Prototyping and dissemination of ecological olive production systems

A methodology for designing and a first step towards validation and dissemination of prototype ecological olive production systems (EOPS) in Crete

PROTOTYPING AND DISSEMINATION OF ECOLOGICAL OLIVE PRODUCTION SYSTEMS

A methodology for designing
and a first step towards validation and
dissemination of prototype ecological olive
production systems (EOPS)
in Crete

Emmanouil Kabourakis

Promotor: dr. ir. E. A. Goewie
Hoogleraar in de Ecologische Landouw
Landbouwuniversiteit Wageningen

Co-promotor: dr. P. Vereijken
Senior onderzoeker
Instituut voor Agrobiologish en Bodem vruchtbaarheidsonderzoek (AB-DLO)

Propositions

Development of sustainable farming systems without the experiences and skills of the farmers is not possible.

Prototyping with farmers enhances sustainable development of agricultural production faster than Multi Linear Goal Planning (MLGP).

Evaluation of research based on experimental and disciplanary science may easily underestimate the social importance of a project.

Searching for something useful in the overwhelming literature of analytical research is like digging for gold. You end only with stones.

Current agricultural research treats farmers as an object rather the objective.

Building theories for agricultural production should follow, not precede, researcher's familiarisation with farming.

Conscious and skilful farmers with good agricultural practices are more effective in stopping erosion than the accumulated literature.

A researcher who starts a project without secure finance is a modern version of Don Quichote.

Being one of the first prototypers is like being a guinea pig.

The most restrictive skill in prototyping is creativity.

The dream of interdisciplinary research can be brought into reality in a prototype project.

Dream and reality are identical. (*N. Kazantzakis*).

Όρτσα, διάλε την πίστη του κι όπου το βγάλει η βράση,
για που θα σάσει μια δουλειά για που θα σοχαλάσει! *(Νίκος Καζτζάκης)*.

Emmanouil Kabourakis

Prototyping and dissemination of ecological olive production systems
A methodology for designing and a first step towards validation and dissemination of prototype ecological olive production systems (EOPS) in Crete

Emmanouil Kabourakis

Prototyping and dissemination of ecological olive production systems

A methodology for designing and a first step towards validation and dissemination of prototype ecological olive production systems (EOPS) in Crete

Proefschrift
ter verkrijging van de graad van doctor
op gezag van de rector magnificus,
dr. C. M. Karssen,
in het openbaar te verdedigen
op dinsdag 5 november 1996
des namiddags om 13.30 uur in de aula

The studies presented in this book were performed in the Festos area, on the western Messara plain, South Crete, Greece in strong co-operation with the Cretan Agri-environmental Group

P. O. Box 59,
704 00 MOIRES,
Crete,
GREECE

Kabourakis, E.

Prototyping and dissemination of ecological olive production systems: A methodology for designing and a first step towards validation and dissemination of prototype ecological olive production systems (EOPS) in Crete / E. Kabourakis. - [S.l.: s.n.].
Thesis Landbouw Universiteit Wageningen. - With ref. -
With summary in Dutch and Greek.
ISBN 90-5485-615-7
Subject headings: ecological prototype systems / multi-objective farming methods / set of parameters / agri-environmental group / Mediterranean; Crete; Greece.

TABLE OF CONTENTS

Acronyms

AB-DLO	Centre for Soil Fertility and Agrobiology-National Research Organisation
AUA	Agricultural University of Athens
FAO	Food and Agricultural Organisation
CAG	Cretan Agri-environmental Group
GEO.C.G	Geotechnic Chamber of Greece
ISPOT-NARF	Institute of Subtropical Plants and Olive Tree-National Agricultural Research Foundation
IVHF-NARF	Institute of Viticulture, Horticulture and Floriculture-National Agricultural Research Foundation
NRC	National Research Council
NRC "Demokritos"	Nuclear Research Centre "Demokritos"
SSF	State Scholarship Foundation
UNDP	United Nations Development Programme
UWA	University of Wales, Aberystwyth
WAU	Wageningen Agricultural University

Abbreviations

EE	Energy Efficiency
EEB	Environmental Exposure to Biocides
EII	Ecological Infrastructure Index
EIM	Ecological Infrastructure Management
EMCW	Ecological Management of Cover crops and Weeds
EMIP	Ecological Management of Insect pests and Pathogens
ENM	Ecological Nutrient Management
EOPS	Ecological Olive Production Systems
EWM	Ecological Water Management
FSO	Farm Structure Optimisation
II	Irrigation Index
KAR	Potassium Available Reserves
KB	Potassium Balances
KLR	Potassium Leaf Reserves
LR	Leaf Reserves
MB	Macronutrient Balances
MLR	Macronutrient Leaf Reserves
NB	Nitrogen Balances
NLR	Nitrogen Leaf Reserves
NS	Net Surplus
OMB	Organic Matter Balance
OMC	Organic Matter Content
PAR	Phosphorus Available Reserves
PLR	Phosphorus Leaf Reserves
PB	Phosphorus Balances
PI	Production Index
QI	Quality Index
QPI	Quality Production Index
SCI	Soil Coverage Index
SER	Soil Erosion Rates
TPSD	Target Plant Species Diversity
TS	Tree Species
TTI	Target Trees Index
TSI	Target Shrubs Index

List of Figures

List of Tables

List of Schemes

List of Maps

ACKNOWLEDGEMENTS

I would like to thank the growers of the Cretan Agri-environmental Group, and especially those of the pilot group and of the working groups. Their active participation in the research project made this book possible. Thanks are due to my supervisors Prof. Dr. E. A. Goewie (Wageningen Agricultural University) and Dr. P. Vereijken (AB-DLO) for adopting and supporting this pilot project, for their active personal support and encouragement, as well as assistance in all the stages of this project. Thanks are due also to them for assistance at the final stages of editing and producing this book. Thanks are due to the steering committee of the project consisting of:

Dr. I. Androulakis, Institute of Subtropical Plants and Olive Tree
Prof. Dr. K. Balis, Agricultural University of Athens;
Assoc. Prof. Dr. N. Beopoulos, Agricultural University of Athens;
Dr. G. Haniotakis, Institute of Biology, NRC "Demokritos";
Prof. Dr M. Karandinos, Agricultural University of Athens;
Assoc. Prof. Dr. L. Louloudis, Agricultural University of Athens;
for their assistance.

The assistance of Mr M. Kabourakis, Ms A. Vassiliou (University of Wales, Aberystwyth), Dr M. Loupasaki (Institute of Subtropical Plants and Olive Tree), Mr D. Karalakis (Institute of Viticulture, Horticulture and Floriculture), Dr. N. Michelakis (Institute of Subtropical Plants and Olive Tree), Mr V. Vardakis (Institute of Viticulture, Horticulture and Floriculture) are also acknowledged.

I am grateful to Dr. I. Androulakis, Dr. G. Haniotakis and Assoc. Prof. Dr. N. Beopoulos for checking the draft of the book and their useful comments and Mrs N. M. Green for checking the English language. Thanks are also due to Prof. Dr. N. Roling for fruitful discussions.

I am grateful to the Dutch bank RABO-BANK for helping me to finance the preparation of this book.

Finally, many thanks are due to the SSF, for financial support during the first two years of this study, Vardilogianion Idrima for financial support for nine months, and to my parents, Mrs T. Brinkman, and many friends who encouraged and supported me during the years of the study.

CHAPTER 1. INTRODUCTION

1.1 Background and motivation

The project described in this book emerged from motivation of several people and from social demands for development of a sustainable agriculture. The motivation for this project will be briefly presented with the project background.

1.1.1 Background

Several approaches and schools of thought propose methods for improving agricultural production (Altieri, 1995; Francis, *et al.*, 1990; Hatfield and Karlen, 1993; NRC, 1989; Pretty, 1995; Vereijken, 1994; Vereijken, 1995). One approach is technological which attempts to improve agricultural production through bio-technology and optimisation of industrial agriculture (optimising synthetic fertilisers, pesticides and agro-technology use). Another is the ecological approach that attempts to optimise agricultural production through optimal land use, optimisation of agroecosystem process, use of agroecosystem-based methods that combine technology (mainly machinery) and information, with minimum use of external and synthetic inputs to the agroecosystem. The ecological approach also attempts to make optimal use of human knowledge and management to combine agroecological, economic and social insights, leading to a broader knowledge system.

In line with the second approach a methodical procedure has been developed for prototyping arable farming systems (Vereijken, 1994; Vereijken, 1995). In our study we adapt this innovative methodical procedure for olive production systems.

The idea of this pilot project emerged during the author's studies in plant sciences at the Agricultural University of Athens. He chose the area - western Messara plain, Crete - as he was born and raised there on an olive farm. There he experienced the shortcomings of conventional agriculture and the degrading effects on the land of conventional farming methods, the environment and the rural society and economy. At the university he was taught technological agriculture, but also came in contact with different views on agricultural development and improvement. After the university he worked as an extensionist in plant protection of the groves in accordance with conventional practices and faced the shortcomings of these practices and of conventional systems. During an MSc study at Wageningen Agricultural University he studied different concepts of agricultural development and came into contact with a different research approach for ecological production systems and for prototyping production systems.

1.1.2 Motivation

In Wageningen the author became motivated to develop ecological olive production systems in interaction with pilot farmers, who shared this motivation. With them he developed the Cretan Agri-environmental Group which attempts to disseminate and share vision, thoughts and actions with other groups and consumers of the olive products.

1.2 Diagnosis of conventional olive production

Conventional olive production in the Mediterranean area is facing increasing agronomic, ecological and socio-economic problems (Allaya, 1988; Kedros *et al.*, 1988) as production methods are aiming at maximum yields whilst price subsides are being increasingly abolished by the European Union and Greece (Table 1). The major problems are related to their various causes, from the agronomic, ecological and socio-economic point of view. These problems are compared with the objectives of Ecological Olive Production Systems (EOPS) (see Chapter 3). They are interrelated and one cause is often related to more than one problems. Although there are indications and observations (Appendix 5) about these problems there is no monitoring and quantification of parameters related to them, in the project area or in Crete regarding olive production. Besides, we have found very few references in the literature with specific information on these problems, regarding olive production. The problems and their causes are explained in detail in the following agronomic, ecological and socio-economic diagnosis.

1.2.1 Agronomic diagnosis

Agronomic problems are mainly due to the monoculture of olive trees in large areas, the high intensity of external inputs, and the increased pesticide residues in the environment.

Pests and diseases influence both quantity and quality of the major products: olive oil and table olives. Monoculture of the olive trees, higher plantation densities, decreased biodiversity in the groves, and disturbance of the natural

Table 1. *Problems of conventional olive production*

Agronomic	*Ecological*	*Socio-economic*
wind and water erosion	depletion of groundwater	dependence on price subsides
decreasing soil fertility (biological, chemical, physical)	decreased biodiversity	low added value olive products
increasing pests and pathogens	levelled down landscape	decreasing incomes
increasing resistance of pests	contamination of air, water and soil with agrochemicals	high opportunity cost
increasing dependence on pesticides	environmental pollution with oil mill wastes	increasing financial problems of co-operatives
imbalances in beneficial entomofauna		toxic biocide residues in products
shortage of water for rainfed groves		health risks for growers and consumers
		abandoned olive production in mountainous and less favoured areas

processes enhances pests and makes their control more difficult and causes pathogen problems. Currently, synthetic pesticides and other biocides are extensively used, often with environmentally harmful methods, like aerial spraying over large areas causing serious imbalances in the beneficial entomofauna, environmental pollution by pesticide residues and health risks for growers and consumers (Alexandrakis, 1990). The severity of the effects depends to a large extent on the climatic conditions and the microclimate of the individual farm as well as on the cultivation practices. Inappropriate cultivation practices, irrigation and pruning aggravate the problems. In the Mediterranean countries there is a tendency to use of toxic substances in a more regulated manner, but methods that also include cultural practices and diversification of the groves are not yet used to a significant extent (Civantos, 1995; Delrio, 1992; Jardak and Ksantini; 1996).

Olive groves tend to be more susceptible to drought because of the poor soil structure (caused by intensive and inappropriate tillage and inappropriate machinery) and the decreasing organic matter levels, both of which limit infiltration of rainwater and water retention. Besides, physiological stress of the trees occurs due to inappropriate dosage and quantities of irrigation water and the decreasing organic matter levels (caused by increased mineralisation rates). Water supply in rainfed groves is suboptimal because of the inappropriate cultivation methods, nutrient imbalances, decreasing organic matter levels and low soil biological activity. These problems are expected to increase because no preventive or corrective measures are being taken.

Nutrient imbalances are increasing due to inappropriate nutrient management based on provision of macronutrients through intensive use of synthetic fertilisers, and to decreasing organic matter levels, decreasing biological activity, bad soil structure, and increasing erosion of the fertile top soil (Androulakis and Loupasaki, 1990; Gavalas, 1978; Kendros *et al.*, 1988). Besides, these factors worsen the physiological condition of the trees.

1.2.2 Ecological diagnosis

Large-scale olive grove monocultures are highly susceptible to wind and water erosion especially in the hills surrounded the plain (Yassoglou, 1971; CEC, 1992) due to reduced organic matter levels, bad soil structure, intensive irrational tillage, and removal of grove hedges and stone walls and in combination with the dry climate and droughts (Kendros *et al.*, 1988; CEC, 1992; Rubio and Rickson, 1990; Grove *et al.*, 1991).

The extent of irrigated olive groves has increased rapidly: almost all the groves are now irrigated. Consequently, ground water is being depleted as there is no control of the exploitation of water (GEO.C.G, 1993).

The intensification of synthetic inputs and the use of inappropriate cultivation practices have led to nature degradation and an unattractive landscape (Sfikas, 1989; Sfikas, 1992; Grove and Rackham, 1993; Naveh, 1993), while there are no measures to reverse the negative effects on nature and landscape.

With the spread of new technologies, industrialisation and concentration of the oil mills in limited areas, the environment is increasingly polluted by oil mill wastes (GEO.C.G, 1994; Leone, 1993). Besides, inappropriate water, nutrient and biocide management have caused ground water pollution with nutrients and pesticides (GEO.C.G 1990). As a result, standards of environmental protection have been enacted.

1.2.3 Socio-economic diagnosis

The olive oil industry due to the competition of vegetable oils and other fats, faces increasing economic problems which are partly overcome with subsidy on prices (Allaya, 1988; Kendros *et al.*, 1988; Malorgio and Geenghini, 1990). The opportunity cost of olive oil production is very high since there is competition between the olive oil sector and the very profitable tourist industry. The competition is not due to the demanded labour time (harvesting and other farm operations take place during non-tourist season), but to the land use and capital investment, especially in coastal and plain areas leading to the intensification of olive groves and to intensive use of inputs.

Olive growers' co-operatives are facing increasing financial problems due to inadequate management and marketing policy, and the lack of state structural policy for the olive sector. Thus, given financial aid favours the processing sector rather than the growers. The majority of exported olive oil, produced in Crete, is sold in bulk, due to the inadequate marketing of exports of the co-operatives and lack of promotion by the state. Thus, olive oil achieves lower added value and lower prices than it could, although its quality is of high standard. The financial problems of olive-oil producers are also due to the current economic situation, characterised by stable price per unit of olive oil and decreasing incomes, since the prices of inputs increase, although the total production and productivity have been increased. Additionally, growers' income is highly dependent on subsidies.

The quality of produce appears to be favoured by improved technologies of harvesting and processing the olives, but actually it is decreasing because of toxic residues of the biocides in the olive products (ISPOT/IOOC, 1980; Cimato, 1990; Civantos, 1995; Lenza, 1991). Besides, organoleptic characteristics and biological value of the produce appear to be reduced due to inappropriate ways of processing, like high extraction temperatures in olive mills and addition of synthetic substances (ISPOT/IOOC, 1991).

In mountainous and less favoured areas (like small islands), olive production is abandoned more and more, due to increasing production cost, and stable or decreasing income of the growers, urbanisation, competition of other activities, and absence of supporting infrastructure, resulting in socio-economic deterioration in these areas (Kendros *et al.*, 1988).

The above problems are caused by the absence of a state structural policy in recent decades; production was intensified and boosted through increasing external inputs, mechanisation and high density planting, instead of investment in agroecosystem-improvement. As a result, as the agricultural modernisation progressed, agroecological principles in olive growing were gradually abandoned (see also Appendix 5).

1.3 Innovation of olive production

The diagnosis of problems faced in Messara plain stresses the need of innovation, for a long term improvement of olive production. A first step to advance olive production is to ecologise the primary production and land use and to re-establish an ecological knowledge system for the olive growers. Although traditional olive growing offered an ecologically sound and sustainable model, it is neither profitable nor attractive to the olive growers under current conditions. This is because (a) traditional agriculture was too labour intensive and laborious, with few possibilities of changing the land use or manipulating the environment resulting often in very low output; (b) was based on a self-sufficient closed economy, very difficult to integrate with the market; and (c) was based on knowledge system, which does not exist any longer. Therefore, innovation should be targeted. The strategy for this innovation should have two stages: in the first stage the olive production is prototyped and the ecological knowledge system is introduced in the research area (Figure 1). During the second stage the prototypes is optimised and widely disseminated in a border regional scale. In this book the first stage and the initial results are presented.

1.3.1 Objectives

The main objective of the research is to design and to establish area specific prototypes of Ecological Olive Production Systems (EOPS) based on a new prototyping methodology (Vereijken, 1994; Vereijken, 1995) and on an ecological knowledge system. Main objectives are: (a) to improve sustainability and stability of olive production and (b) to improve growers' perspectives and regional development.

Figure 1. *Stages in the innovative project for ecological olive production in Crete*

Date	*Conversion and formation of a pilot group*	*Prototyping*	*Thesis table of contents*
1/7/92	discussion of shortcomings of conventional agriculture raising interest among growers	diagnosis of conventional olive production	chapter 1
1/7/93	selection of interest conventional farmers discussing conversion to current ecological agriculture (EU guide-lines and label)	hierarchy of objectives selecting parameters establishing methods & techniques	chapter 3 chapter 4 chapter 5
1/1/94	establishment of Cretan Agri-environmental Group	designing a theoretical prototype	chapter 1 chapter 5
	first year of conversion to current ecological agriculture (EU guide-lines and label)	developing parameters developing methods & techniques	chapter 4 chapter 5
1/1/95	formation of a pilot group within Cretan Agri-environmental Group	continued developing parameters, methods & techniques	chapter 1 chapter 4 chapter 5 chapter 7
	second year of conversion to current ecological agriculture (EU guide-lines and label)	designing variants of the prototype for any pilot grove	chapter 5 chapter 6
1/1/96	initial lay out of the prototyping by the pilot group end of conversion to current ecological agriculture (EU guide-lines and label)	initial testing and improving of the grove variants	chapter 7 chapter 8
1/7/96			

A number of objectives are related to achievement of the main objective and elimination of the olive production problems. The first was to make a hierarchy of long term objectives for EOPS, based on the long term priorities of the farmer's community and the agroecological features of the area. The second step was to select, design and initially quantify a set of parameters and to establish a set of farming methods and techniques for quantifying and achieving the EOPS objectives. The third step was to design a theoretical prototype and farming methods in its context. The fourth step was to test the EOPS prototypes initially on-farm in co-operation with a pilot group of olive growers. The fifth step was to introduce and to re-establish an ecological knowledge system for establishing and disseminating the EOPS prototypes in the area and in the region of Crete. In following section those steps are translated into a methodological pathway for designing farms desired.

1.3.2 Methodology

The five methodological steps used in prototyping arable farming systems (Vereijken, 1994; Vereijken, 1995) were used for the interactive prototyping of Ecological Olive Production Systems (EOPS). These methodical steps are:
(1) make a hierarchy of general and specific objectives for the prototypes
(2) transform the major objectives into multi-objective parameters to quantify them and establish the multi-objective methods needed to achieve the quantified objectives
(3) design a theoretical prototype by linking parameters to methods and design the methods in this context until they are ready for initial testing
(4) test and improve the prototype in general and the methods in particular until the objectives as quantified in the set of parameters have been achieved
(5) disseminate the prototype by pilot groups and regional networks

Introducing and re-establishing an ecological knowledge system (Roling and Jiggins, 1996), for facilitating the dissemination of prototypes in area and regional context, implies three methodical steps:
(1) form a pilot group for the interactive prototyping and the introduction of the ecological knowledge system
(2) form an agri-environmental group facilitating the dissemination of the prototypes and transition to an ecological knowledge system in the area
(3) form a network of satellite groups of the agri-environmental group facilitating the dissemination of the prototypes and re-establishing an ecological knowledge system in a regional scale.

1.4. Scientific basis of conversion from conventional to ecological production

This book presents results obtained from on-farm research about conversion from conventional to ecological olive production systems. Prototyping with emphasis to introduction of ecological production systems and conversion from conventional to ecological production was at the centre of research which might give cause for complaint about scientific validation of designing the parameters involved. Indeed, parameters, quantifying objectives achieved by farming methods practised by the farmers, should be sound and solid for reasons of on-farm research and interaction with the farmers. Otherwise, even if scientifically sound, parameters might not be understood by farmers. However, there is a difference between studying and trying to explain natural phenomena by means of scientific experiments and doing on-farm research with farmer's participation accepting it as being the best feasible for their farmers. On-farm research results might originate from scientific experiments as well as from experiences and knowledge of farmers of their production sites.

In the study presented in this book development of ecological production systems through upgrading conventional farms to ecological ones by means of farmers' support was the first priority. Therefore it was not of primary importance to use and to know how far some designing parameters were validated in a sound scientific way. But, it was of primary importance how far on-farm quantification of certain designing parameters were understood by the farmers and how far parameters were quantified the objectives, setting up in interaction with the farmers. Parameters that are not scientifically validated but are easily understood by the farmers are provisional. They are important in achieving production systems that have more sustainable objectives achieved by self-mobilisation of participating farmers. Designing of prototype systems, which is constituted by sequential designing cycles, might bring participating farmers directly, faster as well as closer to (scientifically sound and approved) aims concerning ecological production systems, than experimentally validated data might do. Obtaining more and more precise figures on soil erosion or the best yardstick for biodiversity within a farm could fill libraries without any effect on practical farming methods.

The methodology used by the European Union (EU) research network for designing ecological arable farming systems (Vereijken 1994; Vereijken, 1995) as adapted and applied in Crete brought a lot of farms moving towards better ecological disposition of olive groves. Further, it upgraded present farmers' co-operation and their role in production. Consequently, conversion towards ecological production did not start only on-farm but also "between the ears" resulting in self-motivation. That very first result and step towards conversion to ecological production systems seems to be of major importance since only self-motivation of farmers maintains movement toward conversion.

The conversion from conventional to ecological production systems indicates that the designing methodology of the EU network also works in less advanced areas, where farmers have fewer opportunities for learning from a sophisticated agricultural knowledge information system. Scientifically validated parameters in the designing process for ecological olive production systems (EOPS) were applied when possible. Besides, criteria like "does it work" rather than "is it completely scientifically validated" were equally important, as parameters were new and applied for the first time in olive production.

