuntia ficus-indica*	Tunisia
Atriplex nitens	Uzbekistan	*Panicum turgidum*	Sudan
Atriplex nummularia	Australia	*Paronychia argentea*	Morocco
Climacoptera lanata	Uzbekistan	*Periploca laevigata*	Tunisia
Colutea gracilis	Turkmenistan	*Plantago albicans*	Syria
Colutea istria	Jordan	*Plantago psyllium*	Morocco
Coronilla glauca	France	*Plantago lanceolata*	Turkmenistan
Dactylis glomerata	Turkmenistan	*Salsola inermis*	Jordan
Ceratoides ewersmanniana	Uzbekistan	*Salsola orientalis*	Uzbekistan
Festuca elatior	Morocco	*Salsola paletzkiana*	Uzbekistan
Haloxylon aphyllum	Uzbekistan	*Salsola vermiculata*	Syria, Jordan
Haloxylon persicum	Syria	*Stipa caspia*	Turkmenistan
Kochia prostrata	Uzbekistan	*Stipa parviflora*	Morocco
Medicago arborea	Spain	*Thymus leucotrichus*	Morocco
Medicago citrina	Spain	*Zygophyllum atriplicoides*	Turkmenistan

Table 3. Density and biomass in protected and grazed plots in April 2001 at the north Im Mial site.

	Protected plots		Grazed plots	
Sample no.	Plants/m^2	Biomass g/m^2	Plants/m^2	Biomass g/ m^2
1	4706	1177.74	1333	182.24
2	3529	400.24	1451	369.52
3	5059	1868.09	1489	176.41
4	4471	989.64	901	342.69
5	1765	1728.52	1686	613.74
Average	3906	1232.85	1372	336.92

Table 4. Density and biomass in protected and grazed plots in April 2001 at the Megherat site.

	Protected plots		Grazed plots	
Sample no.	Plants/m^2	Biomass g/m^2	Plants/m^2	Biomass g/ m^2
1	2235	474.65	1176	378.6
2	3176	1241.16	1489	181.68
3	6824	1466.02	2862	369.29
4	4824	917.95	2156	366.84
5	1176	1035.49	2353	317.04
Average	3647	1027.06	2012	322.69

Activity 1.2 Test and Select Adapted Cultivars

Efforts to promote adapted species and cultivars are continuing in collaboration with Projects 1.6, 2.4 and 2.5. To lever resources and increase the chances of adoption, selected species and cultivars are tested within research and development projects such as and the IFAD Integrated Feed-Livestock project in Central Asia, the Mashreq/Maghreb project, and the Barani Project in Pakistan.

In Central Asia, substantial efforts were devoted within the context of the *Integrated Feed and Livestock Production in the Steppes of Central Asia* Project to overcome the severe feed shortage, in particular during winter. This report highlights results of some activities undertaken in Uzbekistan and Turkmenistan.

In Uzbekistan, an experiment aiming at intensifying the production system was conducted at Boykozon Shirkat, located in Parkent district in Tashkent province. Fodder associations (triticale + oat + fodder pea) were sown on 60 ha as intermediate crops in autumn 2000. Fertilizer was applied at the rate of 75 kg/ha of P_2O_5 before seeding and 70 kg/ha of N in spring. The crops received irrigation in autumn and spring. In spring 2001, the intermediate crops were harvested for hay and green mass. After harvest, the same land was plowed and sown with maize grain (Hungarian hybrids) and maize silage (Uzbek variety Vatan).

Results (Table 5) show not only a net increase of fodder biomass per ha but also a higher feed units yield compared to the control consisting of spring maize for silage. Intensive production of fodder crops in Uzbekistan, based on a rotation of intermediate crops (triticale + oat + fodder pea) followed by maize grain and maize silage, demonstrated the possibility of producing up to 15.7 tons dry matter and 5.8 tons of maize grain per hectare, while the traditional system (spring maize for silage) produced only 9.5 tons dry matter per hectare.

Table 5. Intensive use of irrigated land through intermediate winter crops and production of maize for silage and grain.

Crops	Dry matter (ton/ha)	Grain yield (ton/ha)	Dry matter (ton/ha)
Intermediate winter crops	5.23		5.23
Next in rotation			
Maize for silage	8.70		13.93
Maize for grain	10.5	4.5	15.733
Control: spring maize for silage	9.52		9.52

Also in Uzbekistan, the assessment of potential use of mulberry for feeding purposes, which started in 2000, was continued. In 2001, the leaf yield of mulberry trees of varying ages was determined along with an assessment of the chemical composition of the leaves of white mulberry and its nutritional value. The yield of white mulberry leaves of trees of different ages was recorded in May and October (Table 6). Yields of younger trees (8-20 years) reached only 24% of those of trees over 100 years of age. Even after reaching 50 years of age, trees will produce 50% less than older trees. Yields of trees over 50 years in May, when the leaves are used for the production of silkworm, were nearly 50% higher than yields in October.

Table 6. Seasonal production of leaves per tree according to age and size of trees.

Size	Number	Age (years)	Leaves per tree, kg		Production (big trees taken as 100), %	Difference May/October, %
			May	October		
Small	3	8-20	43	36	24	19
Average	3	50	86	56	37	54
Big	3	Over 100	210	150	100	40

Regarding cultivar development in Central Asia, two varieties were released. Dustlik-85 is a new oat variety for irrigated areas of Uzbekistan developed by the Galla-Aral Branch of the Research Institute of Grain and Grain Legume Crops. The variety is suitable for cultivation in the irrigated areas, in particular in southern regions of the Republic, with possible planting time in spring and in autumn. The growing period is 210 days for spring planting and 85 days for autumn planting. Green mass yield is 3.5-3.8 t/h for spring planting and 1.8-2.4 t/ha for autumn planting. Dustlik-85 can be planted as inter-row crop for green mass production. In the southern region, the variety can yield 1.4-1.6 t/ha of green mass if it is planted as a second crop (October-November). In Kazakhstan, the Academic Council of the Kazakh Research Institute of Agriculture, Almalybak, has approved the release of the elite line of Lathyrus IFLLS# 55) as Ali-Bar.

In the Mashreq countries, efforts were devoted to working with farmers to better identify their perceptions and constraints in order to scale-up the vetch technology. Most of the work was undertaken with a community approach in Iraq, Jordan, Lebanon and Syria, within the context of the Mashreq/Maghreb Project, coordinated by ICARDA and IFPRI and jointly implemented with national programs.

In Iraq, haymaking from common vetch proved successful and has become a common practice in the Ain-Talawi community. The results obtained at two farms indicated that using common vetch hay as replacement of 30% of feed supplement used by sheep owners' could improve the performance of ewes and their lambs. Ewe milk yield increased by 55% and 8% at farms 1 and 2, respectively. Lamb growth rate increased by 8% and 12% at farms 1 and 2, respectively (Table 7).

In 2001, a total of 120 tons of hay from common vetch/barley mixture were produced in Ain Talawi community and stored for use during feed shortages, especially during the drought period.

Table 7. Effect of using vetch hay as supplementary feed during hand-feeding period.

	Farm 1		Farm 2	
	Farmer practice	Vetch hay	Farmer practice	Vetch hay
No. of ewes	20	20	20	20
Days on test	47	47	70	70
Initial ewes wt (kg)	35.00	35.00	41.19	42.03
Final ewes wt (kg)	38.68	39.10	37.00	37.14
Ewe wt changes (kg)	3.68	4.00		
Initial lambs wt (kg)	7.93	7.10	3.73	3.54
Final lambs wt (kg)	13.35	14.43	16.92	17.18
Lambs growth rate (g/d)	115	155	178	194
Ewes milk yield (g/d)	480	520	900	1410
Supplement intake (g/ewe/day)				
- Barley grain	500	350	-	-
- Wheat bran	-	-	500	350
- Vetch hay	-	150	-	150
Total intake	500	500	500	500

In Jordan, the Mashreq/Maghreb project conducted extensive demonstrations on common vetch and on common vetch/barley mixture in targeted communities throughout the country. The objective was to study the performance of common vetch crop grown alone or in mixture with barley as an alternative to follow-barley rotations. Promising results were obtained. At Ramtha, 100 sheep grazed a pure stand of common vetch for 23 days, with an average live weight gain of 135 g/head/day. Growing cereal-common vetch mixtures also proved suitable for haymaking. The area planted to vetch is increasing. The area cultivated with vetch was 1668 hectares in 1997 with a total production of 2892 tons.

In Lebanon, collaborating farmers in the Mashreq/Maghreb project are introducing vetch, but are adapting the technology to fit their production systems. At Deir El Ahmar and the surrounding communities, farmers opted for the barley/vetch mixtures. The potential of the mixtures was demonstrated as a total of 4400 kg of hay was produced per hectare, at a price of 120$/ton. The potential for further technology transfer of hay making in this community as well as in the surrounding communities is high; in addition to producing highly nutritious feed for its own animals, farmers have the opportunity to gain additional income by selling hay to other farmers in or outside the region. In Aarsal, fruits trees (cherries and apricots) are a dominant component of the production systems as they occupy

75% of the arable land. As livestock is a main source of income in the region, farmers developed a win/win option where vetch is grown between rows of fruits trees. Growing more than one crop on the same land gives a higher output than a single crop, and is therefore particularly beneficial in the dry areas where farm sizes are generally small. Intercropping vetch under fruit trees in Aarsal is being adopted by an increasing number of farmers.

In Syria, decision-makers decided to increase the area planted to vetch. As a result of the success of common vetch in El Bab District, the Ministry of Agriculture and Agrarian Reform in Syria decided to increase the area planted to vetch in their 2000/2001 plans. Efforts were made to scale up the vetch/cereal rotation in Syria and encouraging results were obtained in Hama province. Sheep grazing vetch gained 200-240 g/head/day, comparable to sheep fed on concentrate. Most farmers, who used vetch for grazing (Fig. 4), expressed acceptance and belief in the need to secure the necessary green fodder for their sheep and introduce this technique that eliminates the need for them to move with their sheep to distant places looking for fodder, especially during drought seasons. The obvious increase in demand for vetch seed is a clear indicator of a successful technology.

In the Barani area of Pakistan, farmers generally grow Desi sorghum, which is monotiller and monocut, has short vegetative period and gives low fodder yield. To improve fodder production, efforts were devoted to the introduction of improved sorghum varieties, and Sudan grass and pearl millet. Both Sudan grass and pearl millet have longer vegetative period and are multi-tiller, multi-cut, and produce higher fodder yield. The new sorghum variety JS-263, pearl millet MB-87, and Sudan grass was compared with to local sorgum at three different farms at Hafizabad (Jabbi dam). The experiments were planted in a plot size of 3-5 kanals/farmer in January 2001 (20 kanals = 1ha). Fertilizer was used at the rate of 32-23 NP kg/acre, seed rate was 10-15 kg/acre for Sudan grass, 3-4 kg/acre for pearl millet and 25-30 kg/acre for sorghum. Compared with the local sorghum, the improved sorghum variety, Sudan grass and pearl millet MB-87 had higher plant, more leaves/tiller, and bigger leaf area (Table 8). The improved variety of sorghum, Sudan grass and pearl millet gave significantly higher green fodder yield than the local desi sorghum with all the three farmers fields (Table 9). The results are encouraging suggesting that improved varieties of sorghum, pearl millet and Sudan grass will greatly increase the fodder production in rainfed areas.

Table 8. Performance of the local sorghum variety, the improved sorghum variety, Sudan grass and pearl millet MB-87 at three farmers fields.

Crop	Muhammad Altaf			Muhammad Nawaz			Muuammad Mushtaq		
	Plant height (cm)	Leaves/ tiller (No).	Leaf area (cm^2)	Plant height (cm)	Leaves/ tilller (No).	Leaf area (Sq cm)	Plant height (cm)	Leaves/ tiller (No).	Leaf area (cm^2)
Sorghum JS-263	262	17	483	216	16	395	190	13	306
Sudan grass	232	12	386	318	17	380	187	12	266
Pearl Millet MB-87	230	12	367	270	13	380	195	11	292
Sorghum (Local).	189	11	277	207	12	296	297	9	206

Table 9. Green fodder yield of of the local sorghum variety, the improved sorghum variety, Sudan grass and pearl millet MB-87 at three farmers fields.

Crop	Green fodder yield (Maunds/acre)			
	Muhammad Altaf	Muhammad Nawaz	Muhammad Mushtaq	Average
Sudan grass	560	490	322	457
Pearl Millet MB-87	495	385	290	390
Sorghum JS 263	520	485	340	448
Sorghum (Local)	268	235	222	241

One hectare = 2.47 acres One maund = 40kg

Output 2: Forage and Pasture Seed Production Technologies Developed for Small Farmers

Activity 2.1 Develop and On-Farm Testing of Machinery to Feasibly Introduce Pasture and Forage Legumes into Productive Farming Systems

The research on vetch harvest mechanization in El Bab district, northwest Syria, has been successfully completed and transferred to NARS. Investigations started in 1990-91 when farmers in the El Bab area, who have worked with ICARDA for several years on-farm trial comparing cereal/vetch rotations with continuous barley, have said that harvest mechanization is the main impediment to expansion of vetch cultivation. Hand harvesting is possible, but it is uneconomic in the area. Farmers wanted a way of harvesting mechanically.

An experiment was first set on farmers' fields. Plots sufficiently large to demonstrate the harvest techniques were fertilized with 40 kg/ha P_2O_5, and vetch was drilled at a 150 kg/ha seed rate. The following treatments were compared: 1. Rolled, combine harvested; 2. Non-rolled preparation, combine harvested; 3. Rolled, mower, stationary thresher; 4. Non-rolled, mower, stationary thresher; and 5. Non-rolled, hand harvested, stationary thresher.

Results show that none of the mechanized techniques can match the efficiency of hand harvesting. The combine performed better than the mower and rolling improved the dry matter recovery for both techniques. The crude protein (CP) and *in vitro* digestible organic matter (DOM) were similar for vetch harvested with several techniques (Table 10). A small difference in DOM was found in vetch residue remaining on the ground after harvest, suggesting that the main difference among the treatments was the amount of material recovered rather than any differences in the composition of what was recovered. Sometimes, the residue was slightly higher in quality than the whole plant prior to harvest, possibly due to leaf drop. The biggest drop in DOM and CP was attributed to stage of harvest; however, the decline in quality between full flowering and harvest was greater than actual because seeds were removed from the pods and pod walls returned to the sample so as to compare losses in tissue quality between harvest time and after threshing. Losses of 5-7 units DOM and up to 3 percentage units of CP were found.

Farmers were satisfied with the performance of both the combine and of the mower. But they considered the use of the mower a more realistic possibility than making special headers for combines. The mower can be also used for haymaking.

Based on these results, ICARDA introduced a roller and a mower and started collaborating with farmers to demonstrate the possibility of achieving high vetch seed and straw harvest efficiency with proper land preparation, crop management and harvest mechanization. The availability of the rollers and mowers added to farmers' growing enthusiasm about vetch. More significantly, farmers start investing in machinery to produce vetch seed. As mechanical harvesting significantly increase the profitability of the vetch technology, more farmers are introducing vetch into their cropping systems.

A meeting was held to transfer the technology to NARS. Farmers, extension agents from El Bab and Aleppo, representatives from Farmers' Association and the Agricultural Bank, and representative from the Syrian Research Directorate discussed ways and means of scaling-up the cereal/vetch rotation technology, including manufacturing of mowers and the need for loans/credit for farmers to purchase them. As a direct impact of this long-term investigation in the El Bab district, northwest Syria, and because mechanization of seed production made vetch more attractive to farmers, the Ministry of Agriculture and Agrarian Reform in Syria decided to increase the area planted to vetch in the 2000/2001 plans.

Table 10. Vetch quality when harvested by hand or with machines, at several stages in the harvest process.

	Full flower	Before harvest [1]	Field residue	Threshed straw
	Digestible Organic Matter			
Treatment	%			
Hand harvest	59.4	50.1	52.4 ab2	42.7
Combine, rolled	59.9	52.4	51.9 ab	45.5
Combine, unrolled	59.1	52.0	51.5 ab	44.9
Mower, rolled	59.0	-	52.6 a	45.1
Mower, unrolled	59.2	-	50.1 b	44.3
	ns	ns		ns
	Crude Protein			
Treatment	%			
Hand harvest	14.1	8.1	8.4	6.9
Combine, rolled	14.5	8.1	8.8	7.0
Combine, unrolled	14.0	7.9	8.6	7.2
Mower, rolled	14.4	-	8.9	7.4
Mower, unrolled	14.8	-	8.3	7.1
	ns	ns	ns	ns

[1] Seeds were separated from pods and pod walls returned to samples for laboratory tests of forage quality.

[2] Means within a column followed by the same letter are not different ($P<0.05$).

Activity 2.2 Establish locally adapted forage seed multiplication nurseries with NGOs, NARS and communities

Research to establish locally adapted forage seed multiplication nurseries with NARS and communities is continuing. Emphasis is put on the development of an informal seed production in Central Asia where seed supply emerges as a main constraint to the promotion of fodder production. ICARDA and NARS are developing a strategy to supply forage and range seeds on a sustainable basis to farmers.

In Kazakhstan, nurseries were established in the on-farm network and in the Research Station of the Kazakh Karakul Sheep Research Institute, Chimkent, to provide project's farmers a sustainable source of seed production. A total of 350 kg of seeds of range plants were collected in October 2000. The stock of seeds collected included 150 kg of *Haloxylon*, 50 kg *Kochia*, 50 kg of *Eurotia*, 70 kg of *Calligonum*, 10 kg of *Salsola* and 20 kg of *Aellinia*. From the total collected in Year 1, 100 kg were used to plant 10 ha in a degraded area of the Institute's research station (Kysilkum area) and 250 kg to plant 20 ha in sandy soils in Kekilbaev farm. *Kochia* was used in clay sierozem soil and *Calligonum* and *Haloxylon* on sandy loam soils.

In Kyrgyzstan, a nursery was established in Panfilov and Kokjar in 17 ha of mixed grasses including alfalfa + bromus + dactylis, under barley as cover crop. The nursery also included pure stands of alfalfa (0.2 ha), sainfoin (0.2 ha), bromus (0.2ha), dactylis (0.2 ha) and Agropyrum (0.2 ha).

In Uzbekistan, ICARDA and the Karakul Research Institute are developing a strategy to supply these seeds to farmers for the rehabilitation of degraded land on a sustainable basis. In Nurata Experimental Station, seeds of *Haloxylon, Salsola, Ceratoides, Astragalus, Kochia, Halothamnus and Agropyron* were sown in 12 ha. The species, area sown and seed yield are included in Table 11.

Table 11. Species, areas planted, and seed production at Nurata Experimental Station in 2000.

Species	Area (ha)	Seeds collected (kg)	Seeds yield (kg/ha)
Haloxylon aphyllum	5.2	220	42.3
Salsola orientalis	1.1	86	78.2
Halothamnus subaphyllus	1.9	150	78.9
Ceratoides eversmanniana	2.2	74	33.6
Kochia prostrata	1.2	60	50.0
Astragalus agameticus	0.1	5	50.0
Agropyron desertorum	0.3	5	16.7
Total	12.0	586	48.8

In autumn (November 2000), new seed nurseries were again established in Nurata including *Halothamnus subaphyllus* (0.6 ha), *Ceratoides eversmanniana* (0.5 ha), *Kochia prostrata* (0.4 ha), *Salsola paletzciana* (0.3 ha), and *Salsola lanata* (0.4 ha). Growth and development measurements obtained in 2001 are provided in Table 12. Additional seed traits for species with high improvement value in range rehabilitation are presented in Table 13.

Table 12. Growth of the new stands of range species established in 2001 in Nurata Experimental Station.

Plants	Plant /ha	Survival rate %	Height of plants, cm
Haloxylon aphyllum	1200	50	16,4
Salsola orientalis	57000	84	14,0
Halothamnus subaphyllus	5000	86	28,9
Climacoptera lanata	3000	60	12,5
Kochia prostrata	1000	59	8,6
Salsola paletzciana	400	70	13,4

Table 13. Seed traits of range shrubs produced in Nurata Experimental Station.

Plants	Plant height, cm	Seed number per shrub	1000 seeds, weight, g	Seed yield kg/ha
Halothamnus subaphyllus	64.1±1.9	1,556±35.4	14.5±0.3	92.5±3.4
Ceratoides eversmanniana	61.7±2.2	4,592±76.8	2.5±0.1	55.2±2.0
Kochia prostrata	58.9±2.4	6,758±85.6	2.3±0.1	121.2±4.5
Salsola orientalis	44.3±1.5	6,636±72.3	7.4±0.4	215.6±7.6

In Boykozon, the production of seeds of forage crop for main and intermediate crops was conducted. The area sown and seed yields are presented in Table 14. The amount of seed produced fully met the needs of the farm in the basic and intermediate crops. Alfalfa seed was sown in wide rows under barley.

Table 14. Production of seeds of fodder crops in Boykozon farm in 2001.

Crop	Variety, hybrid	Year of sowing	Area, ha	Seed yield, tons
Triticale	Silvery PRAG	2000	1.0	3.5
Fodder pea *(in mix with barley)*	Vostok 55	2000	1.0	3.5
Oat	Broad-leaved Uzbek variety	2001	1.0	2.0
Brassica (Perco)	Local	2001	0.5	0.2
Fodder beet (Mangel)	Uzbek semisugar	2001	0.3	0.2
Maize	Uzbekistan 601 ECB	2001	1.0	2.5
	Uzbekistan 306 AMB	2001	1.0	2.0
Alfalfa	Tashkent 1728	2001	4.0	-

In Pakistan, meetings held with communities at both Hafizabad and Jermot Integrated Research Sites of the Applied Research Component of the Barani Village Development Project clearly indicate that there is a great need for increased seed supply of fodder crops. Also, ICARDA and the Fodder Research Institute, Sargodha started in 2001 a program for the development of an informal fodder seed sector. The Fodder Research Institute, Sargodha in collaboration with communities at the three Integrated Research Sites, will conduct a study and analysis of the fodder seed sector.

The results of the study will be discussed in a workshop involving communities, Seed Corporation and other stakeholders. Experiments will be conducted in the three Integrated Research Sites. In these, farmers' practices will be compared to improved techniques for seed production. Traditional cultivars as well as improved cultivars will be considered. Table 15 lists the species to be included.

Table 15. Fodder species considered for seed production at three sites in Pakistan.

Sites	Rabi Crops[1]		Kharif Crops[2]	
Hafizabad	Traditional	Improved	Traditional	Improved
	Oat	Oat cv. S2000 and PD2LV65	Local maize	Maize cv. AFGOHEE
	Brassica campestris	*Brassica campestri*	Local sorghum	Sorghum cv. JS 2001
			Local millet	Millet cv. Selection from local material
				Sudan grass cv. Green Leaf
				Cowpea cv. Cowpea 2001
Jermot	Oat	Oat cv. S2000 and PD2LV65	Local sorghum	Sorghum cv. JS 2001
	Brassica campestris	*Brassica campestris*	Local millet	Millet cv. selection from local material
Kasilian	Oat	Oat cv. S2000 and PD2LV65	Local guar	Guar cv. BR99
	Brassica campestris	*Brassica campestri*	Local millet	Millet cv. selection from local material

[1]Rabi crops will be sown in October 2001. [2]Kharif crops will be sown in July 2002.

Output 3: Demonstration of Higher and Sustainable System Productivity from Cereal in Rotation with Pasture or Forage Legumes, Compared to Continuous Cereal Cropping or Barley in Rotation with Other Food Legumes, Clean Fallow, Weedy Fallow, or other Crops

Activity 3.1 Conduct Rotation Trials Including Forage and Pasture Species and Assess the Rotation Treatment Effect on Crop Grain and Straw Dry Matter Yields and The Total Nutritive Value of Feeds Produced

Monitoring long-term trends in cropping systems was continued in three benchmark sites: Tel Hadya (northwest Syria), Hemo (northeast Syria) and Terbol (Lebanon). This report highlights barley grain and straw yield results from the Tel Hadya and Terbol experiments.

The experiment at Tel Hadya began in 1985/86. The objective of the study is to compare land-uses common in northwest Syria to potential new cropping systems.

In northwest Syria, pressure on agricultural land is forcing farmers to use non-sustainable cultural practices, such as cereal monoculture. In just ten years, the fallow area in El Bab district decreased from more than 40% to about 10 %. This intensification is associated with cereal yield depression and increased pest pressure. Barley monocropping encourages a seed gall nematode *(Anguina tritici)* locally called Abu Ulaiwi, which devastates barley yields.

Seven rotations are compared: barley/medic (10 ewes/ha), barley/vetch for hay, barley/vetch for seed and straw, barley/vetch for grazing, barley/lentil, barley/fallow, and barley/barley. Plots in the cereal phase were randomly split and then continued as two sub-plots with the same management throughout the trial:

one receiving nitrogen (N) fertilizer and the other half with no N fertilizer. The rotations were randomly allocated within each of the three complete blocks. Both phases of the rotations were present each year. Hence, plots sown to cereal in the first year were in the non-cereal phase in the second year and plots in the non-cereal phase in the first year were sown to cereal in the second year. Plots in the cereal phase were split into two subplots, one receiving N fertilizer, and the other half not receiving N fertilizer. Nitrogen fertilizer was not applied to plots in the non-cereal phase. There were three replicates with treatments being randomly allocated within blocks.

Results from 1994 to 2001 are shown in Table 16. For both levels of Nitrogen fertilization, barley grain yields were significantly higher after vetch than after continuous barley or lentil. There were also differences between rotation in soil nitrogen and organic matter.

Table 16. Barley grain and straw yields Soil nitrogen and organic matter for the different rotations at Tel Hadya, Average 1994-2001.

Rotation	Fertilization N kg/ha	Grain kg/ha	Straw kg/ha	Total Nitrogen ppm	Organic Matter ppm
Barley/Vetch for hay	0	2355	2640	678	1.02
Barley/Vetch for grazing	0	2324	2513	784	1.18
Barley/Medic	0	2286	2559	697	1.06
Barley/Vetch for seed and straw	0	1914	2080	684	1.11
Barley/Fallow	0	1875	1993	713	1.08
Barley/Lentil	0	1610	1596	724	1.08
Barley/Barley	0	859	920	710	1.09
Barley/Vetch for hay	60	3237	4298	753	1.12
Barley/Fallow	60	3086	3967	769	1.21
Barley/Vetch for grazing	60	2911	3852	837	1.29
Barley/Medic	60	2894	3943	748	1.13
Barley/Vetch for seed and straw	60	2790	3558	799	1.21
Barley/Lentil	60	2593	3033	767	1.18
Barley/Barley	60	1873	2410	777	1.20

In semi-arid areas of Lebanon, as in other parts of West Asia and North Africa, continuous barley *(Hordeum vulgare)* cultivation is getting more widely spread due to increasing animal numbers. Since cereal monoculture is known to be unsustainable, there is a need to introduce a better rotation. Under the initiation of the NRMP of ICARDA, a cooperative project to introduce a sustainable rotation to Lebanon was agreed between the American University of Beirut (AUB), Lebanese Agriculture Research Institute (LARI), and ICARDA in 1994.

Under the agreement, a long-term rainfed trial has been planted since 1994 at the Agricultural Research and Educational Center (33° 56´ N, 36°5´ E, 995 masl, 513 mm long-term annual precipitation) of AUB in Lebanon's Bekaa Valley. Four legumes were studied: medics *(Medicago* spp.), lentil *(Lens culinaris)*, bitter vetch *(Vicia ervilia)*, and common vetch *(Vicia sativa)*. Medics were used for green-stage grazing by ewes and their lambs. Seed and straw were harvested from lentil and bitter vetch. Common vetch was used for different purposes: for green-stage grazing by lambs, for hay production, or for seed and straw production. Furthermore, common vetch was grown in mixture with barley for hay production. Thus, there were a total of eight different 2-course (i.e., 2-year) rotations (Table 17).

The experiment was in a randomized complete block design with two replicates. The size of the plots was 0.1 ha (10 m by 100 m) except for barley/medic (100 m by 100 m) and barley/vetch for grazing (25 m by 100 m) rotations. Both phases of each treatment were present each year. Three 1-m2 samples from representative parts of each plot were hand harvested. The whole legume and barley plots were then harvested by hand and machine, respectively.

Rotation with legumes significantly increased barley grain and straw yield (Table 17). Yield of barley monoculture started to decrease from 1997/98. Infestation with wild barley was a main cause for the poor grain yield under continuous barley. Legume yield and income under the different rotations are being analyzed. Preliminary results show that barley/lentil, bitter vetch, or common vetch (for seed) rotations gave much higher incomes than barley monoculture, despite the higher cost for harvesting legumes.

Table 17. Mean barley seed and straw yield (kg/ha) over 6 years (1995/96 to 2000/01) under the different 2-course rotations, in Terbol, Lebanon.

Rotation	Seed yield	Straw yield
Barley/barley	590	2010
Barley/lentil	1010	2900
Barley/bitter vetch	1060	3070
Barley/common vetch for seed	1050	2800
Barley/common vetch for grazing	830	2800
Barley/common vetch for hay	1060	2850
Barley/common vetch + barley for hay	970	2580
Barley/medics	850	2770
L.S.D.	259	552

Activity 3.2 Publish results from rotation trials

A first draft on plant productivity from the long-term trial has been finalized. Contributors: S.K. Yau (AUB), S. Haj-Hassan (LARI), and M. Bounejmate (ICARDA)

Activity 3.3 Conduct Field Days

In our effort to promote sustainable cropping systems in Syria, two field days were organized. On the 3rd of April 2001, a field day was organized at Rabda Village, Hama province. This event was organized as part of ICARDA's efforts to meet the challenges of production system sustainability in dry areas. The specific objective of the field day was to discuss with stakeholders the potential use of vetch as mean to reverse land degradation and to overcome the increasing feed deficit.

The selection of Hama province to promote vetch was based on the vetch technology take off in El Bab District and on a follow-up study undertaken to scale out the vetch/cereal rotation in Syria.. A database established during Phase I of the "Arid Margins of Syria" Project, funded by SDC Switzerland, was used to locate potential area for vetch in the Aleppo and Hama provinces. A sample of six farms in the Hama Province was selected in the identified potential area as verification fields. A total of 37 participants attended the meeting including 18 farmers from six villages. The field day was commenced with an introduction of the agroecological conditions and the production systems in the region. It was followed y a lively discussion about opportunity to introduce forage legumes, and the expected benefits on soil fertility, cereal yield, and livestock production. The field day ended by the visit of the demonstration vetch fields.

The second was held at Barshaya Village in the El Bab area on May 7, 2001. Besides farmers and ICARDA scientists, there were representatives from the Directorate of Agricultural Research in Damuscus and Hama, the Department of Agriculture in El Bab, Al Baath party, and the Farmers' Union. This activity was undertaken in conjunction with others efforts made to scale up the vetch/cereal rotation in Syria. The field day included local farmers from El Bab area who have experience in vetch production technology and use, and new farmers from El Bab and Hama. Mr. Riad Haj Hassan, the extension officer El-Bab, welcomed the participants. He then explained the development of the vetch technology in El Bab Area and highlighted the benefits farmers are getting from introducing vetch cultivation in the farming systems. A lively discussion followed on the potential use of vetch. In particular, farmers with no experience with the vetch technology and those with experience debated about vetch production technology and its effect on soil structure and fertility. The vetch use for animal feeding was also discussed. A field demonstration for vetch mechanical harvest was made. The new farmers from El Bab and Hama expressed their satisfaction and contented that vetch has enormous potential for raising cereal yields and better sheep-feeding. They expressed eagerness to introduce vetch in rotation with cereals.

Output 4: Management Recommendations that Provide the Highest Economic Output at a Minimum Cost from Pasture and Forage Legume Rotation Treatments

Activity 4.1 Assess the Potential Use of Forage and Pasture Crops as Hay, Grazing or Mature Seed and Straw to Suit Land Use and Market Opportunities

The use of vetch in rotation with cereals has enormous potential for raising cereal yields and better sheep feeding. But it has also the advantage of being flexible in use; vetch can be grazed, cut for hay or left until maturity for seed and straw. This is important feature when promoting the vetch technology in the Mashreq countries.

Available biological and economical data clearly show that the rotation barley/vetch grazing is the best bet option,. The rotation provides a higher gross income and avoids the difficulties and expense of harvesting. Also, and because the plants are grazed earlier, when green, vetch leaves more water in the profile for the subsequent cereal. But few farmers adopted the rotation. In Syria, only farmers with large holdings use this option for lamb fattening, and most farmers opted for vetch for seed and straw. In Iraq, the tradition of open grazing (grazing is open to all, even on private land) prevented the adoption of the barley/vetch grazing rotation; haymaking from common vetch proved successful and has become a common practice.

In the Aarsal community in Lebanon, an increasing number of farmers are intercropping vetch under fruit trees. In this region, fruits trees (cherries and apricots) are a dominant component of the production systems as they occupy 75% of the arable land. As livestock is a main source of income in the region, farmers developed a win/win option where vetch is grown between rows of fruits trees. Growing more than one crop on the same land gives a higher output than a single crop, and is therefore particularly beneficial in the dry areas where farm sizes are generally small. At Deir El Ahmar and the surrounding communities in Lebanon, farmers opted for the barley/vetch mixtures for haymaking. In this community as well as in the surrounding communities, and in addition to producing highly nutritious feed, haymaking provides farmers with the opportunity to gain additional income by selling hay to other farmers in or outside the region.

Activity 4.2 Assess the Potential Use of Marginal Water to Irrigate Forage Crops

Investigations on the use of wastewater to produce forage crops are continuing at the Surbolak Integrated Research Site in Kazakhstan. The goal of the study is to valorize the treated wastewater from Almaty city for fodder crop production and to improve the ecological status of the region.

In Turkmenistan, the potential use of drainage water to irrigate range species, alfalfa, and barley was assessed at the Yzgant farm. In a first experiment, several range species (Table 18) were sown on 2.5 ha of salty soil. Density of plants was normal except in the case of annual *Atriplex*, where a high density was recorded. Spring was unusually dry, and humidity was not sufficient to sustain the growth and development of range species. Therefore, irrigation was applied on April 25-30. After this irrigation, the growth increased notably (Table 18). The most intensive growth was recorded in annual *Atriplex (Atriplex heterosperma, Atriplex ornate and Atriplex dimophstida)* and *Suaeda altissima*, which by July 10 were 84 and 65 cm high, respectively. The minimal growth occurred in perennial *Atriplex (Atriplex canescens* and *Atriplex turcomanika)*. Although maximum fodder biomass occurs in autumn, the dry matter production estimated by mid July shows that the technique has potential for the production of halophytes. Halophytes were irrigated twice during the period reported. In another experiment, alfalfa was sown in early March 2001 on 1 ha of irrigated land. Vigorous growth was observed after irrigation. The crop was harvested twice, yielding a total of 4.5 ton. Barley was sown on 6 ha and was irrigated three times during the growing. Harvest occurred on May 25-27. Combined production of grain and hay reached a total of 13.2 ton. Grain production was 2,200 kg/ha. The techniques demonstrated have captured the attention and full interest of participant and non-participant farmers, to whom training was provided during the field visits.

Table 18. Growth characteristics of range species irrigated with drainage water in Yzgant (spring-summer of 2001).

Species	Emergence date	Density, 1000/ha	Average height of plants, cm			Dry matter, kg/ha[1]
			May 16	June 14	July 10	
Climacoptera lanata	End of March	10-12	12.1	28.6	37.5	2,820
Annual *Atriplex*	Second half April	150-170	18.4	52.2	84.1	3,440
Perennial *Atriplex*	Second half of April	2-3	5.8	14.2	21.5	540
Suaeda altissima	First half of April	-	19.7	50.1	65.4	2,590

[1]Estimated by mid July 2001.

In collaboration with the Water Group, an experiment was conducted under controlled conditions at Tel Hadya. The germination of five varieties of *Festuca arundinacea* was assessed under four salinity (EC) levels: (10, 7, 4, and 0.5.), with 24 hours soaking in tap water (EC0.5) and without soaking. Seeds were planted on the 27 June 2001 and germination assessed weekly From 27 June 2001-17 September 2001. None of the varieties germinate at EC10 (Table 19). The variety Bariane showed some tolerance at EC7.

Table 19. Germination (%) of five Festuca arundinacea varieties at 4 level of EC, with and without soaking.

	With 24 hours soaking in tap water (EC, 0.5)				
EC\Varieties	Mylena	Madra	Bariane	Centurion	Lunibelle
10	0.0	0.0	0.0	0.0	0.0
7	0.0	6.6	26.6	0.0	0.0
4	40.0	53.4	53.4	53.4	66.0
0.5	60.0	53.4	86.6	93.4	74.0
	Without soaking				
10	0.0	0.0	0.0	0.0	0.0
7	0.0	6.6	6.6	0.0	0.0
4	66.0	60.0	46.6	20.0	26.0
0.5	80.0	60.0	86.6	86.6	66.0

Activity 4.6 Networking to Exchange Information

The Dryland Pasture, Forage & Range Network
The Network was created in 1991 with the objective of bringing an international focus on the pasture and forage developments in CWANA and to attain a well-coordinated scheme of work among pasture, forage and livestock researchers. The Network is promoting information exchange by the publication of The Dryland Pasture, Forage & Range Network News. A total of 20 issues have been published and distributed worldwide.

The Oat and Vetch Maghreb Network (REMAV) - Réseau Maghrébin de Vesce et d'Avoine
ICARDA initiated the creation of the *Oat and Vetch Maghreb Network (REMAV) - Réseau Maghrébin de Vesce et d'Avoine* in May 1997 in Rabat, Morocco. The second meeting of the Network was held, 13-15 March 2001, Tunis, Tunisia. A total of 11 scientists working on oat and vetch in Algeria, Libya, Morocco and Tunisia attended the meeting. Mr. Mustapha Sinaceur, the FAO Representative in Tunisia, Dr. Fawzi A. Taher, FAO/RNE plant production officer, and high officials from the Ministry of Agriculture attended the opening session.

Increasing feed resources and efficiency of utilization in the Caucasus

Within the context of the *"Increasing feed resources and efficiency of utilization in the Caucasus"* Project the English versions of commodity-oriented feed technologies and their applicability in the changing production circumstances in Armenia, Azerbaijan, and Georgia were finalized. Georgia already published the Georgian version.

Training Workshop on Forage Production in Central Asia

A Training Workshop on Production of Cultivated Forages for Irrigated and Rainfed Areas was held in Bishkek, Kyrgyzstan, 12-16 June, 2001. The workshop was organized within the context of the project on Integrated Feed Livestock Production in Central Asia, funded by the International Fund for Agricultural Development. The main goal of the workshop is to train scientists from Central Asia to improve their skills in research on cultivated forages on the basis of new methodologies and technologies, while enhancing scientific interaction and contacts with other research organizations of the world. An important output of this workshop was the agreement on priority species (Table 20).

Table 20. Priority forage species suggested for Kazakhstan, Kyrgyzstan and Uzbekistan and responsible country (underlined)

Kazakhstan	Kyrgyzstan	Uzbekistan	
Agropyron desertorum (Fisch. Ex Link) Schult.	*Agropyron desertorum* (Fisch. Ex Link) Schult.	*Alhagi pseudo-alhagi*	*Medicago sativa*
Bromus inermis Leyss.	*Bromus inermis* Leyss.	*Avena sativa* L.	*Onobrydis viciifolia* Scop.
Dactylis glomerata L.	*Dactylis glomerata* L.	*Beta vulgaris*	*Pisum sativum* L.
Elymus junceus Fisch.	*Kochia prostrata*	*Brassica napus* L.	*Sorghum vulgare* L.
Festuca arundinacea Schreb.	*Onobrydis viciifolia* Scop.	*Carthamus tinctorius* L.	*Trifolium ambiguum* Bieb.
Kochia prostrata	*Trifolium ambiguum* Bieb.	*Glycine max* (L.) Merr.	Triticale
Medicago sativa L.	*Trifolium repens* L.	*Kochia scoparia* L.	*Vicia sativa* L.
Melilotus alba Desr.	*Vicia sativa* L.		*Zea mays* L
Onobrydis viciifolia Scop.			
Trifolium ambiguum Bieb.			
Triticale			
Vicia sativa L.			

Appendix 1. List of herbaria species from Lebanon

Species	Species
Allium stamineum Boiss.	*Melica cupani* Guss.
Allium truncatum (Feinbr.) Kollmann & D. Zohary	*Poa bulbosa* L.
Anchusa italica Retz.	*Stipa lessingiana* Trin & Rupr.
Anchusa strigosa Banks. & Sol.	*Stipa tortilis* Desf.
Echium sp.	*Leopoldia eburnea* Eig. & Feinbr.
Onosma sp.	*Hyssopus officinalis* L.
Campanula strigosa Banks & Sol.	*Marrubium vulgare* L.
Silene conoidea L.	*Micromeria nervosa* (Desf.) Benth.
Silene italica (L.) Pers.	*Phlomis pungens* Willd.
Achillea aleppica DC.	*Phlomis syriaca* Boiss.
Achillea biebersteinii Afan.	*Salvia palaestina* Benth.
Achillea santolina L.	*Salvia multicaulis* Vahl
Andryala sp.	*Stachys* sp.
Carduncellus eriocephalus Boiss.	*Teucrium montbretii* Benth.
Centaurea pallescens Del.	*Astragalus deinacanthus* Boiss.
Crepis sp.	*Astragalus echinops* Boiss
Crupina crupinastrum (Moris) Vis.	*Astragalus zemeraniensis* Eig.
Crupina sp.	*Cicer* sp.
Echinops gaillardotii Boiss.	*Coronilla scorpioides* (L) Koch
Filago arvensis L.	*Lathyrus inconspicuus* L.
Garhadiolus angulosus Jaub. et Spach	*Lathyrus sativus* L.
Scorzonera schweinfurthii Boiss.	*Lens ervoides* (Brignoli) Grande
Serratula cerinthifolia (Sm.) Boiss.	*Lens orientalis* (Boiss.) Schmalh.
Clypeola lappacea Boiss.	*Lens* sp.
Fibigia clypeata (L.) Medik.	*Lens* sp.
Lobularia libyca (Viv.) *Webb et Berth.*	*Lotus collinus* (Boiss.) Heldr.
Malcolmia crenulata (Dc.) Boiss.	*Lotus palustris* Willd.
Sisymbrium sp.	*Pisum syriacum* (Berg.) Lehm.
Thlaspi perfoliatum L.	*Trigonella* sp.
Pterocephalus involucratus (Sm.) Spreng.	*Vicia peregrina* L.
Euphorbia macroclada Boiss.	*Vicia sativa* L.
Geranium tuberosum L.	*Vicia sativa* L.
Geranium tuberosum L.	*Vicia sativa* L.
Geranium tuberosum L.	*Vicia* sp.
Aegilops sp.	*Vicia* sp.
Avena sterilis L.	*Linum maritimum* L.
Avena sterilis L.	*Rumex conglomeratus* Murr.
Bromus danthoniae Trin.	*Ranunculus macrorhynchus* Boiss.
Bromus rubens L.	*Sanguisorba minor* Scop.
Bromus sterilis L.	*Hyoscyamus* sp.
Bromus sterilis L.	*Coriandrum sativum* L.
Bromus sp.	*Daucus* sp.
Dactylis glomerata L.	*Eryngium creticum* Lam.
Dactylis glomerata L.	*Eryngium glomeratum* Lam.
Dactylis glomerata L.	*Lagoecia cuminoides* L.
Dactylis glomerata L.	*Pimpinella tragium* Vill.
Hordeum bulbosum L.	*Scandix stellata* Banks et Sol.
Hordeum marinum Huds.	*Turgenia latifolia* (L.) Hoffm.
Hordeum marinum Huds.	*Valerianella* sp.
Lolium rigidum Gaudin	*Peganum harmala* L.

Appendix 2. List of herbaria species from Turkey.

Species	Species
Allium truncatum (Fienbr.) Kollmann & D. Zohary	*Vulpia hirtiglumis Boiss.* & Hausskn.
Pistacia sp. -	*Vulpia myuros* (L.) C.C. Gmel.
Rhus coriaria L.	*Vulpia sp.* -
Alkanna strigosa Boiss. & Hohen	*Hypericum triquetrifolium* Turra
Anchusa strigosa Banks & Sol.	*Hypericum sp.* -
Echium sp. -	*Bellevalia flexuosa* Boiss.
Heliotropium hirsutissimum Grauer	*Leopoldia deserticola* (Rech.fil.) Feinbr.
Capparis spinosa L.	*Paronychia palaestina* Eig
Dianthus polycladus Boiss.	*Coridothymus sp.* -
Dianthus strictus Banks et Sol.	*Mentha longifolia* L.
Silene conoidea L.	*Phlomis kurdica* Rech. fil.
Vaccaria pyramidata Medik.	*Salvia multicaulis* Vohl
Velezia sp. -	*Salvia palaestina* Benth.
Noaea mucronata (Forssk.) Aschers.et Schweinf.	*Salvia viridis* L.
Fumana thymifolia (L.) Sp.	*Salvia sp.* -
Fumana sp. -	*Teucrium polium* L.
Helianthemum salicifolium (L.) Mill.	*Thymus syriacus* Boiss.
Helianthemum sessiliflorum (Desf.) Pers.	*Ziziphora capitata* L.
Helianthemum sp1. -	*Astracantha echinus* (Dc.) Podlech
Helianthemum sp2. -	*Astragalus hamosus* L.
Aaronsohnia factorovskyi Warb. & Eig	*Astragalus spinosus* (Forssk.) Muschl.
Achillea biebersteinii Afan.	*Astragalus zemeraniensis* Eig
Anthemis sp. -	*Astragalus sp1.* -
Carduncellus eriocephalus Boiss.	*Astragalus sp2.* -
Carduus pycnocephalus (Jacq.) Boiss.	*Coronilla scorpioides* (L.) Koch
Carlina involucrata Poir.	*Hedysarum coronarium* L.
Carthamus lanatus L.	*Hippocrepis unisiliquosa* L.
Centaurea iberica Trev. ex Spreng.	*Lathyrus sp.* -
Centaurea pallescens Del.	*Lotus collinus* (Boiss.) Heldr.
Centaurea sp1. -	*Lotus tenuis* Waldst. et Kit. ex willd.
Centaurea sp2. -	*Medicago minima* (L.) Bart.
Centaurea sp3. -	*Medicago radiata* L.
Chardinia orientalis (L.) O. Kuntze	*Medicago rigidula var. agrestis* Burnat
Cichorium pumilum Jacq.	*Medicago rigidula var. submitis* (Boiss.) Heyn
Cousinia sp. -	*Melilotus indicus* (L.) All.
Crupina crupinastrum (Moris) Vis.	*Onobrychis aurantiaca* Boiss.
Echinops adenocaulos Boiss.	*Onobrychis caput-galli* (L.) Lam.
Echinops viscosus Dc.	*Onobrychis kotschyana* Fenzl
Filago contracta (Boiss.) Chrtek & Holub	*Onobrychis ptolemaica* (Del.) Dc.
Filago sp. -	*Onobrychis sativa* Lam.
Garhadiolus angulosus Jaub. & spach	*Prosopis farcta* (Banks et Sol.) Macbride
Gundelia tournefortii L.	*Scorpiurus muricatus* L.
Lactuca orientalis (Boiss.) Boiss	*Trifolium campestre* Schreb.
Notobasis syriaca (L.) Cass.	*Trifolium cherleri* L.
Picnomon acarna (L.) Cass.	*Trifolium nigrescens* Viv.
Picris damascena Boiss. & Gaill.	*Trifolium resupinatum* L.
Scorzonera papposa Dc.	*Trifolium scabrum* L.
Scorzonera sp1. -	*Trifolium spumosum* L.
Scorzonera sp2. -	*Trifolium stellatum* L.

Appendix 2 (cont.). List of herbaria species from Turkey.

Species	Species
enecio flavus (Decne.) Sch.Bip.	*Trifolium tomentosum* L.
Serratula cerinthifolia (Sm.) Boiss.	*Trigonella astroites* Fisch. et Mey.
Tragopogon buphthalmoides (DC.) Boiss.	*Trigonella caelesyriaca* Boiss.
Alyssum damascenum Boiss. et Gaill.	*Trigonella filipes* Boiss.
Brassica sp. -	*Trigonella mesopotamica* Hub. - Mor.
Cardaria draba (L.) Desv.	*Trigonella monantha* C. A. Mey.
Hirschfeldia incana (L.) Lagreze-Fossat	*Trigonella monspeliaca* L.
Iberis odorata L.	*Trigonella spicata* Sm.
Iberis sp1. -	*Linum strictum* L.
Iberis sp2. -	*Linum strictum var. spicatum* (Lam. ex Pers.) Pers.
Matthiola longipetala (Vent.) Dc.	*Linum sp.* -
Neslia apiculata Fisch., Mey. et Ave-Lall.	*Alcea setosa* (Boiss.) Alef.
Sinapis arvensis L.	*Jasminum fruticans* L.
Cyperus longus L.	*Orchis sancta* L.
Scirpus holoschoenus L.	*Papaver polytrichum* Boiss. et Ky.
Cephalaria syriaca (L.) Schrad.	*Papaver sp.* -
Scabiosa argentea L.	*Roemeria hybrida* (L.) DC.
Ephedra alata Decne.	*Plantago lanceolata* L.
Andrachne telephioides L.	*Polygala monspeliaca* L.
Chrozophora verbascifolia (Willd.) Ad. Juss.	*Polygonum sp.* -
Euphorbia macroclada Boiss.	*Anagallis arvensis* L.
Euphorbia sp. -	*Androsace maxima* L.
Erodium cicutarium (L.) L Her.	*Androsace sp.* -
Aegilops biuncialis Vis.	*Ceratocephala falcata* (L.) Pers.
Aegilops lorentii Hochst	*Ranunculus millefolius* Banks et Sol.
Aegilops triuncialis L.	*Reseda lutea* L.
Aegilops sp. -	*Amygdalus arabica* Oliv.
Avena fatua L.	*Cerasus microcarpa* (C. A. Mey.) C. Koch
Avena sterilis L.	*Crataegus monogyna* Jacq.
Bromus danthoniae Trin.	*Rubus sanctus* auct.
Bromus hordeaceus L.	*Sanguisorba minor* Scop.
Bromus tectorum L.	*Callipeltis sp.* -
Chrysopogon gryllus (L.) Trin.	*Galium pisiferum* Boiss.
Dactylis glomerata L.	*Rubia sp.* -
Echinaria capitata (L.) Desf.	*Salix sp.* -
Eragrostis diarrhena (Schult.) Steud.	*Anarrhinum forskahlii* (J. F. Gmel.) Cuf.
Eragrostis sp. -	*Orobanche sp.* -
Heteranthelium piliferum (Banks & Sol.) Hochst.	*Parentucellia flaviflora* (Boiss.) Nevski
Hordeum bulbosum L.	*Scrophularia sp.* -
Hordeum spontaneum C. Koch	*Verbascum sp.* -
Imperata cylindrica (L.) Raeuschel	*Tamarix sp.* -
koeleria phleoides (Vill.) Pers.	*Artedia squamata* L.
Lolium loliaceum (Bory & Chaub.) Hand.-Mazz.	*Bifora sp.* -
Lolium rigidum Guadin	*Daucus sp1.* -
Poa bulbosa L.	*Daucus sp2.* -
Psilurus incurvus (Gouan) Schinz & Thell.	*Eryngium glomeratum* Lam.
Rostraria cristata (L.) Tzvelev	*Scandix stellata* Banks et Sol.
Stipa lessingiana Trin & Rupr.	*Torilis leptophylla* (L.) Reichb. f.
Trachynia distachya (L.) Link	*Turgenia latifolia* (L.) Hoffm.
Valerianella vesicaria (L.) Moench	*Turgenia sp.* -

Appendix 3. Species recorded in April 2001 at the North Im-Myal and the Megherat sites in the Khanasser Valley in Syria.

Species	Life form	Palatability & other uses
Allium stamineum	Bulbous, herb	Poisonous
Allium truncatum	Bulbous, herb	Poisonous
Arum sp.	Perennial, herb	Poisonous
Asphodelus microcarpus	Perennial, sub-shrub	Poisonous, medicinal plant
Alkanna strigosa	Perennial, herb	Unpalatable
Arnebia decumbens	Annual, herb	Unpalatable
Echium sp.	Annual, herb	Poisonous
Capparis ovata	Perennial, shrub	Unpalatable, medicinal plant, food
Dianthus strictus	Perennial, herb	Unpalatable, medicinal plant
Holosteum sp.	Annual, herb	Low palatable
Silene coniflora	Annual, herb	Low palatable
Spergula fallax	Annual, herb	
Noaea mucronata	Perennial, sub-shrub	Low palatable, good for camel, for wood, prevent erosion
Salsola spinosa	Perennial, shrub	Good in spring, low in summer
Salsola vermiculata	Perennial, shrub	Excellent palatable, for wood
Helianthemum salicifolium	Annual, herb	Unpalatable
Achillea aleppica	Perennial, herb	Unpalatable
Achillea membranacea	Perennial, sub-shrub	Excellent palatable, medicinal plant
Anthemis cotula	Annual, herb	Unpalatable, medicinal plant
Atractylis cancellata	Annual, herb	Low palatable, good for camel
Carduncellus eriocephalus	Perennial, herb	Low palatable
Carduus pycnocephalus	Annual, herb	Low palatable, good for camel
Centaurea pallescens	Annual, herb	Low palatable, good for camel
Cichorium pumilum	Annual, herb	Good palatable, medicinal plant
Cousinia postiana	Perennial, herb	Low palatable, good for camel
Echinops gaillardotii	Perennial, herb	Low palatable, good for camel
Filago contracta	Annual, herb	Medium palatable, medicinal plant
Filago pyramidata	Annual, herb	Medicinal plant
Gymnarrhena micrantha	Annual, herb	Poisonous
Hedypnois rhagadioloides	Annual, herb	Medium palatable
Koelpinia linearis	Annual, herb	Low palatable
Lactuca orientalis	Perennial, sub-shrub	Low palatable, good for camel, medicinal plant
Matricaria chamomilla	Annual, herb	Low palatable, medicinal plant
Notobasis syriaca	Annual, herb	Low palatable, good for camel
Onopordum heteracanthum	Biennial herb	Low palatable, good for camel
Pallenis spinosa	Annual, herb	
Phagnalon barbeyanum	Perennial, sub-shrub	
Picris damascena	Annual, herb	Poisonous
Rhaponticum pusillum	Perennial, herb	Low palatable, good for camel
Scorzonera papposa	Perennial, herb	High palatable, medicinal plant
Sencecio glaucus	Annual, herb	Poisonous
Alyssum damascenum	Annual, herb	Low palatable
Carrichterra annua	Annual, herb	Good palatable
Eruca sativa	Annual, herb	
Lobularia arabica	Annual, herb	
Lobularia libyca	Annual, herb	
Matthiola longipetala	Annual, herb	Good palatable
Raphanus raphanistrum	Annual, herb	Low palatable
Sinapis arvensis	Annual, herb	Low palatable, medicinal plant
Texiera glastifolia	Annual, herb	Low palatable
Torularia torulosa	Annual, herb	Good palatable
Carex stenophylla	Perennial, herb	Unpalatable

Appendix 3. (Continued). Species recorded in April 2001 at the North Im-Myal and the Megherat sites in the Khanasser Valley in Syria.

