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Evaluation of agricultural practices to improve efficiency and environment conservation in Mediterranean arid and semi-arid production systems: MEDRATE project

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SUMMARY – The objective of the MEDRATE project has been to evaluate and assess the impact and adoption of agricultural technologies, in the field of Land and Water Management, Crop Production and Animal Production, specially adapted to rainfed agriculture and within the framework of well described and defined agricultural systems. The evaluation and the assessment of impact has been carried out at three levels: research, on-farm trials/demonstration and at farm level, using quantitative and qualitative data. Data have been collected by using experimental data and through surveys. The following countries have participated: Algeria, Egypt, Italy, Morocco, Spain, Syria, Tunisia and Turkey. The project has been carried out within a period of 2 years. The deliverables obtained are a reference publication and a website including a database.

Key words: Mediterranean rainfed agriculture, efficiency, environment protection, arid, semi-arid.

RÉSUMÉ – *"Evaluation de pratiques agricoles pour améliorer l'efficacité et la conservation de l'environnement dans les systèmes de production méditerranéens arides et semi-arides : le projet MEDRATE". L'objectif du projet MEDRATE a été d'évaluer et d'estimer l'impact et l'adoption de technologies agricoles, dans le domaine de la Gestion de la Terre et de l'Eau, de la Production des Cultures et de la Production Animale, spécialement adaptées à l'agriculture pluviale et dans le cadre de systèmes agricoles bien décrits et définis. L'évaluation et l'estimation de l'impact ont été menées à trois niveaux : recherche, essais au champ/démonstration et au niveau de la ferme, en utilisant des données quantitatives et qualitatives. Des informations ont été collectées en utilisant des données expérimentales et des enquêtes. Les pays suivants ont participé : Algérie, Egypte, Espagne, Italie, Maroc, Syrie, Tunisie et Turquie. Le projet s'est déroulé sur une période de deux ans. Les obtentions sont une publication de référence ainsi qu'un site web comprenant une base de données.*

Mots-clés : *Agriculture pluviale méditerranéenne, efficacité, protection environnementale, aride, semi-aride.*

Background

Rainfed agriculture is practised over the largest crop surface area in the Mediterranean. The arable and livestock production that accompanies rainfed agriculture in the South and East of the Mediterranean have been and continue to be the main and often only base of economic activity in these areas. The maintenance and efficacy of the agricultural systems in these areas is therefore an indispensable condition for the livelihood of the rural population and for a decline in their migration and concentration in the urban areas. From the point of view of environmental protection, even though excessive pressure from arable and livestock farming has harmful effects, particularly soil erosion, the abandonment of human activity in these lands leads to further risk of desertisation and desertification and to the impossibility of controlling natural phenomena: fires, floods, pests, etc. which are potentially hazardous for inhabited areas and for the equilibrium of ecosystems.

One of the elements that condition the efficiency of the rainfed agriculture systems is the evaluation and implementation of appropriate technologies by the farmers. In spite of the large number of technologies proposed by the research and development services of the different countries, whether they be new systems or evolutions of traditional ones, their introduction into commercial agriculture is slow, giving heterogeneous, if not contradictory, results.

In the light of this situation, several institutions of the region agreed to collaborate in a project for the evaluation of agricultural practices to improve efficiency and environment conservation in Mediterranean arid and semi-arid production systems (MEDRATE). The project has been developed over two years between 2001 and 2003 within the framework of the Regional Action Programme on Rainfed Agriculture (RAP-RAG) included in the EC/EuropeAid-CIHEAM Cooperation Project 1998-2003, whose objective has been to improve regional cooperation to favour sustainable agriculture and to shift towards more open and competitive market economies. The programme has covered the components of training, with specialised short courses, support to cooperative research networks and research projects designed to develop joint research and information exchange, organisation of seminars and workshops, and logistic support to South and East Mediterranean institutions for information and communication technologies.

Objectives

The general objectives of the project are to:

(i) Describe and evaluate Mediterranean rainfed agricultural systems.

(ii) Evaluate and assess the impact and adoption of agricultural technologies specially adapted to rainfed conditions.

The specific scientific and technical objectives are:

(i) To characterise pilot areas and evaluate main constraints and potentialities of representative rainfed agricultural systems within these areas from 8 Mediterranean Countries (Algeria, Egypt, Italy, Morocco, Spain, Syria, Tunisia and Turkey) representative of the main rainfed agricultural systems.