1.5 Networks

1.5.1 Agri-environmental group for conversion and dissemination

The Cretan Agri-environmental Group (CAG), foundation registered (567/94) in Iraklion (Crete), is an agri-environmental non-governmental organisation. It was established in the project area in 1993 by growers involved or interested in the pilot project. Its members can be farmers, researchers, farm advisors and consumers. Until now the 25 member-farmers, are involved in farming, at least part time. CAG in accordance with its constitution is governed by an elected board. It has a simple organisation with direct participation of its members in the monthly or otherwise organised assemblies for taking decisions. It maintains special units and working groups related with special topics. It is related to national and international networks associated with its aims. CAG at present acts as an example to individuals and interest groups in other areas of the region. These interested groups will be the future satellite groups to disseminate prototype systems, new agro-technology and agroecosystems management in the future (see Chapter 7). Thus, CAG may develop into a main innovative farmer's organisation to create a new knowledge system (Roling and Jiggins, 1996) in the region. The success of dissemination of this knowledge system will be dependent on the improvement of CAG's organisation and creation of a regional network of satellite groups (Figure 21). CAG constitutionally aims at (see also Appendix 1):
(1) promotion of ecological farming methods and ecological food systems;
(2) marketing of the ecological products under label;
(3) protection of local agroecosystems, nature and landscape;
(4) research and development of local agroecosystems;
(5) support of regional agri-environmental policy and education;
(6) promotion of local eco-agrotourism.

The CAG facilitates two aspects of the innovative pilot project. The first is conversion of farms to current ecological agriculture (European Union (EU) guidelines and label). The second is dissemination of prototypes in the area of Faistos and around Crete.

CAG acts as a platform for the co-ordination of production and as a central point for providing information to farmers. CAG facilitates the conversion of farms to current ecological agriculture by introducing and educating the farmer's community in the new agroecosystem management methods and the related agro-technology. Conversion requires new management skills and agro-technology. CAG is the central point for interactions and activities related to these skills and agro-technology. Besides, it co-ordinates processing, storage, packaging and marketing of the new ecological product in line with EU standards for organic products. Further, CAG acts as co-ordinator between farmers and institutions related to the inspection and certification concerning the EU standards and label. CAG provides an organisational and legal framework for the farmers and participates in information networks related to the current ecological agriculture.

The second aspect of the innovative project that CAG facilitates is the dissemination of the new way of agro-ecosystem management, the related agro-technology and of the prototype systems in area and region. Those are achieved through demonstration of the farms and of the research results in the rural community. Besides, CAG organises seminars for new members joining the group. It participates in and organises lectures and seminars in other areas of the region. Furthermore, it participates in meetings and congresses related to its constitutional aims. CAG members write articles, give interviews and join in mass media discussions.

1.5.2 Pilot group

The pilot group, the core group of CAG, introduces farmers and the farming community in the new way of thinking and agro-technology, by demonstrating in practice how these may succeed. Besides, it leads to the creation and dissemination of production, processing, packaging and fair trade standards for the CAG.

Prototyping at pilot farms avoids agro-ecological, agronomic and economic distortions when prototyping at an experimental farm occurs. Besides, it saves time and money, as prototyping at an experimental farm always requires continuation of testing and improvement on pilot farms (Vereijken, 1994). Other advantages of prototyping at an experimental farm are (Vereijken, 1995):
(1) The new objectives of the prototype are integrated with the current objectives of a group of farms. Only in that way the new objectives do become economically acceptable in various farm situations.

(2) The new methods of the prototype are integrated with the current methods of a group of farms. Only in this way the new methods do become practically manageable in various farm situations.
(3) The new methods of the prototype are tested and improved in cohesion with the management of a group of farms.

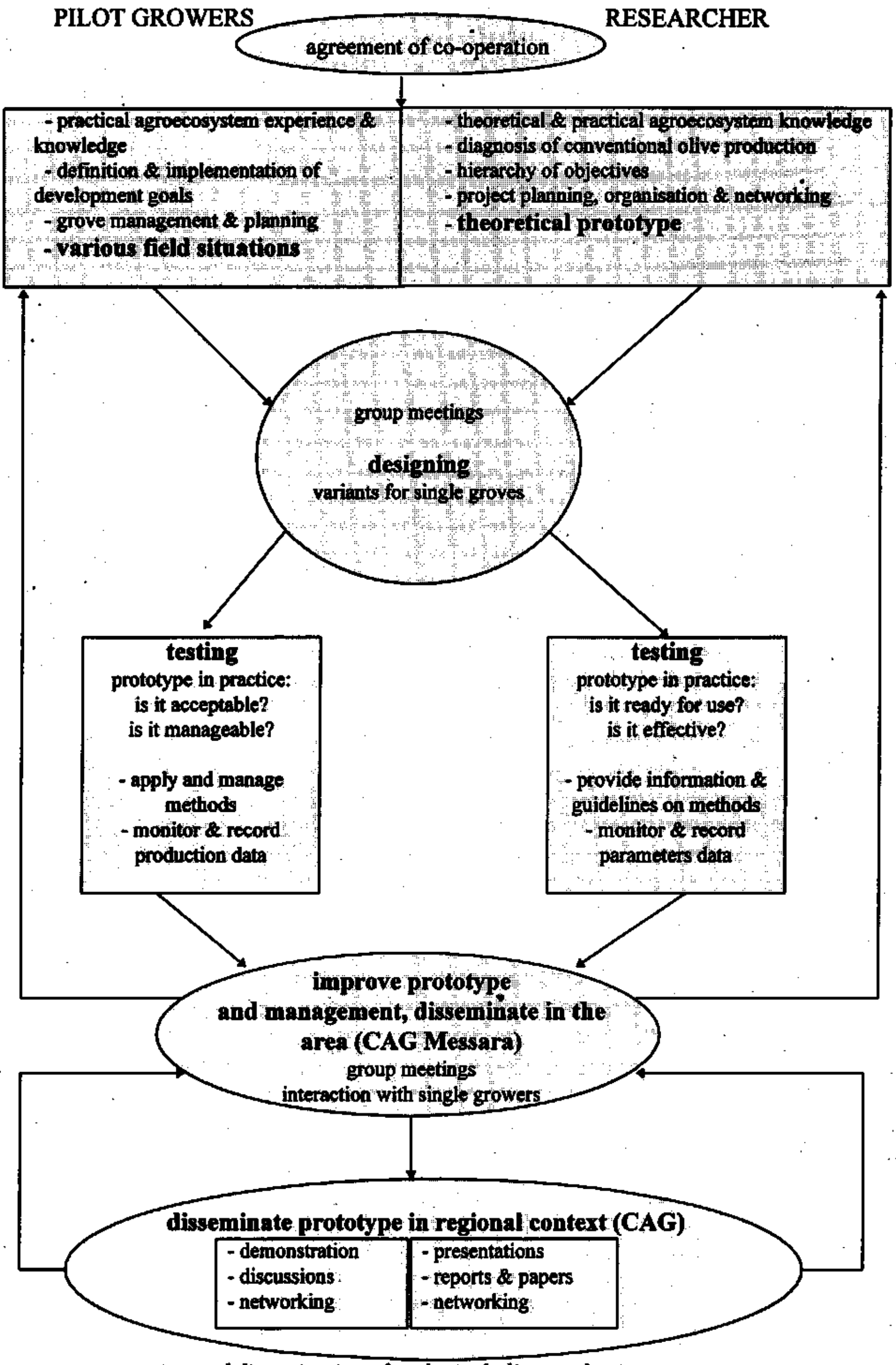
Furthermore, prototyping in pilot farms provides an ideal setting to come to the required knowledge system for production, adoption and use of new agro-technology, as all the social actors are involved.

In the pilot project for ecological olive production the entire methodical way of prototyping olive production and introducing an ecological knowledge system is done by interaction (Figure 2) of a pilot group of twelve olive growers with researchers, in a scheduled way. The pilot group applies and develops the designed methods and registers the parameter related data, that quantify the objectives of the prototype. Besides, it interacts and diffuses methods and information to the rest of the farming community.

Interaction with the farmers' community and the pilot group commenced from the beginning of the project by the establishment of objectives for a prototype in the area (see Chapter 3) and the design of variants for single groves (see Chapter 5 and 6), the improvement of prototypes and management (see Chapter 6) and the dissemination of the prototypes (Figure 21). The entire development and transfer of new agro-technology is based on this interaction.

Potential members of the pilot group were determined using experiences and acquaintances from previous work as farm advisors in the area. At the beginning of the project it was informally announced to social actors of the area with whom there were social contacts and they spread it further through their contacts. Growers who showed interest in participating in the proposed research project were contacted. The research project and the general principles of production, the challenges and probable problems of the proposed new production system were discussed with them. In those discussions their questions and their considerations were recorded and optional answers were discussed. At the end of that round of discussions a selection of growers who could satisfy criteria (Scheme 5) and could be partners in the project was made. In a new round of discussions with the selected growers, they were asked if they could apply the proposed cultural practices in their groves, could satisfy the standards of Regulation (EC) 2092/91 and had a representative grove meeting about the criteria for a pilot grove (Scheme 4). Then a final selection of thirteen pilot growers and eighteen pilot groves was made. Those were the growers who had no doubts about joining the project and could meet all our criteria. Growers who had doubts or researchers had doubts about their participation were left with the possibility of joining the project at a later stage.

Figure 2. *Interactive prototyping and disseminating EOPS in Crete: designing, testing, improving and disseminating a prototype, by interaction of pilot growers and researchers*
(Based on Vereijken, 1995)



Pilot growers were interviewed on their current cultivation practices (see Appendix 5). Meetings were held with the selected pilot group for discussing the prototypes and the project (see Chapter 3, Chapter 4 and Chapter 5)

1.6 Conclusions

Diagnosis of conventional olive production problems (Table 1) shows that they should be eliminated in the future. A solution may arise from interactive, innovative prototype projects. It is difficult and costly to monitor the problems precisely and cleaning technology for environmental pollution is costly too. The development of ecological olive production is important as the general public is increasingly concerned about the safety of its food and the importance of the environment and landscape. Besides, there is increasingly demand for methods more benign to the environment and more sustainable, better and safer for farmers and for products, and healthier for consumers. Furthermore, currently the public realises that there is a cost associated with food quality (including chemical residues, organoleptic characteristics and nutritional and biological value), and with a wholesome environment (including a pleasing landscape, contamination-free surface and ground water, and clean air). The degree of elimination of problems should be related with the development of methods that do not continue and prevent them and the gradual development of an ecological knowledge system.

A pilot group of olive growers is required to lay out and test the designed prototypes. Ecological olive growers are suitable partners as their production should meet strict environmental and quality of production norms and is marketed under label (CEC, 1992; IFOAM, 1992). For this reason all the pilot group members have been converted to current ecological agriculture (organic farming), following the prototyping methods (see Appendix 3). Production and marketing of products with high added ecological value under label seems to be the only sustainable solution as it implies shared responsibilities of rural and urban populations, for environment and nature. The prototypes can be tested and improved by co-operation with the ecological pilot growers. They address the actual shortcomings of the prototypes applying them in the realistic situation of their farms. Besides, using the prototypes they contribute with their knowledge and experience to the solution of these shortcomings, blueprinting solutions. Ultimately, prototypes can be widely disseminated by a regional agri-environmental group. The pilot group acts as the core of this community based agri-environmental group (Figure 21). The challenge will be to link with pilot groups of the satellite groups of the CAG and to disseminate prototypes, agro-technology and management skills successfully.

The main objective of the study is to design and initially test, improve and disseminate prototypes of ecological olive production based on more efficient use of agroecosystem resources, while taking care of nature and the environment. Unfortunately, there are no other projects ongoing in Europe for integrated or for ecological olive production. So, scientific orientation is confined to the EU network for Integrated and Ecological Arable Farming Systems for prototyping methodology (Vereijken, 1994; Vereijken, 1995). Furthermore there are no other projects in Europe combining interactive prototyping with the creation of required knowledge system for the farming community. The EOPS prototypes should contribute to a balance between agriculture and tourism and to the sustainable development of the island. Contrary to conventional systems, they should preserve the environment, nature and landscape,. This is particularly important as the unique beauty of the island, due to the variety of its landscape and the high quality of its natural environment, is the main basis of tourism in combination with the climate and unique monuments of the Minoan civilisation. Besides, marketing the EOPS marketing under label, to certify the added ecological value will contribute to the rural development.

The research that is described in this book deals mainly with the primary production, which should be integrated with research on other levels of production. Besides, research should be continued to the optimisation of the prototypes and wider dissemination on regional scale. Without this the impact of the project for the region will be limited.

CHAPTER 2. REGION OF THE PILOT PROJECT

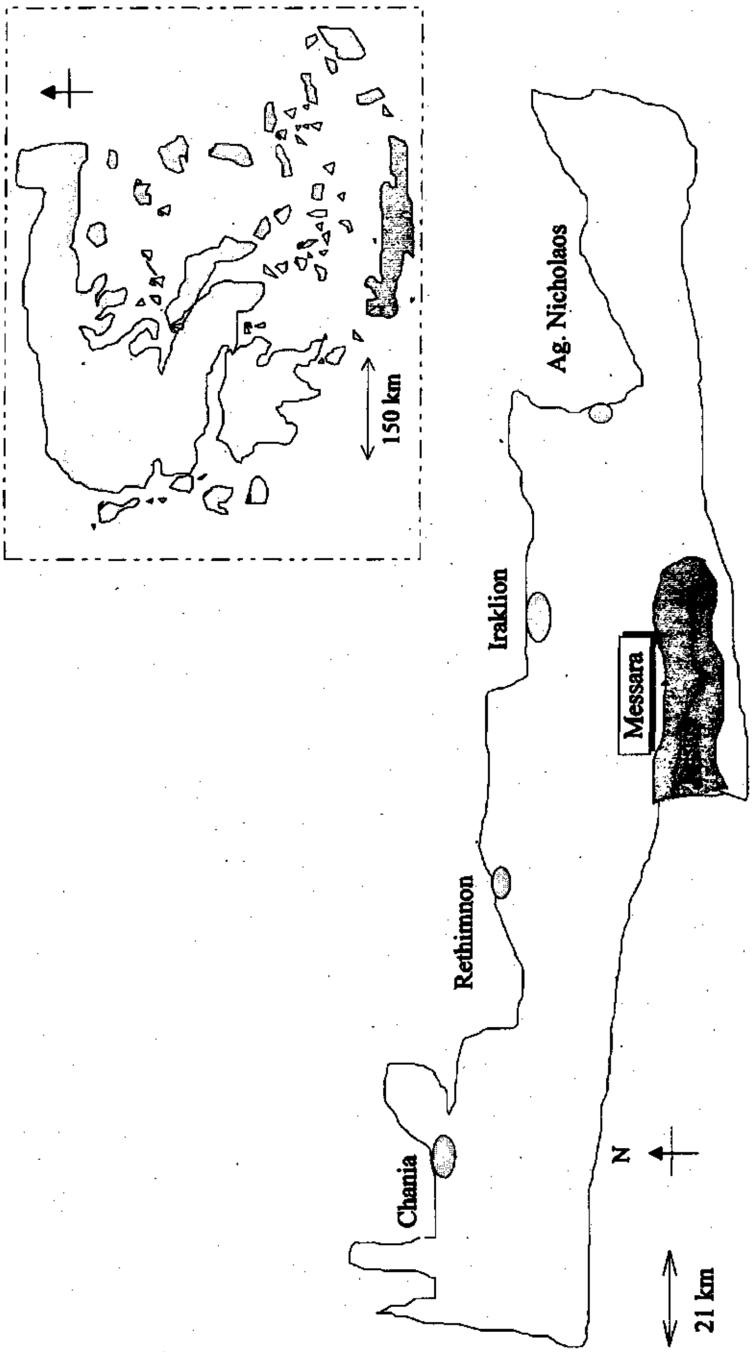
2.1 Geographic characteristics

The prototype groves are located in Faistos area, at the western Messara plain, South Crete, Greece (Map 1). This region is typically semiarid where olives have being cultivated for thousands of years (Anagnostopoulos, 1951). Crete is the southernmost point in Europe and the fifth largest island in the Mediterranean, covering an area of 833,100 ha or 6.31% of the total area of Greece. It is located from 23° and 30' to 26° and 19' longitude and between 34° and 41' northern latitude. It is 260 km long and 12 to 61 km wide. The island constitutes the remains of the high, curved spine which, during the first half of the Tertiary Period, extended from Epirus in the north-west of the Greek mainland down to the island of the Rhodes and the Taurus mountains in southern Turkey. Almost all the area of Crete is occupied by mountains and hills so that only 10% is made up of plains or valleys, with only 316,000 ha agricultural area. The highest mountains are: White (Leuko) Mountain (2,452 m), Ida (2,456 m), Dicti (2,148 m) and Sitia Mountain (1,451 m).

Messara is the largest plain in Crete (Map 1). It lies in southern central Crete (department of Iraklion) and consists of a narrow stretch of land, running from east to west, approximately 50 km long and an average of 6 km wide, with an area of 35,800 ha. It is bounded to the west by the sea to the north by the foothills of the Mount Ida (highest point: 2,456 m), to the south by the Asterousia mountain chain (highest point: 979 m) and to the east by the foothills of the Dicti mountains. Lying between two stretches of high ground to the north and south, the Messara plain resembles a long corridor.

2.1.1 Geology and soils

The Messara plain is an alluvial plain mainly composed of quartenary deposits, bordered to the north by a hilly area of silty-marley neogee and by schist and limestone formations to the south (Mesozoic rocks of the Asterousia mountains). The large limestone massif of Mount Ida, which dominates the island from its centre, has practically no hydrological relationship with the Messara plain. The plain is the lowest zone of a graben structure which also comprises the hilly area to the north. The local existence of major north-south and west-east running faults and frequent north-east south-west and north-west-south-east faults has been verified. Due to the large number of tectonic movements, the depths of the different formations vary greatly from place to



Map 1. ***Map of the pilot project region***

place. This geological complexity is revealed by borehole profiles. The groves in the plain are located on recent alluvial soils and the groves on the hills on soils of recent alluvial terraces, belonging to the order of Entisols (Yassoglou, 1971).

2.1.2 Climatic patterns

The climate is semiarid, classified as a subtropical Mediterranean climate (Papadakis, 1975).

General characteristics

Crete possesses the general characteristics of the Mediterranean climate: windy, mild, wet winters and relatively calm, hot dry summers. In comparison to other parts of the Mediterranean, however, its climate is influenced by two factors which cause slightly different conditions than those usually associated with the term "Mediterranean weather". One factor refers to the fact that the Mediterranean, seen as a whole, is well protected against cold polar or arctic masses by the mountain ranges to the North. There are only four gaps in these mountain ranges, through which cold, shallow air masses from the north can enter the area: the Garonne-Carcassone gap, the Trieste gap, the Vardar gap and the Dardanelles. Between the last two of these gaps and Crete, there is a relatively short distance of more or less open sea; so that the island is more exposed to the cold continental air masses than are most other places in the Mediterranean area. The second factor concerns Crete's situation at the cross roads of the two major Mediterranean cyclone tracks: the polar front disturbances (cyclones originating in the North Atlantic or the Gulf of Genoa) and the Mediterranean front disturbances (cyclones originating in the Sahara desert). Those two factors combined, produce different wind conditions and slightly modified temperatures, whereas the precipitation varies from high values in the western part of Crete to those which follow the general pattern of the central and eastern Mediterranean in the central and eastern part of Crete.

In the Messara plain climatological characteristics are essentially the same as for Crete as a whole. Seen in more detail, however, there are local effects by which certain specific aspects of the Messara climate can be identified i.e.: in summer, the very frequent occurrence of strong, hot and dry ravine-type (katabatic) winds from the north; in winter, going from west to east along the plain, the rapid change from a maritime to a slightly continental type of climate.

Precipitation

The average annual precipitation on the Messara plain is approximately 600 mm (Figure 3). The southern part of the plain which is partly formed by the foothills of the Asterousia mountains, lies in a kind of rain shadow. For this

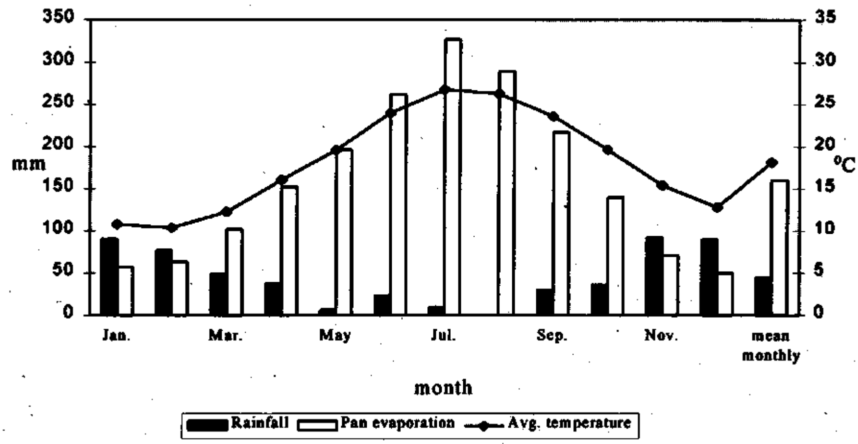


Figure 3. *Climatic data of western Messara plain*
(1983-1993 data from Gortis meteorological station)

reason the precipitation is consequently somewhat lower (500 - 600 mm) than the northern part of the plain (520 - 650 mm).

On the mountains surrounding the plains, precipitation increases rapidly with elevation, reaching 2,000 mm, 1,700 mm and 1,100 mm respectively on the Ida, Dikti and Asterousia mountains. Precipitation is concentrated in the winter months. Monthly precipitation is presented in Figure 3 over the period 1983-1993.

Evaporation

The average Class A pan annual evaporation is around 1,700 mm. January and February, which are the months with the lowest potential evaporation, account together for 5.5 per cent of the total annual potential evaporation. The corresponding figure for the two months with the highest potential evaporation, July and August, is 36 per cent. In Figure 3 Class A pan evaporation data are presented. Figure 3 clearly shows that there is a need to minimise water losses during the period April to October. Besides, in dry years and high production levels, irrigation is necessary for most crops during this period. A further discussion will be continued in Chapter 5.2.4 regarding ecological water management.

Temperature

Average monthly temperature in the Messara region varies between a maximum of about 25°C in July-August and a minimum of about 10°C in January-February.

2.1.3 Vegetation and animal life

A relatively large number of mammals, around 30 or 1/3 of the mammals occurring in Greece, has been identified in Crete and the surrounding sea. The number of birds is similar to those of other regions of Greece. The number of birds and mammals, best studied species, is reduced rapidly in Crete and Messara plain, while for other taxa groups sufficient data are lacking (Sfikas, 1989). This is due to destroyed and polluted biotypes, irrational hunting and irrational use of biocides in agricultural production. Biotypes in western Messara plain have seriously been disturbed or destroyed due to irrational and inappropriate expansion of drainage works, irrigation networks, and of agricultural land. All these have transformed the rainfed Messara plain into an irrigated plain. The western wetland part dried, while irrational intensive use of agrochemicals continuously increase (see also Chapter 1.2). The western wetland part of the Messara plain was particularly important, as it was an intermediate resting place between northern Africa and Europe for migratory birds.