Species	Life form	Palatability & other uses
Pterocephalus involucratus	Annual, herb	Low palatable
Scabiosa prophyroneura	Annual, herb	Low palatable
Andrachne telephioides	Perennial, herb	Poisonous
Euphorbia densa	Annual, herb	Poisonous
Euphorbia macroclada	Perennial, sub-shrub	Poisonous, grazing by bee
Erodium cicutarium	Annual, herb	Good palatable
Geranium rotundifolium	Annual, herb	
Aegilops ovata	Annual, herb	Medium palatable
Aegilops sp.	Annual, herb	Medium palatable
Avena sp.	Annual, herb	Excellent palatable
Bromus danthoniae	Annual, herb	High palatable in spring
Bromus tectorum	Annual, herb	High palatable in spring
Dactylis glomerata	Annual, herb	Excellent palatable
Eremopyrum bonaepartis	Annual, herb	Low palatable in mature stage
Hordeum bulbosum	Perennial, herb	Good palatable
Hordeum murinum	Annual, herb	Good palatable in spring
Koeleria phleoides	Annual, herb	Medium palatable in spring
Lolium rigidum	Annual, herb	Good palatable
Lophochloa phleoides	Annual, herb	Medium palatable in spring
Nardurus sp.	Annual, herb	Medium palatable
Poa bulbosa	Perennial, herb	Excellent palatable
Poa sp.	Annual, herb	Excellent palatable
Polypogon monspeliensis	Annual, herb	Low palatable
Schismus barbatus	Annual, herb	Excellent palatable
Stipa barbata	Perennial, herb	Excellent palatable
Stipa sp.	Perennial, herb	Excellent palatable
Trachynia distachya	Annual, herb	High palatable in spring
Hypericum triquetrifolium	Perennial, herb	Poisonous, medicinal plant
Leopoldia eburnea	Perennial, herb	Unpalatable
Muscari racemosum	Perennial, herb	Unpalatable
Ornithogalum narbonense	Perennial, herb	Low palatable
Herniaria hemistemon	Perennial, herb	Unpalatable
Iris pseudacorus	Perennial, herb	Unpalatable
Ixiolirion tataricum	Perennial, herb	Medium palatable
Lamium amplexicaule	Annual, herb	
Phlomis sp.	Perennial, herb	Unpalatable, medicinal plant
Salvia palaestina	Perennial, herb	Unpalatable, medicinal plant
Satureja sp.	Perennial, small shrub	Unpalatable, medicinal plant
Teucrium creticum	Perennial, small shrub	Unpalatable, medicinal plant
Teucrium polium	Perennial, small shrub	Unpalatable, medicinal plant
Thymus syriacus	Perennial, small shrub	Unpalatable, medicinal plant
Ziziphora tenuior	Annual, herb	Unpalatable, medicinal plant
Astracantha echinus	Perennial, shrub	Unpalatable, good for camel
Astragalus asterias	Annual, herb	Good palatable
Astragalus hamosus	Annual, herb	High palatable, medicinal plant
Astragalus spinosus	Perennial, sub-shrub	Unpalatable, good for camel
Astragalus tribuloides.	Annual, herb	High palatable
Astragalus sp.	Perennial, herb	Good palatable
Hippocrepis unisiliquosa	Annual, herb	Medium palatable
Lathyrus sp.	Annual, herb	High palatable
Medicago minima	Annual, herb	Good palatable
Medicago radiata	Annual, herb	Good palatable

Appendix 3. (Continued). Species recorded in April 2001 at the North Im-Myal and the Megherat sites in the Khanasser Valley in Syria.

Species	Life form	Palatability & other uses
Medicago rigidula	Annual, herb	High palatable
Melilotus indica	Annual, herb	High palatable, medicinal plant
Onobrychis aurantiaca	Perennial, herb	High palatable
Onobrychis crista-galli	Annual, herb	Good palatable in spring
Onobrychi ptolemaica	Perennial, herb	Good palatable
Ononis sicula	Annual, herb	Medium palatable
Scorpiurus muricatus	Annual, herb	Excellent palatable
Trifolium tomentosum	Annual, herb	Excellent palatable
Trigonella astroites	Annual, herb	Good palatable
Trigonella monantha	Annual, herb	Good palatable
Trigonella monspeliaca	Annual, herb	High palatable
Trigonell sp.	Annual, herb	Good palatable
Vicia sativa supsp. amphicarpa	Annual, herb	Good palatable
Vicia sp.	Annual, herb	Good palatable
Gagea chlorantha	Perennial, herb	Poisonous
Linum strictum	Annual, herb	Poisonous, medicinal plant
Malva aegyptia	Annual, herb	Good palatable
Fumaria parviflora	Annual, herb	Medium palatable, medicinal plant
Hypecoum procumbens	Annual, herb	Medium palatable
Papaver rhoeas	Annual, herb	Poisonous, medicinal plant
Papaver sp.	Annual, herb	Poisonous
Roemeria hybrida	Annual, herb	Poisonous
Plantago cylindrica	Annual, herb	Good palatable
Plantago psyllium	Annual, herb	Good palatable
Plantago sp.	Annual, herb	Good palatable
Anagallis arvensis	Annual, herb	Poisonous, medicinal plant
Androsace maxima	Annual, herb	Low palatable
Adonis annua	Annual, herb	Poisonous, medicinal plant
Anemone coronaria	Perennial, herb	Unpalatable
Ceratocephala falcata	Annual, herb	Poisonous
Nigella arvensis	Annual, herb	Unpalatable, medicinal plant
Ranunculus asiaticus	Perennial, herb	Poisonous
Ranunculus sp.	Perennial, herb	Unpalatable
Reseda lutea	Biennial, herb	Low palatable
Callipeltis sp.	Annual, herb	
Galium chaetopodum	Annual, herb	Unpalatable
Verbascum sp.	Biennial, small shrub	Unpalatable, medicinal plant
Anethum graveolens	Annual, herb	Unpalatable, medicinal plant
Bupleurum lancifolium	Annual, herb	Low palatable
Caucalis tenella	Annual, herb	
Coriandrum sativum	Annual, herb	Low palatable, medicinal plant
Eryngium creticum	Perennial, herb	Low palatable, medicinal plant
Eryngium glomeratum	Perennial, herb	Low palatable, medicinal plant
Lagoecia cuminoides	Annual, herb	Low palatable, medicinal plant
Pimpinella corymbosa	Perennial, herb	Low palatable, medicinal plant
Torilis leptophylla	Annual, herb	Low palatable
Valerianella vesicaria	Annual, herb	
Valerianella sp.	Annual, herb	
Fagonia indica	Perennial, herb	Low palatable
Peganum harmala	Perennial, sub-shrub	Poisonous in green stage, medicinal plant

Appendix 4. List of seeds of fodder shrubs, grasses and forage legumes sent to NARS in 2001.

Institution	Species	Amount
GAP Project Turkey	*Medicago rigidula sel. 1919, Medicago rotata sel. 2123, Trifolium angustifolium, Trifolium campestre, Trifolium pilulare, Trifolium purpureum, Trifolium tomentosum, Trifolium speciosum*	50 g from each accession
Aleppo University Faculty of Agriculture Syria	*Agropyron cristatum /1, Agropyron fragile /1, Bituminaria bituminosa /1, Colutea istria /1, Coronilla glauca /1, Dactylis glomerata /1, Eragrostis sp. /1, Festuca elatior 20, Lolium sp. 24, Onobrychis aurantiaca /1, Onobrychis sativa /1, Oryzopsis miliacea /1, Melilotus albus /1, Phalaris tuberosa /1, Agropyron cristatum /1, Agropyron fragile /1, Bituminaria bituminosa /1, Colutea istria /1, Coronilla glauca /1, Dactylis glomerata /1, Eragrostis sp. /1, Festuca elatior 20, Lolium sp. 24, Onobrychis aurantiaca /1, Onobrychis sativa /1, Oryzopsis miliacea /1, Melilotus albus /1, Phalaris tuberosa /1*	50 g from each accession
Douma Research Station Germplasm Section Syria	*Atriplex halimus-halimus /8, Atriplex halimus-halimus /4, Atriplex halimus /9, Atriplex lentiformis /1, Atriplex nummularia /2, Atriplex torreyi /1, Atriplex undulata/1, Atriplex polycarpa, Kochia prostrata /2, Bituminaria bituminosa /2 var.bituminosa, Bituminaria bituminosa /1, Phalaris tuberosa /1, Sanguisorba minor /1, Melilotus albus /1, Festuca elatior 52, Dactylis glomerata /1, Coronilla glauca /1, Colutea istria /1, Colutea istria /2*	From 4 to 20 g according to accession
ICARDA-Seed Unit	*Salsola vermiculata*	2000 (fruits)
Nippon International for Community Development in Jordan	*Atriplex canescens /2, Atriplex halimus-halimus /4, Atriplex halimus /2, Atriplex leucoclada /1, Atriplex polycarpa, Atriplex torreyi /1, Atriplex undulata/1, Colutea istria /2, Haloxylon persicum /1*	10 g from each accession
Amman university Faculty of Agriculture Jordan	*Medicago noeana SA 15485, Medicago rigidula sel. 1919, Medicago rotata sel. 2123, Trifolium campestre, Trifolium lappaceum, Trifolium pilulare, Trifolium purpureum, Trifolium resupinatum, Trifolium speciosum, Trifolium tomentosum*	300 to 1500 g *according to accession*
University of Qatar Agriculture Science Unit, Doha Qatar	*Atriplex canescens /2, Atriplex halimus /1, Atriplex halimus-halimus /8, Atriplex lentiformis /1, Atriplex leucoclada /1, Atriplex nummularia /2, Atriplex torreyi /1, Atriplex undulata/1*	50 g from each accession
United States Dept. of Agriculture,Weed Science Research Unit USA	*Salsola orientalis*	500 fruits

Appendix 5. Publications in 2001

Bounejmate, M. et El M. Mourid (eds.). 2001. Gestion Durable des Ressources Agropastorales. Compte rendu de l'atelier régional, 20-22 février 2001, Oujda, Maroc. ICARDA, Alep, Syrie. iv + 217 pp.

Bounejmate, M.B. E. Norton and A. Bruggeman. 2001. Changes Suffered by the Mediterranean Rangelands in the Recent Past: ICARDA's Experience. Paper prepared for the "Mediterranean Regional Network for Research in Global Change (RICAMARE)" ICARDA, Aleppo, Syria.

Norton, B.E., M. Bounejmate and F. Ghassali. 2001. Reviving Over-Grazed Rangeland And Degraded Cropland: ICARDA's Experience. Pages 303-312 in Proceedings of the Workshop on " Vegetation Recovery in Degraded Land Areas", 27 October - 3 November 2001, Kalgoorlie, Western Australia. Promaco Conventions Pty Ltd, Western Australia.

Erkan, O., S.P.S, Beniwal, J. Ryan and M. Bounejmate. 2001. Sustainable Development of Small-Scale Farmers of the Taurus Mountains of Turkey. Integrated Natural Resource Management, Technical Research Report Series No. 1. ICARDA, Aleppo, Syria. vii+100 pp.

Bounejmate, M., M. El Mourid and B.E. Norton. 2001. Partnership for understanding land use/cover change, reviving overgrazed rangeland and degraded cropland in North Africa: ICARDA's Experience. Paper presented at participated the meeting for launching of a regional Thematic Network Programme (TPN3) for the promotion of rational use of rangelands and development of fodder crops in the context of the Regional Action Programme (RAP) to combat desertification in Africa. Maseru, Lesotho, 27-29 November 2001. (Paper distributed)

Bounejmate, M., M. El Mourid and B.E. Norton. 2001. Technologies for the improvement and management of rangelands in dry areas of West Asia. Paper presented at the Third Regional Technical and Planning and the Third Regional Steering Committee meetings of the GEF-UNDP Dryland Agrobiodiversity Project, 11-13 October 2001, Lattakia, Syria. (Paper given to Dr. Amri)

Dryland Forage, Pasture and Range Network News. 2001. No. 20, En, 30 pp.

ICARDA. 2001. Native shrubs hold back the desert. ICARDA leaflet. ICARDA, Aleppo, Syria. (In collaboration with CODIS)

Susie Emmett, a freelance report for England has written an article about our work in reviving pasture in the drylands in the Internet magazine "New Agriculturist".

Bounejmate, M., A. Herzenni, H. Mahyou and A. Bechchari. 2001.Rehabilitating Rangeland of Northeastern Morocco: A Concern for All. ICARDA CARAVAN 15: SPECIAL AFRICA. ICARDA Aleppo, Syria.

Appendix 6. Trainees and visitors to the Forage and Pasture and Rangeland Projects (NRMP) in 2001

Date and period	Names	Institute/Country	Subject
January 31	President (Satoyo Ono) Professor emeritus (Osamu Ono)	NICCO (Japan) Spelt NICCOD for Arab countries	Visit: Rangeland germplasm,
February 5-8	Mr. Mahmoud Aiady Mr. Nabil Beni Hane Mr. Yahya Nasr	NCARTT, Al Ramtha Station, Barley Center (Jordan)	Visit: Rangeland germplasm & Herbarium
March 16-22	Dr. Fatma Hndan Giray Ms. Inci Avsar, Mr. Taner Soylemez, Mr. Mehmet Yildirir, Ms. Subel Almasulu, Mr. Ramazan Yaman, Mr. Osman Cevik, Mr. Ali Askar Ekici, Mr. Mehmet Ozuberk, Mr. Nevzat Kara	GAP, Urfa, Turkey	Training: Forage, Pasture, Range and Livestock Production
April 1-5	Mr. Mohsen Nahas, Mr. Amjad Najar, Mr. Faisal Humeidi, Mr. Abdullah Fadeli, Mr. Ahmed Da'as, Mr. Gassan Al-Abdullah, Mr. Waed Ibrahim, Mr. Housein Sallan	Different Directorates of Syrian Steppe	Training: GIS data base tools and utilization of geographi-cal positioning System (GPS)
April 3	9 Participants	Lebanon, Egypt, Syria Jordan and Palestinian Authority	Visit: range germplasm
April 4	Mr. Abdel Elah Etter and 60 Students	Steppe and Desertification Institute	Visit: Rangeland germplasm
April 29-May 3	Dr. Shakroon	Tunisia	Visit: Rangeland germplasm Rotation trial
May 1-3	Dr. Jack Anderson	World Bank	Visit: Rangeland germplasm
May 17	Group	GEF Project	Visit: Rangeland germplasm
May 22	Dr. Dana Bernies	USDA- Agriculture Research Service, Foreign Disease Science, Res. unit	Visit: Rangeland germplasm and Herbarium
May 27	Students	Forest Institute of Lattakia	Visit: Herbarium
July 2-3	Dr. Mohamed Khatib with Student	Faculty of Agriculture, University of Aleppo	Visit: Identification 50 speci-mens from Nabk project
July 7-8	Mr. Adel Nassar	ICARDA, Terbol Station	Visit: Identification of 33 medi cinal plant specimens for the biodiversity project in Lebanon
July 22-Aug. 2	Mr. Basem Al -Samman	Douma Research Center, Damascus	Training: Taxonomy of forage and rangeland species
August 27	Mr. Nobuo Nakanishi, Mrs. Kumiko Nakanishi Mr. Majdy Mohammad	Nippon International Cooperation for Community Development (NICCO) Amman, Jordan	Visit: Rangeland Herbarium and Rangeland germplasm
September 8	Prof. Armin Rieser Prof. Mathias Becker Dr. Wilko Schweers Mr. Alois Klewinghaus	Bonn University BMZ Project BMZ Project Germany	Visit: Khanasser Project
September 12	Delegation of 3 Prof.	Cukurova University, Adana, Turkey	Visit Rangeland Herbarium and GIS rangeland
September 27	Delegation	Ministry of Agriculture and Agrarian Reform, Syria	Visit rotation trial, rangeland germplasm and herbarium
October 18-20	Dr. El Houcine El Mazouri Dr. Khalel and Mr. Yahya Nasr Dr. Mohamed Khatib	Morocco Jordan Aleppo University	Visit: Range germplasm, intercropping Barley/Atriplex in Odami
December 9-13	Mahmoud Salem Houssein Angele Korkice Aichou	Hemo research station DSAR, Syria	Training: data analysis of the long-term trial in Hemo
10 Jan.-28 Feb:	Ms. Estelle Papi	Switzerland	Training: range socioeconomic
1 Jan.-31 Dec.	Mr Abdallah Al Yussef	Aleppo University	Training: PhD student

Appendix 7. Staff list

1. ICARDA staff

Mustapha Bounejmate: P
Main duties: Project Manager; Forage production; Biodiversity; Long-term trial; Coordinate the production of the *Dryland Pasture, Forage and Range Network News.*

Amin Khatib Salkini: NPO
Main duties: Identification of plant species; Contribute to maintenance of plant specimen database; Establish nurseries to produce seed and seedlings of plant species as requested by different research programs.

Mohamed Bader Idlebi: GS
Duties: Design machinery for cultivation, handling and seed production of forage, pasture and range species; maintain available machinery in good working conditions.

Adel Nasser: GS
Main duties: Make contacts with Program Counterparts in Lebanon; Coordinate with AUB the management of the joint rotation trial; establish nurseries to produce seed and seedlings of range and pasture species as request by different research programs at ICARDA and for development projects in Lebanon.

Rafik Makboul: GS
Main duties: Manage ICARDA long-term rotation trials.

2. Students:

Mr Abdallah Al Yussef:
Main duties: prepare a PhD thesis at the University of Aleppo on Effect of Forage Legumes in Rainfed Farming Systems of the Northeastern Region of Syria". The supervisors are Drs Hassan Ghazal and Faisal Maya (Aleppo University), and Dr Mustapha Bounejmate (ICARDA).

3. Main collaborators

- Pasture/forage rotation trials with cereals: AUB/LARI, Lebanon; SMAAR, Syria, Aleppo university.
- Forage and pasture management: NARS of Algeria, Egypt, Iraq, Jordan, Lebanon, Libya, Morocco, Pakistan, Syria, Tunisia, Turkey and Central Asia; USDA-ARS; GL-CRSP; INIA, Spain.

- Germplasm: INIA Spain; the Vavilov Institute of St Petersburg (VIR), the Australian Center for International Agricultural Research (ACIAR), the Co-operative Research Centre for Legumes in Mediterranean Agriculture (CLIMA, Australia); The "Integrated Feed and Livestock Production in the Steppes of Central Asia" Project.
- Pasture rehabilitation and vetch in Turkey: GAP 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.

PROJECT 2.4 REHABILITATION AND IMPROVED MANAGEMENT OF NATIVE PASTURES AND RANGELANDS IN DRY AREAS

Project rationale

Small ruminant flocks in the CWANA region are used for subsistence, income generation and risk mitigation, especially drought survival. Many pastoral and agropastoral households are already subject to poverty stress and threatened with further loss of viability due to degradation of the resources on which their livestock depend. Feed resources vary spatially and temporally, and herders manage their flocks accordingly. Rangelands in the semi-arid zone and uncultivable marginal lands in the rainfed-cropping zone supply critical low-cost forage outside the spring growing season or when cereal-crop stubbles are not available. Rangelands also provide households with fuel derived from shrubs that are harvested in significant numbers. Rangeland vegetation covers such vast land areas in CWANA that reversing degradation and increasing range plant biomass can contribute to global welfare via enhanced carbon sequestration. The goal of project 2.4 is to alleviate poverty through productivity improvements integrated with sustainable natural resource management, with an emphasis on rehabilitation of natural pastures and rangelands and on the sustainable exploitation of barley fields for livestock grazing in the marginal zone.

Project objectives

The general objective is to improve the productivity of rangeland and marginal-land resources, and to develop management practices that sustain high levels of production in dry areas in spite of the uncertain rainfall. Rehabilitation and management measures should increase the supplies of fuel-wood and livestock feeds in a cost-effective and socially acceptable manner.

Specific objectives and outputs are:

- to develop management plans for rangelands;
- to develop low-cost techniques for land rehabilitation;
- to make an inventory of useful plant and vegetation resources; and
- to assess methods for introducing fodder shrubs into rangelands.

A synopsis of progress and accomplishment for particular activities listed under these outputs in the Medium Term Plan for 2001 is given in the Appendix. This annual report highlights two activities that are nearing completion, and that will generate papers for peer-review publication in the coming year 2002. An important development during the latter part of 2001 was an evaluation of the range management program at ICARDA by the new Range Management Scientist who was appointed in June 2001. New directions and emphases that emerged from this review will influence the objectives of project 2.4 in the future. A précis of this assessment and new directions for the project precedes the two research reports.

Future directions for the range management project

Past research in range management at ICARDA has emphasized range resource ecology, range rehabilitation technologies, range resource improvement for sheep grazing, and on-farm trials of barley intercropping between forage-shrub hedgerows (some results presented below). There has been relatively little direct interaction with the Syrian government agency responsible for management of rangelands, the Directorate for Steppe and Sheep in the Ministry of Agriculture and Agrarian Reform. Nor has there been significant interaction with the large donor-funded Badia development project. Two grazing studies, one testing the benefit of phosphate fertilization on marginal land on Tel Hadya station and the other measuring vegetation and livestock responses to reseeding rangeland with forage shrubs (conducted on 100 ha of Maragha Protected Area), applied year-long sheep grazing to the resource-rehabilitation treatments. Promising improvements emerged from trials of short-term resting of marginal lands conducted near ICARDA's Terbol station in Lebanon, but the practice could not be extended to a practical scale due to resistance from the local community.

Future research in the NRMP range program will take a management-oriented approach, become more engaged with the Syrian Steppe Directorate and NARS in the region, and address livestock grazing practices that allow maintenance or improvement in ecological condition. A consistent feature of the production systems in Syria and elsewhere in CWANA is that livestock exploit a variety of feed resources that include crop residues and barley grain and straw, as well different parts of the rangeland landscape, depending on season and rainfall. Year-round grazing within a relatively small area is not normal practice. Therefore, in order to maximize the value of research to livestock producers, grazing studies should explore strategies compatible with the existing local production systems.

Syria does not yet have a group of range scientists assigned to support the range management program of the Steppe Directorate. The ICARDA range team can partially fill this niche, and at the same time help Syria establish a unit for range research within the new Directorate for Agricultural Research. About 60% of Syria may be classified as rangeland, most of it lying below the 200 mm isohyet where barley farming has been prohibited. The Steppe Directorate focuses its management efforts on Protected Areas that now comprise several hundred thousand hectares altogether. Protected Areas are improved by the planting or direct seeding of forage shrubs, mainly *Atriplex halimus* and *Salsola vermiculata*.

Livestock grazing in Protected Areas is by permit, and restricted by the Directorate to two months in autumn and two months in spring. The ICARDA range program, in collaboration with the Steppe Directorate, could gather data for evaluating the use of Protected Areas and suggest appropriate management improvements. Another target identified for range research in the Syrian steppe is the rehabilitation of low-lying areas that used to be cultivated for barley. These high-potential sites occupy a small fraction of the landscape but they have deeper and more fertile soil than the upland zone and receive rainfall amendments in the form of run-off from higher ground. These features make the low-lying areas suitable for the establishment of perennial vegetation comprising a mix of perennial grasses, forbs and shrubs (and perhaps some trees such as *Haloxylon* species) that could serve as a livestock feed resource similar to the role of barley, but with greater reliability and seasonal prolongation of forage production. Perennial vegetation will enhance soil organic matter, increase infiltration, improve biodiversity, and reduce the wind and water erosion to which the low-lying areas had been highly susceptible when under barley cultivation, and to which they remain still vulnerable.

Within the CWANA region, the ICARDA range program will pursue two activities in general. With the exception of a few countries in North Africa and West Asia, there is an obvious deficiency among NARS personnel in knowledge of modern range vegetation field methods and range management concepts, especially regarding their application to CWANA ecosystems and to appropriate grazing management research. Strengthening the ability of NARS to conduct range research will be addressed through training and workshops, with the goal in 2002 of developing a set of training modules that could be offered to scientists in the region on a regular basis. The second activity concerns the process for identification of research questions. There is a natural tendency, evident in developed Western countries as well as CWANA, for scientists to derive their research objectives from the work they did for a post-graduate degree, or from the research to which they were exposed while at university, or to find them in books and research publications on the shelf. The consequence is that range research studies are often conceived without reference to the local livestock production system, and may be of little value or irrelevant to that system. In order to solve this problem, the range project will link up with the small ruminant, forage and socioeconomic projects to help NARS carry out diagnostic surveys and develop monitoring protocols to describe critical elements in the production systems. Such characterizations will elucidate the principal constraints to alleviating poverty among rural households, and thereby generate researchable questions that are consistent with ICARDA's mandate within the region.

Intercropping barley between forage-shrub hedgerows

Livestock in North Africa and West Asia are managed in an agropastoral production system that involves seasonal movement between semi-arid rangelands and farmland areas with higher rainfall. The usual annual feed budget for small ruminants consists of rangeland forage in the winter and early-spring rainy season, natural pastures on uncultivable marginal areas in spring, cereal crop residues in summer, and barley grain and straw in late summer and autumn into early winter. Barley is grown in the marginal zone at around 200-250 mm mean annual rainfall, with less than one third probability of a good grain harvest and a similar likelihood of crop failure yielding virtually no grain and little straw for grazing. Under such levels of uncertainty, the rational strategy is to plant every year so as not to miss the occasional high-rainfall growing season. Continuous cropping on poor soils of the marginal zone leads to soil nutrient exhaustion and erosion, especially wind erosion in late summer and autumn.

In the past, farmers have compensated for soil-fertility depletion by expanding into rangelands, taking the best land from the available grazing resources, which are usually common-property resources, and conferring *de facto* private ownership through cultivation. The landscape as a whole experiences a decline in productivity and biodiversity. Syria is trying to halt this downward spiral of degradation through a policy that prohibits cultivation below the 200 mm isohyet and implicitly encourages landowners in the marginal cropping zone to adopt more sustainable farming practices.

One way in which ICARDA is addressing the issue of sustainability of the barley-livestock production system is to test alley cropping of barley between hedgerows of a forage shrub native to West Asia and North Africa, *Atriplex halimus.* Alley cropping 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. The ICARDA 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 2 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. The combination of native forage shrub and a cereal crop restores an element of "rangeland" to sites whose ecological integrity may have been better served if they had been left in their original rangeland state.

Preliminary results of mean values presented in Table 1 show that yield of both barley grain and straw is enhanced in the intercropped alleys, and this higher yield compensates almost exactly for the reduction in cropping area. Average total barley yield was 1117.3 kg/ha on the control fields, and 1116.5 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 30.6% biomass to the yield from barley in the intercropped field. The hypothesis that barley production is depressed when plants are growing close to the shrubs will be tested during the 2002 data-collection season. Visual observation would indicate that there is no competition between the shrub plants and the barley.

Table 1. Production of barley and shrub foliage (kg/ha) and rate of sheep liveweight gain (g/head/day) on pure barley fields compared to fields with hedgerows of *Atriplex halimus* (means of 6 trials)

	Pure barley Field	Barley between hedgerows	Total field (10% shrub)	% change on a field basis
Barley grain	428.8	502.5	452.3	5.48
Barley straw	688.5	738.0	664.2	-3.53
Total barley yield	1117.3	1240.5	1116.5	-0.07
Shrub foliage	-	-	342.2	
Shrub plus barley	1117.3	-	1458.7	30.6
Liveweight gain	108.9		116.4	6.9

Data from individual years show marked differences in barley yield, probably due to variation in rainfall. The mean values in Table 1 are skewed by unusually high production in 2001, which overshadowed the data from previous years that were much drier. The growing season rainfall of around 330 mm in 2000/2001 was associated with a barley yield of 1523 kg/ha, nearly 7 times the average yield for the previous 3 years. The benefit to barley growth afforded by the shrub hedgerows was a yield per m2 increase of 9.9% in 2001, close to the average evident in Table 1. In contrast, the benefit from the shrub rows averaged 31% higher yield in the 3 years preceding 2001, and achieved an increase of 59% in a 1999 trial. From the farmer's point of view, the intercropping technology may have its greatest value as a means to alleviate drought stress, although farmers appear to be more interested at present in what the shrub foliage can do for sheep grazing post-harvest barley stubble.

The shrub foliage production is a bonus from the alley farming, amounting to an average of 342 kg/ha of forage in the ICARDA trials. Sheep grazing intercropped barley stubble in summer have access to the protein-rich *Atriplex* leaves, and daily weight gain on shrub fields was almost 7% higher than on stands of barley stubble alone (Table 1). 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 gDW/head/day.

Perhaps the best indication that barley/shrub intercropping has promise on marginal lands in West Asia may not be the trial results themselves, but rather the fact that farmers who are no longer participating in the research study have nevertheless 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.

Seasonal profile of range vegetation production in Aleppo province

For the past five years, data have been collected on the components of standing biomass of major types of rangeland vegetation at permanent sites in Aleppo province, northwestern Syria, where mean annual rainfall is below 200 mm. In this part of the Syrian steppe, low-growing shrubs characterize the natural vegetation. The two most important rangeland types are dominated by a single species, either *Artemisia herba-alba or Noaea mucronata. A. herba-alba* is a palatable aromatic species that is prized for the flavour it gives to the meat of small ruminants; *N. mucronata* has little forage value, but its woody growth habit makes it an attractive, accessible source of fuel for household needs.

There is abundant growth of ephemerals and herbaceous perennial species in spring. On degraded sites, including areas that were cultivated for barley for many years and have experienced loss of perennials as well as soil erosion, only the ephemerals remain. The dry herbaceous biomass of the herbaceous material standing at the end of the growing season is an important source of feed during the summer, providing dietary energy to complement the nutrient-rich shrub foliage. However, many herbaceous plants are relatively frail and readily succumb to wind and livestock trampling.

The 2000-2001 growing season was particularly favorable, achieving a total of 300 mm at Adamy, southeast of Khanasser, where the average is closer to 180 mm. The rainy season began in September 2000, followed by unusually heavy falls in December and then good rains in February, March and May (Figure 1). Annuals are generally more sensitive to rainfall patterns than the perennial shrubs, whose growth continues into the summer and autumn. In 2001 the response of annuals to above-average rains was dramatic. Figure 2 depicts the monthly change in standing biomass of vegetation on a *N. mucronata* site. The monthly variation in woody plant biomass in Figure 2 is a reflection of different plot locations. Data points are the means of 4 replicates of 10 m^2 plots that were destructively sampled. The foliage production from the shrubs amounted to only about 100 kgDW/ha, whereas the standing biomass of herbaceous species in April and May was more than 800 kgDW/ha.

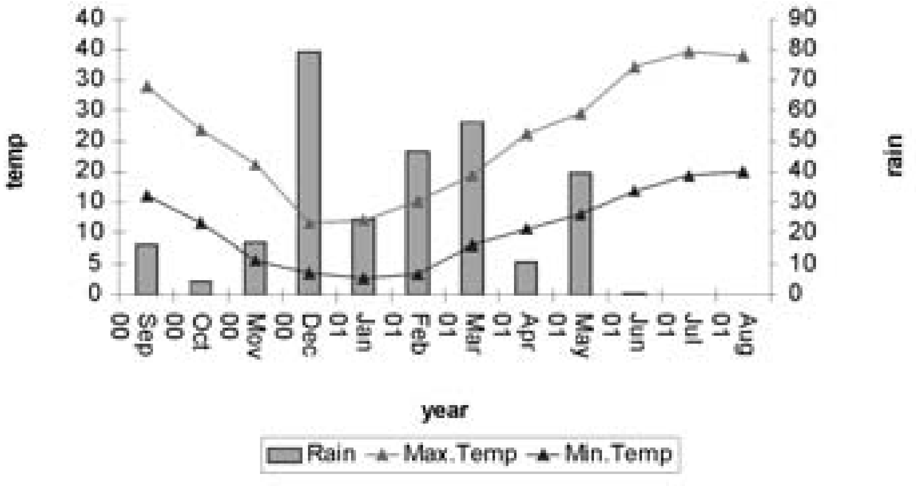

Figure 1. Meteorological conditions of temperature (degrees C) and rainfall (mm) during the growing season of 2000-2001, as recorded at Adamy nursery station.

By June those grasses and forbs had matured and senesced, but although they no longer register in the data record depicted in Figure 2, they nevertheless remain in the vegetation in a hayed-off condition and provide good-quality forage until autumn. The true production from the herbaceous plants was probably a lot more than the monthly amounts shown in Figure 2. The *N. mucronata* sampling site at Kherbet Habal is exposed to open grazing, and livestock in the area would have utilized the herbaceous material in spring in preference to the less-palatable *Noaea mucronata* shrub foliage.

Figures 3 and 4 provide a contrast between an area of A. *herba-alba* range at Bir Hamam subjected to unrestricted grazing, as in the case of the *N. mucronata* site, and an area of A. *herba-alba* range in the Ain Zarqa Protected Area.

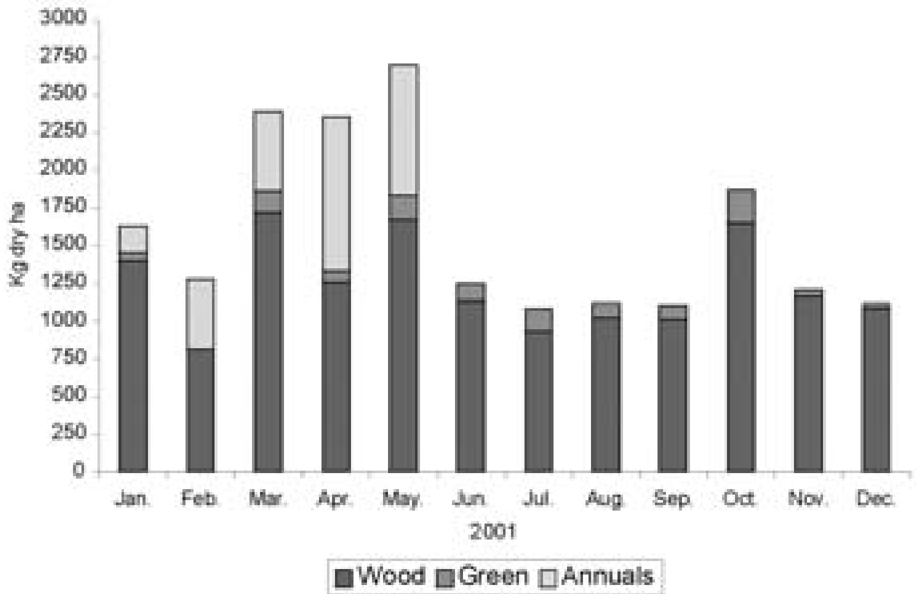

Figure 2. Aerial biomass of wood, green shrub foliage and green annual plants on a *Noaea mucronata* rangeland at Kherbet Habal on a site open to grazing in Aleppo province, 2001

Protected Areas are normally open to grazing for two months in spring and autumn, but 1999 and 2000 were drought years when animals were at risk of starvation, and in those years the government did not attempt to limit the number of animals entering the Protected Areas. In contrast, 2001 was a very favorable year in which the herders did not need access to forage in range reserves. In 2001 the Steppe Directorate took advantage of the higher productivity of rangelands and barley fields and excluded livestock from the Protected Areas in both grazing seasons to allow the reserves to recover from very heavy use in the two previous years. Therefore, the data shown for Ain Zarqa in Figure 4 represent the natural condition of the resource, without any grazing impact.

The *Artemisia herba-alba* shrub plants are larger in the Protected Area. The standing woody material was two to three times greater under controlled grazing, compared to open grazing, except for the winter sampling dates. Standing woody material averaged 655 kgDW/ha in the Protected Area over the 12 monthly samples, but only 369 kgDW/ha in the site open to grazing. The difference between sites in terms of above-ground biomass is probably expressed to some degree in root biomass as well, as suggested by the soil water-profile data presented below.

Available foliage biomass on ungrazed shrubs was about twice the foliage biomass in the open-grazing site. By the end of spring (26 May sample), standing green foliage of *A. herba-alba* shrubs was 383 kgDW/ha on ungrazed plants but only 178 kgDW/ha on plants exposed to grazing. During the 6-month summer/autumn period (June-November) when shrub foliage becomes an important source of dietary protein, the shrub foliage averaged 367 kgDW/ha in the Protected Area versus 211 kgDW/ha available at Bir Hamam under grazing. The highest level of shrub foliage under protection was 514 kgDW/ha in late August, whereas the comparable figure for the grazed site was 302 kg in November.

The shrubs in the open-grazing site may have produced more leaf material than could be measured in the sampling protocol, because flocks of small ruminants could have removed some of it. However, this explanation for the site contrast is probably inadequate, at least for the spring data. Aromatic oils in the leaves of *Artemisia herba-alba* confer a pungent flavor to the foliage that is strongest during the spring growing season, which tends to deter defoliation when nutritious forage is available from other species. The main difference between the open-grazing and restricted sites, in terms of shrub foliage biomass, is more likely due to the stunting of shrub plant growth by a history of heavy grazing which has affected root penetration and root biomass, and reduced branch number and branch length, and/or the density of spring buds on the branches.

Figures 3 and 4 also portray a dramatic difference in biomass of herbaceous species (chiefly annuals) in a Protected Area compared to an open-grazing site. At the 20 March sampling date, both sites had similar standing biomass of annuals (259 versus 286 kgDW/ha on protected and grazed sites, respectively), but then the biomass values diverge. A major burst of growth took place over the 38-day period between the 20 March and 27 April sampling dates, undoubtedly fueled by the high March rainfall and warm April temperatures (Figure 1). In Ain Zarqa Protected Area, standing biomass of herbaceous plants increased by a factor of 5, reaching 1371 kgDW/ha on 27 April. During the same period at the open-grazing site, herbaceous biomass increased by only 84%. It would appear that livestock grazing was beginning to have an impact in April, and stocking rates on the open range may have been elevated by the closure of Ain Zarqa in 2001 during the normal two-month spring grazing period. Standing biomass on the open range recovered remarkably by the 26 May sample, but still trailed the herbaceous biomass in Ain Zarqa (1284 kgDW/ha versus 1023 kg).

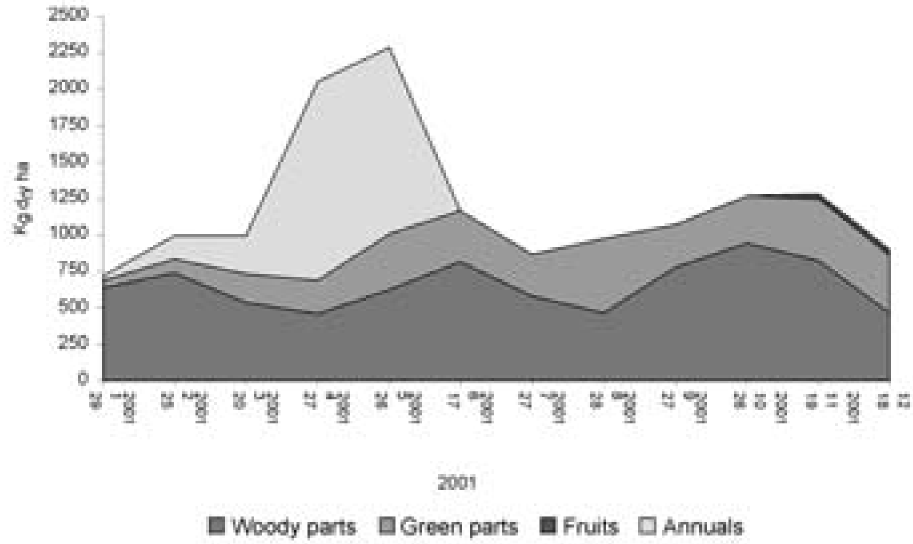

Figure 3. Monthly trends in aerial biomass components of wood, shrub foliage, shrub fruits and annuals on an *Artemisia herba-alba* shrub rangeland protected from year-round grazing in Ain Zarqa.

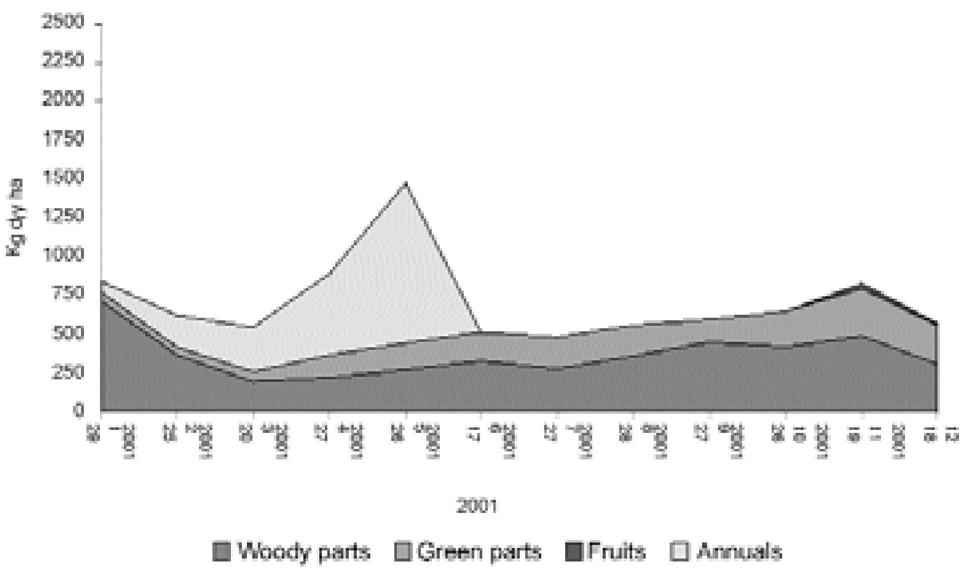

Figure 4. Monthly trends in aerial biomass components of wood, shrub foliage, shrub fruits and annuals on an *Artemisia herba-alba* shrub rangeland exposed to year-round grazing in Bir Hamam.

The high levels of herbaceous plant biomass achieved in the *A. herba-alba* vegetation at Ain Zarqa and Bir Hamam contain a significant component of broadleaf species (dicotyledons). At Ain Zarqa, 83% of the herbaceous biomass in May consisted of broadleaf dicots (1071 kgDW/ha), while dicots comprised 73% (746 kgDW/ha) of the May herbaceous growth at Bir Hamam. The greatest amount of grass biomass recorded in 2001 from 6 sites was 540 kgDW/ha at Ain Zarqa Protected Area in April.

Ain Zarqa Protected Area was planted to fodder shrubs and placed under controlled grazing management in 1995. Differences are evident in the physical characteristics of the soil profile at Ain Zarqa when compared to Bir Hamam, which has experienced unrestricted grazing. Figure 5 compares the values for field capacity (which measure the ability of the soil to hold water) and wilting point (which measures the amount of water retained by the soil when plants begin to wilt) at 5 depths at the two sites, and Table 2 presents the numerical difference between these two measures of soil water.

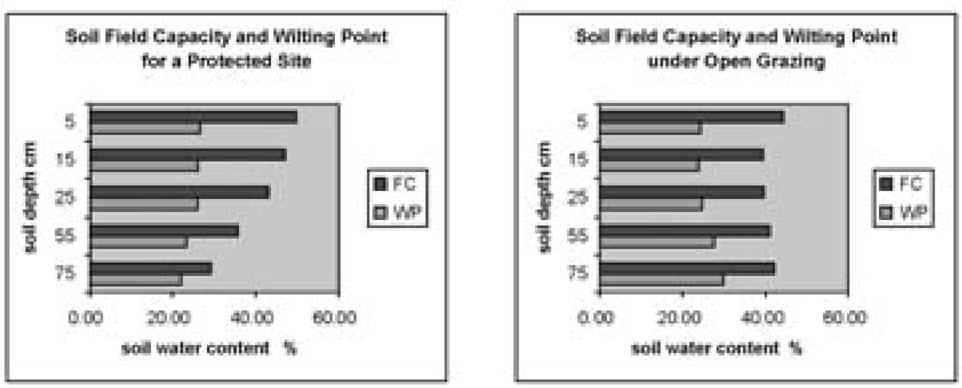

Figure 5. The profile of field capacity and wilting points for soils from a protected site (Ain Zarqa) and a site under heavy grazing (Bir Hamam) averaged from 10 reps sampled each month of the year.

Soil in the Protected Area exhibits higher field capacity values throughout the profile than the Bir Hamam soil. On the other hand, wilting point at Ain Zarqa exceeded values at Bir Hamam for only the top 25 cm; at deeper horizons the Bir Hamam profile had higher wilting points. From the point of view of plant growth, the critical information is the difference between the two, which is an indication of the amount of soil water available for plant uptake. The soil sampled in the Protected Area was clearly superior in this regard for at least the top 25 cm (Table 2). However, at 55 and 75 cm depths the Ain Zarqa soil showed a decline in potential plant-available water, relative to the Bir Hamam soil, that matched the declines in field capacity and wilting point (Table 2 and Figure 5).

Table 2. Numerical difference between field capacity and wilting point (% soil water content) for a protected site (Ain Zarqa) and a site open to grazing (Bir Hamam), at 5 depths in the profile

Soil depth (cm)	protected	open
5	23.07	20.06
15	20.98	15.41
25	17.14	14.73
55	12.42	13.37
75	7.19	12.17

Table 3. Comparison between a protected site (Ain Zarqa) and a site exposed to uncontrolled grazing (Bir Hamam) in terms of percent soil water content (gravimetric method) for five depths, averaged for each season: winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug) and autumn (Sep-Nov).

soil depth	Winter		Spring		Summer		Autumn	
cm	protected	open	protected	open	protected	open	protected	open
5	12.38	16.80	5.38	5.39	0.88	1.02	2.67	3.29
15	8.19	10.96	5.30	5.39	0.88	1.03	1.67	4.05
25	8.51	11.86	5.71	6.88	1.04	4.42	1.91	5.09
55	8.15	14.74	5.22	11.08	2.41	11.28	3.37	8.52
75	6.97	16.53	4.83	12.03	3.44	13.70	5.27	10.13

These data suggest a difference in the physical ability of the two soils to hold water and release it to plants, which to a large degree is due to inherent site differences. It may also be related to changes arising from prevailing levels of vegetation biomass, mediated through different grazing regimes. The attenuation of soil water-retention properties below 50 cm at Ain Zarqa is indicative of a contrast in physical attributes occurring below that depth. However, above-ground biomass categories are clearly different (Figures 3 and 4), and should correspond with contrasting below-ground root biomass and root distribution.

While the data in Figure 5 and Table 2 reflect soil physical properties and indicate potentials for water retention and the limits to a plant's ability to extract water, the data in Table 3 show actual soil water content in the profile in 2001 on a seasonal basis. The soil water status at different horizons is the result of the physical properties already discussed, the input of rainwater via infiltration, and the extent to which plant roots are extracting water from the soil.

Both sites received approximately the same incipient rainfall input during winter and spring (see Figure 1). No further rain occurred in summer (Jun-Jul-Aug), and none was recorded in September or October 2001. We may observe from Table 3 that the protected site lost more water to evapo-transpiration over the winter months of Dec-Jan-Feb than the grazed site, and probably had less water in the profile when the rainy season began. The spring season (Mar-Apr-May) was marked by vigorous herbaceous plant growth (Figures 3 and 4) that dried out the soils on both sites to comparable degrees. Soil water content continued to drop during summer, especially in the top 15 cm, but the decline was relatively greater on the protected site at the 25 cm horizon and below. This may be interpreted as more water uptake from the deeper layers of the Ain Zarqa soil, and evidence of greater active root biomass in the lower profile. In contrast, soil water content at 55 and 75 cm on the grazed site exhibited stability, or even a slight increase, across the summer and autumn seasons, indicating lack of plant uptake in the lower profile. November rains boosted soil water content on both sites, but more of the late-autumn input appears to have been removed at the protected site compared to the grazed site. As the two sites approach the winter period of 2001/2002, the protected area has a lower level of soil water throughout the profile.

The overall impression from the soil-water data in Table 3 is that the lower portion of the profile on the protected site lost more water to plant uptake than occurred on the grazed site at the same depth. This would support the hypothesis that the greater levels of above-ground biomass of *Artemisia herba-alba* vegetation that have developed at Ain Zarqa under restricted grazing are matched by more roots and deeper penetration of the root biomass, compared to a site of comparable vegetation type (Bir Hamam) open to uncontrolled grazing. The significance of the difference in below-ground root biomass is that plants in the Protected Area may be more tolerant of drought than plants exposed to open grazing, because their root systems have access to a greater soil volume. Thus, similar to the barley/shrub intercropping technology, a significant benefit from controlled grazing management may be the alleviation of drought stress.

Appendix

The following synopsis follows the format of the Medium-Term Plan for 2001. Some of the activities listed now fall within the domain of project 2.3, Improvement of Sown Pasture and Forage Production for Livestock Feed in Dry Areas, managed by Dr. Bounejmate, who also served as acting project manager for project 2.4 from August 1999 until June 2001. Following the arrival of the new Range Management Scientist (Dr. Norton) at ICARDA in June, the responsibilities for projects 2.3 and 2.4 were divided between Dr. Bounejmate and Dr. Norton. In general, those activities concerned with seed increase, germplasm collection, the range plant nursery and herbarium, were assigned to Dr. Bounejmate. Activities concerned with range vegetation assessment and range rehabilitation, plus the System-Wide Livestock (SLP) project on grazing forage shrubs in barley fields, were assigned to Dr. Norton.

Output 1: Management plans for rangeland natural resources in two test sites in CWANA.
Indicator: National and community acceptance of management plan.

Milestones for 2001:

- *Report including recommendations on marginal land using native annual legumes.* Research carried out on rangeland at Tel Hadya in the 1980's demonstrated that phosphate fertilization of marginal grazing land whose vegetation already has a complement of native legumes can substantially increase both forage and livestock production. This work has been published in the Journal of Agricultural Science. However, there is a need for an extension bulletin that expresses the recommendations derived from the research in a readily assimilated form. One of the difficulties in placing the results from this study in a local production systems context is that the sheep-grazing treatments were applied year-round, whereas herders generally use marginal grazing land on a seasonal basis. Another problem is that uncultivable marginal land is open to grazing, and unless local farmers can exercise some restrictions on rights of access there is little incentive for them to adopt range improvement practices.
- *Report including recommendations on the barley/Atriplex technology.* The results from on-farm trials of barley intercropping with forage-shrub hedgerows are presented within this annual report. The results from this technology are encouraging, and will lead to specific recommendations for barley farmers when an economic appraisal is available.
- *Data on current use of rangeland natural resources in 2 sites analyzed and discussed.* There is nothing to report on this activity. However, studies conducted in Central Asia since 2000 and anticipated for Syria in 2002 will address this activity for next year's report.
- *Report on range productivity in Syria.* 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. The production data for 2001, a particularly good year, are presented as a highlight of this annual report for project 2.4.
- *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.

- *Report on use of GIS-RS facilities for range rehabilitation and management in Morocco.* A report on this activity, which is based on GIS analysis of satellite imagery of the eastern rangelands of Morocco, funded by the Swiss Development Corporation, was completed by Dr. Bounejmate (project 2.3).

Output 2: Low-cost techniques for rehabilitation of rangeland and marginal lands.
Indicator: Techniques tested and utilized by NARS.

Milestone for 2001:

- *2 range species increased; farmers produce range seed/seedlings.* Seed increase activities are now within project 2.3. However, a relevant comment under this milestone is that at least 2 farmers have been identified in Northern Syria who manage private plantations of forage shrubs (each several hundred hectares in area) and supply seed to the nurseries of the Steppe Directorate.

Output 3: Inventory of useful native and exotic plants for feed, fuel-wood, or erosion control.
Indicator: Documentation, database and herbarium of useful species.

Milestones for 2001:

- *Measurement of CO_2 in two sites in Central Asia completed.* This activity is the responsibility of the Global Livestock CRSP (Collaborative Research Support Program) funded by USAID through the University of California, Davis. No report has been received for 2001.
- *Inventory and survey of range resources in 2 sites completed.* In spring 2001, 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 prepared in 2002.
- *100 accessions collected and conserved in gene bank and/or nursery.* Seed collection and management of the nursery and herbarium were assigned to project 2.3 in June 2001.
- *Networking/sharing of databases initiated within the context of the SLP shrub project.* Research results were shared among NARS scientists meeting in October 2001 to review accomplishments in Phase 1 of the SLP project on "Production and Utilization of Multi-Purpose Fodder Shrubs and Trees in West Asia, North Africa and the Sahel," and to prepare for Phase 2.

- *Four NARS trained in inventory, survey, and mapping of range resources.* Altogether 28 trainees from the Syrian Ministry of Agriculture were trained during 2001 in 3 training sessions. The training was in the fields of computerized database management, use and application of GIS software, the use of a GPS (Geo-Positioning System) receiver to locate the coordinates of field sites, and the use of DEM (Digital Elevation Models) to portray topography in a computer image and model water flows across the landscape. These skills will be integrated with training in spring 2002 on range vegetation inventory field methods, with the objective of creating forage resource maps of Protected Areas in the Aleppo Steppe.

Output 4: Formulated measures for the introduction of fodder shrubs into rangeland settings based on assessment of success and failures in past projects.

Indicator: Documentation of measures made available to NARS.

Milestone for 2001:

Literature gathered. There is nothing to report at this stage.

Appendix 7: Collaboration in Advanced Research

<u>INTERNATIONAL CENTERS AND AGENCIES</u>

ACSAD (The Arab Center for the Studies of Arid Zones and Dry Lands)
- Joint workshops, conferences and training.
- Exchange of germplasm.
- Cooperation in formulation of research programs for UN Convention to Combat Desertification (CCD) Sub-Regional Action Program on Combating Desertification and Drought in Western Asia
- Cooperation in providing technical backstopping and training requested by the National Components of the GEF/UNDP project on "Conservation and sustainable use of dryland agro-biodiversity in Jordan, Lebanon, Palestinian Authority and Syria"

CIAT (Centro Internacional de Agricultura Tropical)
- ICARDA is participating in the Systemwide Programme on Soil Water and Nutrient Management and in the Systemwide Programme on Participatory Research and Gender Analysis for Technology Development, both coordinated by CIAT
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database
- Cooperation in joint project on development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants.

CIHEAM (International Center for Advanced Mediterranean Agronomic Studies)
- Joint training courses and information exchange.
- Collaboration in an analytical review of NARS in WANA
- Study of the tolerance of ICARDA mandate crops to salinity at CIHEAM-Bari

CIMMYT (International Center for the Improvement of Maize and Wheat)
- CIMMYT/ICARDA Joint Dryland Wheat Program. CIMMYT has seconded two wheat breeders to ICARDA.
- ICARDA has seconded a barley breeder to CIMMYT.
- CIMMYT's outreach program in Turkey and ICARDA's Highland Regional Program share facilities in Ankara, Turkey and collaborate in a joint facultative wheat improvement program.
- ICARDA and CIMMYT jointly coordinate a durum wheat research network encompassing WANA and southern Europe.

FAO (Food and Agriculture Organization of the United Nations)

- ICARDA participates in the Inter-agency Task Forces convened by the FAO-RNE (FAO Regional Office for the Near East).
- ICARDA and FAO are co-sponsors of AARINENA.
- ICARDA participates in FAO's AGLINET cooperative library network, AGRIS and CARIS.
- Collaboration in an analytical review of NARS in WANA
- Joint planning in areas of feeding resources and strategies with FAO's Animal Production and Health Division
- Joint training courses, workshops and exchange of information.

IAEA (International Atomic Energy Agency)

- Management of nutrients and water in rainfed arid and semi-arid areas for increasing crop production.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)

- ICARDA and ICRISAT cooperate in a joint kabuli chickpea improvement program.
- ICARDA and ICRISAT are co-conveners of the theme Optimizing Soil Water Use within the Systemwide Programme on Soil Water and Nutrient Management.
- ICARDA is collaborating with ICRISAT on insect pests of grain legumes within the Systemwide Programme on Integrated Pest Management.
- Cooperative Task Force on Wind Erosion in Africa and Western Asia.

IFPRI (International Food Policy Research Institute)

- ICARDA collaborates with IFPRI in the Systemwide Programme on Property Rights and Collective Action.
- Collaboration in policy and property rights research in WANA: ICARDA hosts two joint ICARDA/IFPRI Research Fellows.
- Collaboration within SGRP framework in the development of a costing study of ICARDA gene bank operations.

IITA (International Institute of Tropical Agriculture)

- ICARDA is collaborating with IITA on parasitic weeds within the Systemwide Programme on Integrated Pest Management.
- Joint development of CGIAR Systemwide Microbial Genetic Resources Database

ILRI (International Livestock Research Institute)

- ICARDA is the convening center, in collaboration with ILRI and ICRISAT, for a program on Production and Utilization of Multi-purpose Fodder Shrubs and Trees in West Asia, North Africa and the Sahel as part of the

Systemwide Livestock Programme on Feed Resources Production and Utilization coordinated by ILRI.

- Joint development of CGIAR Systemwide Microbial Genetic Resources Database.
- Cooperation in joint project on development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants.
- ILRI is a partner in a project on integrated feed and livestock production in the steppes of Central Asia, coordinated by ICARDA.
- ILRI is a partner in studies of breed characterization of small ruminants in the Caucasus.