(ii) To evaluate, at the levels of Research, On-Farm Trials and Farmer, agricultural techniques adapted to rainfed agriculture in the field of Land and Water Management, Crop Production and Animal Production.

Methodology

Selection of the main Mediterranean Rainfed Farming Systems in which the study is going to be carried out

This selection has been made taking those published by ICARDA (Fig. 1) as reference. The systems selected are: (i) Wheat based system; (ii) Barley/Livestock system; (iii) Pastures and Livestock system; and (iv) Horticultural/Trees system.

Selection of representative pilot areas

Selection of representative pilot areas of the main Mediterranean Rainfed Farming Systems in Algeria, Egypt, Italy, Morocco, Spain, Tunisia and Turkey are shown in Table 1 and Fig. 2. These areas are situated within a range of rainfall characteristics to the Mediterranean area as shown in Table 2. The areas have included all representative-farming systems as defined in Table 3.

Table 1. Selected pilot areas with their approximate surface area

Country	Area	Region	Surface
Algeria	Kroub	Interior Plane	150,000 ha
	Tebessa	Steppe	250,000 ha
Egypt	North Western Coast of Egypt	Mediterranean Coast	400,000 ha
Italy	Abruzzo	Hilly area	250,000 ha
Morocco	Settat	Chaouia	600,000 ha
	Safi	Abda	600,000 ha
Spain	Oriental Ebro Valley	Aragon-Catalonia	600,000 ha
Tunisia	Oum Zessar (Watershed)	Jeffara Plain (South East)	36,000 ha
Turkey	Ankara	Central Plateau	600,000 ha