It has been estimated that, subspecies not included, about 2000 species of the higher plants occur on Crete (Sfikas, 1992). Notwithstanding the richness of flora in Western Messara plain and surrounding hills, most species, especially endemic ones, have become extinct to a large extent by disturbance and distraction of ecological niches. Disturbance and distraction occurred on a large scale by construction of urban areas, of roads and levelling of landscapes, favouring production sites. The entire plain has been cultivated by now, but the process towards further expansion still continues.

Among animals and plants of Crete many there are endemic species or subspecies that are unique world-wide (Sfikas, 1992). As regards the plants it has been estimated that there are 210 species and subspecies out of the circa of 700 Greek endemic species, and of these some 160 are exclusively endemic to Crete. These constitute 44% of all the endemic plants of the Aegean islands. The endemic species and subspecies of snails (molluscs) come to 60% of the total number of species on Crete (90 out of total 150); 42% in the case of Coleopteran (18 out of 43); and, finally, 10% of all the butterflies are endemic (Sfikas, 1992). Many endemic species occur in the hills surrounding the plain, especially the southern ones (Sfikas, 1992).

2.1.4 Agroecological characteristics

Today the island of Crete is a typical example of man's multilateral over-exploitation of natural vegetation and animal life. Because of the rough topography of the island and the comparatively limited space of arable land, man was forced to implant himself closely within the natural vegetation and to make maximum use of it since early times. Although, this for many periods was done in a fine partnership with nature, this is not the case nowadays (see Chapter 1.2).

Figure 4 simply summarises agroecological characteristics of the project area. Two agroecological zones will be represented: the plain zone and the hilly zone. These zones posses different types of soil and microclimatic conditions, caused by topographic differences.

In the hills surrounding Messara plain during millennia the most valuable and palatable pasture plants, mainly grasses and legumes, have been reduced in distribution and amount or altogether exterminated by grazing animals. They have mostly been replaced by ruderal and unpalatable plants. With time the vegetation in many stretches has become overgrazed and antipastoral.

In the surrounding hills, forests are absent and there are only, at most, some individual trees to testify to arboral plant communities in the past. Side by side with stunted specimens, one encounters handsome trees which have been left for shade or for other reasons.

Four species of wild fruit trees occur at present in the hills around the Messara plain. Those species deeply influenced horticultural history of the island. These species are *Olea europea* var. *oleaster* (wild olive tree), *Ceratonia siliqua* (carob tree), *Amygdalus webbii* (wild almond) and *Pyrus amygdaliformis* (wild pear). The most important among them is the wild olive tree which has been exploited both in its natural state and after being grafted. Even at present, when centuries old olive trees are daily uprooted to be replaced with intensive orchards, one finds among the stretches of the olive groves wild, wild grafted and purely cultivated varieties mixed with one another. There are also grafted and wild carob trees growing side by side, but they become more and more rare. The wild almond is less and less used as a stock for cultivated almond varieties. More common, but also becoming more and more rare, is the wild pear which is distributed wild and partly grafted with the common pear.

The main crops today in Messara plain are olives and vines (Figure 4). To a lesser extent one finds cultivated citrus and horticultural crops, mainly off-season cultivated in hothouses (greenhouse mainly covered with plastic). To a very small extent there are cultivated arable crops (cereals and legumes) and forage crops. Figure 5 represents agroecological characteristics and water use of olive production sites in and around the Messara plain.

	southern hilly groves	*plain groves*	*northern hilly groves*
Soil:	terraced entisols stony, calcareous, sandy loam, sandy clay loam	alluvial deposits sandy clay, clay loam, loam, sandy loam	
Water:	rainfed, drip irrigation	irrigation: drip, sprinklers	
Micro-climate:	moderate cold winter moderate cool summer higher rainfall	cold, frosty winter dry summer lower rainfall	
Vegetation:	high flora diversity	low flora diversity	
Animals:	many species of fauna	few species of fauna	*similar to southern hilly groves*
Crops:	olives, vines, prunes, wheat, vetch, water melon	olives, vines, citrus, hot house cucumber, tomatoes, water melon, pepper, strawberries, outdoor vegetables, pasture vetch, roses, cornflowers	
Livestock:	goats, sheep grazing	cows pastures	
Land use:	extensive	intensive	
Problems:	eroded poor soil water shortages	decreased biodiversity (see Chapter 2.1.3)	
Opportunities:	improve soil fertility extend rational irrigation conserve diversity	maintain soil fertility rationalise irrigation increase diversity	

Figure 4. *Transect of agroecological zones in western Messara*

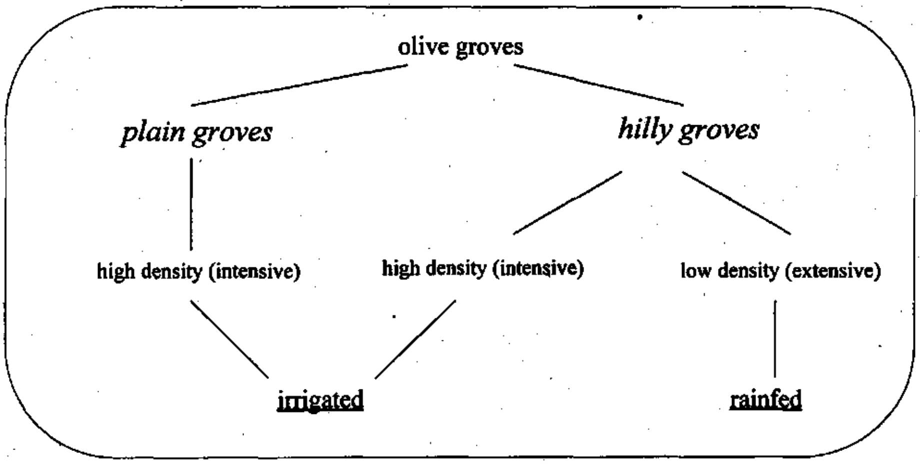


Figure 5. *Schematic characterisation of olive groves at the western Messara plain*

Animal production is concentrated in the hills surrounding the plain. Mainly goats and sheep graze in extensive pastoral systems.

Today, a typical farm in western Messara consists on the plain (mainly vineyards and olive groves and in few cases citrus orchards and horticultural gardens) and hilly fields (mainly olive groves). A scheme of such a farm is presented in Figure 6.

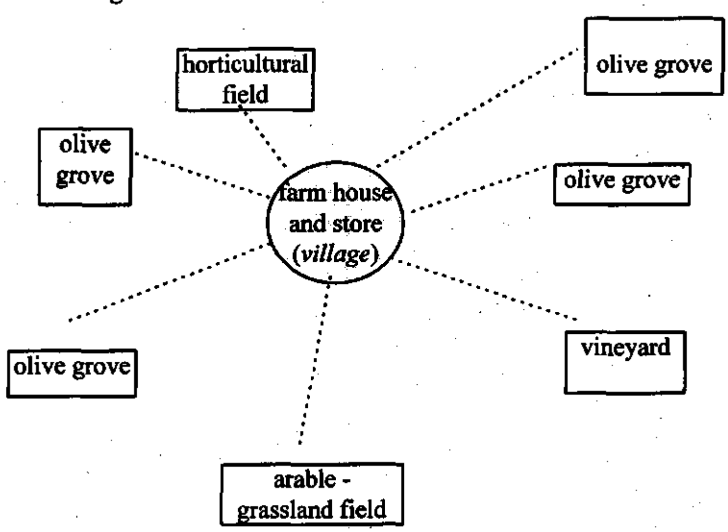


Figure 6. *Schematic characterisation of a typical farm at western Messara plain*
(fields are scattered in the area around the village)

2.1.4.1 Plain groves

The majority of plain groves are new plantations (Figure 5). They have been planted the last three decades as in the past a part of the western Messara was wetland, inappropriate for olive cultivation. The rest of the Messara was assigned to arable crops and vines, because of its dryness during summer, its fertility and of demand for these products. The reproduction cycle of olive and cultural practices are similar with those in hilly groves (Figure 7). At plain olive groves the "*Koroneiki*" variety is mainly cultivated for olive oil production. "*Koroneiki*" is the most suitable variety for high density groves.

Microclimate of the plain is wet with less rainfall and lower temperatures during winter than the surrounding hills (Figure 4). Besides, frost may occur late in winter and early in spring because of the cold north wind coming from Mountain Ida. During the summer the microclimate is dryer with higher temperatures than the hills.

Plain groves are cultivated on deep fertile soils (see Chapter 2.1.1). Irrigation is required for boosted yields, as water is the main limiting yield factor during dry summer months (FAO, 1972). Due to ever increasing needs for water irrigation, water resources are overexploited in Crete. It is urgent that water conserving practices be developed (see Chapter 5.2.1 and 5.2.4).

Wild vegetation and animals have almost completely disappeared from plain and groves because of intensive land use and of high synthetic agrochemical inputs. Biodiversity should be increased for minimising negative side effects of agriculture, pest outbreaks and for maintaining an attractive landscape (see Chapter 5.2.3 and 5.2.5).

Regarding cultivation practices, cover crops in plain groves have the same sowing and reproduction cycles as the ones in hilly groves (see also Chapter 5.2.1). Fertilisation takes place at the same period in both groves, but fewer amounts of fertilisation materials are required in hilly because of soil fertility (see also Chapter 5.2.2). Irrigation starts earlier and extent longer in plain than in hilly groves because of dryness and lower rainfall (see Chapter 5.2.4). Regarding plant protection, the olive fly and scales have similar reproduction cycles in both groves. However, first summer generation of the olive fly appears slightly earlier on the plain than in hilly groves, because of the microclimate (see Chapter 5.2.5). Harvesting and pruning is performed on similar dates in both groves.

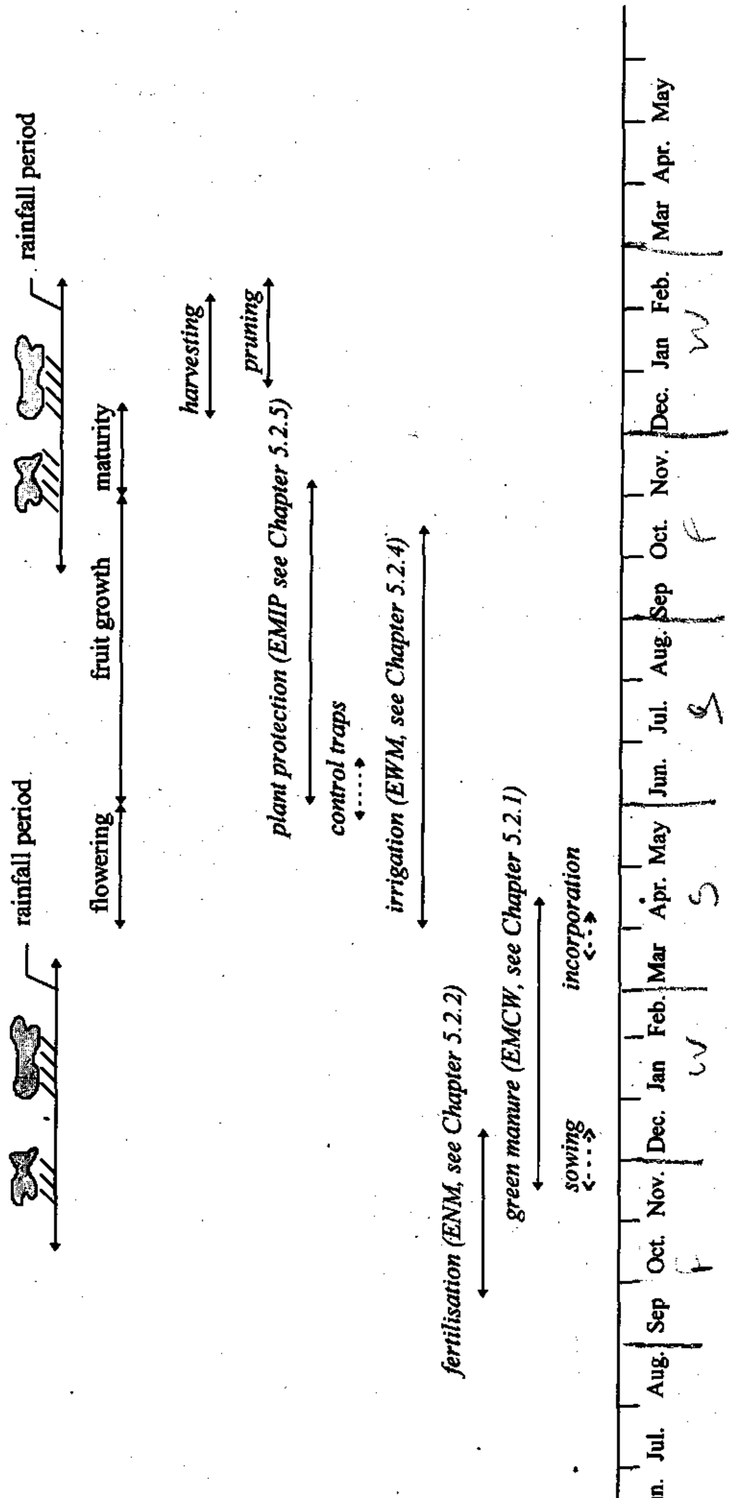


Figure 7. *Reproduction cycle of the olive tree and the timing of cultural practices in Ecological Olive Production Systems (EOPS)*

2.1.4.2Hilly groves

A large portion of hilly groves are old low density (extensive) plantations (Figure 6), while the rest are young high density plantations, often irrigated, similar to the plain ones. Usually levelling earthworks are done without care before the plantation of high density groves, which destroy natural habitats, resulting in increased soil erosion (see Chapter 1.2). Low density hilly groves are cultivated with "*Throubolia*" (or "*Hondrolia*") variety for olive oil and table olives and the high density with "*Koroneiki*", mainly variety for olive oil, as in the plain groves.

The microclimate of the hills is mild with higher rainfall and higher temperatures during winter than the plain (Figure 4). During summer it is cooler and with lower temperatures than the plain.

Hilly groves are cultivated on eroded soils (see Chapter 2.1.1). Irrigation is the necessary input for boosting yields, as water is the main limiting yield factor during summer months. Although the required amount is often lower than the plain groves, water conserving practices should be developed to cope with the over-exploitation of the water resources, due to ever increasing needs for irrigation water (see Chapter 5.2.1 and 5.2.4).

Wild vegetation and animals occur mainly in uncultivated rocky land and small natural areas of the hills where there are more species and higher diversity than the plain groves. Biodiversity should be conserved for minimising negative side effects of agriculture, pest outbreaks and for maintaining an attractive landscape (see Chapter 5.2.3 and 5.2.5).

2.2 Socio-economic characteristics

In Crete 51 % of the total labour force is employed in agriculture compared with 22.2% at the national level (CPER, 1991). In contrast to other islands and coastal Mediterranean regions, there is still a balance between growth in the primary (agricultural sector) and tertiary sectors (services, tourist industry). On the other hand, this balance becomes unstable as investments are currently geared towards the tourist sector. During the last decade 25% of the national investments have been directed to Crete and a significant part of this, (60%), has been procured by the tourist industry. Thus, in the same period, the number of beds in hotels has been doubled representing the greatest increase among all the regions of Greece. Agriculture, however is at a major crisis. Two symptoms may be identified: deterioration of rural income and employment and deterioration of environment, nature and landscape. The latter is mainly due to specialisation and intensification in agricultural production which creates deterioration of the high quality environment which is the strength of the island for development. Besides, even with the specialisation in cash and the so called dynamic crops (off-season vegetable crops), agricultural output is low due to poor infrastructure, organisation and marketing and is expected to be further aggravated under the influence of the free world trade. The fact that the primary sector attracts only a small share of total investments (6.2% in 1992) as mentioned before, indicates little care for Cretan agriculture. That is hard to accept since agriculture stewards the largest part of Cretan land, raises employment for most Cretan inhabitants and cares for people's nourishment now and in the future. In fact, investments are more and more made in business with a quick return on investment. Long term returns seem not to be of interest to investors creating a situation which is highly unsustainable and accumulates present problems for future generations.

The Mediterranean countries produce 81% of the world olive oil and 69% of the world table olives. The European Union's olive producing countries produce 92% of the Mediterranean olive oil and 58% of the Mediterranean table olives (Figure 8). Among the European Union Greece produces 21% of the olive oil and 16% of the table olives (Figure 8b). Crete, the largest producer of olive oil in Greece, produces 33% (Figure 8c). The Iraklion department is the main olive oil production department, producing 43 % (44.79 in 1993-1994), while in Iraklion the olive production (56% of the cultivated area concerns olives) is concentrated in Messara plain and the surrounding hills (Figure 8d).

2.3 Conclusions

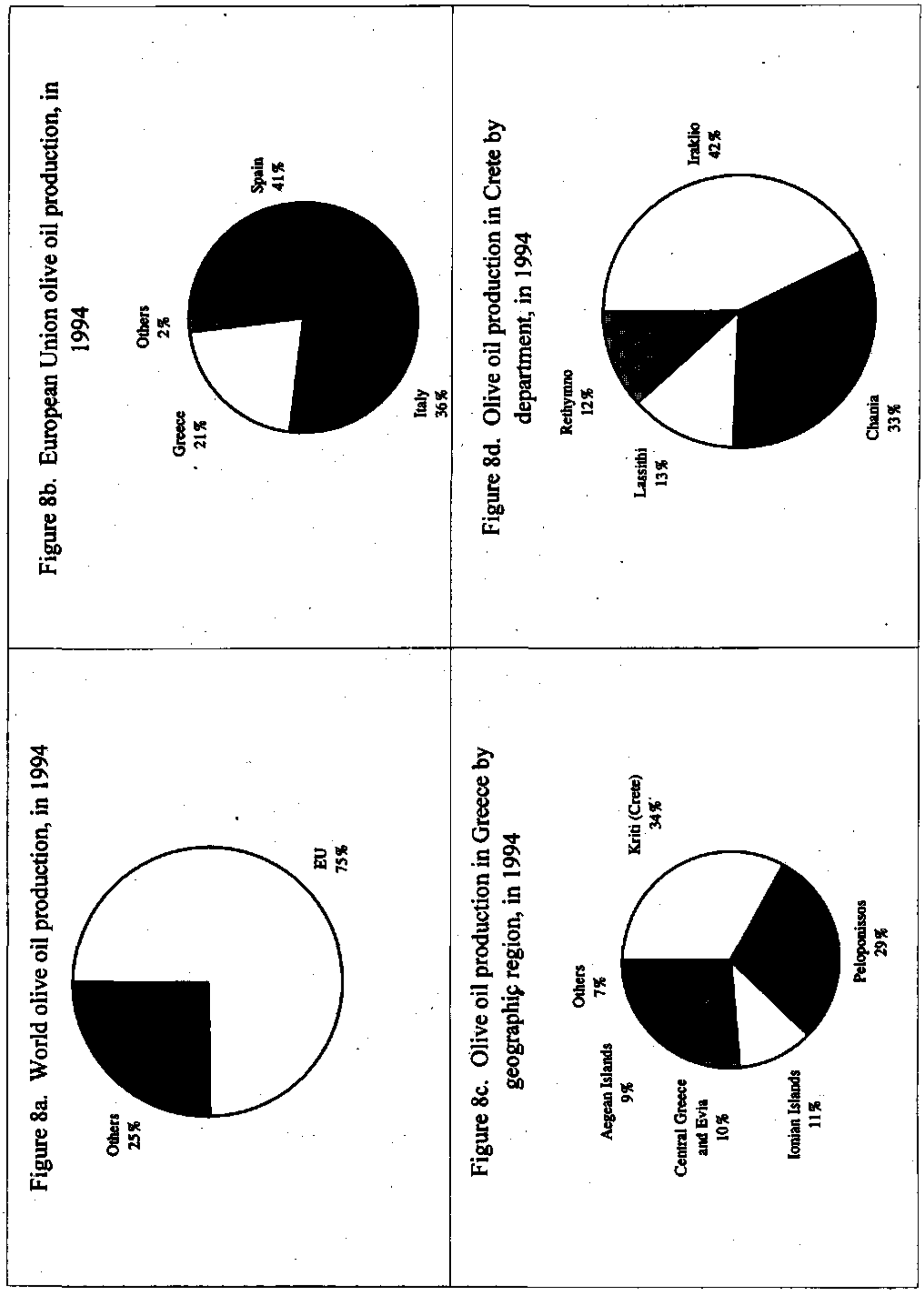
Soils of the project area even if slightly different than those of other coastal areas of the Mediterranean basin are subject of the same potential and constraints for agricultural production. They are shallow, stony, eroded entisols in the surrounding hills of the plain (Yassoglou, 1971) while the plain has deep alluvial fertile soils.

Climatic patterns of the plain are similar to most of coastal areas of the Mediterranean basin, even though the conditions are slightly different. They are characterised by a long dry summer where evapotranspiration exceeds precipitation and by a large variability from year to year.

Crete, because of its geology and position in combination with the mild climate, boasts a unique flora and fauna and a big biodiversity in uncultivated areas. Besides, it holds a unique diversity of landscape. This unique heritage is threatened more and more by agricultural and other human activities.

Plain groves pose different agroecological characteristics compared with hilly groves. The first grow in deep alluvial soils with extreme temperatures and

Figure 8. Olive oil production



little rainfall which does not prevent high production levels due to application of external inputs such as synthetic fertilisers and irrigation water. But such an intensive cultivation all over the plain, also means that ecologising production is more difficult and costly in the short term. Moreover, cultivation of hilly groves is hard to manage, because of their stony, shallow soils and bass relief. Ecologising of groves near semi-natural areas shows to be easier at the moment.

The constantly decreasing employment in agriculture, contrasted with the constantly increasing employment in services as well as the urbanisation, in combination with the low agricultural input prevents rural development. Rural development is particularly important because of the functions of rural areas and agriculture for the preservation of nature and landscape, the environmental protection, and the sustainable development of the tourist industry. Besides, agriculture is important for the facilitation of the socio-economic diversification and the management of the integrated coastal area in Crete. It is particularly important that employment in agriculture is increasingly less attractive for the young ages of population. These developments are contradictory to Greek policy towards sustainable developments to help to preserve nature, landscape, environment, water resources and water quality together with social-economical improvements by tourist industries. However, tourists often visit Crete for its nature, landscape, rural life, life quality and culture which deteriorates tremendously every day. That contradiction should be solved by the introduction of a multi-functional agricultural sector which contributes to the constant improvement of the economy and ecology at the same time. Only such agriculture benefits human, animal, plant life, nature, landscape in the present and in the future.

Participation of growers in all the stages of the project presented in this thesis is very important as it will relate and contribute to agro-ecological and socio-economic development of the Faistos area. The pilot project is aimed to support conversion to ecological production, to the benefit of multi-functional agriculture and to sustain self-regulation. It will also benefit less competitive olive production areas elsewhere in Greece and European Union (EU), as Crete produces 33% of the olive production in Greece (24% of the EU olive production).

Messara plain is a suitable target region for the pilot project as it is the largest plain in Crete and a typical rural area with a one-sided economic and social base in intensive and export oriented agriculture. On the one hand it contributes to the saturation of the Greek and EU markets of various olive, vine and horticultural products suppressing product prices, incomes and employment in less competitive regions. On the other hand it is polluting soil and water resources and degrades nature and landscape, deteriorating the sustainable basis of development for the surrounding areas also. Messara, once ecologised, might be an example of how farmers may contribute to improvement of agricultural commodities or how improved farming systems serve at the same moment agricultural production and good quality of environment, nature and landscape.