IPGRI (International Plant Genetic Resources Institute)

- ICARDA hosts and services the IPGRI Regional Office for Central and West Asia and North Africa (IPGRI-CWANA).
- ICARDA participates with other CG Centers in the Systemwide Genetic Resources Programme, coordinated by IPGRI, in both plant and animal genetic resources.
- ICARDA collaborates with IPGRI in two sub-regional networks on genetic resources (WANANET and CATN/PGR).
- ICARDA participates in developments of the SINGER project coordinated by IPGRI and contributes data to the core SINGER database available on the Internet.
- IPGRI-CWANA is a partner with ICARDA in providing technical backstopping and training requested by the National Components of the GEF/UNDP project on "Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestinian Authority and Syria".

IRRI (International Rice Research Institute)

- Joint development of CGIAR Systemwide Microbial Genetic Resources Database.

ISNAR (International Service for National Agricultural Research)

- ICARDA and ISNAR cooperate in research management for NARS in WANA.
- ICARDA and ISNAR are co-sponsors of AARINENA.

IWMI (International Water Management Institute)

- ICARDA is the convening center for a project on Efficient Use of Water in Agriculture within the Systemwide Water Resources Management Programme coordinated by IWMI.

UNEP (United Nations Environment Programme)

- Cooperative Task Force on Wind Erosion in Africa and West Asia.

WMO (World Meteorological Organization)

- Cooperative Task Force on Wind Erosion in Africa and West Asia.

AUSTRALIA

Australian Winter Cereals Collection, Tamworth.

- Development and conservation of plant genetic resources in the Central Asian Republics.

Australian Temperate Field Crops Collection, Horsham.

- Development and conservation of plant genetic resources in the Central Asian Republics.

University of Adelaide, CRC for Molecular Plant Breeding, Waite Campus

- International collaboration in barley research.

Charles Sturt University, NSW

- Soil physical characteristics in relation to infiltration and surface evaporation under conventional and no-till operations.

CLIMA (Centre for Legumes in Mediterranean Agriculture)

- Improvement of drought and disease resistance in lentils in Nepal, Pakistan and Australia.
- Faba bean germplasm multiplication.
- Germplasm testing and assessment of anti-nutritional factors: Lathyrus spp. and Vicia ssp.
- International selection, introduction and fast tracking of kabuli chickpea.
- Development and conservation of plant genetic resources in the Central Asian Republics.
- Preservation of the pulse and cereal genetic resources of the Vavilov Institute.
- Pulse transformation technology transfer.

La Trobe University

- Development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants.

NSW Agriculture, Agricultural Research Centre

- Durum wheat improvement.
- Selection of legume germplasm for virus disease resistance.

Plant Breeding Institute, University of Sydney

- Near isogenic lines for the assessment of pathogenic variation in the wheat stripe (yellow) rust pathogen

Victorian Institute for Dryland Agriculture

- Improvement of drought and disease resistance in lentils in Nepal, Pakistan and Australia.
- Improvement of lentil and grasspea in Bangladesh.
- Improvement of narbon vetch for low rainfall cropping zones in Australia.

AUSTRIA

Federal Institute for Agrobiology, Linz

- Safety duplication of ICARDA's legume germplasm collection

BELGIUM

University of Gent

- Assessment of Vicia sativa and Lathyrus sativus for neurotoxin content.

University of Leuven

- Participatory agroecological characterization.

CANADA

Canadian Grain Commission, Winnipeg

- Development of techniques for evaluating the quality of barley, durum wheat, and food and feed legumes.

University of Guelph, School of Rural Development and Planning, Ontario

- Role of women in resource management and household livelihood strategies.

McGill University, Montreal, Quebec

- Collaborative project on the use of brackish water in supplemental irrigation in Syria.

University of Manitoba, Winnipeg

- Collaboration in tan spot disease

University of Saskatchewan, Saskatoon

- Improvement of Ascochyta blight resistance and standing ability in lentil.
- Information services on lentil, including publication of the *LENS Newsletter.*
- Evaluation of chickpea germplasm and their wild relatives.

Simon Fraser University, British Colombia

- Collaboration in Sunn pest pheromones.

DENMARK

Risoe National Laboratory, Plant Biology Biogeochemistry Department

- QTL analyses in barley

FRANCE

CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement)

- Bioeconomic and community modeling studies in WANA

Institut National de la Recherche Agronomique (INRA)

- Association of molecular markers with morphophysiological traits associated with constraints of Mediterranean dryland conditions in durum wheat (with Ecole Nationale Supérieure d'Agronomie (ENSA), Montpellier and ENSA-INRA, Le Rheu).
- Water balance studies in cereal-legume rotations in semi-arid mediterranean zone (with Bioclimatology Research Unit of INRA, Thiverval-Grignon).
- Collaboration on cereal cyst nematodes (with INRA-Rennes).

Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM)

- Cooperation in the establishment of a network on water information.

Université de Paris-Sud, Labo Morphogénèse Végétale Experimentale

- Production of doubled haploids in bread wheat and barley

GERMANY

University of Bonn

- QTL analysis in barley

University of Frankfurt-am-Main

- Development and use of DNA molecular markers for indirect selection in chickpea.

University of Hannover

- Development of transformation protocols for chickpea and lentil

University of Hohenheim

- Simulation studies on the sustainability of Mediterranean cropping systems.
- Increasing the heterozygosity level of barley to exploit heterosis under drought stress

University of Karlsruhe

- Use of remote sensing and GIS for identification of water harvesting sites.

University of Kiel

- Assessment of information needs for development of water management models.
- Institutions of supplemental irrigation

ITALY

Institute of Nematology, Bari

- Studies of parasitic nematodes in food legumes.

Catania University

- Developing a decision support system for mitigation of drought impacts in Mediterranean regions.

University of Genova

- Analysis of the climatology of rainfall obtained from satellite and surface data for the Mediterranean basin.

University of Naples

- Development of transgenic chickpea resistant to Ascochyta blight.

University of Tuscia, Viterbo.

- Diversity of storage proteins in durum wheat

University of Tuscia, Viterbo; Germplasm Institute, Bari; ENEA, Rome.

- Evaluation and documentation of durum wheat genetic resources.

JAPAN

Japan International Cooperation Agency (JICA)

- JICA's volunteers program supports research on animal health and animal nutrition

Kyoto University

- Collaboration in molecular characterization of wheat wild relatives

NETHERLANDS

WAU (Wageningen Agricultural University)

- Collaboration on land degradation research in Syria

PORTUGAL

Estacao National de Melhoramento de Plantas, Elvas

- Screening of wheat for resistance to yellow rust, scald, *Septoria*, and powdery mildew.

- Developing lentil, faba bean, chickpea, and forage legumes adapted to Portugal's conditions.

RUSSIA

Krasnodar Lukyanenko Research Institute

- Development of winter and spring barley for the continental highlands of Central Asia and the Eastern States of the former Soviet Union

All Russian Institute of Agricultural Biotechnology, Moscow

- Establishment of barley transformation system

The N.I. Vavilov All-Russian Scientific Research Institute of Plant Genetic Resources (VIR)

- Genetic resources exchange, joint collection missions and collaboration in genetic resources evaluation and documentation.

SPAIN

INIA (Instituto Nacional de Investigacion y Tecnologia Agraria y Alimentaria)

- Barley stress physiology (with University of Barcelona).
- Improvement of drought tolerance and semolina and pasta quality of durum wheat (with University of Cordoba; Jerez de la Frontera; University of Barcelona; Centre Udl-IRTA, Lleida).
- Race identification of Fusarium oxysporum f. sp. ciceri in chickpea in the Mediterranean region (with University of Cordoba).
- Exchange of Fodder, Pasture and Range Plant Germplasm.
- Stabilization of Marginal Steeplands.

SWITZERLAND

University of Bern, CDE (Center for Development and Environment)

- WOCAT Network (World Overview of Conservation Approaches and Technologies)

Institut Universitaire d'Etudes du Développement (IUED), Geneva

- Sustainable dryland resource management in the arid margins of Syria.

Station Fédérale de Recherches Agronomiques de Changins (RAC)

- Duplication of Lathyrus genetic resources and data

UNITED KINGDOM

University of Birmingham

- Joint study tour in Lebanon and Syria on eco-geographic survey of vegetation

Bristol University:

- Analysis of the climatology of rainfall obtained from satellite and surface data for the Mediterranean basin.

Mcaulay Land Use Research Institute

- Research planning on fat-tail sheep as a trait to be used in strategic feeding systems.

University of Reading

- Gender analysis in the agricultural systems of WANA.
- Testing wooly-pod vetch in hillside project in Uganda.

Scottish Crop Research Institute

- Use of microsatellite markers to characterize barley genetic resources of WANA.

UNITED STATES OF AMERICA

University of California, Riverside

- Biodiversity of wheat wild relatives

University of California, Davis

- GL-CRSP (Global Livestock Collaborative Research Support Program): rangeland production and utilization in Central Asia.
- Developing chickpea cultivars with resistance to Ascochyta blight.
- Study of genetic diversity in natural populations of Aegilops tauschii.

Colorado State University

- Testing for stripe rust in barley.

Cornell University, Ithaca.

- Use of molecular markers for genome mapping and marker-assisted selection for stress resistance in durum wheat.
- RNA fingerprinting in barley.

DuPont Agric. Biotechnology

- Development of EST markers in wheat and lentils

University of Massachusetts, Amherst

- Child nutrition in rural areas of Syria.

Michigan State University, East Lansing, Michigan

- Simulation of phosphorus dynamics in the soil-plant system.
- Integrated expert systems/crop modelling of wheat crop management.

North Carolina State University, Department of Statistical Genetics, Raleigh, North Carolina

- QTL estimation for disease data.

Oklahoma State University, Stillwater, Oklahoma

- Collaboration in feasibility study for sustainable renovation of *qanats* in Syria.

Oregon State University

- Molecular mapping of barley within the North America Barley Genome Mapping project.
- Identification of molecular markers associated with resistance to diseases of barley.

Texas A&M University, Blacklands Research Center (BRC-TAMU), Temple, Texas.

- Development and release of an Almanac Characterization Tool (ACT) for Syria.

Texas Tech University, Plant Molecular Genetics Laboratory, Lubbock, Texas

- Adaptation to drought and temperature stress in barley using molecular markers.

USDA/ARS (US Department of Agriculture, Agricultural Research Service), National Germplasm Resources Laboratory.

- Production of PCR primers for detection of viruses.

USDA/ARS Beltsville Agricultural Research Center, Beltsville, Maryland

- Development of bread wheat cultivars facilitated by microsatellite DNA markers.

USDA/ARS Range Sheep Production Efficiency Unit (RSPEU), Dubois, Idaho

- Central Asian rangeland and sheep evaluation.

USDA/ARS Forage and Range Research Laboratory (FRRL), Logan, Utah

- Central Asian rangeland and sheep evaluation.

USDA/ARS Grain Legume Genetics and Physiology Research, Washington State University

- Gene mapping of economic traits to allow marker assisted selection in chickpea.

- Exploitation of existing genetic resources of food legumes.
- Inheritance and mapping of winter-hardiness genes in lentil for use in marker-assisted selection.

USDA/ARS Western Regional Plant Introduction Station, Pullman, Washington

- Conservation of temperate food, pasture and forage legume biodiversity.

Utah State University

- GL-CRSP (Global Livestock Collaborative Research Support Program): rangeland production and utilization in Central Asia.

University of Vermont

- Use of entomopathogenic fungi for the control of Sunn pest in West Asia.

University of Wisconsin, Land Tenure Center, Madison

- Rangeland production and utilization in Central Asia through the GL-CRSP (Global Livestock Collaborative Research Support Program).

Washington State University, USA

- The use of CropSyst simulation model in the WANA region for generalization of the site-specific research results for wider ecoregions.

Yale University, Center for Earth Observations

- Feasibility study of use of remote sensing and image analysis for land use mapping and evaluation.

PROJECT 2.5 IMPROVEMENT OF SMALL RUMINANT PRODUCTION IN THE DRY AREAS

RESEARCH REPORT

SOCIOECONOMIC RESEARCH

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.

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

To study sheep milk market channels in northern Syria, surveys were conducted in three production fronts of the production chain: producers, intermediaries and consumers. The surveys involved 147 producers, 484 intermediaries (329 retailers and 155 wholesalers), and 628 consumers. Customized questionnaires were applied to each interviewed category in three locations around the large Aleppo market: Aleppo, El Bab and Khanasser.

While the summarization and analytical treatment of the obtained information is on going, the following is a summary of preliminary findings gathered in the survey to producers.

Category of surveyed farmers

Producers included farmers participating at ICARDA's on-farm network and independent farmers that are simply milk producers. The identification of farmers was facilitated by the information provided by key producers in the villages that provided useful information about their neighboring communities.

Among the 147 interviewed farmers, 101 (69%) were sedentary and 46 (31%) were semi-sedentary. The latter ones were scattered mostly in the Khanasser valley (32/70%) where the climate and the breeding conditions are less favorable for sheep breeding than in El Bab. The sheep migration period in the semi-sedentary group varied from two to eight months, with an average of 4.6 months, mostly between March and May depending on the climate, the availability of forage and the condition of the grazing lands each year.

All semi-sedentary households rely on their own on-farm income, derived from crop and sheep production. The income of 9 out of 27 semi-sedentary households all located in Khanasser solely depend on livestock, which was the group with less resources. Less than half (41%) of the sedentary producers have off farm income and most of this group (73%) gets their wages as construction laborers both within and sometimes outside Syria.

The majority (81%) of the 101 sedentary producers live in El Bab. Though there are 46 households that are dependent on on-farm income, only three are specialized sheep farmers and 10 households evenly depend their income on crop and sheep production. Paralleling semi-sedentary farms, half of sedentary farmers (54%) have off farm income. Most of this group (72%) earns wages, while the remaining gets rent for services with tractors, combines and minibus.

Land tenure and land use for cropping

Most of the interviewed producers, 126 out of 147 (86%), are landowners, with a large range of tenure varying from 1-70 ha (average of 15.9 ha). Animals graze in nearby land and ranges, and sporadically in the steppes if the year is good. Cropping of rainfed barley ranked first as the main crop followed by olive trees, cumin and chickpea. Rainfed wheat and Lentil are also cultivated in many locations (Table 1 and Figure 1, Annex 1).

Flock size

Table 2 (Annex 1) provides a general account of flock size, reflecting large differences in size, as the range varies from 4 to 774. The average number of total livestock of semi-sedentary producers is more than twice of that of sedentary farmers. The proportion of females was roughly 50% of the flock. This proportion could be increased among sedentary milk flocks as a means to increase flock productivity. The proportion of goats in all flocks was nearly the same.

Labor

Milking sheep is done both by men and women in the field, however the processing of milk into derivatives is mainly done by women with some assistance from men and/or children (children are considered here as any person, boy or girl, ≤15 years age).

Constraints to produce and market milk and transformed products

In relation to milk production and production of derivatives, almost all farmers cite forage and feed availability as main constraints, while for the transformation of derivatives they additionally claimed that availability of electricity and adequate facilities are limiting (Figures 2 and 3, Annex 1). In particular small-scale producers claim that electricity could provide the means to accumulate milk to reach a critical volume of milk to transform. The percentage of the semi sedentary farmers that do not have any electricity in their location (48%) is 1.5 times more than that of the sedentary producers (Figure 4, Annex 1).

As for the marketing of transformed milk derivatives, quality of milk is considered to be the first problem confronted in addition to better price for the products and the severity of climate (Figure 5, Annex 1).

Market Channels

Except for a few exceptions, milk producers send their products (cheese and yogurt) to dealers located in the nearby big city mainly by transporters. The commissions for handling any kind of cheese (salty and sweet) are 10% per kg, for yogurt it varies from 5 to 10% per kg, and for ghee from 4 to 20% per kg. The fact that farmers are or not debited does not seem to affect the amount of commission that they have to pay to the dealers.

Selling of milk derivatives directly in the market is rare. Only two farmers having pickups and around 150 milking ewes, out of the 147 interviewed, have tried to sell their products in the market. Mainly because of time constraints, unavailability of vehicles, shortage of labor and lack of marketing knowledge, producers of milk derivatives prefer sell their products through dealers.

Improvement of the current situation

Most farmers (79%) are aware of the need of investments (i.e. better and attractive packing or in medical costs to improve the health of their animals) to improve the quality of their products, as this is an aspect frequently requested by their dealers. To improve present market channels, producers admitted that their products should be cleaner, well manufactured, made of pure sheep milk and thus having high quality.

To improve quality of milk derivatives, milk filtration and the process to bring milk to the boiling point before transformation, were two aspects addressed as important. The availability of useful tools such as a scale and a mold for even shaped cheese were mentioned as issues of consideration. Some producers insisted in the need of refrigeration and adequate shook proof transportation, particularly in the case of yogurt, to maintain the quality of products delivered.

For the improvement of milk production farmers perceived that there is a need to improve the production of healthier and productive ewes, regarding milk production, and availability of forage and feeds. Though 61% of farmers were aware of the prevalence of brucellosis, 53% indicated that they do not know how to avoid it.

1.1.2. Research on markets in Central Asia

Annex 2 contains information on assessments made in Kazakhstan and Uzbekistan during 2001.

It must be noted that the international scenario for wool and pelts, as well as for meats of small ruminants is not promising in the region, thus necessitating the need to explore and exploit the internal markets that are still underdeveloped and subject to speculation and unfair management.

The skills necessary in the critical area of socioeconomics were not yet developed in the region, which resulted in a low rate of accomplishments of planned activities. However, significant progress was made in Kazakhstan, and, in particular, Uzbekistan, where scientists are already applying the appropriate methodologies. Kazakhstan and Uzbekistan were the only two countries that submitted significant contributions to research on socioeconomics. In the case of Turkmenistan and Kyrgyzstan, only general reviews were produced.

In conjunction with the national coordinators of Central Asia it was concluded that 1) the skills required to conduct research on farming socioeconomics are definitely not available among our research partners in Kyrgyzstan and Turkmenistan, but are developing gradually in Uzbekistan and Kazakhstan; 2) the available expertise in economics is limited specifically to the field of macroeconomics, and here there is a good understanding of the problems involved. However, it seems that the macroeconomists involved do not consider farming socioeconomics as a research priority; 3) biophysical scientists are beginning to realize the importance and priority of socioeconomic issues in the research process; and 4) the macroeconomists involved have very little background in the area of animal, range and fodder production, because these skills are not required to any great extent in the analysis of economic problems.

In the current year, an economist was hired for a period of a year to help develop, in line with the workplan, concrete activities in all the relevant countries. One of these tasks will be training the scientists involved in the economic analysis of the different technologies being applied. The economist has been active in all four countries from August-September 2001, and the first surveys conducted are encouraging.

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

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

2.1.1. Constraints analysis and characterization of production systems in Central Asia

Annex 2 contains information regarding still preliminary assessments of farm typologies and their constraints in Uzbekistan and Kazakhstan in 2001. The rate of achievement of results in this area has been slow because of the reasons given in section 1.1.2. As indicated above, during this year the economist hired to assist in the implementation of activities under the area of socioeconomics organized the first formal surveys that are presently ongoing to characterize the production systems associated with small ruminant production. Previous information served to include households as sampling elements in these surveys, because of their direct implications in the economy of the Central Asian republics and the development of the rural societies.

Information from Uzbekistan and Kazakhstan highlights the importance of considering the interactions between farming types in the production scenario of the country. In particular the interactions between househol0ds and Shirkats in Uzbekistan (the organizations descending from the former cooperative system) and between households and medium farmers are crucially important to assess, as many conflicts regarding the utilization of the natural resources are emerging as a consequence. Households maintaining a handful of animals usually cannot manage rotational schemes for better utilization of resources and consequently there is overgrazing and degradation of land around villages. But householders are also a source of labor for larger enterprises. Information of areas of complementation and conflict are being considered in the surveys.

ON-FARM RESEARCH

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

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 adaptive research in Central Asia

Annex 2 includes different chapters concerning on-farm research in Central Asia, conducted in the on-farm network supported by the Integrated Feed Livestock Production project. Table 1 below summarizes the research areas in each country and a brief summary of findings, which can be tracked for more details in Annex 2.

Table 1. Themes of on-farm research in relation to forage, range and small ruminant production in Central Asia.

Country and activity number	Title	Main findings
Kazakhstan		
3	Assessment of the biomass, nutritive value and carrying capacity of rangelands	•Better knowledge is accumulated regarding: -Seasonal production of ranges -Grazing around villages and range undergrazing in remote areas -Grazing in the steppes where indigenous sheep (Edelbay and Karakul sheep) are raised •The need to evaluate range productivity along with animal productivity and interactions with households is identified
9	Identify and test potential crop by-products and agroindustrial by-products to balance feed gaps	Production volumes of byproducts with potential to be used in animal feeding are listed
10	Production monitoring to assess production problems and potentials, production changes due to reforms and markets	Better knowledge is accumulated on production and reproductive performance of sheep under present production scenarios. Fluctuations in feed availability are reflected in sharp changes in body weight and allowed identification of critical periods when improved flock management is required
13	Assess the suitability of the breeds based on market opportunities	•Native fat-tailed breeds are increasing in numbers in the country and seem to be competitive to wool breeds if the prices of wool continue to remain low •Programs of increased prolificacy for areas with better forage availability seem to have a place if mutton prices and demand are kept high
Kyrgyzstan		
1	Assessment of the biomass, nutritive value and carrying capacity of rangelands	•Better knowledge is accumulated regarding: -Seasonal production of ranges -Grazing around villages and range undergrazing in remote areas •The need to evaluate range productivity along with animal productivity and interactions with households, is identified
4	Production monitoring to assess production problems and potentials, production changes due to reforms and markets	•More knowledge is accumulated on socioeconomic changes in the on-farm network monitored through the year, including price fluctuation of SR products per month (wool remains low in price determining farmer's frustration, while price per kg of mutton increases from February to May)

		•Better knowledge is accumulated on production and reproductive performance of sheep under present production systems •In a market scenario with depressed wool prices, native fat-tailed sheep raised for mutton production produces competitively to wool breeds •Fertility and health in the flocks improved from former year due to better culling procedures and management
7	Assess the suitability of the breeds based on market opportunities	With a slightly lower prolificacy, Kyrgyz coarse wool fat-tailed, showed similar production performance to Kyrgyz fine wool, the most important breed during Soviet times
8	Assessment of the health status and epizootic diseases in livestock production systems	•GI-parasites are more active at the beginning of Autumn and at the start of spring •The low incidence of health problems in general reflected the timely application of preventive treatment through a health calendar in on-farm network flocks •The need of better monitoring design of diseases with the inclusion of households was identified
Turkmenistan		
5	Assessment of the status of rangelands and production and nutritive value of feed produced in rangelands	Better knowledge is accumulated regarding: •Seasonal production of periurban foothill and desert ranges •The need to evaluate range productivity along with animal productivity, in addition to interactions with households and migration to Karakoum desert, is identified
10	Production monitoring to assess production problems and potentials, and production changes due to reforms and markets	•Trends that determine changes in the composition of small, large ruminants (dairy cattle) and pigs, are better understood Knowledge is accumulated on production performance of Sarajin sheep in the on-farm environment and critical periods affecting changes in body weight are identified •Farmers are adopting successful technologies: introduction of milking sheep and cheese elaboration
13	Milk production of karakul sheep in Turkmenistan and technologies for milk collection and processing	Key aspects of milk production of Karakul sheep, which is strongly affected by litter size, are learned. Maximum productivity of milk is attained by the first month (41-43%), while by the second month 70% of the total milk produced in 4 lactation months is obtained.

14	Assessment of the status of parasitic and non-contagious diseases of small ruminants and preventive management	•Fasciola and GI-parasites represent a problem, particularly fasciola in Yzgant farm (where drainage water is accumulated in a swamp). In almost all seasons GI-parasitism and Monezia were higher in foothill irrigated areas (Yangigala) and lesser in desert areas (Yzgant) •The need of more adequate monitoring of diseases with the inclusion of households was identified
Uzbekistan		
3	Assessment of the biomass, nutritive value and carrying capacity of rangelands	•Better knowledge is accumulated on seasonal production of ranges in high elevations (Baykozon) and in desert areas (Nurata) •The need to evaluate range productivity along with animal productivity, in addition to interactions with households, is identified
5	Monitoring soil degradation	•Status of land degradation (involving land) and degression (involving vegetation) assessed in Baykozon and Nurata: -In Baykozon ranges are still in good condition though require deferment for seed production and enhanced production of fodder to keep up with increased animal numbers -In the desert steppes of Nurata the degradation of land reached 58%, with large areas in initial stages of degression. Cultivation of dry areas to produce crops has resulted in the increase of patches of degraded land with difficult recovery prospects. Animal stocks are beyond the productive capacity of the range that requires special management
9	Assessment of the potential use of mulberry as forage	•100 million mulberry trees were estimated to exist in Uzbekistan, along with assessment of the production per tree per year. In the area of Nurata there are about 50,000 trees with capacity to produce about 1,800 ton of leaves in October (assuming a small size tree) that could be incorporated to solve the problems of feed shortage •Analysis conducted at ICARDA reported 19% CP and 69% DMD, though large variability in protein content and digestibility was found depending on species and genotypes

10	Production monitoring to assess production problems and potentials, production changes due to reforms and markets, and behavior of tested technologies	In both Nurata and Baykozon, deficiencies in the monitoring process have been identified as well as the need to rectify and start a more systematic monitoring with control groups outside the interventions and treatments introduced during the test of technologies
14	Market-oriented flock of Karakul sheep	•More knowledge is accumulated on production of a large size Karakul selected flock that exceeds the average weight by about 7 kg. Data on growth showed that lambs increased about 30 kg from birth to weaning while normal lambs only increase 22 kg •The need to test these animals under a GXE design, such that all genotypes will be present in a given environment, was identified
15	Application of technologies for milk collection and processing in Karakul sheep flocks	The potential of Karakul sheep to produce milk has been evaluated over a period of 70 days. The breed is not a milk-producing sheep, however could produce up to 50 kg of milk in a period of 70 days, after the lamb is removed (for pelt production) at birth.
16	Assessment of ecto-, endoparasite infestation and prevalence of infectious diseases in flocks of small ruminants and technologies to reduce parasite loads integrated in a production management calendar	•Fasciola was only found in Baykozon (wetter area) •Marshallagia, Monezia and Trichostrongylus: higher in winter in Baykozon, while higher in Nurata in Spring •Nematodes: Higher in spring in Baykozon and low in Nurata all the year •The need of a better monitoring design involving households and a control flock was identified

Activity 3.2. Identify promising technologies to improve small ruminant productivity and farmers' income and technology test in on-farm market-oriented research networks.

3.2.1. On-farm testing of technologies to improve small ruminant productivity in Central Asia.

The different technologies tested in the on-farm networks of Central Asia are included in detail in Annex 2. A referential summary of these is produced in Table 2, below.

Table 2. Activities involving the test of technologies to improve range, forage, feed and small ruminant production in Central Asia.

Country and Activity number	Title	Status
Kazakhstan		
4	Testing of techniques for range improvement and rehabilitation: Planting range species in degraded areas	ONG
5	Testing of options for rational utilization of rangelands. A mobile herd to restore seasonal-rotational grazing with farmer's participation	NYS
6	Testing local and alternative cultivated forages, annual and perennial, to enhance the feed base for winter-feeding	ONG
7	Seed production of range species for the improvement and rehabilitation of rangelands	ONG
8	Management of winter-feeding	ONG
11	Adequate flock management including strategic feeding in most critical periods of the year, integrating feeding, health, reproduction and breeding aspects	ONG
12	Early weaning and fattening technologies	NYS
Kyrgyzstan		
2	Identify and test techniques for range improvement and rehabilitation and rational use of rangelands	ONG
3	Identification and test local and alternative annual and perennial forages and forage technologies, for winter-feeding	ONG ONG
5	Adequate flock management including strategic feeding in most critical periods of the year, integrating feeding, reproduction, breeding and animal health	
6	Early weaning and fattening technologies	ONG
Turkmenistan		
6	Identification and test of techniques for range improvement and rehabilitation	ONG
7	Use of drainage water to increase range productivity	NYS
8	Use of drainage water to produce cultivated forages to enhance the feed base for fall/winter-feeding: production of alfalfa, barley and halophytes	ONG
9	Production of cultivated forages in irrigated land, as part of rotations involving cash crops	RFM
11	Adequate flock management including strategic feeding in most critical periods of the year, integrating feeding, health, reproduction and breeding aspects	ONG
12	Early weaning and fattening technologies	ONG

Uzbekistan

4	Test of different techniques for rangeland rehabilitation	ONG
6	Collection and increase of important local range species to be used for rangeland rehabilitation	ONG
7	Seed production of range species and irrigated fodder crops	ONG
8	Test of improved cultivars and agronomic practices for irrigated fodder crops	ONG
11	Adequate use of fodder resources for winter, strategic feeding fattening of lambs	ONG
12	Reproduction strategies in combination with appropriate flock management and strategic feeding in most critical periods of the year	ONG
13	Early weaning and fattening of lambs to target market opportunities	ONG

ONG: Ongoing.
NYS: Not yet started.
RPR: Reformulated.

Emerging successful and promising results include:

- Range evaluation regarding the effects of overgrazing and lack of rotational grazing (particularly in Kazakhstan and Kyrgyzstan) definitely indicate the benefit of a shift towards restoring the rotational grazing patterns that we are advocating.
- In spite of the drought in the region, outstanding results were produced in range rehabilitation with the use of Haloxylon (Saxaul) and other shrubs (In Kazakhstan, Turkmenistan and Uzbekistan).
- Utilization of drainage water, otherwise dumped in the deserts of Turkmenistan, enabled the production of halophytes during critical periods of water scarcity, for instance making available at least 2 ton DM/ha of fodder in July (summer), when little biomass was available in the range.
- Intensive production of fodder crops in Uzbekistan, based on a rotation of intermediate crops (triticale + oat + fodder pea) followed by maize for corn and silage, demonstrated the possibility of producing up to 15.7 ton of DM/ha and 5.8 ton of corn grain/ha, as compared to only 9.5 ton of DM/ha produced by the traditional system.
- The utilization of sainfoin in irrigated areas of Kyrgyzstan offers promising prospects for the preparation of winter-feeding.
- Important achievements in advancing the lambing season, for more efficient winter-feeding management, better utilization of spring pastures and for targeting the selling of lambs, offers better production choices to farmers.
- Market-targeted techniques pertaining to lamb fattening are also adding to the menu of alternatives for generating income.

- The application of milk transformation techniques learned directly by farmers in a traveling workshop in West Asia, opens new production possibilities for farmers to exploit. Farmer Sasak milked for the first time 40 of his Sarajin ewes to obtain 1,148 kg of milk at an average rate of 28.7 kg/ewe. He transformed the milk, with technologies learned in West Asia, into 230 kg of cheese that was sold for about 7.6 million Manat.

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

On-farm research is projected in northern Syria focusing on sheep milk production and its transformation in milk derivatives. To this end different avenues to improve the productivity of sheep milk producers are explored.

A rapid rural appraisal to understand better farmers views regarding the production of their flocks and what they conceive as needs for improvement was conducted in areas of El Bab and Khanasser where an on-farm network was organized. The appraisal involved 20 farmers in El Bab and 10 farmers in Khanasser.

More relevant findings regarding the production aspects discussed are listed below:

- The dominant production systems of the region are semi sedentary. Land is mainly used for cultivation, while grazing land is very limited. Sheep graze cereal stubbles for over 4 months, which is followed by the grazing on cotton, sugar beet and corn residues. Supplementation of animals is practiced on the basis of barley grain, agricultural by-products (cotton seed cake, wheat bran and sugar beet pulps), cereal straw and lentils straw.
- Sheep are raised for meat and milk production. Farmers pay consideration to both traits while no interest in wool is expressed.
- Due to inadequate and untimely management, particularly with regard to feeding resources, sheep perform below potentials and the need of management improvement is recognized.
- Milk represents in the region a main source of income, and it is converted into cheese, ghee and yogurt. Milk processing is the responsibility of women and the need to improve this production phase is recognized.
- Male lambs, mainly, and few female lambs are sold after weaning and fattening. Most female lambs having good conformation are kept as replacements. Ewes are usually produced within the farming environment and in only few cases acquired from outside sources, the same being true for ewe lambs. Culled ewes are only sold when there is a need for cash.
- There is a poor knowledge regarding the correct reproduction management of the flock, for instance in relation to timing and duration of mating season rams are left with the flock permanently, determining an irregular spread of lambing and milk harvesting during the milk season.

- Feeding during the critical periods of mating, late pregnancy and early and advanced lactation is inadequate, which derives in poor reproduction and milk production rates.
- Inadequate attention is given to lambs at birth and during their growth and development.
- Animal health aspects are poorly managed.
- Hygiene in milk collection and processing is poorly observed and is source of main quality problems that reflect in lower prices of the derived products.

Introduction of changes in the farm environment to overcome production problems

The plan was to integrate a number of technologies in the farm environment to improve the prevailing management system while keeping costs low and targeting the product that receive major marketing attention and contributes more to farmer's income, that is, milk. Technologies were introduced in the on-farm network by discussing the advantages and disadvantages of each with participant farmers that were fully involved in the process. Some farms were recipients of this integrated technological package (System I) while others remain managed in the traditional manner (System II), thus a contrast of farms with and without the improved management was established. The farms were monitored monthly, through the collection of production records such as body condition scores, reproductive performance, milk production and health, flock composition and feeding.

The network involved two villages with nine cooperative farmers in El Bab and eight farmers in Khanasser.

The improved system include:

- Adjusting the traditional overspread mating to a controlled mating that will concentrate the lambing into a short period, such that the production of milk will reach critical volumes and occur when the demand is high
- Introduce improved rams to improve fertility and reduce inbreeding
- Introducing a simple performance recording to help the application of decisions, particularly regarding to the culling of unproductive sheep
- Introduce strategic feeding with low cost feeds to correct feeding deficiencies in critical periods, particularly during six weeks prior to lambing
- Improve the traditional milk collection methods
- Improve milk processing to obtain better quality products, to increase profitability
- Follow a planned health plan, minimizing costs by timely applying control of internal parasites
- Careful supervision of lambing and lambs to reduce mortality

The plan is schematized in Figure 1 of Annex 3.

Training of farmers was targeted during all visits in the monitoring schedule, through ample discussions about the technologies introduced. A workshop specially organized for the improvement of milk production for woman was also part of the training efforts. During the year also easy-to-read materials were systematically developed with the participation of farmers to help improving their knowledge on improved sheep management.

Some preliminary results
Tables 1and 2 of Annex 3, provide the first summaries of changes in the management of animals in view of introduced changes in the farm environment.

Thus far the decisions regarding the number of animals to be kept in the flock were not altered and were not discussed. The trend in both systems was to slightly increase the flock size (Table 1, Annex 3). Remains to be studied whether this increase is to compensate potentials losses in former years or a reflection of the better environmental conditions of 2001.

The improvement of the reproduction performance of the system was clear, that is from a fertility mean of 70% (range 64-75%) in System II to 83% (range 69-98%) in System I (Table 2, Annex 3). The better feeding during the late pregnancy also resulted in better twin rates, less deaths of adult ewes, less abortions, and larger lambs with larger growth rate in System I as compared to System II (Table 2 Annex 3).

3.2.4. On-farm parasite dynamics for epidemiological low-cost strategies for parasite control
This study aimed at assessing the infestation dynamics of GI nematodes and lungworms in sheep production systems of Syria, particularly in systems of collaborating farms that conform ICARDA's on-farm network in northern Syria.

Preliminary results in 2000 showed little parasite problems. This situation was confirmed in the present year and seems to reflect the application of a controlled program of parasites. In the region an animal health program, government managed, is yearly applied to control parasites free of charge. The application of this program, however, is projected on periodical interventions that may not be actually required. Two aspects of consideration are worth to mention here, one concerns the excessive use of chemicals to control parasites that could eventually raise resistance to the drugs administered, and the second the sustainability of the control plans after the support of the state is lifted.

In 2001 the observations involved a second sub-site in El Bab (250-300mm annual rainfall) and the new site in Khanasser (<200mm rainfall). The locations at El

Bab included sheep flocks of 9 farmers in sub-site 1 and 4 farmers in sub-site 2, the Khanasser site included sheep flocks of 4 farmers. At least 10 animals of various ages totaling a sample of about 15% animals per flock were marked for consecutive collections of fecal samples.

Samples were collected in critical months identified in a former study conducted at ICARDA, these included September 2000, November 2000, January 2001 and June 2001, which overlapped with the end of the hot summer, the beginning of the rainy season, mid-wet season and mid-dry season, respectively. From June 2001 El Bab 2 and Khanasser were included in the monitoring. The samples were processed with standard techniques following the McMaster method to assess fecal egg counts, for GI nematodes (including *Marshallagia marshalli, Nematodirus spp.* and other *Trichostrongylus spp.).* Simultaneously, an assessment of presence of cestodes including *Monezia spp*. was also part of the laboratory inspection. The counts of lungworm fecal larvae were obtained by the migration into a centrifuge tube.

In every area the results followed the trends obtained in a former evaluation (Thomson and Orita, 2000). By the end of the dry season the parasites showed activity as they end a dormant period immersed in the intestinal mucosa during the severe hot and dry summer. From June to August, the activity of GI-parasites starts in El Bab sites and becomes more evident by September to then peak in November and December (Figures 1-4, Annex 4). The control programs then operates effectively in reducing the parasite loads that are minimal by January. In Khanasser, with less rainfall, there was almost no activity during June-September while the activity starts only in October.

The plan for control of parasites provided by the government operates usually in April and in October, however these dates are not followed strictly. It is felt that the periodicity applied to flocks may be not necessary and could compromise seriously the sustainability of the plan. On this basis new methods environmentally friendly for control parasites have been considered and discussions started with the Agricultural University of Copenhagen (KVL) in this regard. To this end a survey was conducted to identify areas with high parasite infestation, in spite of the high frequency of treatment application that is now norm in the country. The average of eggs per gram counted in November in Afrin, Maskaneh and Jerablos, reputed areas with high infestation are plotted in Figure 1.

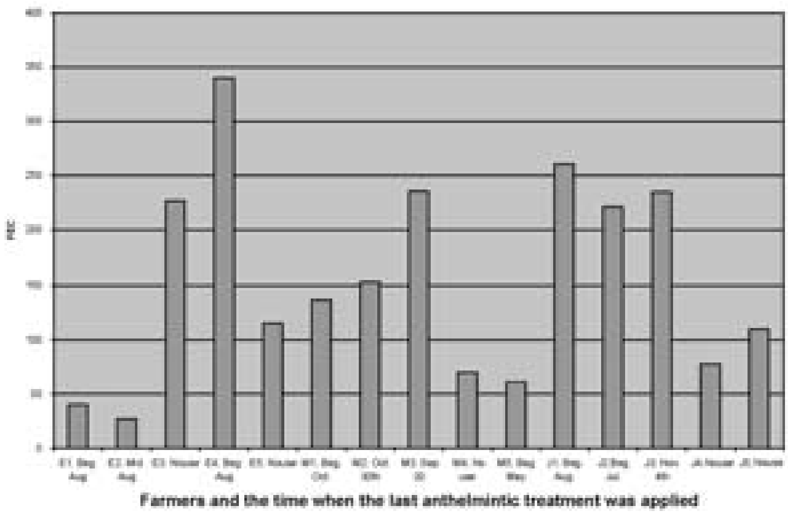

Figure 1. Average egg counts (November 2001) of GI-parasites, locations and time when the last application of anti-GI parasite chemical was applied.

E: Afrin, M: Maskaneh and J: Jerablos

Notice that the range of months when the last application of anti-GI drugs were applied (May, July, August, September and October). It is clear that the application plans did not follow a rational pattern and many administrations may have not been effective. There were treatments in August-September apparently effective in two cases (E1 and E2) while did not produce much effect in most cases (E4, M3, J1). It was interesting to observe little problems in farmers that did not adopt the control plan (E5, M4, J4 and J5) as compared to those adopting.

MILK PROCESSING AND TRANSFORMATION

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

Activity 4.1 Integrate and test technologies for the transformation of primary products (i.e. to process milk into milk derivatives) that capitalize on added value

4.1.1. Collaboration with the Jordan Cooperative Corporation (JCC) and woman farmer-to woman farmer interactions for testing technologies to improve milk transformation

Syrian women from El-Bab were trained to produce Jameed (skimmed dry yogurt) and Jordanian women were trained to make cheese (Moshalaleh) in a woman farmer-to-woman farmer exchange workshop conducted during April with the collaboration of JCC. Three farmer women specialists and trainers from the JCC network of farms from Jordan visited El Bab to initiate an exchange of technologies with 10 women from El Bab. The workshop achieved the following:

- Discussion of the Jordanian experience of improving income through improved and hygienic collection of milk and milk handling, use of proper tools for ensuring hygienic milking and milk storage, as well as use simple means to alleviate the milking work
- Discussion of the impact of levels of simple mechanization attaining better products and less waste. In addition to discussion of the advantages of a cooperative association for marketing products with greater profits
- Processing local white cheese and Moshalaleh according to Syrian local techniques
- Comparison of the processing of ghee according to Syrian and Jordanian processing techniques
- Processing Jameed using the Jordanian system, analyzing details of associated steps such as heating duration, proper cooling duration before fat isolation, salting, curd filtrations and formulation, and drying

This interaction not only served as a means for farmers to learn from each other different elaboration techniques and improved hygienic procedures but also to realize that Jameed, a product that is virtually wasted in northern Syria, has a commercial value in Jordan. On this basis farmers from Syria started to explore a marketing agreement with JCC to produce commercially and export Jameed to Jordan.

4.1.2. Building of a pilot plant for demonstrations for milk collection and transformation of products using traditional technologies in El Bab.

A milk parlor and processing plant was built with the participation of farmers in El Bab. The parlor is a new design undertaken by ICARDA to facilitate the community collection of milk, improve the hygiene and the collection process that imposes serious burden for women and back problems. The design introduces a simple procedure to hold animals that minimizes milk contamination.

The processing plant is simple and geared to hygienic production. With simple tools the plant will introduce next year heating techniques for pasteurization prior transformation. The plant was designed as a demonstration unit and teaching center to work with farmers' means to improve quality as well as to look for diversification of products.

4.1.3. Milk processing and Transformation unit (MPTU)

The MPTU at Tel Hadya was completed and has been operational during the milk season of 2001, producing cheese and yogurt under improved techniques.

Pasteurization of milk was followed before transformation in yogurt and cheese as a preliminary step to rescale this technique to the level of equipment available for farmers. The latter will be emphasized in 2002.

4.1.4 Traditional knowledge and constraints in the transformation of sheep milk into milk derivatives in West Asia

To catalog the traditional knowledge as well as identify constraints and researchable problems in the processing of milk into products such as cheese, yogurt, ghee, doberkeh, kishik and other products, a survey was projected on a nationwide scale in Syria. In the ongoing survey conducted by Inger Waldhauer, JPO of the DANIDA JPO program, approximately 200 households were interviewed in Aleppo, Idleb, Hama, Homs, Raqqa, Hassakeh and Deir Al-Zour areas. The last phase of the survey is programmed to cover in 2002 the south of Syria, including Damascus, Qunitra, Daras and Swida areas.

In the Hama and Homs areas milk producers sell their milk to middlemen who process the milk into other dairy products - mainly into cheese. In other areas such as in northern Syria, milk is processed by farmers into different derivatives. In the latter case the dairy products are produced to cover household needs while any surplus sold to the nearest market. Processing involves manual work, which results in a large variation in quality.

All visited cheese processing farmers use raw milk without heat treatment, in spite of the awareness of presence of brucellosis and tuberculosis.

RESEARCH ON GENETIC DIVERSITY

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

Activity 5.1 ***Conduct genetic and production characterization of small ruminant breeds of CWANA, along with characterization of their production and market environments.***

5.1.1 Towards the Management of Genetic Small Ruminant Diversity in Central Asia and the Caucasus

Editorial iterations of the country reports with authors of the CAC countries with the exception of Tajikistan (report still not submitted) continued during 2001. The target, as planned, is the publication of this material in 2002.

The on-farm characterization of breeds also continued in all Central Asian countries with the incorporation of Kazakhstan to characterize Edelbay sheep. Characterization of Caucasian breeds continued in Georgia and started in Armenia and Azerbaijan. The expansion to the Caucasus was possible by funds provided by the SLP in late 2000.

5.1.2 Past on-station characterization of small ruminant breeds in 11 countries of WANA

With funds provided by the System wide Genetic Resources Program, coordinated by IPGRI, the on-station characterization of small ruminant breeds in WANA was initiated in late 2000. Senior researchers submitted their reports and editing iterations started with authors. Researchers from the following countries submitted their reports: Morocco, Tunisia, Egypt, Syria, Turkey, Lebanon and Cyprus. Till now reports from Iran, Iraq, Algeria and Jordan were not yet received.

5.1.3. Assessment of potential for the improvement of mohair, cashmere and fine wool production in Kazakhstan and Kyrgyzstan

To explore the possibilities to diversify production as well as looking for the insertion of farmers to market trends, an assessment of the potential for production of fine fibers was conducted in two countries of Central Asia (Kazakhstan and Kyrgyzstan) by Dr. Joaquin Mueller an animal breeder, specialist in wool and animal fibers.

The production scenario of the two countries confronts a range of production and marketing problems. For example in the foothill areas are signs of overgrazing while wasted grazing range is also observed, largely due to range management and land tenure policies. Fodder production for winter is limited by lack of investments and machinery obsolescence, leading to serious gaps and feed shortages. Housing facilities, essential in the steppes, are also limited by obsolescence and lack of investments. Many other basic supplies (spare parts, veterinary medicines, etc.) and technologies (advise, telecommunication, etc.) are not readily available to farmers. Moreover at present farmers do not have access to reasonable bank credits. All these aspects hamper production efficiency and farm profitability. Thus short-term improvement projections may turn into disappointment if expectations are set high.

Improvement of fiber marketing

Despite favorable international prices for mohair, cashmere and fine wool, most farmers in Kazakhstan and Kyrgyzstan obtain only a fraction of international market values. Sometimes the achieved prices do not compensate for production and harvest costs. Factors impeding access to international prices include unfavorable marketing procedures, excessive intermediation and fiber quality. A comprehensive task is needed to adapt production and marketing procedures to competitive standards. In what follows some ideas on actions in that direction are listed.

- Market information and fiber description is essential for optimal negotiation. Most farmers ignore market demands and trends, but more importantly they ignore the quality of their own fiber produce. Some sort of market intelligence is needed to monitor market trends and opportunities. Careful screening of the INTERNET may be sufficient for gathering basic information on the fiber value chain, and updated prices and markets. Translation of such information is required as well as distribution and explanation.
- Objective description of wool is common practice all over the world. Small flocks may not justify objective fiber description but wool gathering centers and larger flocks should have objective information of their wool offer.
- Feedback is essential for breeding and management decisions. Collective marketing is useful to reduce intermediation. Joint fiber offer may attract more buyers and hence improve fiber price. Opportunities for specific arrangements with processors may also require to accomplish a specified amount of guaranteed fiber quality. Kyrgyz cashmere may take advantage of the Almaty processing plant and both countries may organize joint offers to specific European textile industries.
- Adding value to raw fiber is another obvious avenue for increasing farmer's income. At the farmer level there is the possibility of spinning fiber and producing craftsmanship, but market is usually restricted to locals and tourists (very few at the moment). Regional processing requires investments, technology and predictable market. It should be noted that customers of high quality wool (and other fibers) prefer to purchase the raw fiber and process it themselves because of blending flexibility and proper technology. Nevertheless, here again may be room for joint ventures with foreign processors interested in primary processing (scouring and spinning).

Finally farmers should be aware of the risk of depending exclusively on fiber production. Special fibers are subject to very volatile markets and aggressive competitors. Smallholders will benefit from diversified production (including improved reproduction rate for meat in fiber animals) and concentrate on fine wool and special fibers wherever a genuine competitiveness can be verified and other activities or diversification options have been evaluated.

Improvement of fiber quality

Kazakh and Kyrgyz cashmere has good regional reputation but mohair production is almost unnoticed. Both goat fibers are exported to third countries, which enjoy international recognition for these fibers. Central Asian wool is definitively considered to be of low quality associated with soviet mass heavyweight apparel fabric, upholstery and other less valuable textiles.

Quality is a broad concept involving many aspects depending on the fiber considered. In general fiber quality is related to the genetic background of the animals (influencing for example odd fiber contamination, fiber diameter, style, etc.) but fiber quality also depends on the nutritional management of animals (influencing for example fiber diameter variation along the staple), harvesting procedures (shearing system and shearing conditions), clip preparation (skirting), classing (separating inferior fleeces) and storing (packaging and baling material). All these aspects need attention to improve quality.

The message for Central Asian fiber production is that while during soviet times emphasis was on bulk production, today and in the foreseeable future quality will determine market possibilities and price level. What can be done? Farmers may be instructed to follow a quality production protocol, including simple but relevant rules. Examples of such wool quality schemes are found in Uruguay and Argentina (Prolana). An uncomplicated and useful program for mohair improvement and marketing is also operating in Argentina (Propelo). Propelo is based on genetic improvement, proper on farm shearing, skirting and classing and collective fiber auction. In general these schemes require initial investments in training of farmers and extension officers but progressively become cheaper and independent. Some aspects may require adaptive research and development (for example about appropriate fiber classification system).

Genetic improvement of fiber production

Farmers tend to simplify the issue of fiber quality assigning a central role to the genetic quality of their animals. There is a generalized claim for improved genetic material in both Kazakhstan and Kyrgyzstan since both countries lack almost completely of a functional genetic structure that supplies sires for their sheep and goat populations. Such structures existed in soviet times but central nucleus and studs disappeared or were privatized leaving many farmers without their source of replacement sires. This explains the interest in importation of breeding stock, expressed by the industry, farmers and interviewed authorities.

It is easy to agree with such demands but looking ahead it seems even more important to develop (or reestablish) a sustainable genetic structure in these countries for each of their small ruminant breeds. Such structures basically consist of a sire-producing layer subject to a genetic improvement program and commercial flocks with access to those sires. Import of genetic material can be a crucial initial input but such imports require a multiplying structure and a dissemination scheme.

Interest in such a program differs slightly in both countries. In Kazakhstan demand is for high quality foreign Angora bucks (less so for fine wool rams).

For cashmere improvement upgrading to the fine Orenburg breed is preferred. In Kyrgyzstan there is also interest in Angora bucks and also in the high producing Kazakh Pridonskaya cashmere bucks.

In summary genetic improvement programs are required and desired for both mohair and cashmere production but a mohair program is more dependent on external cooperation due to less regional germplasm and experience.

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.

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

6.1.1. Improvement of cereal stubble grazing for sheep production in the dry areas by supplementation with urea-based feed blocks

Cereal crop stubble is an important feed resource in the dry areas of WANA to both animals grown in crop-livestock zones as well as those raised under more extensive range-based operations that displace flocks/herds into cropping zones after the harvest of cereals. Usually, cereal stubbles are available in summer in a period that coincides with mating and early pregnancy. Grazing in this period could have the potential to improve fertility, which is usually lower in these regions, and thus the flock productivity. Due to the lack of appropriate management, stubble grazing occurs with no consideration of either the stubble's carrying capacity or the possibilities to induce a more efficient digestibility of the already lignified product.

A former research conducted at ICARDA on the effect of stocking rate and grazing in Awassi sheep in northern Syria revealed that, as expected, the level of nutrition reduces with time or heavy stocking. In fact, ME intake was about 2.5 times the maintenance requirements in days 1 to 4 and declined to 0.7 maintenance requirements in days 23 to 28. Likewise, the intake of crude protein was already below maintenance requirements in the first few days of grazing. In this experiment, small amounts of supplements offered to ewes grazing on cereal stubble increased body weight at mating and reduced lag time to conceive, and thus improved reproductive efficiency.

An experiment to improve the utilization of cereal stubble by using feed blocks as a vehicle to transfer urea, contrasted by supplementation with the traditional supplements offered by farmers in this period, was conducted on-station and with collaborating farmers at ICARDA's on-farm network in northern Syria. The trial at Tel Hadya used 3-year-old ewes in their second reproduction season to assess the improvement of stubble grazing by two treatment groups, the first receiving feed blocks containing urea and the second no supplementation. The on-farm trial at El Bab was geared to both demonstrate the need of better utilization of the stubble as well as the reduction of traditional feeding costs.

As reflected in Table 1 in Annex 5 better utilization of cereal stubble promoted by the use of FB contrasted sharply with grazing on only stubbles, as FB-supplemented ewes gained 96 g/day compared only to 8 g/day weigh increase of ewes with no supplementation over a period of 50 days. The implications of this trial are very important for both farmers that supplement ewes with rather expensive concentrates and farmers that only graze stubbles without realizing the nutritive potential of cereal stubble if a source of urea is incorporated in the feeding system.

In the trial at El Bab sheep supplemented with feed blocks containing urea demonstrated to promote similar growth over a period of 40 days. In one case (Farmer 1) the weight increase was lower than that gained under traditional supplementation using rather an expensive but well-balanced supplement, and in the second case the gain was actually larger in the treatment with feed block supplementation (Table 1, Annex 5). Supplementation under traditional feeding (0.37 - 0.5 kg/sheep/day) based on a mixtures of barley gain, wheat bran and cotton seed meal, amounted 2.3-3.2 SL*; while under feed blocks (0.20-0.28 kg/day) 0.7-1 SL while. Thus, the use of feed blocks has the potential to save 1.6-2.2 SL per kg. Further assessment of this experiment will be during lambing time to assess the gains in fertility and in lambing time.

* 1US$=45 Syrian Lira

6.1.2. Evaluation of byproduct feeding values and integration in feed block technology for optimizing feeding systems in northern Syria: Tomato pulp

Tomato pulp is an available byproduct with the potential to be incorporated as an alternative to reduce feed shortages in the Mediterranean dry areas of WANA. Only in Syria (1999), with a production of about 610,000 MT of tomatoes, the total production of tomato pulp amounts 42,000 MT per year. This byproduct obtained as the residue of juice and paste extraction, has a high moisture content (18-20% DM) and also good nutritional value. The pulp is available in July-August when the only feed available consists on scarce dry pastures, straw and stubble.

The pulp's high moisture however poses the problems of loosing soluble nutrients that could be wasted in the effluent; in addition the product is susceptible to spoilage due to rapid fermentation and molt development. Furthermore, transportation costs of the wet product are prohibitive for farmers.

On these considerations, a search for an effective method of preserving and using tomato pulp has been conducted in this year at ICARDA. The goal was a simple, low-cost and effective method, accessible by farmers, for preserving the pulp.

During this development two methods were considered: ensiling and sun drying, alone or mixed with chopped straw or crude olive cake that are high on dry matter content. The drying procedure was thought to be coupled with feed block technology to integrate this product to other available byproducts in the region.

Sun drying of tomato pulp alone or mixed with other agricultural by products
The pulp alone or mixed with chopped straw or olive cake was spread on plastic sheets in an open area for sun drying. The drying time as well as the nutritive and feeding value was then assessed.

The results suggest that sun drying is highly effective to preserve the pulp alone or mixed with straw or crude olive cake, producing a feed of high nutritional value (Table 2, Annex 5). The Crude protein content of sun-dried pulp (21%) was very close to that of fresh pulp (22%), in addition, the ME value of both fresh and sun-dried products were similar (9 MJ) (Table 3, Annex 5). It was evident that the dry matter digestibility of wheat and olive cake notably improved with the addition of dry tomato pulp.

Ensiling tomato pulp
Tomato pulp (T) collected from a local factory was ensiled alone and in combination with wheat straw (TS) (T:S= 75:25 and 50:50), or crude olive cake (TO) (T:O= 75:25 and 50:50). In addition, tomato pulp alone (T+) and together with different proportions of wheat straw (TS+), or olive cake (TO+) (T:S or T:O= 90:10, 80:20, and 75:25) was ensiled with additives (2% molasses, 2% urea, and 1% soybean meal). The materials were fully mixed, and filled into polyethylene bags in 35-liter plastic containers with exclusion of air. The bags were opened after 4, 8 and 12 weeks. Three people evaluated the smell, color, taste, and texture of silage, and representative samples collected for chemical analysis and pH measurement, in each of the times that the bags were opened.

The results of the evaluation of silage quality are included in Tables 4 of Annex 5. T, TS, and TO silages developed good quality, particularly with regard to color that was always bright. Other characteristics improved while the pH reduced as the ensiling period increased. The pH of TO silage was lower than that of T and TS silage.

