International Center for Agricultural Research in Dry Areas

TUNISIA-USDA-ICARDA Collaboration

Annual Report 2004

ICARDA North Africa Regional Program

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USDA

ICARDA

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Forward

This annual report presents the main achievements of USDA-Tunisia-ICARDA collaboration during the cropping season 2003-2004.

The tripartite collaboration between Tunisia NARIs, USDA and ICARDA is highly appreciated. This collaboration aims at improving the livelihoods of rural communities, build human capacities, and exchange experiences in arid and semi-arid regions of Tunisia. Six projects are implemented and involve more than 10 research institutes and universities in Tunisia and USA (IRESA, IRA, INAT, INRAT, ARS, Purdue University, Mississippi University, University of Minnesota) in fruitful partnership with ICARDA. Within this framework, important issues were tackled as "the sustainable water management in the arid regions of Tunisia", the "biological diversity, cultural and economic value of medicinal, herbal and aromatic plants in southern Tunisia", "Improvement of oats productivity", "Improvement of the rural livelihood in North Africa and West Asia through strengthened teaching and research on sheep and goat production", "biological control of weeds with plant pathogens". In addition, ICARDA in collaboration with USAD launched an initiative to develop Maghreb biotechnology capability.

ICARDA would like to express its high appreciation to USDA-FAS for its continuous support.

Dr. Mohammed El Mourid
ICARDA North Africa Program
Regional Coordinator

Dr. Ibrahim Shaqir
International Affairs Specialist
Office of International Research Programs – ARS/USDA

G.I.S. for Watershed MANAGEMENT IN the arid region of Tunisia (Project No. FG-TN-103)

M. Ouessar

IRA – Médenine, Route El Jorf, 4119 Médenine, Tunis – Tunisia

1. Background

Objectives

(i) Investigation on the hydro-morphological behaviour of arid watersheds,

(ii) Development of tools for management and decision-makers based on GIS and IS technologies for a sustainable use of water and soil resources in arid environments.

Partner institutions

- Institut des Régions Arides (IRA), Médenine, Tunisia
- Purdue University, West Lafayette, USA
- International Centre for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria.
- Institut National Agronomique de Tunisie (INAT), Tunis, Tunisia

Funding

Foreign and Agricultural Services (FAS) of the USDA.

Project team

Name	Institution	Function
Mohtar, Rabi H.	Purdue Univ. West La Fayette	Associate Professor US principal investigator
Khatteli, Houcine	IRA – Médenine – Tunisia	Professor Director General
Ouessar, Mohamed	IRA – Médenine – Tunisia	Researcher Foreign principal investigator
Ben Mechlia, Nétij	INAT – Tunis - Tunisia	Professor
Bruggeman, Adriana	ICARDA – Aleppo	Expert Natural Resources Management Program
Engel, Bernard A.	Purdue Univ. West La Fayette	Professor Head of the Purdue Center for Advanced Applications in GIS

Sammons, David J.	Purdue Univ. West La Fayette	Professor Associate Dean of Purdue University School of Agriculture Director of the International Programs in Agriculture
Abdelli, Fethi	IRA – Médenine - Tunisia	M.Sc.
Bracmort, Kelci	Purdue Univ. West La Fayette	Student
Ouerchefani, Dalel	IRA – Médenine - Tunisia	M.Sc.
Zerrim, Ammar	IRA – Médenine - Tunisia	Engineer

2. Achievements

2.1. Overview of water harvesting in Tunisia

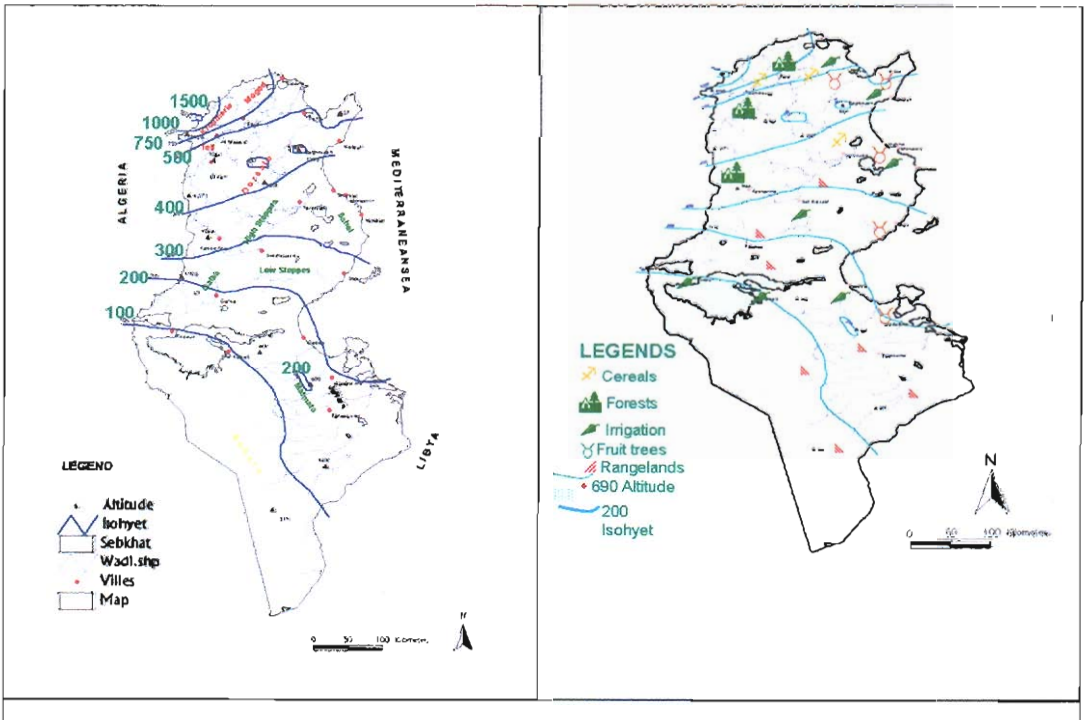


Figure 1. Agro-ecological zones of Tunisia

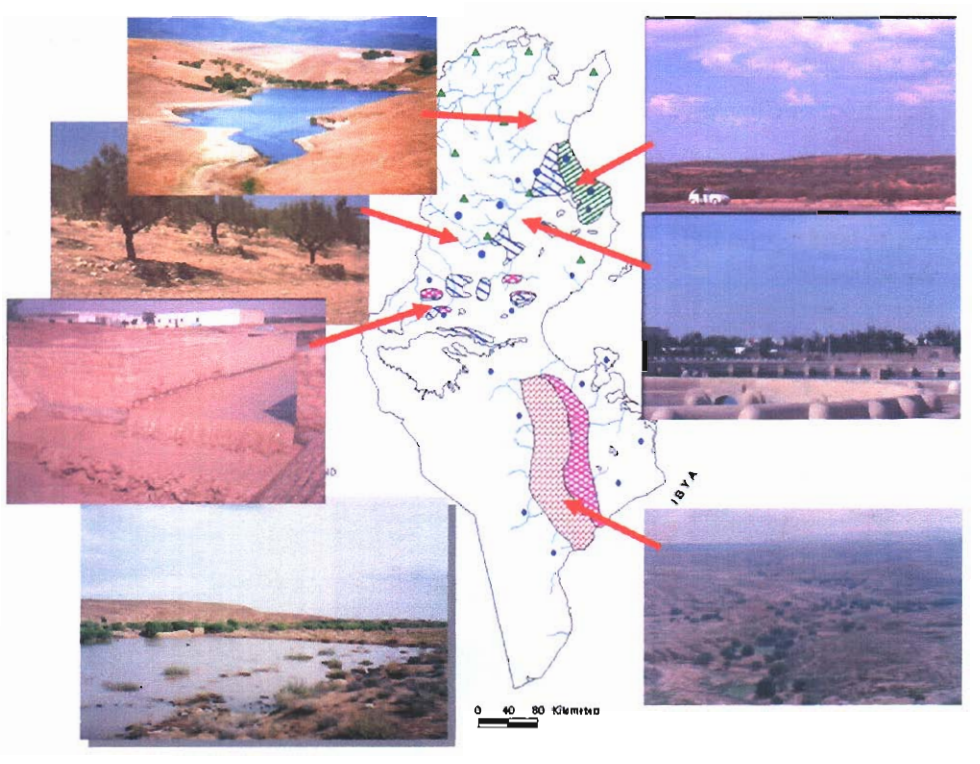


Figure 2. View of water harvesting techniques in different agro-ecological zones of Tunisia

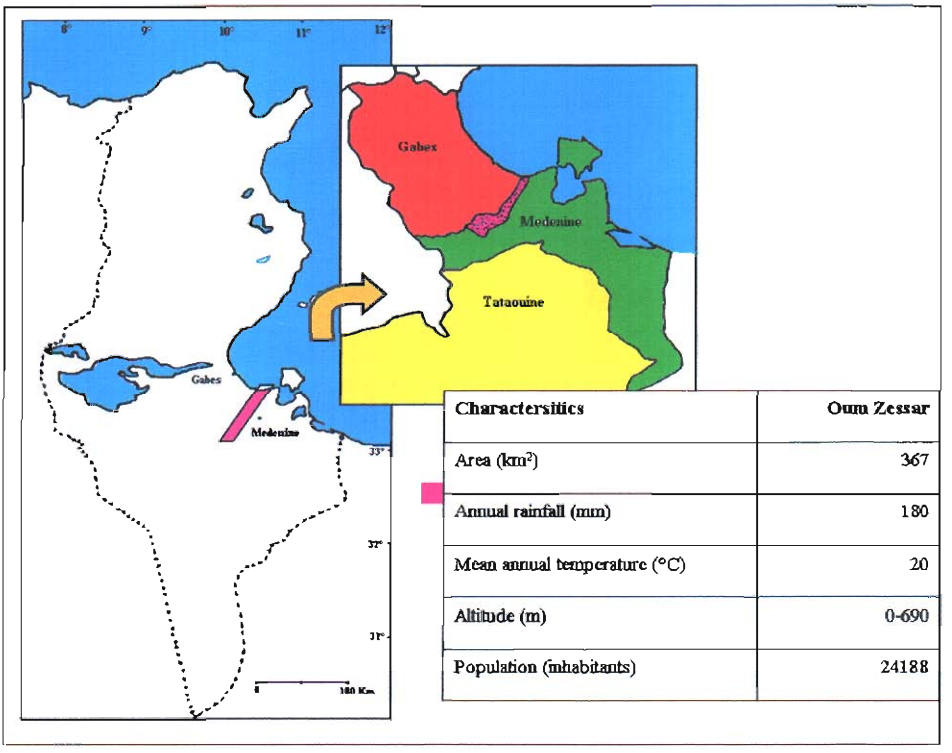
2.2. Watershed modelling with SWAT

The US-developed Soil Water Assessment Tool (SWAT), jointly developed by the USDA-ARS Grassland, Soil and Water Research Laboratory and Texas Agricultural Experiment Station Blackland Research Centre, both Temple Texas, is used to model the Oum Zessar watershed in Tunisia. The following modelling issues and data have been reviewed in detail:

- climate data
- soil physical data
- watershed delineation
- initial soil moisture content
- Irrigation from reach (to simulate water-harvesting by Jessours)
- crop dormancy
- surface runoff delay
- lateral flow

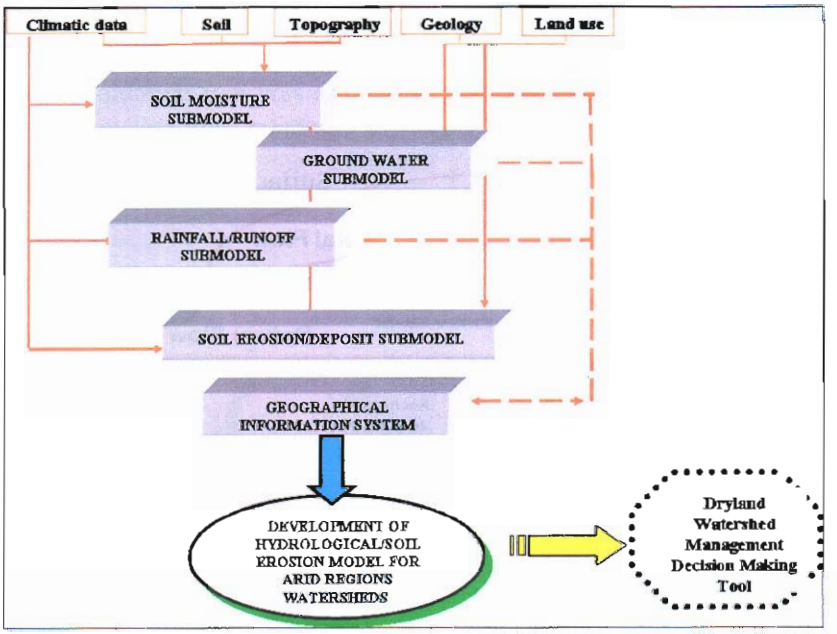
- groundwater processes
- assignment of climate data to sub-basins
- How groundwater recharge and transmission losses being modeled as these are functions of water level in the reservoir.
- How to best represent Jessours, Gabions, and Tabias (multiple of these within the subbasin?

Study site

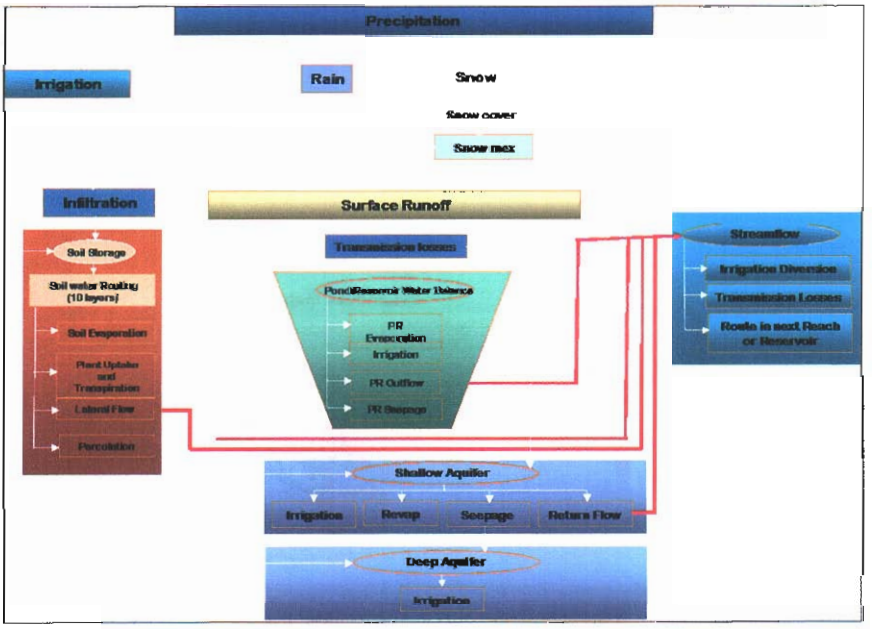


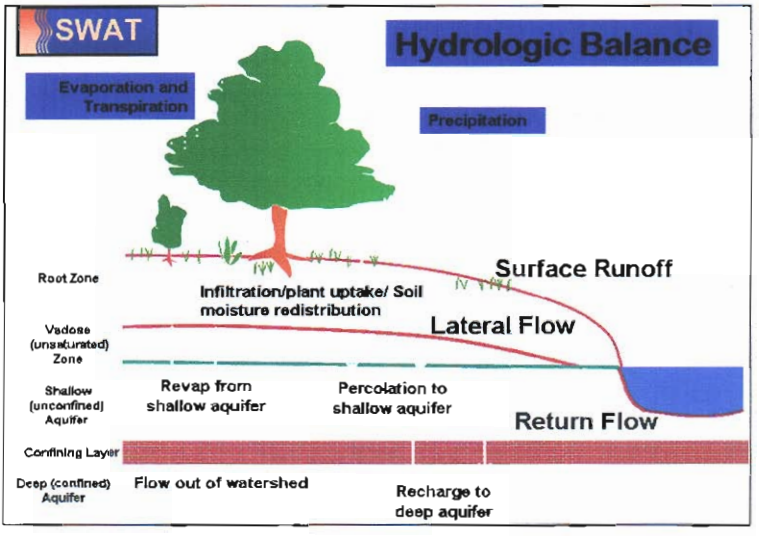
Charactersitics	Oum Zessar
Area (km²)	367
Annual rainfall (mm)	180
Mean annual temperature (°C)	20
Altitude (m)	0-690
Population (inhabitants)	24188

Figure 3. Location and characteristics of experimental site



Schematic of pathways available for water movement in SWAT





Input data

The map Grid themes

- Elevation map Grid (DEM)
- DEM Mask (Watershed of oum Zessar)
- Land use map Grid
- Soil map Grid

Weather Data

Soils data

Crops data

Water data (Groundwater and irrigation)

Examples of input maps

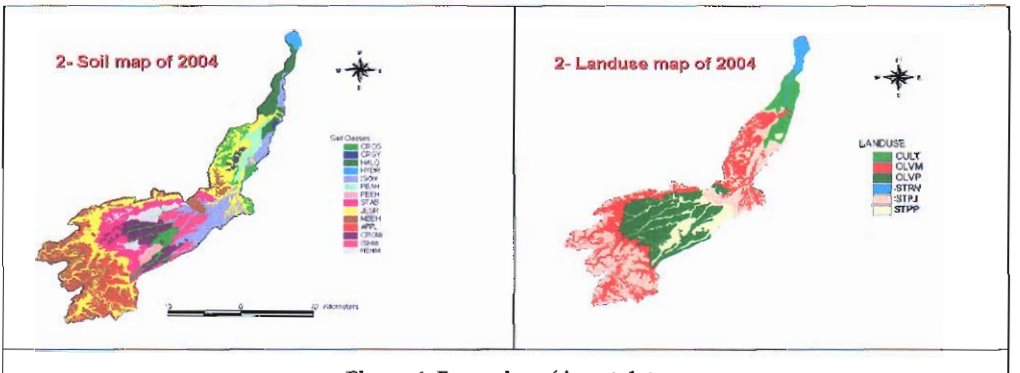


Figure 4. Examples of input data

2.3. WHT evaluation tool

A WHT evaluation tools was developed for jessours, tabias and gabions. The evaluation tool gives an index of the WHT present-day functionality based on physical inspection of a number of characteristics vital to the functionality of the WHT. The evaluation tool was applied to a random sample of WHT in southern Tunisia. The evaluations rated the following WHT characteristics: cross section, infiltration potential, cropping potential for cultivated areas, drainage area vegetation, dike material, and dike erosion. All WHT evaluated were in fair to good condition.