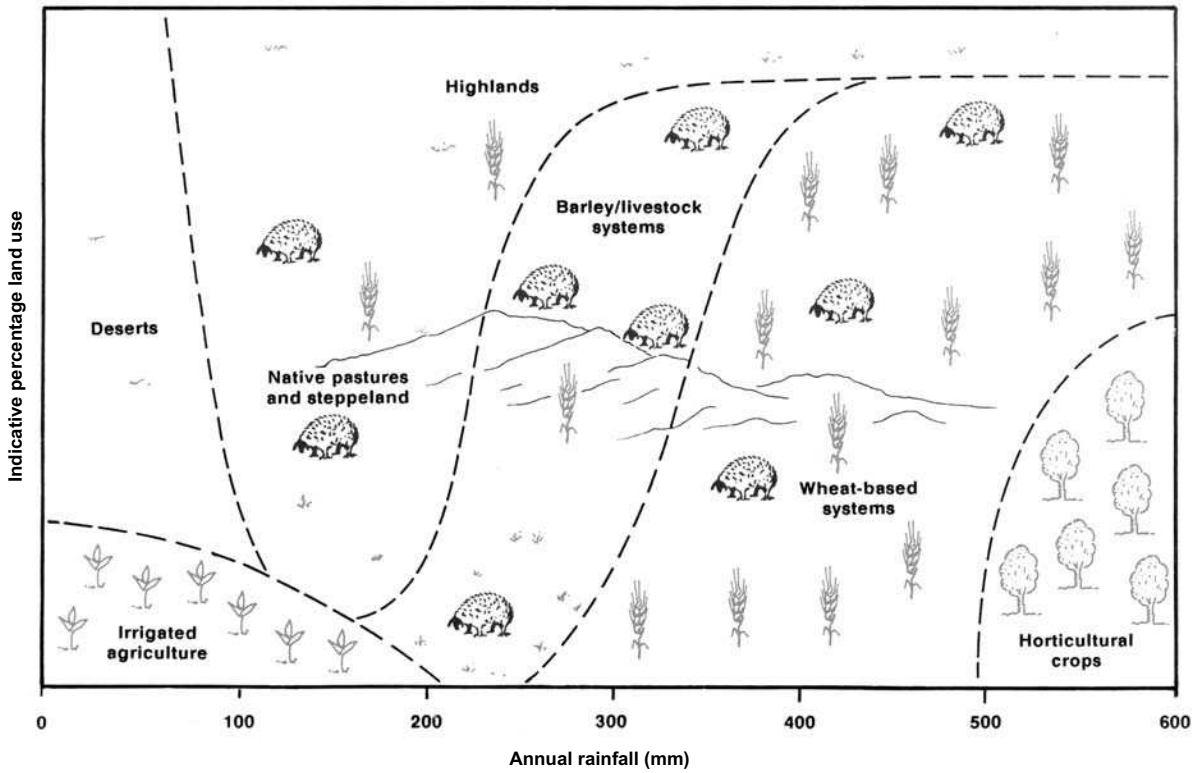

Fig. 1. Diagrammatic representation of the major agro-ecological zones in West Asia and North Africa. The zones are primarily based on different rainfall bands but constitute a continuum with a large number of overlapping agro-ecologies. Obtained from the ICARDA document "*Sustainable Agriculture for the Dry Lands. ICARDA's Strategy and Medium-Term Plans*", 1989, page 12.

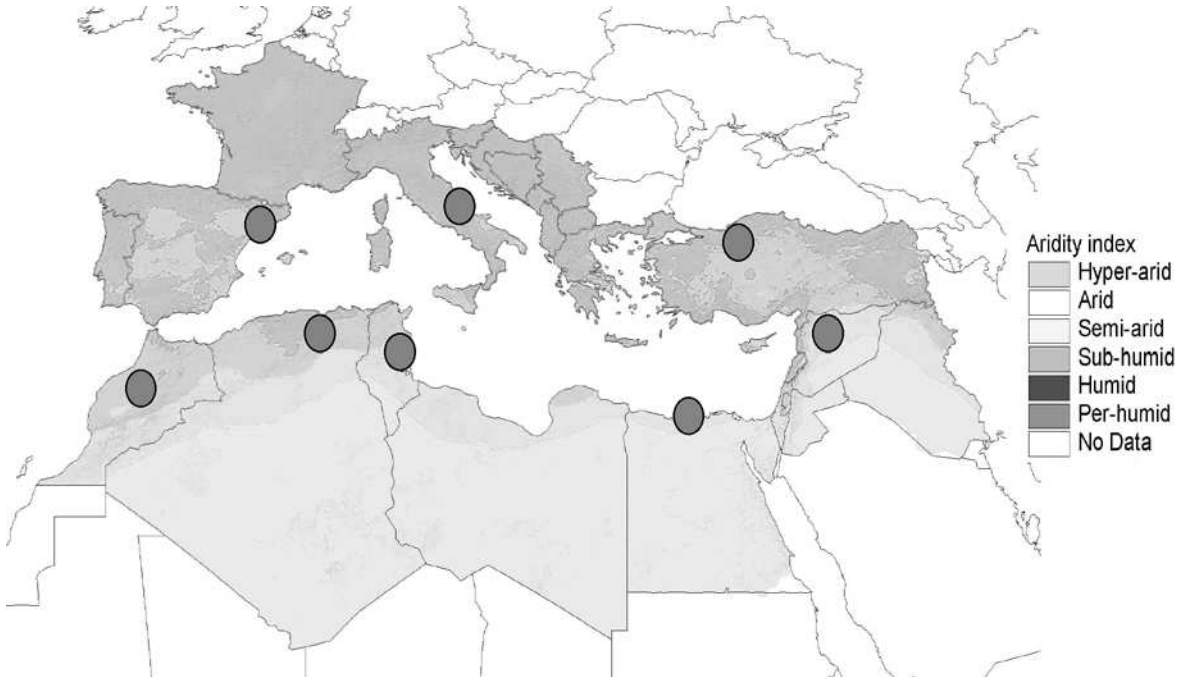

Fig. 2. Geographical location of the selected Pilot Areas.

Table 2. Rainfall level of the selected areas

Rainfall level	Sub-level†	Egypt	Tunisia	Algeria	Syria	Morocco	Turkey	Spain	Italy
High	h								●
>400 mm	m							●	
	l						●		●
Medium	h					●	●		
200-400 mm	m			●	●	●		●	
	l		●	●					
Low	h		●						
<200 mm	m	●							
	L								

†H: high; m: medium; l: low.

Table 3. Farming systems represented by the pilot areas. The number of ● represents the importance of the systems and crop within the area

System/Crop	Algeria	Egypt	Italy	Morocco	Spain	Syria	Tunisia	Turkey
Wheat	●●		●●●	●●●	●●	●		●●●
Barley	●●●			●●	●●●	●●		
Pastures & Livestock	●	●●●		●		●●	●●	●
Trees†			●●		●●		●●	

†Tree species concerned are: Spain = olive, almond, pistachio and carob; Italy = olive, vine.