The silages treated with additives (T+, TS+, and TO+) developed into a low quality product because of ammonia smell, slightly sour taste and high pH (> 6), though its texture and color were good. The palatability of silages with additives, however, was very good.

Table 5 of Annex 5 shows the high CP content, good energy density of tomato pulp and also its high moisture content. The same table presents the chemical composition of silages after 4-week ensiling. The composition of T silage was similar to that of fresh tomato pulp even after 4 weeks. Ensiling with straw or olive cake resulted in a decrease in CP content, *in vitro* digestibility, and ME as the proportion of straw or olive cake increased, though the quality of TO silage was better than that of T silage. This is due to the low nutritional value of both straw and olive cake.

The CP content and *in vitro* digestibility of TS+ and TO+ silage apparently increased by the additives, however the latter influenced little T+ silage. It was thought that ammonia, from urea, run out with the effluent because T+ is high moisture silage.

Though these results suggested that ensiling is a suitable technique to store tomato pulp, it remains to be assessed the suitability of this technique in relation to sun drying, considering costs of processing and the possibility in the latter case of incorporating fresh tomato pulp into the process of feed block technology.

Activity 6.2 Assessment of the potential for lambing out-of-season in West Asia to target better market opportunities.

Experiments conducted at ICARDA during the last two years to assess the potential for out-of-season breeding, revealed that Awassi sheep could be bred by a prolonged period of time as estrus activity was detected from August to January. From February to May the activity becomes irregular with many ewes exhibiting anestrus. This finding supported the feasibility of moving the breeding season for those production systems with access to an enhanced feed base in order top target better market opportunities occurring off season.

With this orientation in 2000 three breeding seasons were over imposed to the normal lambing season to ICARDA's flock and the first results evaluated with the 2001 lambing season. A total of 181 ewes aged 3-6 years, were allocated within age and live weight to three unequal groups to be mated out-of-season in December, January and February, respectively. In relation to fertility, litter size, lamb mortality lamb growth and milk production the mating groups ranked December>January>February (Table 3). It is assumed that the lowest values attained by the group mated in January were due to the high temperature during the months of lambing, while the group mated in February hit a period of low reproductive activity. These results suggest to target the October-December as the period with potential to obtain a good out-of-season performance. However provisions to offer a shade for ewes should be made in order to overcome the drop in milk production due to heat during lactation.

Table 3. Reproductive performance of Awassi ewes mated/lambed out-of-season

Date of mating	**December**	**January**	**February**
Date of lambing	**May**	**June**	**July**
Number of ewes put to ram	47	49	85
Number of ewe lambed	45	37	35
Number of lamb born	51	39	35
Number of lamb weaned	47	29	30
Fertility, %[1]	96	76	41
Litter size[2]	1.09	0.80	0.41
Lamb mortality, %[3]	8	26	14
Lamb growth, g/day[4]	210	160	180
Salable milk, kg[5]	45	20	15

[1] Number of ewes lambed /number of ewe put to ram.
[2] Number of lambs born alive/number of ewes put to ram.
[3] Number of lambs died during the suckling period /number of lamb born alive.
[4] During the suckling period that lasted 8 weeks.
[5] From weaning until drying.

Activity 6.3 Assessment of milk production traits and improved genotypes for milk production.

6.3.1. Towards a better productivity of milk in Awassi sheep. Utilization of improved genotypes.

In March 1991 ICARDA introduced to its flock of Awassi sheep an improved Awassi genotype from Turkey, known to have improved milk productivity. Though previous work at ICARDA revealed that introduced Turkish Awassi (T) produced about 22% more milk than the Syrian Awassi (S), no crossing attempts were conducted in order to quantify the breeding value of T animals.

To render contemporary female offspring for consistent contemporary comparisons of productive performance, reciprocal crosses were conducted in 1999, 2000 and 2001, involving T rams and ewes, as well as S rams and ewes, in addition to purebred matings. Out of the offspring produced by these crosses in the season 119 females that reached the age of 18 months (60 SxS, 40 TxS[1] and 20 TxT) were crossed in 2001 for evaluation of overall production and particularly milk production during their first lambing season in 2002. The 18-month contemporary ewes were crossed in accordance to the following array:

Genotype of the ewe	N	Genotype of the ram
SxS	30	T
SxS	30	S
TxS	20	T
TxS	20	S
TxT	19	T

[1]This group pools the reciprocal SxT and TxS crosses

TRAINING

Output 7: Training

Activity 7.1 Training of the Project's staff in research methodologies for updating and improving research performance.

7.1.2. Training of Project 2.5 staff in new research methodologies, technologies and equipment

- Muhi El Din Hilali visited Sardinia (June 14 - 24) to acquire full information of procedures involving milking sheep. In this visit he worked: 1) with small-scale milk producers using Bonsaglia's technologies for milk collection and transformation in Milan and Sardinia, and 2) with scientists from the Animal Production Institute of Sardinia (Olmedo) in key elements in production and transformation of milk into typical derivatives in Italy, and technologies related with starters.

- Safouh Rihawi attended a course on Optimizing the Use of Local Conventional and Non-Conventional Feed Resources in Mediterranean Arid and Semi-Arid Areas organized by CIHEAM-FAO in Egypt (12-23 May 2001) to assess new developments and trends in animal nutrition research in the region.

Activity 7.2 Training of scientists as part of the Project's outreach workplans.

7.2.1. Central Asian scientists trained at ICARDA as part of the IFAD funded project

Training abroad was limited only to two persons. The training of one scientist at ILRI did not take place because of the limited level of English of the candidate. Furthermore, the countries could not select candidates for adequate training in feeding systems and evaluation of feeding values.

Training in this project is part of a process that starts with the development of English courses in each of the participant countries, followed by workshops in research methodologies where advanced scientists are identified for further trained at ICARDA. The idea behind this activity is the development of a nucleus of trained scientists that could serve in the region with their expertise in specific areas of research and the consolidation of a multi-site analysis of the on-going research of similar aspects across countries.

7.2.2. Central Asian scientists trained in Regional workshops

Four regional training workshops, with the same goal targeted by the training of scientists at ICARDA (develop skills for multi-site research), were successfully conducted, and the salient features are listed below.

- The workshop on Epidemiological Tools for Control of Important Livestock Diseases in Central Asia (Almaty, Kazakhstan), co-organized with ILRI, was avidly welcomed by the Central Asian animal health research scientists, as attention to these areas of research is urgently needed. The introduction of modern concepts in animal Epidemiology will improve the design of the animal health research effort conducted in the project. Further training, and the follow up of specific research in the field are still required.
- In the workshop on Feeding Strategies to Improve Livestock Production, the technologies promoted by the M&M project in feed block and straw ammoniation were demonstrated along with basic principles of improved feeding systems and strategic feeding. The importance of using modern approaches to the evaluation of forages and fodder was addressed. As a consequence it was agreed, for instance, that ambiguous utilization of feed units should be replaced by the use of digestible protein and metabolizable energy values.
- The workshop on Production of Cultivated Forages for Irrigated and Rainfed Areas generated particular attention in countries like Kazakhstan, Kyrgyzstan and Uzbekistan, where many areas are dedicated to forage production under irrigated and rainfed land. In this workshop, decisions were taken to encourage the countries to specialize in research topics pertinent to their regions. Kazakhstan, Kyrgyzstan and Uzbekistan agreed to become focal points for the research in Triticale, sainfoin and alfalfa, respectively.
- The workshop on Socioeconomics Research Methodologies in Central Asia, with Emphasis on Livestock Production, was organized for a second time, in view of the difficulties in promoting research in this particular area (as outlined in the introduction to this report). The feature of this workshop was that it targeted practical rather than theoretical training, and served also to discuss the next steps to be taken in the workplan.

Table 4 lists the people trained in English courses and in training workshops. There were 25 people trained in English courses in all participant countries, and 53 trained in training workshops. In these events, ICARDA made efforts to bring a selected expertise into the region and link the Central Asian scientists and institutions to other organizations that could establish further collaborative work in the region.

Table 4. English training and training workshops in Central Asia.

Country	Scientists Trained in English language	Topic	Training workshop Participants		Lecturers
			From host country	From remaining countries	
Kazakhstan	5	Research methodology in AnimalEpidemiology (ILRI)	6	6	Subhash Morzaria and John McDermott (ILRI)
Kyrgyzstan	10	Production of Forage crops*	10	4	Mustapha Bounejmate (ICARDA) Ken Albrecht (University of Wisconsin-Madison, USA) Christer Olsen (DIAS-Foulum, Denmark)
Turkmenistan	5	Research methodology in socioeconomics	6	7	Aden Aw-Hassan and Malika Martini (ICARDA) Liba Bent (University of Wisconsin-Madison, Land Tenure Center, USA)
Uzbekistan	5	Feeding systems and strategic feeding*	10	4	Luis Iniguez (ICARDA) Robert Orskov (Macaulay Institute, UK) Harinder Makkar (IAEA, Vienna)
Total trained	**25**	**53**			

*In these events the Turkmenistan participants were not represented due to difficulties in obtaining exit visa authorizations

7.2.3. Turkish scientists trained at ICARDA under the GAP ICARDA project

A total of eight Turkish scientists from the GAP-Regional (South Eastern Anatolia Project) were trained at ICARDA, during in October 8-11, in the area of On-Farm Livestock Research. The training consisted of a mix of theory discussions in relation with ICARDA's on-farm adaptive research strategy and practical work at ICARDA's on-farm network in northern Syria.

7.2.4. Other people trained

- Two persons from a Jordan NGO funded by Japan trained (August 26-30) organization in Formulation, manufacturing and utilization of agricultural and agro-industrial by products including feed blocks.

- Two scientists from the Finland-Egypt Agricultural Research Project (Ismailia) trained (November 4-15) in issues connected with production and utilization of agricultural by products, and manufacturing of feed blocks.

STAFF AND ACTIVITIES OF THE RESEARCH LABORATORY

Staff

Luis Iniguez (Project Manager)
Monika Zaklouta (Animal Laboratory Manager)
Saadalah Filo (Animal Research Facility Manager, ended his work at ICARDA in December 2000 because of retirement)
Safouh Rihawi (Animal Nutrition Scientist)
Adnan Termanini (On-farm Research Scientist)
Azusa Fukuki (Economist, market researcher)
Muhi El-Din (Milk transformation technology and manager of the Milk Processing Unit)
Dr. Sota Kobayashi (Veterinarian, JICA Volunteer Program)
Tsuyoshi Takahashi (Animal Nutritionist, JICA Volunteer Program)
Inger Waldhauer, Junior Professional Officer (DANIDA program) in the area of milk transformation research
Birgitte Hartwell, Junior Professional Officer (DANIDA program) in the area of research on production systems

Activities of the Animal Research Laboratory: Samples analyzed

The Animal Research Laboratory at the Orita building analyzed 5,756 samples (Table 5). The samples included cereals and legume plants (straw & grain), forages, shrubs, plant residuals, cotton seed cake, olive cake pulp and leaves, whole olives, silages, as well as milk and cheese from the milk processing plant. Table 5 shows the distribution of the different analyses conducted.

Table 5. Analysis conducted at ICARDA's Animal Research Laboratory

Analysis	Samples
Dry matter/ Ash	670
Crude protein/ N	3,020
ADF	629
NDF	303
Lignin	15
Fat	27
IVDMD	643
Milk NIR	409
Total	**5,716**

Adaptation of new techniques and protocols during 2001 included the Gas Production Test for evaluation of nutritive values, following the Hohenheim

University procedures. At this stage we are comparing results from this test with the ones from the traditional Tilley & Terry method used in our laboratory.

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 University of G?ttingen, Germany, through Dr. Barbara Rischkowsky with whom the project started a collaborative study on production systems in Syria
- The University of Hohenheim (UH), through in transferring knowledge in new methodologies in feed evaluation that started with the training of a staff member of ICARDA at UH in 2000.
- 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
- The Teshreen University, Lattakia, Syria, in a joint research on citrus pulps as livestock feed developed with Dr. W. Rahmon
- Instituto Nacional de Tecnolog?a Agropecuaria (INTA) of Argentina, through Dr. Joaquin Mueller, in the area of research on fibers produced by small ruminants

CO-FINANCING

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

Annex 1
Preliminary Results of the Survey of Producers of Sheep Milk in Northern Syria

Table 1. Crops and their cultivated areas.

	Barley[1]	Other	Rainfed wheat	Lentil	Irrigated wheat	Vegetables	Faba bean	Vetch
Total Area (ha)	1152.2	351.5	297.6	56.5	45.4	30.5	8.5	7
Average Area (ha)/land owner	10.6	6.1	4.7	2.7	2.5	2	2.1	2.3

[1]Rainfed and Irrigated.

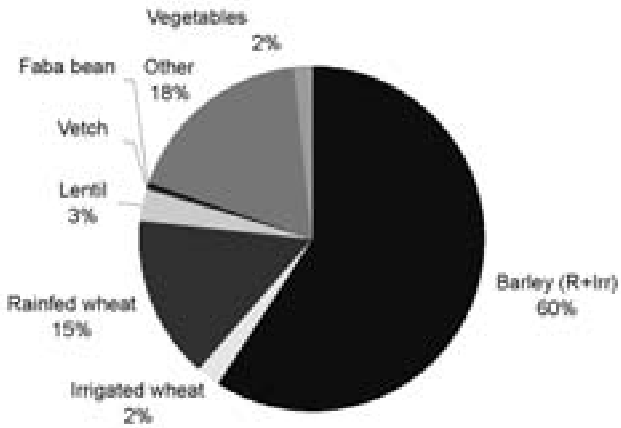

Figure 1. Use of the land for cropping.

Note: the percentages dedicated to faba bean and vetch, amount 0.4 each, respectively, of the total land.

Table 2. Flock size and distribution of different categories of animals within a flock.

Flock size	Total livestock	Milking ewes	% of M Ewes in total #	Rams	Ram lambs	Ewe lambs	Goats
All groups							
Maximum size	774	400	100	21	100	100	154
Minimum size	4	1	0	0	0	0	0
Average (head)	64.8	33	49.6	1.4	14.4	14.2	2.2
Sedentary							
Average (head)	73.2	36.2	49.8	1.4	16.7	16.4	3.8
Semi-Sedentary							
Average (head)	152.2	77.0	49.2	35.3	32.3	6.3	3.4

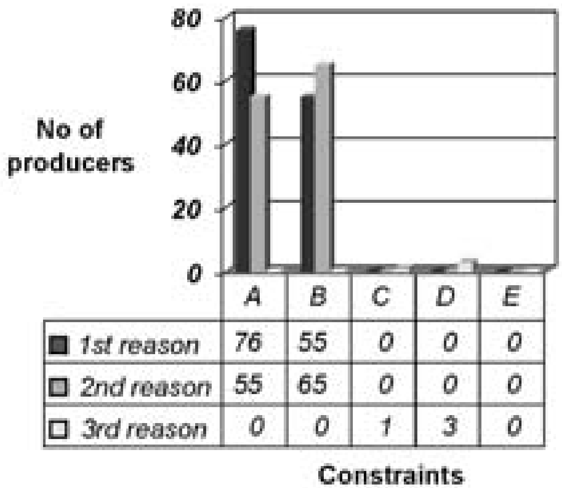

Figure 2. Constraints to milk production as perceived by farmers.

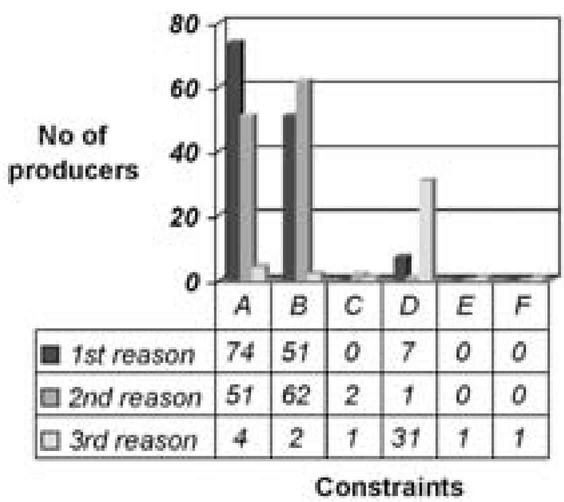

Figure 3. Constraints to production of milk derivatives as perceived by farmers.

A: Forage, B: Feed; C: Facilities; D: Electricity; E: Labor; F: Other

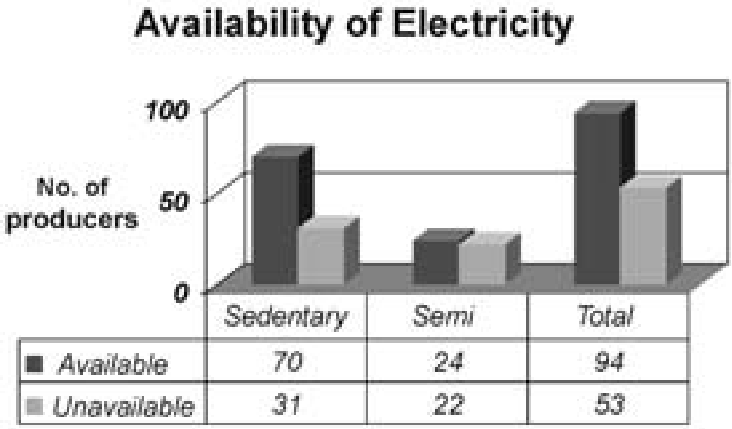

Figure 4. Distribution of sedentary and semi-sedentary farmers in accordance to availability of electricity.

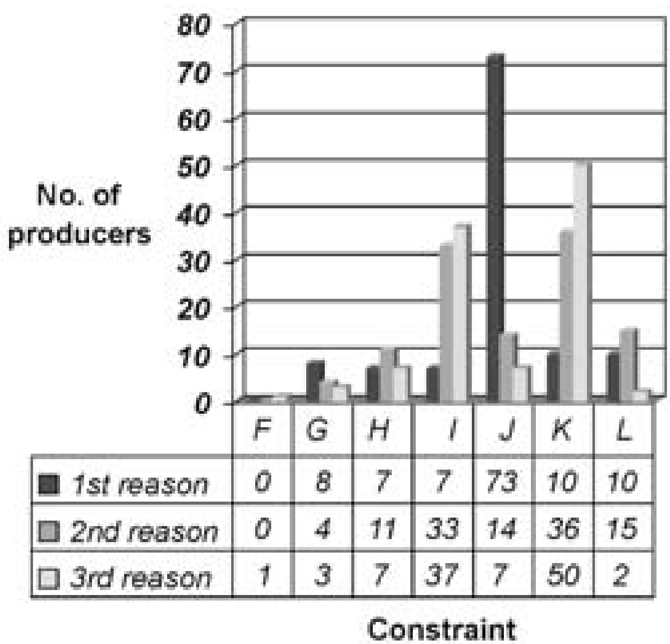

Figure 5. Constraints to the marketing of milk derivatives, as perceived by farmers.

F: Distance to markets; G: Availability of intermediaries; H: Transportation; I: Climate; J: Quality of milk, K: Price; L: Others.

Annex 2

For the full report, please write to NRMP, ICARDA

INTEGRATED FEED AND LIVESTOCK PRODUCTION IN THE STEPPES OF CENTRAL ASIA

IFAD Technical Assistance Grant (TAG): ICARDA-425

ANNUAL REPORT
September 2000-August 2001

Discussed and reviewed at the National Coordination Meetings in Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan (July 18-August 15, 2000)

Prepared and Edited by
Luis Iñiguez and Ben Norton

Annex 3

Preliminary Results of On-farm Test of Technologies to Improve Sheep Milk Production Systems in Northern Syria

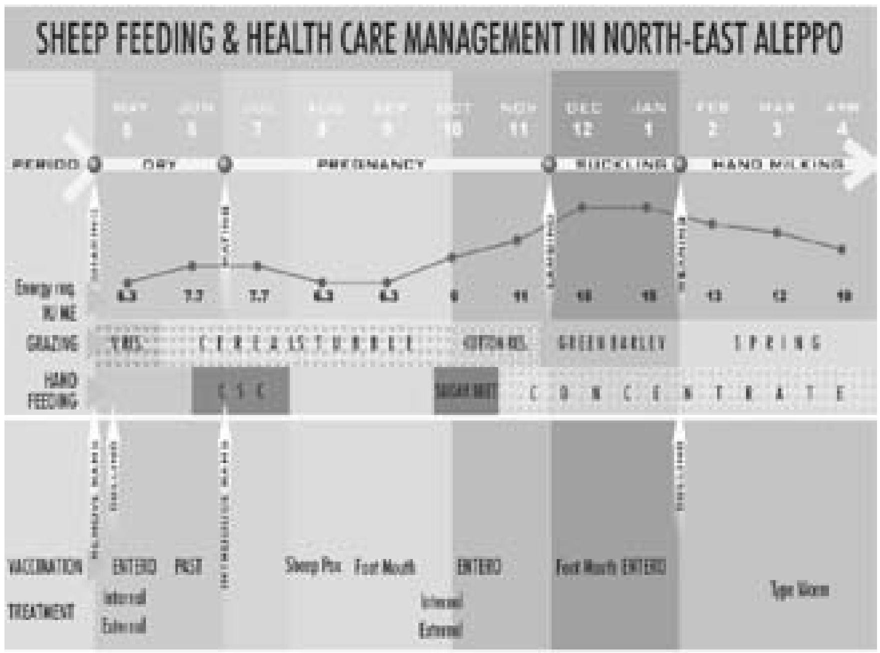

Figure 1. Plan applied for strategic feeding, programmed mating/lambing and health control.

Table 1. Changes in flock size during a year of monitoring of flocks under an improved management (System 1) and the traditional management (System 2).

System	Farmers	SheepStart	Sheep End	Change%
I	1- Faik Shikho	90	97	8
	2- Sakeb Shikho	82	96	17
	3- Sharif Hamsorek	68	73	7
	4- Hasan Omar	90	107	19
	5- Ahmed Abdo Sharifo	95	102	7
	6- Hamid Hamsork	88	102	16
	Mean system I	85	96	12
II	7- Mameq Shikho	53	50	- 4
	8- Jamal Hammo	61	73	20
	9- Khalil Al-Naief	25	24	- 4
	Mean system II	46	51	11

Table 2. Changes in reproductive performance and lamb growth during a year of monitoring of flocks under an improved management (System 1) and traditional management (System 2).

System	Farmers	Fertility %	Lamb survival %	Lamb growth rate (g/day)	Twin rate %	Aborts %	Ewe mortality %
I	1- Faik Shikho	89	96	232	8	1	4
	2- Sakeb Shikho	89	90	254	6	0	2
	3- Sharif Hamsorek	81	91	175	0	3	10
	4- Hasan Omar	98	89	154	4	0	9
	5- Ahmed Abdo Sharifo	73	93	183	4	1	6
	6- Hamid Hamsork	69	95	178	0	0	5
	Mean system I	**83**	**92**	**197**	**3.7**	**0.8**	**6**
II	7- Mameq Shikho	64	92	145	4	9	6
	8- Jamal Hammo	72	85	160	0	19	18
	9- Khalil Al-Naief	75	94	184	0	0	8
	Mean system II	**70**	**90**	**163**	**1.3**	**9.3**	**10.7**

Annex 4
GI and Lugworm Parasite Infestation in Sheep Flocks in Northern Syria

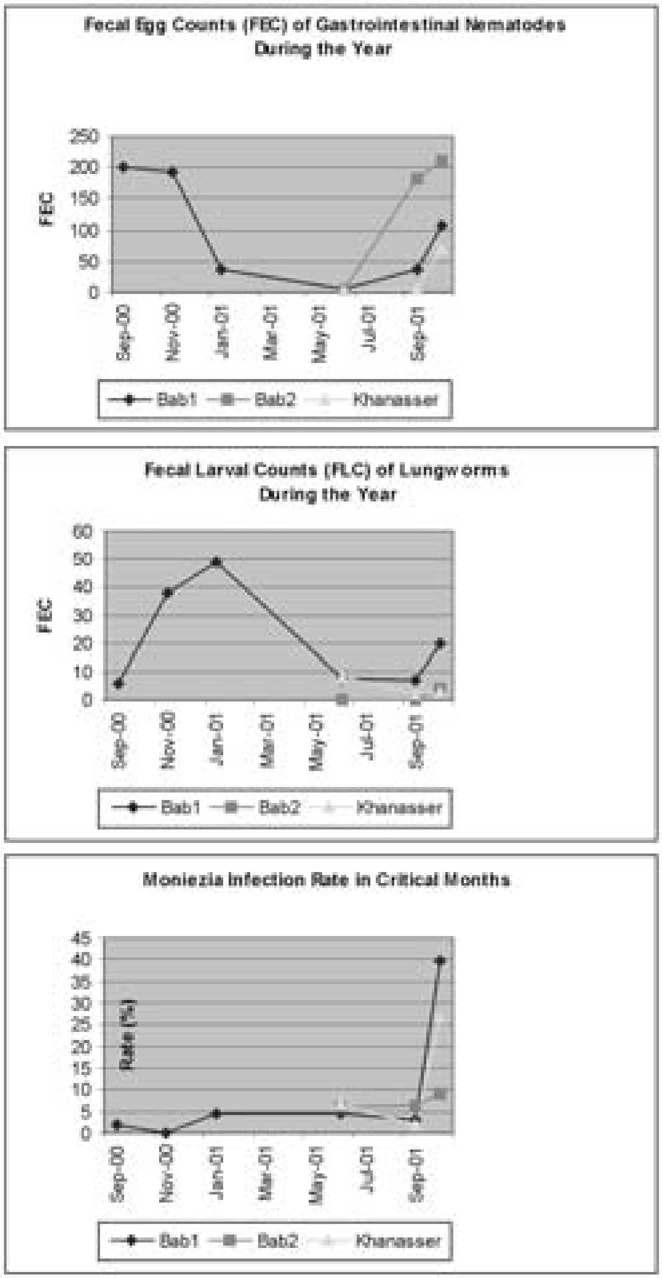

Figure 1. Overall dynamics of parasite infestation through the year.

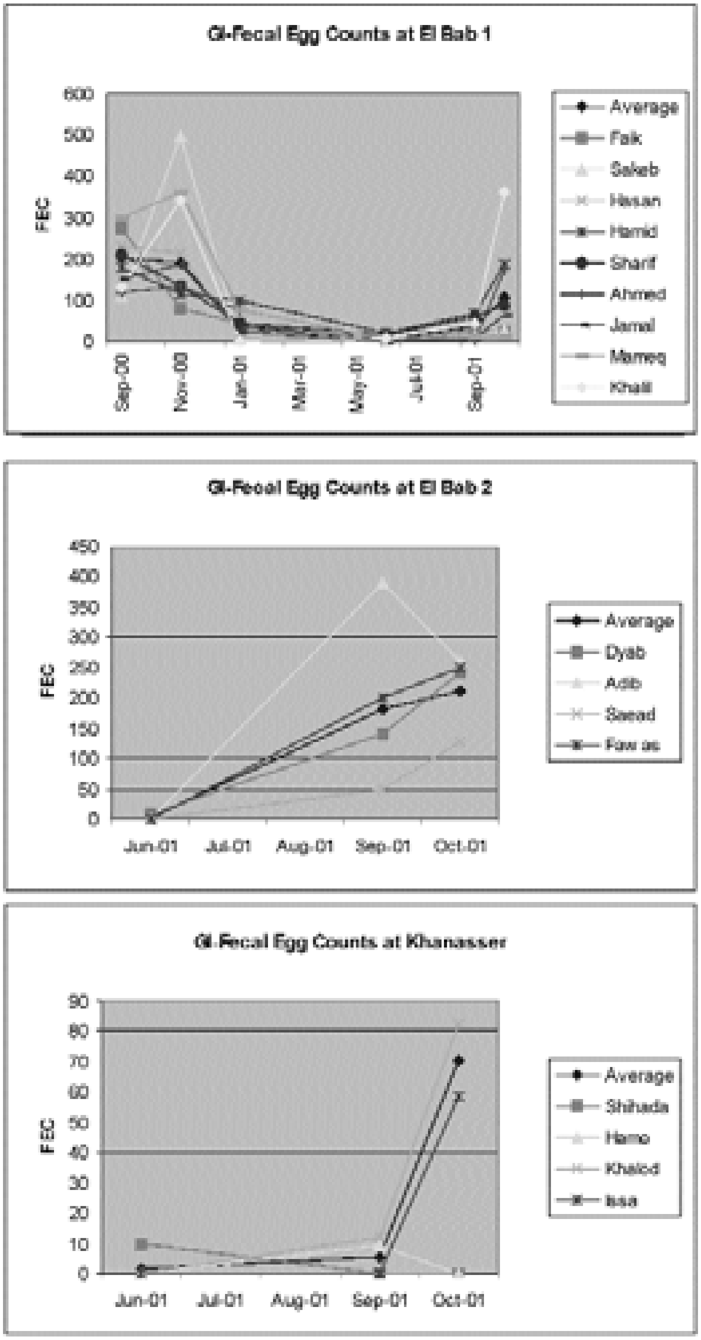

Figure 2. Changes in GI-parasites during the year.

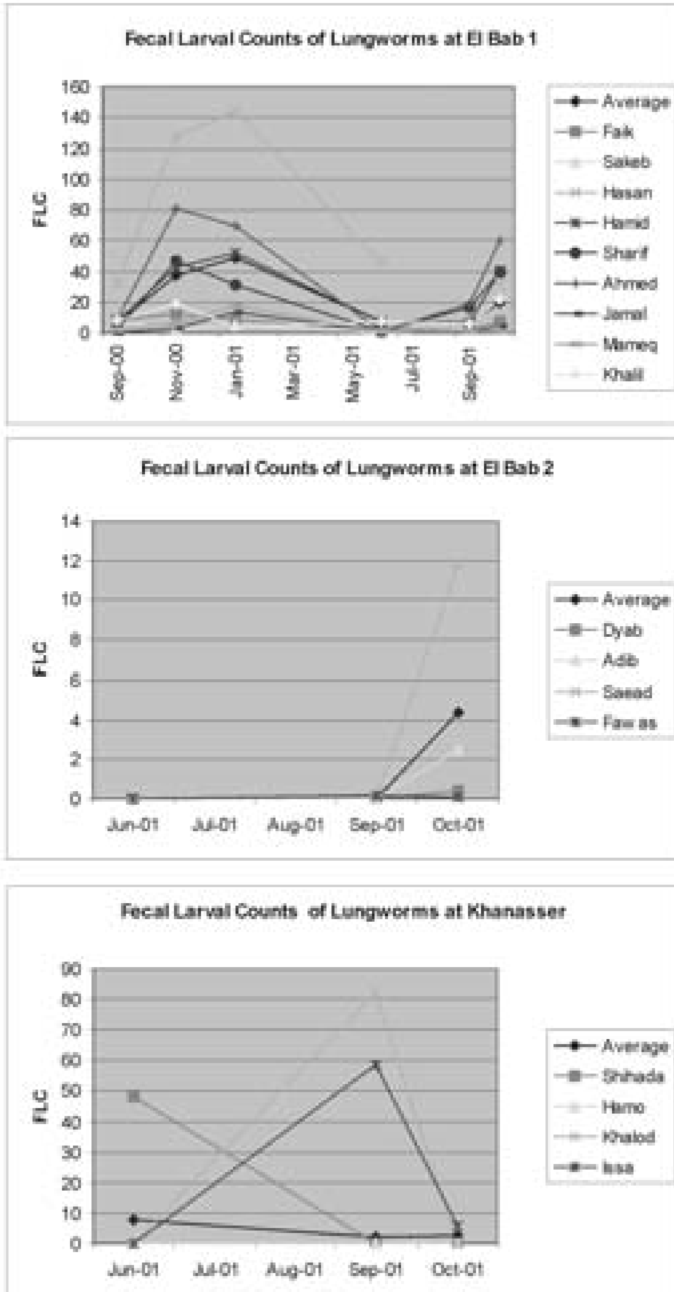

Figure 3. Changes in lungworm infestation during the year.

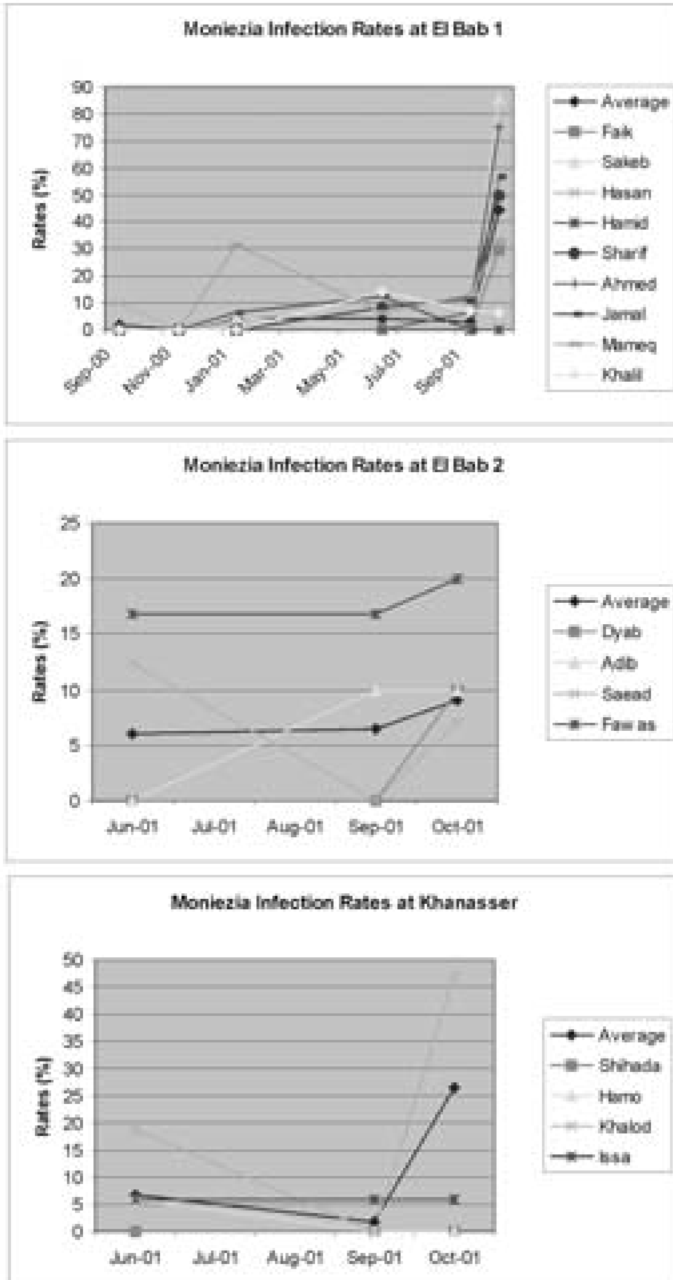

Figure 4. Changes in Moniezia infestation during the year.

Annex 5
Research Results on Use of By-products

Table 1. Live weight changes in Awassi sheep and costs of supplementation with feed blocks containing urea to improve the use of stubbles and with traditional concentrates at two locations in northern Syria.

	Tel Hadya		**El Bab**			
			Farmer 1		**Farmer 2**	
Stubble grazing period	8 July-28 August		31 July-10 September			
Grazing days	50		40			
Physiological stage of ewes	Mating and early pregnancy					
No. of animals	15	15	30	38	30	30
Supplementation treatments	**None**	**FB**	**S1**	**FB**	**S2**	**FB**
CP provided by Sup. (g/sheep/day)	0	125	109	106	62	76
ME provided by Sup. (MJ/sheep/day)	0	2.7	4.4	2.4	3.3	1.6
DM intake Stubble (kg/sheep/day)	1.6	1.3	-	-	-	-
DM intake supplement (kg/sheep/day)	0	0.33	0.50	0.28	0.37	0.20
Live weight start (kg)	43.9	43.1	48.9	47.1	52.3	51.5
Live weight end (kg)	44.3	47.9	52.9	50.3	55.0	54.4
Weight change	0.4	4.8	4.0	3.2	2.7	2.9
Daily weight change (g/day)	8	96	100	80	68	73
Cost of supplement (SL/sheep/day)	0	1.2	3.2	1.0	2.3	0.7
Saving of replacing supplement by FB (SL)			2.2 (69%)		1.6 (70%)	

FB: 20% crude olive cake, 20% sugar beet pulp, 20% wheat bran, 17% molasses, 10% urea, 1% salt-minerals-vitamins and 12% binders.
S1: 200 g Barley Grain, 100 g Wheat Bran and 200 g Cottonseed meal.
S2: 200 g Barley Grain, 100 g Wheat Bran and 66 g Cottonseed meal.

Table 2. Preserving tomato pulp by sun drying alone or mixed with chopped straw or crude olive cake in different proportions.

Ingredients	**Pulp alone**	**Tomato pulp/Straw**			**Tomato pulp/Crude olive cake**		
Ingredients (%)	100	75/25	50/50	25/75	75/25	50/50	25/75
Fresh wt., kg	50	37.6/12.4	25.0/25.0	12.4/37.6	37.6/12.4	25.0/25.0	12.4/37.6
Sun-dried wt., kg	37.0	37.8	38.8	39.4	38.2	39.0	40.4
DM% (sun-dried)	74.0	75.6	77.6	78.8	76.4	78.0	80.8
Days to dry	11	8	6	4	9	7	6
DM% (oven drying at 700 $^{\circ}$C)	87.5	88.1	88.6	89.7	86.4	87.6	88.2
Chemical composition							
DM, %	92.2	93.3	93.3	93.2	93.7	93.5	93.4
Ash, %	5.9	10.4	14.1	14.0	4.4	3.5	3.4
ADF, %	43.0	37.4	43.1	44.7	38.2	46.2	48.2
CP, %	21.3	10.0	6.9	6.6	11.1	10.3	8.7
Digestibility (In vitro)							
DMD, %	63.1	49.4	45.8	45.6	32.5	23.0	22.6
DOMD, %	61.4	45.4	40.1	40.6	30.2	18.9	17.7
ME (MJ/kg)	9	7	6	6	5	3	3

Table 3. Chemical composition and digestibility of tomato fresh pulp and other ingredients of the mixes.

Byproduct	CP%	DMD%	DOMD%	ME (MJ kg)
Tomato pulp fresh (collected in July 2001)	22	65	61	9
Wheat straw	3	38	32	4
Solvent Extracted Crude Olive Cake	4	8	5	1

Table 4. Quality of silages of tomato pulp alone and in combination with straw and olive cake after 4, 8 and 12 week storage periods.

Ensiling period	4 weeks	8 weeks	12 weeks
Tomato pulp (TO)			
Smell	Good	Very good	Very good
Color	Bright	Bright	Bright
Taste	Sour	Sour	Sour
Texture	Good	Very good	Very good
PH	4.8	4.8	4.6
Tomato + Straw (TS) 75:25			
Smell	Good	Very good	Very good
Color	Bright	Bright	Bright
Taste	Little sour	Sour	Sour
Texture	Good	Very good	Very good
PH	5.0	4.9	4.7
Tomato + Straw (TS) 50:50			
Smell	Good	Very good	Very good
Color	Bright	Bright	Bright
Taste	Little sour	Sour	Sour
Texture	Good	Very good	Very good
Texture	Good	Very good	Very good
pH	5.2	5.1	5.0
Tomato + Olive Cake (TO) 75:25			
Smell	Good	Very good	Very good
Color	Bright	Bright	Bright
Taste	Sour	Sour	Sour
Texture	Good	Very good	Very good
pH	4.8	4.7	4.4
Tomato + Olive Cake (TO) 50:50			
Smell	Good	Very good	Very good
Color	Bright	Bright	Bright
Taste	Sour	Sour	Sour
Texture	Good	Very good	Very good
pH	4.8	4.6	4.3

Table 5. Chemical composition (g/kg) and in vitro digestibility of ingredients and silages

	DM	CP	Ash	ADF	IVDMD	ME(MJ/kgDM)
Tomato pulp	136	221	60	436	666	9.2
wheat straw	926	35	118	437	462	6.4
Olive cake	928	57	49	616	190	2.6
Silages after 4 weeks						
T	157	259	57	481	674	9.3
75T/25S	304	75	103	448	470	6.6
50T/50S	453	57	118	441	468	6.1
75T/25O	368	111	43	548	337	4.1
50T/50O	485	81	56	560	280	3.5
Silages with additives[1] after weeks						
T	146	255	79	512	538	7.6
90T/10S	193	150	103	483	509	7.3
80T/20S	265	128	163	426	522	6.9
75T/25S	296	136	158	405	442	6.6
90T/10O	205	199	66	490	423	6.0
80T/20O	319	261	48	455	357	4.9
75T/25O	362	204	47	449	357	4.7

T: tomato pulp, S: wheat straw, O: olive cake.

[1] 2% molasses, 2% urea and 1% soybean meal.

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 around 1250 m^3 compared to the world's 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 is 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 Mandate, activities are aimed at optimizing supplemental irrigation in rainfed areas, promoting water harvesting in drier environments, increasing water use efficiency in irrigation, utilizing sustainable marginal-water and building the capacity of NARS in water resources management.

Objectives

Water resources in the dry areas that are potentially available for agriculture, efficiently and sustainable utilized for improved and stabilized agricultural production. Immediate Objectives include:

1. Rainfall in the drier areas properly managed through water harvesting in sustainable and integrated production systems for improved agricultural production and less degradation or desertification.
2. In rainfed areas limited water resources are utilized efficiently and effectively in conjunction with rainfall through supplemental irrigation for improved and stabilized agricultural production.
3. 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.
4. Unconventional water resources, in particular saline waters and sewage effluent, are managed properly for improved potential in agriculture through new technologies that ensure safety and sustainability.
5. Ground water resources in rainfed areas, in particular shallow aquifers, are optimally and sustainable used (quantity and quality) in irrigation.
6. Clients of on-farm water management are well trained on issues related to conducting needed research and transfer of technologies.

Research in 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.

Runoff Modeling of Micro-catchment Water Harvesting

Adriana Bruggeman and Theib Oweis

Rationale

Water harvesting, the collection and beneficial use of surface runoff, has the potential to greatly increase the water availability for agricultural production in the dry areas. The amount of runoff water that can be collected depends on the characteristics of the precipitation and the physical properties of the catchment area. Hydrological models that estimate surface runoff can aid the design of efficient water-harvesting systems. To assess the effect of various factors on runoff generation and to collect data to evaluate the use of runoff estimation models, 36 micro-catchments were installed on a montmorrillonitic clay soil (Calcixerollic Xerochrept) in northern Syria. The plots varied in the following features: soil depth (deep and shallow); slope (5% and 10%); catchment length (4, 8, and 12 m); and surface treatment (natural, compaction, and NaCl). This report analyzes the rainfall and runoff data from five seasons, starting in the fall of 1994.

Objectives

To aid the design of micro-catchment water-harvesting systems for agricultural production in dry areas, runoff monitoring plots were installed on clay soil at Tel Hadya, in northern Syria. Two low-cost surface treatment techniques, compaction and salt application, were included in the experiment. The objectives of this study are: (i) to test the runoff efficiency of micro-catchments for different soils, slopes, catchment lengths, and surface treatments; and (ii) to evaluate the potential use of runoff estimation models for micro-catchment water-harvesting design, considering readily available data.

Introduction

The harvesting of runoff water from precipitation has a long tradition in the West Asia and North Africa region (e.g., Bruins *et al*., 1986; Brunner and Haefner, 1986). Increasing pressure on land and water resources in the dry areas has sprouted renewed interests in these techniques. The occurrence of surface runoff is common in arid regions where high rainfall intensities, shallow soils, dense surface crusts, and poor vegetative cover often cause the rainfall to exceed the infiltration capacity of the soil. Collection of this runoff water may allow crops, shrubs, and trees to grow in areas where the natural rainfall alone would not be sufficient for their growth. The term "water harvesting" is used to describe a wide range of methods for collecting and concentrating different forms of runoff water such as rooftop runoff, overland flow, and stream flow. Uses of the collected water include crop production, livestock watering, and domestic needs. Reij *et al.* (1988) have presented a review of the different terms and classifications used to categorize the various water-harvesting systems and techniques. For agricultural production, two broad categories can be distinguished: macro-catchment and micro-catchment techniques. Macro-catchment techniques are often referred to as water spreading or floodwater harvesting. These systems reduce, divert, or collect the runoff water from ephemeral streams *(wadis)* to allow infiltration of water in the stream channel bed, irrigation of adjacent cultivated fields, or storage in surface reservoirs. Micro-catchments collect surface runoff over a flow distance of usually less than 100 m and store the water in the adjacent root zone of a crop, or of one or several shrubs or trees. Typical examples of micro-catchment systems are small basins (*"negarims"*), semi-circular bunds, and contour ridges. Advantages of micro-catchments as compared to macro-catchments are that these smaller systems: (i) have a higher runoff efficiency; (ii) do not require water conveyance or storage facilities; (iii) are less susceptible to destruction by heavy storms; and (iv) can be installed by small farmers using commonly available tools and resources.

The amount of water that can be harvested during a rainfall event depends on the intensity, quantity, and distribution of precipitation events and on the size and characteristics of the catchment area. Factors that affect surface runoff from the catchment area include the soil properties, surface roughness, vegetative cover, stoniness, and slope. To increase the quantity of surface runoff the catchment area can be modified. Techniques may vary from simple surface clearance or compaction to application of sodium salts, paraffin wax, latex, silicone, bitumen, asphalt and oil emulsions, or plastic sheets. Although promising results of experiments with various surface treatments have been reported (e.g., Rauzi, 1973; Mehdizadeh *et al.*, 1978; Frasier *et al.*, 1979), cases of successful use by small farmers seems to be less well documented.

To design efficient micro-catchment water-harvesting systems the optimum ratio between catchment and cultivated area need to be estimated. Data on micro-catchment runoff efficiencies are few and variable (e.g., Sharma, 1986; Boers, 1994; Oweis and Taimeh, 1996). Critchley and Siegert (1991) advice to install experimental plots for measuring rainfall and runoff at newly to develop water-harvesing sites. To capture the natural variability of the rainfall, plots need to be monitored for various years. This requires considerable investments, time and human resources. Although various mathematical models for the design and of water-harvesting systems have been presented (e.g., Ben Asher and Warrick, 1987; Oron and Enthoven, 1987; Boers, 1994; Sanchez-Cohen *et al.*, 1997), the lack of data required by these models often hampers their application.

To aid the design of micro-catchment water-harvesting systems for agricultural production in dry areas, runoff monitoring plots were installed on clay soil at Tel Hadya, in northern Syria. Two low-cost surface treatment techniques, compaction and salt application, were included in the experiment. The objectives of this study are: (i) to test the runoff efficiency of micro-catchments for different soils, slopes, catchment lengths, and surface treatments; and (ii) to evaluate the potential use of runoff estimation models for micro-catchment water-harvesting design, considering readily available data.

Materials and Methods

Thirty six runoff plots were installed at Tel Hadya, ICARDA's main research station in northern Syria, and 30 km southwest of Aleppo. The experimental site is located 310 m above sea level. The mean annual precipitation (20 seasons) observed at Tel Hadya's meteorological station is 346 mm. The rainfall distribution is typical Mediterranean; approximately 95% of the total annual precipitation occurs from October to April with a maximum in January. The rainfall occurs during the cold season with low evaporation rate. Annual mean evaporation (class-A pan) is 7 mm/d. Evaporation is lowest in December and January (1-2 mm/d) and peaks in July (15 mm/d).

The soils at Tel Hadya's experimental station are Inceptisols. The soil at the water harvesting plots is classified as Calcixerollic Xerochrept (Ryan *et al.*, 1997). The soil is well drained and consists of moderately weathered minerals with a high clay fraction (montmorillonitic). There is low biological activity in the subsoil and bulk density is higher than in the surface layer; thus less pores and a reduced hydraulic conductivity in comparison to the surface layer can be expected. The underlying limestone is slightly weathered. The soil depth is approximately 80 cm.

The 36 plots are laid out across the contour. The width of the plots is 4 m; and lengths are 4, 8, and 12 m. Small earthen embankments are installed along the boundaries of the plots, preventing upslope runoff to enter the plot. Small metal flumes guide the runoff water from the lowest corner of the plot into a 0.22-m^3 barrel. A tipping bucket rain gauge is installed in the center of the experimental area. The amount of runoff in the barrels was measured daily, in the morning and afternoon.

To test the effect of surface treatment on the runoff potential of clay soils, 12 plots were compacted (5 kg/cm^2) and 12 were treated with sodium chloride

(1.25 kg/m²), during the installation of the plots. Although the plots are weeded regularly, annual species cover the plots during part of the rainy season. Summing up, the plots varied in the following factors: (i) soil depth: deep, shallow; (ii) slope: 5%, 10%; (iii) catchment length: 4, 8, 12 m; (iv) surface treatment: natural, compacted, salt. The shallow soil is of the same type as the deep soil, but its surface layer has been removed to simulate the properties of a shallow or partly eroded soil.

Results and Discussion

Precipitation

The average precipitation of the five observed seasons at the water-harvesting site is 352 mm, which is close to the 346 mm long-term mean (1980-1999) for Tel Hadya. The driest and wettest season of the five observed years (Table 1) fell within the 25% left and right tail, respectively, of the annual rainfall distribution. Daily rainfall from the rain gauge at the site was highly correlated with the precipitation observed at Tell Hadya's meteorological station, located approximately 1 km southwest of the site ($r^2 = 0.993$ for the 1998-1999 season). However, the annual precipitation at the site was consistently 5 to 8% lower than the precipitation observed at the meteorological station. This might have been due to the topography of the area. The micro-catchments are located at the lower part of a gentle, westward facing slope, whereas the meteorological station is located in a flat plain.

The distribution of the daily rainfall events in depth classes is presented in Table 1. The relatively dry 1994-1995 season had a high number of small events, which are not expected to generate runoff. During the wet 1996-1997 season, four events exceeded 20 mm. The distributions of the depths of the daily rainfall events of the five seasons were, however, not significantly different at the 5% probability level, according to the Kolmogorov-Smirnov test (SAS Institute Inc., 1988).

Table 1. Precipitation characteristics observed at the water-harvesting site.

Season	Precip.	Number of events in depth class					
		0-5 mm	5-10 mm	10-20 mm	20-30 mm	30-40 mm	40-50 mm
	mm						
1994-95	313	80	12	5	1	2	0
1995-96	374	71	20	10	0	0	0
1996-97	405	70	14	8	3	0	1
1997-98	387	63	18	12	1	0	0
1998-99	283	56	10	7	2	0	0

Runoff Efficiencies

The design of water harvesting systems for agricultural production is often based on annual runoff coefficients. This runoff coefficient, also called runoff efficiency, is simply the ratio of catchment runoff to the precipitation falling on the catchment area. Thus, the annual runoff coefficient is computed as

$$RC = R/P \quad \text{..}(1)$$

where R is the total annual runoff (mm) and P is the total annual precipitation (mm). The runoff depth is obtained by dividing the runoff volume by the catchment area.

The annual runoff coefficients of the micro-catchments at Tel Hadya varied between 0.0 and 0.53. However, these runoff coefficients slightly under-estimate the runoff, because overflow of the observation barrels occurred during some of the larger events. The highest runoff efficiencies were obtained at the salt-treated plots on the shallow soil during the wet 1995-96 and 1996-97 seasons. During the dry 1998-99 season no runoff was observed from all three 12-m plots on deep soil with a 10% slope.

To assess the long-term efficiency of the micro-catchments under variable rainfall conditions, the annual runoff coefficients were averaged for the five seasons (Table 2). As expected, runoff efficiencies were higher on the shallow soil than on the deep soil. The effect of the surface slope was less clear. An increase in slope decreases the surface storages and increases the flow speed, thus, reducing the potential for the runoff water to infiltrate. The data showed differently: on the shallow soil, runoff efficiencies were higher on the 5% slope than on the 10% slope. The difference was most pronounced at the 4-m plots. For the deep soil the differences between the runoff efficiencies of the 5 and 10% slopes were small. Sharma (1986), conducting experiments on sandy loam micro-catchments in an arid region in India, found a substantial increase in runoff when the slope increased from 0.5 to 5%, but almost similar runoff efficiencies for 5 and 10% slope plots. Casenave and Valentin (1988) concluded from work in West Africa that the effect of slope on runoff reduced above a slope of 5%.

Table 2. Average annual runoff coefficients of the water-harvesting plots.

Soil depth	Slope	Natural			Compacted			Salt		
	%	4*	8	12	4	8	12	4	8	12
Shallow	5	0.11	0.04	0.04	0.17	0.09	0.05	0.34	0.24	0.13
Shallow	10	0.08	0.05	0.02	0.11	0.10	0.03	0.24	0.21	0.15
Deep	5	0.09	0.04	0.02	0.07	0.03	0.02	0.11	0.08	0.06
Deep	10	0.06	0.05	0.02	0.06	0.04	0.02	0.12	0.09	0.06

* Plot length (m).

The runoff coefficients consistently decreased with an increase in catchment length. This is a commonly observed feature, caused by the spatial variability in the infiltration capacity of the soil, microtopography, and vegetation. Surface runoff generated on an area with low infiltration capacity may infiltrate on an adjacent area with higher infiltration capacity. Thus, the longer the plot, the more chance the surface runoff has to infiltrate on its way down. Although the smaller catchments are more efficient, they may not yield sufficient runoff water needed for agricultural production. The longer plots are likely to generate higher runoff volumes, because of the larger contributing area. For the natural and compacted plots on deep soils, the average annual runoff volumes at the 5% slope were higher for the 4-m plots than for the 8- and 12-m plots; at the 10% slope runoff volumes were highest for the 8-m plots. On the shallow soil, average annual runoff volumes for the natural plot with 5% slope and the salt-treated plot with 10% slope were higher for the 12-m plots than for the 8 and 4-m plots. At the other slope-treatments combinations the 8-m plots produced more runoff. Theoretically, if one expands a plot in the upstream direction, runoff volumes can only become more, not less. Obviously, the measured runoff volumes were strongly affected by the inherent natural variability of the soils.

Effect of Surface Treatment

The average annual runoff coefficients (Table 2) indicate that the compaction of the catchments had almost no effect on the runoff efficiencies of the deep soils. On the shallow soil, compaction was more effective; it doubled the runoff of the 8-m plots, as compared to the natural plots. However, the effect of compaction decreased with time. After three season, the runoff coefficients of the compacted plots are almost the same as those of the natural plots (Figure 2).

The salt treatment had a substantial effect on the runoff from all plots. The applied NaCl caused soil dispersion, resulting in the plugging and sealing of the surface pores by the finer soil particles, similar to the effect caused by irrigating with high sodium content water (Ayers and Westcot, 1985). During the wet second season the runoff of the salt treated plots was almost five times as high as from the natural plots. The effect of the salt started to decrease during the third season, especially on the deep soil (Figure 2). In the fifth season (1998-99), the average runoff volume harvested from the salt-treated catchments was 0.50 m^3, as compared to 0.29 m^3 for the compacted catchments, and 0.26 m^3 for the natural catchments.

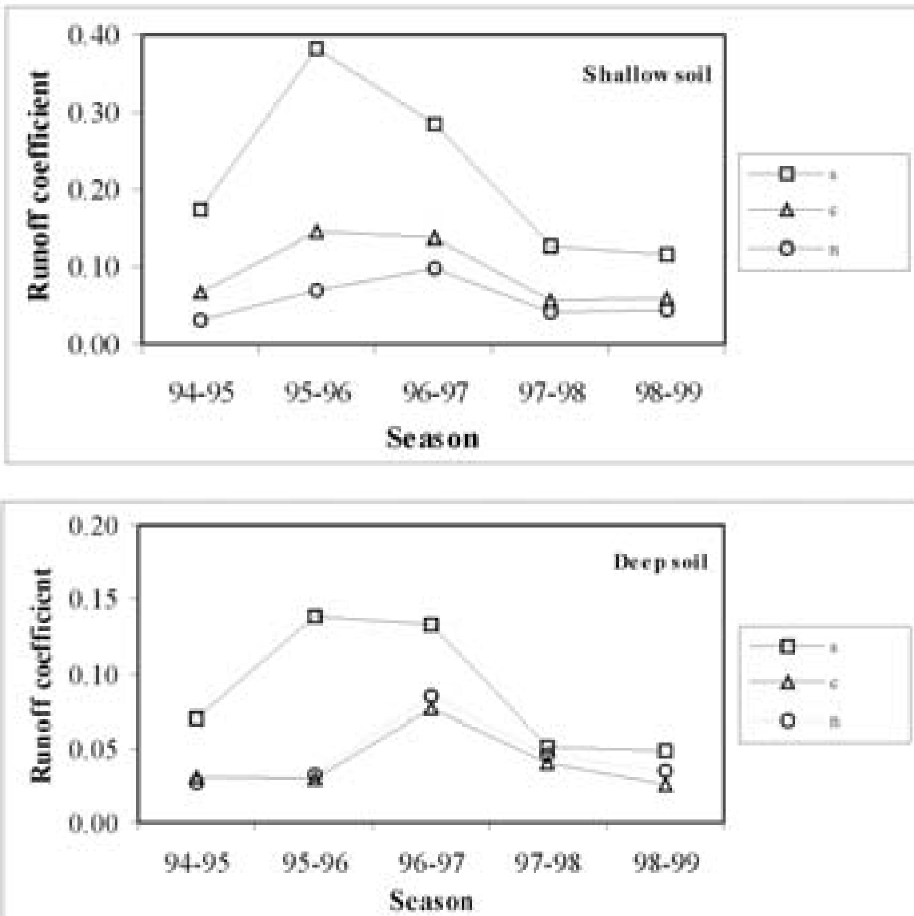

Figure 1. Runoff efficiencies of surface treatments during five seasons after application.