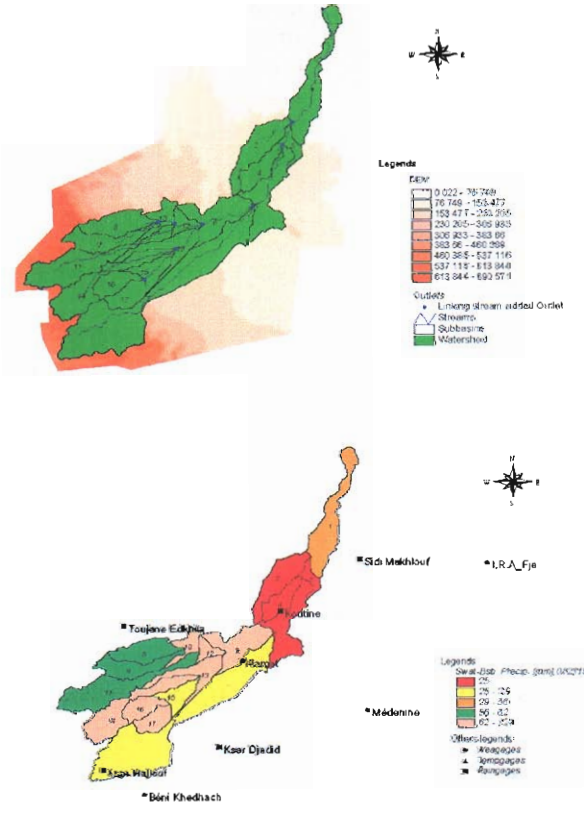
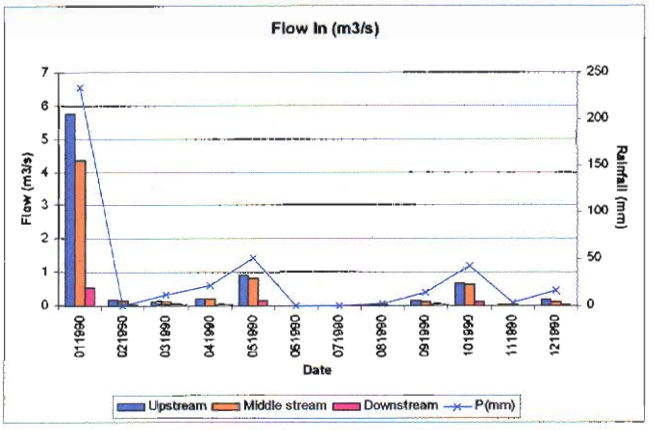


Figure 5. DEM and watershed delineation

It was used also to estimate the inflow and the outflow at the level of the different compartments of the watershed.



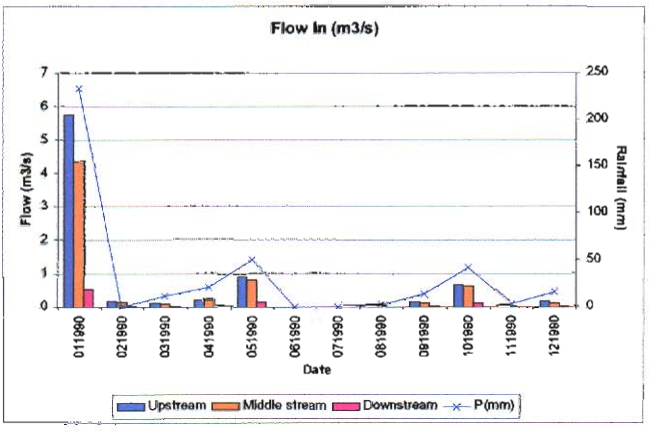


Figure 6. Flow in and flow out at the level of upstream, middle stream and downstream of the watershed

2.4. Meetings & exchanges

1. Two visits of Dr. Adriana Bruggeman to IRA: February 2004 and October 2004.
2. Two visits of Mr. Mohamed Ouessar to ICARDA: April 2004 and July 2004.
3. Visit of Dr. Rabi Mohtar to IRA: June 2004.
4. Training of Fethi Abdelli at ICARDA: April 2004.

- Training visit of Mrs Kelci Bracmort (Purdue University) at IRA: June 2004.
- Training of two technicians from IRA at ICARDA: July 2004.

2.5. Publications

Papers in preparation:

Bracmort, k., Mohtar, R.H., Ouessar, M., Bruggeman, A., Abdelli, F., Ouerchefani, D., Engel, B., 2005. Evaluation of Water Harvesting Techniques (WHT) in Southern Tunisia .

Ouessar, M., Bruggeman, A., Abdelli, F. Mohtar, R. Application of the SWAT model in a dry watershed of southern Tunisia.

The team was invited to contribute to a special issue of the *Arab Journal of Engineering Sciences* with a section on 'water harvesting' as following:

- Current practices : Ouessar and Bruggeman
- Site selection and sizing: Faraj and Mohtar
- Impacts of WHT : Ouessar and Faraj

3. Plan of future activities

3.1. SWAT modeling

The work on SWAT modeling will be achieved before the end of the year. It will concern mainly Validation and Scenarios development.

3.2. International workshop

An international workshop on *"Watershed management in dry areas: Challenges and opportunities"* will be held in Djerba, 4-6 Janaury 2005. It will be attended by scientists from Tunisia, Algéria, Morocco, USA, Syria and France. The proceedings will be published by ICARDA.

3.3. Exchanges / meetings

- It is expected that Mr. Abdelli Fethi (IRA) will spend one month (February 2005) training at Purdue University to work with Dr. Mohtar and his collaborators on the application of the HEC model to a sub-catchmeent of Oum Zessar watershed and the development web based simulation modeling.
- The final meeting of the project will be held on the occasion of the ASAE annual meeting in Florida (July 2005).

Partnership to improve the rural livelihood in North Africa and West Asia through strengthened teaching and research on sheep and goat production

M. Djemali
INAT, 43 Avenue Charles Nicolle 1082 Mahrajène, Tunis, Tunisia.

Period: September 2002- November 2003

Project partnership: IRESA (INAT & INRAT), ILRI, ICARDA, FVSU-USA, USDA

Efficient utilization of small ruminants in developing countries is a prerequisite for the opportunities to meet the future demands of food to improve the livelihood of poor people. Presently 800 million people suffer from hunger and malnutrition. A livestock revolution has to take place to meet the demands for food of animal origin. The productivity of small ruminants must increase to avoid overgrazing and subsequent degradation of natural resources. Animals and production systems must be adapted to local environmental, socio-economic and cultural conditions, and we have to ensure enough genetic diversity for the unknown future. Sheep and goats are important for the well being of poor farmers and national economic development in the countries of the sub-tropics and seasonally dry tropics of WANA. However, farmers in all countries face constraints to improving SR production, especially the links to markets, breeding, nutrition and management, and concerted action is needed to enable smallholder sheep and goat producers improve their livelihoods and contribute fully to national economic development and food security. There is need in WANA to assess markets and propose a production strategy that could include cross-breeding and accelerated (intensive) production of lambs for target markets as well as the organization of producers in cooperatives under semi-industrial production systems geared to produce, process and market lambs. To address all these issues and to help smallholders achieve their potential requires research and extension staff to be equipped with the necessary expertise, information and tools.

Teaching SR production is often not integrated with all other relevant disciplines. Furthermore in many universities those teaching sheep and goat production are more familiar with cattle production. As a result there are few university courses in the universities that give adequate attention to improving sheep and goat production.

The production of training materials will support the work of University faculty to train research and extension staff to meet the issues outlined above. The materials will provide trainers with ready access to case studies, data sets etc, relevant to the issues and constraints in their countries and regions. Despite the importance of

sheep and goats (small ruminant livestock - SR) in the economic development and well being of poor people in the sub-tropics and seasonally dry tropical areas of North Africa and West Asia (WANA), farmers in this region continue to contend with problems in management, health, production and marketing of their livestock. R&D professionals in Tunisia work closely with farmers, and have the skills and awareness to address the complex of inter-linked issues, experience which will be valuable for the project. However, not all national research and teaching systems share this expertise. To sustain or to strengthen progress, universities need to train more small ruminant specialists with the skills to tackle complex issues. This process will be assisted by providing trainers with modern training and extension tools and materials which have been adapted for the particular socio-economic, environmental and market circumstances of smallholder sheep and goat producers in these regions.

To meet the above goal, the Institut National Agronomique de Tunisie (INAT) and Institut National de la Recherche Agronomique de Tunisie (INRAT), ICARDA, Fort Valley University, Georgia, USA, USDA/FAS/ICD and ILRI collaborated on the project "Partnership to improve rural livelihoods in North Africa and West Asia through strengthened teaching and research on sheep and goat production" to develop and introduce training tools and materials that use information technologies to integrate data, information and knowledge products from WANA to address the smallholder sheep and goat production problems. This training resource CD-ROM on "Capacity building for sustainable use of small ruminants in developing countries" is an output from this project. It represents Version 1 and it is anticipated that Version 2 will be produced in the future by more partners in WANA and will be more comprehensive in providing more case studies, breed information, etc.

The training resource consists of six modules. These modules are the closest the product comes to a text book, because each module summarizes a set of basic knowledge, principles and concepts. We refer to this material as the "core knowledge". It should be emphasized that the modules are a summary – albeit a comprehensive summary – and not an exhaustive treatment of the subject. The information in the modules is structured to help engage the attention and interest of users – both faculty and students. Other resources on the CD complement the core knowledge and include case studies, breeds, books on sheep and goats and a small library.

Module 1. Livestock Development Objectives (LDO)

M'Naouer Djemali

National Institute of Agriculture of Tunisia (INAT),

Animal and Feed Resources Research Lab., 1082 Mahrajéne Tunisia

This module describes a generic process that could be used by livestock specialists in general and animal breeders in particular to establish Livestock Development Objectives (LDO), prior to specification of elements to be implemented for livestock development such as the breeding strategy and its breeding goal. Small ruminants development in a region, country or in a particular production system can benefit from results of this approach. This fundamental aspect of livestock development is commonly poorly addressed at the local, country, and international levels without proper involvement in the process of the main stakeholders in the livestock sector. At the end of the process an agreed overall strategy should be documented in detail with strong local ownership and including clear statements of the LDO and establish strategic priorities for action that are feasible technically, institutionally and financially. A link is made to a case study illustrating the use of this approach.

Module 2. Husbandry practices of ovine flocks in Tunisia: Present status and future prospects

Gley Khaldi

Institut National Agronomique de Tunisie. 43, Avenue Charles Nicolle, 1082 Tunis Mahrajène, Tunisie

In spite of its socio-economic importance and government policy support for the last three decades (bank loan, subsidy, etc.), the sheep production systems in Tunisia remained traditional and extensive, and are characterized by low productivity. The average productivity, expressed in number of lambs produced/female/year hardly exceeds 0.7 in dry regions of central and southern Tunisia. The figure for humid regions of the northern part of the country is also 0.85 which doesn't differ much from the previous one. Similarly, lamb growth rate is relatively poor and supplementary feeding is very rare. The average body weight at slaughter was around 22kg. A female up to the term of its productive life produces, on average, less than 11-12 kg of meat/year.

The low productivity of sheep in Tunisia, therefore, can only be explained by the likely limited genetic potential and/or by the unfavorable condition of the environment under which they are raised, particularly shortage of feed resources, common in all countries of North Africa. In order to try to understand the situation and determine the cause of low productivity of Tunisia's sheep flocks, so as to be able to suggest possibilities for productivity improvement. This module includes:

- Presenting meat-type ovine breeds of Tunisia, particularly their productive and reproductive performances.
- Presenting external constraints associated with harsh natural environmental conditions and husbandry practices.
- Suggesting techniques for improvement of productivity of sheep flocks, that could be easily adopted by farmers, who generally are poor and with limited skills.

Module 3. Small ruminants genetic resources

M. Djemali[1], S. Bedhiaf[2], R. Cardellino[4], H. Ibrahim[4]

[1].National Institute of Agriculture of Tunisia (INAT),

Animal and Feed Resources Research Lab., 1082 Mahrajéne Tunisia

[2].National Institute of Agricultural Research (INRA Tunisia). Animal and Forage Research Lab, Rue Hédi Karray, Ariana 2049

[3] FAO, Rome

[4] International Livestock Research Institute, P O Box 5689, Addis Ababa, Ethiopia

This module recognizes the importance of animal genetic resources, the need to use, develop and conserve these essential resources in a sustainable manner. Threats to world's animal biodiversity and the Global response to the loss of farm animal genetic resources are discussed. Breeding strategies and conservation programs to maintain and improve sheep and goats productivity are presented.

Module 4. Adding value to small ruminant raw products

H. Ibrahim

International Livestock Research Institute, P O Box 5689, Addis Ababa, Ethiopia

Farmers in developing countries, including smallholders in crop-livestock systems, strive to increase their income. There are three alternatives available to the farmers: reduce the production costs, increase intensity of production or increase the value of the products sold. To a crop-livestock system farmer this means adding value to crop or livestock products. The concept of 'adding value' to farm products attracts attention among many researchers and development agents (Bachman 2001). The value of farm products can be increased in many ways but the effort can only be successful if all the stakeholders (farmers, processors, traders, government agents etc.) work together. Many policy makers believe that adding value to farm products is critical to sustainable development. The concept of value added agriculture gained

momentum in response to the argument that the value of the raw farm product in consumer dollars continues to decrease.

Value added products are products that have an increased value because of processing. Adding value to livestock products can be done in various ways: small-scale processing, packaging or marketing. Farmers can add value by retaining ownership beyond the commodity stage. For example farmer co-operatives can share ownership of meat, dairy or skin processing plants.

This module discusses value added products with a focus on products from small ruminants and gives broad outlines of ways in which to add value to products. Links (full texts or Internet address) are available for additional information and detailed processing procedures. At the end of the module additional information resources are provided. The topic is complex and broad and therefore it is not possible to fully cover it in this module.

Module 5. Research methods

M. Djemali[1], H. Ibrahim[2]

[1] National Institute of Agriculture of Tunisia (INAT),

Animal and Feed Resources Research Lab., 1082 Mahrajéne Tunisia

[2] International Livestock Research Institute. P O Box 5689, Addis Ababa, Ethiopia

The goal in almost every experiment or a conducted survey is to condense and summarize the numbers that are gathered into a few values (known as parameters) or statements quantitative or descriptive that convey the essential of the results, the average or mean of a set of numbers is the most familiar and widely used summary. There are certain and relatively simple basic components that must be understood before even designing for an experiment. The same thing can be said about analysis methods and results interpretation. The objective of this module is describe what is needed as a prerequisite in order to have a reliable experimental approach in order for statistical summaries and analysis statements to be reliable.

Module 6. Farming System Approach: Concepts, Methods and Applications-The Case of the Zoghmar Community, Tunisia[1]

Véronique Alary[1], Mohammed Elloumi[2], Salah Selmi[3]

[1] CIRAD-Emvt/ICARDA, ICARDA Tunis, 6 rue Ibn Rachik, 2080 Nouvelle Ariana, Tunisie

[2] INRAT Tunisie,

[3] Ecole Supérieure d'Agriculture de Mograne, Tunisie

The understanding of the farming system, such as a complex and "unique" system, is recognition of major roles played by people not only as a steering element but also as historical and social components of the systems. However, research as well as development should understand the complexity of this system for reorganising it in more simplified models that allow reasoning some changes, technological and institutional innovation for example. So the typologies of farming systems are progressively developing and now they are integrating in an approach of research for the diagnostic of the whole functioning of the farms. This approach is based on a conceptual framework related to the systemic modelling approach of the farms including the "family-farm" system (Osty, 1978; Brossier, 1987; Jouve, 1984).