CHAPTER 3. MAKING A HIERARCHY OF OBJECTIVES

3.1 Hierarchy of objectives

Prototyping Ecological Olive Production Systems (EOPS) implies a systematic methodology for establishing the objectives of production, considering biological, ecological and socio-economic circumstances and constraints of the area. Making a hierarchy of objectives is the first step on the methodical procedure to prototype EOPS.

Objectives of the ecosystem-oriented vision for agriculture described by Vereijken (1992), were used as a basis for EOPS. In this vision agriculture is the management of agroecosystems aimed at sufficient and sustainable supply of the market with food and other natural products (Vereijken, 1992). These general objectives were used as a basis as it was considered that they sufficiently covered the objectives of production for EOPS. Based on these objectives a hierarchy of objectives for EOPS was made by taking into consideration the shortcomings of conventional olive production in the Messara plain (see Chapter 1.2 and Appendix 2) and the desired contribution of the prototypes to improve agronomic, ecological and socio-economic situation in the long term. The objectives of the EOPS (Table 2) were selected and ordered by reviewing relevant literature on oliviculture, agroecology, ecological agriculture, and on the project area and by discussions with growers and farm advisors in the region.

The process of selection and order of the objectives are as follows: First insight was gained on:

- farmers production practices (see also Appendix 5) and issues related to these practices;
- current agricultural production and policy issues of the area;
- on the socio-economic condition of the area and the situation of the farmers;
- on concepts, theories and practices of ecological production systems.

This insight was gained by reviewing existing mass media references on agricultural issues and policy trends in the area. This review was conducted during work in the area at the farm advisory service for conventional olive production (see Appendix 2). Issues were discussed with colleagues and there was participation in meetings with topics related to conventional production and related problems (Chapter 1.2 and Appendix 5). During the period working as farm advisor, familiarity was increased and involvement heightened with conventional practices and issues of concern for the farmers relating to these practices. The socio-economic condition of the area and the socio-

Table 2. *Hierarchy of the general and specific objectives in Ecological Olive Production Systems (EOPS)*

general	*specific*
1. Abiotic environment	
	1.1 Soil
	1.2 Water
	1.3 Air
2. Basic income / profit	
	2.1 Farm level
	2.2 Regional level
	2.3 National level
3. Nature / landscape	
	3.1 Flora
	3.2 Landscape
	3.3 Fauna
4. Food supply	
	4.1 Quality
	4.2 Stability
	4.3 Quantity
5. Health / well-being	
	5.1 Rural people
	5.2 Landscape
	5.3 Urban people
6. Employment	
	6.1 Farm level
	6.2 Regional level
	6.3 National level

economic situation of the farmers, as well as prospects to improve it, were observed and discussed with the farmers. Later literature on agroecology and sustainable agriculture and research and project reports related to ecological production systems was reviewed. Besides, experience was obtained in a running project aimed at ecological production systems. During this period a theoretical insight and, as far as possible, an objective critical view on conventional practices and on the desired contribution of ecological production was obtained.

At the beginning of the innovative project, described in this book, a provisional hierarchy of objectives for the EOPS was constructed. It was presented and discussed with the pilot group as well as with several other farmers and social actors. They had diverse points of view and ideas about improving agricultural production and the socio-economic situation at the rural area. The hierarchy of objectives (Table 2) was finalised after taking into consideration the insight and comments from all these discussions.

Following a procedure of two rounds of ranking objectives by the author, the top ten specific objectives were ranked in line with the methodological procedure of prototyping (Table 3; page 35) (Vereijken, 1994; Vereijken, 1995). In the first round the general objectives were rated from six to one in descending order of importance. In the second round the specific objectives, within each general objective, were rated from three to one in descending order of importance. Then the top ten specific objectives were established by multiplying the ratings of the specific objectives by the rating of their general objective.

The hierarchy of objectives for the ecological olive production presented in Table 2 will be explained in the following paragraphs.

Abiotic environment is the main objective, before basic income and profit, and nature and landscape in the prototyping at Messara plain. The abiotic environment is focused on the *soil*, by avoiding pesticides and nutrient accumulation, which is needed as a highly unpolluted medium for important biological and chemical interactions and for the maintenance of soil fertility. Soil is related to the stability, quality, quantity and sustainability of the production. Besides, it is aimed at optimum management including protection against soil erosion. In addition to this, water is considered as a major specific objective because of the agroclimatic conditions of the dry area and the gradual lowering of the groundwater levels caused by over-exploitation. Further, its quantity and quality is important for the sustainability, stability and quantity of the production.

Basic income and profit is the second main objective, since the market for biological olive oil is small and premiums on current market prices are small as well. Therefore, production costs are to be minimised and production benefits are to be maximised to make the prototype more competitive than the current farming system. Besides, it will stimulate the efforts for development at the farm level and the dissemination of the results, while it will help to maintain the number of growers and the population of the rural areas under the pressure of other activities and urbanisation. This objective is focused on basic income and profit at the *farm level*, since competitive farms are considered as the best basis to maintain olive production in the region.

Nature and landscape and specifically *local flora and landscape* are considered to be the third objective, as up to the present ecological agriculture has no explicit guidelines and technology for landscape and nature, although it is essential for quality, stability and quantity of production based on biodiversity. In ecological farming systems biodiversity is to be increased especially by an ecological infrastructure. Besides an ecological infrastructure will stimulate ecosystem-oriented consumers to turn to species and creating attractive nature and landscape for humans and animals. On account of a higher diversity of flora, diversity of threatened fauna and landscape will also be increased.

Food supply is the fourth main objective. This objective focuses at optimum balance between *quantity* and *quality*, as a basis for basic income or profit, and health and well being. Quality production requires amongst others, ecological management of pests and pathogens rather than pesticides. The balance between quantity and quality also requires ecological nutrient management to maintain soil fertility and to stabilise production at a sustainable level.

Health/well-being and *Employment* are objectives numbered 5 and 6 (Table 2). Their need of improvement is considered to be sufficiently covered by the improvements in the foregoing objectives.

3.2 Conclusions

Making a hierarchy of objectives is the first step in the methodical procedure of prototyping and the basis of prototyping (Vereijken, 1994; Vereijken, 1995). In fact the methodology of prototyping is a kind of designing. Designing methodologies always starts by making inventories of objectives that should be achieved by the construction that is wished to be assembled. Such a construction might be a machine, a building or a road. Here the construction is a farming production system. That production system differs from industrial ones, since natural processes are not excluded, but it is attempted to include them, as much as possible. Besides, an important part of the farming system is the farmers and the rural society, which also interacts and effects the design. Self-regulation of the farming system is tried to be enhanced, by sustaining ecological and physiological phenomena by management and facilitation, however, without dropping economical objectives of the farm. Prototyping of innovative farming production systems according to the methodology of Vereijken, strongly advocated by Goewie (1993) and Ugas (1995), seems a promising way to create farms that meet future standards for agricultural production coming from human society. That methodology does not dwell on questions related with a better understanding of nature or an explanation of phenomena. The methodology wonders about questions such as "does the innovation really work?" or "is the innovation manageable for farmers?", or "does the methodology improve by itself?".

Considering the above, a diagnosis of the conventional olive production shortcomings (Chapter 1.2) was made at first. Besides, the targeted contribution of Ecological Olive Production Systems (EOPS) to improve the agricultural situation in the long term in the area was determined. Consequently, if the diagnosis has not been correctly made then the contribution of EOPS will be insufficient. Therefore, the diagnosis and the hierarchy should be done in interaction with the major actors involved in olive oil production and after careful examination of all available resources, agro-technology, experience and knowledge. Indeed the inventory of objectives according to responses and observations of the farmers and the members of the pilot group was made at the beginning of this innovative project. The agri-environmental group confirmed correctness of diagnosis of shortcomings in current olive production farms as well as the objectives and the hierarchy between them, such as identified by co-operating farmers. So, it may be concluded that the current hierarchy of objectives represents a realistic basis of EOPS prototypes, that is to say olive production systems with more ecological and socio-economic sustainability than conventional ones.

CHAPTER 4. QUANTIFYING THE OBJECTIVES

The second step on the methodical way to prototype EOPS is the transformation of the graded objectives into appropriate parameters to quantify them.

4.1 Transforming objectives into parameters

The hierarchy of objectives (Table 2; page 31) is transformed into a suitable set of multi-objective parameters to quantify them. The set is identified by reviewing relevant literature on oliviculture, agroecology, soil science, entomology, phytopathology, agronomy and ecological agriculture. Besides, the parameters used by the European network for Ecological Arable Farming Systems were reviewed (Vereijken, 1994; Vereijken, 1995). The criterion of being integrated or being indispensable for a single objective was used for the parameters' selection. In this way the quantified objectives can be used as desired results, to evaluate the achieved results of the EOPS prototypes.. The prototypes are tested and improved until the results achieved match with the desired ones.

4.2 Quantifying objectives with parameters

A set of twelve multi-objective parameters is used to integrate and quantify the objectives (Table 3). These parameters are new for olive production. Ideas on parameters were obtained by the European Union (EU) research network on integrated and ecological arable farming systems (Vereijken, 1994; Vereijken 1995). Except of the Soil Erosion Rates (SER), all the parameters were gradually introduced and operationalised. The Soil Erosion Rates are quantified in the later stage of the pilot project. In Table 3 for Soil Erosion Rates (SER), Organic Matter Balance (OMB) and Energy Efficiency (EE) provisional desired results are presented. Those results should be adjusted to legal standard norms or if legal standard norms are absent at achievable results, gained after optimisation of relevant technology and management. The values of the desired results are mainly relevant to the project area. These values were developed during practical work of the farmers and after discussions with them about the desired values for quantifying the objectives of the prototype systems. They were not available for the project area (for the most part, they are not references in literature for either Greece and the Mediterranean). The experiences of and the knowledge of the farmers were valuable to establish these innovation values.

Table 3. *Quantifying and achieving objectives in Ecological Olive Production Systems (EOPS)*

major objectives ranked	*major objectives quantified in multi-objective parameters*	*major objectives realised by multi-objective farming methods*
1. Abiotic environment - soil	1.1 SER<1 t ha^{-1} $year^{-1}$ 1.2 OMB≥1, <1 1.3 MB≥1, <1 1.4 1.6%<NLR<1.8% 0.09%<PLR< 0.11% 0.7%<KLR<0.9% 1.5 EEB=0	1.1-1.3 EMCW 1.3-1.4 ENM 1.5 EMIP
2. Basic income and profit- at farm level	2. NS>0	2. FSO
3. Abiotic environment - water	3.1 SCI=0.5 3.2 II≤1 see 1.3, 1.4, 1.5	3.1 EMCW 3.2 EWM see 1
4. Nature and landscape - flora	4.1 EII=1 4.2 TPSD (a)TII=1, (b)TSI=1 see 3.1	see 1 and 3
5. Basic income and profit - at regional level	see 2	see 2
6. Food supply - quality	6.1 0<QPI<1 see 1.5	see 1 and 3
7. Nature and landscape - landscape	see 1.1, 4.1, 4.2	see 1 and 2
8. Health and well-being - of rural people	see 1.1, 1.2, 1.5, 2, 3.1, 4.2, and 6.1	see 1, 2, 3
9. Food supply - stability	9.1 EE> 10 see 1.3	see 1 and 2
10. Abiotic environment - air	see 1.4 and 1.5	see 1

4.2.1 Soil Cover Index

<u>Definition</u>

Soil Cover Index per month (SCI) is the percentage of grove ground covered by green manure crops, natural vegetation, cover crop residues at the end of every month, throughout the year.

<u>Formulas</u>

- SCI month^{-1} = [SCI (at start) + SCI (at end)] / 2
- SCI period^{-1} = sum SCIs month^{-1}/number of months

<u>Procedure</u>

(1) Establishing desired results of SCI in every month and period (Table 4):
- in view of the need for soil cover throughout the grove in order to control erosion, water and nutrient losses by runoff or leaching and to provide nitrogen;

- in view of the need for soil cover throughout the grove in order to benefit fauna and landscape.

Ranges
The achievable ranges can be:
- SCI = 1 at maximum, if soil is fully covered by a cover crop or cover crop residues
- SCI = 0 at minimum, if soil is fully fallow throughout the period of the year

The desired SCI's are presented in Table 4. These SCI's are according to the potential of optimum soil cover for the groves at the area because of the absence of literature on soil cover at olive groves and of the absence of legal standard norms. The desired values for SCI's were derived by studying with the growers soil coverage possibilities in their groves and by observing soil cover in natural ecosystems of the area. Besides, experiences of growers regarding soil cover in the past before introduction of synthetic inputs and machinery and when mixed farming was occurred in the area were of great importance. The desired SCIs of Table 4 were established considering all the above.

(2) Monitoring the actual extent of soil cover of the groves as share of the grove area every month; and calculating the actual SCI for every grove or for a period.

Table 4. *Desired Soil Cover Indices (SCIs)*

time period	*SCI*
January	0.85
February	0.90
March	0.50
April	0.40
May	0.50
June	0.55
July	0.50
August	0.45
September	0.40
October	0.50
November	0.45
December	0.60
overall year	0.50

Monitoring is done with:

- Beaded string method (Sarantonio, 1991), for the green manure cover crops, with the formula:
  dots with green manure plants/total dots counted * 100 = % soil coverage;
- Visual estimations.

(3) Establishing possible shortfalls between actual and desired SCI (Table 4).

(4) Improving SCI in the case of shortfalls in regard to spatial and temporal continuities.

<u>Evaluation</u>

When the actual soil cover is smaller than the desired one then the responsible Ecological Management of Cover crops and Weeds (EMCW) and the Ecological Infrastructure Management (EIM) should be improved (see theoretical prototype, Figure 9).

4.2.2 Soil erosion rates

<u>Definition</u>

Soil Erosion Rates (SER) are the rates (tonnes/ha/year) of water soil erosion during a crucial period.

<u>Procedure</u>

(1) Establishing desired ranges of SER during the crucial period (the rainfall period, from November to March):

- in view of the need for minimising soil erosion throughout the grove in order to control soil fertility losses due to nutrient and organic matter losses by runoff;
- in view of the need for protecting the soil from gullies throughout the grove in order to benefit fauna and landscape.

Range

The desired soil erosion should be smaller than 1 tonne ha^{-1} $year^{-1}$. This value is referred to the maximum acceptable soil erosion rates for Mediterranean countries (Chisci and Morgan, 1988). Because of the absence of research data from the project area this was adapted as provisional value after reviewing literature (CEC, 1992; Pastor and Castro, 1995) and discussing with local experts. Besides, acceptable soil erosion rates were discussed with experts from Mediterranean countries, working on soil erosion and olive production during the advanced course "Sustainable Agriculture in Rainfed Systems", 15-26 January 1996, IAMZ, Zaragosa - Spain. This value was also discussed with farmers taking in consideration their observations on soil losses.

(2) Monitoring the extent of soil losses from the groves as an amount of soil lost in the grove area with:

- Soil catchment method, as it is a simple method to make a general estimation of soil losses, growers can have a visual picture of the soil losses in their groves.

(3) Establishing possible shortfalls between actual and desired SER.

(4) Improving SER when shortfalls occur.

Evaluation

When the actual soil erosion rates are higher than desired, then the responsible Ecological Management of Cover crops and Weeds (EMCW), the Ecological Infrastructure Management (EIM) and the Ecological Water Management (EWM) should be improved (see theoretical prototype, Figure 9).

4.2.3 Macronutrient balances

Definition

Macronutrient Balances (MB) are the annual ratios of nitrogen (N), phosphorus (P) and potassium (K) outputs by the product to the external nitrogen (N), phosphorus (P) and potassium (K) inputs applied at the grove.

Procedure

(1) Establishing desired ranges of MB:

- in view of conserving soil fertility and minimising soil losses;
- in view of maintaining agronomic desired ranges of soil macronutrients for optimum production;
- in view of maintaining environmentally desired ranges of soil macronutrients in order to minimise environmental pollution with nutrients.

Ranges

The desired ranges are:

- MB<1 if Potassium Leaf reserves (KLR) are below the desired range. Besides, Potassium Available Reserves (KAR), Phosphorus Available Reserves (PAR), and Organic Matter Content (OMC) (Appendix 4) are taken into consideration (see Chapter 5.2.2).
- MB=1 if Potassium Leaf reserves (KLR) are within the optimum range.
- MB>1 if Potassium Leaf reserves (KLR) are above the desired range. Besides, KAR, PAR and OMC (Appendix 4) are taken into consideration (see Chapter 5.2.2).

KAR, PAR, OMC are the agronomically desired and environmentally acceptable ranges of exchangeable potassium and absorbed phosphorus soil reserves and organic matter content. These ranges were estimated by values reported in literature (Yassoglou, 1971) and discussions with local experts (Linadarkis (1994), Soil Laboratory of Institute for Viticulture, Horticulture and Floriculture, NARF, Iraklion) in the absence of experimental data for olive groves (especially under management with use of non-synthetic fertiliser materials) and of experimental data from the project area.

(2) Monitoring and calculating actual annual MB:

- Monitoring olive yields and residues extracted (like pruning branches), by grove;
- Monitoring of annual application of animal manure and of external residues (like wood residues, plant residues, etc.) by grove.

The macronutrient content of the produced olives, the animal manure and the other external residues should be analysed with lab analyses. Exchangeable potassium, absorbed phosphorus and organic matter content are determined by lab analyses, end of spring.

- Calculating the annual ratio of outputs to inputs by grove.

(3) Establishing possible shortfalls between actual and desired MB.

(4) Improving MB in the case of shortfalls.

Evaluation

When the actual macronutrient balances do not correspond with those desired, responsible methods Ecological Management of Cover crops and Weeds (EMCW) and the Ecological Nutrient Management (ENM) should be improved (see theoretical prototype, Figure 9).

4.2.4 Leaf reserves

Definition

Agronomically acceptable ranges of potassium leaf reserves (KLR), phosphorus leaf reserves (PLR) and nitrogen leaf reserves (NLR).

Procedure

(1) Establishing desired ranges of KLR, PLR and NLR:
- in view of the absence of correlation between macronutrient soil and leaf reserves;
- in view of maintaining agronomic desired ranges of leaf macronutrients for optimal production;
- in view of optimising physiological condition of the olive trees and quality of olive products.

Ranges
The desired ranges for leaf reserves are (Gavalas, 1978):
- 0.7%<KLR<0.9%,
- 0.09%<PLR<0.11%,
- 1.6%<NLR<1.8%.

(2) Monitoring actual KLR, PLR and NLR, annually for every grove by lab analysis.

(3) Establishing possible shortfalls between actual and desired KLR, PLR and NLR.

(4) Improving KLR, PLR and NLR in case of shortfalls.

Evaluation

When actual leaf reserves do not conform to the desired ranges, responsible method Ecological Nutrient Management (ENM) has to be improved (see theoretical prototype, Figure 9).

4.2.5 Organic matter balance

Definition

Organic Matter Balance (OMB) is the annual output/input ratio of effective organic matter (Vereijken, 1995) in the pilot groves. Inputs are crop residues (green manure included) and organic waste materials such as manure (kg ha^{-1}) multiplied with humification coefficients. Output is the estimated loss of soil organic matter by respiration and possibly by erosion.

Procedure

(1) Establishing desired ranges of OMB:
- in view of conserving soil fertility and minimising soil losses;
- in view of maintaining agronomic desired ranges of soil macronutrients for optimum production;
- in view of maintaining environmental desired ranges of soil macronutrients for minimising environmental pollution with nutrients.

Ranges
The desired ranges are:
- OMB>1 if Organic Matter Content (OMC) is below the desired range (4%<OMC>6%).
- OMB=1 if OMC is in the desired range.
- OMB<1 if OMC is above the desired range.

The desired ranges are provisional because of the absence of experimental data from the area (and from Greece) on effective organic matter and humification coefficients.
The desired range of OMC was determined by the values reported in literature for the soil types of the pilot groves (Yassoglou, 1971), by discussion with local experts (Linadarkis (1994), Soil Laboratory of Institute for Viticulture, Horticulture and Floriculture, NARF, Iraklion; Manios (1995) Technological Institute of Iraklion) and by the initial values in the pilot groves (Appendix 4).

(2) Monitoring and calculating actual annual OMB:
- Monitoring of applied animal manure, green manure and external residues by grove.
- Monitoring actual OMC of the groves by lab analyses (loss on ignition) end of Spring.
- Calculating the annual ratio of outputs to inputs by grove.

(3) Establishing possible shortfalls between actual and desired OMB.

(4) Improving OMB when shortfalls occur.

Evaluation

When the actual OMB of the groves is outside the desired ranges, responsible methods Ecological Nutrient Management (ENM), the Ecological Management of Cover crops and Weeds (EMCW) and the Ecological Water Management (EWM) should be improved (see theoretical prototype, Figure 9).

4.2.6 Ecological infrastructure index

Definition

Ecological Infrastructure Index (EII) is an index which expresses that part of the grove that is managed for maintaining habitats of wild flora and fauna, as well as the corridors between those habitats, including surrounding bufferstrips. Habitats and relating corridors should be considered as a linear or non-linear network at the grove, in which wild life is allowed to survive by selfregulation.

Formulas

- EII=Ecological Infrastructure (EI) achieved/EI desired
- EII month^{-1}=[EII (at start)+EII (at end)]/2
- EII period^{-1}=sum EIIs month^{-1}/number of months

Procedure

(1) Establishing desired ranges of EII:
- in view of conserving nature and biodiversity;
- in view of preventing soil erosion and deforestation;
- in view of maintaining an attractive landscape to humans and animals.

Ranges
The desired ranges are:
- EI should be 4% of the grove area on plain groves and 8% on hilly groves per year.
- in the grove area of EI 15% consists non linear elements (e.g. spots of wild vegetation, spots of stones, etc.), and 85% consists linear elements (e.g. linear strips of wild vegetation, interrelated rows of stones, etc.).

These desired ranges were determined after discussions with the pilot group about the Ecological Infrastructure Management (EIM) method and the importance of ecological infrastructure for the pilot groves and the prototype. Besides, calculations were made for estimating the optimum area for ecological infrastructure on hilly and plain groves. In these calculations the above mentioned prerequisites were taken in consideration as well as the different situation of the hilly and plain groves. Finally, the practical work of introducing the EIM by the growers was taken in consideration and discussed with them. For the EII no references in the literature regarding the local conditions, or Greece can be found.

(2) Monitoring monthly EII of the groves, regarding linear and non-linear elements, with visual assessment.

(3) Establishing possible shortfalls between actual and desired EII.

(4) Improving EII in the case of shortfalls.

Evaluation

When the actual EII is smaller than desired, then there is no appropriate layout of linear and non-linear elements, including buffer strips at the grove, and there is no spatial and temporal continuity the responsible method Ecological Infrastructure Management (EIM) should be improved (see theoretical prototype, Figure 9).