Sodium chloride has an adverse effect on the quality of water for plant, animal, and human consumption. Although most of the applied salt will stay in the surface layer of the catchment, still, part of the salt will wash off and pollute the harvested water, and part may even leach to the groundwater. Therefore, the application of salt, although a relatively simple and low-cost method, should be used with caution. Rauzi *et al.* (1973), who tested the runoff efficiency of different surface treatments on loam and sandy loam soils, not recommended the use of salt, because its dramatic effect on erosion from the catchment area and its low efficiency, relative to gravel-covered plastic and asphalt roll roofing.

Runoff Modeling

Models can be used to improve our understanding of field observations and to allow the transfer of experimental results to areas without monitoring systems. Infiltration and runoff are rate-based processes, driven by the intensity of a rainstorm (rainfall rate). Because rainfall intensity data are seldom available for potential water-harvesting sites, the here presented model assessment relates runoff empirically to daily rainfall. The application of empirical models requires that the catchment properties and daily rainfall events used to develop the model are representative of the catchment properties and the rainfall intensity pattern in the area of model application. Graphical analysis of the rainfall-runoff data of each runoff plot showed very irregular patterns. The linear model and the curve number method were selected for testing, because of their widespread use.

Linear Model

The most commonly used model for representing the rainfall-runoff relationship is the empirical linear regression model (e.g., Diskin, 1970; Sharma, 1986; Boers *et al.,* 1986). This model can be expressed as follows:

$$R = 0 \qquad \text{for } P \le P_o \qquad (2a)$$

$$R = c\,(P - P_o) \qquad \text{for } P > P_o \qquad (2b)$$

where R is runoff (L), P is precipitation (L), and c (-) and P_o (L) are constants. The constant P_o is the threshold rainfall above, which runoff occurs, and c is the runoff coefficient after the threshold rainfall has been exceeded (-). Due to the variation in rainfall-runoff events, the threshold value is not known *a-priori.* To determine P_o, Diskin (1970) ranked experimental rainfall-runoff pairs in order of increasing precipitation and computed different linear relationships by varying the value of the constant (P_o). The optimum value of P_o was found by minimizing the sum of square residuals, computed for all rainfall events, for all models.

Because the compacted and salt-treated plots were affected with time, the model assessment focused on the natural plots. The first three years of data were used to develop the models, the fourth and fifth season were used to evaluate the models. Linear models for the eight natural plots were obtained according to the above procedure using the data for the first three seasons. Because of the scatter of the data the sum of square errors was very large. Therefore, the total annual runoff was used as an evaluation criterion for selecting the models, by minimizing the maximum error in the annual runoff. Application of the thus selected models reduced the errors in the estimation of the annual runoff of the fourth and fifth season. The threshold rainfall (P_o) varied between 0.074 and 0.821 at the shallow soil and between 0.029 and 4.449 at the deep soil. The runoff coefficients (c) varied between 0.021 and 0.106 at the shallow soil and between 0.019 and 0.119 at the deep soil. The highest coefficient of determination (r^2) was 0.30. The average error in the estimation of the annual runoff was 154% for the first three seasons and 146% for the last two seasons. For the shallow soil these errors were 299% and 164%, respectively. These results indicate that the linear models have little potential for application.

Curve Number Method

A different approach for estimating runoff from daily precipitation is provided by the curve number method, developed by the U.S. Soil Conservation Service (SCS, 1972). The runoff properties of the catchments are represented by the curve number, which is selected from a table, based on land use, soil type, soil moisture, and hydrologic condition of the catchment area. Due to its ease of use, the concept is widely used over the world, and additional insights and criteria have been added by various researchers (e.g., Boughton and Stone, 1985; Dilshad and Peel, 1994; Steenhuis *et al.*, 1995; Hawkins, 1996). Although this model was developed for small agricultural watersheds in the United States, the form of the rainfall-runoff relation indicate that this approach may also apply to micro-catchments. Similar to the linear model, runoff starts after some rainfall has accumulated (threshold). The plotted curves of runoff versus rainfall depths asymptotically approach a line with a 450 slope; the difference between rainfall and runoff is defined as the potential maximum retention. The runoff threshold, referred to as the initial abstraction, was empirically estimated as 0.2 times the potential maximum retention. For convenience, the retention parameter is converted into a dimensionless parameter, the curve number, which varies between 0 and 100. The curve number method is expressed as follows

$$Q = 0 \qquad \text{for } P \leq 0.2S \text{..........................} (3a)$$

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)} \qquad \text{for } P > 0.2S \text{..........................} (3b)$$

$$CN = \frac{1000}{S/25.4+10} \qquad \text{...} (3c)$$

where Q is the daily runoff (mm), P is the daily precipitation (mm), S is the potential maximum retention (mm), and CN is the curve number.

To account for the effect of soil moisture on the runoff process, the method uses three sets of curve numbers, i.e., for dry, average, and wet conditions. Ponce and Hawkins (1996) explain that the definition of these conditions, based on the rainfall amount for the previous five days (SCS, 1985), was rather arbitrarily. They report that the current version of the curve number model leaves the selection of the moisture condition to the user. Obviously, there are more sources of variability that affect the runoff process. Ponce and Hawkins (1996) suggest that the curve numbers for dry and wet conditions should be considered as a stochastic component, or error margin.

Curve numbers were determined for the first three seasons of the natural plots, using the above equations. The computed curve numbers for each plot could generally be described by a beta distribution. The 10%, 50%, and 90% cumulative probabilities were used to determine the lower limit, average, and upper limit of the curve numbers for each plot. For the 8-m plots with 5% slope on shallow soil, the low, average, and high runoff conditions are represented by the curve number values 84, 93, and 98, respectively. For the same plot on the deep soil, the curve numbers are 81, 91, and 98. These results confirm the lower runoff potential of the deep soil, as compared to the shallow soil. A more interesting observation is that under extreme conditions, such as high intensity rainfall and high soil moisture conditions, the deep soil could generate as much runoff as the shallow soil. Evaluation of the models for the 1997-98 and 1998-99 seasons showed that a very small percentage of the daily events fell outside the so-called error margins. For the 8-m plot with 5% slope on deep soil, runoff for 2% of the rainfall events fell above and 7% of the events fell below the error margin (Fig. 2). For all natural plots the total annual runoff fell within the boundaries predicted by the 10% and 90% boundaries. However, the predicted boundaries are so wide that they are of limited practical use. For the afore mentioned plot the error margins of the annual runoff for the 1998-99 season are 0.12 and 3.87 m3. Thus, this approach will only be useful if the curve numbers can be correctly assigned for each rainfall event, based on the effect and occurrence probabilities of the rainfall intensities, soil moisture conditions, and any other factors.

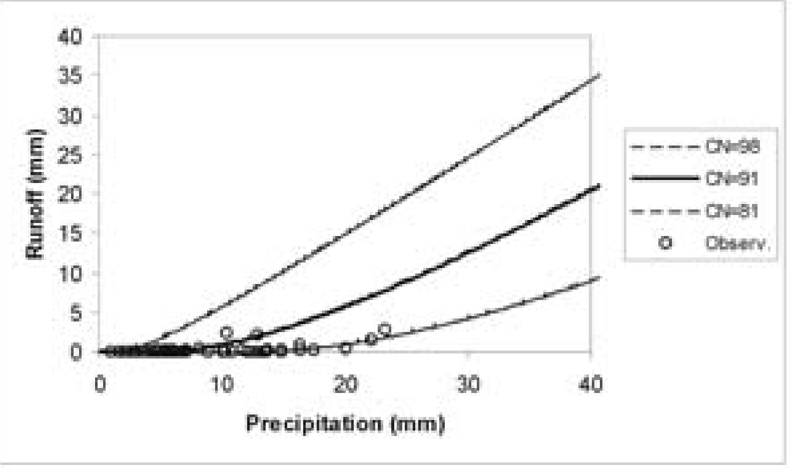

Figure 2. Curve number model for a natural plot on deep soil with 5% slope and catchment length 8 m.

Summary and Conclusions

Five years of runoff observations from micro-catchments on a montmorillonitic clay soil in northern Syria indicated that these soils have a very low potential for water harvesting. The average ratio of runoff versus rainfall for the study period was 0.05 at deep soils and 0.06 at shallow soils. Surface compaction (5 kg/cm^2) doubled runoff on the shallow soils, but had little effect on the deep clay soils. Surface treatment with NaCl (1.25 kg/m^2) has the potential to increase the runoff efficiencies with a factor five. The results indicated that to be effective both compaction and the salt treatment need to be applied once every three years. Because of its potential harmful effect on the environment, the use of salt need to be treated with caution.

The observed daily rainfall-runoff data were used to test runoff simulation models that could then be used for predicting micro-catchment runoff in similar environments. The linear model and the curve number method were tested. The observed runoff volumes showed an enormous variability between plots, and between events at the same plot. Runoff is affected by the variability and spatial distribution of the soil properties, microtopography, growth of natural vegetation. The effect of these factors could not be combined into a single runoff coefficient for a plot. The model analysis showed that the linear model was not suitable for estimating runoff from the plots.

Instead of falling into the trap of model over-parameterization, it seems more logic to consider a stochastic approach. Because the statistical properties of daily rainfall can be easily determined from existing long-term records, stochastic rainfall-runoff models often consider rainfall a random parameter, while ignoring the variability of the catchment properties (e.g, Oron and Enthoven, 1987; Sanchez-Cohen *et al.*, 1997). The work of Ben Asher and Warrick (1987) is a notable exception. Another interesting approach was presented by Hawkins and Cundy (1987). These authors addressed the effect of the spatial arrangements of variable infiltration capacities along a slope. It should be emphasized, however, that for stochastic models to be meaningful, in-depth knowledge of the statistical properties of the model parameters at the field site is required. The use of the curve number method, combined with a stochastic approach, showed a potential for predicting micro-cactchment runoff. However, a stochastic assessment of the effect of rainfall intensities, soil moisture conditions, and seasonal growth of natural vegetation in the catchment area on the curve number remains a subject of further study.

Finally, some observations should be made with respect to the experimental methods. The variability observed at the runoff plots suggests the necessity of an adequate number of replicates. Rainfall and runoff should be checked daily, but it is advisable to not take measurements during a rainfall event. Although models that are based on daily data use the rainfall observation time (e.g., 8:00 am), to distinguish between events, this time does not always coincide with the actual storm events. Therefore, the exact time of measurement should always be reported and the rain gauge should be read at the same time. When an automatic rain gauge is used, the daily rainfall amounts should be extracted based on the actual observation time. Finally, the measurement of runoff with collection tanks or barrels, as recommended by Critchley and Siegert (1991), can be found at experimental plots around the world. When labor costs are low, the use of runoff tanks provides indeed an easily applicable and low-cost technique. However, the runoff observation records indicated that the accuracy of this technique is low and prone to human error. If the data will be used for the evaluation of models and transfer of results, it should be considered to install an automatic rain gauge at the site and to equip each plots with a simple hydraulic flumes (e.g., H-flume) and stage recorder. The thus obtained runoff hydrographs also provide more insight in the hydrologic processes.

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

Supplemental irrigation strategies for winter wheat in northern Syria

T. Oweis, P.N. Rodriguez and L.S. Pereira

Rationale

The present, general practice in irrigated agriculture is to maximize crop yield per unit land by applying full crop water requirements. However, for several crops, maximizing yield is at the account of the water productivity, i.e. harvestable yield per unit volume of water used. For small grain cereals, water productivity drops at high yield levels under full irrigation (Zhang and Oweis, 1999). Maximum water productivity is attained at lower than potential yields. In areas where water is the most limiting resource to production, maximizing water productivity is more profitable to the farmer than maximizing yield per unit land. This is because water saved by deficit irrigation can be used to irrigate additional land, since land is not the most liming factor, at much higher overall water productivity. In northern Syria, applying 50% of full supplemental irrigation requirements would reduced yield by only 10-15%; applying the saved 50% water to lands that would otherwise be rainfed could increase total farm production up to 38% (Oweis, 2001). Such relation is important to determine the proper strategies for irrigation in areas where water, not land, is the most limiting factor. This is of particular importance when planning supplemental irrigation to cope with droughts.

Objectives

Supplemental irrigation strategies for coping with droughts and water scarcity assessed at field level and through model simulations to extend results to wider climatic demand and supply conditions. Specifically; to use the irrigation scheduling simulation model ISAREG, after appropriate validation, to simulate various irrigation schedules for winter wheat under average, high and very high climatic demand conditions to cope with water supply restrictions.

Materials and Methods

The winter wheat supplemental irrigation under limited water availability in north Syria was studied in ICARDA's research station at Tel Hadya, located 30 km north of Aleppo (latitude 36° 01'N, longitude 36° 56'E, elevation 284 m above sea level). The study used historical meteorological daily data, from September 1984 to August 2000, recorded in the weather station installed at the research site. The average monthly rainfall, average monthly reference evapotranspiration (ET_o), and average monthly minimum and maximum temperatures for that period are shown in Figure 1. ET_o was computed with the Penman-Monteith method using the program EVAP56 (Allen *et al.*, 1998). The average monthly minimum and mean relative humidity, and the average monthly wind speed at 2 m height for the same period are presented in Figure 2. The minimum relative humidity was estimated from the ratio of saturated vapour pressure at minimum and maximum temperature.

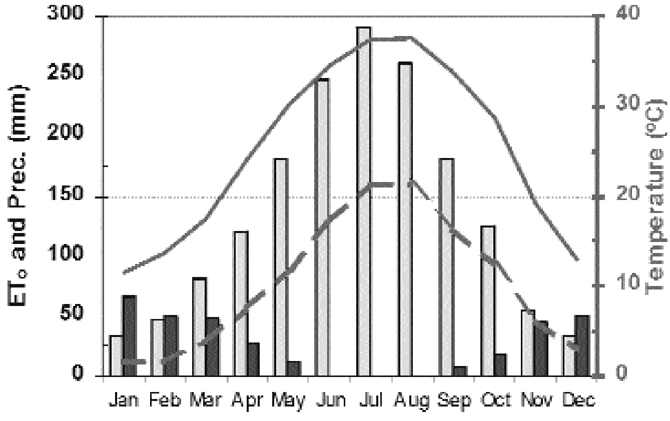

Figure 1. Average monthly rainfall (▬), average monthly reference evapotranspiration, ET_0 (▬), and average monthly minimum (– –) and maximum (—) temperature at Tel Hadya, 1984 - 2000

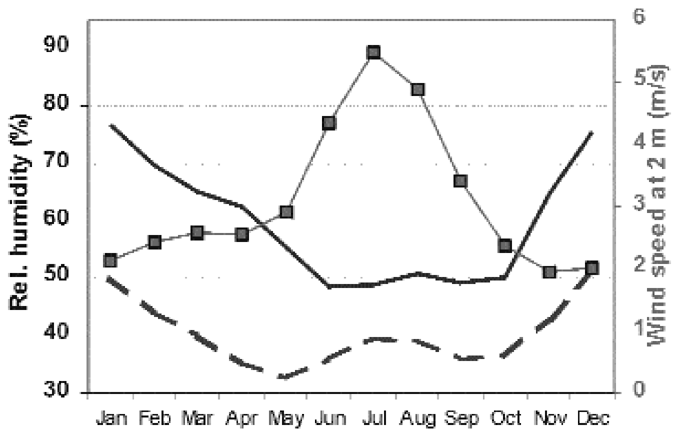

Figure 2. Average monthly minimum (- -) and mean (—) relative humidity, and average monthly wind speed (–■–) at Tel Hadya, 1984 - 2000

The main soil type at Tel Hadya is a Calcixerollic Xerochrept. On average, the textural classes are 15 % sand, 25 % silt and 60 % clay. The volumetric soil water content at field capacity (θFC) and at the permanent wilting point (θWP) is 44% and 24%, respectively (Zhang and Oweis, 1999). The soil depth within the experimental plots ranges from 1.0 to 1.8 m.

Modeling tools

The ISAREG model (Teixeira and Pereira, 1992) has been used to simulate different irrigation water management strategies and performs the soil water balance using different options to define and evaluate the irrigation schedules, as described by Teixeira and Pereira (1992) and Liu *et al.* (1998). The crop data parameters were determined with the KCISA program (Rodrigues *et al.*, 2000), which follow the updated methodology proposed by FAO (Allen *et al.*, 1998). The crop coefficients (K_c) and the soil water depletion fraction for no stress (p) have been adjusted to the Tel Hadya climate.

Yield losses due to water stress are estimated by using the yield response factors proposed by Stewart *et al.* (1976) and Doorenbos and Kassam (1979), adjusted to local conditions according to Alves (1990), Alves *et al.* (1991), and Alves and Pereira (1998). Two approaches are used. In the first, the Relative Evapotranspiration Deficit (RID) and the Relative Yield Losses (RYL) are used. RID is defined by ($1 - ET_d / ET_c$), where ET_d and ET_c are the seasonal crop evapotranspiration (mm) under deficit and full satisfaction of crop water requirements, respectively. RYL is defined by ($1 - Y_d / Y_c$), where Y_d and Y_c are the yields achievable when crop evapotranspiration is equal to ET_d and Et_c, respectively. RYL is assumed proportional to RID, this proportionality being represented by the crop yield response factor Ky (Stewart *et al.*, 1976; Doorenbos and Kassam, 1979).

The second approach considers the multiphase model proposed by Stewart *et al.* (1976)

$$1 - Y_d / Y_c = [\ \Sigma_i K_{yi} (ET_{ci} / ET_{di})\ ] / ET_c$$

where ET_c and ET_d, defined as above, are computed for each crop phase i, and K_{yi} are the crop yield response factors for the same phases i. The crop yield response factors for the considered growing stages are given in Table 1. The K_{yi} values utilised are not constant but vary with the intensity of water deficit in each phase and in the precedent phases in the range referred by Stewart et al, 1976.

Table 1. Crop yield response factors used in the model

Crop	Seasonal yield response factor, Ky	Multiphasic yield response factors, K_{yi}		
		Vegetative Growth	Flowering and yield formation	Maturation and senescence
Winter wheat	1.05	0.50 - 0.75	4.30 - 1.25	2.45 - 0.50

Stewart et al.,1976

The gross irrigation depths applied were estimated from the ratio between the net irrigation depths computed with the ISAREG model and the application efficiency estimated for the set sprinkler systems and for surface irrigation.

Water supply strategies

In the Tel Hadya research station, several irrigation methods are used. In this study surface irrigation and set sprinkler systems are considered. The average net irrigation depth In = 80 mm was adopted for surface irrigation and In = 40 mm for sprinkling.

When water availability is non-limiting, the frequency of irrigation is not restricted and varies along the crop season according to the crop demand since the supply system operates on-demand. Under limited water availability, the supply is made with restrictions in the available water volumes. Several irrigation scheduling strategies are applied in practice. For simulation purposes, the Management Allowed Depletion fraction (MAD), which is a common criterion for irrigation scheduling (Martin et al., 1990), is adopted for defining the alternative schedules. For full irrigation, the MAD fraction equals the soil water depletion fraction for non-stress (p), which is a well-defined crop and climate dependent factor (Allen et al., 1998). For water limited schedules, the MAD is a percentage of p. Restrictions were selected by combining different MAD fractions with different levels of the total available irrigation water during the crop season.

The non-restricted irrigation schedules are only constrained by the irrigation system characteristics, and correspond to the achievement of the maximal yield (MAD = 100 %p). The supplemental water saving schedules were simulated by imposing restrictions on the irrigation period, decreasing the available water (net season irrigation depth), and increasing water stress represented by progressively lower MAD. The corresponding irrigation strategies analysed in this study are summarised in Table 2. The alternative irrigation schedules are evaluated based on the indicators used in (Rodriguez et al. 2001; Zairi, et al., 2001).

Table 2. Supplemental irrigation schedules for the winter wheat to cope with limited water availability

Surface irrigation (I_n = 80 mm)		*Set-sprinkler systems (I_n = 40 mm)*	
Management Allowable Depletion (% p)	Available water; Irrigation dates	Management Allowable Depletion (% p)	Available water; Irrigation dates
100	No restrictions	100	No restrictions
100	After 01/04	100	After 01/04
90	01/04 - 15/05	90	01/04 - 17/05
80	240mm; 01/04 - 15/05	85	01/04 - 15/05
70	160mm; 01/04 - 15/05	75	01/04 - 15/05
70	80mm; 01/04 - 15/05	70	240mm; 01/04 - 15/05
Non irrigated	0	70	200mm; 01/04 - 15/05
		70	160mm; 01/04 - 15/05
		70	120mm; 01/04 - 15/05
		70	80mm; 01/04 - 15/05
		70	40mm; 01/04 - 15/05
		Non irrigated	0

Results

Model validation in north Syria

The ISAREG model validation is performed comparing the soil water content (% in volume) observed in field experiments throughout the crop season with those simulated by the model. Data of field trials with surface irrigation using variable irrigation depths for 3 irrigation seasons (1991/92, 1992/93 and 1993/94) in addition to data on rainfed conditions for the first two seasons were used in the analysis. Figure 3 presents the results of the model simulation for winter wheat at Tel Hadya in 1992/93 for the irrigated and rainfed treatments. Also included the rainfall events for the same crop season. It shows that the model appropriately describes the soil water content along the entire crop season. Results for the same experiments given in Figure 4 show that the regression line relative to the simulated vs. observed soil water content is close to the 1:1 line. Results in both figures indicate that the model appropriately describes the soil water content along the entire crop season.

Figure 5 compares the simulated and observed soil water content (% in volume) for all field trials analysed at Tel Hadya. It shows a regression coefficient b =1.00 but a relatively low determination coefficient, R^2 = 0.60, due to a quite large dispersion around the regression line, particularly for the high soil water content values. This may be due to the fact that the location of the weather station is distant from the field trials sites, which can cause errors in the rainfall estimates when local storms pass over Tel Hadya. In fact, for 1991/92 a negative difference between observed and simulated soil water content was observed following one rainfall event that causes a nearly constant model underestimation from there on. On the contrary, for 1993/1994 the model steadily overestimated the soil water after another rainfall event. These facts may indicate that in the first case rainfall was overestimated for that particular event and rainfall was underestimated for that day in 1993/94. For verification of this hypothesis, a correction in the rainfall depths for both events were simulated that produced results similar to those for 1992/93 (results not shown). However, because it was not possible to appropriately correct the rainfall data, results are kept as originally observed, so with the discrepancies identified in Figure 5. Nevertheless, the fact that the regression coefficient for all data is b = 1.0 indicates that the prediction capability of the model is satisfactory. Thus, the validation results are appropriate and show that the ISAREG model is able to predict the soil water content for irrigated and rainfed winter wheat in Tel Hadya. Therefore, it can be used to simulate alternative deficit supplemental irrigation schedules for similar conditions.

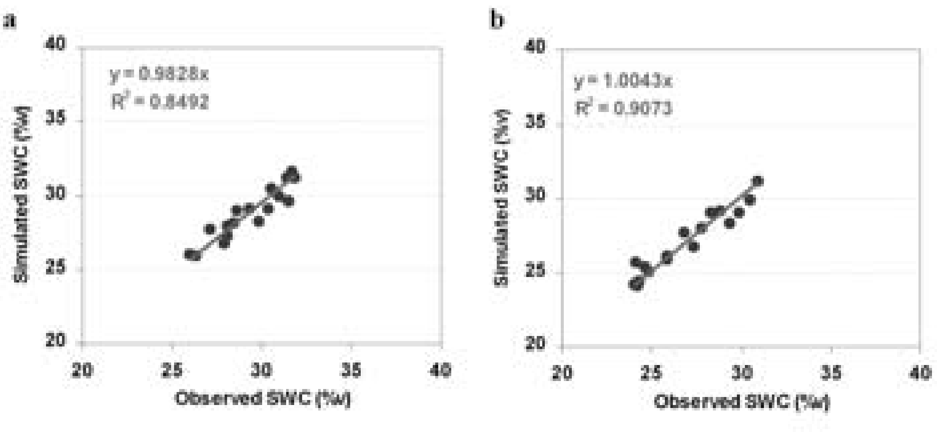

Figure 3. Simulated (—) and observed (•) soil water content (expressed in % volume) for irrigated (a) and rainfed (b) winter wheat treatments at Tel Hadya in 1992/93, and c) the observed daily rainfall for the season.

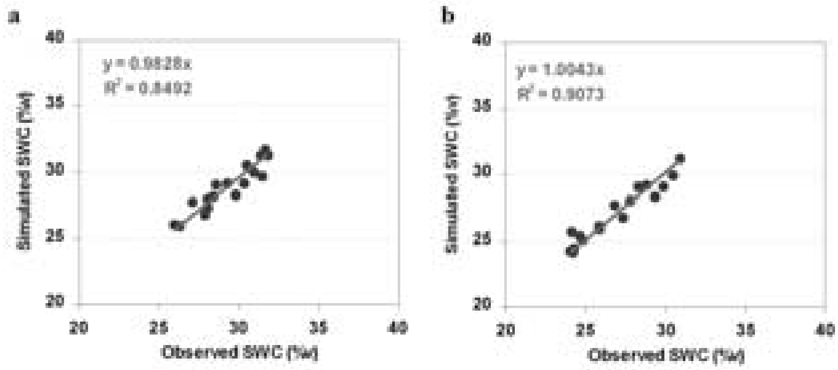

Figure 4. Regression between simulated and observed soil water content (expressed in % volume) for the irrigated (a) and rainfed winter wheat treatments shown in Figure 3 (Tel Hadya, 1992/93)

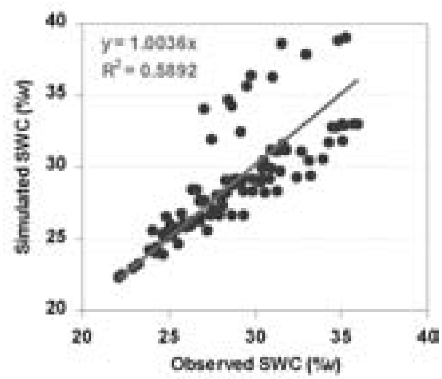

Figure 5. Regression between simulated and observed soil water content (expressed in % volume) for all winter wheat field trials analysed (Tel Hadya, 1991/92, 1992/93 and 1993/94)

Net irrigation requirements

The average dates for the crop development stages, the crop coefficients (K_c) and the soil water depletion fractions for no stress (p) are presented in Table 3 for winter wheat in Tel Hadya. The maximum effective rooting depth was estimated to be 1.5 m.

Table 3. Average crop parameters for wheat

Parameters	Crop development stages			
	Initial	Development	Mid season	End season
Wheat:				
Period length (dates)	20 Nov - 29 Dec	30 Dec - 9 Apr	10 Apr -14 May	15 May - 8 June
Crop coefficients, K_c	0.87	0.87 - 1.19	1.19	1.19 - 0.25
Depletion fraction, p	0.60	0.60 - 0.53	0.53	0.53 - 0.67

The Annual Net Irrigation Requirements (NIR) for the time series 1984-2000 were computed with the ISAREG model, as shown in Fig. 6 by performing a sequential soil water balance.

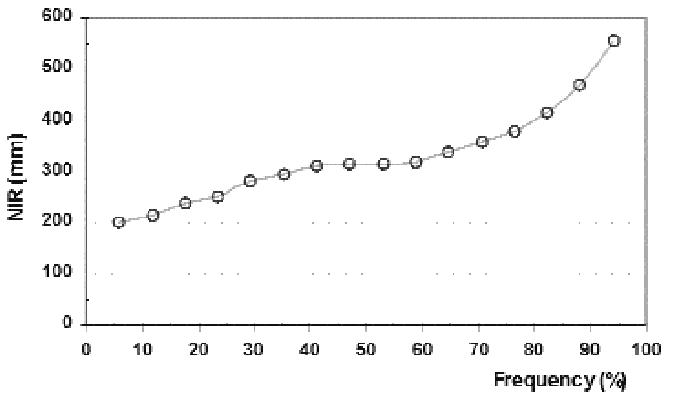

Figure 6. Frequency distribution of the wheat net irrigation requirements

Assuming a normal distribution for the computed NIR, the irrigation requirements for average, high and very high demand conditions, which correspond to the probabilities of 50, 20 and 5 % for being exceeded were identified. The analysis that follows is performed for these three reference years. Table 4 summarizes the Total Available Soil Water at Planting (TAWP), the season rainfall, the season crop evapotranspiration, and the season net irrigation requirements for the average, high and very high climatic demand conditions.

Table 4. Total available soil water at planting, seasonal rainfall, crop evapotranspiration, and net irrigation requirements (NIR) for average, high and very high climatic demand conditions for wheat at Tel Hadya

Demand condition	Available soil-water at planting (mm)	Seasonal rainfall (mm)	Non used rainfall (mm)	Season ETc (mm)	Net irrigation requirements (mm)
Average	50	307	37.4	537	316
High	50	221	0.0	554	417
Very high	50	152	0.0	682	555

Responses to deficit supplemental irrigation strategies

When water is not scarce, this study shows that water requirements of winter wheat in north Syria are about 320, 420 and 560 mm for the average, high and very high climatic demand conditions, respectively. It is recommended to apply one irrigation of 80 mm when surface irrigation is practised, or two irrigations of 40 mm in case of sprinkling at planting and early crop development stages if rainfall is insufficient to ensure appropriate crop establishment.

Model results indicate that under average climatic demand conditions (Figures 7 and 8), the adoption of supplemental irrigation for wheat is easily achievable. In fact, the water-yield characteristics of the wheat crop (Kirkham and Kanemasu, 1983) favour such strategies. Considerable reductions in the seasonal irrigation depths, from 320 to 80 mm, produce relative yield losses (RYL) not exceeding 26 % for both surface irrigation and set-sprinkler systems. This happens because the seasonal rainfall is enough to ensure producing grain yield. So limited yield losses occur when adopting supplemental deficit irrigation. When irrigation is applied in an average season, it is recommended to be practised during April.

Figure 7. Relative evapotranspiration (- - -) and relative yield loss (—) of the wheat crop in response to different supplemental surface irrigation (In =80 mm) strategies in Tel Hadya for average (-✳-), high (-■-) and very high (-○-) climatic demand

For high and very high climatic demand conditions it becomes difficult to adopt the winter wheat crop as a rainfed crop. Supplemental irrigation should be used in these conditions to avoid excessive yield losses at the final crop development stages. For systems with surface irrigation under high and very high climatic demand, it is necessary, for satisfying full crop water requirements, to apply about 160 mm (two irrigations by early and end April) and 320 mm (four irrigations from early April to early May), respectively to produce the same relative yield loss (30 %) as for rainfed under average climatic demand. For the set sprinkler systems the results are not significantly different. However, taking in account that the simulations were performed using net irrigation depths and that application efficiency tends to be larger when sprinkler systems are adopted (Pereira and Trout, 1999), it may be considered that sprinkling could be more appropriate to save water in the supplemental irrigation of the winter wheat in regions with scarce water resources. Obviously, the systems should be properly designed and managed.

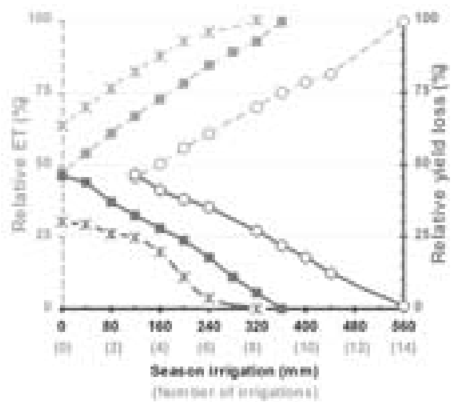

Figure 8. Relative evapotranspiration (---) and the relative yield loss (—) of the wheat crop in response to different supplemental irrigation strategies in Tel Hadya for average (–✳–), high (–■–) and very high (–○–) climatic demand conditions using set-sprinkler systems (In =40 mm)

Conclusions

The analysis presented in this paper show that simulation models, such as the ISAREG, could be used to establish alternative supplemental irrigation schedules in relation to the available seasonal irrigation water. Also it is useful to evaluate the feasibility of the adoption of these schedules to winter wheat to cope with drought and water scarcity. The modeling approach is also useful to interpret the field experimental results and to extend results to wider climatic conditions.

Results of this analysis show different responses of the winter wheat crop to supplemental irrigation under different climatic demand conditions. For this winter crop, traditionally non-irrigated, adopting supplemental irrigation is generally feasible, even under very high climatic demand conditions. However, it is important that the mode technical outputs be complemented with an economical analysis for definitive conclusions.

Acknowledgments

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Output 3: **Water management packages for sustainable optimizing on-farm WUE particularly in irrigated areas.**

Activities:

- Soil and water project in Central Asia
- Natural resource Management project in Egypt
- Water use efficiency component of the Arabian Peninsula project

No ready output available.

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

Activities:

- Sorbolak trials on the use of treated sewage effluent in Kazakhstan
- Use of saline water for agriculture in Uzbekistan
- Use of drainage water in agriculture in Egypt

No ready output available.

Output 5: **Methods for assessing the safe utilization of renewable ground-water resources in agriculture.**

Activities:

- Sustainable use of shallow groundwater in Aleppo area
- Ground-water monitoring in Khanasser valley

Output presented with project 4.1.

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.**

Activities:

- Training course on improving WUE in agriculture with CIHEAM in Amman, Jordan
- Training course in CA on various aspects of soil and water
- Individual training

Human resources in 2001

P-Staff	GS-Staff	Consultants
A. Bruggeman	A. Hamwieh	A. Hachum (50%)
F. Karajeh (until August)	P. Hayek	A. Karimov (CA)
I. McCann (until June)	I. Halimeh	A. Akhtar (MRMP)
T. Oweis	A. Haj Dibo	I. Kononenko
M. Sulimanov (CA 20%)	J. Abdullah	
A. Salkini (MRMP 25%)	H. Halimeh (20%)	
E. De Pauw (NRMP 10%)		
A. Aw-Hassan (NRMP 10%)		
M. Pala (NRMP 10%)		

Publications

Bruggeman, A. 2001. Rainfall measurement and analysis. Water Saving and Increasing Water Productivity: Challenges and Options, Advanced Short Course: Water saving and increasing water productivity: challenges and options. 10-23 Mar 2001, Amman, Jordan. p. b1.1-b1.11. Hamdy, A. (comp.). CIHEAM-IAMB, Bari, Italy. Bruggeman, A. 2001. Integrated watershed management in the dry areas. Water Saving and Increasing Water Productivity: Challenges and Options, Advanced Short Course: Water saving and increasing water productivity: challenges and options. 10-23 Mar 2001, Amman, Jordan. p. b4.1-b4.7. Hamdy, A. (comp.). CIHEAM-IAMB, Bari, Italy. Hamdy, A.; Karajeh, F. 2001. Treated wastewater as an additional source: challenges and perspectives. Water Saving and Increasing Water Productivity: Challenges and Options, Advanced Short Course: Water saving and increasing water productivity: challenges and options. 10-23 Mar 2001, Amman, Jordan. p. a7.1-a7.21.

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PROJECT 3.2 SOIL CONSERVATION/LAND MANAGEMENT PROJECT

LAND RESOURCE STUDIES IN KHANASSER

(Contributors: Eddy De Pauw, Greet Ruysschaert, Ine Arits, Nathalie Cools)

The Khanasser area is located between latitudes 35°28'N-36°10'N and longitudes 37°17'30"-37°57'E, in a rainfall gradient of about 315 mm in the northwest to 185 mm in the southeast (Figure.1).

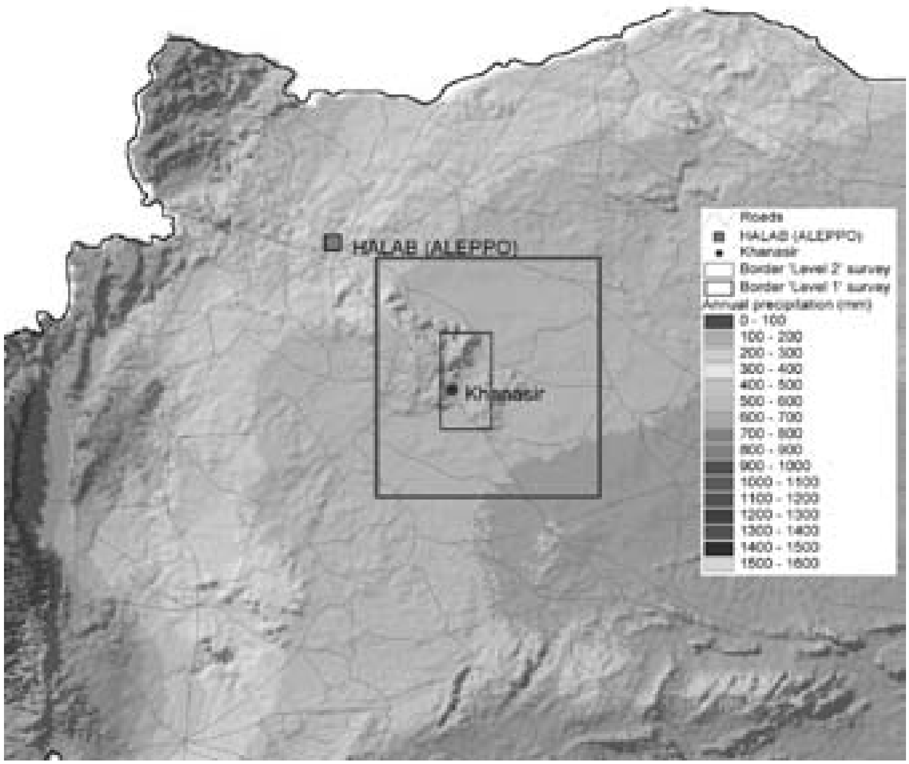

Figure 1. Location of the Khanasser area.

This area is the focus of an integrated natural resource management project, undertaken in collaboration with the University of Bonn and the Atomic Energy Commission of Syria. The project, named "An Integrated Approach to Sustainable Land Management in Dry Areas", aims to produce an integrated and transferable approach for evaluating land use and management options in dry areas. For this purpose the Khanasser Valley, which has already been selected by ICARDA as an integrated research site, serves as the reference (pilot) area for the project.

One of the expected project outputs is a comprehensive description of the land resources, land capability, current and potential land degradation.

Activity 1.1   Multi-scale land resource assessment

To achieve this output a soil/land suitability classification study was undertaken at three different levels of detail:

- reconnaissance, covering the area SE of Aleppo, particularly the Khanasser valley proper, the Jebel Hos and Jebel Shbeith, and a few areas north and south of Khanasser.
- semi-detailed survey of the Khanasser valley proper.
- a detailed survey, using participatory techniques, in a village of the Khanasser area.

1.1.1. Reconnaissance survey of the Khanasser area

The first stage provided a macro-scale agroecological characterization of the whole Khanasser area, at a scale of 1:200,000 (red frame in Fig.1). This inventory includes soil resources and land use/land cover. The soil resources were assessed using a 'soilscape' (soil-landform associations) framework, developed through interpretation of recent (1998 and 1999) Landsat imagery, supplemented with field checks, including terrain observations and representative soil sampling by augering and profile pits.
The reconnaissance 'soilscape' map is shown in Figure 2.

The objective of this 'level 1' assessment was to obtain an overview of the major soil types, their location and general management properties, and identify areas for more intensive survey work. The basic mapping units are landforms differentiated by soil association. The building blocks of the soil associations are soil types classified according to the World Reference Base (Deckers *et al.*, 1998), a recent adaptation of the FAO soil classification system (FAO, 1974 and FAO, 1988). Each of these soil types represents a *conceptual* soil, and is further characterized by a *phase*, a prominent soil characteristic. The soil association is further characterized by the distribution of the included soil types, which is expressed by the approximate percentage of land each soil type occupies.

The land use/land cover map was developed on the basis of the same Landsat imagery using image analysis software (ERMapper) and supervised classification methods. The map is shown in Figure 3.

1.1.2. Semi-detailed soil survey of the Khanasser Valley

The second stage provided a meso-scale inventory of the land resources of the Khanasser valley, at a scale of 1:50,000 (blue frame in Figure 1). The objective of this 'Level 2' assessment was to define landscape units with distinctly different management requirements and land utilization options. Given the more specific objectives, this inventory was more intensive, relying heavily on field work, with more auger and soil pit observations along transects, followed by soil analysis. The soil map of the Khanasser Valley is shown in figure 4. At this scale land suitability maps were prepared for a limited range of important crops and land utilization types, following standard land evaluation procedures based on land characteristics. The land suitability map for rainfed barley is shown in Figure 5.

1.1.3. Detailed participatory soil survey of Khanasser Township

The third assessment stage focused on a single village, Khanasser. The objective of this 'Level 3' assessment was to understand farming systems and farmer perceptions of resource-related problems. In contrast with the previous stage, this assessment was undertaken in participation with farmers. Through interviews with target groups and participatory transect analysis, farmers of the village provided information about land quality, productivity, production risks, degradation and land use for different parts of the village areas. They also indicated natural breakpoints in the landscape where they saw changes in soil types.

The soil map of Khanasser is shown in figure 6. A visual comparison of this map with the soil map of the whole valley (Fig.4) shows that the detailed soil survey is unable to capture much more variability in soil characteristics than the semi-detailed survey. The main soil groups are the same and the boundaries between them are virtually identical, although derived from more intensive sampling. There can be two reasons for this lack of increase in resolution with increasing survey intensity:

1. the semi-detailed survey is conducted at the optimal scale and sampling density to capture the existing soil variability;
2. the classification system used (WRB) is not equipped to take account of the variations in soil properties that can be expected at detailed level.

The second explanation is probably closer to the truth. The WRB, an offspring of the FAO soil classification system, is - like its parent - mostly designed for smaller-scale mapping. Soil Taxonomy (Soil Conservation Service, 1994), which incorporates more hierarchical levels, would probably have been more suitable at this level of detail.

However, the best approach would have been to design an *ad-hoc* soil classification based on criteria that affect land management, that are identified jointly with farmers, and that can be consistently mapped.

1.1.4. Conclusions

From these inventories of the land resources of the Khanasser area, some lessons were learnt, which can be put to good use in other integrated research sites.
The multi-scale approach offers a very efficient and cost-effective framework for

conducting land resource studies and upscaling research results from the integrated sites. In addition, it offers a methodology for integrating farmer knowledge with scientific mapping procedures. It is important, however, to develop at each scale a legend that will capture the maximum range of variability. A 'one-size-fits-all' soil classification system is suitable for correlation with other areas, but not the best vehicle for mapping.

The second lesson is that land evaluation methods have to be adapted to local conditions. In a multi-scale approach it makes no sense to adopt the same matching procedure irrespective of scale and study objectives. Instead, at each particular scale of study, a new land evaluation 'model' needs to be constructed. Such a model is essentially a set of decision rules linking crop or system requirements to individual or 'integrated' land characteristics (land qualities). At each scale, systems or crops have to be represented by requirements, and matched to characteristics that can be spatially represented with confidence. Otherwise, the evaluation will come up with unrealistic conclusions.

Activity 1.2 Land degradation assessment

The Khanasser area is located in the transition zone between rainfed and irrigated crop production systems and livestock production systems. Different forms of land degradation have been observed, notably salinization in irrigated fields, water and wind erosion, groundwater depletion and contamination, and decline in the cover and quality of the natural vegetation. In dry areas it is often difficult to distinguish human-induced land degradation from natural processes. In such areas, severe droughts, gullies in sloping lands, wind deposition in the dry season, and saline depressions ('sabkhas') are normal expressions of aridity.

It is only by observing terrain and vegetation or land use features at different times that one can draw unequivocal conclusions about land degradation. A problem with this approach is the time-scale over which one should study this phenomenon. Land can degrade rapidly or slowly, depending on the resilience of the land resources and the pressure exerted on them. To monitor slow degradation processes, there are usually no datasets available that go back far enough. In addition, there is always the possibility that some forms of degradation occurred in a distant past and that the area has actually found a new equilibrium.

To study land degradation in the Khanasser Valley, a comparison was made between aerial photographs taken in 1958 with Landsat satellite imagery of the year 2000. On these datasets changes were studied in settlement pattern, land cover and use, gully patterns and wind deposition. This remote sensing exercise was complemented with field observations of visual indicators of land degradation, and interviews with farmers who were already farming in 1958.

Comparison of land use/cover between 1958 and 2000 showed an expansion of rainfed agriculture from about 30% of the valley to nearly 100%. The expansion has occurred at the expense of rangelands, which was the predominant land use in the valley in 1958. There has been little change in the area under irrigation. (Fig. 7a and 7b).

The farmer interviews indicated that barley has remained the dominant crop in the Valley, with few other crops being grown. Farm size had changed little in the 40-year period. Although land ownership is distributed among surviving sons, families continued to farm the land in common operations. Fertilizer use has been non-existent and fertility was maintained through a fallow period. However, a reduction of the fallow periods has occurred from 1 year out of 2 in 1958 to 1 year out of 4 in 2000. In addition, after making allowance for productivity fluctuations due to rainfall variability, the farmers perceived a trend of fertility decline.

Over the 40-year period they also observed a reduction of the diversity and area of the natural vegetation, due to the encroachment of farmland and the destructive effects of tractor cultivation. The role of small ruminants as a contributing factor to land degradation was perceived as either negative (pulverization of top soil, promotion of wind erosion) or neutral. Farmers who did not own livestock tended to perceive a negative effect of sheep on soil quality. They also claimed that they have no control over the numbers of sheep and the grazing intensity. Farmers who did own livestock, unsurprisingly, considered the economic benefits outweighing the negative effects on the land.

The combination of these two information sources, land use change quantified by remote sensing and interviews of old farmers, provides indirect evidence of decline in fertility and productive capacity, a major form of land degradation.

Farmer management practices to combat fertility decline have been ineffective. Fertilizer use is widely considered uneconomical in a dry environment with high risk of crop failure. Deep ploughing every four years has been mentioned as a 'nutrient pumping' practice to replace nutrient-depleted topsoil with less depleted subsoil. Considering the lowered availability of some nutrients in calcareous and gypsiferous soils, the effects of this practice on the longer-term nutrient availability in the soils of the Valley requires further study.

Other forms of land degradation appear less important. Gullies are very common on hill slopes in the area. However, the farmer interviews indicate that the gullies probably existed before 1958 and extended only slightly in the last 40 years. Measurements of gullies with GPS and comparison with the 1958 aerial photographs will indicate whether any significant elongation has occurred.

Further work will be needed in mapping different forms of land degradation using the GLASOD framework and the mapping units differentiated in the land resource studies.

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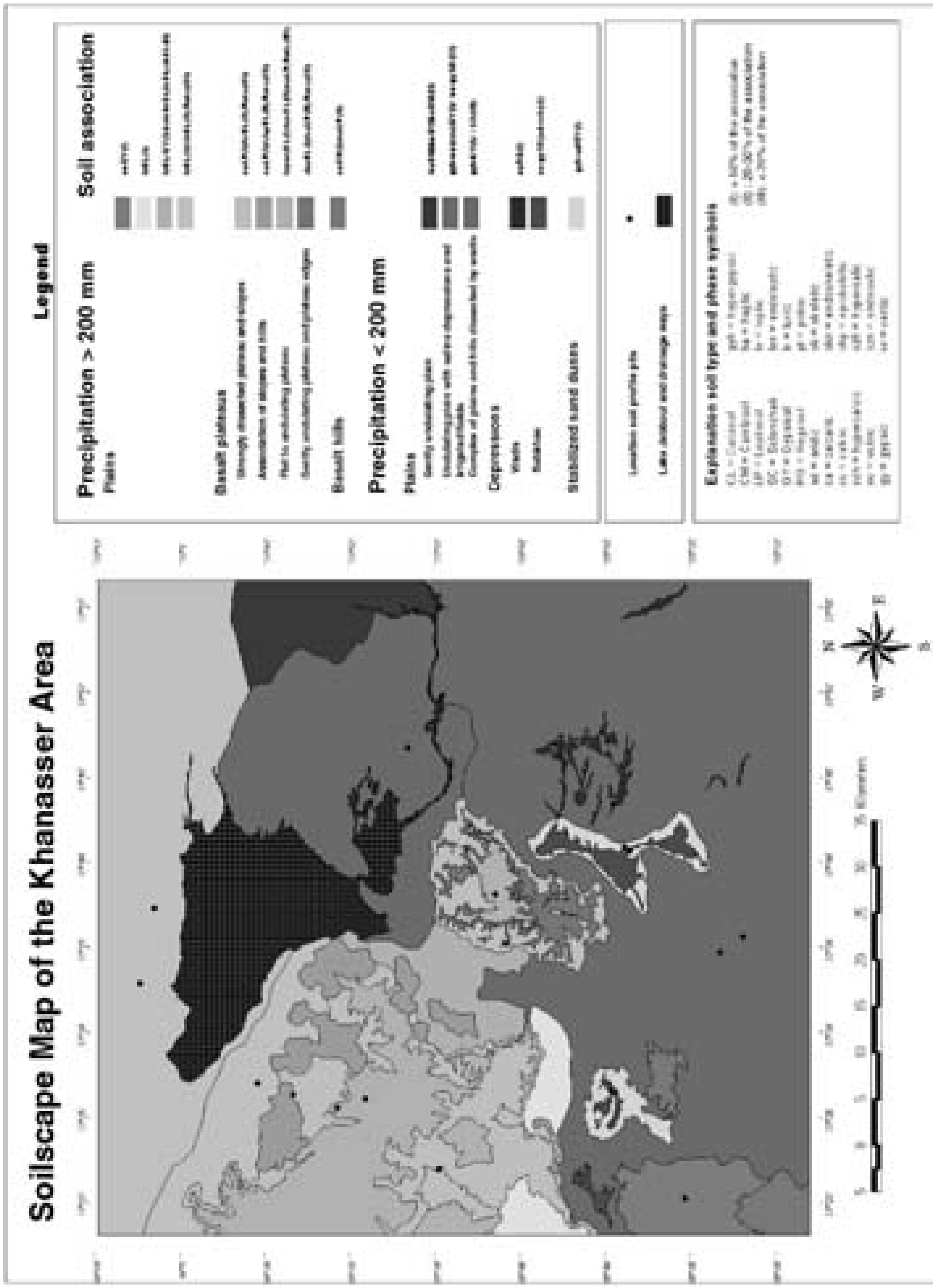