The typologies are mainly based on multidisciplinary knowledge on the farms. If the holistic approach of the farming systems based on the systemic principles knows few changes during these last years, typological methods have improved a lot in order to respond to operational objective (use of typology under the framework of adaptation of technical advises) and to bring research outputs to end-users.

This module aims to describe the research method through the experience developed in a research project for the development in the Zoghmar community. The Zoghmar community is located in the Sidi Bouzid governorate in the semiarid zone of Central Tunisia. Despite the recent development of irrigation schemes, Zoghmar is known as agro-pastoral area and its main characteristic are: 1) its isolation 2) dominance of small ruminant production 3) integrated crop production for livestock maintenance 4) the importance of pasture land.

This community was selected under the framework of « the Mashreq/Maghreb Project » (ICARDA)2, a research and development project with major objectives being development through dissemination of new technologies (already verified by research) in arid and semiarid agro-pastoral areas, mainly engaged in small ruminant production. A modelling tool is also put in place so as to analyse the obstacles or preference for alternative technologies taking into account the mode of functioning of the farming systems, theirs interactions at the community level and theirs relations with their global environment.

Case studies

This training material includes a total of 10 case studies covering a variety of topics of great importance to readers.

List of Case Studies

1. Inventory of small ruminant genetic resources (Djemali and Bedhiaf)
2. Fattening and commerce of sheep: The role of Aïd El Kébir in the strategy of the Zoghmar livestock producer Community (Selmi et. al.)
3. Small ruminant development objectives: Tunisian example (Djemali)
4. Small ruminant management in M&M Project (Bedhiaf et. al.)
5. Characteristics of Small Ruminates Reproduction in Tunisia: Case Study of Female Ovine of Barbarine Breed (Khaldi)
6. Alternatives to improve the sheep recording system in Tunisia (Bedhiaf and Djemali)
7. Feeding, production and reproduction of Ewes of Barbarine breed in Tunisia (Khaldi)
8. Cross-breeding of native goats in Tunisia (Djemali)
9. Improving Prolificacy of Ewes In Tunisia (Khaldi)
10. Market opportunities for production and market insertion for small ruminant producers in Tunisia (Alary)

Management of indigenous sheep genetic resources and improvement of farmer's income under changes promoted by new market demands in North Africa and West Asia / Case of Tunisia (New Project)

Research team:

Principal investigators:

M'Naouer Djemali (INAT), Luis Inigues (ICARDA), Sonia Bedhiaf (INRAT), Brigitte Hartwell (ICARDA), Micah Rosenblum (USDA).

Collaborators:

Seyoum Gelaye (Fort Valley state University, USA), Veronique Alary (ICARDA), Maria Wurzinger (University of Natural Resources and Applied Life Sciences, Austria), Office de l'Elevage et des Pâturages (Béja-Tunisia), Sicilo-Sarde Breed Association in Béja.

Starting date-Ending date: October 2004-December 2006.

Introduction

Tunisia is endowed with a wealth of sheep genetic resources adapted to a range of dry environments with extreme climate fluctuations during the year. Most of these resources (80%) are owned by small farmers with low income in rural areas. The Barbarine fat-tailed sheep is the most numerous and important breed in the country. The breed is well adapted to the prevailing agro ecologies with at least 9 different ecotypes allowing farmers to access specific production niches. However the breed has a rather low growth rate and its preference in the large urban markets is under change for an animal that produces carcass with a thin tail in contrast to the fat tail. The Barbarine fat tail represents an important portion (15%) of the carcass. In response to this trend, farmers are crossing the Barbarine with thin tailed breeds which in the long terms could have an impacting consequence in the integrity of the genetic resources. This is happening at the time when the fat tail is known as a criteria for adaptation to harsh conditions and fat-tailed animals are preferred for religious practices.

It has been, also, identified that the Sicilo-Sarde breed, the only indigenous milking sheep in the country is undergoing considerably population reduction due to the lack of management skills to produce competitively and a lack of information of farmers on the existing market opportunities. Indiscriminate crossbreeding with meat breeds could lead irreversible changes in the Sicilo-Sarde genetic structure. Interestingly important facts interact in the current production conditions of this breed:

- A well defined market with an unsatisfied demand for increased production to be processed into derivatives

- The involvement of the private sector that has installed capacity to absorb the production and processes the milk and strive toward organizing farmers in the region.
- The recently formed association of the Sicilo-Sarde producers and its need for technological improvement.

Objectives

- assess the degree of change in the genetic structure of Barbarine flocks and the degree of crossing between the Barbarine breed and thin tail breeds,
- identify appropriate management strategies for securing the integrity of small ruminant genetic resources while helping rural farmers to target opportunity markets.
- to develop management and institutional tools for market oriented production geared to the improvement of livelihood of producers of the Sicilo-Sarde sheep, through technological improvement of productivity, and conservation of the natural resources base and the genetic integrity of this breed,
- to test a model for application in other regions where similar situations exists.

Expected outputs

The expected outputs will be measured at:

- The household level by an increase of sheep owners income
- The national level by a total meat production increase
- An improvement of milk production
- A generating income through cheese making
- The organizational level by linking production to market through a breeding organization that will help producers alleviate existing constraints and promote their products
- The breed level by wise genetic management schemes to protect the Barbarine and the Sicilo-Sarde breeds from the negative effect of crossing them with other breeds
- The scientific level by enhancing research team work, publishing journal articles and developing case studies for the SR-CDROM.

Methodologies

Project 1. Barbarine-fattening

(i) Survey to characterize the production system:

- types of lambs produced and fattened,
- types of farmers that fatten and those that do not

(ii) Survey to characterize market channels

(iii) Survey to characterize consumers preference

(iv) Assess crossbreeding effects on lambs produced and the integrity of the Barbarine breed.

(v) Three Master degree students are identified:

- One for Sidi Bouzid region
- One for Siliana region
- One for "Big" Tunis

Project 2. Sicilo-Sarde-milk and cheese

- Organize a workshop with farmers to assess the problems and constraints and to define issues that will be included in the characterization of the associated production systems.
- Develop the basis of an open nucleus system, decentralized and participatory, managed by the cooperative of producers.
- Assess individual milk production of main large dairy flocks in Béja
- Constitute an elite flock on the basis of a large screening of animals regarding their milk production.
- Develop genetic evaluation tools to enhance selection of rams and replacements
- One Master degree student is identified.

Plan of activities 2004-2005

- Prepare surveys (October-November, 2004)
- Field surveys (November-May, 2005)
- Milk recording (November – June, 2005)
- Screening of elite ewes (April-May, 2005)
- Present preliminary results (June, 2005)
- Masters results presentation (September, 2005)

Diversité biologique et importances économique et culturelle des plantes aromatiques et médicinales (PAM) de la Tunisie méridionale

Mohamed Neffati

Directeur de Recherche – Chef du Laboratoire d'Ecologie Pastorale à l'Institut des Régions Arides 4119 Médenine-Tunisie. E-mail : Neffati.Mohamed@ira.rnrt.tn

1. Introduction.

La production nationale moyenne des principales PAM et leurs dérivés est de l'ordre de 8500 tonnes dont prés du quart est exporté, principalement vers l'Europe. La valeur de cette production est estimée à 14,2 millions de dinars dont près de 40% proviennent des produits exportés. Les huiles essentielles à elles seules rapportent plus de 65% de la valeur de ces exportations soit environ 3,7 millions de dinars.

En raison de leur importance économique, sociale, médicinale, écologique et culturelles, les PAM commencent, ces dernières années, à occuper une place de choix au niveau des différents secteurs, et notamment, celui de la recherche, de l'industrie, de l'agriculture, de la médecine et de l'environnement. Cette préoccupation s'est concrétisée à travers les politiques sectorielles et les orientations au niveau de ces secteurs.

Aujourd'hui, tous les justificatifs économiques, sanitaires et environnementaux sont réunis pour un regain d'intérêt pour l'utilisation des substances naturelles. Ce retour à la nature, motivé en outre par l'existence d'effets secondaires des produits de synthèse, a conduit les chercheurs ainsi que les industries pharmaceutiques, alimentaires et cosmétiques à investir dans la recherche des produits naturels comme les antioxydants, les colorants, les arômes, les huiles essentielles...

Au vu des opportunités qu'offre une conjoncture nationale et internationale assez favorable, les perspectives de développement du secteur des PAM s'avèrent réellement prometteuses et ce en raison de l'existence, entre autres :

- d'un patrimoine phytogénétique très riche en espèces utiles;
- d'un savoir-faire local en matière de valorisation des PAM;
- d'une demande accrue des PAM sous leurs différentes formes tant au niveau national qu'international;
- d'acquis et de compétences scientifiques et techniques au niveau des différentes fonctions de la filière des PAM.

Diversité biologique et importances économique et culturelle des plantes aromatiques et médicinales (PAM) de la Tunisie méridionale

Mohamed Neffati

Directeur de Recherche – Chef du Laboratoire d'Ecologie Pastorale à l'Institut des Régions Arides 4119 Médenine-Tunisie. E-mail : Neffati.Mohamed@ira.rnrt.tn

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Si à travers l'histoire, nos ancêtres ont su conserver le patrimoine culturel et cultural dont nous disposons aujourd'hui et surtout celui qui se rapporte aux plantes aromatiques et médicinales ; notre tâche aujourd'hui est de savoir valoriser ce précieux héritage en fournissant à la pharmacie, à la cosmétique, à la parfumerie et à la confiserie, des bases végétales pour leurs industries. Dans le présent travail nous tentons de diagnostiquer ce secteur en vue de lui permettre de jouer pleinement son rôle dans le développement économique du pays.

En adoptant comme définition des plantes médicinales et aromatiques toute plante renfermant un ou plusieurs principes actifs capable de prévenir, soulager ou guérir des maladies et/ou qui renferment des principes odorants, la gamme des PAM en Tunisie s'avère très longue et élastique et peut concerner la plupart des plantes spontanées et de nombreuses espèces arboricoles et herbacées cultivées. C'est pour cette raison que le nombre des plantes considérées comme médicinales varie considérablement d'une étude à une autre. Ce nombre varie en effet de quelques dizaines à plus de deux cents espèces.

Dans ce qui suit nous présentons succinctement le bilan des travaux effectués dans le cadre d'un projet de coopération IRA/USDA/ICARDA sur les PAM intitulé :" *Biological diversity, cultural and economic values of medicinal, herbal and aromatic plants (PAM) in southern Tunisia* " ainsi que les principaux enseignements qui ont pu en être tirés.

Ces activités peuvent être subdivisées en activités scientifiques et techniques et activités d'appui.

La première catégorie d'activités se rapporte aux aspects suivants :

- la réalisation d'une étude de filière des plantes aromatiques et médicinales et leur importance socio-économique tant au niveau national qu'au niveau de la zone cible du projet (la chaîne montagneuse des Matmata);
- la constitution d'une base de données, d'un fonds documentaire et d'un site Web pour le projet;
- l'élaboration de fiches techniques pour les espèces cibles les plus prometteuses;
- la réalisation de travaux de recherche sur ces espèces.

Les activités d'appui consistent en ce qui suit :

- l'identification des opérateurs nationaux intéressés par les PAM et de leurs rôles respectifs;
- l'échange d'expériences avec d'autres projets similaires à travers l'organisation de visites à ces projets et de rencontres scientifiques;
- la constitution d'un comité technique et d'un comité de pilotage pour le projet;

- la formation de chercheurs et techniciens participant à la réalisation du projet.

2. Présentation succincte du projet

Partenaires

Ce projet est réalisé dans le cadre d'un partenariat entre l'IRA, l'USDA - ARS-OIRP et l'ICARDA. Plusieurs autres partenaires nationaux (Organismes de développement, Organisations Socioprofessionnelles, ONG, Promoteurs privés, Institutions de recherche et d'enseignement supérieur ...) contribuent activement à la réalisation de ce projet.

Rappel des objectifs

Le projet vise les principaux objectifs suivants :

(i) Conserver, gérer et utiliser durablement, aussi bien *in situ* qu'*ex situ* les PAM des zones arides et semi-arides ;

(ii) Renforcer la collaboration entre les différents opérateurs;

(iii) Sensibiliser le public aux intérêts des PAM et aux risques qui pèsent sur ces plantes;

(iv) Mettre en place une base de données nationale sur les PAM.

3. Principales Réalisations

3.1. Choix des espèces prioritaires

En Tunisie, le nombre de plantes considérées comme aromatiques et/ou médicinales varie, en fonction des inventaires, de près de 40 espèces à plus de 200 espèces et ce en fonction de plusieurs facteurs dont parmi il y a lieu de mentionner l'étendue de ces inventaires, l'usage majeur des espèces ciblées par l'étude (médicinal, aromatique, condimentaire...) et l'importance accordée par l'étude aux aspects économiques et sociaux des espèces considérées. Le choix des espèces prioritaires dépend en effet de l'objectif visé et des activités à entreprendre sur ces espèces et de la région considérée.

Lors des discussions qui ont eu lieu à l'occasion des différentes rencontres organisées dans le cadre du projet (réunion des comités technique et de pilotage, mission de suivi...) il a été convenu de se limiter, à un nombre limité d'espèces. Il s'agit de celles qui présentent le plus d'intérêts tant économiques, sociaux qu'écologiques au niveau de la zone du projet (*Allium roseum, Artemisia herba-alba, Rosmarinus officinalis, Thymus capitatus, Capparis spinosa,...*).

3.2. Elaboration de fiches techniques pour les espèces cibles

A partir des informations disponibles, il a été procédé à l'élaboration de fiches techniques pour *Capparis spinosa* et *Rosmarinus officinalis*. Plusieurs informations se rapportant aux caractéristiques biologiques, à la répartition géographique, aux

exigences écologiques, aux modes de propagation, aux techniques culturales, à la conservation, à l'usage *etc.* de ces espèces ont été consignées dans ces fichiers. Des fiches techniques de trois autres espèces sont en cours d'élaboration. Etant donnée le manque d'informations sur ces espèces leurs fiches restent préliminaires en attendant les données qui seront régénérées à travers les différentes activités de recherche menées par l'IRA et les autres institutions de recherche.

3.3. Constitution d'une base de données relatives aux PAM et d'un site Web pour le projet

Plusieurs activités ont été accomplies pour la création d'une base de données sur les PAM et d'un site Web pour le projet.

Parmi ces activités il y a lieu de mentionner :

- La collecte de références bibliographiques se rapportant aux PAM. Ces références ont été recherchées aussi bien au niveau national qu'international. L'appui des chercheurs américains à ce propos mérite d'être souligné. Grâce à leur aide des dizaines de références se rapportant aux plantes cibles du projet ont pu en effet être identifiées.
- La création d'un SIG constitué de plusieurs couches d'informations se rapportant aux paramètres suivants : climat, sol, végétation, niveau d'exploitation, infrastructure... En vue de compléter la formation des chercheurs spécialisés de l'IRA dans ce domaine, il a été procédé dans le cadre du projet à l'organisation d'une mission à l'ICARDA du 01 au 15/12/03.
- La création d'un site Web pour le projet. Ebauché à l'occasion d'une mission effectuée à l'IRA par un technicien spécialisé de l'ICARDA du 12 au 18 septembre 2003, ce site a été complété lors d'une mission qui a été effectuée par le technicien de l'IRA au siège de l'ICARDA du 01 au 15 décembre 2003.

Parmi les informations consignées dans ce site Web, il y a lieu de mentionner :

- la description du projet (objectifs, résultats, attendus, partenaires,...) ;
- la présentation des espèces cibles ;
- la liste des principaux rapports scientifiques et techniques élaborés dans le cadre du projet ;
- des photos galeries illustrant les différentes activités menées dans le cadre du projet.

3.4. Importance socio-économique et étude de la filière des PAM

Cette étude est réalisée à trois niveaux : local, national et régional.

3.4.1. Au niveau local

L'objectif est d'étudier l'importance socioéconomique et culturelle des PAM en milieu rural dans la région montagneuse des Matmata (zone cible du projet) (délégations de Mareth, Béni Khedache, Matmata El Guedima et Ghoumrassen).

La démarche méthodologique s'est basée sur des enquêtes par questionnaire auprès d'un échantillon représentatif des chefs de ménages intéressés par les PAM.

Les principaux résultats obtenus sont ci-dessus récapitulés :

- 63.5 % des exploitants exercent une activité en dehors de l'exploitation. La collecte et la vente des PAM constituent cependant une source de revenu non négligeable pour certains ménages de la zone;
- La collecte des PAM dans la chaîne des Matmata est destinée en grande partie à l'autoconsommation. Cependant, 25 % des ménages procèdent à des opérations de vente lorsque l'occasion se présente. D'apparence faible, cette proportion cache un important potentiel d'une prédisposition latente de la population à développer les activités économiques basées sur la valorisation des PAM;
- Sur un total de 72 espèces collectées et utilisées au niveau de la zone d'étude, la vente des PAM est limitée principalement à 4 espèces (Rosmarinus officinalis, Thymus capitatus , Juniperus phoenicea et Artemisia herba-alba). La quantité moyenne écoulée sur le marché est de 750 kg/an par ménage (30 kg à 4500 kg).
- Les prix de vente et les quantités moyennes vendues des PAM sont marqués par une grande variabilité liée à l'espèce, à la période de vente, à la nature de l'année et à la qualité du produit. La fréquence des ventes est plus importante pour Thymus hirtus et Rosmanirus officinalis .
- Les cartes de filière des principales espèces sont relativement simples et traduisent un nombre limité d'intervenants (les producteurs / exploitants, les intermédiaires, les marchands de détails et les consommateurs locaux).
- Les principaux problèmes entravant le développement du secteur des PAM d'après les ménages enquêtés se rapportent à la sécheresse, au méthodes inadéquates de récolte, aux méfaits du surpâturage et de la surexploitation.