Characterisation and evaluation of the farming systems

This has been done following the guidelines in which a complete characterisation of the farming system is made. That includes a first step description of selected areas whose main points are:

(i) Situation, boundaries and surface areas.

(ii) Atmospheric environment (climate).

(iii) Edaphic environment (soil).

(iv) Biotic environment.

(v) Plant production systems.

(vi) Animal production systems.

(vii) Relationships between production systems.

(viii) Socio-economic characteristics of the farming system.

(ix) Level of research, experimentation and technology transfer.

Finally, a second step includes an evaluation of the main limitations of the system.

Selection of the techniques to be evaluated

A selection of technologies to be evaluated was made taking into account partners' previous knowledge based on available data and also the most interesting techniques to be developed. Selected technologies and countries in which they have been evaluated are listed in Tables 4, 5 and 6.

Table 4. Land and Water Management Technologies

1. Reduced tillage (including non-tillage)
2. Water harvesting
3. Supplementary irrigation

System/Crop	Algeria	Egypt	Italy	Morocco	Spain	Syria	Tunisia	Turkey
Wheat	1		1	1	1	1		1 3
Barley	1			1 3	1	1 3		
Pastures and livestock		1 2 3					2	
Trees			1		3†		2	

†Olive and almond.

Table 5. Crop Production Technologies

1. Soil test calibration and fertiliser recommendation
2. Seeding and planting techniques
3. Improved plant material
4. Weed control (early)
5. New crops and cropping systems

System/Crop	Algeria	Egypt	Italy	Morocco	Spain	Syria	Tunisia	Turkey
Wheat	1 2 3 4 5		1	1 3 4	1 3	1 2 3 4		2 3
Barley	1 2 3 4 5			1 3 4	1 2 3 5	1 2 3 4		2 3
Pastures and livestock	5	1 2 5				2 4	5	2
Trees					3† 5††		5	

†Olive, almond, pistachio and carob.
††Olive (plantation lay-out).

Table 6. Animal Production Technologies

1. Alternative and non conventional feed resources
2. Control of reproduction
3. Breeding (selection and crossing)
4. Processing of animal products (dairy, wool & hair, pelt)
5. Forage conservation
6. Range management and preservation

System/Crop	Algeria	Egypt	Morocco	Spain	Syria	Tunisia	Turkey
Wheat	3		1 2 3	1 2 3	1 2 5 6		1 6
Barley	1 2 3						
Pastures and livestock	1 2 3	1 2 3 4	6			1 2 3	

Description of the technologies to be evaluated

This description was made in order to make the meaning and definition of the technologies uniform. These technologies are described in Table 7.

Criteria and methodology for evaluation of innovative technologies

Evaluation has been carried out at the three levels indicated in Table 8 where criteria for assessment are also shown.

Table 7. Description of technologies to be evaluated in the MEDRATE project

Land and Water Management		
Technology	Objectives	Description
1. Reduced tillage (including non-tillage)	Conserve physical,chemical and biological soil properties Protect against erosion Improve the soil-plant water balance Reduce crop and farm inputs	Reduced tillage aintensity Increase the use of conservation tillage systems, including non-tillage Maintain crop-plant residues for mulching
2. Water harvesting	Encourage harvesting of rainwater Establish an appropriate distribution of available water in time and space in relation to the crop cycle To recharge aquifers	Practise conservation tillage Build and maintain structures for capturing and routing water towards the crop zones Establish structures (pools, etc.) for water storage
3. Supplementary irrigation	Make more water available for crops to increase their productivity Apply a limited amount of supplementary water in time and space to increase productivity Establish an appropriate distribution of water in time and space in relation to the crop cycle	Establish storage structures in capture zones and transport to irrigation zones Consider tight irrigation schedules to increase production quantitatively and qualitatively Establish water application systems for optimum efficiency in the distribution of water

Table 7 (continuation). Description of technologies to be evaluated in the MEDRATE project