Figure 2. Reconnaissance soil map of the Khanasser Area

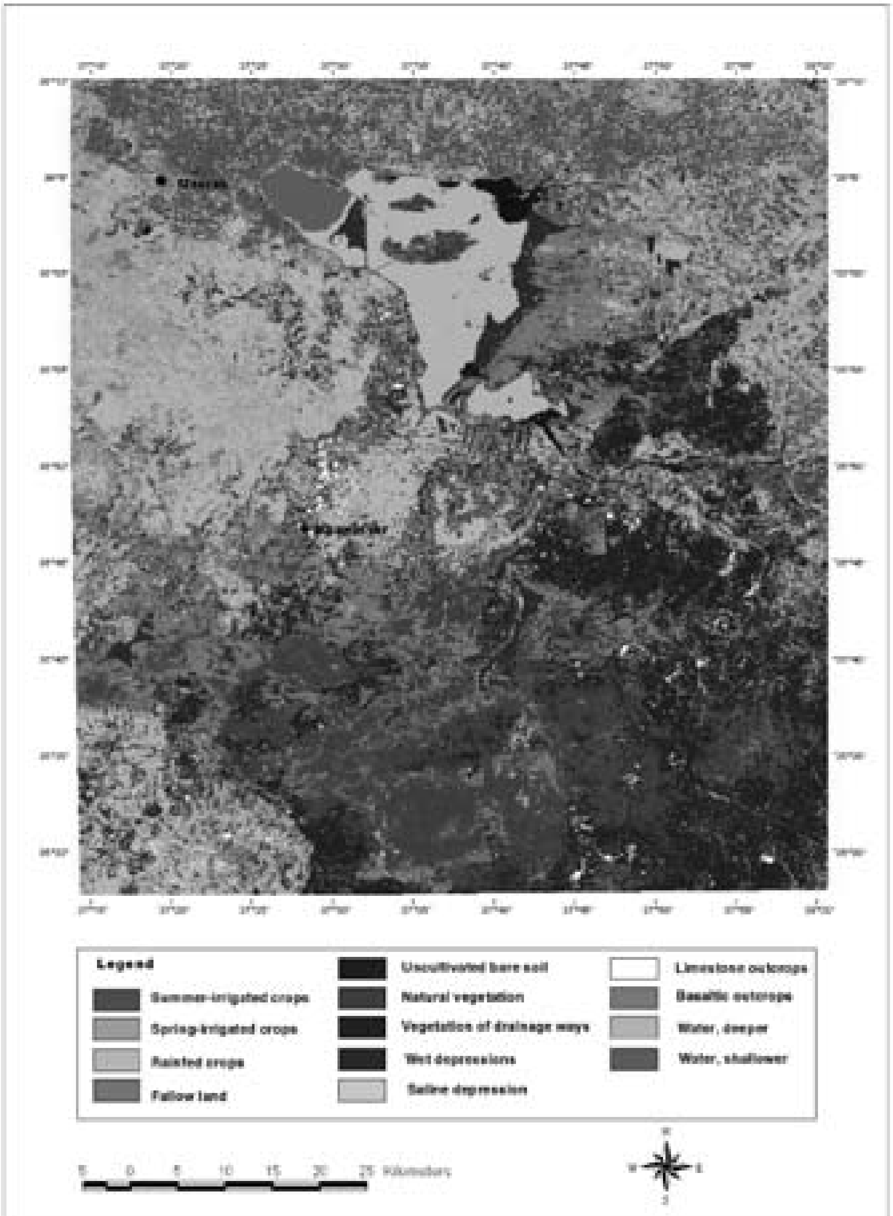

Figure 3. Land use/land cover map of the Khanasser area

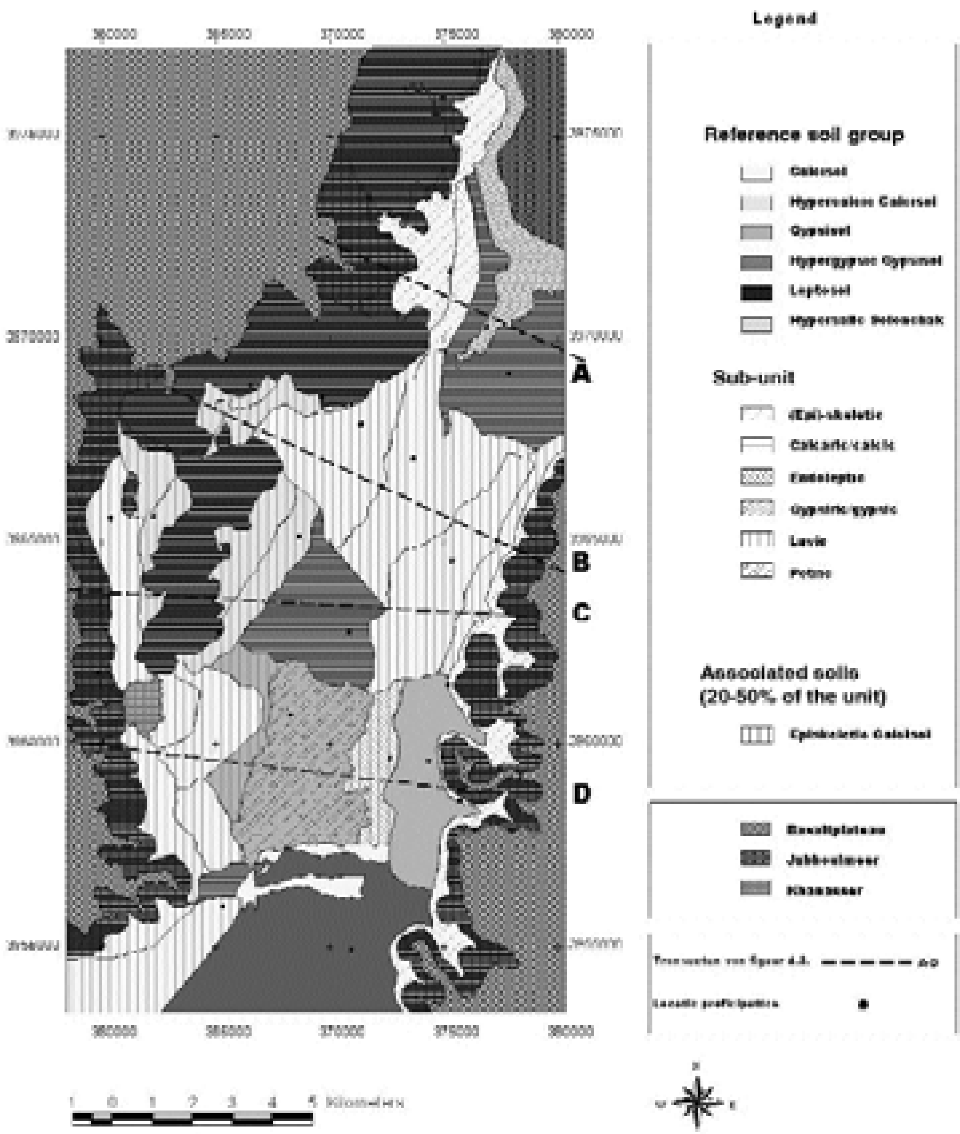

Figure 4. Semi-detailed soil map of the Khanasser Valley

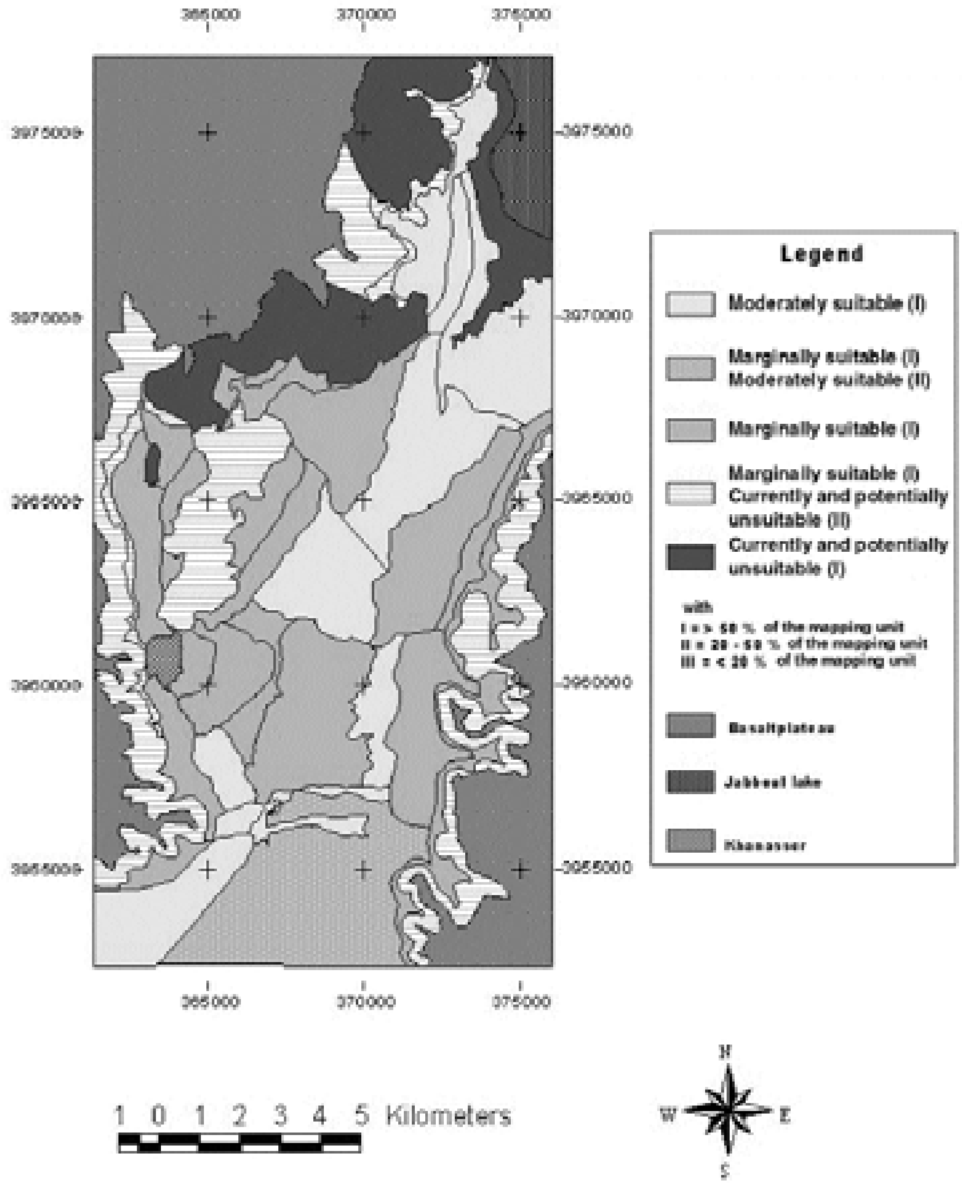

Figure 5. Land suitability map for barley in the Khanasser Valley

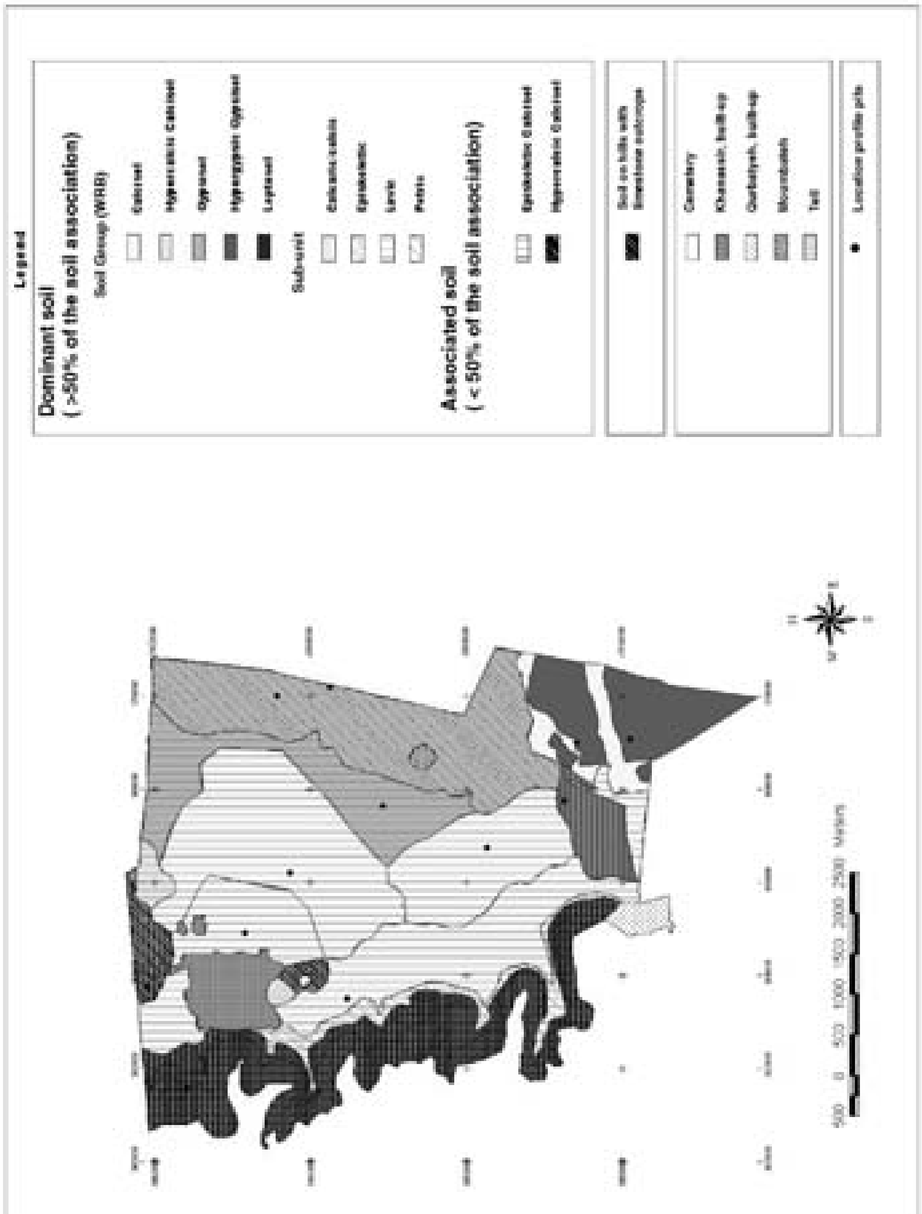

Figure 6. Detailed soil map of Khanasser township

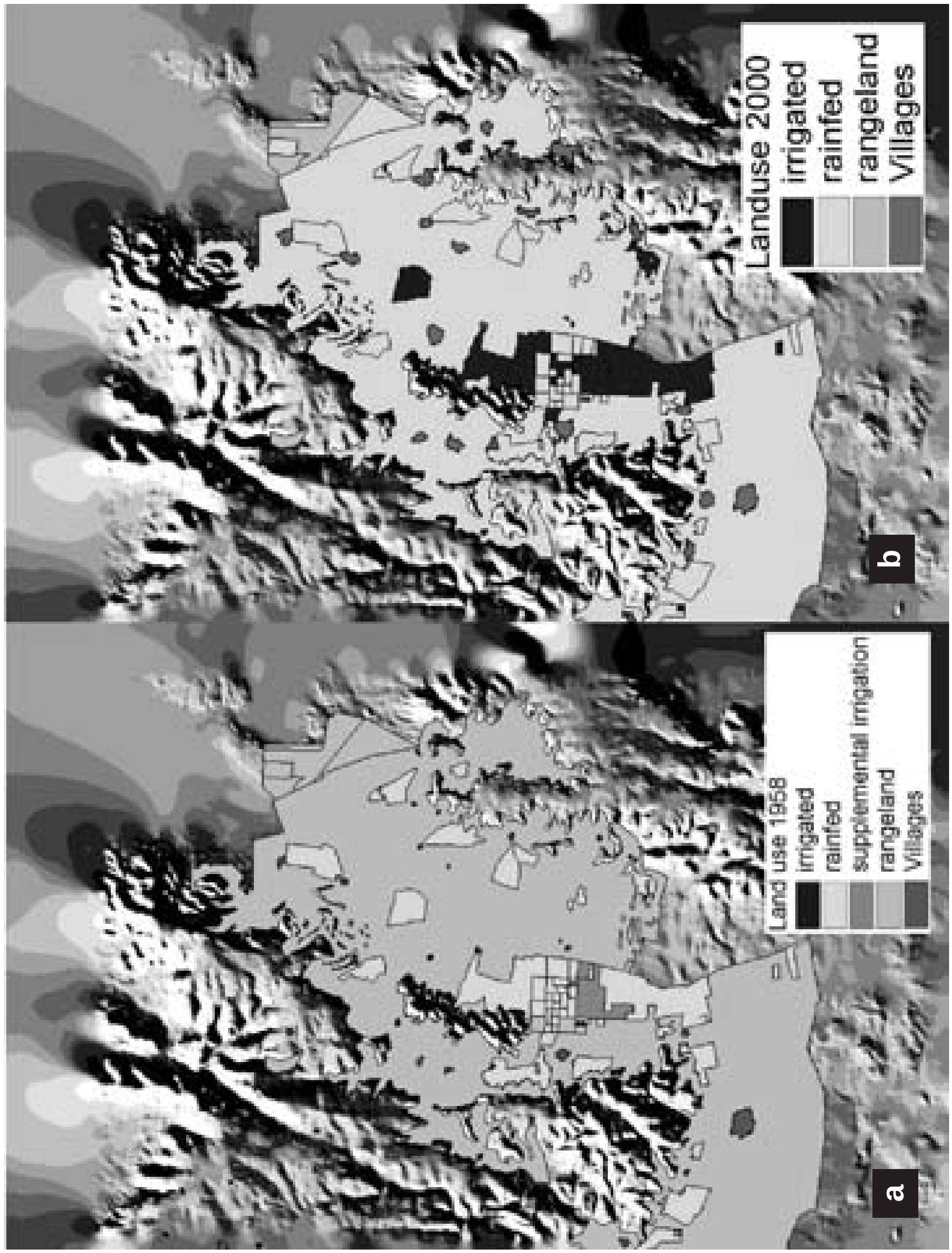

Figure 7. Comparison of land use between 1958 (a) and 2000 (b)

PROJECT 3.4 AGROECOLOGICAL CHARACTERIZATION PROJECT

ADVANCES IN AGROECOLOGICAL ZONING OF CWANA

(Contributors: Eddy De Pauw, Felix Pertziger)

Rationale

Agroecological zones are areas that are fairly homogeneous in landforms, climate, soils, vegetation and land use systems, and have definable potentials and constraints for specified land uses and management. This definition is based on the following understandings:

(i) Agroecological zones are land areas defined by integrating thematic information on climate, terrain, soils, vegetation, water resources and land use patterns.

(ii) Within an agroecological zone land should be sufficiently homogeneous in order to allow assessment of potential and constraints for specified land use types or land management practices.

(iii) The term 'fairly homogeneous' is used, because absolute homogeneity is an impossibility with land. There are no two sites that are identical, even if a short distance apart.

One of the problems with agroecological zoning is that the methodologies, objectives and data sets can be quite different, which may result in completely different maps. This situation is unlikely to inspire much confidence in the concept. The term 'agroecological zones' is also used indiscriminately in the literature, covering climax vegetation, agroclimatic zones, or even crop suitability. For example, the FAO approach to agroecological zoning (FAO, 1978-81; Fischer et al., 2000) is essentially a land suitability classification at global level for different crops.

Our own interpretation of agroecological zones is that they are static and unique entities, determined by the combinations of climate, terrain, soils, water resources and land use systems. The focus of the mapping is thus on the characteristics of the land, rather than the interactions with crops or production systems. This perception of agroecological zones as ,natural regions' is more close to the 'eco-district' concept, used for example in the USA and Canada, than to the FAO concept.

Defining the agroecological zones of ICARDA's mandate region can have important applications. It offers a natural framework for the assessment of land degradation, drought risk and vulnerability, land suitability, and for land use planning with an ecological/sustainability dimension. It can also be a basis for assessing similarity between different locations, and thus be of use for research planning, but also for better targeting of existing or new crops and species.

General approach

There is a consensus that for the integration of spatial datasets that cover different themes and scales, a geographical information system (GIS) is the only feasible approach. The major challenges for a GIS approach are what aspects of the agricultural environment to combine and how to combine them. The characteristics or derived qualities of climate, soils etc. that can be combined in GIS are numerous. For example, when dealing with climate data sets, should we look at annual rainfall, length of growing period, annual temperature, growing-degree-days, or all of these?

There are two approaches:

- Overlay approach
- Framework approach

Overlay approach

The overlay approach is illustrated in Figure 1. A new layer is created by the overlaying of different thematic layers, in this example natural drainage, infrastructure, major land uses, and topography in the form of contours. The principle of the overlay approach is simple, but it can be applied to very complex map calculations involving many layers, formulas and even models, as used, for example, for crop yield simulation. The overlay approach works very well for the creation of base maps (Fig.1) or in straightforward combinations of data layers. An example is the creation of agroclimatic zones by combining layers of different climatic parameters.

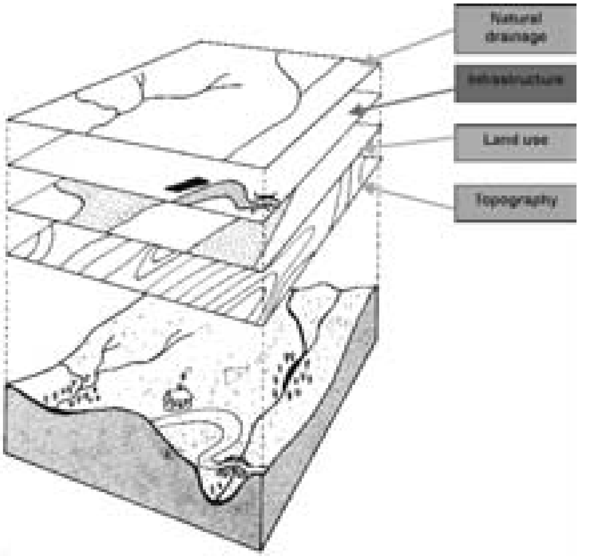

Figure 1. Overlay approach in GIS

The overlay approach does not work well for thematic layers that can not be combined in any obvious way. For example, it is not clear how overlaying an agroclimatic zones map with a soil map is going to tell more than that area X has agroclimatic zone Y and soil Z. In short, *the overlay approach is not the best for the integration of data layers that have an entirely different thematic content.*

Framework approach
The challenge in integration of thematic datasets for agroecological zoning is in selecting those attributes of the environment that can be successfully combined to generate new information that is more than the sum of the attributes.
This data integration can be achieved by defining a limited set of *mutually independent frameworks that are internally integrated and are afterwards combined in a GIS by modeling or overlaying techniques.*

The most important internally integrated frameworks are:
- Agroclimatic zones
- Soilscapes

Agroclimatic zones are areas that are more or less homogeneous in the climatic characteristics of importance for agricultural production systems.

Soilscapes are areas that are distinguished on the basis of their landscape-soil patterns.

The framework approach is based on the **step-wise integration** of individual thematic parameters into themes. Figure 2 illustrates this approach for the framework *agroclimatic zones.*

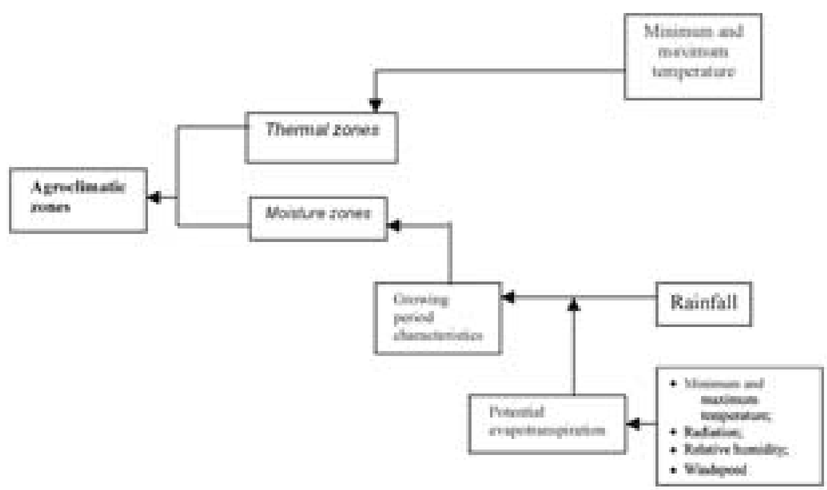

Figure 2. Step-wise integration in the framework approach

Agroclimatic zones

This figure shows a theoretical model of how individual climatic parameters (data layers) are gradually integrated into more complex parameters and themes, and ultimately result in agroclimatic zones. The actual differentiation of agroclimatic zones will depend on the model selected for integrating the climatic parameters. For example, one could select existing climate classifications (UNESCO, Köppen, Thornthwaite, etc.) or build one's own model that best suits the data, the scale and objective.

Soilscapes

A major problem in combining climatic data with soils data at regional level is that in general the scales of variation of climatic and soil characteristics do not match. One way of overcoming this limitation is by working with landscapes in which the soil pattern has been reasonable well established. Such landscape-soil patterns (or 'soilscapes') are complex mapping units that vary within similar spatial ranges as climate.

The fundamental idea of the soilscape framework, which is based on the *catena* concept (Young, 1976), is thus that soils are associated with certain landscape positions and that the linkages between the landscape and the soils show patterns that can be described in a more or less predictable way.

The description format for a soilscape is based on the definition of a *pattern* and *composition.* The ***pattern*** describes the nature of the relationship of the concerned soils with the landscape (table 1). The different types of pattern are shown in Figure 3.

Table 1. Soil patterns as related to landscape positions

Pattern	Type of relationship with landscape
Association	The specified land attributes occur together regularly in an established pattern that bears some relationship with the landscape.
Mosaic	The occurrence of the specified land attributes within a landscape is random.
Complex	The attributes are known but their relationship to the landscape is unknown.

The ***composition*** of a soilscape can be described in terms of the relative or absolute occurrence of its component soils (table 2)

Table 2. Soilscape composition

Composition	Meaning
Dominant	The most common soil in the given pattern
Associated	Important soil units in the pattern, which, however, are not dominant e.g. covering 15-40% of a soilscape
Inclusions	Minor soil units in a pattern, covering e.g. <10%.

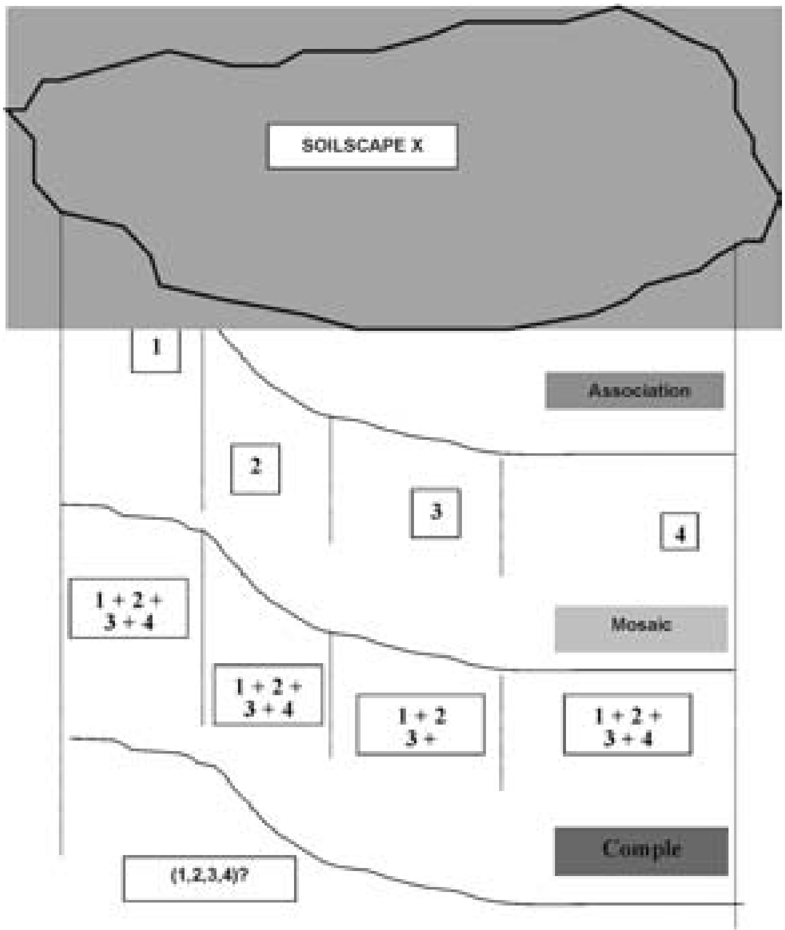

Figure 3. Types of soilscape patterns

The soilscape framework is virtually scale-independent and is particularly suitable to allow incorporation of large-scale soil variability in small-scale maps.

In order to integrate all the components of the land a four-step approach is followed:

- Definition of an agroclimatic framework
- Definition of a 'soilscape' framework;
- Merger of the two frameworks into a single one;
- Addition of attributes related to other themes (e.g. land cover or use, water resources, farming systems): characterization
- Validation of the established zones through field checking and remote sensing.

The overall approach is visualized in the flowchart (Fig. 4).

Bold lettering and solid lines indicate defining frameworks, which are the ones that are essential for the definition of agroecological zones. *Italics* and dashed lines indicate characterizing frameworks: while usually non-essential and often difficult to obtain, they nevertheless provide important information that can be incorporated in the AEZs as table attributes. Double lines indicate ***validation needs:*** ground truthing is an integral part of the definition of agroecological zones.

The integration of agroclimatic zones and soilscapes is a merger of two frameworks, whereby boundary adjustment can be assisted by field checking and remote sensing.

With the exception of the base layer (human infrastructure and topography), which can be added as a separate overlay, other frameworks are added in the form of attributes of the agroecological zones defined on the basis of agroclimatic zones and soilscapes.

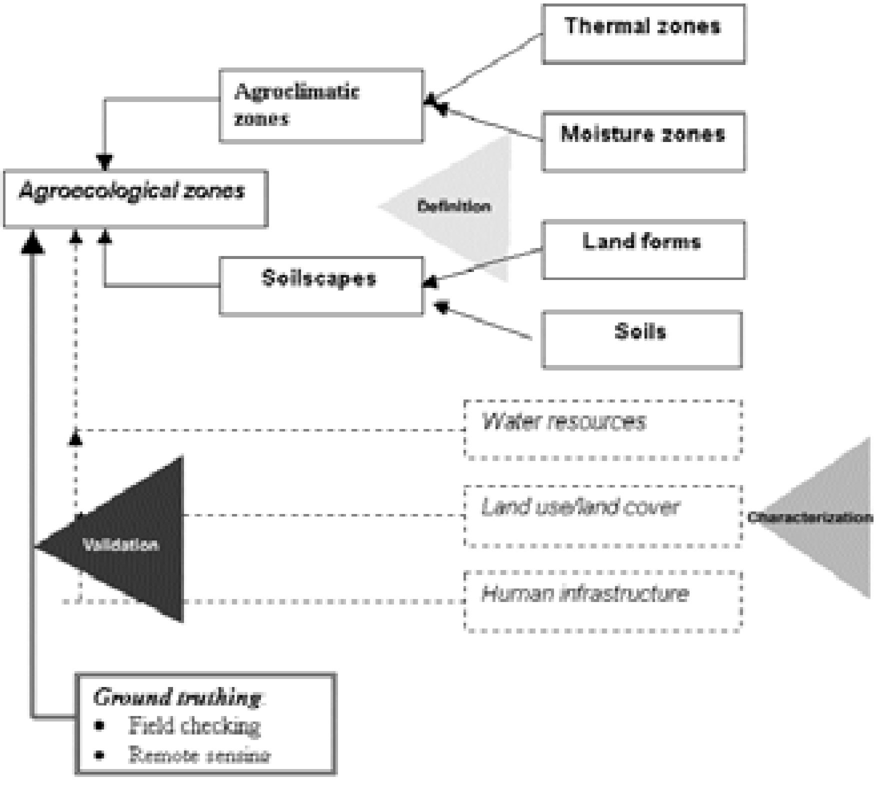

Figure 4. Stepwise development of thematic frameworks

This approach emphasizes the database capabilities of GIS. Attributes can be retrieved from the internal database and displayed as individual thematic maps. This also implies that 'agroecological zones' are only one thematic component of a comprehensive layer-based Land Resource Information System. This would be an invaluable database that will serve as the spatial backbone for multiple spatial applications of use to the research community, donors and the international public.

Current status of development of the agroclimatic framework

Generation of basic and derived climate 'surfaces'

Climate 'surfaces' are raster maps in which climatic variables are presented as continuous 'fields' or 'surfaces'. Such maps are obtained by spatial interpolation from a database of point data, obtained at representative stations. There are many interpolation methods, but the important innovation in our approach is that the interpolation is 'topography-guided'. This allows a much more accurate interpolation, because temperature and precipitation are highly correlated with elevation. The general approach is illustrated in figure 5.

The interpolation technique used for spatial interpolation is a thin plate smoothing spline using the method of Hutchinson (Hutchinson, 1995) and the software package ANUSPLIN. This method is essentially a radial basis interpolation function of the type:

$B(h) = (h2 + R2) \log (h2 + R2)$

With:

B: weight at the grid node

H: anisotropically rescaled, relative distance from the point to the node

R2 smoothing factor specified by the user

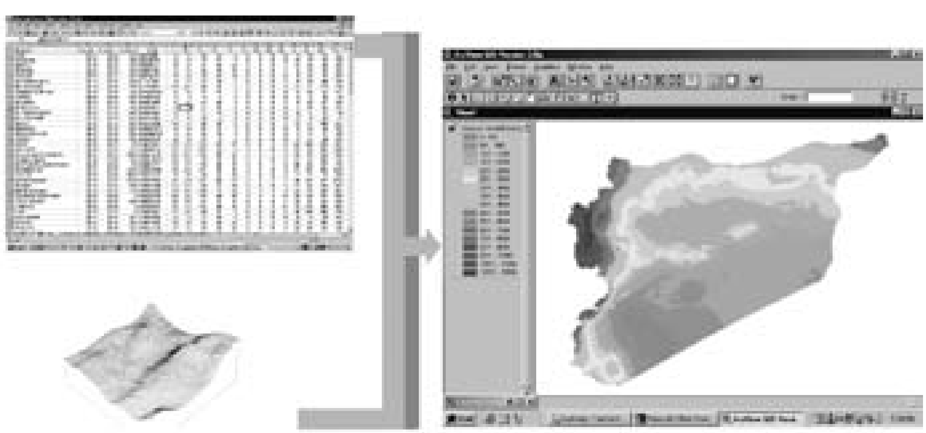

Figure 5. Combining a climate database with a DEM for spatial interpolation

In the approach of Hutchinson the smoothing factor, or inversely, the degree of complexity of the created 'climate surface,' is determined automatically from the database by minimizing a measure of predictive error of the fitted surface given by the generalized cross validation (GCV). In the surface fitting procedure three independent spline variables are used, longitude, latitude, and elevation above sea level. They are considered the most appropriate for fitting surfaces related to temperature or precipitation parameters. The elevation variable is obtained from a digital elevation model (DEM) with 1 km resolution, GTOPO30 (Gesch and Larson, 1996). The technique thus allows to create maps with 1-km grid cells and is particularly suitable for data-sparse areas, such as CWANA, because the use of a DEM compensates to some extent for the low-density climate data network.

Basic climate surfaces

For testing purposes maps of basic climatic variables (mean maximum and minimum temperatures, mean precipitation) have been derived for several parts of CWANA, ranging from countries (Syria, Uzbekistan, Kazakhstan, Iran, Ethiopia) to entire regions (West Asia, North Africa, the Arabian Peninsula). All separate climate maps will eventually be joined into a single CWANA dataset.

For all regions concerned 12 monthly climate surfaces were created for each of the above basic climatic parameters and combined into seasonal or annual maps. Figure 6 illustrates the approach with the annual precipitation map for some Central Asian countries (Afghanistan, Pakistan, Uzbekistan, Turkmenistan and Tajikistan).

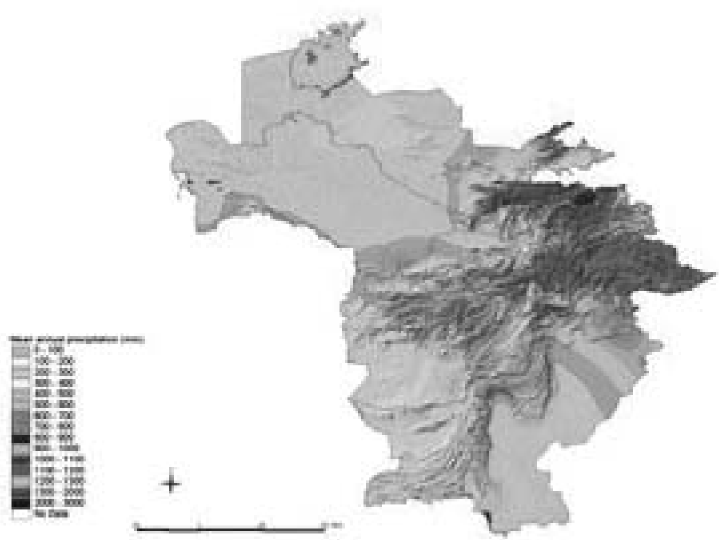

Figure 6. Annual precipitation for some Central Asian countries

Derived climate surfaces

These elementary climate surfaces can be combined into various derived climate surfaces using formulas and models.

A good illustration of the overlay approach using formulas is the creation of the monthly potential evapotranspiration (PET) surfaces with the Penman-Monteith method. The Penman-Monteith calculation procedure (Allen et al., 1998) requires data on mean temperature, sunshine or radiation, air humidity and wind speed. The approach is outlined in figure 7 and an example is given in Figure 8, which shows the monthly and annual potential evapotranspiration for Uzbekistan.

The overlay approach can also be used in models. A good example is the climatic growing period, a model used by the Food and Agriculture Organization of the United Nations in its global assessment of agroecological zones (FAO, 1978-81). The growing period, as a climatic concept, is the time of year when neither moisture nor temperature limit crop production. The components of the climatic growing period (onset, duration, and end) are determined by a waterbalance approach, which matches monthly rainfall to monthly potential evapotranspiration. In technical terms the growing period is the 'period of the year during which the actual evapotranspiration exceeds a critical threshold' (De Pauw, 1983). This threshold is usually taken as 50% of the potential evapotranspiration. In cold areas, a temperature threshold can be built into the model.

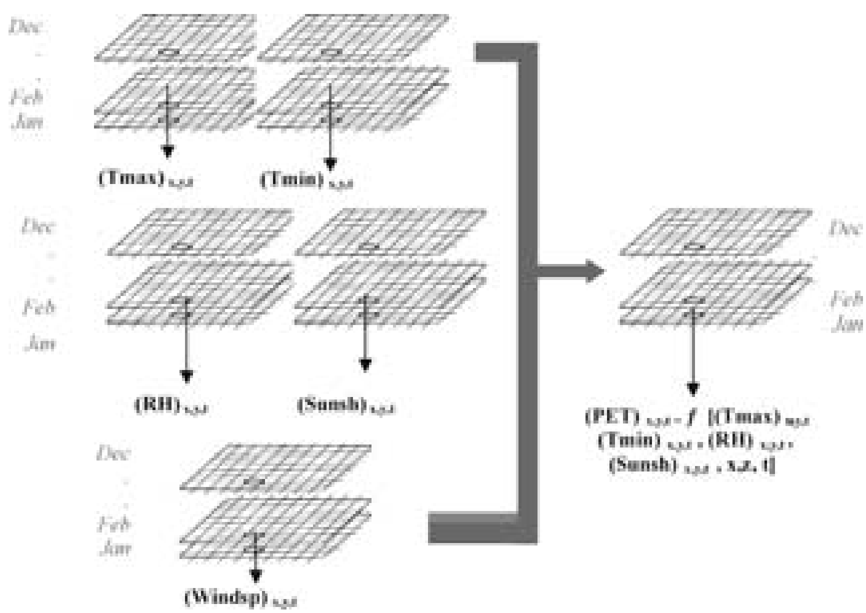

Figure 7. Generating Penman-Potential Evapotranspiration surfaces from basic climate parameter layers.

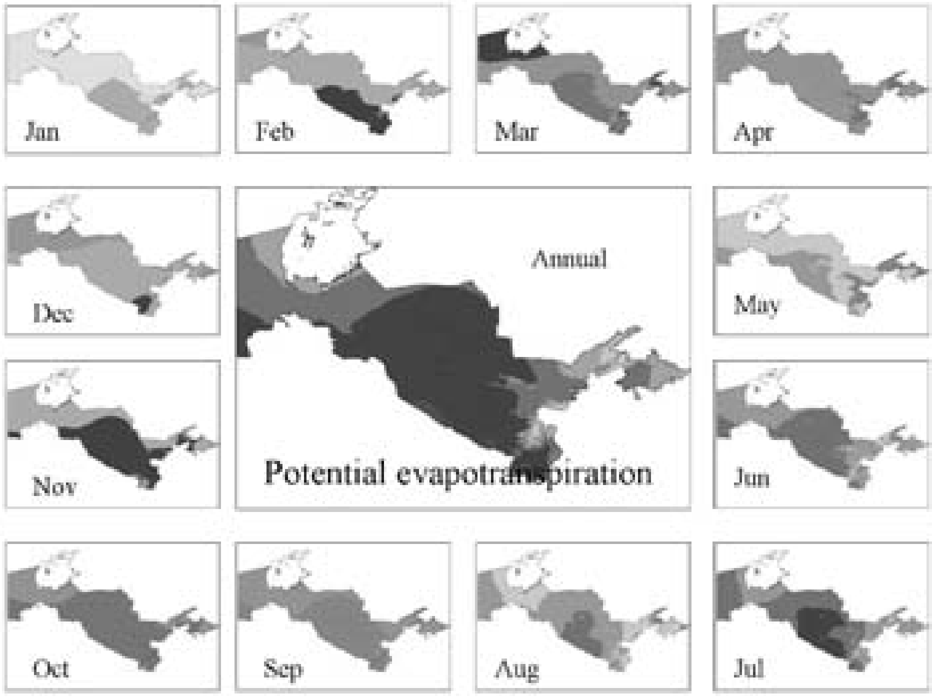

Figure 8. Mean monthly and annual potential evapotranspiration maps for Uzbekistan

The model used for areas without temperature limitations is given in the following equations.

$GP\_ON = (Date)_{aet/pet>Threshold}$

$GP\_END = (Date)_{aet/pet<Threshold}$

$LGP = GP\_END - GP\_ON$

with: GP_ON: growing period onset date
GP_END: growing period end date
LGP: length of growing period

$$GP\_ON = M\_Start + NDays \frac{Thre - R_0}{R_1 - R_0}$$

$$GP\_END = M\_End + NDays2 \frac{Thre - R_{n-1}}{R_n - R_{n-1}}$$

with: M_Start: the number of days from 1 January up to the end of the last month that is not part of the growing period
M_End: the number of days from 1 January up to the end of the month preceding the last month of the growing period
NDays: number of days in the first month of the growing period
NDays2: number of days in the last month of the growing period
Thre: AET/PET threshold for defining a growing period (user-defined; for this study set to .5)
R_0: AET/PET ratio for the month preceding the first month of the growing period;
R_1: AET/PET ratio for the first month of the growing period;
R_{n-1}: AET/PET ratio for the month preceding the last month of the growing period;
R_n: AET/PET ratio for the last month of the growing period.

AET/PET ratios are calculated from the following simple waterbalance model:

If $P_t + I_t + SM_{t-1} \geq PET_t$ $\quad AET_t = PET_t$

$SM_t = P_t + I_t + SM_{t-1} - PET_t \leq Smax$

else

$AET_t = Pt + I_t + SM_{t-1}$

$SM_t = 0$

with
Pt : rainfall depth in month t
I t : irrigation depth in month t
SM t : soil moisture storage at the end of month t
SM t-1 : soil moisture storage at end of month t-1
PETt : potential evapotranspiration at the end of month t
AETt : actual evapotranspiration at the end of month t
Smax : maximum moisture storage capacity within rooting depth

An example of an assessment for the main attributes of the climatic growing period (types, length, onset and end) is given in Figures 9-12.

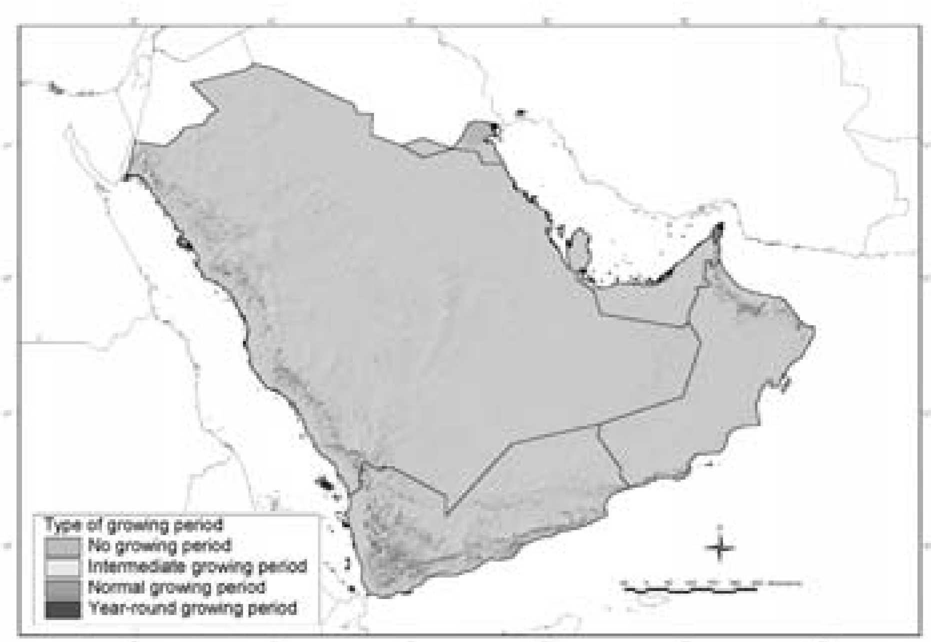

Figure 9. Types of growing period in the Arabian Peninsula.

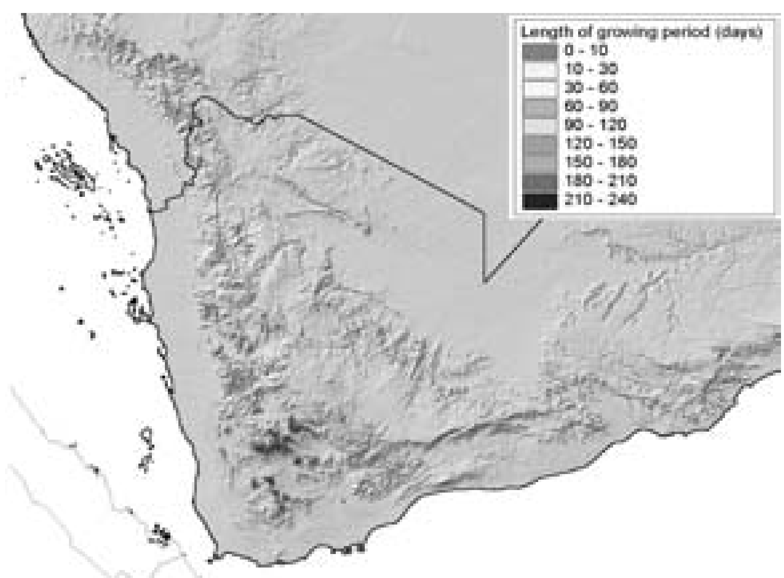

Figure 10. Length of the first growing period in the Southern Arabian Peninsula.

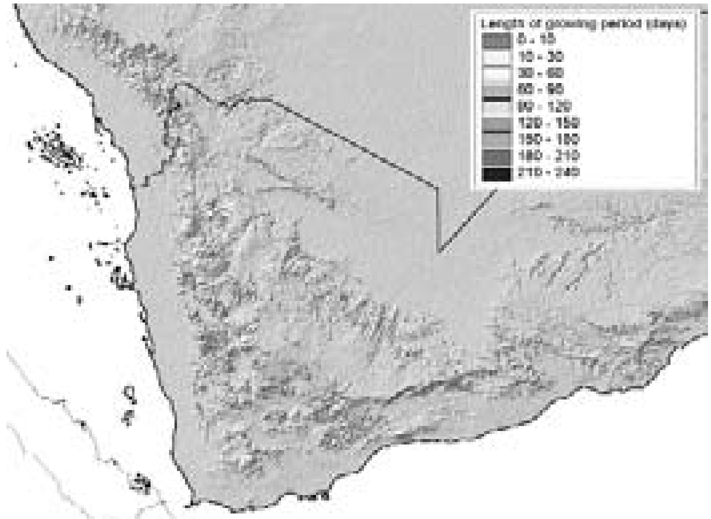

Figure 11. Length of the second growing period in the Southern Arabian Peninsula.

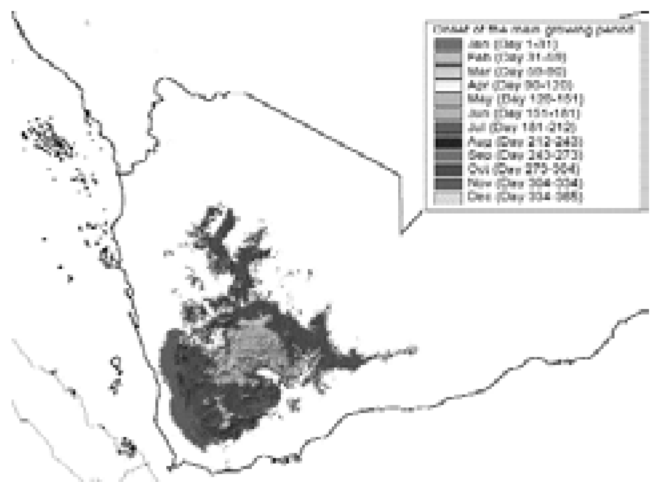

Figure 12. Onset month of the main growing period in the Southern Arabian Peninsula.

Biomass productivity and climate

A further step in the spatialization of climatic data is the development of biomass productivity indices. Climate is the primary determinant of potential biomass productivity of plants and crops. This is because assimilation - the capture by plants of carbon dioxide from the atmosphere and its conversion into carbohydrates - is determined by radiation energy and water availability. Biomass productivity should, therefore, be related to climatic factors, in particular temperature (as proxy for the radiation energy) and soil moisture. Apart from radiation and moisture regime, the rate of assimilation and biomass production is strongly determined by crop characteristics.

Crop biomass productivity indices

In relation to the response of assimilation rate to temperature, FAO (1978-81) has proposed four crop groups (Table 3). Each crop group has a different response function, or adaptability range, to temperature (Fig. 13).

Table 3. Adaptability ranges of different crop groups

CROP GROUP	**CROP TYPES**	**Optimal mean temperature range**	**EXAMPLES**
1	C3	15-20	Barley, bread wheat, chickpea, lentil, olive, sunflower, cabbage, oats, rye, grape, sugar beet; temperate grasses; almost all trees
2	C3 adapted for higher temperatures	25-30	Cotton, groundnut, cowpea, soybean, tobacco, sunflower, sesame, rice, fig, grape, olive
3	C4	30-35	Maize, sorghum, sugarcane, all millets, fonio rice; tropical grasses
4	C4 adapted for lower temperatures	20-30	Maize, sorghum, millets

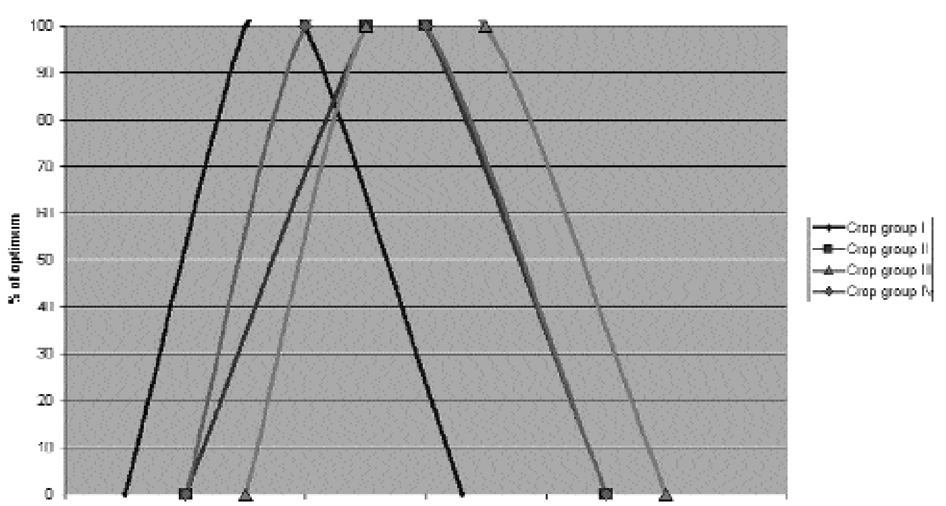

Figure 13. Response of assimilation rate to temperature for different crop groups.

Using this concept of crop adaptability groups, crop biomass productivity indices (CBPI) have been developed for each crop group according to the following model:

$$CBPI_j = \sum_{i=GP\_ON}^{GP\_END} (ATI)_{i,j}$$

with: j: crop group
I: day number
ATI: daily adjusted thermal increment (°C)
GP_ON: growing period onset date
GP_END: growing period end date

in which ATI is calculated as

ATI = 0	[Tday <= T0 or Tday >= Tx]
ATI = Tday - T0	[Tday > T0 and Tday < T_{opt1}]
ATI = (T_{opt1} + T_{opt2})/2 - T0	[Tday >= T_{opt1} and Tday <= T_{opt2}]
ATI = Tx - Tday	[Tday > T_{opt2} and Tday < Tx]

with:

T_0 : the daytime temperature below which no assimilation takes place (cold-limited);

T_{opt1} : the lower daytime temperature threshold above which maximum assimilation takes place;

T_{opt2} : the higher daytime temperature threshold above which assimilation rate declines;

T_x : the day-time temperature above which no assimilation takes place (heat-limited)

These represent the four cardinal temperature points of Figure 13 with the threshold values shown in Table 4.

Table 4. Adaptability to temperature for different crop groups (adapted from FAO, 1978)

Crop group	T_0	T_{opt1}	T_{opt2}	T_x
I	5	15	20	33
II	10	25	30	45
III	15	25	35	50
IV	10	20	30	45

The biomass productivity indices defined by this model have been tested out in the Arabian Peninsula. The results show that only in part of the Yemen Highlands do the indices have non-zero values. This is not surprising because the CBPI is strongly correlated with growing period, which is absent in most of the Peninsula.

Figure 14 focuses on the Yemen Highlands and shows the values of the CBPI for each crop group. Generally speaking, these figures show that the areas are better adapted to crop groups 2, 3, and 4 than to crop group 1.

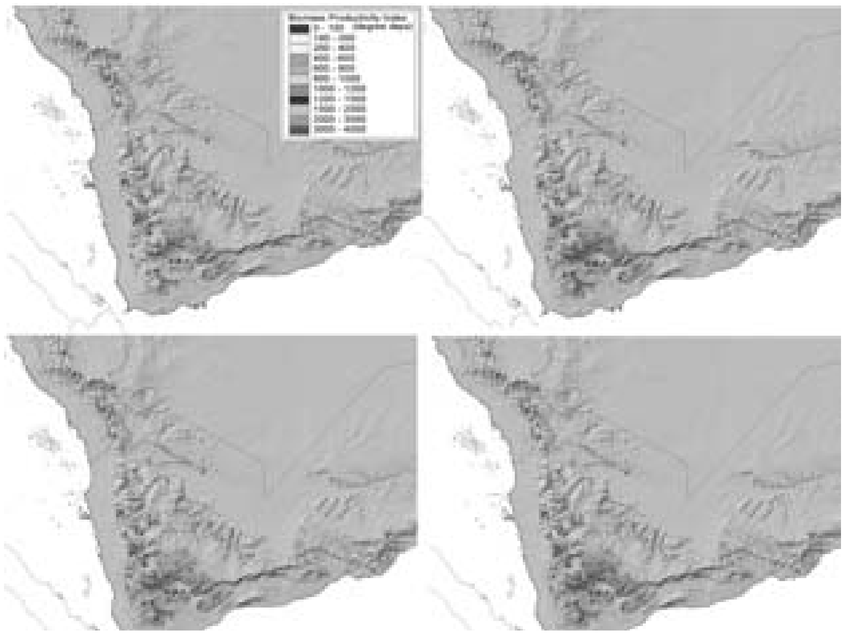

Figure 14. Crop biomass productivity indices in the Southern Arabian Peninsula for different crop groups

Rangeland productivity index

To assess the potential productivity of rangelands, a different kind of index is required that is less demanding in terms of moisture regime. The rangeland biomass productivity index (RBPI) is the product of the aridity index and the annual accumulated heat units

RBPI = AHU x AI

with: AHU: annual heat units (°C days)

AI: aridity index

in which:

$$AHU = \sum_{i=1}^{12} (Temp_i x NumDays_i)_{Temp > Threshold}$$

with: Temp: mean monthly temperature (°C) during month i

NumDays: number of days in month I

Threshold: temperature below which no accumulation is done (in this study: 0°C) and

$$AI = \sum_{i=1}^{12} prec / \sum_{i=1}^{12} pet$$

with i: month number
prec: total precipitation during month I
pet: total potential evapotranspiration (Penman-Monteith) during month I

An example of application of the RBPI is shown for West Asia (Fig.15).

The value of these biomass productivity indices is that they can be derived from simple climatic data and allow extrapolation from site-specific productivity measurements. By calibration with the results of actual crop or rangeland biomass measurements (or even from simulation models) at research sites, they could be used for the regional extrapolation of site-specific data. However, it has to be realized that they provide a measure of *potential* productivity, not current productivity, and, therefore, do not take into account management factors, such as overgrazing, etc.

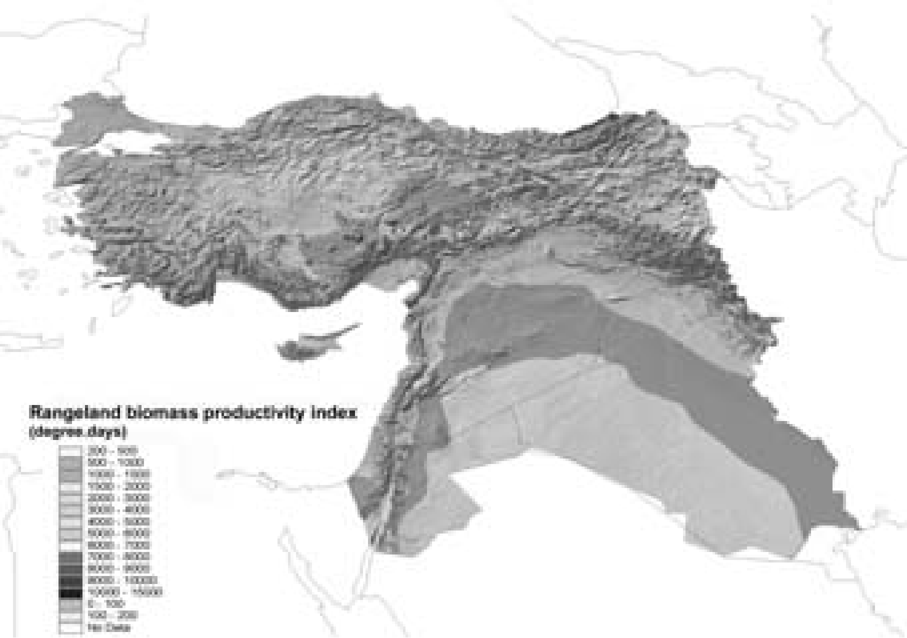

Figure 15. Rangeland biomass productivity index (RBPI) for West Asia

Similarity analysis

A potentially very useful application of climate surfaces is to take the value of a climatic parameter or index at one location (the 'match' location) as the benchmark, and to map similarity of other locations ('target' locations) with the benchmark site. This approach is valuable for assessing the likelihood of successful introduction of a plant species in a different area, in the assumption that the more similar the environments the more likely will be the adaptation.

The key is to be clear in the purpose and define similarity indices accordingly. If the purpose is to assess adaptation to heat stress, a temperature-based similarity index is needed. If the objective is to assess adaptation to drought, a precipitation-based index is needed. If the purpose is to assess similarity both in moisture and temperature conditions, a combined similarity index needs to be developed.

For testing this concept, a combined temperature-precipitation similarity index has been developed for the Arabian Peninsula, using the following procedure:

1. For each grid cell the 12 monthly mean temperature (Temp) and precipitation values (Prec) are taken;
2. The square deviations with the match locations are summed:

$$Tr = \sum_{i=1}^{12} \left[10 \left(Temp_i - T_i \right) \right]^2$$

and

$$Pr = \sum_{i=1}^{12} \left(\mathrm{Prec}_i - P_i \right)^2$$

3. The deviations are sorted and ranked into arrays $[Tr]_n$ and $[Pr]_m$
4. The similarity index for temperature in a grid cell j is then calculated as:

$$Ts_j = 100 \left[1 - \frac{1 - rank\left(Tr_j, \overline{Tr} \right)}{N - 1} \right]$$

and similarity in precipitation as:

$$Ps_j = 100 \left[1 - \frac{1 - rank\left(Pr_j, \overline{Pr} \right)}{M - 1} \right]$$

in which *(b,* $\bar{A}$*)* is a ranking number of b in array $\bar{A}$.