4.2.7 Target plant species diversity

Definition

Target Plant Species Diversity (TPSD) indicates whether target plant species in the ecological infrastructure occur in space and time. Target species are defined as plants attractive to human beings or animals (notably beneficial insects and birds) by conspicuous flowers, by supply of food (pollen, nectar and seeds) or shelter (Vereijken, 1994; 1995).

Formulas

- TPSD is subdivided to Target Trees Index (TTI) and Target Shrubs Index (TSI)
- TTI=desired target tree species / achieved target tree species
- TSI=desired target shrub species / achieved target shrub species

Procedure

(1) Establishing a list of target plant species by grove:
- in view of conserving nature and biodiversity;
- in view of preventing soil erosion and deforestation;
- in view of maintaining an attractive landscape to humans and animals.

Such an initial list for all the groves is given in Table 5. Growth and flowering calendars of the target plant species of this list have been drawn. It has been established in view of the above aspects and:

- in view of being a host of beneficial predators and parasites of the pests of the olive tree;
- in view of a multipurpose use for providing food as a compensation for the farmer;

Table 5. *Target plant species list for the pilot groves*
(resulted from the plants inventory at the pilot groves, in 1994)

Latin name	*Family name*		*English common name*
Carduus pycnocephalus	*Compositae*	A	-
Chamomila recutita	*Compositae*	A	wild camomile
Chrysanthemum coronarium	*Compositae*	A	-
Cistus creticus B.	*Cistaceae*	P	-
Cupressus sempervirens forma horizontalis	*Curpressaceae*	T	cypress
Cydonia oblonga M.	*Rosaceae*	T	quince
Cynara scolinous	*Compositeae*	P	artichoke
Daucus carota ssp carota	*Umbeliferae*	A	wild carrots
Ebenus cretica	*Leguminosae*	P	-
Foeniculum vulgare ssp piperitum	*Umbeliferae*	P	fennel
Juglans regia	*Juglndaceae*	T	walnut-tree
Laurus nobilis L,	*Lauraceae*	P	laurel
Lupinus albus	*Leguminosae*	A	lupine
Lupinus angustifolius	*Leguminosae*	A	lupine
Lupinus micranthus	*Leguminosae*	A	lupine
Lupinus varius	*Leguminosae*	A	lupine
Malva silvestrys L	*Malvaceae*	P	mallow
Narcissus tazetta ssp italicus	*Amarylidaceae*	P	narcissus
Ocimum basilicum L	*Labiatae*	P	basil
Phoenix theophrastii	*Arecaceae*	T	palm
Pinus pinea	*Pinaceae*	T	umbrella pine
Pinus brutia	*Pinaceae*	T	calabrian pine
Platanus orientalis	*Platanaceae*	T	plane tree
Prunus amygdallus	*Rosaceae*	T	almond
Punica granatum	*Punicaceae*	T	pomegranate
Pyrus communis L.	*Rosaceae*	T	pear
Rosmarinus officinalis L	*Labiatae*	P,S	rosemary
Salvia trtbola L.	*Labiatae*	P,S	sage
Scolymus maculatus	*Compositae*	A	-
Silybum marianum	*Compositae*	A	-
Tamarix cretica	*Tamaricaceae*	T	cretan tamarisk
Thymeleae hirsuta	*Thymeleaeceae*	P,S	
Thymus capitatus	*Labiatae*	P,S	thyme

Symbols: S = Shrub, T = tree, A = annual, P = perennial

- in view of species which may reproduce easily and which are of interest for enhancing local biodiversity within the scope of farmers skills;
- in view of conserving local species and their functions in the food chain and the landscape;
- in view of conserving endemic and threatening species;
- in view of not including species difficult to control and manage by the growers.

Ranges

- TSPD>10 species of the initial list (Table 5) in ecological infrastructure.
- (a) shrub species /100 m of field margin ≥70 for hilly groves and ≥50 for plain groves (b) tree species/100 m of field margin≥12 for hilly groves and ≥8 for plain groves
- flowers, fruits, seeds and shelter for benefit throughout the year, especially during early spring and autumn.

These desired ranges were determined after discussions with the pilot group about the Ecological Infrastructure Management (EIM) method and the importance of target species for the pilot groves and the prototypes. Besides, calculations were made for estimating the optimum species and their number for ecological infrastructure on hilly and plain groves. In these calculations the above mentioned prerequisites were taken in consideration as well as the different agroecological position of the hilly and plain groves (see Chapter 2.1.4). Finally, the practical work of introducing the EIM by the growers was taken in consideration and discussed with them. References in the literature regarding local or Mediterranean conditions have not been found.

(2) Monitoring monthly TPSD of the groves with visual assessment and target plant species counts.

(3) Establishing possible shortfalls between actual and desired TPSD.

(4) Improving TPSD in the case of shortfalls.

Evaluation

When the actual target plant species diversity is smaller than desired and when there is not a sufficient number of plant species in Spring and in Autumn, then the responsible method Ecological Infrastructure Method (EIM) should be improved (see theoretical prototype, Figure 9).

4.2.8 Quality production index

Definition

Quality Production Index (QPI) is the comprehensive parameter of quality and quantity of crop production (Vereijken, 1994; Vereijken, 1995).

Formula

QPI = Quality Index (QI) * Production Index (PI) =
= (achieved price kg^{-1}/top quality price kg^{-1}) * (marketed kg ha^{-1}/field produced kg ha^{-1})

Procedure

(1) Establishing desired ranges of QPI:

- in view of optimising quality of production;
- in view of minimising losses of production and optimising levels of production;
- in view of providing best quality of food for consumers and a fair income for growers.

Range
$0 \leq QPI < 1$, optimum is towards 1

- QPI = 1 at maximum, if an olive product has been marketed for a top quality price (QI = 1) without any losses before, during or after harvest (PI = 1). This may only occur if olives are vital with optimal growth and minimal physical (soil structure, water and oxygen supply), chemical (nutrients supply) and biological stress (weeds, pests and diseases) (see also Vereijken, 1995).
- QPI = 0 at minimum, if an olive product has been completely wasted before or after the harvest because of pests or diseases whether or not in relation to conditions of weather, soil or preservation (PI = 0) or if the product has not been marketed because of unacceptably low quality whether or not in relation to a surplus on the market (QI = 0) (Vereijken, 1995).

(2) Monitoring annually QI and PI of the groves by:

- Quantification of losses in quality (prices kg^{-1}).
  - dividing achieved price by top quality price achievable at the moment of marketing a product (QI);
  - assigning possible price losses to assessed causes (any cause ≥5% of top quality price).
- Quantification of losses in production (kg ha^{-1}).
  - estimating losses before (ripening stage), during or after harvest. For these estimations the following are monitored:
  * Blooming of olives by grove.
  * Fruiting of olives by grove.

* Estimation of losses due to olive pest and diseases through monitoring of the fruit drop, the symptoms of damage, the presence of organisms, and the insects caught by trapping.
* Estimation of losses in quality due to inappropriate harvesting, processing and storage.
* Olive oil content of the production.
* Losses due to inappropriate pruning.
- calculated field produced kg ha^{-1} = pre-harvest losses + post - harvest losses + marketed kg ha^{-1};
- dividing marketed kg ha^{-1} by field produced kg ha^{-1} (PI)
- assigning possible production losses to assessed or probable causes (any cause ≥ 5% of field production).

(3) Establishing possible shortfalls between actual and desired QPI.

(4) Improving QPI in the case of shortfalls.

Evaluation

When the achieved quality production index does not conform to the desired range, the responsible methods EMCW, Ecological Management of Insect pests and Pathogens (EMIP), EWM and ENM have to be improved (see theoretical prototype, Figure 9).

4.2.9 Net surplus

Definition

Net surplus (NS) is turnover minus all costs, including a payment for all labour hours, equivalently valued for comparable labour in other economic sectors (Vereijken, 1994; Vereijken, 1995).

Formula

NS = turnover -fixed costs -variable costs -farmer labour payment

Procedure

(1) Establishing desired range of NS:
- in view of a fair income for the growers;
- in view of optimum use of farm resources (labour, machinery, capital and land).

Range
The achievable ranges can be:

NS<0 implies labour has not been equally paid and the grove has made no profit.

NS=0 implies equal payment of labour, though no profit.

NS>0 implies both equal payment and profit.

The desired range is NS>0.

(2) Monitoring monthly the variable and fixed costs of the grove and quantifying the gross revenue and all the input costs.

In the formula for the calculation of the NS the following terms are used:
- turnover = oil yield * price achieved
- fixed costs = irrigation network + machinery + equipment + buildings + nets + permanent employees + depreciation
- variable costs = manure + green manure + plant protection + harvesting + ecological infrastructure + pruning + irrigation + weed control + field works + interest rate

The gross revenue is equal to turnover minus the variable costs.

(3) Establishing possible shortfalls between actual and desired NS.

(4) Improving NS in the case of shortfalls.

<u>Evaluation</u>

When the achieved net surplus is smaller than the desired one, all the methods have to be improved. If the desired NS can not be achieved with current farm structure, the responsible method Farm Structure Optimisation (FSO) must be undertaken (see theoretical prototype, Figure 9). If the desired NS has been achieved then the dissemination of the prototype, in large scale, may start directly.

4.2.10 Energy efficiency

<u>Definition</u>

Energy efficiency (EE) is the ratio of the energy equivalent of the yield to the energy inputs in the grove.

<u>Formula</u>
EE = (kcal outputs)/(kcal inputs)

Procedure

(1) Establishing desired range of EE:
- in view of conserving natural resources;
- in view of optimum use of natural resources.

Range
The achievable ranges can be:

EE<10 implies not optimum use of natural resources, waste of energy and the grove has made insufficient energy use.

EE>10 implies optimum use of natural resources and the grove has made sufficient energy use.

The desired range is EE≥10 and it is achievable with best ecological means. We came to this innovation value by discussing with the pilot group the agrotechnology used and the most energy consuming practices. How these practices could be optimised and energy consumption be minimised was discussed. There are no references in literature related to energy consumption on olive growing and there have not been energy studies on olive growing in Crete or in Greece.

(2) Monitoring monthly the inputs of the grove and quantifying the yield of the grove.

In the formula for the calculation of the EE the following terms are used:
- outputs = the energy equivalent of yield
- inputs = the energy equivalent of inputs (machinery, manure, green manure seeds, plant protection materials, irrigation network materials)

(3) Establishing possible shortfalls between actual and desired EE.

(4) Improving EE in the case of shortfalls.

Evaluation

When the achieved energy efficiency is smaller than desired, all the methods have to be improved (see theoretical prototype, Figure 9).

4.2.11 Environmental exposure to biocides

Definition

Environmental exposure to biocides (EEB) is the annual exposure of the grove and of the environment in biocide active ingredients. EEB is specified as EEB air, EEB soil, and EEB groundwater by biocide (Vereijken 1994; Vereijken, 1995).

Procedure

(1) Establishing desired range of EEB:

- in view of avoiding contamination of olive products with biocides;
- in view of avoiding polluting the environment with biocides;
- in view of minimising health risks of growers and consumers due to the use of biocides.

Range

The desired range is EEB=0. This desired range was derived by considering the European Union (EU) regulation and its requirements on organic farming as well as the requirements of consumers regarding toxic residues in olive products. All the above were discuss with the pilot group and then this innovation norm was derived. References in the literature regarding EEB on olive growing have not been found. Further, current legal norms in Greece, as well as in EU, deal only with levels of toxic residues in olive products and not with levels at the environment.

(2) Monitoring monthly the biocide inputs by biocide and by grove.

Calculating the EEB, as EEB air, EEB soil, and EEB groundwater by the formulas:

- EEB air = active ingredients (kg ha^{-1})*vapour pressure (Pa at 20-25^{0}C)
- EEB soil = active ingredients (kg ha^{-1}) * 50% degradation time (days)
- EEB groundwater = active ingredients (kg ha^{-1}) * mobility (mobility = K_{om}^{-1} and K_{om} = partition coefficient of the pesticide over dry matter and water fractions of the soil / organic matter fraction of the soil).

(3) Establishing possible shortfalls between actual and desired EEB.

(4) Improving EEB in the case of shortfalls.

Evaluation

When the achieved environmental exposure to biocides is larger than the desired ones, then the responsible methods Ecological Management of Insect pests and Pathogens (EMIP) and Ecological Infrastructure Management (EIM) have to be improved (see theoretical prototype, Figure 9). In practice also if any high ranked biocides are used they can be replaced by non-chemical protective measures or lower ranked biocides.

4.2.12 Irrigation index

Definition

The Irrigation Index (II) is the ratio of the monthly or annual amount of irrigation water used to the monthly or annual desired amount of irrigation water.

Formulas

- II $month^{-1}$ = amount of irrigation water used (m^3 $month^{-1}$ ha^{-1}) / desired amount of irrigation water (m^3 $month^{-1}$ ha^{-1})
- II $period^{-1}$ = amount of irrigation water used (m^3 $period^{-1}$ ha^{-1}) / desired amount of irrigation water (m^3 $period^{-1}$ ha^{-1})

Procedure

(1) Establishing desired amount of irrigation water in every month and period (Table 6):

- in view of the need of control of the exploitation of water, to avoid depletion of ground water;
- in view of the need of optimum production, to avoid financial problems of the growers;
- in view of the need of resistance to olive pests, to avoid production problems.
- in view of the need of less susceptibility to drought, to avoid production problems.

The desired ranges of Table 6 were derived after discussing the above with the pilot group of farmers and taking in consideration their experiences with irrigation and their wishes regarding production. Besides, desired ranges were determined by running CROPWAT computer programme for irrigation planning and management with all the available data. The effects of irrigation to pests and pathogens, to mineralisation and leaching of nutrients and to yields of the trees were considered. Furthermore, the recommendations for irrigation of olive groves provided by the local state extension service were consulted.

Ranges
The desired result of the II is: II $\leq$ 1.

(2) Monitoring the actual water used by the groves; and calculating the actual II for every grove or for a period. The applied irrigation water is measured. Monthly, or of a period, grove water requirements are quantified using CROPWAT (Smith, 1992). Related data to CROPWAT are measured (temperature, rainfall, humidity, wind speed, etc.).

Table 6. *Desired amount of irrigation water*

time period	$m^3\ ha^{-1}$
January	0
February	0
March	20
April	140
May	200
June	200
July	300
August	270
September	150
October	50
November	0
December	0
overall year	1330

(3) Establishing possible shortfalls between actual and desired II.

(4) Improving II in the case of shortfalls.

Evaluation

When the actual water consumption does not conform to the desired range, the responsible method Ecological Water Management (EWM) should be improved (see theoretical prototype, Figure 9).

4.3 Conclusions

Transformation of the objectives into appropriate parameters is the second step in the methodical procedure to prototype Ecological Olive Production Systems (EOPS). It is based on the careful examination and selection of parameters related to the objectives and the production system and determines the quantification of the objectives of EOPS. Consequently, if the parameters are not correctly selected and quantified, the objectives, then it will be not possible to evaluate whether the objectives of the EOPS have been achieved. It will neither be possible to test EOPS in practice. Therefore the selection of the parameters should be done after careful examination of the objectives and the production system.

For most of the parameters there were no standards available to be used as desired results, as they were non-existent. The used desired results came after reviewing relevant literature and discussing with experts and the pilot group. Therefore assumptions were made and on-station and on-farm research is required to determine genuine ranges and to make fully operational the set of parameters. So it may be concluded that the current set of parameters provides a sound bases for quantifying the objectives, and on-farm and on-station research will be required for a more accurate quantification of the desired results.

CHAPTER 5. DESIGNING A THEORETICAL PROTOTYPE AND METHODS

The third step on the methodical way to prototype Ecological Olive Production Systems (EOPS) is the design of a theoretical prototype by linking parameters and farming methods. Appropriate methods and techniques are designed, established and tested to achieve the objectives.

The design of a theoretical prototype concerns finding appropriate farming methods which help the grower to realise desired standards, identified for all relevant parameters, described in the preceding chapter. Those farming methods should integrate the objectives as much as possible. For reasons of efficiency, we are more interested in fact, in those farming methods which link each parameter to one another. That linking of parameters is the most creative step of the designing process. Besides, when appropriate farming methods and techniques are not available new ones are created in the context of the theoretical prototype. Creation of new farming methods may be the result of adaptation of current methods within the context of a theoretical prototype. Application of farming methods within the context of a theoretical prototype is a cyclic process of establishing, evaluating and testing towards the objectives to be achieved.

5.1 Designing a theoretical prototype

A theoretical prototype (Figure 9) was designed by linking parameters to farming methods and used for designing relevant methods. It should be noted that matching of methods and parameters has to be done in a non-conflicting way. The one should support the other.

The process of designing the theoretical prototype and of the methods had as follows. At first theory on agroecology (Altieri, 1995; Carrol *et al.*, 1990; Cox *et al.*, 1979; Dover and Talbot, 1987; Francis *et al.*, 1990; Gliessman, 1990; Lawrance *et al.*, 1984; Tivy, 1990) was reviewed and how it could be applied in olive production was examined (see also Chapter 2.1.4). Then discussions were held with growers and the pilot group concerning how specific objectives regarding soil, nutrient, water, nature and landscape and pest management could be achieved in practice without the use of synthetic inputs and in accordance with the agroecological principles of the agroecosystem. During these discussions the traditional knowledge and experiences of the farmers were examined. At the end of these discussions a general outline of the

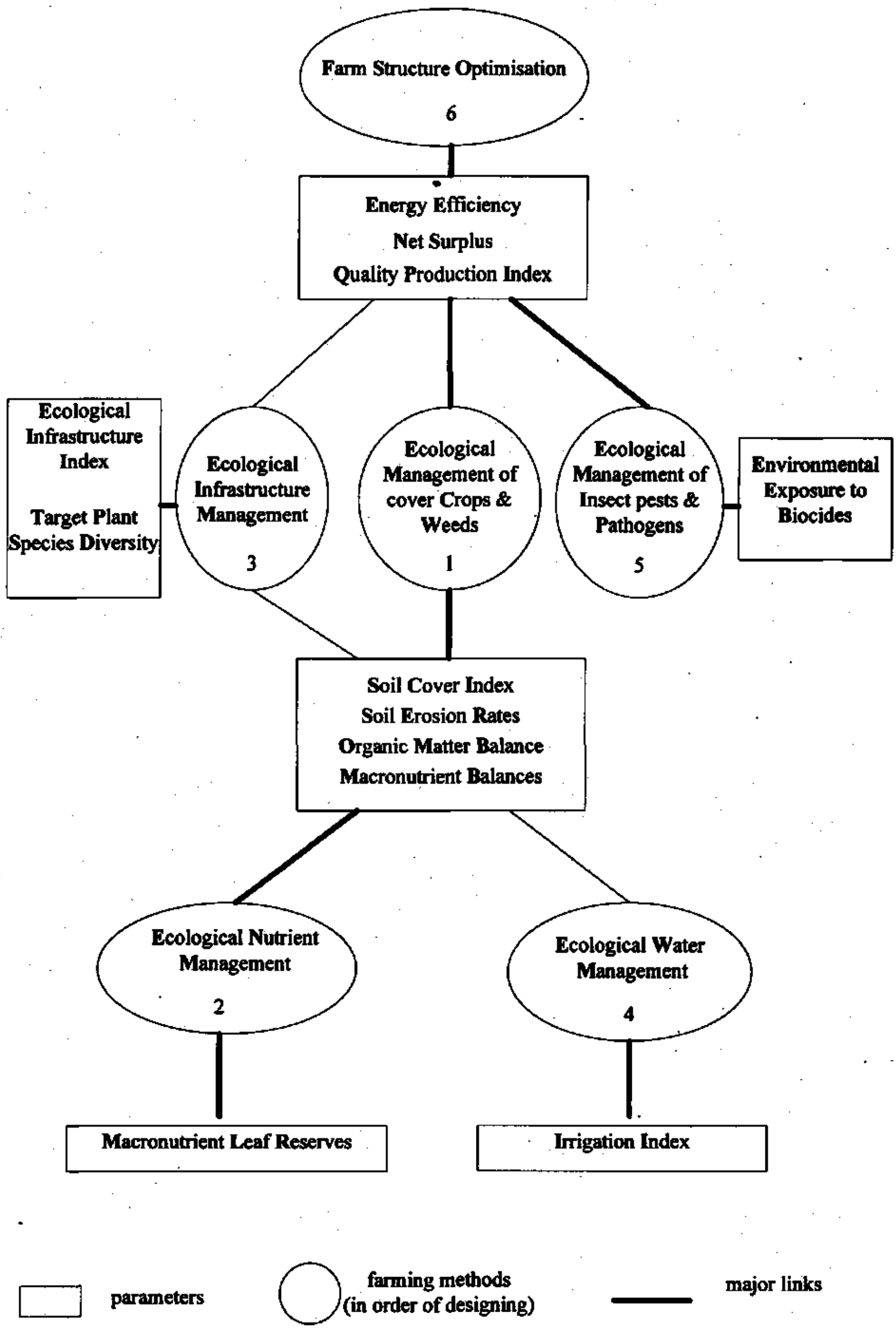


Figure 9. *Theoretical prototype of an Ecological Olive Production System (EOPS)*

methods was made. Specific information and research results related to the outline of the methods were examined. An initial version of a theoretical prototype was constructed by synthesising all the information collected in the above steps. That initial version of the theoretical prototype was presented to the pilot group. The outline of the methods was presented in a simple form as well as the related parameters for the quantification of objectives. The growers commented on this version of the protötype and gave their recommendations. A final version of the theoretical prototype was then designed based on these recommendations and it was presented to the pilot group.

The six multi-objective farming methods have been designed initially and further elaborated (criterion 1 in Scheme 1). The six methods cover the main components and process of the agroecosystem while achieving the objectives of the prototype.

The Ecological[1] Management of cover Crops and Weeds (EMCW) plays a central role. EMCW is a major method to achieve desired results in multi-objective parameters by linking all soil fertility and secondary crop multi-objective parameters to the Quality Production Index (QPI) of the olive production. QPI on its turn is the (multi-objective) parameter links parameters concerning soil fertility, secondary crops, environment, nature and landscape parameters to (multi-objective) parameters concerning economy (Net Surplus (NS) and Energy Efficiency (EE)).

Scheme 1. *Criteria for improving the multi-objective methods* (adopted from Vereijken, 1994)
(1) Is it sufficiently elaborated by the researchers?
(2) Is it manageable by the growers?
(3) Is it acceptable by the growers?
(4) Is it effective in the pilot groves?

[1] The term ecological is used for the designed methods in accordance the Greek meaning of the word ecology. In accordance with this meaning, regarding agroecosystems, ecology means the study of the pattern of sustainable relations of plants, animals and people to each other and to their surroundings. We use this term to indicate that the methods are taking into consideration the interrelationships between them and also the organisms and their environment with which the methods are dealing.

The Ecological Nutrient Management (ENM) is designed to support EMCW in achieving optimum QPI by maintaining agronomically desired and ecologically accepted nutrient reserves in soil and olives and with the Ecological Water Management (EWM), by maintaining an appropriate Organic Matter Balance (OMB) and minimising Soil Erosion Rates (SER).