3.4.2. Au niveau national :

L'étude nationale a porté sur les aspects suivants :

- Place des PAM dans les stratégies nationales sectorielles;
- Importance des PAM dans l'économie nationale;
    - Contribution des PAM au PIB
    - Evolution des importations et des exportations des PAM

- Contribution des PAM à l'équilibre de la balance commerciale

- Les opérateurs nationaux et leurs rôles / les cartes de filières.

Les principaux résultats de cette étude peuvent être ainsi récapitulés :

- Sur la base des exportations de la dernière décennie du siècle écoulé et des estimations de la consommation locale, la production nationale moyenne des principales PAM et leurs dérivés est de l'ordre de 8500 tonnes/an dont près de 23% est exporté.
- La valeur de cette production est estimée à 14,2 millions de dinars dont 5,7 millions de dinars (40%) générés par les produits exportés, principalement, aux pays européens. Les huiles essentielles rapportent plus de 65% de la valeur de ces exportations.
- De l'ordre de 13,3 MD/an, la part du PIB généré par les principales PAM représente environ 0,06% du PIB total et 0,4% du PIB généré par le secteur agricole.
- La valeur moyenne des importations au cours des dix dernières années est de l'ordre de 2,3 MD enregistrant une réduction relative de 17% durant les cinq dernières années.
- La balance commerciale des PAM durant les dix dernières s'avère cependant toujours positive avec un taux moyen de couverture de l'ordre des 180% en 1992.

3.4.3. Au niveau international

Réalisée avec l'appui de l'USDA et de l'ICARDA, cette étude permettra de positionner la Tunisie au niveau du marché international et portera sur l'identification des contraintes et des opportunités de promotion des exportation des PAM et dérivés, de la formulation de recommandations permettant de surmonter ces contraintes et de maximiser ces opportunités.

Afin d'atteindre cet objectif, il est prévu de réaliser les travaux suivants :

- Identification des pays importateurs des PAM à partir de la Tunisie ;
- Identification des PAM susceptibles d'intéresser ces importateurs (l'UE et les EU) ;
- Evaluation de la compétitivité des produits tunisiens (identification des principaux concurrents) ;
- Evaluation de la régularité de l'approvisionnement, de la qualité des produits, de l'organisation du secteur des PAM, de la régularité des besoins des pays importateurs.

4. Conclusion et perspectives de développement du secteur des PAM en Tunisie

L'enseignement majeur tiré des informations recueillies à travers les différentes études relatives aux secteur des PAM en Tunisie est la nécessité de traiter ce secteur comme une filière globale comprenant un ensemble de fonctions faisant intervenir plusieurs opérateurs. Du fait qu'il concerne des intervenants qui relèvent de plusieurs départements (Santé, Agriculture, Recherche, Commerce, Industrie...), le développement de ce secteur ne peut, par conséquent, être assuré qu'à travers une approche multidépartementale et pluridisciplinaire impliquant les différents intervenants et ce en vue d'assurer la complémentarité requise et la synergie escomptée.

Le choix des plantes médicinales prioritaires doit s'effectuer en fonction de leur utilisation effective et/ou potentielle et de leurs intérêts économiques tant au niveau national qu'international, d'où la nécessité d'établir des listes spécifiques pour chaque zone agro-écologique.

La promotion de ce secteur requiert, par ailleurs, la prise en compte des deux dispositions suivantes :

- Instaurer un environnement économique et législatif permettant de favoriser les dynamiques de production et de transformation et d'encourager les initiatives des acteurs de développement qu'elles soient individuelles ou collectives.
- Développer une recherche appliquée et innovatrice qui doit être en mesure de mieux faire connaître notre potentiel naturel, de le préserver et d'offrir des solutions techniques à l'ensemble des questions qui se posent à tous les niveaux de la filière, depuis la production jusqu'à la transformation.

L'analyse des données relatives aux importations et exportations des PAM et dérivés, d'une part et du marché national et international en produits pharmaceutiques, cosmétiques, de parfumerie et de produit « Bio » à base de « PAM » d'autre part, met en exergue l'existence d'un marché immense pour ces produits.

Compte tenu des particularités de ses conditions écologiques et de la richesse de ses ressources phytogénétiques, la Tunisie peut, à travers la promotion des cultures des plantes aromatiques et médicinales, faire augmenter ses exportations dans des proportions considérables.

Le développement des exportations en PAM requiert cependant la prise en considération des aspects suivants :

- <u>En ce qui concerne les espèces cibles</u> :

Un inventaire exhaustif des plantes présentant un intérêt aromatique et médicinal constitue un préalable à toute activité visant la valorisation de celles-ci. Des données sur les potentialités productives de ces espèces ainsi que sur les conditions optimales garantissant une production de bonne qualité doivent être disponibles.

La domestication des plantes spontanées et leur mise en culture sont à considérer surtout pour celles qui sont très recherchées et qui se sont, par conséquent, raréfiées au niveau des formations végétales naturelles.

- En ce qui concerne les aspects juridiques et réglementaires :

L'instauration d'un environnement législatif permettant de favoriser les dynamiques de production et de transformation et d'encourager les initiatives des acteurs de développement qu'elles soient individuelles ou collectives s'avère d'une grande utilité pour le développement de ce secteur.

- En ce qui concerne le marché :

Le suivi de l'évolution de la consommation tant quantitative que qualitative et la connaissance des conditions d'accès aux marchés et des circuits appropriés de commercialisation et les techniques de commercialisation doivent être renforcés.

La réglementation et les exigences des importateurs devraient être préalablement connues par les fournisseurs et les exportateurs qui doivent être bien informés des normes, exigées par les marchés internationaux. Les capacités des organismes de promotion des exportations et des associations d'affaires doivent être renforcées afin d'augmenter leur efficacité.

Par ailleurs et afin d'assurer un marketing rapide et efficace le développement de techniques alternatives de vente (commerce électronique) s'avère indispensable.

Figure 1a. Conservation in situ d'espèces prometteuses de PAM

Figure 1a. Conservation in situ d'espèces prometteuses

Figure 2. Création d'une banque de gène d'espèces prometteuses

Figure 3. Mise en place d'un comité national de pilotage qui assure le suivi permanent des activités du projet

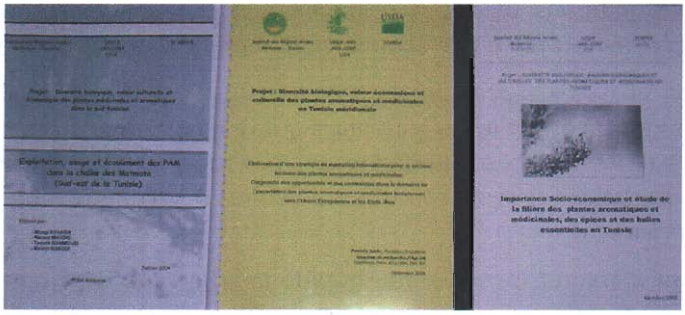

Figure 4. Elaboration de fiches techniques et d'études socio-économiques et techniques

Research on Improving Productivity of Oats as Priority Forage Species (FG-TN-106 (INRA/USDA-ARS)

M. Chakroun

INRAT, Rue Hédi Karray, 2049 Tunis - Tunisia

1. Introduction

Oats, (*Avena sativa* L., *Avena bysantina* Koch) in pure stands, or associated with vetches are the major grown forages and the main component of crop rotation in Tunisian farming systems. They are mainly grown as a source of harvested fodder (silage or hay) for livestock, over a wide range of climatic and edaphic conditions ranging from the subhumid to the semi-arid regions of northern Tunisia. Increased production, resulting from using adapted varieties, will help to meet the ever increasing demand for forages and, therefore, to improve livestock products self-sufficiency. Better varieties associated with improved management practices will also provide a high return to farmers. Technology transfer packages on seed production will help the growth of a sustainable seed production system.

2. Objectives

- Evaluate and select oat varieties that are superior to presently prevailing ones for forage yield, tolerance to foliar diseases and with dual purpose capacity for use as green forage or hay.
- Develop improved associated with management practices and technology transfer packages for seed multiplication and large-scale production.

3. Expected output

- Oats are the major grown forage crop in Tunisia. They are also used extensively for grazing in the southern US. These forage crops play a key role in the productivity and sustainability of agricultural systems in both countries. Therefore, the transfer of improved technology packages to farmers would increase the sustainability of crop/livestock production and thus improve the rotational system and contributing to the preservation of the environment.
- This joint research project would strengthen the ties among investigators involved with this species and consequently, between their respective institutions. This project is complimentary to ongoing research in both countries.
- At the completion of the project, the best lines selected for this species would form the basis for large scale testing and seed increase and would help the sustainability of forage production.

Research Team

Principal Investigators

Name	Area of specialization	Institution
Mohamed Chakroun	Plant Breeding	Animal & Forage Production Lab. INRAT, Tunisia
Deon D. Stuthman	Plant Breeding	Dep. of Agronomy and Plant Genetics, Univ. of Minnesota, MN, USA

Collaborators

Name	Area of specialization	Institution
Mohamed B. Allagui	Pathology	INRAT, Tunisia
Salah Ben Youssef	Agronomy	INRAT, Tunisia
Joann F.S. Lamb	Plant Genetics	Plant Sci. Res. Unit, USDA-ARS MWA, MN, USA
Mohammed El Mourid	Regional Coordinator	ICARDA, Tunis

Starting date – ending date: October 2002 – December 2005

4. Methodologies – Research highlights

During the 2003-2004 growing season, five evaluation trials of oat genotypes, one seed density and one foliar fungicide application on crown rust (Puccinia coronata f.sp. Avenae) of oat experiments were conducted in northern Tunisia on research stations and experimental fields using the appropriate experimental design and the number of replicates. In all trials, seeding rate of each genotype was adjusted based on laboratory germination and seed weight, planting were made in November 2003within the optimum planting-date window for the oat growing area, standard agronomic practices, in well prepared fields and with appropriate fertilization were adopted. Plots were hand-harvested except at Lafareg which were combine-harvested. Appropriate statistical analyses were performed for each character at each experiment. General view of the field trials at selected sites are given in figures 1, 2, 3 and 4.

Figure 1. General view of the field experiment at Lafareg station (cropping season 2003-2004)

Figure 2. General view of the field experiment at Bou Rabia station (cropping season 2003-2004)

Figure 3. General view of the field experiment at Bargou experimental field (cropping season 2003-2004)

Figure 4. General view of the experiment related to the effect of seeding rate on forage and grain yield of fodder oat established at Lafareg

The amount of rainfall at the experimental sites is presented in Table 1. Most of the season was ideal for oat growth and development. Rains were frequent throughout the winter and spring months. The major constraints encountered were heavy rains during December and weeds infestations which did not favor good stands at Bargou and Ftetissa stations. Adequate moisture received during mid to late season favored later maturing genotypes at the subhumid sites (Fretissa and Lafareg). Rains received in June delayed grain harvest.

Table 1. Monthly rainfall (mm) during 2003/04 growing season at the experimental sites: Fretissa, Lafareg, Bou Rabia and Bargou.

	Location			
	Fretissa	Lafareg	Bou Rabia	Bargou
September 2003	91.6	64	136.6	60
October	34	65	59.8	92
November	23.6	34	49	11.5
December	247.5	185	140.9	200.5

January 2004	108.5	97	49.8	38
February	11.4	14	25.4	48.5
March	64	57.5	80.2	94
April	74	65	45.9	51
May	22.8	8	20.6	24
June	54.5	73	112	35.5
July	0	0	0	0
August	0	13	30.4	18
Total	731.9	675.5	750.6	673

4.1. Agronomic and morphological study of local oat genotypes

The trial included nine local genotypes collected from farmers over different regions of northern Tunisia: Bezina, Bni-brahim, Maachar, Blelma, Skhira and Borj-dhab from Bizerte; Nefza from Beja; Fernana, from Jendouba, and Sidi-khiar from le Kef, the commercial variety Fretissa and two experimental lines (Av01-9 and Saia). These genotypes were evaluated for a second consecutive cropping season for their agronomic characters at two experimental stations: Lafareg station, near Beja and "Fretissa" farm, near Mateur. The experimental design was a randomized complete block with three replications. Plot size, seeding rates and management practices were similar to those reported last year. Forage was assessed by harvesting one time during heading stage. Grain harvest was carried out when all the genotypes reached maturity.

Analysis of variance was performed on yields, plant height and reaction to diseases. The response means were compared using Duncan's test at 5% level of significance.

4.1.1. Days to heading and plant height

Genotypic differences in days to full heading were significant. Local genotypes are mostly late maturing. Genotypes were grouped in three classes; an early heading group represented by Fretissa and Av01-9, intermediate heading represented by Bni-brahim, Fernana, Nefza, Saia and Sidi-khiar while late maturing is represented by the local genotypes Blelma, Bezina, Borj-dheb, Maacher and Skhira (table 2).

Concerning plant height, local genotypes were taller than genotypes Fretissa and Av. 9 which make them more suitable for high fodder yield.

Table 2. Earliness of the 12 genotypes.

Genotype	Earliness*
Bezina	181
Bni-brahim	174
Fernana	174
Maachar	181
Blelma	188

Skhira	188
Nefza	174
Av01-9	167
Fretissa	167
Borj-dhab	188
Saia	174
Sidi-khiar	174

At both sites, highest dry matter (DM) yields were recorded for Bezina and Borj-dhab, while the lower DM yields were obtained with Av01-9. Genotype Fretissa had the lowest grain yields mainly at Lafareg. This genotype is an early maturity type and was severely attacked by birds.

4.1.2. Dry matter yield (DMY)

The combined analysis of variance did not show significant differences of yield between the 2 sites. However, the DM yields produced at Lafareg were slightly higher than those registered at Fretissa. Additionally, the interactions of genotypes by sites were not significant indicating that ranking of genotypes on DM yield basis was almost similar in the 2 sites. However, forage yield varied among genotypes (table 3). Genotype Sidi Khiar was the most productive with 10.8 T DMY / ha while Bni Brahim was the less productive (6.82 T DMY/ha).

Table 3. Forage yield and plant height of oat varieties studied at Lafareg, Fretissa

Genotype	Lafareg			Fretissa		
	DMY ($t\ ha^{-1}$)		Plant height (cm)	DMY ($t\ ha^{-1}$)		Plant height (cm)
Bezina	13.251	(1)*	142	13.255	(2)*	138
Bni-brahim	10.628	(7)	133	11.864	(4)	144
Fernana	10.553	(8)	131	11.512	(5)	141
Maachar	10.143	(10)	124	12.307	(3)	148
Blelma	11.934	(6)	147	10.024	(8)	128
Skhira	12.927	(3)	135	11.076	(6)	133
Nefza	10.159	(9)	128	7.648	(10)	140
Av01-9	9.226	(12)	139	6.734	(12)	137
Fretissa	9.972	(11)	138	10.706	(7)	129
Borj-dhab	13.077	(2)	146	13.630	(1)	144
Saia	11.982	(5)	153	9.859	(9)	140
Bni-khiar	12.397	(4)	151	7.464	(11)	133
Means	11.354		139	10.507		138
CV (%)	20.36		3.92	17.16		10.25

*Rank

4.1.3. Grain yield Reaction to major diseases

Analysis of variance showed significant differences among genotypes for both 1000 seeds weight and the number of spikes m^{-2}. Grain yield varied greatly among genotypes. Grains from Fretissa and Av. 9 could hardly be recovered because of bird attack (table 4).

Table 4. Grain yield and straw yield of oat genotypes at Lafareg and Fretissa.

Genotype	Lafareg				Fretissa			
	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
Bezina	0.753	(8)*	9.577	(8)*	1.529	(6)*	9.815	(8)*
Bni-brahim	0.630	(9)	9.243	(11)	1.306	(7)	10.833	(6)
Fernana	0.478	(11)	10.375	(5)	1.637	(5)	9.259	(10)
Maachar	0.771	(7)	10.590	(3)	1.766	(4)	9.491	(9)
Blelma	0.968	(2)	10.347	(6)	1.292	(8)	6.250	(12)
Skhira	0.950	(3)	10.486	(4)	1.216	(10)	11.296	(5)
Nefza	0.922	(4)	10.257	(7)	1.895	(3)	11.667	(4)
Av01-9	1.503	(1)	10.889	(2)	2.805	(1)	15.741	(3)
Fretissa	0.404	(12)	9.396	(9)	1.280	(9)	19.769	(2)
Borj-dhab	0.506	(10)	6.833	(12)	1.173	(11)	8.704	(11)
Saia	0.807	(6)	13.111	(1)	0.792	(12)	21.389	(1)
Bni-khiar	0.908	(5)	9.257	(10)	2.193	(2)	10.741	(7)
Means	0.82		10.218		1.596		11.813	
CV (%)	18.89		17.76		36.18		24.90	

*Rank

There was little variation among genotypes in reaction to diseases (Table 5). Among the local genotypes, genotypes Nefza, Fernana and Sidi-khiar were moderately tolerant.