5. The combined temperature-precipitation similarity is calculated as:

$$S = 100\sqrt{\frac{(T_S W_T)^2 + (P_S W_P)^2}{W_T^2 + W_P^2}}$$

where the W_T and W_P are the weights assigned to temperature and precipitation, respectively. In this study, equal weights have been used for W_T and W_P.

This approach is illustrated in figures 16-17, which shows similarity between each part of the Arabian Peninsula and a reference location. In figure 16, the reference location is Abha, a station representing the Asir and Yemen Highlands. In figure 17 the reference location is Al Jouf, representing the desert interior of the Arabian Peninsula. In both cases, similarity is shown on the same scale between zero and one, with zero indicating total dissimilarity and one total similarity. These examples demonstrate that in some cases the adaptability domain, as expressed by a high similarity index value, is very widespread, and in other cases very limited.

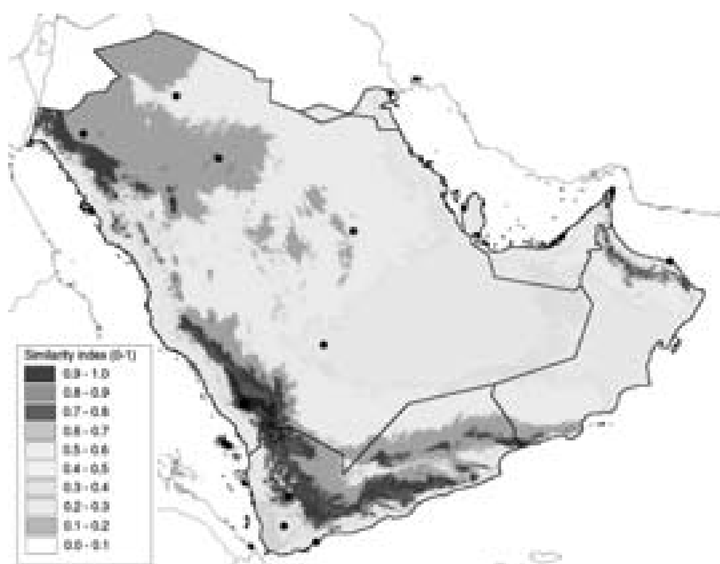

Figure 16. Similarity in temperature and precipitation with Abha, Saudi Arabia

Figure 17. Similarity in temperature and precipitation with Al Jouf, Saudi Arabia

CONCLUSIONS

Agroecological zoning at the level of CWANA requires development of an agro-climatic and soilscape framework which are subsequently merged.

Good progress has been made with the development, application and testing of spatial interpolation methods for the mapping of agroclimatic characteristics at the level of CWANA, with a resolution of 1 km. This has allowed the automated mapping of any climatic theme that can be generated by data overlaying, through straightforward combination, formulas or models. In 2002 these methods will be used for systematic and comprehensive mapping.

Initial work undertaken in 2001 shows that similarity analysis is a very promising research line for germplasm targeting. New similarity indices will be introduced in 2002, based on simple models combined with weather generators.

In 2002 more emphasis will also be given to research for development of soilscape frameworks, based on the combination of digital elevation models with soil maps. This research hopefully will lead to automated methods for differentiating land systems.

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PROJECT 4.1: SOCIOECONOMICS OF NATURAL RESOURCE MANAGEMENT IN DRY AREAS

Rationale

Conservation and sustainable use of the natural resource base for agricultural and livestock production in CWANA is an important goal of ICARDA. This can be achieved only if there is appropriate analysis of the social, institutional and economic factors that influence resource management from which greater understanding of resource users' perceptions, goals and limitations can be developed. This understanding enables the design of technical interventions, reveal where opportunities may exist for community action and cooperative management of resources, and identify where policy and institutional changes are needed to achieve that goal. This project aims to conduct the necessary social, economic, institutional and policy analysis to help achieve that goal.

Objectives

1. Targeted research and identification of appropriate technical or policy interventions based on a greater understanding of users' perceptions, attitudes and objectives.
2. Documentation of the role of property rights in control of and access to natural resources, and analyses of patterns of formation and evolution of social institutions.
3. Natural resource valuation methods developed and applied to decision-making.
4. Methods and tools for resource?use decision making under alternative socioeconomic conditions and technology impact.

Output 1: Analytical models for evaluation of land and water use in small watersheds or provincial level (Syria and Yemen).

Activities:

1. No activities had been done in the development of the model because of lack of adequate staff.
2. Socio-economic and hydrological data were collected in three watersheds in Yemen. This information will form the basis for developing and testing the model mentioned in point 1.This activity is in collaboration with water management project (3.1)

Realized outputs

This output was not realized due to lack of assigned research staff.

Output 2: Research report on institutions for ground water use in Syria.

Activities:

1. Survey of the institutions (formal and informal) affecting ground water use conducted and analyzed
2. Survey of farmers' water use and irrigation practices conducted and crop water use computed for farmers in 5 villages in four agricultural stability zones (1 to 4). This work is done in collaboration with water management project (3.1).
3. Economic analysis of alternative uses of ground water in agriculture conducted using with and without price support and subsidy scenarios

Realized outputs

1. Research summary report on the project produced for the corporate annual report.
2. Research report on farmers' water use and the economics of water use and price policies is prepared for the NRMP annual report (attached)
3. The draft of the project report, which includes institutional, economic, hydrology, water use irrigation practices and simulation models, is in progressing well and expected to be completed in January 2002. This multi-disciplinary report is planned to be one of INRM series to come out this year. Several journal papers also will be produced from this report.
4. One publication (see list of publications)

Output 3: Report on collective action and participatory methods for needs assessment and evaluation of soil and water conservation technologies in dry countries (Syria, Pakistan and Yemen).

Activities:

1. The rehabilitation of ancient qanat system with in the Khanasser valley is completed
2. A sociological and hydrological survey in the community, its land and water, property rights and the rehabilitation process is conducted.
3. Project proposal for scaling up the qanat work was developed and funded by the Swiss Embassy. Survey of working qanats in Syria conducted, rehabilitation of one site is planned and work is in progress.

Realized outputs

1. Draft report detailing the qanat system, the community management and the rehabilitation process completed (draft available)
2. Several publications (see list of publications)

Attachments:

1. The returns to ground water use for different crops in the dry areas: The case of five villages in Syria.

Refereed publications

Non-refereed publications e.g meetings proceedings, posters

1. Wessels, J, R. Hoogeveen, A. Aw-Hassan. 2001. Renovating Traditional Water Supply Systems in Syria. Poster, ICARDA
2. J.I. Wessels. 2001. Little Water Fall; Renovating Qanats in a Changing World, a Case Study in Syria. Paper Presented at the International Symposium on Qanats, Yazd, Iran, May 2000 (in press at Oxford University Press)
3. Partnership with local communities; Syria: Relying on Traditional knowledge. (Contributed by J.Wessels) In Combating Desertification /SDC, September 2001.
4. Wessels, J. 2001. The Water System of the Qanat - An Option for The Future. Inamo, Reports and analyses on politics and human society of the Near and Middle East. Water politics problems and perspectives. Information project Near and Middle East. Number 27, 2001. [in German]
5. Mueller, R.A.E., Rohwedder, N. and Aw-Hassan, A. 2001. Dynamic Simulation and Sustained Groundwater Management in Syria. In: Kögl,H., Spilke, J. and Birkner, U. (Publ.). Proceedings at the 22. GIL-Yearly conference in Rostock 2001. Berlin: Society for Computer Science in Agriculture, Forestry and Food Science. [in German].

Other publications such as booklets

Other products such as training materials web pages, videos, radio programs etc.

Training activities

1. The socio-economists from Kazakhstan, Kyrgystan, Uzbekistan and Tajikistan were trained in methods in economic analysis of water management in a workshop in Ashkabat, Turkmenistan, May 28-June 3, 2001
2. Training of the research collaborators in Yemen on participatory research methods and socio-economic data collection techniques.

Staff list including students

1. Aden Aw-Hassan (Project Manager)-50%
2. George Arab (Research Assistant)-50%
3. Hala Khawam (Research Assistant)-50%
4. Madina Musaeva (Student on Treated sewage water use in agriculture in Kazakhstan).
5. Fadil Rida (Student on the economics of ground water use)-50%
6. Joshka Wessels (NPO-The Netherlands)-100%

Financial support

1. Core budget project 4.1.
2. GTZ through the Kiel University, Germany.
3. Swiss Development Corporation through the Swiss Embassy in Damascus,
4. The Ministry of Foreign Affairs, The Netherlands, through their Support to the NOP (Joshka Wessels)
5. IDRC, Cairo office
6. Asian Development Bank, through the Water Management Project in Central Asia

The returns to ground water use for different crops in the dry areas: The case of five villages in Syria

Aden Aw-Hassan, Fadil Rida, Adriana Bruggeman and Rolf Mueller,

Rationale

Due to continued population growth and growing market demand for food and fiber, much is expected from irrigated agriculture for the foreseeable future. FAO (1993) expected that, Food security in the next century will be closely allied to success in irrigation because about 80 percent of the additional food required during the next 30 years will have to be produced on irrigated land. Similarly, Serageldin (1995, p. 11) estimates that half to two-thirds of the increment in food production in the future will have to come from irrigated land.

However, irrigated agriculture, which is by far the largest consumer of the world's scarce water resources (FAO, 1993), has to adjust to the increasing water scarcity and improve water use efficiency. One of the needed adjustments is to change unsustainable management of ground water. Symptoms of unsustainable groundwater use, such as increasing water extraction costs, drying up of wells, intrusion of low quality water into aquifers are common in the dry areas of the Near East and North Africa (FAO 1993). The depletion of groundwater poses a serious threat to the sustainability of agricultural systems and the well-being of communities that rely on groundwater.

In Syria the irrigated area produces over 50% of the total value of agricultural production on approximately 19% of the cultivated land (FAO, 1997). Water use for agriculture comprises more than 90% of the country's total water use. This water irrigated an area of 1.2 million ha in 1997. Approximately sixty percent of this area is irrigated with groundwater. Groundwater is estimated to constitute more than 50% of the total volume of irrigation water in Syria (JICA 1997). Only a fraction of this water is rechargeable. In spite of that, current irrigation practices are deemed to have low water use effectiveness. Irrigation efficiency coefficient, defined as the ratio of crop water use to the total water delivered to the field, was estimated to be between 0.25-0.55 (Wakil 1993). Hence, irrigated agriculture in Syria depends to a large extend on mining the country's groundwater heritage which is unsustainable. Signs of unsustainable groundwater use for irrigation are evident in some parts of Syria where groundwater irrigation has been practiced for some time: water tables are reported to be in decline and in some areas such as in Khanasser valley near Aleppo water quality could deteriorate due to salt water intrusion from Jabul lake.

This study analyzes the economic and policy factors that were driving the rapid exploitation of groundwater use in Syria for the last few decades and the institutions that affected farmers' investment decisions in wells and groundwater abstraction. The main objectives of this research were to establish a dialogue among irrigators, government departments, research and extension services on the overuse of groundwater resources, and to analyze the driving forces of ground water depletion. The study aims to contribute to the development of policy and institutional options necessary to achieve more coordinated and sustainable groundwater use. More importantly, the study, by engaging directly with irrigators and involving them in the dialogue, stresses their importance of user participation and contribution to the success of any action.

Objectives

As a first step towards the above long-term goal, the immediate objectives ofthis research were:

1. to understand farmers' opinions and perceptions of the causes of groundwater depletion and their solutions to the problem.
2. to analyze the crop water use and water productivity.
3. to analyze the different institutions that affect farmers groundwater use behavior.
4. to use computer simulation models to induce learning among change agents - researchers, extension agents, staff of regulatory agencies and policy makers - concerned with the management of groundwater resources.

Progress in research

Study area

The research area covers a transect northwest of Aleppo across the four agricultural stability zones (1 through 4)[1] , which represent different rainfall conditions (Figure 1). The five sites and their climatic characteristics are listed in Table 1. The precipitation at the five sites exceeds the potential evapotranspiration only during the months of December, January, and February. The groundwater bearing formations in the research area are predominantly limestone, with low productivity. The quality of the water is good. Much of the water flow in limestone formations takes place in fractures, resulting in very different water yields for nearby wells. The Miocene Helvatian aquifer, which occurs in the northwest of Fafin and Barshaya, is a productive aquifer, with good quality water (Technoexport, 1967). Groundwater resources of the villages in the lower rainfall zones southeast of Aleppo are affected by the Jebel Al Hoss (Figure 1). This hill range is covered by a basalt layer, which is by itself not a productive aquifer, but rainfall may leach through this layer to recharge the underlying limestone formations. Throughout the study area, groundwater levels are higher in winter than in summer. Not all farmers have sufficient water to irrigate crops in summer. Due to the unknown and limited availability of groundwater resources the establishment of an irrigation well becomes a search for water. Sometimes multiple wells are drilled without any success. Often water from productive wells is transported by pipes to distant fields.

Research approach

Irrigators, well drillers, extension specialists, hydrologists, water engineers, crop scientists, and social scientists form a formal and informal knowledge system that can be utilized for the design of institutions governing the judicious use of scarce groundwater for irrigation in Syria. This study was, therefore, a multidisciplinary action research involving irrigators and change-agents (extension research and regulatory institutions) to exchange knowledge, perceptions and representation of factors affecting farmers' decision to invest in water extraction technology. This was done at two levels. At the first level, wells and irrigation practices were monitored with irrigators who agreed to record and calculate their crop water uses. Farmers' perceptions of groundwater depletion problems, their causes and solutions were solicited using participatory tools. In the second level, a computer simulation model was developed that was aimed to communicate farm-level intelligence to change- agents and facilitate the change-agents' insights into

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[1] zone 1, average annual rainfall exceeds 350 mm, with a 33% probability to be less than 300 mm; zone 2, average annual rainfall exceeds 250 mm, with a 33% probability to be less than 250 mm; zone 3, average annual rainfall exceeds 250 mm, with a 50% probability to be less than 250 mm; zone 4, average annual rainfall exceeds 200 mm, with a 50% probability to be less than 200 mm; zone 5, average annual rainfall is less than 200 mm.

farmers' water extraction behavior in alternative economic and regulatory environments. The computer simulation was used to illustrate the effect of different crop choices, well interference, and irrigation competition or groundwater availability. The computer simulation demonstrations were conducted in workshops attended by irrigators and change-agents. The purpose of the workshops were to create a forum where stakeholders (farmers, researchers, government regulators, and people with indigenous knowledge such as well drillers) can discuss the problems and generate ideas that contribute to solutions for sustainable agricultural production in water scarce areas. The crop, water use and water productivity analysis are presented in this report.

Data and methods

Observations on crop water use were collected for the 1999-2000 crop season during regular field visits from four to six selected farmers in each village. In Barshaya (zone 2) and Hobs and Harbakieh (zone 4) the irrigation water use of the complete village was monitored. Land use maps of Barshaya were prepared for the 1998-1999 season.

Precipitation was measured with a plastic rain gauge by a farmer in the village. In the Hobs and Harbakieh area precipitation was monitored with an automated rain-gauge. To compute the amount of water used for irrigation, the farmer was asked the number of times he irrigated, the time it takes to irrigate his field, and the size of the field. Well discharges were measured with a 98.7 liter barrel at different times throughout the season. The water use for each crop was computed from the total irrigation time and the measured well discharges. If no well discharge was measured, the water use was estimated from the median irrigation depth for that particular crop in the village. Back-computation of the well discharge from the irrigation water depth for different crops sometimes resulted in different discharges for a specific well. The results indicated that the irrigation estimates of the farmers were less reliable for small areas of land.

The water requirements of the crops planted by the selected farmers was computed using CROPWAT (Smith, 1992), the long-term potential evapotranspiration averages (Corbett *et al.*, 2000), and the observed rainfall. Additional information on crop water use was obtained from Allen *et al.* (1998), Doorenbos en Kassam (1979) and Doorenbos and Pruitt (1979). The computations are based on planting and harvesting dates, collected during the meetings with the farmers.

Irrigation costs were calculated based on the number of irrigations and the cost per irrigation. Farmers reported the number of hours required to irrigate one hectare and the required fuel to operate the pump engine for one hour. The cost of irrigation is estimated as the product of the number of irrigations, the number of pumping hours and the cost of fuel and labor per irrigation. The Gross margins per hectare, which are the returns to fixed capital and management, were calculated as the difference between total revenues and total variable costs. Given water resources as the main constraint to agricultural production in the dry areas, farmers' water allocation is examined in the light of crop water productivity. Water productivity is defined as the value of gross margin per unit of water applied.

Results and discussion

We found that the combination of agricultural support, effectively unrestricted access, and improved technologies that raised profitability of irrigated agriculture has contributed to the expansion of ground water pumping (Figure 2), and led to rapid groundwater depletion. The figure indicates that population growth and economic incentives have exponentially increased both drilled wells and irrigated areas. As the number of irrigators has increased, wells have dried up and irrigated areas per farm have decreased in many villages. Given these trends, there will be a decline in groundwater-irrigated areas due to a decline in water tables and an increase in dried-up wells. This negatively affects farm income and rural employment, and accelerates rural out-migration. Farmers' response to the depleting groundwater has largely been a search for more water by lowering the depth of pumps, increasing the depth of wells and drilling more wells. Adoption of water saving technologies and switching to less water-demanding crops has been slow.

Wells and pumping equipments constitute the most important investment for the farmers in the study area who rely on groundwater for irrigation. This investment includes drilling of wells, purchase of pumps and engines, deepening of wells, horizontal drilling to increase potential water yields and pipes used to transfer water from the pump to the fields. On the average the farmers in the study villages invested about 280 thousand Syrian pounds (SL) in well establishment, pumping equipment and PVC pipes. An additional annual cost of 13,000 SL is spent on maintenance. The water lifting equipment accounts for almost 40% of this investment, while drilling accounted for 21% and the PVC pipes about 14%.

Due to the variation and complexity of the geologic formation (see figure 1), well depths and water yields vary considerably between the study villages and between wells within a village. The location and construction of the well has considerable effect on its water yield and wells that are in close proximity may have different discharges. The irrigation cost, therefore, varied between villages and between farmers within a village. Farmers operating wells with scarce water conditions have higher irrigation costs than those with abundant water. For example, Hobs village in zone 4, a farmer operating a well with relatively low yield had a per irrigation cost of SL 6000/ha for cotton. This farmer applied only 6 irrigations. Another farmer in the same village with a well of relatively good yield had a per irrigation cost of 2000 SL/ha. This farmer, who had sufficient water, applied 18 irrigations and sold water to other community for domestic use. But because of the differences in the number of irrigations the two farmers have similar cost of irrigation per hectare but with different outputs. In Seyaleh, in the zone 4, farmers applied from 15 to 18 irrigations to cotton with a cost of about 2300 to 4000 SL per irrigation/ha. Again this reflected the situation of the water situation of the wells.

Although, farmers in the study villages face water shortages they largely use traditional surface irrigation methods because they perceive that this is suitable for their soil conditions and can give them high yields. The initial investment cost required for modern irrigation methods and the uncertain water availability due to depleting groundwater may have led farmers to maintain their traditional practices. However, few innovative farmers are using sprinkler irrigation for wheat and drip irrigation for cucumbers.

In this study we found that, in spite of the fact that these villages have experienced a continues drop in water tables, drying of wells and reduced irrigated areas, farmers who had sufficient water consistently over-irrigated their winter as well as their summer crops. Applied water exceeded for up to 62% of the crop water requirement. The same farmers, however, were not always able to apply the crop water requirement during critical crop stages in April for wheat and July for cotton. Farmers in zone 1,2, and 3 over irrigated wheat unless their wells exhausted. Excessive irrigation was attributed to farmer's irrigation practices including irrigation methods, frequency of irrigation and low energy cost. For example, in Table (2) it is clear that excess water used for wheat in Fafin was 1,700 m^3. This constituted 40% of the irrigation cost. Similarly, excess water applied to cotton comprised 30% of the crop requirement which increased irrigation cost by 12,000 SL/ha and constituted 25% of average irrigation cost. The farmers in the drier villages of zone 4 were not able to apply sufficient water to their summer crops and discontinued irrigation during the growing season with substantial financial losses.

The gross margins per hectare of nine crops, including cotton, the main summer crop; summer vegetables: cucumber, onions, potatoes and tomatoes; winter field crops: wheat and faba beans; and winter vegetables: garlic, were compared (Table 3). The three summer vegetables namely, potatoes, cucumber and beans gave the highest gross margins per hectare, in that order. The second highest gross margins were generated by cotton, garlic and tomatoes in that order. The least profitable crops were onions, faba beans and wheat in that sequence.

Cotton generated higher income than wheat in all villages. However, cotton gross margins declined with decreasing groundwater conditions. These were estimated at 42000, 36000, 30000 and 17000 SL/ha for villages in zones 1 through 4 in that order. Farmers who operated wells with relatively abundant water grew cotton in all villages, while those who grew cotton under water-scarce conditions incurred losses. For example, in the year 1998/99 farmers abandoned crops due to insufficient water and dried up wells in villages in zone 4. One farmer in Harbakieh village, in zone 4, failed to provide sufficient water to his cotton crop during July 2000 and incurred a net loss of 50,000 SL/ha.

With the exception of Fafin village in zone 1, wheat gross margins were higher in the higher rainfall zones due to lower irrigation costs and higher yields. Wheat gross margins were lower than all other crops. Wheat gross margin in Barshaya village, in Zone 2, was estimated about 17,000 SL/ha and was higher than that in the villages in zones 3 and 4, which received an average of about 10,000 SL/ha, and 3,000 SL/ha respectively. In the villages in zone 4, particularly Hobs and Harbakieh, farmers who were not able to provide sufficient irrigation water to their wheat crop discontinued irrigation due to exhausted wells in the 1998/99 season; hence incurring net losses. But because of the variable characteristics of the aquifer one farmer had sufficient water and was able to produce 4.5 t/ha with a gross margin of 18,000 SL/ha.[2]

Faba beans generated higher gross margins, 15,000 SL/ha, in Barshaya (zone 2) than in Fafin (zone 1), 13,000 SL/ha, due to higher irrigation cost in the later. However, faba beans generated higher gross margin than wheat in zone 1 because of the relatively lower wheat yields reported there. Potatoes, beans and cucumber generated the highest gross margins, ranging from 50,000 SL to 68,000 SL per hectare on average, in the villages in zones 1 and 2. Potatoes gross margins were two fold the gross margins of cotton and over seven and half times that of wheat.

Although cotton showed high gross margins, compared to other crops and was ranked in the 4th place among the nine crops analyzed, it consumed the largest volume of water across all farmers and villages compared with other crops. Water use, with the exception of Seyaleh, ranged from 10.4 to 16.8 thousand m^3/ha across villages. On the average, cotton generated higher gross margin per hectare than garlic and onions, but the amount of water that it consumed was about 3 times that of garlic and 3.5 time that of onions. Similarly, while the cotton gross margin was more than 2 folds that of wheat and faba beans, the volume of water diverted to cotton was more than two times that of wheat and nearly 5 times that of faba beans. While the other crops with higher gross margins than cotton, such as potatoes, cumber and beans consumed less than 30-50% of the volume of irrigation water.

[2] The same farmer was also selling water to neighboring villages.

The different volume of water applied to each crop resulted in different rankings of the nine crops by water productivity, in terms of gross margin per cubic meter, than by gross margin per hectare. Potatoes, cucumber and beans ranked the highest in water productivity as well as in gross margin per hectare in that order. Onions, because of its lower water consumption, came in the 4^{th} place in water productivity ranking compared to the 7^{th} place in gross margin per hectare. Similarly, faba beans, ranked higher in the 6^{th} place compared to the 8^{th} place, because of its relatively low water use. The highest water consuming crops, cotton and tomatoes ranked lower in water productivity in the 8th and 7^{th} places, respectively compared to the 4^{th} and 6^{th} places in the gross margin per hectare, while wheat remained the last crop in both rankings.

This analysis shows that although cotton and wheat gave the lowest returns to water, farmers in areas where groundwater is depleting still consider these as good options. This can be explained by the more predictable returns of these crops, once irrigation is successful, than vegetables. This is changing because, on one hand, the government has banned cotton cultivation in zones 3 and 4 and in some villages, farmers are replacing cotton with vegetables. However, vegetable production due to seasonal fluctuation remains a risky proposition for using scarce groundwater in spite of its high returns to water. In this study we found that removing 75% of the diesel fuel subsidy made both cotton and wheat unprofitable.

The project's workshops were attended by farmers using different irrigation methods and in different water scarcity situations, farmers with water meters, well drillers, and officials from different departments that deal with different aspects of ground water, and researchers. These workshops were milestones because farmers and officials met together, for the first time, to discuss the groundwater problem in a common platform. The officials cautioned farmers from drilling new wells, but farmers, while showing their awareness of the problem, asked alternative solutions. Farmers were eager to learn more about the applicability of modern irrigation systems used at Der El Hafer Irrigation Research Station near Aleppo that we visited during one of the workshops. They expressed concern about the uncertainty of their groundwater supply as well as their need for credit assistance to adopt these technologies. They were unaware of existing government programs that provide credit opportunities.

Conclusion

Certainly, there is growing public awareness of the groundwater problem in Syria and several policy measures are being taken. But as clear from this study that although some farmers replaced high water demanding crops by vegetable crops, some farmers still give priority to crops with low returns to water in their water allocation. This is partly because of the incentive structure in terms of price support and fuel subsidy and partly because of the greater uncertainty in the returns of vegetables, which face market price fluctuations. The full report of this project examines the institutional and policy options for sustainable groundwater management. The stakeholder dialogue that this project initiated needs to be continued and strengthened to build public awareness and consensus for action. Further research is needed to determine the full range of policy options and assess their potential impacts.

Table 1. Longterm annual precipitation and potential evapotranspiration for the study sites. (After Corbett *et al.*, 2000).

Village	Zone	Elevation	Average precipitation (mm/yr)	Average potential evapotranspiration (mm/yr)
Fafin	1	416	349	1500
Barshaya	2	461	309	1493
Baggat and Rabia'a	3	362	264	1544
Hobs and Harbakieh	4	416	237	1576
Seyaleh	4	390	225	1571

Table 2. Water use and requirements for the five villages.

Village		Crop	N	Area (ha)	Total irrig. (m3)	Median irrig. (m)	Water requirement (mm)	Season total (m3)
Fafin	Winter	Wheat	4	20.0	90660	0.38	0.21	
	Summer	Beans	1	0.4	2659	0.66	0.34	
		Cotton	1	1.2	20160	1.68	1.20	
		Eggplant	3	0.3	3601	1.20	0.39	
		Onions	2	2.0	10676	0.53	0.58	
		Potatoes	4	13.0	43370	0.38	0.40	
		Tomato	3	1.5	18005	1.20	0.39	
		Watermelon	1	0.5	1101	0.06	0.42	
		Total	15	19	99572			190232
Barshaya	Winter	Barley	1	1.2	3751	0.32	0.11	
		Fababean	23	39.7	133847	0.36	0.06	
		Garlic	14	5.7	28896	0.49	0.13	
		Wheat	33	91.1	470702	0.54	0.17	
		Wintercrop	1	1.5	1818	0.12	0.00	
		Total	72	139.2	639014			
	Summer	Beans	25	25.3	219486	0.64	0.38	
		Cucumber	30	16.8	110020	0.64	0.36	
		Cotton	2	2.1	23627	1.43	1.20	
		Melon	1	1.0	12599	1.28	1.05	
		Onion	1	0.4	1135	0.20	1.25	
		Fruit trees	3	2.8	6234	0.39	0.75	

(Contd Table 2)

Village		Crop	N	Area (ha)	Total irrig. (m3)	Median irrig. (m)	Water requirement (mm)	Season total (m3)
		Potato	1	0.3	956	0.32	0.69	
		Sugarbeet	1	1.0	7738	0.78	0.96	
		Summercrop	1	0.3	81	0.03	0.58	
		Tomato	1	0.2	1507	0.76	0.89	
		Vegetables	2	1.0	10811	1.10	0.58	
		Total	68	51.1	394194			1033208
Baggat	Winter	Barley	2	2.8	3323	0.18	0.13	
		Fababean	1	0.6	2077	0.35	0.03	
		Wheat	5	31.5	204888	0.51	0.32	
		Total	8	35	210288			
	Summer	Cotton	5	17.6	281972	1.44	1.13	
		Corn	1	0.6	2492	0.42	0.43	
		Vegetables	1	0.6	9029	1.50	0.57	
		Total	7	18.8	293493			503781
Hobs	Winter	Barley	10	11.5	29632	0.31	0.13	
		Garlic	1	0.1	702	0.70	0.24	
		Fababean	2	0.8	4841	1.00	0.09	
		Wheat	8	8.2	65956	0.83	0.26	
		Total	3	0.9	101162			
	Summer	Cotton	1	1.2	12458	1.04	1.12	
		Olive	5	5.3	5843	0.10	0.64	
		Total	6	6.5	18301			119463
Seyaleh	Winter	Barley	1	2.0	2867	0.14	0.28	
		Wheat	4	8.0	52757	0.51	0.46	
		Total	5	10	55624			
	Summer	Cotton	3	3.3	55155	0.87	1.15	110779

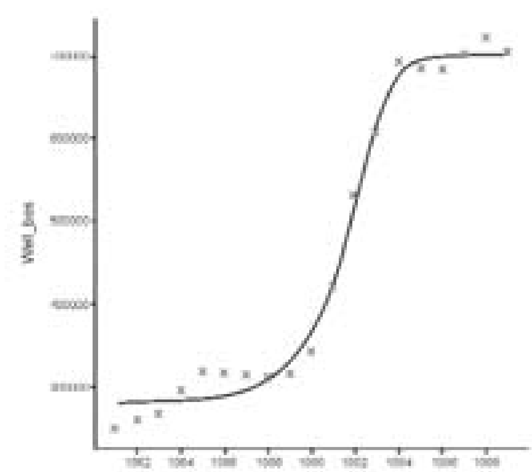

Figure 2. Growth of drilled wells from 1982 to 1999 in Syria

Table 3. Water use, cost, yield, gross margin and are allocated for different crops across different stability zones

Crop	Village	Zone	Area %	Water use 1000 m3/ha	Crop area allocated		Irrigation cost		Yield	Gross Margin		Ranks by:	
					ha	%	SL/ha	%	Tons/ha	SL/ha	SL/m^3	Gm SL/ha	GM SL/cu.m
Cotton	Fafeen	1	2	16.8	7.7	20	42000	52	4.3	42251	2.51		
	Bershaya	2	1	14.3	9.5	18	37800	56	3.5	34146	2.39		
	Rubia & Bagat	3	33	14.4	23	48.9	37000	53	3.6	35781	2.48		
	Hubs & Hurbakia	4	6	10.4	3.7	16	44000	60	2.5	NG*	NG		
	Sayala	4	25	8.7	3.5	56	41600	60	3.1	20218	2.32		
												4	8
Wheat	Fafeen	1	32	3.8	22	56	9000	34	3.4	10845	2.85		
	Bershaya	2	50	5.4	29	56	10000	38	4.0	17212	3.19		
	Rubia & Bagat	3	59	5.1	24	51.1	12200	35	4.3	10388	2.04		
	Hubs & Hurbakia	4	38	8.3	15.2	32	15000	51	3.0	1550	0.19		
	Sayala	4	60	5.1	8	70	13750	45	3.3	5435	1.07		
												9	9
Faba bean	Fafeen	1	32	3.6	6.5	17	16215	41	2.5	12771	3.55		
	Bershaya	2	21	3.6	8.5	16	10200	31	2.3	14504	4.03		
												8	6
Cucumber	Fafeen	1	5	6.4	2.9	7	12000	19	20.0	55365	8.65		
	Bershaya	2	9	6.4	1.2	2	8400	12	23.2	70307	10.99		
												2	2
Beans	Bershaya	2	1	6.4	3.4	7	10925	17	12.5	59374	9.28		
	Fafeen	1	14	6.6	9.5	18	10800	19	10.0	41775	6.33		
												3	3
Tomato	Fafeen	1	2	12.0	8.5	16	10000	22	15.0	28680	2.39		
	Bershaya	2	0.1	7.6	29	56	11250	22	15.0	23195	3.05		
												6	7
Potatos	Fafeen	1	21	3.8	23	49	15000	15	35.0	92860	24.44		
	Bershaya	2	0.2	3.2	24	51	21000	22	25.0	43850	13.70		
							18000					1	1
Onions	Fafeen	1	3	5.3	3.7	8	16000	18	25.0	34361	6.48		
	Bershaya	2	0.2	2.0	15.2	32	22500	21	25.0	16250	8.13		
							19250					7	4
Garlic	Fafeen	1	2	4.9	3.5	30	9600	14	10.0	29261	5.97		
	Bershaya	2	3	4.9	8	70	12000	13	12.0	26800	5.47		
												5	5

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PROJECT 4.2: SOCIOECONOMICS OF AGRICULTURAL PRODUCTION SYSTEMS IN DRY AREAS

Rationale

Sustainable improvement of the welfare of poor people in dry areas, through the proper identification of problems and the development, transfer and adoption of viable options, can be achieved only if there is a full understanding of the economic and social dimensions of rural poverty. This can be accomplished though micro-economic and social (including gender) analysis of farm households and rural poverty. Such understanding allows proper design and adaptation of land use options and superior practices and enhances their diffusion in the farming communities. In addition, it enables the identification of policy and institutional changes that remove the constraints that limit rural peoples' abilities to improve their livelihoods and to fully utilize those options and practices.

Specific Objectives for 2001:

1. Efficient and effective identification of research problems within farming systems.
2. Appropriate solutions and recommendation domains for identified problems.
3. Improved targeting of research and technology transfer efforts towards the rural poor.
4. Improved adoption rates of appropriate new technologies.
5. Measured impact of technology use on productivity, poverty alleviation, and the environment (disaggregated by population group, including gender).
6. Human resources for problem identification, technology evaluation, and impact assessment increased within NARS partners.

Anticipated Outputs for 2001:

Output 1 expected in 2001

Production problems of small-scale, resource-poor farmers identified jointly by researchers and producers within two farming systems of WANA- Problem identification and farm typologies study completed in Central Asia.

Activities

1. In collaboration with the livestock project leader (Dr. L. Iñiguez) a consultant (Mr. Roberto Tellaria) was hired for the economic component of the Central Asian project.
2. Production and marketing surveys were conducted in Kazakhstan, Turkmenistan, Uzbekistan and Kyrgystan. The data compilation and processing of these surveys are now underway. This work is being coordinated by Mr. Roberto Tellaria.

3. Mr. Yerbol Yakhshilikov who is currently working at ICARDA Tashkent office as research assistant fror this project has prepared a paper on the cooperatives in transition with emphasis on karakul sheep farms. I have reviewed the draft and it is in relatively good shape but needs some more work.

Realized outputs

1. The write-up of the outputs of the livestock study in Central Asia has not been yet completed partly because of the week NRAS and the limited resources we have here. The hiring of Mr. Tellaria has contributed substantially to the resources in this area. The encouragement given to Yerbol seems to producing results. But resources for this output will have to be strengthened in the 2002 plan.

Output 2 expected in 2001

Potential new technologies evaluated by researchers and users in two production systems:- Case study of local community participation in evaluation of technology options completed. Guidelines and methods for farmer participation in research developed.

Note

It was decided that the activities under this output be reported under the following output because of the close similarities of the two outputs. In next years plan this will not stand as an independent output but will be merged with output 3 below.

Output 3 expected in 2001:

Documented feedback of user evaluations into the technology generation process:- Study on farmer-to-farmer diffusion of new barley varieties in Syria completed.

Activities:

1. Data collection on the farmer-to farmer seed distribution survey, data entry and cleaning completed; partial analysis of the data done.
2. Survey on participating farmers of the participatory barley breeding program and non-participating farmers conducted with the aim to assess the impact of the program, data entry is in progress (this work is done in collaboration with PRGA of the CG which is coordinated by CIAT).

Realized output 2001:

Draft report of the farmer-to-farmer seed distribution prepared (report attached).

Output 4 expected in 2001:

Identified circumstances of rural poverty and social diversity (including gender) that may constrain or enhance the adoption of potential new technologies in one production system: Study on the determinants of child malnutrition in different food systems completed in Syria. Gender analysis network for CWANA established.

Activities:

1. Child nutrition study: Data collection using formal survey and key-informant interviews completed in three production systems, data entry and cleaning completed; data analysis partially completed.
2. Preparation of project proposal on the effects of lysine fortification on the households mainly depending on wheat flour completed with United Nations University and University of Massachusetts
3. Preparation of publications on the effects of agricultural changes on female labor in Syria.

Realized outputs:

1. Draft report of the descriptive statistics analysis of the nutritional study prepared (report attached).
2. The lysine fortification project funded.
3. Two papers on the effects of recent changes in Syrian Agriculture on female labor were submitted for publications. A report summarizing the findings of this research is prepared for the NRMP report (report attached).

Output 5 expected 2001

Quantified ex-ante and/or ex-post impact of new technology use in two production systems: Study on the determinants of agricultural productivity changes in WANA completed

Activities

1. A comparative study of the relative performance and productivity of the agricultural sector of WANA was conducted using total factor productivity indices.
2. Ex-ante impact analysis of ICARDA's germplsam research on Australian agriculture is conducted; draft report is complete and expected to be printed in the first quarter of 2002. The impact assessment of the IPM on sunn pest on wheat in Iran, Syria and Turkey in initiated. This work has just stated and its progress will be reported in 2002 annual report.
3. A review of the livestock sector in the WANA region including projections is conducted
4. Impact assessment of modern wheat technologies conducted in Syria

Realized outputs

1. Draft paper on the Comparative analysis of the productivity of agricultural sector for selected WANA countries prepared (paper attached). The paper is planned for publication.
2. Draft report on the impact of ICARDA's germplasm research on Australian agriculture prepared. Summary of the report will be reported in next 2002 NRMP annual report.

3. The livestock production review that Farouk Shomo is undertaking is not complete yet. This will be completed in early 2002.
4. Draft report on the Impact of modern wheat technologies (varieties and management practices) is completed.

Output 6 expected in 2001

Strengthened research capacity of NARS: Socio-economic training (including on-the job individual and group training and training workshops) organized for NARS in collaborating projects

Activities

1. Carried out in country training course on trasfer of technology through on-farm trials held in Iran, 18-21 May 2001.
2. Conducted a planning and training workshop in Ashkabat for the social scientists working in the project. Dr. Malika Martini, Mr. Roberto Telleria and Liba Brent (University of Wisconsin) participated in this workshop.

Achieved outputs

1. Although not measured the above activities have certainly contributed to the capacity of the trainees.
2. Drafts of training material were produced on "Farm Survey Research Methods" and on "Overview of Adoption and Diffusion Theory". These could form a basis for on-farm research manual which includes a collection of our experiences in the region.

Other activities

This project supported the regional priority setting for (CWANA) where Dr. Ahmed Mazid allocated time for questionnaire design, meetings, and data analysis.

Attachments:

1. Nutrition
2. Female labor
3. Farmer-to-farmer seed distribution

Other reports mentioned in this report are available.

Collaboration with other project

This project is collaboration with the projects:

1. Barley Germplasm Improvement for Increased Productivity (1.1)
2. Durum Wheat Germplasm Improvement for Increased Productivity (1.2)
3. Food Legume Germplasm Improvement (1.5)
4. Integrated Pest Management in Cereal and Legume-based Cropping Systems (2.1)
5. Improvement of Sown Pasture and Forage Production for Livestock Feed (2.3)

6. Water resource Conservation and Management for Agricultural Production (3.1)
7. Land Management and Soil Conservation to Sustain the Agricultural Productive Capacity of Dry Areas (3.2)
8. Socioeconomics of Natural Resource Management in Dry Areas (4.1)

The impact of agricultural development on the feminization of agricultural labor in Syria
Malika A. Martini

Rationale

Male out-migration to urban centers and abroad in search of better living for their families is common in the dry areas. This reduces the agricultural labor supply. Female labor may not readily replace the out-migrated male labor in conservative societies where women's tasks are traditionally confined to the attendance of home, children and specific tasks on own farm and where social norms are not conducive to the development of female labor market. The question is whether the economic forces; that is the agricultural labor demand and the household's need for additional earnings to supplement their income, will outweigh the social forces that limit female labor supply.

This study analyses the changes that have occurred in the agriculture sector in Syria for the last three to four decades and their effects on agricultural labor in general and on women's labor in particular. The findings of this study will reinforce the need for research and extension services to increase their collaboration with rural women in the development and transfer of agricultural innovations.

Objectives

The objectives of this research are to:
1. Identify the allocation of family and wage labor by gender within different farming systems, labor supply and employment patterns in relation with agricultural intensification.
2. Assess the implications of male migration trends on the increased involvement of women in agricultural production.

Progress in research

Study description
The study area is located in northwest Syria covering Aleppo and Idlib governorates. It is an area where rapid changes in agriculture (agricultural intensification) have been observed, particularly during the last two decades. This area is also characterised by a diversity of farming systems, in addition to the changes due to the spread of irrigation, and the introduction of new agricultural inputs.

Informal surveys, participant observation and formal survey questionnaire were used in this study. The informal survey has been conducted in the study area in 38 villages. Three different farming systems fall into different agricultural stability zones of the study area. The wheat-based farming systems are mainly found in zone 1B, the mixed farming systems are located mainly in zone 2, the barley-livestock farming systems are found in the area of zone 3. These zones were targeted in an attempt to cover an area where the diversity in agro-ecologies would indicate important aspects of agricultural labor. The interview survey area covered districts in Aleppo and Idlib Provinces across three stability zones. Random multistage sampling was followed using the list of farms available in the Directorate of Agriculture and covered 117 farm households from 46 villages.

The data collected was used for a characterization of cropping patterns, irrigation, new inputs, and labor use. Labor requirements gender disaggregated by crop were used to produce a calendar of activities. This information was collected in order to identify the main features of the study area in terms of agricultural and labor trends. The farm household survey included the historical development of the household, in terms of demography, labor allocation, and production system. The analysis of this data takes into account the different household types according to their labor needs, labor supply, and types of labor used in production in order to examine the relationships between household characteristics and participation in the wage labor market. Also, women are largely employed in this area as indicated by the informal survey. The agricultural stability zones were taken into consideration in the sampling design in order to focus on the differences in farming systems, and the conditions as well as the diversity of labor requirements and allocation.

Results and discussion

The results show that due to agricultural intensification, important changes in production and labor have occurred in the study area. These changes and their effects on the feminization of agricultural labor is discussed below.

Changes in agriculture. The major developments in the agriculture sector in Syria for the last three decades were the expansion of irrigation that supports more intensive cropping systems and the introduction of mechanization in cereal production. Irrigation by canal water form the Euphrates River and by groundwater has expanded substantially. It was found that 40% of the surveyed farming households have a source of irrigation. Irrigation is largely spread on farms of less than 8 hectares, constituting 32% of the total irrigated farms. Irrigated farms are mainly located in Zone 1 representing 45% of the total irrigated farms, but are also found in Zones 2 and 3 where important well irrigation have spread during the nineties.

The agricultural development, particularly irrigation expansion, has brought noticeable changes in the cropping patterns and the use of commercial inputs, such as fertilizers, and new varieties. This has resulted in considerable crop diversity, new production practices, introduction of new crops such as potatoes, cotton, and other summer crops in the drier areas. Farmers are using more inputs in agriculture. For example, 97% of the farmers used fertilizers at a rate of 50-200 kg/ha. Irrigation in the drier areas of zone 3 had positive effects on farming households; i.e. diversification of production and increased crop residues for livestock which means increased income. But its negative effect was decreased or complete cessation of fallow and reduced labor availability for grazing animals in the steppe as a result of increased demand for labor in crop production. Livestock flocks have decreased considerably particularly in zones 2 and 3 due to reduced fallow land which was used for grazing, as a result of the introduction of new rotations in the farming systems and intensification of crop production.

The effect of the irrigation expansion can also be noted from the distribution of cotton production in the sample. Although cotton constitutes only 2.5% of the total planted area in the sample, 48% of that was grown in the drier areas (zone 3), and 38% in the wetter area (zone 1). Another important change in agriculture was the expansion of tree production.

There have been important changes in holding sizes and farming systems which vary from one locality to another taking into account the differences in natural conditions. Holding sizes-ranging from 2 to 120 hectares- have considerably decreased due to the land fragmentation resulted from inheritance and population growth (about 3.5% annually) The largest proportion of households own about 10 hectares on the average. The increasingly smaller holding sizes and increasing cost of living meant that households have to seek alternative sources of employment and income.

The mobility of people in the agricultural sector including agricultural workers and the individuals working on agro-pastoral production became feasible due to the improvements in transport allowing individuals to get additional income from various activities. Both people and animals are now moving longer distances with vehicles to transport labor and bring water (Leybourne, 1993). In the past, labor was utilized within villages. Now people move more frequently, particularly women, in order to get a daily wage. Large numbers of workers leave their villages daily to work elsewhere, returning in the afternoon. Improved transportation has contributed to greater availability of work opportunities in rural communities. Men migrate to neighboring countries such as Lebanon and Jordan seeking employment both in the agricultural and non-agricultural sectors. After getting a job, they encourage their relatives to follow; in one case all migrants to one village in Lebanon originated from the same village in Syria, and may even belong to the same extended family. Migrants then recreate the atmosphere of their communities in a different environment. The junior male members of the households are mainly the ones who migrate to urban areas and abroad. The household heads usually continue to manage their farms as they allow their sons to migrate.

Increasing integration with markets. Another important aspect of these changes was the increasing integration of farmers' activities into the market place. Farmers decide their land use options and management practices based on their expected returns. These returns are often influenced by market prices. Therefore, they pay attention to the market signals which have immediate impact on their production and resource allocation decisions. The increasing use of purchased inputs and hired labor are additional factors that contribute to increased integration of farming sector into to the market. Some studies have emphasized that farm decisions are increasingly guided by market demand rather than by local needs (Maclachlan 1987). Another reason for greater integration with markets is the increasing reliance on off-farm income. A greater proportion of the rural families in the study sample (64%) increasingly rely upon household members to provide cash that is invested in agriculture, while close to a third of the surveyed households (26%) spend their off-farm income on consumption to improve household welfare, and some families (10%), especially those living in very harsh environments where technological interventions are not applicable, invest in non-agricultural activities.

Growing food processing industry. Agricultural intensification and increased production has generated growth in agro-industry and food processing, particularly in peri-urban areas. In addition to their agricultural activities, about 50% of the sampled households were involved in food processing activities. Much of agro-industry is organized in such a way that risk is reduced. Agro-industry produces jobs in both sectors, in the cities such as cheese, laban[1], and burghul[2], in the villages often completely controlled by women such as tomato and pepper paste (particularly in El-Bab district where 30% of the surveyed households are involved in this activity) in addition to laban and cheese on a small scale.

Impact on women's labor. Above changes in the agriculture sector have had important implications for agricultural labor. The introduction of mechanization in cereal production, on one hand, has reduced the demand for manual labor for land preparation and harvesting and replaced that with smaller number of skilled workers carrying out mechanized operations. The introduction of irrigation, on the

1 Laban is local yogourt

2 Burghul is crushed wheat.

other hand, has led to the use of more inputs and more intensive cropping or changes in the cropping pattern which imply increased total labor requirement per hectare. These requirements are important because most operations are still performed manually for crops other than cereals, particularly legumes, forages, and summer crops, considered the most labor-hungry crops. Heavy machinery is sometimes found on large commercial farms, but is not always used due to problems of maintenance or repair. New operations and tasks have developed as a result of using new inputs in agriculture.

Overall, these changes mean increased labor demand for agriculture. The consequence of male out-migration, therefore, was labor shortages in certain periods of the year. Farmers reported that labor shortages were concentrated during three periods of the year; April-May-June, July-August and October-November. The most crucial period reported by farmers was April-May-June, representing 82%, mainly due to the needs of the legume harvest competing with other tasks related to other crops. The second most important period of labor shortage is in October-November, reported by 13% of farmers. This period concerns particularly olive producers. Finally, a smaller number of farmers (4%) reported that the most crucial period of labor shortage is during July and August.

As a result of the out-migration of males, the women who are left behind in the agricultural sector have increasing responsibilities. They are more available for work and their income is indispensable to their families. An important consequence of the male-out migration and the changes in the agriculture sector brought about by the intensification has been the increase in female labor demand and supply for agriculture. This increase was identified in all the areas including the drier areas of zone 3 where irrigation from the Euphrates' river is spreading. As a result of mechanization, women's labor have shifted from the activities that became mechanized such as harvesting of cereals to other manual operations while the mechanized work has been performed exclusively by men. The new land use patterns have generated new labor requirements for crops and livestock production. This has led to an increase volume of the "traditional" women tasks such as harvesting and weeding, and a development of new demands for "nontraditional" tasks such as fertilizer application, and irrigation. These changes have created diversity in women's labor tasks, and had an impact on male and female labor allocation. The changes also increased the work of women in agriculture as farmers have more opportunities to diversify and intensify their production using more inputs and extending the agricultural work to a longer period during the year.

In the past, all activities that were related to cereals, including post-harvest operations, were performed manually, and agricultural workers were required for a relatively long period of time. Labor was firmly rooted in the social relations of the family and the household. Now only some of these activities still exist. Labor, particularly female labor, is more intensively used. More women are working as agricultural wage laborers, as men work in the urban sector to supplement their agricultural income, or leave their women folk as substitute workers in agriculture.

The increase in the female wage labor can be described as a 'feminization of agricultural labor' in contrast to the 'feminization of agriculture' as described in the literature[3], because the household heads in this case remain to manage their farms while allowing their sons to migrate seeking better paid work and their female relatives to work on their farms and on other farms to supplement household income.

Conclusion

The research has shown that, as a result of rapid agricultural growth in Syria for the last few decades, female labor demand and supply in agriculture has increased. Women's labor has specialized in manual activities characterized by low wages. While men's labor has shifted to off-farm work, mechanized activities in agriculture and non-agricultural work in urban areas. Mechanization has shifted activities from women to men and has at the same time decreased the demand for men's labor in agriculture. There are intimate links between different paths of rural transformation and the need for female labor in agriculture where the household produces for the market or when men migrate for work, there is an intensification of women's contribution as unremunerated family laborers. Also, when households loose access to productive resources and come to rely on additional cash income, they allow daughters to work off-farm in agriculture on other farms.

It appears that the economic forces that determine rural labor demand and supply have outweighed the social forces that limit female labor supply. Intensification and commercialization of agriculture have certainly increased the demand for labor that pulls people in poor households to seek wage employment. In addition, population growths, increasing household needs and the growing importance of women's earned wages in household livelihood strategies have increased female labor supply in agriculture.

Other factors such as the difference in relative geographic, economic, and social mobility of men and women in rural households have created a new balance in

[3] (Boserup, 1980, Townsend and Momsen, 1987, Momsen, 1987 and Momsen 1995, Townsend and Momsen, 1987, Davison, 1997)

male and female utilization. Men are relatively more mobile than women and are, therefore, less available locally. A great many of the families that are supplying women to wage labor in agriculture also have men working for wages, but not as often in agriculture and frequently outside their home communities--in urban centers or abroad. Women tend to stay closer to home and to work within a familiar context.

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Figure 1: Syrian Population 1960 -2030

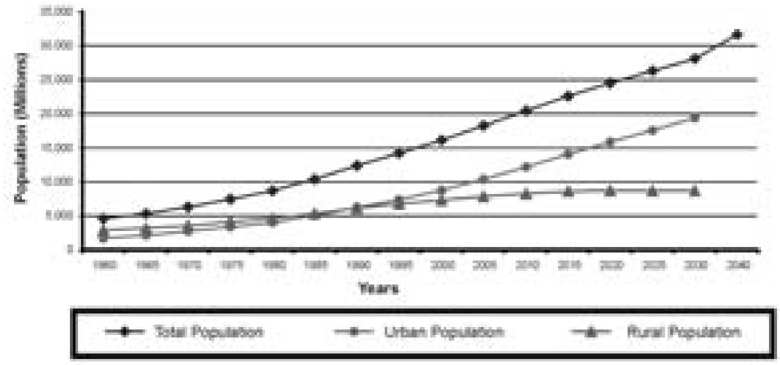


Table 1: Farmers' Investments

Holding Size Categories	Nature of Investment: In Agriculture for Profit	In Non-Agriculture for Profit	Welfare and Consumption	Total
0 - 8 ha	21 (56.8)	5 (13.5)	11 (29.7)	37 (100)
> 8 - 20 ha	24 (57.1)	4 (9.5)	14 (33.3)	42 (100)
> 20 - 40 ha	20 (80.0)	1 (9.1)	4 (16.0)	25 (100)
> 40 ha	7 (77.8)	1 (11.1)	1 (11.1)	9 (100)
Total	**72** **(63.7)**	**11** **(9.7)**	**30** **(26.5)**	**113** **(100)**

Source: Farming Household survey conducted in 1996.

Poverty, Food Systems and Nutritional Wellbeing of the Child.

Shibani Ghosh and Aden Aw-Hassan

Rationale

Poverty is an interlocking multidimensional phenomenon. The World Bank defines poverty "as the lack of what is necessary for material well being - inclusive of food, housing, land and other assets (World Bank 2000)". The definition has been expanded to include psychological aspects, lack of basic infrastructure, illness and poor health.

In West Asia and North Africa (WANA), some 450 million people have low annual incomes while 300 million have been defined as living below their nationally determined poverty lines. Furthermore poverty in this region is highly dominant in the rural areas. It is reported that 72 % of those defined living below their nationally determined poverty lines live in rural areas and are largely dependent on agriculture as a source of income. Rural people, particularly women and children, suffer the most from poverty and its physical and social deprivations. These include under-nutrition and high rates of infant mortality. Forms of under-nutrition include stunting, wasting and underweight. Wasting is a consequence of an acute inadequacy in the diet or occurrence of acute infections. Stunting or linear growth faltering occurs over a period of time and is a result of poor nutritional and health conditions and is the most common form of under-nutrition in non-disaster situations. Underweight in absence of significant wasting reflects long term nutritional and health conditions of the population.

The etiology of under-nutrition is multi factorial in nature and its determinants are classified into three levels; immediate, underlying and basic. The immediate causes are nutritional and health in origin. The major underlying causes of malnutrition are poor food production and/or supply, poor food distribution, poor food security both between families and within families, poor education, poor care and poor sanitation and health. The basic cause of under nutrition however is poverty.

The present project "Poverty, Food Systems and Nutrition well being of the child" is being conducted to determine occurrence and causes of under nutrition in North West Syria. It aims to trace the linkages between food systems of households dependent on agriculture and the nutritional well-being of the child and to identify local perceptions of poverty. The impact of poverty on rural households' food system and hence nutritional well-being of child is being examined.

The study will be important in identifying the causes and outcomes of rural poverty and help identify farm household constraints that may contribute to poor development of rural women and their children. It is expected to create research capacity in ICARDA in the area of nutrition and agricultural household food systems and will help generate information on the problems and constraints faced by farm households. It is anticipated to help strategize future agricultural research more effectively towards poverty and hunger alleviation and eradication via the development of rural women and children.

Objectives

- To study the variation in food systems in Northwest Syria based on differences in production systems
- To determine the usual food intake pattern of rural households and examine the growth pattern of children under 10 of these households.
- To evaluate the socioeconomic status of rural households and study its impact on the household food system and nutritional and growth status of children.

Progress of Research

Research Approach

To accomplish the study objectives, the food system was observed as a process with focus on production, acquisition, processing/preparation, and distribution and consumption practices. Components within each of these were examined. In addition factors such as perceptions of food and nutrition, seasonal variation in food availability, level of education of household members were considered. Food intake pattern and growth status of the children were used to evaluate their nutritional well being. Furthermore information on the socioeconomic status of the families was obtained. These data were collected from households that belong to one of three different production systems. These include the barley-livestock, irrigated agriculture and olive/fruit tree systems.