Crop Production Technologies		
Technology	Objectives	Description
1. Soil test calibration and fertiliser recommendation	Perform analysis programmes to be used for the recommendations of soil management and techniques and dosage of crop fertilisation	Establish plans to make a physical and chemical characterisation of arable soils Develop, test and use rapid analysis methods of the main nutritional elements of the crop soils and plants Maintain a regular analysis programme of the main characteristics in which the farmer is involved
2. Seeding and planting techniques	Establish the most appropriate sowing and planting techniques and characteristics (season, rate, frameworks, etc.) according to the crop and the soil and climate characteristics of the zone	Determine the most appropriate seasons and dates for crop sowing and planting, according to the variety Establish the sowing and planting dosage according to the soil and climate characteristics of the zone and available water for the crop Develop mechanical sowing and planting systems according to the possibilities of each zone. Consider direct sowing
3. Improved material	Develop and encourage use of improved plant material appropriate for the soil and climate conditions of each zone	Plant material experimentation programmes (including seed companies) Extension service programmes of the characteristics and behaviour of varieties and their use
4. Weed control (early)	Establish mechanical and chemical weed control techniques	Use mechanical weed control systems Use early chemical weed control methods Other agronomical practices (crop rotations, intercropping, etc.)
5. New crops and cropping systems	Develop alternative crops in the zones Develop and use crop systems (rotations, fallow and associated and intercropping) considering the global balance between water and the economy	Develop and use alternative crops (legumes, oil seed, improved pastures, new fibres) Make appropriate use of fallow according to water and nutrient availability Establish and use rotations and most appropriate crop mixtures

Table 7 (continuation). Description of technologies to be evaluated in the MEDRATE project

Animal Production Technologies		
Technology	Objectives	Description
1. Alternative and non-conventional feed resources	To keep animals in limited areas with cheap and well balanced rations and little labour To obtain forages in dry areas in some strategic periods of the year To obtain cheap rations with non-usual feed resources To overcome lack of shepherds	Manufacturing of complete rations and distribution to farmers Combined with self-service mangers in some cases Grazing rotations including cereals and forage shrubs
2. Control of reproduction	To have parturitions in the desired periods of the year To increase numerical productivity	Management of males. Separation and sudden introduction ("Male effect") Hormonal treatments + Controlled mating and/or Artificial insemination
3. Breeding (selection and crossing)	To increase the productivity of local populations maintaining their adaptation to Mediterranean dry environments To increase farm profitability	Within-breed selection programmes Crossbreeding
4. Processing of animal products (dairy, wool and hair, pelt)	To transform animal raw products into marketable products To increase the added value of animal products	Transformation of milk into cheese and other dairy products Production of craft animal products Different scales: at farm, medium, large
5. Forage conservation	To preserve quality forages to be available during the periods of scarcity To design complete feeding calendars	Forage harvesting and appropriate handling in the field Forage storing Forage distribution
6. Range management and preservation	To optimise sustainable forage yields in rangelands To environmentally preserve rangelands and prevent degradation	Appropriate grazing management Introduction of well adapted and ecologically integrated plant species

Table 8. Methodology and criteria for the evaluation of the innovative technologies

Level of evaluation					
Research		On-farm trials / Demonstration (be aware of the control of the experiments)		Farmer	
Criteria	Methodology	Criteria	Methodology	Criteria	Methodology[†]
1. Yield/Production 1.1. Level 1.2. Stability (risk)	Available data	1.Yield/Production 1.1. Level 1.2. Stability (risk)	Available data	1. Yield/Production 1.1. Level 1.2. Stability (risk)	Available data/Survey
2. Quality of product (price)	Available data	2. Quality of product (price)	Available data/Estimation	2. Quality of product (price)	Available data/Survey
3. Costs and margins	Available data/ Estimation or Projection	3. Costs and margins	Available data/ Estimation or Projection	3. Costs and margins	Available data/Survey/ RRA
4. Technical feasibility/ Need for training	Appraisal	4. Technical feasibility/ Need for training	Appraisal	4. Technical feasibility/ Need for training	Survey/RRA
5. Gender impact	Appraisal	5. Gender impact	Appraisal	5. Access to technology	Survey/RRA
6. Environmental impact	Available data/Appraisal	6. Environmental impact	Available data/Appraisal	6. Farmer dependence	Survey/RRA
7. Social acceptance	Appraisal	7. Social acceptance	Appraisal	7. Gender impact	Survey/RRA
				8. Environmental impact	Survey/RRA
				9. Social acceptance	Survey/RRA
				10. Level of adoption	Survey/RRA
				11. Effect on employment	Survey/RRA
				12. Effect on well being	Survey/RRA

[†]RRA: rapid rural appraisal.