Genotypes Saia and the selected line Av. 9 proved to be resistant. Genotypes Fretissa and Av. 9 scored lower mean than the local genotypes and Saia (*A. strigosa*) which suggest that *A. sativa* varieties are more resistant to lodging than *A. bysantina.*

There was less variation among genotypes in reaction to diseases. Promising local genotypes are much better adapted than the selected ones and in consequence they could be introduced in a crossing nursery.

Table 5. Reaction to CR, PM and BYDV of the tested genotypes at Lafareg and Fretissa stations.

Genotype	Lafareg			Fretissa		
	Crown rust (CR)	Powdery Mildew (PM)	BYDV	Crown rust	Powdery Mildew	BYDV
Bezina	5	5	3	6	5	4
Bni-brahim	6	5	2	4	4	3
Fernana	4	3	3	5	5	3
Maachar	4	3	3	4	6	3
Blelma	7	5	2	4	4	2
Skhira	5	3	3	6	4	2
Nefza	4	5	2	6	4	3

Av01-9	3	1	2	2	5	1
Fretissa	2	1	2	3	3	1
Borj-dhab	5	5	2	4	5	4
Saia	1	1	3	2	5	1
Sidi-khiar	5	5	2	4	4	3
Means	4.25	3.5	2.55	4.38	4.55	2.61
CV %	28.81	0	31.71	40.96	21.50	33.77

4.2. Evaluation of the 2003 Quaker International Oat Nursery (QION) pure lines

Small amounts of seeds (6 g) of 95 pure nearly homogeneous lines of oat, obtained from Dr. R. D. Barnett, University of Florida, Quaker Oat International Nursery and the two Tunisian varieties (Fretissa and Mejerda) used as local checks (systematically after every 10 lines) were evaluated.

Seeds from each pure-line and checks were planted as un-replicated plots of 2 m rows with 0.3 m apart at two experimental stations: Bou Rabia station (near Tunis) and Lafareg (near Beja), during 2003-04 cropping season in an observation nursery. Standard agronomic practices were adopted. Visual rating (1-9) where 1 is excellent and 9 is poor have been used to evaluate vigor and disease tolerance. Observations on phenological stages, straw diameter, grain yield and 1000 seeds weight were recorded.

Based on their average grain yield; scored forage yields, and tolerance to the major foliar diseases, 20 lines were selected. These were: Q03-18, Q03-31, Q03-45, Q03-46, Q03-49, Q03-60, Q03-62, Q03-63, Q03-69, Q03-74, Q03-78, Q03-79, Q03-82, Q03-83, Q03-84, Q03-85, Q03-86, Q03-89, Q03-90, Q03-100 (Table 6).

The above identified lines will be advanced to preliminary yield trials at two sites, to estimate their forage and seed yielding ability and tolerance to the major foliar diseases, particularly crown rust.

Table 6: Major characteristics of the selected 20 lines at Lafareg.

Entry No.	Source	Earliness	Growth habit	Grain yield (g per 0.6 m^2)
L18	MN02124	Intermediate	Erect	218,7
L31	MN02215	Late	Erect	225,9
L45	MN02218	Late	Erect	200,5
L46	MN02220	Late	Erect	221,7
L49	MN02226	Late	Erect	137,7
L60	MN02235	Late	Erect	171,1
L62	TX01Ab7093	Late	Prostrate	159,6
L63	TX01Ab7096	Late	Prostrate	120,5

L69	WIX6865-5	Intermediate	Erect	193,3
L74	MN94238	Intermediate	Erect	274,4
L78	MN98133	Intermediate	Erect	161
L79	MN00206	Intermediate	Erect	122
L82	ND970651	Late	Erect	153.7
L83	ND981502	Late	Erect	237.9
L84	ND981674	Intermediate	Erect	195.3
L85	ND980351	Late	Erect	126,4
L86	ND981275	Intermediate	Erect	231,5
L89	AC Assiniboia	Intermediate	Erect	157.6
L90	IL96-10351	Intermediate	Erect	186,6
L100	Drummond	Late	Erect	67,9

4.3. Evaluation of selected pure lines from the 2002 QION

Twenty-five oat lines from 2002 Quaker International Oat Nursery (QION-2002) were screened for resistance to crown rust in greenhouse conditions, after artificial inoculation with three Tunisia prevalent populations of crown rust. Twelve lines showed reactions ranging from immunity (no visible symptom) to moderately resistant (moderate pustules with chlorosis or necrosis). These were: Q02-11, Q02-15, Q02-18, Q02-20, Q02-28, Q02-29, Q02-35, Q02-37, Q02-42, Q02-44, Q02-48, Q02-55 (Table 7). These lines will be tested in 2004-2005 for resistance consistency.

Line reactions to the 3 isolates between 0-1 were considered resistant (R) and retained to a second evaluation next year (2005), the others were susceptible (S). The following nine lines Q02 were resistant to artificial inoculations: 11, 18, 20,28, 29,35,37, 42 and 44 (table 8). Notation scale ranged between 0 (healthy plant) to 4 (plant leaves covered by large pustules without chlorosis or necrosis).

These 25 pure lines were also evaluated at 2 INRAT experimental stations: Bou Rabia and Lafareg using a randomized complete-block design with three replications. Each plot consisted of 4 rows, 3 meter long. Observations were taken on the phenological stages; reaction to powdery mildew (PM), crown rust (CR), stem rust and BYDV which were noted during March and April. Measurements were also recorded on grain yield at Lafareg (table 9).

Table 7. Infection type and line reactions to artificial inoculation with 3 races of crown rust performed to oat seedling lines in pots under greenhouse culture.

Line code	CR_{Pc45}	CR_{Pc54}	CR_{Pc40}	Global line reaction
Q02-08	3	;	4	S
Q02-09	2	1	4	S
Q02-11	0	0	;	R
Q02-13	3	3	2	S
Q02-15	0	;	1-2	R
Q02-18	;	0;	0	R
Q02-20	;	;	;-1	R
Q02-24	4	3	4	S
Q02-28	0	0	;-1	R
Q02-29	;	0	;	R
Q02-30	4	2	2	S
Q02-34	3	3	4	S
Q02-35	0	;	;	R
Q02-37	0	0	;	R
Q02-42	;	;	;-1	R
Q02-44	;	0	1	R
Q02-48	;	3	;	S
Q02-55	;	0	2	S
Q02-70	2	3	4	S
Q02-71	2	4	4	S
Q02-73	4	4	4	S
Q02-85	3	3	4	S
Q02-87	2	4	4	S
Q02-93	4	2	2-3	S
Q02-96	2	2	3	S

Table 8. Infection type and line reactions to natural infection of CR, stem rust, PM and BYDV virus performed in open field at Lafareg station during 2004 growing season. Notation were done in late May at grain-filling stage.

Line code	Crown rust	Stem rust	Powdery mildew	BYDV	Global line reaction
Q02-08	3-4	0-4	+	++	S
Q02-09	0-1	0	+	+	MR
Q02-11	0	0	-	+	R
Q02-13	2	4	-	-	MS
Q02-15	0	0-4	-	+	R
Q02-18	0-1	0	-	+	R
Q02-20	0	4	-	+	R
Q02-24	4	0-4	-	-	TS
Q02-28	0	0	-	-/+	TR
Q02-29	0	0	-	-/+	TR
Q02-30	4	4	-	-	TS
Q02-34	4	4	-	-	TS
Q02-35	0	0-4	-	-/+	TR
Q02-37	0	0	+	-	R
Q02-42	;	0	+	-	TR
Q02-44	0	4	+	-/+	TR
Q02-48	0	0	-	-	TR
Q02-55	0	0	-	-	TR
Q02-70	3	0	-	+	S
Q02-71	3	4	-	-	S
Q02-73	3	4	-	-	S
Q02-85	4	0-4	-	-	TS
Q02-87	4	4	-	-/+	S
Q02-93	3-4	4	-	-	S
Q02-96	2-3	0-4	-	-	S

Table 9. Mean values of DMY, plant height, grain yield, and harvest index for the 25 genotypes studied at Lafareg.

Genotype	Source	DMY (t ha^{-1})	Plant height (cm)	Grain yield (t ha^{-1})	Harvest index (%)
8	ND960851	7.64	155.0	1.96	0.27
9	ND960620	8.79	151.0	2.33	0.29
11	ND960611	8.27	147.0	2.46	0.25
13	IL95-1241	11.15	141.0	3.27	0.38
15	MN98133	12.11	161.5	1.78	0.21
18	ND961161	6.67	126.5	2.13	0.24
20	ND970651	9.30	157.0	1.76	0.20
24	WIX7994-2	8.82	153.5	1.67	0.25
28	Il96-11037	12.16	158.5	2.07	0.24
29	Il96-11039	10.17	166.0	3.85	0.39
30	P971A9-7-4	11.86	151.0	2.78	0.29
34	MN98244	8.59	145.5	2.14	0.30
35	WIX8177-1	9.63	148.5	2.89	0.32
37	,A9535D118-4	8.32	132.5	1.82	0.28
42	,A978GIB-172	6.29	116.5	1.77	0.27
44	,A9818IBIB-I4	7.89	109.5	2.07	0.40
48	L9424-A12-B1	8.71	93.5	1.77	0.26
55	Drummond	8.59	102.5	2.92	0.29
70	ʍN01AR1036	10.02	152.0	1.94	0.20
71	ʍN01AR1039	11.67	155.5	1.94	0.20
73	ʍN01AR1047	11.79	148.5	2.94	0.27
85	ʍN01AR1092	11.74	156.0	2.24	0.23
87	ʍN01AR1096	8.83	159.5	2.35	0.20
93	ʍN01AR1252	7.23	160.0	2.05	0.26
96	ʍN01AR1286	12.63	162.0	1.84	0.18
Means		9.55	144.40	2.27	0.27
CV (%)		20.41	5.60	29.60	23.11

On the basis of agronomic score and CR tolerance under field and greenhouse conditions, twelve lines Q02-11, Q02-15, Q02-18, Q02-20, Q02-28, Q02-29, Q02-35, Q02-37, Q02-44, Q02-48, Q02-55, Q02-73 with superior forage and grain yields and good tolerance to CR were selected for further evaluation in intermediate yield trials.

4.4. Evaluation of selected pure lines from the 2001 QION

From the 100 QION lines grown in 2001, 25 lines were selected in 2002 for their agronomical performance, and were screened in 2003 for their resistance to crown

rust. Only 12 lines were chosen and evaluated during 2003/04 growing season. The experimental design was a randomized complete block with three replications. Plots consisted of 6 rows that were 0.30 m apart and 3.0 m in length. The trial was planted early November 2003. Forage was assessed by harvesting one time during full heading stage. Grain harvest was carried out when all the genotypes reached maturity. Analysis of variance was performed on yields, plant height and reaction to diseases. The response means were compared using Duncan's test at 5% level of significance.

Most of these lines were resistant to crown rust, but due to a heavy stem rust attack during the 2003-2004 season, some of these lines proved highly susceptible to this latter pathogen. According to our observations at Bou Rabia and Lafareg stations, only 5 lines were resistant to both crown and stem rusts, and have good tolerance to powdery mildew and BYDV. Among these 5 lines, only 3 were also good performers for DM and grain yields.

These were: Q01-26, Q01-25, and Q01-33. Q01-26, mainly has a high potential to become a candidate for registration in the Catalog. They have as a source ND 9508252, ND 950981 and TAMO 397, respectively (table 10, 11).

Table 10. Mean values of DMY, plant height, grain yield and harvest index for the genotypes studied at Lafareg.

No. entry	Genotype	DMY (t ha^{-1})	Plant height (cm)	Grain yield (t ha^{-1})	Harvest index (%)
25	ND 9508252	7.67	133.67	1.97	0.16
26	ND 950981	**11.91**	141.33	**3.29**	0.23
33	TAMO 397	9.12	118.33	1.50	0.15
34	LA 604	7.46	109.00	2.09	0.20
35	Horizon 314	6.85	112.00	3.21	0.28
39	FLX512-1-B3-W1	8.34	79.33	3.11	0.32
43	LA9326E10-4-2-I1	9.06	101.67	2.3	0.19
44	TX93Ab715-G2	8.03	118.33	1.51	0.16
46	TX98Ab2680	6.33	109.33	1.13	0.13
52	TX96M1384	7.15	123.33	1.66	0.15
85	00MNAR1156	6.46	128.00	2.41	0.22
95	QR1730	10.34	135.67	2.26	0.17
Fretissa	Fretissa	7.20	125.33	0.90	0.10
Av01-9	Av01-9	7.39	136.33	1.81	0.14
Means		8.09	119.40	2.08	0.18
CV (%)		17.84	5.75	16.36	17.87

Table 11. Reaction to CR, PM and BYDV of the tested genotypes at Lafareg.

Genotype	Crown rust	Powdery Mildew	BYDV

25	1	5	2
26	1	2	1
33	1	6	2
34	1	2	2
35	1	2	2
39	1	4	2
43	1	5	2
44	6	4	1
46	1	3	2
52	4	4	2
85	2	5	2
95	2	4	1
Fretissa	1	3	2
Av01-9	2	4	1
Means	1.76	3.86	1.71
CV (%)	58.89	37.85	58.44

Resistance to CR in oat genotypes is not stable and new fungi races frequently develop. Therefore, selecting new oat genotypes with tolerance or resistance to CR allows for more profitable oat production.

4.5. Performance of selected advanced lines for forage production

Twelve oat genotypes: four commercial varieties (Fretissa and Mejerda from Tunisia; Amlal et Tissir from Morroco), four introduced varieties from Spain (Prevision, Coker, Saia and Cobina) and four advanced lines (Av01-1, Av01-2, Av01-3 and Av01-9), were evaluated for agronomic characters at four sites: Lafareg, near Beja; Fretissa, near Mateur; Bargou, near Siliana; and Bou Rabia, near Tunis. The experimental design was a randomized complete-block with three replications. Plot size, cultural practices, observations, measurements and data analyses were similar to the agronomical study of local and introduced oat genotypes (7-1 section).

The combined analysis of variance showed significant differences of DM and grain yields and plant height between the 3 sites. Generally, the DMY produced at Lafareg were higher than those registered at Fretissa and Bargou. Additionally, the interactions of genotypes by sites were significant indicating that ranking of genotypes on DM yield basis was not similar in the 3 sites.

Forage yield varied significantly among genotypes (table 12). The 2003-2004 cropping season was favorable for both hay and grain oat production. Whenever good stands were achieved and harvest was on time, oat yield were very good. Late planting due to wet soils reduced yield at Bargou and Fretissa sites. The performance of the genotypes at Fretissa and Lafareg and Bargou sites are presented in tables 12, 13.

Table 12. Forage yield and plant height of oat varieties studied at Lafareg, Fretissa, and Bargou.

Genotype	Lafareg		Fretissa		Bargou	
	DMY (t ha^{-1})	Plant height (cm)	DMY (t ha^{-1})	Plant height (cm)	DMY (t ha^{-1})	Plant height (cm)
Prévision	9.952	131	8.816	121	3.52	86
Coker	8.957	97	4.129	111	2.201	74
Saia	12.414	164	10.854	130	4.106	115
Mejerda	15.095	160	7.466	132	3.331	93
Fretissa	11.790	148	5.296	121	2.498	71
Amlel	11.532	149	6.105	121	3.999	99
Tissir	13.924	132	13.881	133	3.596	87
Av-9	13.105	153	7.952	125	3.463	86
Cobina	12.080	160	8.514	126	5.08	102
Av.01-1	13.180	125	8.556	127	2.646	76
Av.01-2	11.418	153	9.227	122	2.309	71
Av.01-3	11.737	153	7.745	124	1.399	83
Means	12.099	144	8.212	124.444	3.178	87.222
CV (%)	12.16	4.99	23.09	8.49	27.939	8.926

Variation between genotypes were noted for the heading date. Fretissa and Av-9 were earlier than the introduced genotypes.

Table 13. Earliness of the 12 genotypes

Genotype	Earliness Nbr of days
Prevision	196
Coker	203
Saia	189
Mejerda	203
Fretissa	182
Amlel	175
Tissir	203
Av-9	175
Cobina	189
Av.01-1	196
Av.01-2	182
Av.01-3	182

*Number of days from sowing to anthesis

At both sites, reaction to crown rust (CR), powdery mildew and BYDV were more important at Fretissa station than at Lafareg, although weather conditions were almost similar. The most tolerant genotypes were Saia, Fretissa, Amlel. Tissir and Av.01-2. Severe symptoms were noted on Prevision, Coker and Cobina, the three Spanish varieties (table 14).

Table 14. Reaction to CR, PM and BYDV of the tested genotypes at Lafareg and Fretissa stations.