Methods

The study employed both qualitative and quantitative methodologies. These include informal interviews and observations, seasonal calendars, food card sorting exercise, participatory socioeconomic evaluation, community level socioeconomic characterization, food frequency questionnaires and anthropometry. The villages studied belong to three above mentioned production systems. The households were purposively selected in the different villages based on presence of children under 10 years of age. A total of 207 households were interviewed and 538 children of the interviewed households were measured from the following villages: Serdah, Ruwayhib in Khannaser (barley/livestock), Trinda and Al Staro (irrigated system) and Yakhor (olive and fruit tree system) in Afrin. All data has been collected and is in process of analysis. The focus of this article will be to shed light on the determinants of growth of children in North West Syria using the data on the socioeconomic characterization and the growth measurements of the children under 10 years of age.

Participatory Socioeconomic characterization. Initial tests were conducted to determine local definition of wellbeing and its relation to socioeconomic status. Villages were chosen within the same production system so as to be representative of the social and economic situation. Through these we found that wellbeing categorization was largely based on economic status, in form of the family agricultural land holdings or livestock ownership or wage labor presence. The actual type of asset varied in the different production system. Housing quality, household characteristics, material comforts such as TVs, refrigerators etc, quality of food available were consequences of wellbeing or socioeconomic status. Since the local definition of wellbeing was based on the economic situation of the household this was the key focus of the exercise.

The exercise was conducted in the 5 target villages. In each village a group of key informants (3-4) were identified. Key informants included village headmen, elders or members of the community who were aware of the social and economic situation of the families. A community characterization was also conducted to collect information on relevant socioeconomic variables. Key informants were asked to define in the local context the most important social and economic criteria that would categorize the village households and to define the number of SE categories using the same criteria. Each household was classified into these categories. Once this was established, differences between families based on specific indicators such as housing quality, education, quality of food available (eg meat and milk product intake, fruit and vegetable availability), health access and utilization of services, women's education levels etc were recorded.

The final step was to collect quantitative data on the specific criteria. Variables included total land, irrigated and rainfed land ownership, olive trees (actual number), number of fruit trees, livestock ownership, number of laborers (agricultural and non agricultural, male and female) if any, other sources of income (external migration, government employee,) and sheep fattening.

The information was then compared to the descriptive categories. Ideally, to make this comparison it is necessary to collect the socioeconomic data at the level of the household i.e. through in depth household interviews. However, through several qualitative observations we came to consider the community level characterization as a close proxy to the in depth household interviews. These include:

1. The villages were social units with their own informal networks thus giving them a clear idea of each other's social and economic situation. Also most of the households in the villages were interrelated to each other by birth or marriage (except one village, which had four large family groups. Here those key informants in the village who were knowledgeable about all the groups were included).

2. The village head, who was included in the interview, deals with all official agricultural and non-agricultural issues of the village and have valuable household level data.
3. Since the socioeconomic aspect is part of a larger study, the in-depth household interviews conducted focused on the determination of nutritional and health status. With respect to time constraints and efficiency the data was collected at the level of the community.
4. Lastly, an ongoing study at ICARDA (Khelifi and Ngaido) on rural women and income conducted a similar community characterization followed by in-depth interviews in selected households and the key field researcher reports that data collected at the community level are not noticeably different from those collected at the household level.

Estimation of growth status of children under 10. To estimate the growth status of the children anthropometry was used. This is a universally applicable, inexpensive and non-invasive method to assess size, proportions and compositions of the human body. Moreover, since growth in children and body dimensions at all ages reflect the overall health and welfare of individuals and populations, anthropometry is often used to predict performance, health and survival.

The basic measurements for growth assessment are weight and height and the most common indices calculated are weight for height, height for age and weight for age in terms of Z-scores or standard deviations. These deviations allow the classification of populations and sub populations for the prevalence of malnutrition according to international standard references.

Actual measurements of height were conducted using the Shorr Adult/Child/Infant Height and length board. The measurement procedures outlined by the WHO and were used as guides for the measurement of height/length and weight. Weight measurements were conducted using a SECA model digital scale, with an accuracy of 50g.

Results

Sample size and Demographic characteristics. Some household demographic variables are tabulated in Table 1. The Barley/livestock group had the largest household sizes with more number of children under 10 years of age than the other two systems. Using the One Anova test significant differences were observed at the 0.01 level.

Growth Status of Children in the different systems. Anthropometric analysis was conducted on the indices calculated for weight and height of children under 10 years of age in the different production systems. They were then compared to the international reference recommended by WHO and a distribution of local school children. The highest stunting rate was in the barley/livestock households (23%) and the lowest in the irrigated system households (13%) (Figure 1). Girls of the barley/livestock (27.8%) had the highest prevalence. Wasting was very low in the studied households (Figure 2). It did not exist in the irrigated system and was highest in the barley/livestock group. Both the barley/livestock (1.8%) and olive tree group (1.2%) had levels lower than the usual prevalence. Underweight prevalence was the lowest in the irrigated system (3.5%) and highest in the barley/livestock system (14.3%) (Figure 3). There were a higher percentage of boys compared to girls who were underweight in all the three systems, the worst being the boys of the barley/livestock system (15.4%). However, the difference for the two latter indices was not as drastic as that for stunting.

Means were calculated for number of stunted, underweight or wasted children (irrespective of gender) per household. One Way ANOVA results show that the values are significantly different for wasting and stunting with barley/livestock having the highest mean number of children stunted (Table 2). Underweight prevalence were not significantly different.

Participatory SES characterization. Through the participatory SE exercise differences in perception of socioeconomic status of households at the village level were observed. Quantitative household data were collected on the most important variables identified by the key informants[1]. The definition of different categories by each community was different (Table 3) and comparisons can be made only within villages. With respect to the categories defined, all communities defined three categories. Each definition is localized. However, there is a distinct trend of classifying households into categories ranging from the worst off to the most better off. The criteria for classification are summarized in Table 3. Ownership of land and supplementary form of income was important to all systems. With respect to land ownership, in the irrigated system this was the most important criterion for classification. In the barley/livestock villages it was important, however, not considered a major income source, as they were not assured good harvests every year. This was also the case in the villages of the olive system, where poor quality soils were considered a detriment to a good olive harvest. Livestock ownership was important in the barley/livestock system. Striking differences occur with respect to supplementary income. In the irrigated and olive tree system, type of supplementary income was important. Wage labor was only for households in the lower categories. In the barley/livestock system, wage labor was the only form of supplementary income and number of wage laborers per household was

[1] *Community characterization data for the village of Ruwayhib was provided by Ms. Rahmouna Khelifi and Dr. Tidiane Ngaido who are currently working on study examining role of rural women in household livelihood strategies.*

important. Households classified in higher wellbeing categories in the irrigated system were more educated and had jobs as school teachers or employees, owned shops or were involved in a business while those of the olive system were traders or olive press owners, shops being owned by households in lower wellbeing categories.

Comparison of Wellbeing categories for selected villages. The means of the quantitative data for some of the major defining criteria were calculated for selected villages of each production system (Table 4). The terms of worst, moderate and best are used in context to the village and not to compare between villages. In the irrigated village, the average holding size, number of sheep, number of employees and occurrence of business increased in households of the better off category while the mean household wage labor decreased. In the olive system village, the average number of olive and other fruit trees increased while household wage labor decreased with increase in wellbeing category. Interestingly the mean number of employees was highest for the moderate wellbeing group whilst the occurrence of business was lowest. The occurrence of business was highest in the better off well being category and low in the worst off. For the barley livestock village, total land, number of sheep and sheep fattening increase with increase in wellbeing categories. Wage labor increased from worst to moderate and decreased in the best. The occurrence of a business was also very small and there were no employees in this village, which explains the importance of wage labor as source of supplementary income. A correlation analysis was conducted within the same villages to determine which of the key variables were correlated to the socioeconomic category. The results are presented in Table 5. We found that for the irrigated village (Trinda) total land, rainfed and irrigated land ownership, olive trees, presence of pickup and tractor were positively correlated to socioeconomic category. In the olive village, total land, olive and other fruit trees were positively correlated. For both presence of male labor was negatively correlated to socioeconomic category. In Serdah (barley/livestock village), rainfed land, sheep presence, fattening presence and tractor were positively correlated. Labor characteristics did not vary with socioeconomic category. This confirms that wage labor was important across all categories for the barley/livestock group.

Mean comparisons of socioeconomic variables at production system level. The data were pooled by production system to examine if the differences in means for key variables were significant. Wellbeing categories were discarded, as they were localized definitions and cannot be used to compare across groups. One way ANOVAs conducted indicated significant differences in household composition, average holding size as well as type of holding (irrigated versus rainfed), total labor (male and female), and number of female laborers per household.

Livestock ownership and fattening were also significantly different (at 0.01 level). The results are presented in Table 6.

Discussion

The highest prevalence of stunting and underweight occurred in the barley livestock system and the lowest in the irrigated system, the worst off being the girls of the barley/livestock system. Preliminary analysis on the socioeconomic variables indicated that the barley/livestock system households were the worst off. Table 3 shows the proportion of households in each welfare category from the worse off to the better off for each village. The barley/livestock villages which had the highest stunting and wasting had also the highest percentage of worst-off households (for example 49% in Serdah and 72% in Ruwayhib), while this was lower in the olive (59%) and the irrigated (5% in Trinda and 22% in Al Staro) systems, respectively. Furthermore it can be seen from Table 4 that 50% of the families in Serdah have less than 2 sheep. Sheep presence was one of the most important criterion for wellbeing classification as is indicated by the qualitative and quantitative descriptions of the different wellbeing categories for Serdah (Table 3 and 5). The same group was completely dependent on wage labor with skilled labor and businesses being virtually non-existent. The One-Way ANOVA to compare means across different production systems indicates that there are significant differences in assets and labor characteristics (Table 6).

Higher dependence on wage labor, unproductive lands, higher number of households with lower assets for e.g. small flock sizes, lower access to diversified income (no irrigated lands, low number of skilled labor) makes the barley/livestock system most vulnerable. These factors could account for lower access to potential income, which could affect food intake behavior and thus the growth status. Our qualitative results also indicate a distinct difference in diet, lifestyle of the three systems. The irrigated and olive system households were found to have a greater access to a larger variety of fresh foods such as fruits and vegetables in comparison to barley/livestock households. Storage and processing practices were more pronounced in the former. Differences were observed in the level of awareness of nutritional content of foods and the importance of the variety of foods in the diet. Thus higher education levels, better access to potential income, markets and health and sanitation facilities and lower birth rates give a distinct advantage to the irrigated and olive system households over the barley/livestock households and could account for the poorer growth status of the children of this system.

Conclusion

Preliminary results of the ongoing study show a high stunting prevalence (a reflection of poor growth) in the barley livestock system and low prevalence in the irrigated system, the worst off being the girls of the barley/livestock system.

Underweight prevalence is distributed in a similar manner with barley/livestock as a group being the worst off. The low rates of wasting indicate that the percentage of underweight and stunting is a reflection of long term health and nutritional experiences of the children. This could be attributed to poor access to food supply, poor household food production, and poor food security between and within households. These were the results of poor economic situation of the household explained in terms of land ownership, livestock ownership, male and female wage labor and other forms of supplementary income.

In this paper we do not identify the exact cause of poor growth. More analysis of the food intake data and that of the socioeconomic variables at the system level will help identify the causal relationships. However, it is apparent that the barley/livestock group is the most vulnerable. From the results of this study, it is clear that policies that increase rural households' access to productive assets such as livestock coupled with increased livestock productivity enhancing technologies could reduce this vulnerability.

Table 1: Mean values of basic demographic variables for the different production systems.

System	Sample size	Household size**	No of children**	No of girls **	No of boys **
Irrigated	58	7.07	4.53	2.43	2.1
		(2.7)	(2.4)	(1.9)	(1.3)
Olive and	76	7.28	4.28	2.2	2.08
fruit tree		(2.6)	(2.4)	(1.7)	(1.4)
Barley/livestock	73	8.99	6.42	3.32	3.08
		(3.9)	(3.7)	(2.2)	(2.2)

** Significant at 0.01 level using One Way ANOVA
Figures in parentheses represent standard deviation

Table 2: Mean values of number of children stunted, underweight and wasted in the three different production systems of North West Syria.

System (N)	Sample size	Height below -2SD **	Weight below -2SDS **	Weight for height below -2SDS
Irrigated	58	0.35(0.7)	0.09 (0.4)	0.0 (0.0)
Olive and fruit tree	76	0.46(0.7)	0.28 (0.6)	0.04 (0.2)
Barley/livestock	73	0.84(1.1)	0.52 (1.0)	0.03 (0.2)

** Significant at 0.01 level using One Way ANOVA
Figures in parentheses represent standard deviation

Table 3: Criteria for SE classification and percent of households per category for each surveyed village, by production system.

Village	Production system	Category definition	Percent HHs per category	Criteria for well being classification
Trinda	Irrigated	➢ Rich ➢ Medium ➢ Poor	25 53 22	➢ Total and percent of irrigated land ownership ➢ Access to water ➢ Supplementary income and type (eg shop owner versus wage labor). ➢ Wage labor in lower categories only ➢ Olive tree ownership
Al Staro	Irrigated	➢ Upper medium ➢ Medium ➢ Lower medium	36 59 5	➢ Total and percent of irrigated land ownership ➢ Type of supplementary income (wage labor only in lower categories) ➢ Olive tree ownership ➢ Land fragmentation
Serdah	Barley/ livestock	➢ Upper medium ➢ Medium ➢ People with fatigue economic	22 30 49	➢ Land ownership (rainfed only) ➢ Livestock ownership (for household and commercial purposes ➢ Wage labor (agricultural and non agricultural) in all categories- absolute number important
Ruwayhib	Barley/ livestock	➢ Medium ➢ Poor ➢ Very poor	8 19 72	➢ Land ownership (rainfed only) ➢ Livestock ownership ➢ Wage labor (agricultural and non agricultural) in all categories- absolute number important. ➢ Land fragmentation
Yakhor	Olive/ fruit tree	➢ Medium ➢ Lower Medium ➢ Poor	17 24 59	➢ Olive tree ownership ➢ Quality of land ➢ Supplementary income and type ➢ Wage labor only in lower categories ➢ Land fragmentation

Table 4: Mean values of major contributing socioeconomic variables for different categories for selected communities in the three different production systems

	Total Land (ha)	No.of Wells	Olive trees ha	Irrigated ha	Rainfed ha	No of Olive trees	Other fruit trees	No of Sheep	No Sheep Fattened	Wage labor	No female wage labor	No male wage labor	Employee	Business
Trinda (Irrigated)														
Worst	2.06	0.89	1.03	0.61	0.41	103.33	0.00	0.00	0.00	0.56	0.00	0.56	0.00	0.22
Moderate	3.98	1.16	0.82	2.39	0.76	82.11	0.00	4.47	0.00	0.11	0.00	0.11	0.37	0.11
Best	15.8	2.0	3.9	6.3	4.5	385.0	0.00	27.8	0.0	0.0	0.0	0.0	0.1	0.5
Yakhor (Olive/fruit tree)														
Worst	0.67	0.00	0.67	0.00	0.00	66.89	1.51	0.78	0.00	0.64	0.00	0.64	0.02	0.11
Moderate	3.26	0.00	3.26	0.00	0.00	325.83	10.22	0.00	0.00	0.50	0.00	0.50	0.28	0.00
Best	3.83	0.00	3.83	0.00	0.00	383.08	23.46	0.00	0.00	0.15	0.00	0.15	0.23	0.54
Serdah (Barley/livestock)														
Worst	6.61	0.00	0.00	0.00	6.61	0.00	0.00	1.94	0.00	2.22	0.67	1.56	0.00	0.11
Moderate	6.18	0.00	0.00	0.00	6.18	0.00	0.00	11.18	12.73	3.36	1.64	1.73	0.00	0.00
Best	23.50	0.00	0.00	0.00	23.50	0.00	0.00	46.25	25.00	2.13	0.75	1.38	0.00	0.00

Table 5 Correlations of major socioeconomic variables with socioeconomic categories of selected communities of the three different production systems of North West Syria.

Village	Total land ha	Rainfed ha	Irrigated ha	Olives Ha	Other fruit trees (#)	Sheep (no)	Fattening presence	Pickup	Tractor	Female labor	Male labor	Employee	Business
Trinda (n=36)	.609**	.520**	.579**	.561**	.(a)	0.284	.(a)	.472**	.528**	.(a)	-.491**	0.093	0.216
Yakhor (n=76)	.561**	.(a)	.(a)	.561**	.437**	-0.087	.(a)	0.214	0.13	.(a)	-.399**	.275*	.332**
Serdah (n=37)	.554**	.554**	.(a)	.(a)	.(a)	.600**	.334*	0.267	.512**	0.117	-0.044	.(a)	-0.22

** Significance at 0.01 level
 * Significance at 0.05 level

Table 6: Mean values and ANOVA results of key socioeconomic variables for three different production systems of North West Syria.

System	Sample size	Total land ha **	Rainfed, ha **	irrigated ha **	olive trees, ha **	Noagri wells **	Mean no of sheep **	Fattening **	Pickup**	Tractor**	Total labor **	Female labor**	Male labor **	Employee
Irrigated	58	4.96	0.93	2.1	1.75	0.64	5.33	0.36	0.26	0.67	0.9	0.31	0.59	0.16
		(6.4)	(2.2)	(2.8)	(1.8)	(1.2)	(26.5)	(0.0)	(0.6)	(0.8)	(1.8)	(1.0)	(1.0)	(0.5)
Olive and fruit tree	76	1.82	0	0	1.82	0	0.46	0	0.03	0.11	0.53	0	0.58	0.12
		(2.4)	(0.0)	(0.0)	(2.4)	(0.0)	(4.0)	(0.0)	(0.2)	(0.5)	(0.5)	(0.0)	(0.5)	(0.4)
Barley/ Livestock	73	7.0	7.0	0.0	0.03	0.01	13.95	0.15	0.01	0.14	2.18	1.01	1.17	0.01
		(8.7)	(8.7)	(0.4)	(0.2)	(0.1)	(25.5)	(0.0)	(0.1)	(0.3)	(1.7)	(1.3)	(0.9)	(0.1)

** Significant difference using one way ANOVA
Figures in parentheses represent standard deviation

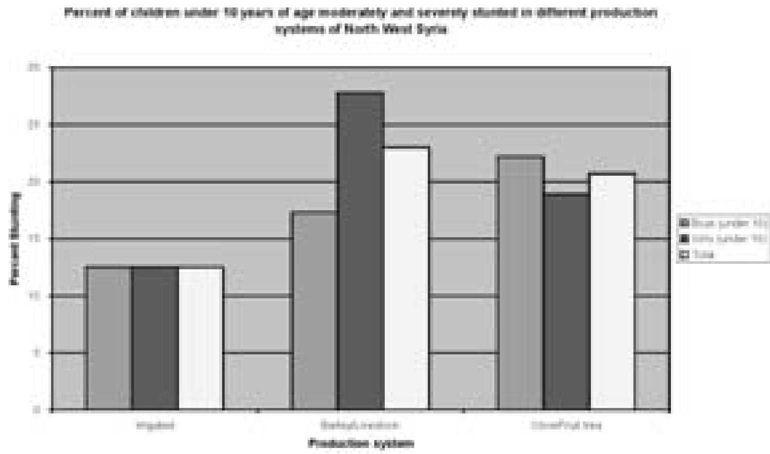


Figure 1: Percent of children under 10 years of age moderately and severely stunted in different production systems of North West Syria.

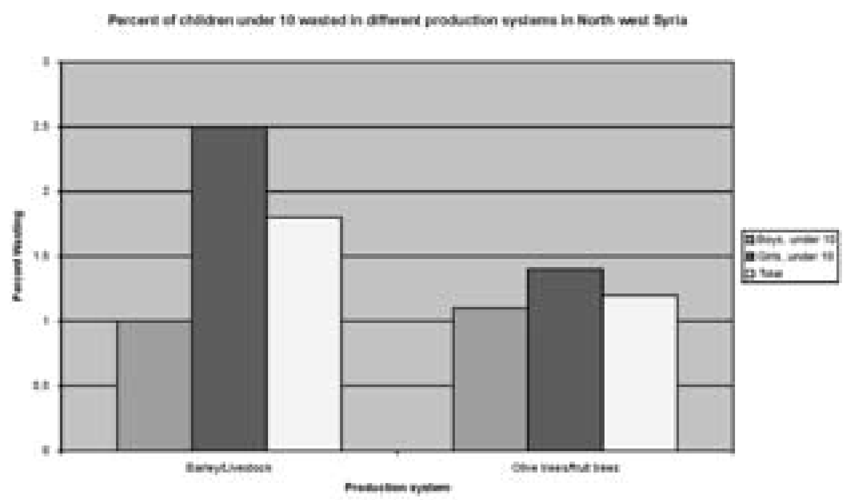


Figure 2: Percent of children under 10 years of age moderately and severely wasted in different production systems of North West Syria.

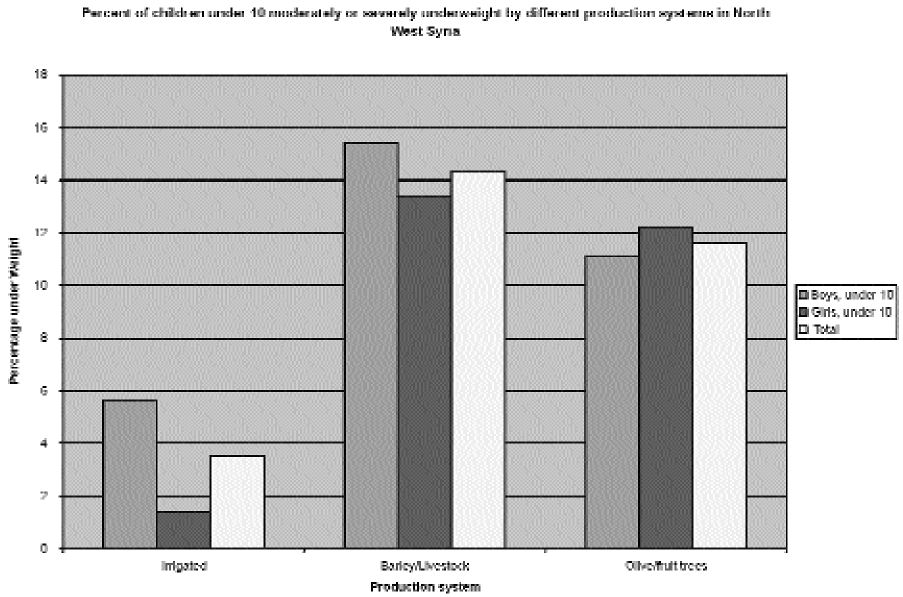


Figure 3: Percent of children under 10 years of age moderately and severely underweight in different production systems of North West Syria.

Analysis of farmers' performance criteria for new barley varieties and their diffusion through farmer-to-farmer seed distribution
Ahmed Mazid, Aden Aw-Hassan, Hisham Salahieh

Rationale

Adoption of new crop varieties in the dry areas has been much slower than the more favorable areas. This is because of the inherent difficulty in breeding for dry areas due to the enormous weather and environmental variabilities. The failure of the formal seed systems to serve these environments is another reason for the slow diffusion of new varieties. The formal seed systems work very well when they can produce large quantities of few crop types for large areas. The diffusion of new crop varieties in the dry areas, therefore, requires better understanding of farmers' variety performance criteria and identification of alternative sources of seeds. Although new barley varieties can on the average increase the barley yield by 20% over local landraces without additional inputs, the 1.5 million hectares of barley cultivated in Syria is largely based on two local landraces, Arabic Abiad (white seed color) and Arabic Aswad (black seed color). The former is common in relatively more favorable environments (annual rainfall between 250 and 400 mm) and the later in harsher environments (annual rainfall < 250 mm). The breeders of ICARDA's barley program have distributed seeds of new promising varieties to farmers who participated in variety trials program. This study has traced for 5 years (1994 to 98) the diffusion of these new varieties among farmers and villages, and documented farmers' criteria for new barley varieties and their diffusion.

Objectives of the study

The main objective of this study is to determine reasons for farmers' acceptance of new barley varieties under different agro-ecological zones within five provinces in Syria, and determine the extent which farmer-to-farmer seed exchange contributes to the diffusion of new barley varieties.

Research in progress

Study desription

The collaborative research between ICARDA and the Syrian Program has produced several new barley varieties including Arta, Rihan, Zanbaka, Tadmor and WI 2291. ICARDA's barley breeders had in 1994/95 cropping season distributed seeds of these varieties to 52 farmers in five provinces (Aleppo, Idleb, Hama, Raqqa and Hasakeh) covering 3 stabilization zones (1 through 3) in Syria. The majority of these farmers has collaborated with the Barley Improvement Project through on-farm trials on their fields or has learned about these varieties in farmer's field days. Some farmers selected more than one variety and others chose only one that they thought more suitable for their environment.

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 from 1994/95 and until 1998/99 season. All farmers did not grow barley every year for one reason or another, for example due to the nature of the crop rotation or due to lack of seeds. But once a farmer, who obtained new barley variety which originated from the initial 52 farmers, is interviewed that farmer was also interviewed every year until the end of the study. So, in the first year the initial 52 farmers were interviewed using a designed questionnaire. 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 last and fifth year (Table 1). The farmers in the sample were visited in their villages once every year at the end of the planting season.

The study focused on farmers' assessment of the performance of these varieties under different environments using their normal production practices. Farmers planted the seeds of new varieties using the same practices and inputs as their local barley without any supervision either from ICARDA or National Extension Agents.

Results and discussion

Yields. Diagnostic farm surveys on barley in Syria (Somel, Mazid, and Hallajian, 1984) have found that average barley yields in the long run are less than 1 ton/ha. Table 2 summarized average rainfed grain yields obtained by farmers during the study period for all types of new barley varieties by agro-ecological zones. It seems that average yields in 1996/97 and 1998/99 seasons were less than other years. The reason was that a severe frost occurred in 1996/97 season during tillering stage which affected barley crop, especially the new varieties. Rihan was the most sensitive variety to frost damage compared to other new varieties, which forced some farmers either to graze it instead of harvesting, or to re-cultivate their fields and grow spring chickpeas instead of barley. This affected the area planted by Rihan in the following year due to unavailability of Rihan seeds again. In 1998/99 season, the average grain yields also dropped due to the drought in that year. Over all seasons, average grain yield obtained by farmers in zone 1 was 2.9 ton/ha, and this yield was declining towards dry areas essentially due to decrease in rainfall precipitation, and to other factors such as fertilizer rate used, previous crop, seed rate, etc. The grain yields comparison among new and local barley varieties, based on published official statistics (Table 2), indicated that the performance of new barley varieties was higher than the local once during all the seasons among different zones. The percentage increases in average grain yields during 5 years were: 53% in zone 1, 160% in zone 2, and 140% in zone 3.

Farmers' assessment of new varieties. Farmers usually know what they like and what they do not like about a new technology and are able to express their opinions. These opinions reflect their own experience related to the new technology. In this study, farmers were asked to rank the new barley varieties, which they have already used in their farms compared to their local varieties. Table 3 summarizes farmers' top ranking of new varieties that they have planted compared to the local. There was significant difference between rank of top variety and zones at 0.1%.

Farmers' opinions on the ranking were influenced by the prevailing conditions of the seasons. The results in Table 4. It appears that farmers weighted very heavily the performance of the variety in the last period and this affects their decisions to plant in the next season. About 78% of farmers who planted Arta variety ranked this variety as the best variety in both zones 2 and 3. Rihan variety was mentioned by 74% of farmers as a top variety, but there was significant variation among farmers in different zones, where 96% of farmers in zone 1 reported that Rihan is the best variety, 66% in zone 2 and 25% in zone 3 (Table 3). This result is an indication of the characteristic of this variety which is suitable to more wetter environments. About 35% of farmers who knew Zanbaka indicated that this variety is the best, this percentage was higher in zone 3 (41%) compared to zone 2 (25%). This result confirms the characteristics of this variety, which is appropriate to the drier environments. Tadmor was mentioned by 58% of the farmers who planted it as the top variety. For WI 2291 indicated by 44% as the best variety.

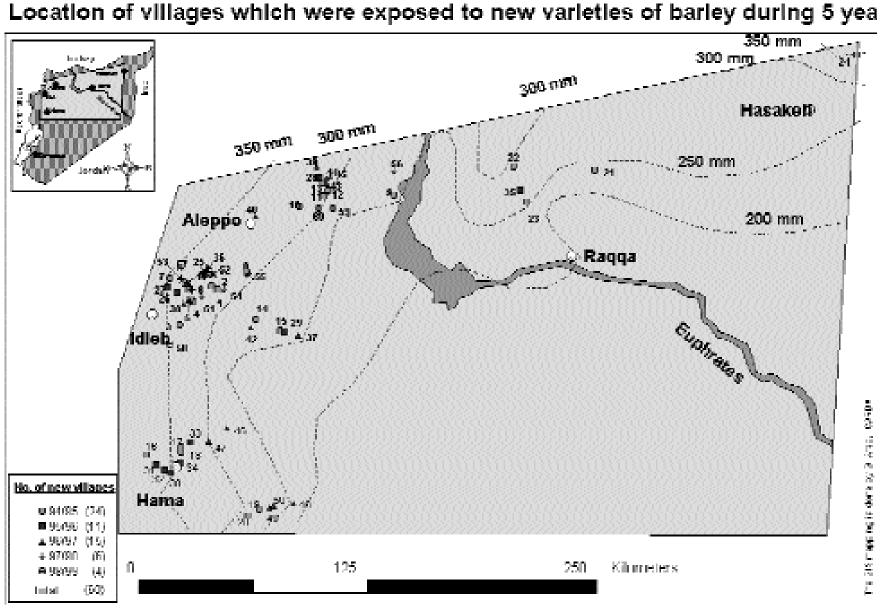
Farmers in the sample were asked to identify their reasons to continue growing the new barley varieties, and farmers who did not adopt new varieties were asked to state their reasons for non-adoption. Table 4 summarized reasons stated by farmers related to each variety in the three zones. Yield was the most important factor mentioned by farmers who continued growing Arta variety due to its higher grain yield followed by good size of grain and good quality as feed for both grain and straw. For Rihan, the farmers in zone 1 and zone 2 indicated its higher grain yield and lodging resistance as the reasons for adopting. Farmers adopted Tadmor variety because of its better grain yield, drought resistance, black seed color, and good grain size. For Zanbaka, plant height and drought resistance were the most important factors influenced the adoption of this variety especially in zone 3, while drought resistance and black seed color were the most frequent characteristics mentioned by farmers. Farmers who adopted WI 2291 listed plant height, good grain yield, lodging, and drought resistance as the most important factors.

Most of the reasons for non-adoption were farmers lack of convention with their performance under local farm conditions, particularly due to susceptibility to frost damage, fungus, diseases and lodging. Not all the farmers who planted promising varieties continued using it for the following years, but that did not mean that they have rejected them. Some of them (i.e. 35% of monitoring farmers) stopped growing barley as crop in their farms due to many reasons such as introducing fruit trees in their stony and shallow land, which was essentially allocated for barley. This occurred in zones 1 and partially in zone 2, where farmers believe that fruit trees are more profitable compared to rainfed barley in addition to agricultural policy which encouraged expanding fruit trees especially olives in such soils. Other farmers also stopped growing barley because they had an access to new water source, and moved to irrigation farming system where barley is not considered as irrigated crop in the new system. Some farmers did not continue planting barley and moved to other rainfed crops such as wheat and cumin, which they consider more profitable.

Diffusion of new barley varieties. The initial group of farmers who received seeds of new varieties in the first year were located in 24 villages as shown in Table 1. These farmers were not evenly distributed in these villages, because only the farmers who were willing to try the new varieties got the seeds from ICARDA in the first year. Most of the initial farmers that received seed in 1994/95 season were located in zone 2. The number of villages exposed to one or more promising barley varieties during the study period within agro-ecological zones increased from 24 to 60. The increase of villages in zone 2 increased much higher than in other zones. This is mainly due to the stability of barley production in this zone.

On other hand, it was noticed that the diffusion of new barley varieties through farmer-to-farmer seed distribution is essentially clustered around the villages, which received the seeds in the first year. Fig.1 shows the locations of these villages in each year of the study period in five provinces: Aleppo, Idleb, Hama, Raqqa, and Hassakeh.

Location of villages which were exposed to new varieties of barley during 5 years.



Diffusion of varieties by agro-ecological zones indicated that Arta variety was mostly grown in moderate environment (zone 2), while Rihan variety was spread in wetter environments (zone 1 and 2). Zanbaka and Tadmor varieties were allocated mostly for drier zone (2 and 3). WI2291 was planted only in drier environment (zone 3). Table 5 shows the frequencies of farmers growing new barley varieties by years. The Table clearly shows that while the numbers of farmers who grow two varieties (Arta and Rihan) increased or remained stable over the 5 years, the cultivation of other three varieties has noticeably declined.

It is noticeable that about 30% of growers in the first year were growing more than one promising barley variety, some of them planted up to 4 varieties. But this percentage has declined over time and ended with only 4% in the fifth year. This indicates that farmers take deliberate decisions on testing new varieties then select the best varieties for their environments. This may also indicate that farmers tend to keep multiple varieties or mixtures on the same field to reduce losses in bad years. Table 6 summarized diffusion of new varieties among farmers during the study period. The adoption of new varieties in the fifth year was 51% for all varieties and zones.

Farmers who grew the new barley varieties sold some of their production as seeds to other farmers either from their villages or from other villages. Growers, who sold part of their barley production to other farmers as seeds, ranged from 10 to 24% during the study period. This percentage was higher in the beginning of this study and trend to decline by time. Most of the new growers reported that they received the promising variety seeds by purchasing it from farmers who were growing it in the previous year. Neighbors were the most important source of seeds of promising barley lines. The earlier growers usually saved their seeds from own production for next year's planting.

Table 7 shows the amount and sources of seeds of new barley varieties. In the 5th year of this seed tracer study, about 27% of the seeds cultivated by the 206 sample farmers were new varieties. About half of the farmers (49%) used own seeds saved from previous season and 37% of them purchased 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 breeding program.

Conclusion

The factors influencing adoption behavior of farmers for new barley varieties were investigated and identified; this theme will be published in a separate report. However, this study confirms that farmer-to-farmer seed exchange plays important role in the diffusion of new barley varieties. The relatively high adoption rates, about 50% in the fifth year, of new varieties among farmers who received these varieties through other farmers and the fact that farmers' decisions to continue growing new barley varieties are based on their evaluation of the performance of new varieties suggest that farmers' participation in varietal evaluation which increases farmers access to seeds of new varieties, in addition to its contribution to varietal development, could increase adoption through farmer-to farmer seed distribution. The second most important source of seeds of new varieties after seeds saved from previous harvest, was buying from neighbors. This indicates the existence of local commercial systems of seed distribution. This opens the opportunity for exploring ways of strengthening these seed systems for crops like barley where seed companies, whether state or private, have not succeeded in supplying seeds. Community level seed technology needs to be developed to guarantee seed quality and establish trusted local seed experts that ensure constant flow of new germplasm into communities. Such experts could be focal partners of participatory germplasm improvement program. The results of the study also show that many farmers decided not to continue planting some varieties after they evaluated them under their conditions, particularly in the drier zones, indicating that their participation in the breeding process maybe the way to go. The barley breeding project has been pursuing this strategy for several years now.

Table 1. Changes in number of villages and farmers monitored during the study period.

Years	Zone 1		Zone 2		Zone 3		Total	
	Villages	Farmers	Villages	Farmers	Villages	Farmers	Villages	Farmers
1994/95	1		17	37	6	14	24	52
1995/96	4	12	23	58	8	27	35	97
1996/97	4	25	32	86	14	38	50	149
1997/98	4	28	37	115	15	43	56	186
1998/99	4	28	41	134	15	44	60	206

Table 2. Average rainfed grain yields (ton/ha) of barley new varieties obtained by monitoring farmers compared to average rainfed grain yields (ton/ha) of local barley in Syria (on national level).

	Years					Average 5years
	1994/95	1995/96	1996/97	1997/98	1998/99	
			New Varieties (1)			
Zone 1	4.8	3.1	1.5	3.0	1.9	2.9
Zone 2	2.5	3.3	2.3	3.1	2.0	2.6
Zone 3	1.1	1.8	1.4	1.0	0.8	1.2
Mean	2.8	2.7	1.7	2.4	1.6	
			Local Varieties (2)			
Zone 1	2.1	2.2	1.6	2.1	1.3	1.9
Zone 2	1.3	1.4	0.8	1.1	0.6	1.0
Zone 3	0.6	0.9	0.6	0.4	0.1	0.5
Average barley yield in Syria	0.9	1.1	0.6	0.6	0.3	0.7

Sources: (1) Survey, (2) MAAR, Directorate of Statistics and Planning, Periodical statistics of winter crops for 1995 to 1999.

Table 3. The first top new barley varieties compared to local ranked by farmers who planted the variety by zones.

	Zones			Total
	1	2	3	
	Growers (%) ranked top variety			
Arta		78	78	78
Rihan	96	68	25	74
Zanbaka		25	41	35
Tadmor		64	50	58
WI 2291			43	43
Total	100	100	100	100
	Number of growers			
Arta	-	116	9	125
Rihan	46	151	4	201
Zanbaka	-	12	17	29
Tadmor	-	22	16	38
WI 2291	-	-	48	48
Total	46	301	94	441

Table 4. Number of subjective reasons for adoption and non adoption of barley new varieties by zone during 5 years.

Reasons / Varieties	Arta			Rihan			Zanbaka			Tadmor			WI2291		
	Z1	Z2	Z3	Z1	Z2	Z3	Z1	Z2	Z3	Z1	Z2	Z3	Z1	Z2	Z3
Positive attributes for adopting new barley varieties (frequency)															
Better yield than local	-	78	6	36	84	1	-	1	3	-	7	12	-	-	14
Early maturing	-	1	-	-	-	-	-	-	2	-	1	-	-	-	2
Cold resistance	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Good size of grain	-	28	1	10	30	-	-	1	2	-	4	7	-	-	-
Good quality for sheep	-	31	1	-	7	-	-	-	-	-	3	-	-	-	-
Lodging resistance	-	8	2	36	82	1	-	-	-	-	1	-	-	-	9
Good tillering	-	9	1	-	1	1	-	-	-	-	-	3	-	-	-
Good purity	-	14	-	10	1	-	-	2	2	-	3	3	-	-	-
Good plant height	-	2	-	-	21	2	-	3	6	-	-	3	-	-	16
Drought resistance	-	4	1	-	-	-	-	-	5	-	-	10	-	-	7
Black seed color	-		-	-	-	-	-	-	2	-	5	9	-	-	-
Diseases resistance	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-
Grain shattering resistance	-	1	2	-	2	-	-	-	-	-	-	-	-	-	-
White seed color	-	14	-	-	2	-	-	-	-	-	-	-	-	-	-
Good tall heads	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Total No. of observations	-	119	9	48	155	4	-	12	17	-	15	24	-	-	49
Negative attributes for not adopting new barley varieties (frequency)															
Seed are not suitable for planting	-	7	1	-	15	-	-		2	-	-	1	-	-	3
Sensitive for lodging	-	11	-	-	-	-	-	3	1	-	-	-	-	-	-
Rotation effect	-	7	-	9	9	-	-	-	-	-	-	-	-	-	1
Lower yield than local	-	4	1	1	15	2	-	4	2	-	5	6	-	-	8
Sensitive for frost	-	5	-	2	33	1	-	-	-	-	2	1	-	-	-
Lower feed quality	-	-	-	-	28	3	-	-	-	-	-	4	-	-	2
Sensitive for diseases	-	-	1	-	-	-	-	-	-	-	-	-	-	-	24
Lower vegetation	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1
Broken heads,thin stem	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
Grain shattering	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Late maturity,sensitive for drought	-	-	1	4	5	3	-	-	-	-	-	-	-	-	-
Total No. of observations	-	119	9	48	155	4	-	12	17	-	15	24	-	-	49

Table 5. Frequency of planting new barley varieties by sample farmers.

	Years					
	1994/95	1995/96	1996/97	1997/98	1998/99	Total
Arta	20	29	36	22	21	128
Rihan	17	34	57	58	41	207
Zanbaka	16	7	2	1	3	29
Tadmor	12	6	6	8	7	39
WI2291	8	17	15	9	0	49
Total	73	93	116	98	72	452
	No. of farmers growing more than one variety (%)					
	29	11	7	4	4	

Table 6. Diffusion of new barley seed varieties among farmers.

	Years					
	1994/95	1995/96	1996/97	1997/98	1998/99	Total
Total number of growers	52	84	110	94	68	408
Adopter (1)	-	39	58	59	48	204
New growers	52	45	52	35	20	204
Adoption rate (2)	-	0.75	0.69	0.54	0.51	

1) Previous year growers (Adopters: at least second time growers)
2) Number of adopters /total number of growers in the previous year

Table 7. Amount of seed of new and local barley varieties used by sample farmers.

		Years					
		1994/95	1995/96	1996/97	1997/98	1998/99	Total
		Quantity of seed used (ton)					
Variety	Arta	9	21	31	14	14	88
	Rihan	10	25	63	52	44	194
	Zanbaka	9	13	0	1	5	27
	Tadmor	14	26	26	31	33	130
	WI2291	4	10	7	4	0	24
Zones	Zone 1	1	6	7	6	5	25
	Zone 2	22	56	84	75	59	295
	Zone 3	22	33	36	20	32	142
Total new varieties		45	94	127	101	96	463
	Local	228	218	261	261	279	1248
Total	All	273	312	388	362	375	1711
New varieties (%)		16	30	33	28	27	27
		Source (% farmers)					
ICARDA		100	7	8	9	14	
Neighbors			55	53	41	37	
Own seed			38	39	50	49	
Total		100	100	100	100	100	
Total growers		52	84	110	100	68	

PROJECT 4.3: POLICY AND PUBLIC MANAGEMENT RESEARCH IN THE DRY AREAS OF WEST ASIA AND NORTH AFRICA

Determinants of Women Involvement in Agricultural Labor Market in Syria

R. Khelifi, T. Ngaido, J. Fitzsimons, and S. Salem

There has been a general recognition of the growing involvement of rural women in the West Asia and North Africa (WANA) region on a large range of livelihood strategies to enhance their household revenues (Abu Naser, 1984; Buvinic, 1978; FAO, 1998; Jabra & Jabra; 1992; Khelifi, 2000; Larson,1998; Martini, 2000; Pape-Christiansen *et al.*, 1995; Rassam, 1984; Shukri, 1996; Triki, 1997; Tully, 1990a; Tully, 1990b). Gender-related studies argue that the productive role of women in the rural areas of Syria is changing in two ways: first, there is a distinct shift from family unpaid agricultural labor to migrant paid labor, and, second, an increase in the household dependency on women's off-farm income (Pape-Christiansen *et al.*, 1995; Martini, 2000). The general arguments postulate that these trends are favored firstly by the development of commercial irrigated crops such as wheat, cotton and sugar beets that are prompting high labor demands both within and outside the family labor pool for manual tasks such as weeding and planting, which are customarily performed by women (Rassam, 1984; Martini, 2000) and secondly by increasing male out-migration that is pushing female household members to take over many on-farm activities and play a greater role in the sustenance of their households (Tully, 1990; Pape-Christiansen *et al.*, 1995; FAO, 1998; Martini, 2000; Khelifi *et al.* 2001).

However, such trends may be hiding the increasing poverty of many rural households that have to access different labor markets to generate the required income to sustain their families. Many programs are being introduced in rural Syria to enhance household income. These programs include mainly training, tailoring, dairy production, poultry, and small credit systems. Their impacts have been limited and did not in most of the cases prevented women from integrating the agricultural labor market. The determinants of their involvement in the agricultural labor market are not well understood and constitute an important constraint to the effectiveness of many women based programs. Furthermore, the effectiveness of women's programs would depend on household's resources and livelihood strategies. The present report, which attempts to fill some of the gap and provide policy guidance, tests the hypotheses of whether households with poor resource base compensate for inadequate household agricultural income through the involvement of women in the agricultural labor market and what are other household factors that may push or refrain women from selling their labor in the agricultural labor market.

RESEARCH AND METHODS

This second step of the research being conducted under the CCLF funded project after the characterization of 39 communities in different production systems and the analysis of their pathways (ICARDA Annual Report 2001). The research is based on data collected from 26 villages for critical variables that were considering as affecting household livelihood strategies. A complete census was conducted amongst 3,372 households on household assets, labor allocation strategies, quality of labor. A probit model was constructed to evaluate the determinants of women involvement in the labor market. Five equations were estimated and the results are presented in Table 2.

HOUSEHOLD CHARACTERISTICS AND PRODUCTION SYSTEMS

Rural households in Syria are characterized by large disparities in asset ownership. The average household land holding varies from 4.26 ha under full irrigation to 9.83 ha in the barley-livestock production system while average household flocks vary between 6 and 23 sheep. Similar trends were found on the ownership of productive assets such as tractors and trucks (Table 1). Landless households accounted for 24% under the barley-livestock system, 34% under the rainfed system, 23% under supplemental irrigation and 39% under full irrigation. Moreover, the Gini coefficient, which measures inequality, was the highest under the full irrigation system with 0.82. This explains the large number of sharecroppers under the full-irrigation system (Table 1). This high level of inequality between households questions the effectiveness of many of the agricultural reforms that were conducted in rural Syria during the late 1950s and 1960s.

Crop production was the major activity conducted by households in the rainfed, supplemental and full irrigation. Livestock production was more important in the barley-livestock with 19% of household heads breeding sheep. Off-farm activities were more important under the barley-livestock and rainfed systems and the number of heads in those activities accounted for 59% and 58% respectively. However, activities differed between production systems. For example, the main off-farm activities of household's heads are public and private sector jobs in the barley-livestock and supplemental-irrigation systems while under the rainfed and full irrigation systems, the major activity was outmigration that accounted for 21% and 16% respectively (Table 1). It is generally expected that women do not get involved in the agricultural labor market if their husbands can tend to their needs and hence the relationship between off-farm activities is expected to be negative.

The number of educated women is very low in all production systems. The share of women with primary school education ranged from 7% under rainfed system to 12% under supplemental. The variable was constructed by dividing the number of women under the specific education level divided by the size of the household. The share of women with secondary education and university training ranged between 0.1% and 5% (Table 1). The education variable is very important as many women reported that education was an important means for escaping from poverty and becoming a laborer.

RESULTS AND DISCUSSIONS

Table 2 shows the results of the Probit estimates (coefficients and asymptotic t-ratios) of the propensity of women to be involved in the agricultural labor market. The factors affecting such involvement could be classified into the push-factors that force women to work on other farms and pull-factors that prevent women from getting involved in the labor market.

Asset ownership

The general equation, confirms some of the hypotheses of the importance of assets and asset building for many poor households. The coefficient for household size confirmed the general hypothesis that the large the household the more likely women would work as agricultural laborers. The lowest effect was recorded under supplemental irrigation. These results are due to the changing production system and the development of vegetables and fruits that is mobilizing the household labor. The coefficients for land holding, ownership of livestock and tractors were negative and significant suggesting that households endowed with more land, livestock or machinery are likely to get less involved in the labor market than poor households. However, the effects of assets vary depending on the production system. Firstly, under the barley-livestock system, number of sheep, ownership of wells and tractors were the negative and significant variables. Secondly, sheep and truck ownership were the negative and significant variables under the rainfed system. Thirdly, cows and trucks were the negative and significant variables under the supplemental irrigation. Finally, household land, goats, cows, and tractors were negative and significant variables under full irrigation. The significant and contrary signs of the land variable under the full and supplemental irrigation systems has suggest that more household holding in the dry areas may induce women to work as laborers.

Activities of household heads

The activities of the household head are important determinant for women's involvement in the agricultural labor market. The household heads with cropping as their major source of income are used as control variable. The general equation shows that household heads who are either sharecropping or working in the private sector in Syria are likely to have their female households working as laborers than farming households. Sheep breeders, civil servants, businessman, or household heads with other professional activities are less likely to not have their female members work as laborers. However, effects differed between productions systems. The effect of outmigration in other countries was important mainly for under the barley-livestock system. Most of the people migrating to Lebanon and Jordan work in construction jobs and agriculture where they receive higher wages (Birks and Sinclair C.A, 1980, Martini, 2000; Winckler, 1997).

Women's Education

The lack of education is generally viewed as an important constraint that is maintaining women as agricultural laborers. Women in surveyed communities have a right to education, especially since elementary education in Syria is compulsory, however often they do not receive that right for a combination of various reasons, which could be of social, family or economic nature. The highest coefficients were found for education and the share of female household members with secondary and university education is likely to reduce the involvement of women in the labor market. For the barley-livestock system, secondary education was the most significant variable but primary has the expected negative sign suggesting that education at any level contributes to reducing women work as laborers. Under this system, the majority of women illiterate are 20 years older. In general, few girls reach the 6th grade because many households prefer to stop their daughter's education at an early age (between 10-12 years) to use them as caretakers of younger siblings or agricultural wage laborers.

Agricultural rainfall zones

In the overall equation, the effects of the rainfall zone variables were significant for all the four rainfall zones. However, the coefficients for Zone 1, Zone 2 and Zone 3 suggest that households in these zones are less likely to have women work as laborers than households in Zone 5 while for Zone 4, households are more likely to work more as they are in the dryer areas are more susceptible to droughts. The villages included in the analysis as Zone 5 and are now under full irrigation. The introduction of irrigation in many of the dry areas has changed the production systems and livelihood strategies. This explains the reason why households in the Zone 5 (under irrigation) are less likely to have their female members work as agricultural laborers.

CONCLUSION AND POLICY IMPLICATIONS

Policies aiming at improving rural livelihoods in Syria, especially of women, should target assets that are considered as pull-factors because any investment is likely to improve the capacity of households to generate additional income. For example, the introduction of dairy cows should be limited to the supplemental and full irrigation because of the availability of water and forages. As for households in the crop livestock system, there is a need to secure other income-generating activities, which will reduce women's involvement in off-farm agricultural work. It is important to note that improving the household resource base does necessarily prevent the involvement of women in agriculture but will limit their involvement as agricultural laborers.

The major variable that is likely to improve women's access to better and sustainable income generating activities is education. This variable emerges from the analysis as the most important factor that would reduce their involvement in the agricultural labor market. These results were true in all the productions systems. There is a need to sensitize policy makers for the importance of secondary and university education for rural women. At the household level, there is need to break with the old belief that "it was enough for women to know how to read and write as their final lot is to raise a family".

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Table 1: Description of women's role

	Variables	Barley	Rainfed	Supplemental	Full
Assets					
Age household head (years)	hhhage	45.88	45.79	49.37	45.18
Household lands (ha	totlandha	9.83	5.61	7.87	4.26
Household size	hhsize	6.86	7.25	7.53	7.46
Number of adult sheep (heads)	sheep	22.99	5.91	22.10	6.46
Number of goats (heads)	goat	1.15	1.12	0.88	0.34
Number of cows (heads)	cows	0.08	0.15	0.66	0.67
Wells	agrwell	0.13	0.02	0.36	0.17
Tractor ownership	tractor	0.08	0.07	0.19	0.07
Truck ownership	pickup	0.06	0.07	0.17	0.08
Major activity of household head					
Sheep breeder	hhhsheep	0.19	0.09	0.10	0.03
Sharecropper	hhhsharecrop	0.00	0.01	0.01	0.08
Civil servant	hhhgovoccup	0.21	0.14	0.25	0.14
Wage laborer in Syria	hhhwagesyria	0.22	0.13	0.05	0.15
Migrant outside Syria	hhhwageout	0.06	0.21	0.03	0.16
Businessman	hhhbusiness	0.01	0.07	0.12	0.01
Others	hhhhmisco	0.09	0.03	0.04	0.03
Labor Quality					
Women with primary education (%)	primpc	0.09	0.07	0.12	0.09
Women with secondary education (%)	secpc	0.02	0.05	0.04	0.04
Women with university education (%)	univpc	0.010	0.002	0.004	0.005
Agricultural suitability zones					
Zone 1	Zone 1	0.00	0.00	0.00	0.11
Zone 2	Zone 2	0.00	0.20	0.19	0.00
Zone 3	Zone 3	0.10	0.80	0.81	0.07
Zone 4	Zone 4	0.90	0.00	0.00	0.19
Observations	3372				

Determinants of women's involvement in Agricultural Labor market

	All	Barley	Rainfed	Supplemental	Full
Assets					
Age household head (Years)	0.001	0.003	0.001	0.001	0.002
	(1.09)	(2.26)**	(0.65)	(1.54)	(0.26)
Household size	0.016	0.018	0.022	0.001	0.017
	(7.37)***	(3.19)***	(3.92)***	(3.98)***	(4.60)***
Number of adult sheep (heads)	-0.001	-0.007	-0.014	0.004	0.003
	(4.44)***	(4.54)***	(2.93)***	(2.47)**	(0.93)
Household lands (ha)	-0.004	-0.002	-0.004	0.004	-0.004
	(4.73)***	(1.31)	(1.27)	(2.01)**	(3.06)***
Number of goats (heads)	-0.014	0.014	0.023	-0.005	-0.069
	(2.53)**	(1.36)	(1.38)	(1.53)	(3.74)***
Number of cows (heads)	-0.028	0.025	-0.097	-0.006	-0.032
	(3.67)***	(1.05)	(1.55)	(3.38)***	(2.89)***
Wells (0,1)	-0.046	-0.152	0.124	-0.003	-0.013
	(2.24)**	(2.23)**	(0.82)	(0.86)	(0.43)
Tractor ownership (0,1)	-0.094	-0.31	0.047	0.007	-0.158
	(2.77)***	(1.91)*	(0.49)	(1.61)	(2.61)***
Truck ownership (0,1)	-0.037	-0.062	-0.159	-0.02	0.03
	(1.22)	(0.77)	(1.97)**	(2.68)***	(0.64)
Major activity of household head					
Breeder	-0.178	-0.138	-0.009	-0.004	-0.199
	(6.20)***	(2.52)**	(0.10)	(0.80)	(2.08)**
Sharecropper	0.098		0.231		0.109
	(2.35)**		(1.01)		(2.10)**
Civil servant	-0.081	-0.009	-0.068	-0.003	-0.122
	(3.95)***	(0.21)	(1.13)	(0.98)	(3.32)***
Wage laborer in Syria	0.055	0.013	-0.02	0.02	0.055
	(2.26)**	(0.27)	(0.31)	(2.04)**	(1.42)
Migrant outside Syria	-0.008	-0.105	-0.039	-0.001	-0.01
	(0.31)	(1.79)*	(0.66)	(0.09)	(0.25)
Businessman	-0.105		-0.041	-0.002	-0.042
	(2.71)***		(0.53)	(0.66)	(0.29)
Others	-0.105	-0.08	-0.166	-0.004	-0.075
	(3.10)***	(1.44)	(1.72)*	(0.79)	(1.09)
Labor Quality					
Women with primary education (%)	0.093	-0.182	0.073	0.024	0.189
	(1.86)	(1.54)	(0.51)	(3.16)***	(2.25)**
Women with secondary education (%)	-0.058	-1.093	-0.204	0.019	-0.04
	(0.70)	(2.49)**	(0.93)	(1.60)	(0.31)
Women with university education (%)	-1.182		-0.969	-0.047	-1.095
	(3.00)***		(0.82)	(0.66)	(1.81)*
Agricultural suitability zones					
Zone 1	-0.117				-0.151
	(3.40)***				(3.25)***
Zone 2	-0.131		-0.003		
	(4.62)***		(0.05)		
Zone 3	-0.092		-0.155		
	(4.49)***		(2.97)***		-0.041
					(0.68)
Zone 4	0.152				
	(6.49)***				0.264
					(6.55)***
Observations	3372	607	1545	457	734

Absolute t-statistics are in parentheses *** significant at 1%, ** significant at 5%, and * significant at 10%

Natural Resource Management Program

Annual Report for 1996-2001

International Center for Agricultural Research in the Dry Areas

About ICARDA and the CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR).

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

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

CGIAR

The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. The CGIAR receives support from many country and institutional members worldwide. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South–North partnership to reduce poverty and hunger.

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

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

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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 Resource Management Program, ICARDA.

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International Center for Agricultural Research in the Dry Areas (ICARDA)

P.O. Box 5466, Aleppo, Syria
Tel.: 963-21-2213433
Fax.: 963-21-2213490
E-mail: icarda@cgiar.org
Website: http://www.icarda.cgiar.org

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