The Ecological Infrastructure Management (EIM) is designed to support Ecological Management of Insect pests and Pathogens (EMIP) in achieving optimum QPI and minimum Environmental Exposure to Biocides (EEB) by providing beneficial predators and parasites a place to settle and to migrate. Besides, EIM concerns optimal nature and landscape objectives (optimising Target Plant Species Diversity (TPSD)) and supports EMCW in achieving optimum soil coverage (Soil Cover Index (SCI)) and minimum Soil Erosion Rates (SER).

The Ecological Water Management (EWM) is designed to support EMCW in maintaining an appropriate OMB and minimising SER. Besides, EWM by optimising the Irrigation Index (II) is maintaining agronomically desired and ecologically acceptable water reserves in soil and olives.

The Ecological Management of Insect pests and Pathogens (EMIP) is jointly designed to support EMCW and EIM in achieving optimum QPI by preventing and selectively controlling harmful species with minimum exposure of the environment to biocides and minimum expenses.

The Farm Structure Optimisation (FSO) method will be designed to determine the quantities of land, labour and capital goods which are required to achieve the desired Energy Efficiency (EE) and the necessary Net Surplus (NS).

5.2 Designing the methods

For the development of the Ecological Olive Production Systems (EOPS) prototypes, with a sufficient integration of the conflicting objectives, a suitable set of multi-objective farming methods has been designed. Because of the lack of adequate methods we designed them at first theoretically: (a) by reviewing the traditional methods of oliviculture in the region, (b) by reviewing relevant literature on oliviculture, agroecology, soil and water conservation, entomology and phytopathology, agronomy, nature and landscape conservation and ecological agriculture, and (c) by discussion with olive growers. The experiences of the olive growers, especially the ones before the introduction of synthetic fertilisers and machinery were valuable because they reflect the centuries of trial and error experimentation on agroecosystem management. Besides, they were reflecting the harmonic and sustainable symbiosis of the farmers with the olive tree agroecosystem. In relation to current conditions and technology and having in mind future conditions and needs, an attempt was made to use these experiences in designing the methods.. The criteria for the design of the methods were to be integrated and consistent with growers' potential for technical improvement.

Initial versions of six multi-objective methods were designed and established to develop the EOPS prototypes in which potentially conflicting objectives are sufficiently integrated (Table 3). These methods were designed in conformity with their links, presented in Figure 9, as they were absent for olive production. The annual version of each method was elaborated according to four criteria (Scheme 1) (Vereijken, 1994; Vereijken, 1995). Initially the early versions of the methods have been applied, mainly as codes of good agricultural practices (Appendix 3), by the pilot group and the members of the Cretan Agri-environmental Group.

In Table 7 the three variants of the prototype for the agroecological zones, as laid out at the pilot groves are presented. The first variant comprises five high density groves of the hilly zone The groves are irrigated and planted mainly to "*Koroneiki*" variety or to a mixture of "*Koroneiki*" and "*Throubolia*" variety (see Maps 2-4, Chapter 6.1). Two low density, rainfed groves planted with "*Throubolia*" variety are included in the second variant (see Maps 2-4, Chapter 6.1), representing the old traditional olive groves and farming. The third variant consists of 10 high density plain groves (see Maps 2-4, Chapter 6.1), representing the "modern" mechanised type of plantations. The growers, in interaction with the research team are making a specific design for their own pilot grove(s) each year, taking note of each method. In this design their practical experiences are valuable.

5.2.1 Designing ecological management of cover crops and weeds

Definition

Ecological Management of Cover crops and Weeds (EMCW) is a basic and comprehensive method dealing with management of soil and ground cover and secondary crops grown in the groves. It aims to create a sustainable soil fertility (physically, chemically and biologically), increased biodiversity (both spatially and temporally) with minimum external inputs (manual and machine labour, fertilisers, biocides) and minimum expenses. It includes the integration of weed and erosion control by cover crops and minimum soil tillage, and saves fossil energy by using leguminous cover crops instead of synthetic nitrogen fertilisers. It sustains Quality Production with a minimum of inputs (pesticides, manual and machine labour, fertilisers and support energy).

Scheme 2. *Criteria for the identification of cover crop plant species for Ecological Olive Production Systems (EOPS)*
• nutrient and water requirements; • temperature and light requirements; • size of biological cycles; • requirements for improvement of soil texture and structure (shallow or deep rooting); • requirements for soil conservation; • susceptibility to local pests and diseases; • interdependence of cultural practices (e.g. harvesting with nets for varieties like "*Throubolia*" variety in west Messara plain); • susceptibility to wild fires, especially in dry windy areas; • feeding requirements of animals, in case they are grazed; • degree of soil cover in space and time; • machinery requirements for their management, in chopping or incorporating operations; • cost of seeds.

Design

Cover crops should cover around 70% of the grove surface, in strips between the trees. They should be indicated for every grove in accordance with a set of criteria related to their potential role in biological, physical and chemical terms, in the cover crop plan (Scheme 2). They should be selected for every grove in accordance to (a) the soil type and the nutrient and water requirements of the grove, (b) the microclimate of the grove, (c) the labour, machinery, capital, and management potential of the grower. After selecting a cover, crop plans should be designed for every grove separately.

Cover crops are sown around December. There are three management options, depending the conditions of the grove. The first option concerns green manuring and in that case cover crops are incorporated in the end of March, beginning of April, depending on the agroclimatic conditions. It is important that cover crops are incorporated in the soil in such a way that contours between trees at the grove are followed. On behalf of the beneficials necessary for maintaining a stable ecological infrastructure at the grove (Ecological Infrastructure Method (EIM)), it is also important that strips of blooming cover crops are left (not incorporated in the soil). In that case the cover crop is self re-seeded every year. The second option concerns mulching. Mulch from cover crops might be used in the end of May only, when cover crops might be grazed by cattle from the end of March when agroclimatic condition are favourable. In last options, both are mentioned before, cover crops might be multi-annual. Re-sowing is not necessary each year.

Seed for cover crops should preferably originate from local varieties, since those are better adapted to local soils and climate, and they are identified in accordance with a set of criteria (Scheme 2). The weather conditions and the ways of sowing and managing of the cover crop are important for the success of the method. When cover crops are not applied in an appropriate way, then they may harm productivity of the trees, due to water and nutrient competition. Therefore, sowing should be done as early as possible. If so, then incorporation under the soil, mowing or grazing might happen at the right moment, that is to say: water competition in springtime or labour demands at harvest time, are avoided. When a cover crop is used as a green manure, a five year rotation should be designed in order to optimise the various aspects of cropping: rooting development, pest or disease prevention and soil fertility. Cover crop rotation implies alternation of leguminous and cereal crops (an example has been given in Appendix 3). When cover crops are used for forage or mulching, cover plants should be selected for growing at the same time. Leguminous and cereal crops might be a part of that mixture. The selected cover crop mixture could be used as long as resource and management requirements of the grove permits. Appendix 3 also shows technology belonging with EMCW in case of application in growers' management and in case of application in extensionists' advice.

Designs for the agroecological zones

Design for the hilly groves

In hilly groves (see Chapter 2.1.4.2) mulching and grazing are preferred, because of low fertility of groves and erosion problems. Incorporation of cover crop under the soil is not advisable in hilly groves, since there is a more wet and cooler microclimate.

In hilly groves mixed farming is a tradition, because of the surrounding larger natural areas. Therefore sheep grazing (or cows in low density groves) is preferred above green manuring, provided that manure is returned to the groves in accordance with the fertilisation plan (see Ecological Nutrient Management

(ENM) method). Grazing should be combined with mulching, depending on the weather. In dry years with a small amount of biomass, unsuitable for grazing animals, mulching should be preferred.

In low density groves leguminous cover crops should be sown in a cycle of a radius around two times the diameter of the tree canopy (root zone distribution), in order to avoid leaching of nitrogen and to minimise cost.

Cover crops should not be established in rainfed groves, in years with low rainfall. In such years green manuring is preferable (see Appendix 3).

Design for the plain groves

In plain groves (see Chapter 2.1.4.1) because of the earlier flowering of the olives, incorporation, grazing or mulching should be also earlier to avoid competition of water and nutrients between the cover crop and the olives. Besides, partial incorporation is preferable in years with a spring with low rainfall because of the large amount of biomass produced and the competition of nutrients and water between olives and the cover crops. Partial incorporation minimises nitrogen losses and increases humification.

In summer, a combination of grazing and mulching is better than grazing only which minimises losses of water due to high temperatures. Otherwise, grazing in the plain groves is more difficult than in the hills. In the plain land use is more intensive and therefore animal grazing is harder applicable. On the other hand, animal husbandry in the plain is possible considering soil fertility and the allied biomass production for fodder.

Assessment

Assessment of the success of the EMCW would be done by testing the parameters Soil Cover Index (SCI), Soil Erosion Rates (SER), Macronutrient Balances (MB) and Organic Mater Balance (OMB), functioning as indicators for its success. Application of EMCW requires extra labour for sowing and farm management, extra investments for special equipment for incorporation of cover crops, higher seed inputs for creating cover crops used as a green manure and animals for grazing. Conversion towards ecological production systems demands extra costs and creates more risks. Trying to cover those, farmers deliberate carefully and doing so, reduce attainable progress. Regular assessments help farmers to face obtained results in comparison with potential results, considering the objectives to be attained after the conversion period.

5.2.2 Designing ecological nutrient management

Definition

Ecological Nutrient Management (ENM) is a method additional to Ecological Management of Cover crops and Weeds (EMCW), dealing with preservation of chemical soil fertility and recycling of organic residues. ENM aims at the development and maintenance of agronomically desirable and ecologically acceptable levels of soil nutrient reserves, by tuning inputs of nutrients to outputs, in order to sustain quality production, primarily through recycling of organic residues. It includes cover crops (biological dinitrogen fixation), animal manure, compost products, pruning and harvest residues and olive plant wastes (solid and liquid fractions).

Design

The ENM method must fit into the EOPS, and should be compatible with the other methods for maintaining soil fertility, especially EMCW and Ecological Water Management (EWM).

The general design of ENM is (adapted from Vereijken, 1995):

appraisal of the available leaf Potassium Leaf Reserves (KLR), Phosphorus Leaf Reserves (PLR), Nitrogen Leaf Reserves (NLR)
and soil Potassium Available Reserves (KAR), Phosphorus Available Reserves (PAR) and Organic Matter Content (OMC)

agronomically undesirable	<	*desired range*	<	*ecologically undesirable*
input > output		input = output		input < output

nutrient management to be followed

In accord with the ENM nutrient inputs for the current year are planned. Tuning of inputs and outputs is primarily based on potassium for several reasons. First of all, it is a macronutrient which is easily manageable in the long term and an indicator of soil fertility. Furthermore, potassium is often the limiting nutrient for nutrition of the olive tree, accordingly to the reported frequencies of leaf deficiencies and the annually extracted amounts of potassium from the soil, through the harvesting olives and the pruning residues (Pansiot and Rebour, 1961; Klein and Lavee, 1977; Gavalas, 1978).

Tuning of the nutrient inputs is based at first on optimum ranges of nutrients in the leaves. Leaf analyses are needed since soil analyses are not reliable means of judging the nutrient requirements of trees. There are three possibilities:

1. The leaf potassium levels are above the optimum range and have to be reduced. So the applications of potassium and phosphorus have to be lower than the outputs. The amount of the inputs is determined by the soil KAR, PAR, and OMC. In case the PAR are larger than the desired ranges then no application of inputs is made to avoid pollution of water resources with phosphorus. In case PAR, KAR, OMC are smaller than desired ranges then the application of inputs is around 70% of the outputs, in order to avoid gradual depletion of soil reserves. In case that the PAR are in the desired range but the KAR and OMC are smaller than the desired then the application of inputs is around 40% of outputs, provided that best effort is made to have inputs with minimum content in phosphorus.

2. The leaf potassium levels are within the optimum range. In this case the soil reserves should be maintained by nutrient inputs equal to nutrient outputs.

3. The leaf potassium levels are below the optimum range and should be increased. In this case the inputs should be higher than the expected outputs. Again the next nutrient taken under consideration is phosphorus because of the pollution of water resources.

Firstly, before winter, growers should estimate the nutrient outputs as the expected output (tonne/ha) of olives multiplied by their nutrient contents. Secondly, they should estimate the potassium and phosphorus requirements of each grove from plant and soil reserve analyses. Then they should choose the most appropriate type of animal manure, with a potassium/phosphorus ratio, optimally covering the potassium/phosphorus ratio required for the olives. Initially the need for manure is estimated according to its average potassium content. After manure analysis, the needed tonnage is adjusted according to its real potassium content. If this amount of manure does not cover the potassium needs, additional non-synthetic potassium fertiliser can be applied. The manure should be analysed at the moment of application since the nitrogen content decreases during storage by the gradual decomposition of the organic matter.

Thirdly, growers should estimate the nitrogen input into the grove by manure and atmospheric deposition. For manure inputs it is assumed that 70% of the nitrogen in winter applied manures will be available for the olives. The need for dinitrogen fixation is calculated from the estimated nitrogen removed by products and the available nitrogen from manure and deposition. The required proportion of leguminous crops in the cover crop plan is derived from the need for dinitrogen fixation. It should be noted that the estimates for the leguminous crops, nitrogen input are based on the ecological nutrient management estimations of the previous year. This is due to the fact that the fixed nitrogen will be available to the crops in the following years.

Since the application rate of manure is based on potassium, there are three possible outcomes for the nitrogen balance as estimated from inputs minus outputs. In case inputs minus outputs are zero or the difference is less than 10% of the requirement, the cover crop plan and the fertilisation are properly done. In case the balance is negative, the nitrogen inputs can be increased by growing more green manure leguminous crops in the current year. Thus the available mineralised nitrogen will be increased and less nitrogen from the soil reserves will be used. If inputs minus outputs are positive, nitrogen inputs should be decreased to avoid the negative effects of a nitrogen excess. This can be done by decreasing the share of legumes in the plan of green manure crops for the following year.

Because of changing agroclimatic conditions the cover crop plan may not be followed exactly by the farmers. In that case the ENM is slightly disturbed and this should be taken into consideration the cover crop plan of in next year.

After the growing season the researchers recalculate and evaluate the ENM considering the effect of any changes brought about to the initial cover crop plan.

Timing

Olive grower's calculations are done in summer, when they can make a good estimation of the expected production and the results of plant analyses are known. The fertilisation takes place at the end of November before sowing of cover crops. The fertilisers are fully incorporated in the soil by the seed bed preparation for the cover crops. Because of the desirable biennial production of the trees (optimum use of resources) in case of production every two years the whole ENM is modified considering the averages of leaf and soil reserves (which also is more realistic) and the average inputs and outputs over the two years. The fertilisation is done in the year of no production as it improves the available reserves in the year of production when there is a large nutrient uptake; it creates minimum disturbance to the grove and it is compatible with the farmers' activities and labour.

Leaf sampling should be done at two times, with sampling from the middle of the last year shoots (the ones started in spring). The first will be done at the moment when cover crops are sowed, as leaves have a rather constant nutrient composition. For several reasons, second leaf sampling should be done in April. Those reasons are: nutrient levels are at maximum mineralisation rates and are mobile, new vegetation started without flowering yet, thus absorbing large amounts of nutrients and trees started recovering from olive fruit production. Soil sampling will be done annually in springtime, when soil microbial activity is optimum and soil temperature and humidity are optimum for the mineralisation and mobilisation of nutrients.

Designs for the agroecological zones

Design for the hilly groves

Soils of hilly groves are often eroded (Yassoglou, 1971) so there is urgent need to build up soil fertility. Measures for minimising soil erosion should be taken (Ecological Management of Cover crops and Weeds (EMCW) method) and organic matter has to be added. This is possible since the availability of animal manure is larger in the hilly groves. There are more animals and very often mixed farming is practised.

Due to the presence of traditional old plantations and due to levelling of the land within groves, low densities of plantations requires low nutrient additions. But there are limits, as eroded soils currently of low fertility and current nutrient management spoiled large amounts of nutrients. Low soil fertility in combination with microclimate variations in individual groves might stress olive trees' physiology. Such conditions are favourable for pathogen and pests outbreaks (see Ecological Management of Insect pests and Pathogens (EMIP) method). In such cases extra modifications of the ENM method may be required to overcome them.

Design for the plain groves

Soils of plain groves are more fertile (Yassoglou, 1971) and a good availability of nutrients is present. But, as grove densities and so yields are higher, production levels can only be maintained with animal manure. Animal manures are required to maintain satisfactory crops and soil fertility. The availability of manures however is smaller as there is no mixed farming and the entire area is cultivated with cash crops.

Assessment

The Potassium Leaf Reserves (KLR), the Phosphorus Leaf Reserves (PLR), the Nitrogen Leaf Reserves (NLR), the Organic Matter Balance (OMB) and the Macronutrient Balance (MB) parameters are indicators of the success of the method. As fertilisation requires some labour, ENM may interfere with the harvest activities. Besides, animal manure price is maybe slightly higher than the price of equivalent synthetic fertilisers and in case of liquid manure application, special equipment will be required.

5.2.3 Designing ecological infrastructure management

<u>Definition</u>

Ecological Infrastructure Management (EIM) is a method additional to EMCW dealing with conservation and provision of habitats and corridors for wild flora, fauna, predators and parasites. In addition, EIM also concerns landscape conservation and protection. It aims at the development and maintenance of a network of line elements (field margins, hedges, ditches), enabling wild species to settle and to migrate and people to recreate, helping and protecting the surrounding small natural areas avoiding degradation (Goodman, 1987; Lande, 1988), and buffering the cumulative effects of the agricultural practices (NRC, 1989). Besides, it aims to the protection of the endemic species and a more attractive landscape. It affects the pest and pathogen populations by providing better conditions for survival to their natural enemies. It includes diversification of the olive grove through border planting and planting of targeted species.

<u>Design</u>

The EIM method must be compatible with the other methods especially Ecological Management of Cover crops and Weeds (EMCW) in order to increase biodiversity. At least eight percent of the field surface in hilly groves and four percent in plain groves (including buffer strips, field margins, ditches and hedges) should be managed as natural habitat and corridor. Tree and herb species (Table 5) are planted in buffer strips and the field margins, for diversifying the groves, while, depending on the bas-relief, stone hedges and structures as well as the ditches are maintained. Besides, target species (Table 5) are planted in the field margins attractive for humans, by conspicuous flowers, and to animals, by supply of food or shelter (Vereijken, 1994). Seeds and the nursery stock should originate from native species since they are adapted to local soil and climate but also to preserve local flora. In addition to this, grasses and annual weeds will be left in the ecological infrastructure to encourage insects and small mammals. The system created will also be an attractive environment for birds, which are insect eaters and predators on mice and lizards. Small ponds should be created to provide water for birds and other animals especially during the dry summer months.

Trees and herbs included in Table 5, are used for border planting and intercropping, provide an extra income. The target wild flowers and endemic species are *Anèmone spp., Ranunculus spp., Papaver spp., Malva spp., Teucrium spp., Thymus spp., Salvia spp., Pulicaria spp., Palenis spinosa, Senecio spp., Centaurea spp., Sonchus spp., Lilium spp., Alium spp., Narcissus spp., Gladiolus spp.* and *Orchis spp.* Besides, trap plants for pests, will be planted such as *Cistus incamus* for the olive fly. An EIM plan should be done for every grove ensuring continuation of the existence of food (flowers and seeds) and shelter all around year for beneficial species. On the other hand, this plan should prevent, as far as possible, the existence of food and shelter for harmful species. Consequently an inventory of beneficial and harmful species should be made in the area of every grove. Besides, the food chains of these species should be examined.

Designs for the agroecological zones

Design for the hilly groves

At least eight per cent of the field surface in hilly groves should be used as an ecological infrastructure, because of the levelling of the land and the land mosaic. Stone hedges should be protected as they offer shelter for beneficials, prevent erosion, harvest water and contribute to landscape aesthetics. Besides, because of the ample supply of stones, rows of stones constructed along contours help to harvest water and function as corridors for beneficial animals.

In traditional large density groves, target trees (Table 5) can be planted for diversifying the groves and for offering shelter to birds. Because of the density of animals in the hilly groves ecological infrastructure, heavy grazing should be avoided.

Design for the plain groves

Up to at least four per cent of the field surface in plain groves should be used as ecological infrastructure because of the intensity of land use. Burning of the vegetation of the ditches should be avoided. Besides, wastes should not be disposed in ditches. The borders of groves should not be ploughed and target species (Table 5) should be planted.

Assessment

EIM requires extra labour from farmers for planting target species and extra seed and nursery stock inputs. Besides, it requires extra information and tools for the management the new species. It must be economically sustainable and for this reason fruit trees will be used as border planting. However, it will be difficult to establish and sustain EIM without some subsidy to defray capital investment. The Ecological Infrastructure Index (EII), the Target Plant Species Diversity (TPSD) and the Soil Cover Index (SCI) are parameters for the success of the method.

5.2.4 Designing ecological water management

Definition

Ecological Water Management (EWM) is the method dealing with water harvesting and irrigation water management. It aims at water use while preserving water resources and soil fertility on the long term at minimum expenses. It concerns inputs of nutrients into and losses from groves through leaching and erosion and includes integration of cultural practises and irrigation. Water harvest and conservation, based on cover crops and cultural practices, and management, based on irrigation, should stabilise yield and prevent losses of yields.

Design

The EWM method must be compatible with the entire olive production scheme, especially Ecological Management of Cover crops and Weeds (EMCW). Undercrop covering reduces run-off and evaporation by improving the effectiveness of precipitation, which falls in the form of irregular, brief bursts of rain. Current olive production highly depends on irrigation to increase yields, by stimulating new fruiting wood, fruit induction as well as fruit-size and prevention of shrivel of fruits (Hartman and Panetsos, 1961). Practically the entire olive acreage in Messara is irrigated by drip irrigation. The water requirement (seasonal deficit) of the olives is estimated on the basis of the evapotranspiration (Deidda and Dettori, 1990; Dettori, 1987; Michelakis, 1986).

The required cultural practices for water conservation and harvest are described in the EMCW, Ecological Infrastructure Management (EIM) and Ecological Nutrient Management (ENM) methods. Water application by drip irrigation must be adjusted regarding the total amount of water to be applied per area/season, the dosage and the timing of applications. The olive tree consumes most of the water between the end of flowering and pit hardening in rainfed groves (Ozyilmaz and Ozkara, 1990). It has been stated that the olive is sensitive to water stress in this period (Dorenbos and Kassam, 1979; Ozyilmaz and Ozkara, 1990). The pit hardening period may demand irrigation due to the increased evapotranspiration and the lack of rain. Irrigation applied at the colouring period of the olives may be counterproductive (Cimato and Fiorino, 1986; Hartmann et al., 1980; Ozyilmaz and Ozkara, 1990). Besides, excessive irrigation may provoke an outbreak of olive fruit fly and losses of nutrients. Excessive amounts of water in the soil stimulates migration of the nitrate nitrogen zone below the tree's root area. Nutrients are thus unavailable for trees and may pollute groundwater. But denitrification by soil organisms may also favour soil fertility. Optimum irrigation, however improves mineralisation of organic substances in the soil. Nitrates and potassium thus contribute to optimal tree growth as well as to optimal growth of cover crops. An indicative irrigation plan for western Messara is given in Appendix 3.