Genotype	Lafareg			Fretissa		
	Crown rust	Powdery mildew	BYDV	Crown rust	Powdery mildew	BYDV
Prevision	6	5	3	6	4	2
Coker	8	1	1	6	6	2
Saia	1	7	1	2	4	2
Mejerda	2	3	1	4	4	1
Fretissa	1	3	1	2	4	2
Amlel	1	3	1	1	2	2
Tissir	1	7	1	2	3	2
Av-9	2	5	1	3	4	1
Cobina	6	3	3	4	4	2
Av.01-1	4	3	1	4	6	2
Av.01-2	1	1	1	2	4	2

Av.01-3	2	7	1	3	5	2
Means	3	4	1.33	3.27	4.28	1.83
CV %	30.15	0	0	36.28	31.43	56.97

Grain yield varied significantly between genotypes (table 15). Over all sites, Amlal gave the highest grain yield while Coker the lowest. Variety selection is an important decision when changing from the subhumid to the semi-arid regions.

Table 15. Grain yield, Straw yield and harvest index of oat varieties studied at Lafareg, Fretissa. and Bargou stations.

Genotype	Lafareg					Fretissa					Bargou				
	Grain yield (t ha^{-1})		Straw Yield (t ha^{-1})		HI (%)	Grain yield (t ha^{-1})		Straw Yield (t ha^{-1})		HI (%)	Grain yield (t ha^{-1})		Straw Yield (t ha^{-1})		HI (%)
Prévision	2.476	(7)*	8.975	(9)*	0.22	0.717	(11)	4.213	(12)*	0.15	0.289	(3)	1.602	(9)*	0.15
Coker	1.06	(12)	7.199	(12)	1.33	0.899	(9)	6.805	(10)	0.10	0.206	(8)	2.176	(5)	0.10
Saia	1.182	(11)	13.492	(1)	0.08	0.879	(10)	20.185	(1)	0.04	0.209	(7)	2.621	(3)	0.07
Mejerda	1.921	(9)	10.260	(4)	0.16	0.672	(12)	9.167	(8)	0.07	0.257	(5)	1.704	(6)	0.12
Fretissa	1.870	(10)	9.664	(8)	0.16	1.921	(5)	12.963	(6)	0.13	0.172	(9)	1.657	(8)	0.09
Amlel	3.111	(2)	9.889	(5)	0.24	3.662	(1)	15.556	(4)	0.19	0.572	(1)	1.685	(7)	0.25
Tissir	2.822	(4)	9.781	(7)	0.22	1.576	(6)	17.824	(2)	0.08	0.237	(6)	3.769	(1)	0.06
Av-9	2.621	(6)	10.524	(3)	0.20	2.470	(3)	14.722	(5)	0.14	0.454	(2)	2.241	(4)	0.16
Cobina	2.264	(8)	11.020	(2)	0.17	1.256	(7)	8.056	(9)	0.14	0.27	(4)	3.241	(2)	0.08
Av.01-1	2.708	(5)	8.834	(10)	0.23	0.937	(8)	5.185	(11)	0.15	0.162	(10)	1.574	(10)	0.08
Av.01-2	3.285	(1)	9.868	(6)	0.25	2.449	(4)	12.454	(7)	0.16	0.159	(11)	1.213	(12)	0.12
Av.01-3	3.006	(3)	7.973	(11)	0.28	2.931	(2)	15.648	(3)	0.16	0.083	(12)	1.241	(11)	0.06
Means	**2.36**		**9.790**		**0.20**	**1.697**		**11.898**		**0.13**	**0.255**		**2.060**		**0.11**
CV (%)	21.42		14.80		24.24	25.28		22.12		24.77	53.12		31.22		46.41

* Rank

1.1. Effect of seeding rate on forage and grain yield of fodder oat (cv Meliane) under favorable environments in Tunisia

Abstract

The effect of eight seeding rates (from 100 to 450 seeds m-2 with an increment of 50) on subsequent forage and grain production of Meliane fodder oat cultivar was studied over two sites and two consecutive cropping seasons. Results showed that grain yield, forage yield and plant height did not significantly varied with seeding rate but depended significantly on year and site by year interaction. Individual plant phytomass, stem diameter and major grain yield components were significantly affected by seeding rate, and grain yield seems to be compensated through variation of grain yield components. Over all sites and years, Meliane averaged 0.2234 and 1.4445 kg DM m-2 for grain and forage yield, respectively. Principal component analysis revealed that with lower seeding rates (until 250 seeds m-2, plants with high stem diameter and high individual phytomass were obtained; while greater seeding favored forage yield and we obtain smaller plants with lower stem diameter.

Introduction

Fodder oat constitutes the main widely cultivated forage crop in sub-humid and semi-arid regions of Tunisia under rainfed conditions. It covers over 170000 hectares and accounts for about 60% of yearly winter forage cultivated areas (Anonymous, 2000). Generally, farmers are advised to sow forage oat at a rate of 300 viable seeds m-2 for either forage and grain production purpose (Chakroun and Gouhis, 1998). Nevertheless, more needs to be known about the effects of seeding rate on grain yield of the new released cultivars. Therefore, a two-site trial was carried out for 2 years on Meliane cultivar where the effect of several seeding rates on fodder yield, grain yield, yield components were examined.

Material and methods

The Meliane cultivar was used in this study. It is a new oat cultivar (cv) released in 1998, and is a high yielding erect oat cultivar and moderately resistant to crown rust. Trials were carried over two cropping years 2002-03 and 2003-04, at 2 different sites each year. The first year, the trial was established in Lafareg experimental station of INRAT (in North West region of Tunisia) and in Oued Souhil experimental station of INGREF in Cap Bon region. Each site belongs to sub humid bioclimatic stage. Soil types were vertisol and sandy clay soils in Lafareg and Oued Souhil, respectively. The Oued Souhil station is provided with an irrigation network with treated wasted water of ONAS enabling a complementary irrigation when needed. In the second cropping year, trial was carried out under rainfed conditions, in Lafareg site and in Fretissa, which is an OEP (Office de l'Elevage et des Pâturages) pilot farm belonging to sub-humid climatic stage with 600 mm of long term annual precipitation mean. Table 1 describes the main characteristics of the sites used.

Table 1. Experimental sites characteristics.

	Lafareg	Oued souhil	Lafareg	Fretissa
	2002-03	2002-03	2002-04	2003-04
Soil type	Vertosoil	sandy clay	Vertosoil	Vertosoil
Climatic stage		Sub-humid		
Sowing date	12/11/2002	26/11/2002	4/11/2003	19/11/2003
Previous crop	chickpea	fallow	Vicia	Sulla
Seedbed preparation		Conventional		
Long term precipitation (mm)	650	550	650	600

In each site, a randomized complete block design with three replicates was employed. Eight seeding rates, 100, 150, 200, 250, 300, 350, 400 and 450 viable seeds m-2 were used. Plots consisted of 6 rows, 2 m long and 25 cm apart. Plots was fertilized with 50 kg P ha-1 prior to sowing and 120 kg N ha-1 partitioned in 40 kg N ha-1 at emergence, 40 kg N ha-1 at tillering stage and 40 kg N ha-1 at the booting stage. Weeds were controlled with 1.5 l ha-1 of Basagran M (bentazone at 480 g ai l-1 + MCPA at 125 g ai l-1) at 4 leaves stage while weeds are at 3 leaves stage. During 2002-03 cropping year in Lafareg , manual harrowing was necessary in march to control the remaining weed species (such as Ridolfia segetum Morris and Bromus rigidus Roth). In each site, crown rust was controlled by one application of a triazole fungicide at its recommended rate.

Observations were taken on the phenological stages according to Zadoks et al. (1974) scale.

The following morph physiological traits were also recorded:

- Emerged Seedlings m^{-2}
- Forage yield (kg ha^{-1}); calculated on 2 rows basis at anthesis. Fresh weight was recorded and a sub-sample of 500 g was dried to determine dry-matter content.
- Individual phytomass (g $plant^{-1}$). the mass of an individual plant.
- Plant height (cm) measured on ten random plants from each plot, as the distance from the soil surface to the top of panicle
- Grain yield calculated on one row basis
- Number of panicle m^{-2}, grain yield per plant, number of grains per panicle and 1000 grains weight.

Data were analyzed by GLM procedure of SAS software (SAS, 1990), where site and year are considered as random. Because, sites were different each year, we tested the significance of nested effects: site within year noted site (year); replication within the

interaction year by site noted Block (Year x S)m and the site by seeding rate interaction within year noted Site x D (Year) .

Results and discussion

For all sites used (Lafareg, Oued Souhil or Fretissa), total annual precipitation was above thirty year mean precipitation in both years. In Oued Souhil, irrigation was unnecessary because of regular distribution of the precipitations during the whole growing season. The 2002-03 season was favorable between tillering to pre-anthesis period due to the above mean precipitation from November to February. Also, high spring precipitation occurred in March to April which was favorable to the post anthesis development and grain formation period (table 1). In Oued Souhil site, strong North West wind occurred in winter and caused significant wind damage which consisted in significant mechanic lodging area.

Table 1. Monthly precipitation occurred in Lafareg and Oued Souhil respectively during 2002-2003 cropping season.

month	Lafareg	Oued Souhil	Lafareg	Fretissa
	2002-03	2002-03	2003-04	2003-04
September	23,9	38,2	64	91.6
October	24,4	14,4	65	34
November	48,7	100,7	34	23.6
December	40	54,7	185	247.5
January	115,7	102,5	97	108.5
February	59,9	50,4	14	11.4
March	23,9	35,3	57.5	64
April	86,3	50,3	65	74
May	16,3	9,3	8	22.8
June	17,5	4,3	73	54.5
July	0	0	0	0
August	0	9,3	13	0
Growing season precipitation	408,3	407,5	533.5	606.3
Annual precipitation	**456,6**	**469,4**	**675.5**	**731.9**

Also, a good precipitation occurred in the 2003-04 cropping year either in Lafareg or in Fretissa sites. A very high precipitation happened in December in Fretissa caused lodging and seedlings losses in some plots.

Emerged seedlings m^{-2}

Number of seeds emerged for each seeding rate and sites are given in table 2. Emergence rate was closely dependant on seeding rate, and we noted that a highly significant and positive coefficient of correlation was obtained between the two parameters ($r = 0,95$; $n=96$, $p<0,01$ for all sites). Good seedbed preparations and significant rain occurrence just after sowing may constitute well conditions for a good emergence and cover establishment.

Table 2. Emerged seedlings number m-2 at each site.

Treatments viable seeds m^{-2}	Seedlings emerged $m^{-2} \pm$ SD			
	Lafareg	Lafareg	Oued. Souhil	Fretissa
	2002-03	2003-04	2002-03	2003-04
150	137,3 ± 13	169 ± 17	168,0 ± 34	152.3 ± 20
200	236,0 ± 90	202 ± 10	193,3 ± 6	192 ± 3.4
250	229,3 ± 29	275 ± 31	284,0 ± 54	246 ± 9
300	274,7 ± 32	312 ± 11	301,3 ± 48	304.3 ± 9.6
350	321,3 ± 20	379.3 ± 9	369,3 ± 28	350.3 ± 16
400	393,3 ± 10	454. ± 40	440,0 ± 38	406 ± 5
450	448,0 ± 32	481. ± 39	504,0 ± 80	437.6 ± 6

Forage production

The results of the combined analysis of variance for forage yield are shown in table 3. Differences between cropping years and sites were statistically significant. However, statistical analysis revealed no significant effect of seeding rate on forage yield.

Table 3. Source of variation significance of the combined analysis of variance for two cropping years, three sites (different sites each year), and eight seeding rates for forage yields. Years (Y), 2002-03 and 2003-04; Site (S), Lafareg and O.souhil, the fist year and Lafareg and Fretissa at the second year; seeding rates (D), from 100 to 450 viable seeds m-2. Effect within blanks refers to the nested variables tested because different sites are considered each year.

.	df	Forage yield	Phytom ass	Stem diameter	Grain yield	Plant height
Year	1	***	***	***	***	***
Site (year)	2	***	*	NS	***	NS
Block (Year x S)	8	*	*	NS	NS	NS
D	7	NS	***	***	NS	NS
Year x D	7	NS	*	NS	NS	NS
Site x D (Year)	14	NS	NS	NS	NS	NS
Total	95					
Error	56					
Coefficient of Variation (%)	-	17.25	23.79	15.56	22.99	7.44

*; **; ***: significant at 5%, 1% and 0,1% levels respectively

The forage yield obtained was significantly higher in 2002-03 than in the subsequent cropping year. The mean highest forage yields were recorded in Oued Souhil (1.973 kg DM m-2). The proximity of this site from the sea influence (higher winter mean temperature), and also the amendment of the soil with ONAS peat, a sub-product of wasted water treatment, which has been done in 2001-02 cropping year may explain the very high mean yields obtained. The lowest forage yield was obtained in Fretissa in 2003-04. Meliane cultivar yielded 1.1764 kg DM m-2 over the eight seeding rates (table 4). A severe non treated crown rust attack in late season caused this low yield performances comparatively to the other sites.

Table 4. Values (± s.e.) of forage yields for the eight seeding rates over three sites and two cropping years. Averages values are significantly different if fallowed by different letters.

Seeding rates	Lafareg	Oued Souhil	Lafareg	Fretissa	Average
	2002-03	2002-03	2003-04	2003-04	
100	1,48 ± 0.39	2,00 ± 0.14	1,03 ± 0.28	1,12 ± 0.17	1,411a
150	1,35 ± 0.11	1,95 ± 0.2	1,01 ± 0.31	1,07 ± 0.12	1,347a
200	1,62 ± 0.16	1,92 ± 0.09	1,09 ± 0.11	1,14 ± 0.23	1,447a
250	1,47 ± 0.17	1,92 ± 0.18	1,02 ± 0.28	1,32 ± 0.22	1,436a
300	1,67 ± 0.08	2,27 ± 0.12	1,10 ± 0.35	1,17 ± 0.24	1,554a
350	1,66 ± 0.07	2,00 ± 0.21	0,86 ± 0.17	1,14 ± 0.12	1,417a
400	1,64 ± 0.31	1,88 ± 0.07	1,13 ± 0.12	1,14 ± 0.17	1,455a
450	1,93 ± 0.07	1,82 ± 0.10	1,07 ± 0.13	1,28 ± 0.01	1,528a
average	1.0± 0.23a	1.97± 0.17c	1.04a±	1.17 ± 0.17b	

In another side, seeding rate had significantly influenced phytomass as expressed by individual plant dry matter weight (iP) and also mean stem diameter as expressed by the third node mean stem diameter. A strong relationship was found for both parameters with seeding rates (figures 1, 2). These relationships imply a morphological differentiation of plants with varying seeding rates, which can be proven through variation of stem diameter and individual plants size.

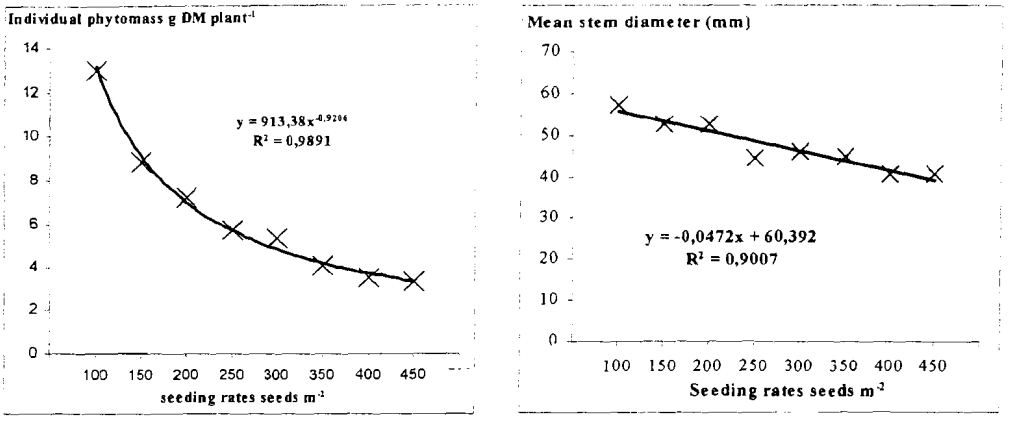

Figure 1. Relationship between seeding rates and both individual plant phytomass and mean stem diameter.

Grain yield and yield components

Grain yield depended significantly on the year and the sites within years factor, and was not statistically affected by seeding rate. The grain yield was significantly higher in 2002-03 (2400 kg ha-1) than in 2003-04 where it averaged 2000 kg ha-1 (Table 5). The highest grain yields were obtained in Lafareg in both years (2760 kg ha-1). The lowest yields were recorded in Fretissa in 2003-04 year. Oat yielded 1325 kg ha-1 because of a severe crown rust attack in late season. In Oued souhil, mean grain yield was equal to 2081 kg ha-1. It was negatively affected by mechanic lodging caused by winter strong winds occurred in late February which affected randomly the plots. However, the average mean yield of 2230 kg ha-1 still comparable to that mentioned by Chakroun et Gouhis (1998) for the cultivar Meliane.

Table 5. Values (± s.e.) of grain yields for the eight seeding rates over three sites and two cropping years. Means values followed by different letters are significantly different at 5% level.