Evaluation at Research and On-Farm Demonstration (On Trial) levels has been performed to obtain available data in selected areas for the chosen technologies. A survey model was prepared to obtain data from research or demonstration experiments carried out in the past. The survey form for evaluation of the technologies at Research and Experimentation levels included the following points:

a. Identification

1. Technology
2. Country/Partner

b. Description of the technology in the selected area

1. Objective
2. Implementation
3. Description of conventional/traditional system
4. Description of alternative system

c. Results

For quantitative available data, average, standard deviation, absolute and percentage difference from the control (traditional system) was recorded for each experiment or set of experiments with the same features. When quantitative data was not available, qualification from the researchers and technical personnel was required. In those cases, from 0 up to +3 or –3 was recorded depending on the positive or negative value of alternative systems compared with traditional system. Points that included this evaluation were:

Yield

Yield stability

Resource use and efficiency (i.e. water, nutrients, etc.)

Quality of the product (i.e. fruit weight, protein content, oil content, etc., specified for each case)

Economic features. Production cost and economic margin

Environmental impact: loss of biodiversity, soil loss, soil organic matter, leaching, crop residues, etc.

Technical feasibility

Need for training

Gender impact

General social acceptance

d. Conclusions

The conclusion for each survey included a summary of the aspects about the improvement, disadvantages, limits, conditions of use and recommendations for the development of the alternative system.

e. List of references where data was obtained

On-Farm surveys have been carried out following two types of survey, one to obtain the opinion and data from users of the technology and another for the non-users. The survey for users has been adapted to each group of technologies, or even, when they are very specific, for each technology. For non-users, the same survey has been utilised for all technologies. Number of surveys and their sampling have been determined in accordance with the following procedure.

The *minimum number of farmers surveyed* was stated, between 15 and 20 for each technology and country (if available), with an equal distribution amongst production systems and use or non-use of the technology.

Concerning *Crop Production Technologies*, technology evaluation study sampling has been country specific and technology dependent, taking into account the farming systems, the farm size and the use or non-use of the technology to be evaluated.

For each technology to be evaluated (ET) a given number of user farmers (UF) and the same number of non-users (NUF) have been surveyed. If all the ET were used by a known group of farmers, the UF and NUF group might be the same for all evaluated technologies.

Persons surveyed have been both representative UF and NUF or development technicians who are experienced in the use of the technology and who are in contact with UF and NUF through technical programmes. In this latter case, one technician may have completed more than one questionnaire on behalf of the farmers.

A wide range of aspects were surveyed between users and non-users at this level. In this survey the following was included:

(i) General characteristics of the farms for users of the alternative technology: agricultural land, crop and cropping system distribution, crop yields, livestock features, farming equipment and social and economic features.

(ii) Characteristics of the alternative technology practised on the farm by users: farming system characteristics, crop yield comparisons between alternative and traditional technologies, production cost and benefit between compared systems, technical feasibility, environment, access to technology, level of adoption and social aspects.

(iii) General characteristics of the farms for users of the alternative technology: agricultural land, crop and cropping system distribution, crop yields, livestock features, farming equipment and social and economic features.

(iv) Characteristics of the crops and cropping system and the reasons for non-adoption and disadvantages for the alternative technology of the non-users of the alternative technology.

Analysis of results

Results have been analysed separately by levels of Research-on trial evaluation and On farm evaluation for each technology. A summary of Research-on trial level surveys for each technology was prepared that include the following main points:

(i) Yield, yield stability and quality of the product.

(ii) Natural resource use and use efficiency (i.e. water and nutrients).

(iii) Environmental impact.

(iv) Social and economic aspects.

A much more intensive summary was prepared from the results of On farm surveys. First, each country prepared a summary for each technology in each selected area, which included all surveys for individual farmers. Secondly, and with these summaries from each country, a complete document was compiled taking into account the number of surveys from farmers in each selected area. In this last document, weighted averages and percentages for all aspects considered were obtained for each technology.

Finally an end summary has been prepared for each group of technologies considering the research and on-farm quantitative and qualitative data and conclusions. A general introductory consideration about the present technical problems and alternatives has been made in this summary and a general integrated conclusion for the group of technologies has been included. These End Summaries are the basis of the following presentations of this Final Seminar of the MEDRATE project.