Growers should make an irrigation plan, estimating the water requirements, the amount of irrigation water and its dosage, based on the average potential (reference) evapotranspiration. Potential water requirement is 60% of the potential evapotranspiration during the dry season. An irrigation plan for the whole period without sufficient precipitation should be done using CROPWAT computer programme (Smith, 1992).

Timing of irrigation will be based on the use of tensionmeters, on monitoring of leaf wilting early in the morning, and on observing wilting of plant indicators e.g. mallow (*Malva silvestris* L.) and melilotus (*Melilotus officinalis* L.). After irrigation fulfilment of soil water requirements can be tested by drilling holes in the field. Irrigation is preferably to be done late in the afternoon or very early in the morning to minimise water losses. In addition, frequent irrigation with small amounts of water is preferable to irrigation of longer periods with large amounts of water because the water losses. The frequency of irrigation will depend also on the soil type.

After the dry season researchers should recalculate and evaluate the EWM using actual outputs and inputs.

The olive grower estimations should be done in spring, when they can estimate the expected production and the precipitation of the wet season is known. Irrigation season extends from April until October, depending on the weather conditions. The timing of irrigation may be planned with the water budgeting method. The usual amount to be applied on most Messara plain and the surrounding hills varies between 1000-1500 m^3/ha/year.

Designs for the agroecological zones

Design for the hilly groves

In hilly groves, because of the bas relief, water harvest techniques should be applied to minimise run off. These techniques are especially important for rainfed, high density groves, depending exclusively on the variable year to year rainfall for covering their water requirements. Such techniques (see also Ecological Infrastructure Management (EIM) and Ecological Management of Cover crops and Weeds (EMCW) methods include contour ploughing, following the soil bas relief, construction of lines with stones, following the contours of the slopes, for increasing infiltration. Hilly groves require lower irrigation water amounts compared with plain groves because of the smaller evapotranspiration due to the more wet microclimate and the lower temperatures. Considering efforts to avoid competition between cover crops and olive trees, rainfed groves should not include vegetative cover crops in dry years (see also EMCW method).

Design for the plain groves

Plain groves need frequent irrigation and larger amounts of water because of the soil type and the warmer and dryer microclimate. Consequently more frequent irrigation with small amounts of water should be preferred as well as the use of mulches considering minimising evaporation of water (see also EMCW method).

Excessive irrigation in the plain groves may create pollution of the water reservoirs, underlying the plain, due to leaching of nitrates.

<u>Assessment</u>

The EWM method requires monitoring of the precipitation and water status of the crop. Additional labour is needed for the timing of irrigation when using tensionmeters. The Irrigation Index (II), and the Soil Cover Ihdex (SCI) are parameters for the success of the method.

5.2.5 Designing ecological management of insect pests and pathogens

<u>Definition</u>

Ecological Management of Insect pests and Pathogens (EMIP) is the method dealing with prevention and control of insect pests, pathogens and weeds at levels that do not reduce production levels together with prevention of nature degradation and environmental pollution. Since chemical pesticides are not part of EMIP, product quality is sustained at a high level. EMIP also includes monitoring of enemies in the olive grove. Cultivation practices are combined with biological control procedures. Preventive methods, based on diversification, and curative methods, based on biological control, should stabilise yield and prevent losses.

<u>Design</u>

The EMIP method must fit into the entire olive production scheme, and be compatible with the other methods for increasing biodiversity and controlling weeds, especially Ecological Management of Cover crops and Weeds (EMCW) and Ecological Infrastructure Management (EIM). The required cultivation practices for the control of the crop enemies are described in the EMCW and

EIM methods. EMIP strongly relies on biological control for the main enemies of the olive trees in the region, namely the olive fruit fly (*Bactocerae oleae* Gmel..), the black scale (*Saissetia oleae* Oliv.), the sooty mould (*Capnodium sp.*) and the peacock spot (*Spilocaea oleaginea*). The biological control uses cultivation practices combined with biocides, approved by the organic agriculture standards and release of parasites, predators and native natural enemy fauna. It is expected that after the first transition phase and the optimisation of the farm structure the phytopathological problems will be minimised, as also will be the need for specific control.

The specific control methods for the above main enemies are: (a) the olive fruit fly is controlled with the mass trapping method (Haniotakis *et al.*, 1991). Timing of trap installation is determined by McPhail or pheromone trap catches, and usually occurs around the middle of June. Trapping period is extended through October; (b) the sooty mold and the peacock spot are controlled and/or prevented with copper compound sprays in October. When serious outbreaks occur (as in years with above-average rainfall) an additional spray may be applied early in March. Need for spraying depends on the level of the infestation and the agroclimatic conditions. Agroclimatic conditions are important for the EMIP incorporation in the farmer's practices. Besides, careful execution of the mass trapping method and the timing of the disease control sprays are important for the success of the method. If they are done inappropriately then they will harm the productivity of the grove, due to fruit fly and pathogen increased infestations. It is important the trees to be maintained in a good physiological condition by (a) proper fertilisation (Ecological Nutrient Management (ENM) method), (b) proper pruning (c) proper irrigation (Ecological Water Management (EWM) method). A more detailed description for the prevention and control of the specific insects and pathogens is presented in Appendix 3.

Designs for the agroecological zones

Design for the hilly groves

In traditional groves planted to "*Throubolia*", which are currently irrigated, precise irrigation planning (see EWM method) is required. That requirement addresses prevention of peacock spot for which "*Throubolia*" is susceptible. Inappropriate water use creates favourable conditions for peacock spot and olive fly and promotes outbreaks of this pest. Continuous monitoring of peacock spot infestation in spring is required as well. In springtime copper spraying should be avoided because beneficial insects are reproducing during this period. Increasing numbers of beneficials are necessary from that time, since those levels decreased due to preceding winter time.

The mass trapping of the olive fly in "*Throubolia*" requires more control traps because of the size and the density of the trees. In traditional groves pruning is very often neglected as it is difficult because of the height of the trees. This should be avoided because of the required adequate air movement and sunning for limiting a favourable microclimate for pests and pathogens. Besides, for the control of the olive fly some very sensitive olive trees (early fruit set, very receptive olives) may be used as traps as they attract the flies. Olives of these trees may be harvested directly after infestation and removed from the grove (e.g. used as animal foodstuff).

Ecological infrastructure (see EIM method) should be protected by heavy grazing thus promoting predators and parasites of the grove pests. Besides, in traditional groves because of the planting distance of the trees, appropriate corridors should be maintained and pruning should not be neglected.

Design for the plain groves

Excess of water should be avoided to prevent favourable conditions for pests and resulting outbreaks, which are also promoted by the high density of plantations. Because of the intensive land use in the plain, linear elements (see EIM method) should be incorporated in the groves for promoting beneficial predators and parasites. Besides, cover crops (see EMCW method) should be managed mainly with grazing and mulching. In winter time cover crops may also create unfavourable ground conditions for the larvae of the winter generations of pests.

<u>Assessment</u>

The required labour for the EMIP method, pest, pathogen and weed populations are monitored. Additional labour is needed for olive fly mass trapping, in the case where growers prepare home made traps; while labour is saved by the decreased number of sprays. The Quality Production Index (QPI), the Environmental Exposure to Biocides (EEB), the Soil Cover Index (SCI) and the Target Plant Species Diversity (TPSD) parameters are indicators for the success of the method.

5.2.6 Farm structure optimisation

<u>Definition</u>

Farm Structure Optimisation (FSO) is mostly an indispensable final method to obtain an agronomically, economical and ecologically optimised prototype, by determining the minimum amounts of land, labour and capital to achieve the required Net Surplus (NS) and Energy Efficiency (EE) (Vereijken, 1995).

Design

The design of this method is based on:
- establishing a model of a farm structure to quantify the required land, labour and capital by linear programming;
- establishing a database on the inputs and outputs of the prototypes;
- running different scenarios of the FSO model in interaction with researchers and pilot growers

The design of this method has been prepared in co-operation with our research associate A. Vassiliou of the Welsh Institute of Rural Studies, University of Wales.

Assessment

This method will be fully operational after optimisation of agronomic and ecological aspects of the prototypes to be established in farms. The Energy Efficiency (EE) and the Net Surplus (NS) parameters will be indicators for the success of the method.

5.3 Conclusions

The theoretical prototype should secure the inter-link of the new methods at all olive production levels: physical, biological-agronomic, product-market, and farm level. Otherwise objectives would not be achieved and sustainability and productivity of the groves will be damaged.

Conventional methods only serve one or two of the objectives and mainly harm the others. The new methods avoid that. Trials on-farm are required for selection of local varieties of the most appropriate cover crops. Besides, new advanced machinery and equipment are required for management of cover crops, fertilisation with animal manure and wastes, and irrigation planning and management. Furthermore, the growers need training and time to adopt and practise efficiently the new methods.

In the prototypes Ecological Management of Cover crops and Weeds (EMCW) and Ecological Nutrient Management (ENM) methods mainly contribute to control soil erosion. Soil erosion is a serious environmental problem, especially in hilly agroecological zones with already eroded shallow soils. Erosion reduces the productivity of the land and increases the need for fertilisers to replace the lost nutrients. The techniques related to these methods conserve soil resources.

Ecological Management of Cover crops and Weeds (EMCW) and Ecological Infrastructure Management (EIM) methods conserve genetic diversity in the prototypes and prevent genetic losses. This is particularly important because of the environmental extremes of the Mediterranean climate and the scenarios of global climate change, predicting Mediterranean area to be drier. Besides, genetic diversity prevents rapid increase of pests and thus prevents vulnerability to devastating epidemics and pressures of diseases and insects. Besides, EMCW and EIM conserve the endemic species of Crete and its unique outstanding landscape. The latter is also of direct concern for the tourist industry and the urban population.

Ecological Management of Cover crops and Weeds (EMCW) and Ecological Water Management (EWM) methods are important for the prototypes as groundwater tables decline and costs for irrigation rise. Besides, inefficient irrigation practices and planning may contribute to aquifer depletion, while on sandy soils may contribute to the movement of nitrate into surface and groundwater and their contamination. This effect is related to the fact that most conventional, compact, irrigated groves also receive irrationally high levels of fertilisers, especially nitrogen. This is avoided in ecological olive production and is secured by Ecological Nutrient Management (ENM) method. Until now no monitoring or prevention measures have been taken to prevent such problems.

Olive tree is a xerophytic species resistant to drought. Irrational irrigation limits its ability to use soil water, while depleting aquifers. The project area should be examined to ascertain whether the recharge of aquifers exceeds withdrawals. Besides, as other industries, like tourism, compete for water, agriculture and olive growing will have to conserve water, requiring more prudent water use. All these make indispensable the development of an EWM method for a more efficient water use.

CHAPTER 6. INITIAL TESTS AND IMPROVEMENTS OF THE PROTOTYPE

6.1 Laying out the prototype in farm specific variants
6.2 Testing the prototype: initial results
6.3 Improving the prototype
6.3 Conclusions

The prototype as a result of linking procedures of methods, which may achieve all identified objectives expressed in quantified parameters, should further be tested and thus improved by establishing it in practice. Testing and improving procedures should be continued until desired results are obtained. Testing and improving the prototype in practise is done in close interaction with the group of pilot farmers. They themselves continue to layout their prototypes each year at their groves until the achieved results match with the desired ones. Testing and improvement can be carried out at best using a set of five criteria (Scheme 1; page 55). Improvement procedures are adopted from Vereijken (1994) (Scheme 3).

Scheme 3. *Procedure to improve the prototype* (adopted from Vereijken, 1994)
(1) Establishing which parameters have shortfalls between achieved and desired results
(2) Establishing from the theoretical prototype which methods are involved
(3) Establishing which criterion(a) are not fulfilled yet by these methods
(4) Establishing targeted improvements to meet the successive criteria
(5) Laying out and re-testing

6.1 Lay out of the prototype in farm specific variants

Pilot growers provided eighteen pilot groves, located at the western Messara plain and on the surrounding hills, that cover the main agroecological types of olive production for this area (see also Chapter 2.1.4.1 and Chapter 2.1.4.2). For obtaining an optimal layout, the pilot groves were selected in accordance with a set of agroecological criteria (Scheme 4), and comprise high and low density groves. Maps 2-4 show the layout of the prototype on pilot groves is presented for the three specific variants: (a) high density groves in the hilly agroecological zone, (b) low density groves in the hilly agroecological zone and (c) intensive groves in the plain agroecological zone (see also Table 7).

Scheme 4. *Agroecological criteria for the selection of pilot olive groves*
(1) Grove size ≥ 0.5 ha
(2) Ratio of field length to width ≤ 4
(3) Olive grove tree density ≤ 250 trees/ha
(4) Possibility for applying five years cover crop rotation.
(5) Possibility for using annual leguminous, cereal and mixed cover crops
(6) Compatibility of neighbouring activities (agricultural and non agricultural)
(7) Typical physical conditions and grove management of the area

These variants differ in more than one of the following factors (see also Chapter 2.1.4.1 and Chapter 2.1.4.2): (a) microclimate, (b) soil type, (c) water use, (d) plantation type, (e) olive tree variety.

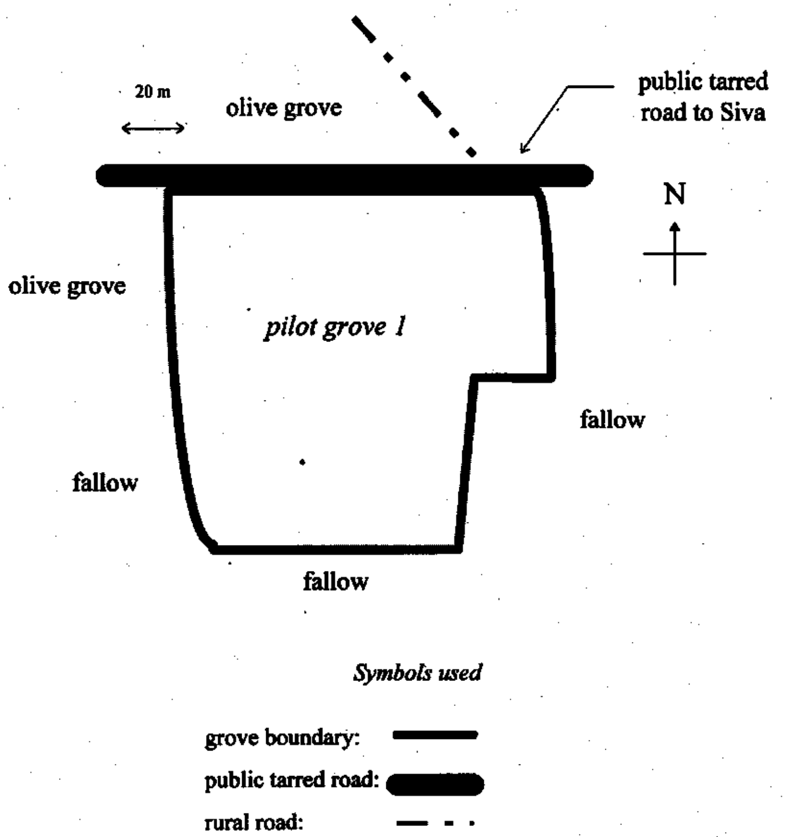
Table 7. *Prototype variants for the agroecological zones, as laid out on the pilot groves*

Grove code	hilly groves *intensive* [1]	hilly groves *extensive* [2]	plain groves *intensive* [1]
1	X		
2			X
3			X
4			X
5			X
6			X
7			X
8			X
9			X
10			X
11			X
12	X		
14	X		
15	X		
16	X		
17		X	
18		X	
Total	5	2	10

[1] *intensive (high density or compact plantations): >130 trees/ha*
[2] *extensive (low density plantations): ≤130 trees/ha*

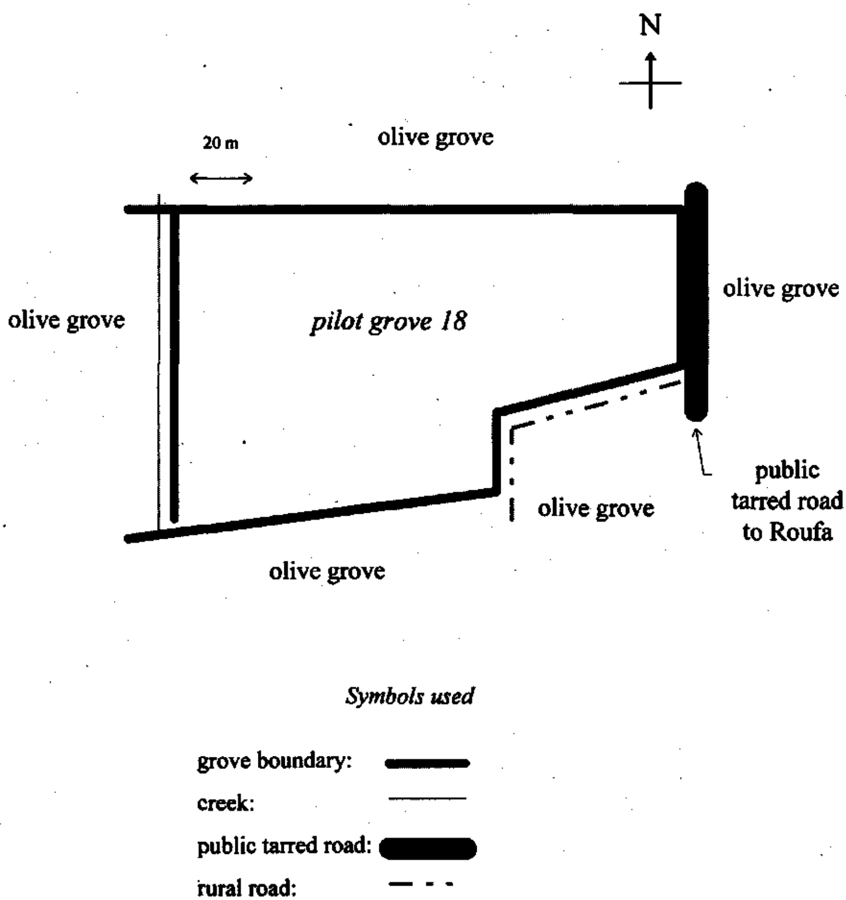
Map 2. *Layout of intensive hilly groves*

per grove	(lowest - highest)
extent	0,5 - 2,5 ha
mean grove length/width	1 - 3.8
mean slope	4 - 16,6 %
mean altitude	110 - 235 m
soil texture	SL - SCL
planted in	1930 -1991
no. of trees/ha	140 - 326
variety	*"Koroneiki" - "Throubolia"*



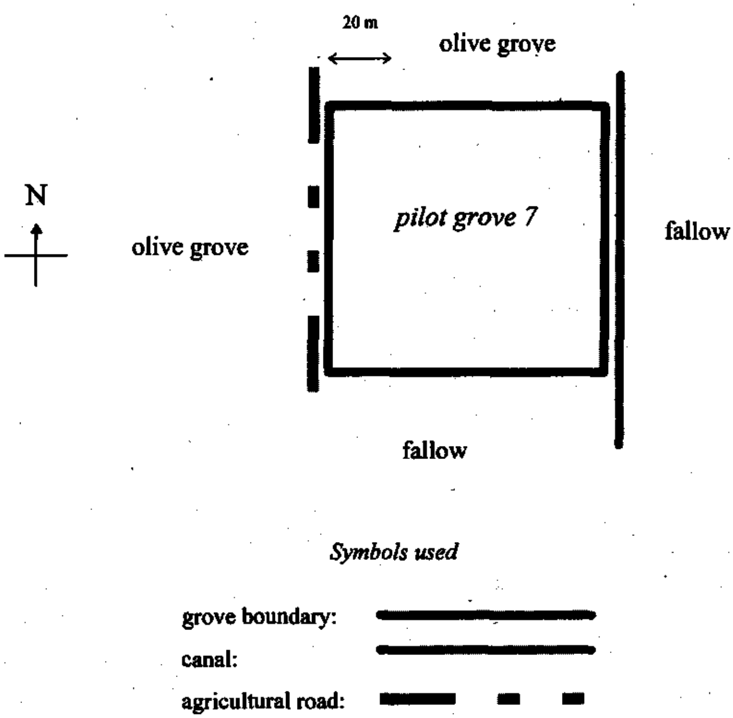
Map 3. *Layout of extensive hilly groves*

per grove	(lowest - highest)
extent	0.8 - 1.7 ha
mean grove length/width	1 - 1.6
mean slope	5 %
mean altitude	242 - 270 m
soil texture	SL - SCL
planted in	1910 -1970
no. of trees/ha	35 - 56
variety	"*Koroneiki*" - "*Throubolia*"



Map 4. *Layout of intensive plain groves*

per grove	(lowest - highest)
extent	0.4 - 0.8 ha
mean grove length/width	1 - 2.4
mean slope	0 - 2 %
mean altitude	35 - 60 m
soil texture	L - SL - SCL - SC - CL
planted in	1974 -1991
no. of trees/ha	167 - 290
variety	"*Koroneiki*" - "*Manzanilla*"



6.2 Testing the prototype: initial results

An initial version of the prototype was laid out and tested in 1994 and in 1995 based on the six innovative methods. Initial results of 1994 and 1995 from laying out in 17 pilot groves managed by 12 pilot growers, as well as the results of testing the prototype with 10 parameters are presented in Table 8. The results are presented in the order of the 6 major methods required to achieve the objectives, as transformed and quantified in the set of the 12 multi-objective parameters (see theoretical prototype in Figure 9 and Chapter 4.2). The results are presented as means of 1994 and 1995 because of the biennial production habit of the olive tree and the related timing of cultural practices (Figure 7).

The data related to parameters and methods are recorded in spreadsheets and databases with the Microsoft Excel computer programme. In accordance to the methods' research plans a number of tables are constructed with data provided by the growers and measured by the growers and the researchers. Growers provide data related to the activities of their farms, the application of the methods to their groves and the quantification of parameters. Researchers measure data related to the quantification of the parameters. The data of the filled tables were used by the researchers to calculate the parameters achieved results for every grove, each year. Research was also shown to the growers in practical form using Excel.

6.2.1 Ecological management of cover crops and weeds

Ecological Management of Cover crops and Weeds (EMCW) is the major method to achieve desired results in Soil Cover Indexes (SCI) and Soil Erosion Rates (SER). The EMCW variants of the 17 pilot groves have been designed and initially laid out following the demands made of EMCW, as specified in Chapter 5.2.1.

Figure 10 presents the SCIs throughout the pilot group, over the year (Figure 10a) and by month over the whole pilot group (Figure 10b). All pilot groves, except one that had permanent soil cover in 1995, are below the desired results due to soil management. Soil cover is very low in spring time, because of management of the cover crops, as also in summer time and early autumn, because of the spring management of the cover crops and dryness of climate (see Chapter 2.1.2). Initial results of testing SCIs show that EMCW method was not yet acceptable by the pilot growers, as it was neither fully elaborated scientifically nor did growers know how to apply EMCW exactly in practise. Besides, results also show effects of previous conventional soil management Figure 1.A5, Appendix 5, presents the SCIs during conventional management of the pilot groves.