Seeding rates	Lafareg	Oued Souhil	Lafareg	Fretissa	Mean
Seeds m-2	2002-03	2002-03	2003-04	2003-04	
100	2872 ± 110	2129 ± 600	1862 ± 788	3261 ± 481	2531 ± 79a
150	3000 ± 455	1526 ± 352	1729 ± 652	2537 ± 113	2198 ± 87a
200	2967 ± 536	1560 ± 801	1112 ± 266	2747 ± 502	2096 ± 96a

250	2848 ± 301	2745 ± 681	1201 ± 126	2745 ± 484	2385 ± 85a
300	2665 ± 513	2125 ± 308	1094 ± 562	2565 ± 147	2112 ± 74a
350	2738 ± 555	1854 ± 428	1175 ± 431	2751 ± 285	2130 ± 78a
400	2502 ± 590	2389 ± 816	1379 ± 146	2668 ± 258	2234 ± 33a
450	2605 ± 114	2318 ± 273	1047 ± 175	2779 ± 749	2187 ± 65a
Mean	2775 ± 450a	2081 ± 526b	1325 ± 546c	2756 ± 513a	

Grain yield components

Table 6 shows the results of the analysis of variance for grain yield per plant , and the three primary yield components.

Table 6. Source of variation significance of the combined analysis of variance for two cropping years, three sites (different sites each year), and eight seeding rates for grain yields and primary components

Source of variation	dl	Grain yield	Panicles m^{-2}	1000 kernels weight	Grain yield $plant^{-1}$	Spiklets $panicle^{-1}$	
						dl	significance
Year	1	***	NS	NS	***	1	NS
Site(year)	2	***	**	***	***	1	NS
Block(Year x S)	8	NS	NS	NS	NS	6	NS
D	7	NS	***	***	***	7	NS
Year x D	7	NS	NS	***	NS	7	NS
Site x D (Year)	14	NS	NS	NS	NS	7	NS
Total	95	-	-	-	-	70	-
Error	56	-	-	-	-	41	-
Coefficient of Variation (%)	-	22.99	24.26	9.52	34.34		22.19

*; **; ***: significant at 5%, 1% and 0,1% levels respectively; $\bar{}$: represent Block mean square

Grain yield per plant

Grain yield per plant was significantly affected by the year, site(year) and seeding rate factors. The average yield per plant was 1.09 g plant-1 in 2002-03 and 0.92 g plant-1 in 2003-04. Increasing seeding rate from 100 to 450 seeds m-2 caused a significant reduction of grain yield per plant by about 80% (from 2.34 to 0.46 g plant-1; figure 3).

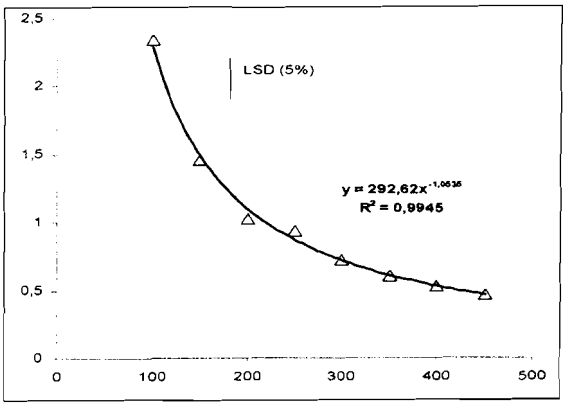

Figure 3. Variation of the grain yield per plant parameter with seeding rates. Values are averaged through two years and three sites.

Panicle m^{-2}

This component was strongly and logically dependant on the utilized seeding rate because it was high positively correlated to number of seedling emerged (data not shown). It also depended on the site (year) effect. In fact, in Fretissa, a huge rain occurred in December (over 240 mm; table 1) caused the elimination on some emerged seedling in the first block.

Number of spiklets per panicle

This component was not measured in Lafareg in the second cropping year. It was no significantly affected by any factor and remained stable and relatively high over the eight seeding rates, the three sites and two cropping years. This parameter averaged 55.3 spiklets panicle-1 over two years which confirm the high potential of Meliane cultivar for seed production.

1000 grains weight (TGW)

Only the first year thousand kernel weight was submitted to the analysis of variance. It was significantly dependant on the seeding rate and site factors (table 6). Mean TGW averaged 40 g and seemed to increase with seeding rate (figure 4).

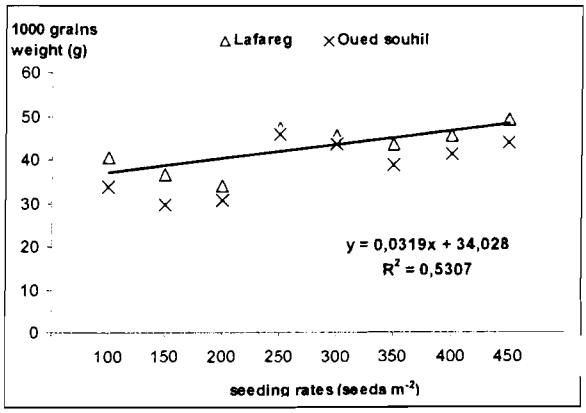

Figure 4. Variation of thousand grain weights with seeding rates

Correlation with yields

Table 8 shows the Pearson correlation coefficients between grain yield and grain yield components for the whole data, the two cropping years, three sites, and eight seeding rates.

Correlation analysis indicated a strong positive relationship between grain yield and both number of panicles m-2 and thousand grain weight (Table 8). Since the grain yield was not affected by seeding rate, there is a matter of evidence that a compensation amongst yield components occurred. In fact, a moderate negative correlation was obtained between number of spiklets panicle-1 and 1000 grains weight. Compensation had also occurred through a negative relationship between grain yield per plant and both panicle m-2 and spiklets per panicle (r= -0.2, n=96).

Table 8. Pearson correlation coefficient matrix of between

	Grain yield	Grain yield per plan	Panicle m^{-2}	Spiklets $panicle^{-1}$	TGW
Grain yield	1				
Grain yield per plant	0.58***, $n^{\surd}$=96	1			
Panicle m^{-2}	0.27***, n=96	-0.20*, n=96	1		
Spiklets per panicle	ns	-0.20*, n=96	ns	1	
1000 grains weight	0.41***, n=48	Ns	0.38***, n=48	-0.40*, n= 71	1

*; **; ***: significant at 5%, 1% and 0,1% levels respectively; $^{\surd}$: indicates the number of observations on which the coefficient of correlation was calculated.

In O. Souhil, no evident relationship was obtained between seeding rates and grain yields. best R2 obtained was equal to 0.08 for a quadratic regression.. However, in

Lafareg, although seeding rate did not significantly influenced grain yield, a quadratic regression with high R2 was established e between these two parameters. Maximum yields were obtained with the lower seeding rates (100 to 200 seeds m-2). Correlation matrix indicated that, grain yield variation was mainly related to kernel weight (r = 0,41, n = 48; p = 0,0039). Among grain yield components, only kernel weight was significantly affected by seeding rate. In fact, seeding rates was positively correlated to kernel weight (r = 0.51; n = 48; p = 0.0002). and the number of panicle m-2 (r = 0,46; n = 48; p = 0.0005) and negatively correlated to the number of grain panicule-1 (r = -0.65, n = 24; p = 0.0002).

Principal component analysis

The two years mean values of all variables were submitted to principal component analysis to determine effect of seeding rates on forage, grain yield and related variables.. The eigen values indicated that the two first components account for 85% of the standardized variance (67.8% and 18.0%, respectively). Study of the vector loading revealed that the first principal component had positive loading on individual phytomass, stem diameter grain yield, and negative loading on forage yield. The second principal component was highly and positively represented by grain yield t (table 4).

Table 9. Relative contribution of most measured variables to the grouping of seeding rates as quantified by principal component analysis. Loading of each variable and the first two principal component with explanatory percentages are presented.

Variable	First Principal component	Second Principal component
Grain yield	**0,411535**	**0,82009**
Stem diameter	**0,548369**	-0,288604
Phytomass	**0,585287**	0,056788
Forage yield	**-0,432862**	0,490852

Consequently, seeding rates located in the positive side of the axis 1 (right side) induced an increase in stem diameter, individual phytomass and grain yield This increases was permitted by the lowest seeding rates (until 250 seed m-2; figure 5). The greatest seeding rates (300 seeds m-2 and higher) which are located at the negative side (left side) of the first axis favored, however, forage yield.

Conclusion

In this two years trial, we found that contrarily to the rationale admitted by farmer, varying seeding rates from 100 to 450 seeds m-2 did not significantly alter both forage and grain yield of fodder oat. In General, farmer trends to increase unjustifiably seeding rates to much higher extend than it is needed. It is proven in

this trial, that it is not necessary to use high seeding rates for maximizing either grain or forage production. Reduction of plant density is compensated by kernel weight and grain number panicle-1.

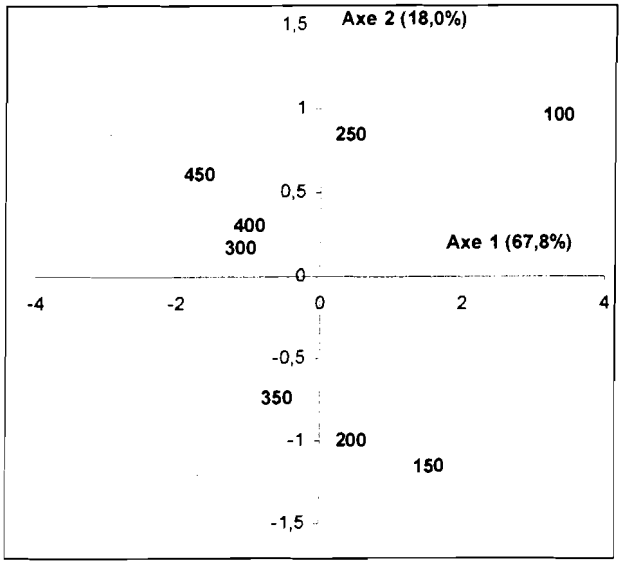

Figure 5. Principal component biplot for 8 seeding rates.

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1.2. Effect of foliar fungicides application on crown rust (Puccinia coronata C.) of oat

Rationale

Crown rust is the main oat disease in Tunisia. Some years, it causes losses of over 50% of forage and grain yield. In order to establish a technical package for both oat forage and oat seed production, a two sites trial was carried for two years on two oat varieties known for their high susceptibility to crown rust.. This report presents the results obtained in the first year.

Material and Methods

During the cropping seasons 2003-04, three foliar fungicides programs were applied on two susceptible cultivars which are Av95, an Avena sativa oat genotype known for its high susceptibility to crown rust (Mansour et al., 2001) and a local oat variety (Avena byzantina Koch) originated from Maacher (near Sejenane) region which proved to be highly susceptible to the disease (Chakroun et al. 2003). The fungicides programs applications are as follows.

A : Control, no chemicals applied

B : Mancozèbe (1500 g ai ha^{-1}) at late tillering (february 6th) + Epoxiconazole (125 g ai ha^{-1}) at heading (march 26th)

C : Two applications of Epoxiconazole (125 g ai ha^{-1}): the first at heading (in march 26th) and the second at one month later

D : One application of Mancozèbe (1500 g ai ha^{-1}) at late tillering (application in February 6th)

During the first year, the trial was installed in the INRAT Experimental station of Lafareg and it was designed as a split plot design with three replications. Fungicides programs were arranged as the main plots, and all possible combinations between 2 varieties and two clipping treatments in sub-plots. Clipping treatments consisted of two forage harvesting strategies which are:

- One harvest of forage at heading stage
- dual harvesting of forage, once at la tillering (growth stage 31 at Zadoks et al. (1974) scale) and then harvesting regrowth when it reaches heading stage (stage 59 at Zadoks scale).

Seedbed preparation was done according to a conventional scheme with deep plow tillage after the first significant autumn rain (> 10 mm) followed by two Offset disk tillage before sowing. Phosphate is applied at 45 Kg P2O5 ha^{-1} and were incorporated to soil with the offset tillage. The trial was hand sown on 1st November 2003. Nitrogen was applied at 30 kg ha^{-1} at emergence and 70 kg ha^{-1} at late tillering. Clipped plots received 30 supplementary kg N ha^{-1} just after the cut (forage removal). Observations were taken on forage yield, seed yield, and visual disease severity expressed as the percentage of attacked foliar surface by crown rust. Crown rust disease notations were based on the international oat descriptor of IPGRI. Data were analyzed by the mean of ANOVA procedure of SAS software and means were separated by the Duncan test at 5% level.

Preliminary results

Table 1 shows the analysis of variance for the measured variables for one year and one site.

Table 3. Source of variation significance of the analysis of variance for four fungicides application programs, (P), two clipping treatments, two genotypes (G) and three replications (Rep)

	df	Forage yield	Grain yield	1000 grains weight	Seeds density	Attacked surface % (1)	Attacked surface % (2)	Attacked surface % (3)	Attacked surface % (4)
P	3	*	***	Ns	***	*	**	***	***
P x Rep	8	*	ns	Ns	***	ns	ns	ns	*
Cl	1	***	***	**	ns	ns	ns	ns	ns
Cl x P	3	ns	ns	Ns	ns	ns	ns	ns	ns
G	1	***	***	*	***	*	***	***	***
G x P	3	ns	***	Ns	ns	ns	***	*	*
G x Cl	1	ns	***	Ns	***	ns	ns	ns	ns
G x Cl x P	3	ns	ns	Ns	ns	ns	*	ns	ns
Total	47	-	-	-	-		-	-	-
Error	24	-	-	-	-		-	-	-
Coefficient of Variation (%)						110.32	81.2	60	29,8
R^2						58.0	77.0	81.6	93.4

*; **; ***: significant at 5%, 1% and 0,1% levels respectively; ns : no significant

Visual percentage of leaf area covered with crown rust symptoms

Percentage of leaf area covered with crown rust symptoms was visually estimated four times after heading stage. The four percentages were statically affected by either fungicides program or genotypes. Differences between treatments are more significantly affected by fungicides program with the two latest estimated percentages. In fact, Av95 was significantly more sensitive to crown rust than Maacher. Furthermore, the lowest estimated percentage was usually observed in the dual triazole application program. The control (A) and the D program (one early application of mancozeb) were not significantly different.

Forage yield

Forage yield was significantly affected by fungicide combinations applied at, clipping treatment and oat genotype. Over all treatments, Maacher local genotype yielded more than the cultivar Av95 (1027 g DM m-2 against 816 g DM m-2). The best forage yield was obtained with the C combination which consisted of dual applications of epoxiconazole. The C and B programs of fungicides application gave the best mean forage yield (0.96 kg m-2), They are followed in a decreasing order by control and B program (0.86 kh m-2). In economic term, dual-application of Epoxiconazole can not justify the forage yield enhancement comparatively to the one application treatment.

Grain yield and seeds density

Grain yield was significantly affected by either fungicides combinations, clipping treatment,, and genotype. A strong interaction was found between genotype and fungicide program indicating that the two oat cultivars reacted differently to the applied fungicides combinations. Best grain yield was obtained with dual application

of epoxiconazole fungicide (combination C), where it reached 324 g m-2. Grain yield was statically the same for the remaining fungicides treatment, control, B and D and reached a mean value of 150 g m-2 which represent a yield reduction of about 38% comparatively to the C dual application treatment.. One early season application of Mancozebe did not protect the crop against later fungi contamination. Furthermore, Lower grain yields and seeds densities obtained in control treatment and with D program have proven the interest of using fungicides for oat high quality seed production.

Forthcoming steps in 2004-2005

- Continue the evaluation trials of the selected plant material from the 2002 and 2003 QOIN with emphasis on the leaf rust resistance under greenhouse and field conditions.
- Introduction of Oat genetic material from the USA universities and the Quaker International Oat Nursery (2004 nursery) and preliminary evaluation.
- Selection for evaluation under different environmental (field) conditions (outstanding lines will be increased at the main location for preliminary replicated trials).
- Seeding rates effect on oat forage seed yield at the field level (using conventional driller).
- Effect of foliar fungicides application on crown rust (*Puccinia coronata* C.) of oat (for a second year).

Developing Regional Biotechnology Capability in Algeria, Morocco and Tunisia

Three main activities were implemented, namely:

- USDA Review of Biotechnology Capabilities
- Workshop
- Development of proposal on a project for biotechnology development in the Maghreb.

1. USDA Review of Biotechnology Capabilities in Algeria, Morocco and Tunisia

The review mission (February 15-23, 2003) included Dr. T. Blake (ICARDA), Dr. M. Baum (ICARDA), Prof. C. Town (TIGR-USA), Prof. P. Langridge (Adelaide-Australia) and Dr. R. Waugh (SCRI-UK).

The following recommendations are proposed by the panel based on the observations made during the regional visits and their experience of biotechnology research elsewhere in the world. The recommendations are only briefly described and members of the panel would be happy to provide more detailed information and, in many cases, examples and other materials.

Recommendation 1: Centre of Excellence in Crop Biotechnology

Establish a regional Centre of Excellence in crop biotechnology as a physical entity. The Centre should be staffed with excellent scientists who should be recruited from within the region. The Centre should have a Scientific Board with strong International representation who would approve key staff appointments.

Recommendation 2: Competitive research funding scheme

The available funds should be used to leverage additional funds from the Tunisian Government, USDA, European Union and other international sources. This can be most effectively achieved by focusing efforts on developing a regional capability and Centre of Excellence through a competitive funding regime.

A possible model for establishing the competitive funding regime is given below.

(i) The majority of the available funds be used to establish a competitive project funding system. The aim would be to seek matching funds from outside sources. These funds would be available to fund individual projects. The Tunisian funds would only be awarded to researchers based in Tunisia while the additional funds would be available to any researcher in the region. Researchers would be invited to submit applications for funds. Applications would be assessed by a rigorous evaluation system and it is anticipated that only the 10 to 20% most highly rated projects would be funded. Projects would be for three years with funding of

US$50,000 to $100,000 per annum. A consistent feature of all centres visited was the lack of sufficient funds for consumables. Adequate consumable costs must be included for all funded projects.

(ii) Projects would be evaluated against a strict set of criteria that would include:

- Research area; do they match a research priority (see below)? A process for establishing the research priorities should be developed.
- Track record of applicant relative to opportunity; will the applicant deliver on the project?
- Significance and innovation of the research; is the research internationally competitive and would it result in international patents, publications, products with high end-user relevance or related outputs?
- Approach; is the research achievable given the available resources, the capability of the applicant and the funds requested?
- Regional benefit; will the research outcomes offer significant economic, social or environmental benefits to the region? Applicants would be expected to provide reliable information for this section.
- Collaboration; does the project develop or enhance linkages within the region? International collaboration would also be a high priority but would come second to regional collaboration.

Project applications should be evaluated by international assessors who are recognized experts in the area covered in the project. For this reason applications should be in English. Assessor should be asked if the project would be regarded as competitive and likely to be funded in their country. Only projects that are clearly internationally competitive should be funded. Funds should not be allocated to meet a target amount but to reach a targeted standard. It is probable that only few projects would be supported in the first round since researchers would need to develop grant writing skills and rigour. The final decision on funding should be made a regional panel with international representation to ensure high standards are maintained.

Recommendation 3: Setting research priorities and research management

A clear process for setting research priorities should be established. This should provide a clear framework for researchers and should address the long-term needs of the region. A regional group should be established to develop a research plan and research management structure for crop biotechnology research for the region. The plan should be updated annually.

The research plan should identify and prioritise crops and targets. It should contain an assessment of strengths and weaknesses in the existing research capabilities, the status of research with respect to delivery and the timetable for delivery.

For example; what would the olive industry and research capability look like in five, ten and twenty years time? What will the markets look like over these time periods? Where will the markets be and what would be their expectations on the suppliers? What capability exists to deliver these outcomes? Where are the gaps and how can they be filled? Can the necessary research be sourced from elsewhere or must it be developed in the region? What will be the major factors hindering the delivery of the outcomes and how will these be overcome?

Once the research plan has been developed, researchers would be asked to show how their activities fit into this framework and what factors affect their capacity to deliver outcomes.

Recommendation 4: Target species

The panel recommends that the major target crops for research should be olive, date palm and durum wheat.

All three crops are of considerable economic significance to Tunisia and the region. For these species, Tunisian and other groups in the region have already made considerable progress and have developed a strong biotechnology capability. Technology delivery capacity is also available through breeding and improvement programs and an extensive germplasm resource is also available. These species are not being strongly developed elsewhere, so the region will not be able to acquire the technology or outputs from other sources. This also means that the region can develop strong international research credibility for these species.

High quality, internationally competitive research on other species is difficult given the high level of activity elsewhere. The group felt that research in other species was generally weak. The emphasis for other crops, such as chickpea, faba bean and potato should be through participation in international networks. ICARDA is strongly encouraged to develop and coordinate an international collaborative program for faba bean and chickpea and groups in Tunisia and the region should be encouraged to participate in these programs. However, it should be recognized that the most effective role for the region will be in technology transfer through breeding programs rather than development of a region capability for these species.

Recommendation 5: Germplasm conservation and Biosafety

The region should continue the development of its capacity for the conservation of genetic resources and the screening and evaluation of genetically modified organisms, particularly crops. The emphasis of genetic resource programs should be on the stable conservation of germplasm and the phenotypic evaluation of the collections. While molecular marker screening of germplasm is of value, it should not represent the major activity of collections.

The potential wide-scale release of GM crops in the region should be preceded by careful assessment of the possible impact of GMOs on existing germplasm and crops. For example, GM crops should only be released if there is clear evidence that they will not impact on the distribution or survival of species endemic to the region.

Recommendation 6: Technologies

The panel felt that too much emphasis was being placed on genetic engineering as the focus for biotechnology research. This was not necessarily the most appropriate application. Molecular markers will offer more rapid delivery as has been proved in other countries. For example, the panel was particularly impressed with genetic resources available in some species, notably olive, that could allow the region to develop international excellence in the genetics and biotechnology of this species.

Recommendation 7: Bioinformatics

Bioinformatics should be a high priority for support in the new Centre. The Centre should have a high speed internal network and outside connection. The Communications unit should also develop and maintain an informative website. All existing facilities should develop a public website describing their resources and capabilities

Recommendation 8: Lab supplies

All biotechnology researchers in Tunisia and the region should have access to a rapid cost efficient supply network. The panel encountered a variety of different mechanism that had been developed to address this issue. The most efficient appeared to be that developed by the Pasteur Institute, Tunis and CBS, Sfax and this may be an appropriate model.

Recommendation 9: Equipment purchase

Major equipment purchases should be made after consultation across the region. The panel noted that duplicated and inappropriate equipment was being purchased by some groups.

Recommendation 10: Communcations Unit

The new Centre would house a communications unit that would provide information on the Centre's activities, the role of biotechnology in agriculture to the region, and resource materials for schools and community groups on gene technology. The prime focus of the unit should be on farmers and the general community. The unit would also provide editorial support to researchers in the biotechnology area. This is aimed at improving the quality of publications and research presentations to facilitate raising the international profile of the biotechnology capability of the region.

Recommendation 11. IP and commercialisation support

The panel noted potential issues related to the utilization of third party intellectual property and in providing resources to the protection of regionally developed IP. Researchers should be made aware of the problems through training programs and possibly by establishing an advisory unit. The unit could provide the training programs, advice on specific projects and topics and could develop a database of IP information relevant to the projects of the region. New project applications should include evidence that IP searches have been conducted.

Ideally the unit should have the resources for taking out and maintaining patents.

An additional function of the unit could be to provide support and advice on the commercialisation of research outcomes. A key component of this support would be through the identification of commercial opportunities, the introduction of research groups to potential commercial partners and the training of staff in research commercialisation.

Recommendation 12. Universities

The panel noted that the universities were generally poorly equipped relative to the research institutes. Given the high demand for training and the need to provide students and university staff with access to high quality facilities, plans should be developed for expanding the research capabilities at the universities.

Recommendation 13. Sabbaticals

The panel felt strongly that a process and resources should be established for regular sabbatical leave for core staff. This is particularly important for university staff but would enhance the linkages and capabilities of staff at all institutions. The sabbatical stays should be for six months to one year leave every five to seven years.

2. Workshop on biotechnology

Background and objectives

Based on an US initiative to fund some activities aiming at developing the national capacities on biotechnologies, and going back to previous discussions between Tunisian and US officials, the US Department of Agriculture (USDA), jointly with the International Center of Agricultural Research in the Dray Areas (ICARDA), and with support of the three Maghreb countries (Algeria, Morocco and Tunisia), has organised a consultation workshop of the possibilities and opportunities to set up a regional collaborative action programme. The workshop was organised at INRA-Algeria on April 16th, 2004 and all participants agreed on the following objectives:

(i) Review the opportunities for a regional collaborative work at the Maghreb level;

(ii) Identify some principles on which these opportunities, if any, would be based;

(iii) Identify some common ground for the regional collaborative work (constraints, objectives, topics, etc.) on biotechnologies development;

(iv) Identify priority crops with comparative advantages for the Maghreb region;

(v) Discuss some priority techniques and methods on biotechnologies to be developed within the intended regional collaborative work;

(vi) Identify the types of support expected from USDA and ICARDA.

Opening session, participants and methodology of the workshop

Given the importance of the workshop, the opening session was chaired by Mr. Aomar Air Amer, representative of the MARD Secretary General. During this session, Dr. Kamel Feliachi, DG of INRA-Algeria, Dr. Mohamed El Mourid, ICARDA-NARP Regional Coordinator and Mme. Merrit Chesley, USDA Rep for the Maghreb, took one after the other the floor to express their concern about this workshop. A common of the three was that there is a need to join efforts and resources to develop the biotechnology in the region.

After having mentioned the interest of the workshop on the perspective of the Ministry of Agriculture and Rural Development of Algeria, he pronounced the official opening of the workshop, which was attended by 22 participants and facilitated by Dr. Mustapha Malki, a free lance consultant on group moderation.

After the coffee break, the facilitator took over and explained the methodology adopted for this workshop (brainstorming with the use of the Metaplan technique). He stressed that the workshop is a free- and open-thinking meeting whose object is not to validate an already-taken decision. Any regional issue that is related to the subject of the meeting which meet an consensus in the group can be discussed.

However, it has to be mentioned that the following sections of the present report do not provide a detailed work plan; they represent some indications on the "directions" that this collaborative work would take and which were discussed within the workshop, given that this workshop is a first step of a started process that would lead a detailed regional plan of actions.

Main outcomes of the workshop

a. Principles of Maghreb collaborative work

The participants agreed that the regional collaborative work with the support of USDA and ICARDA biotechnology development would serve and support agricultural development, in general, ensuring sustainability. However, it concern mainly to apply biotechnologies on the main selected crops.

Given the history and evolvement of biotechnologies in the Maghreb countries, and based on the orientation developed before, the regional collaborative work would help the three countries to bridge the gap that exist between their capacities and the advanced countries in the specific field of modern biotechnologies (based on Carthagena Protocol definition), which will aim at developing the Maghreb capacity on genetic engineering and genomics.

In order to plan this collaborative work, three time horizons were envisaged by the participants: (1) short term of 1-2 years; (2) mid-term of 5 years; (3) long-term of 10 years.

b. Common constraints and objectives

The "common ground", required for a regional collaborative work that was identified by the participants is represented in the following elements:

(i) Priority research topics

- Tolerance to salinity and drought stresses (mid- to long-term perspective)
- Quality improvement (long-term perspective)
- Productivity increase (long-term perspective)
- Resistance to biotic stresses (mid- to long-term perspective)
- Molecular characterisation of plant genetic resources (mid-term perspective)

(ii) Capacity building

- Human resources development (first priority and mid-term perspective)
- Facilities improvement and upgrading (mid-term perspective)

(iii) Regulative and institutional aspects at regional level

- Setting-up a regional committee on bio-safety (short- to mid-term perspective)
- Developing bio-safety analytical tools (short term perspective)

(iv) Setting-up a regional common strategic plan on biotechnology development (mid-term perspective)

c. Concerned crops

The participants agreed that the collaborative work cannot embrace any crops. There was a need to identify some priority crops with tangible comparative advantages for the Maghreb region. Henceforth, the following crops and species were identified:

- Cereals (durum wheat and barley)
- Food legumes (faba bean, chickpea and lentils)
- Fruit trees (date palm and olive trees)

d. Methods and techniques to be promoted within this collaboration

According to the participants, modern biotechnologies are lagging behind in the Maghreb region, as compared with the advanced countries, or at least on the North

Mediterranean countries, and the regional collaborative work should help the three countries bridge this gap somehow. Given this, the following methods and techniques should receive a great attention within the endeavoured regional collaborative work:

(i) On the short-term perspective

- Bio-informatics

(ii) On the mid-term perspective

- Genetic transformation and DNA recombination
- Tissue culture
- Genomics and DNA molecular markers

(iii) On a longer perspective

- Proteomics

e. Mechanisms to be developed

Among the mechanisms to be developed in order to organise the planned regional collaborative work, the participants agreed, after a long discussion, to **set-up a regional network on biotechnologies**. During the same discussion, a suggestion to set-up a Regional Center on Biotechnologies was made by Dr. Moncef Harrabi but did not meet the consensus among the participants. However, given previous networking experiences in the region, sustainability of the regional network was questioned and the participants agreed that the suggested network should receive a support from USDA at the beginning but for the long run, **founding a regional funding mechanism to sustain the network functioning** is extremely necessary. This regional network would be "coached" by an **International Steering Committee**. A **National Coordinator**, nominated for each of the three countries, would be the focal point of this regional network and would be in charge of animation of a **National Network on Biotechnologies**. All national coordinators will be part of the International Steering Committee, as well as USDA and ICARDA representatives. Until another appropriate mechanism would be identified, the regional coordination of the workshop would be devolved to ICARDA, as it is the case for other regional networks such as REMAV, for instance. This would help **strengthen partnerships** within NARS in the Maghreb, on the one hand, and between NARS and advanced research institutions and IARCs, such as ICARDA, on the other.

Under the aegis of this Regional Network and given the support of USDA and ICARDA, scientists exchange within and outside the region will be intensified; collaborative regional competitive research projects will be developed; and, biannual (once every two years) **international conferences on biotechnologies** will be organised.

In order to strengthen information exchange between biotechnologists in the Maghreb, and with others in the world, a **regional website** will be developed under

the aegis of the intended regional network that will be hosted and managed by ICARDA.

f. Types of support expected from USDA and ICARDA

Among the numerous types of support expected by the Maghreb countries from USDA and ICARDA in the light of the planned (although briefly) regional collaborative work on biotechnologies development, the following were adopted unanimously:

- Facilitate access to scholarships to Maghreb scientists to undertake graduate studies (MSc and PhD) in US universities.
- Provide assistance in the development of curricula and didactic facilities in Maghreb high education institutions in order to foster local training of under-graduate and graduate scholars on biotechnologies.
- Facilitate two-way scientists exchange between the US and the Maghreb (medium and long sabbatical leaves).
- Provide funding for short- and mid-term regional training inside and outside the region.
- Secure funding of regional research projects (based on a balance between competitiveness and utility for the region)
- Provide funding for lab facilities upgrading and improvement.
- Provide funding to ensure functioning of the regional network on biotechnologies to be set-up in the frame of the intended regional collaborative work.
- Provide technical assistance for the set-up of a regional common strategic plan on biotechnology development.

Closing remarks

The workshop was well-organised and produced consensually- and largely-accepted outcomes. This remark was stressed by the workshop by Dr. Kamel Feliachi, DG of INRA-Algeria, Dr. Mohamed El Mourid, ICARDA-NARP Regional Coordinator and Mme. Merrit Chesley, USDA Rep for the Maghreb, who took one after the other the floor, during a closing session chaired by Mr. Aomar Air Amer, representative of the MARD Secretary General, to express their satisfaction about the workshop outcomes. Intervening at the end of the session, Mr. Ait-Amer expressed his satisfaction about the clarity of the recommendations which were achieved in a very short time (one day). He hoped that the intended regional collaborative work would come into being in the shortest time possible and asked USDA to do its best to mobilise the required input to start the regional collaboration as soon as possible.

Development of proposal on a project for biotechnology development in the Maghreb

Based on the earlier biotech review in Morocco, Tunisia, Algeria, a competitive research-funding scheme was suggested for the Maghreb countries. This is the most important recommendation of the review. The competitive project funding system would be available to fund individual projects. Researchers would be invited to submit applications for funds. Applications would be assessed by a rigorous evaluation system and it is anticipated that only the 10 to 20% most highly rated projects would be funded. Projects would be for three years with funding of e.g. US$50,000 per annum (depended on funds allocated). Adequate consumable costs must be included for all funded projects.

Projects would be evaluated against a strict set of criteria that would include:

- Research area; do they match a research priority (see below)? A process for establishing the research priorities should be developed. Incase the process is administered by ICARDA, research priorities should be on ICARDA mandated crops including extended mandates on fruit tress
- Track record of applicant relative to opportunity; will the applicant deliver on the project?
- Significance and innovation of the research; is the research internationally competitive and would it result in international patents, publications, products with high end-user relevance or related outputs?
- Approach; is the research achievable given the available resources, the capability of the applicant and the funds requested?
- Regional benefit; will the research outcomes offer significant economic, social or environmental benefits to the region? Applicants would be expected to provide reliable information for this section.
- Collaboration; does the project develop or enhance linkages within the region? International collaboration would also be a high priority but would come second to regional collaboration.

Project applications should be evaluated by international assessors who are recognized experts in the area covered in the project. For this reason, applications should be in English. Assessor should be asked if the project would be regarded as competitive and likely to be funded in their country. Only projects that are clearly internationally competitive should be funded. Funds should not be allocated to meet a target amount but to reach a targeted standard. The final decision on funding should be made a regional panel with international representation to ensure high standards are maintained.

Setting research priorities and research management

A clear process for setting research priorities should be established. This should provide a clear framework for researchers and should address the long-term needs of the region. A regional group should be established to develop a research plan and research management structure for crop biotechnology research for the region. The plan should be updated annually.

The research plan should identify and prioritise crops and targets. It should contain an assessment of strengths and weaknesses in the existing research capabilities, the status of research with respect to delivery and the timetable for delivery.