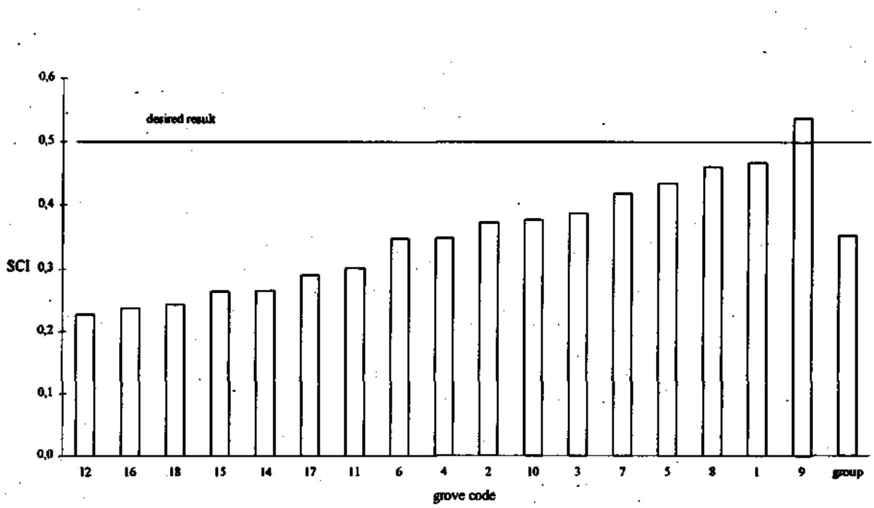


Figure 10a. *Soil Cover Index (SCI) by pilot grove over the year, mean 1994-1995*

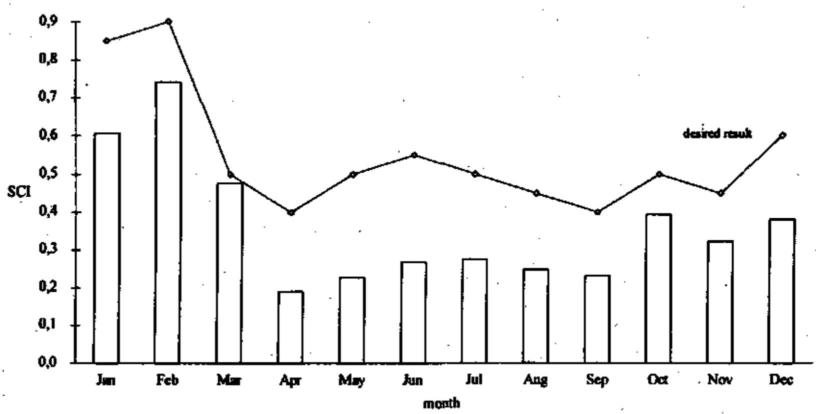


Figure 10b. *Soil Cover Index (SCI) by month over the pilot group, mean 1994-1995*

Data on SER are not available yet. Future experiments are planned.

6.2.2 Ecological nutrient management

Ecological Nutrient Management (ENM) is the major method to achieve desired results in Potassium Leaf Reserves (KLR), Phosphorus Leaf Reserves (PLR), Nitrogen Leaf Reserves (NLR), Macronutrient Balances (MB) and Organic Matter Balance (OMB). The ENM variants of the 17 pilot groves have been designed and initially laid out following the demands made for ENM, as specified in Chapter 5.2.2.

Figure 11 presents the KLRs, PLRs, NLRs throughout the pilot group. Most of the groves are above the desired levels but this is due to the unbalanced nutrient management before conversion to Ecological Olive Production Systems (EOPS). These results are also related to the nutrient management in the past, which was based on irrational and inappropriate use of synthetic fertilisers, mainly nitrogen fertilisers (see Appendix 5). Initial results of testing with leaf reserves show that ENM method is not yet fully manageable by the pilot growers in the pilot groves.

Figure 12 presents Macronutrient Balances (MBs) (Potassium Balances (KBs), Phosphorous Balances (PBs), and Nitrogen Balances (NBs)) in the groves of the pilot group. Phosphorus (Figure 12b) and nitrogen (Figure 12c), were not managed effectively in almost all the groves. Potassium (Figure 12a) was managed effectively in only three pilot groves. These initial results of testing with macronutrient balances show that the ENM method is not yet fully manageable by the pilot growers in the pilot groves. Figure 2.A5, Appendix 5, presents the MBs during conventional management of the pilot groves.

The results on OMB are not available yet because of lack of data on humification coefficients and effective organic matter for the pilot project area. Future further experiments are planned.

6.2.3 Ecological infrastructure management

Ecological Infrastructure Management (EIM) is the major method to achieve desired results in Ecological Infrastructure Index (EII) and Target Plant Species Diversity (TPSD). The EIM variants of the 17 pilot groves have been designed and initially laid out following the demands made by EIM, as specified in Chapter 5.2.3.

Figure 13 presents EIIs throughout the pilot group. Most of the groves are below the desired result and this is due to land management. The tendency of the growers was to cultivate and to plant olives on all the available land, especially in the plain groves. Besides, they were destroying all ground cover with soil management or herbicides on land unsuitable for cultivation, as it was considered as a source of pests (see Appendix 5). Initial results of testing with EII show that the EIM method is not yet manageable in the pilot groves. Only three hilly groves meet the desired result as they have uncultivated land mainly because of the bas relief. Exception is grove one which has land devoted to species other than olive trees.

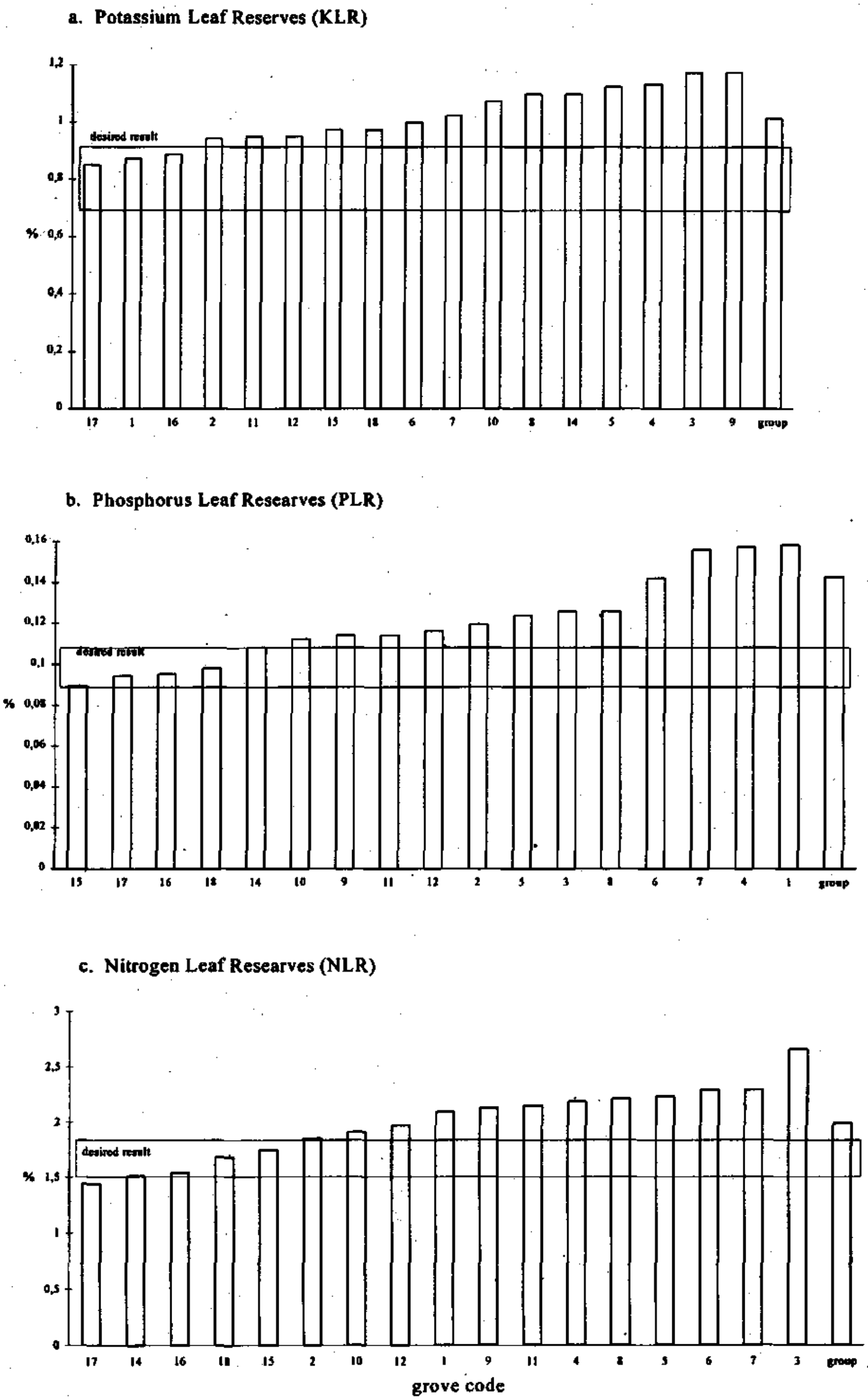


Figure 11. *Leaf reserves by pilot grove, mean 1994-1995*

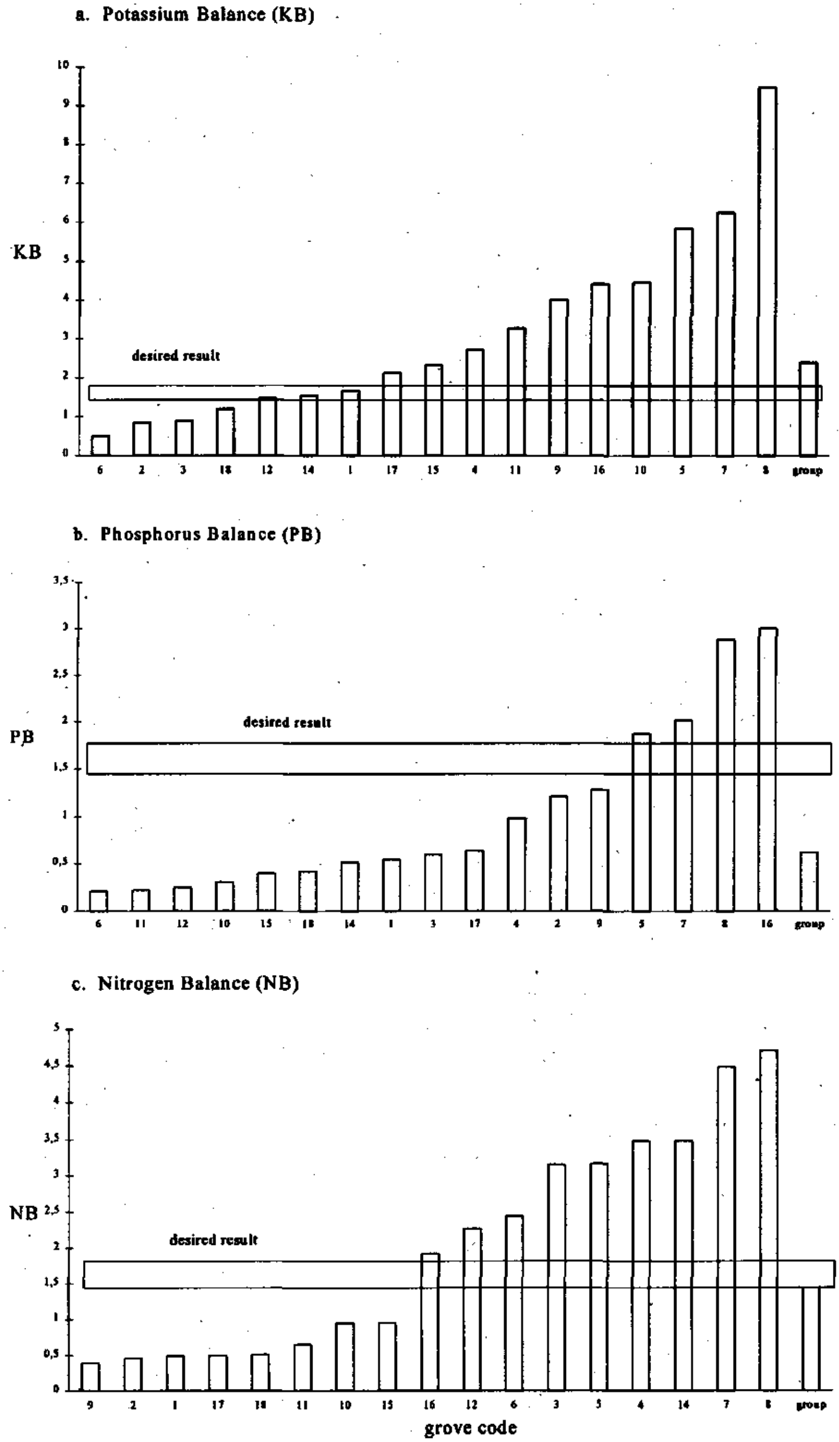


Figure 12. *Macronutrient Balances (MB) by pilot grove, mean 1994-1995*

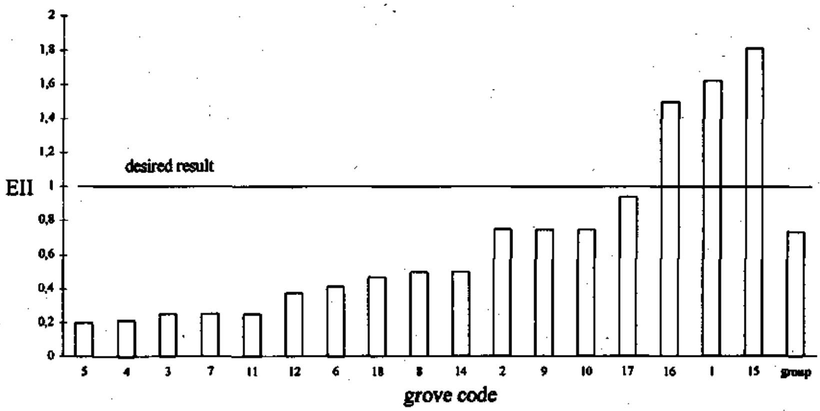


Figure 13. *Ecological Infrastructure Index (EII) by pilot grove, mean 1994-1995*

Figure 14 presents TPSDs throughout the pilot group. TPSD tests the efficiency of EIM for flora, fauna and recreation. Almost all pilot groves are far below desired results and this shows that the EIM method is not yet effective. Most growers did start structuring an ecological infrastructure within their farms. That happened by creating uncultivated corridors throughout their farms and by planting some of the advised trees or shrubs (Figure 14). Further planting with more plants and other species is in progress, while exercising management of such an infrastructure. Data on annual Target Plant Species Diversity (TPSD) are not available yet. Identification of a list of target plant species suitable for permanent creation of a relevant ecological infrastructure is still in progress.

The above results should not be discussed without considering that Ecological Infrastructure Management (EIM) was not presented at farms before (see Appendix 5) and without considering that testing EIM is still in progress. Knowledge, experience and skills related with EIM management should be developed at first.

6.2.4 Ecological water management

Ecological Water Management EWM is the major method to achieve desired results in Irrigation Index (II) and contributes to achieving desired results in Quality Production Index (QPI) (see Chapter 6.2.5). The EWM variants of the 17 pilot groves have been designed and initially laid out following the demands made of EWM, as specified in Chapter 5.2.4.

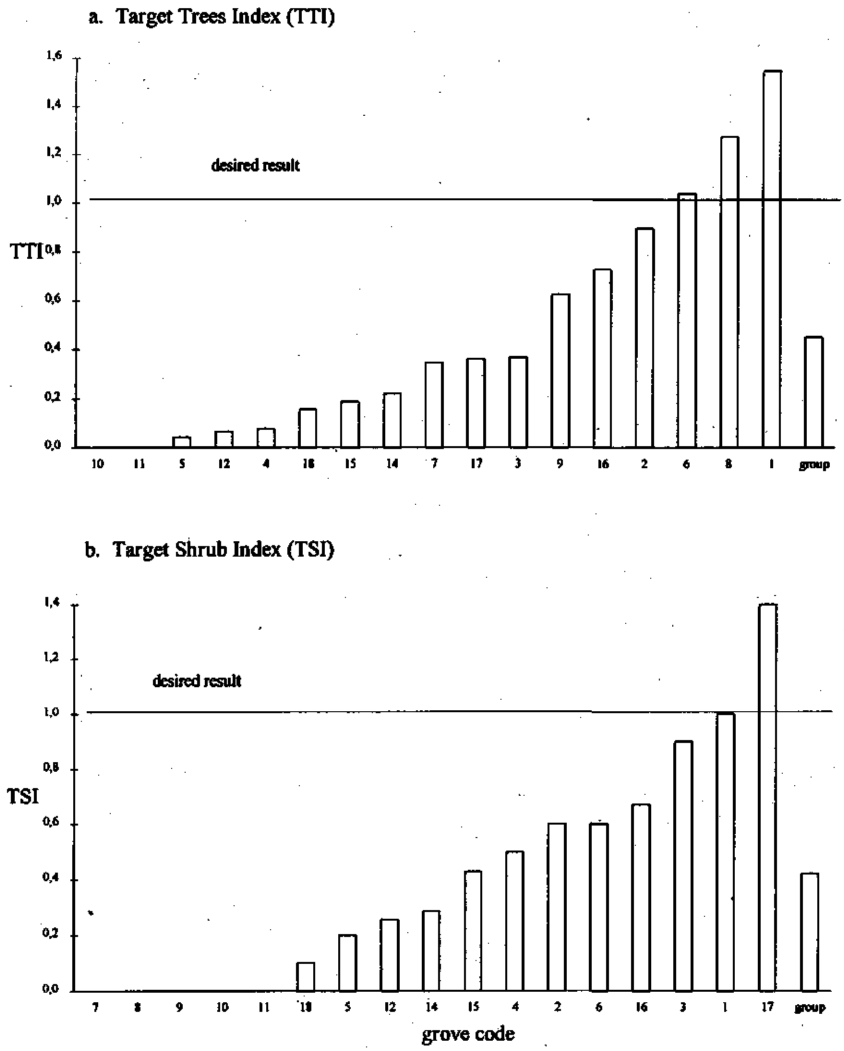


Figure 14. *Target Plant Species Diversity (TPSD) by pilot grove, mean 1994-1995*

Figure 15 presents IIs throughout the pilot group, groves 17 and 18 are rainfed. Most of the groves are above the desired result, due to excess of irrigation. Growers tend to over-irrigate, especially in the plain groves, and they do not time irrigation in a rational or a scientific sound way. The initial results of testing with II show that the EWM method is not yet effective in the pilot groves. Only six groves are below the desired result and this was due in a large extent to the unavailability of water for irrigation rather than to irrigation planning. Thus pilot groves are contributing to over-exploitation of water

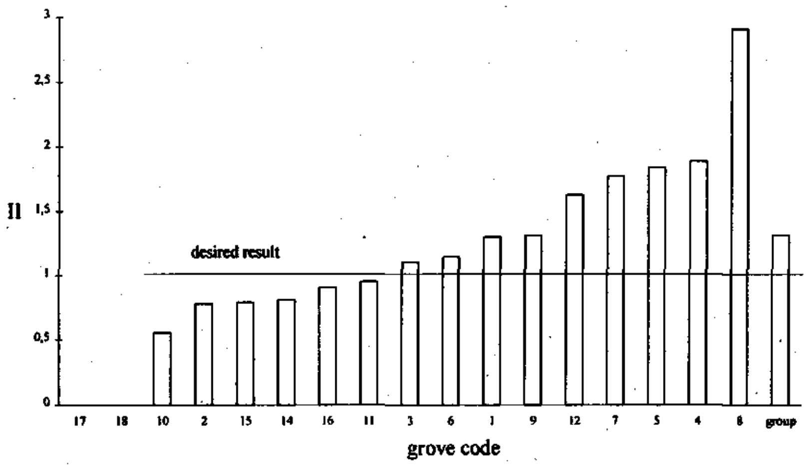


Figure 15. *Irrigation Index (II) by pilot grove, mean 1994-1995*

resources in the area. An exception is grove two where even if water was available was not used in excess. Figure 4.A5, Appendix 5, presents the IIs during conventional management of the pilot groves.

Above results should also be related with the initial status of testing procedures of prototypes. Continuing elaboration by science, farmers and farm advisors is important.

6.2.5 Ecological management of insect pests and pathogens

Ecological Management of Insect pests and Pathogens (EMIP) is the major method to achieve desired results in Quality Production Index (QPI) and Environmental Exposure to Biocides (EEB). The EMIP variants for 17 pilot groves have been designed and initially laid out following the demands of EMIP, as specified in Chapter 5.2.5.

Figure 16 presents QPIs throughout the pilot group. All groves are below the desired result and this is due to losses in yields and the failure to achieve top quality price. Pilot groves have similar QPIs as growers usually bring their commodities to the market collectively. Growers should still learn how to get top quality prices at markets. Therefore their prices do not reward their commodity quality. Production losses were due to pest problems (because of insufficient management) and to losses related to insufficient water management during the dry 1994 and 1995 years. The initial results of testing with QPI show that the EMIP method was not yet fully effective in the pilot groves.

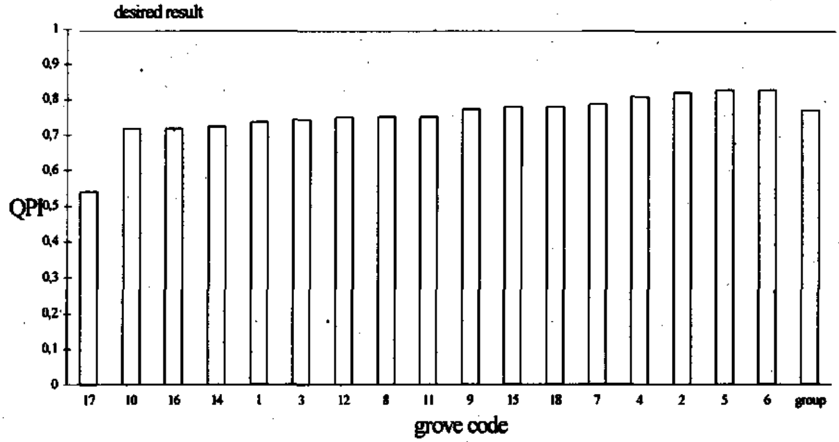


Figure 16. *Quality Production Index (QPI) by pilot grove, mean 1994-1995*

Figure 17 presents EEBs throughout the pilot group. All the groves are below the desired result. This is due to the application of control measures, for the olive fly management. Even if the EEB is low, farmers still use a selective pesticide in the traps for the control of the olive fly. The initial results of testing with EEB show that the EMIP method was not yet effective in the pilot groves. Figure 3.A5, Appendix 5, presents the EEBs during conventional management of the pilot groves.

6.2.6 Farm structure optimisation

Farm Structure Optimisation (FSO) is the major method to achieve desired results in Net Surplus (NS) and Energy Efficiency (EE), if all the other methods do not succeed to do so, and contributes to achieve desired results in Quality Production Index (QPI) (see Chapter 6.2.5). The FSO is subject of a separate study by A. Vassiliou at the University of Wales, Aberystwyth (Chapter 5.2.6).

Figure 18 presents NSs throughout the pilot group. Seven groves succeeded in obtaining a desired NS in 1994-1995, while the others stay below the desired result. This is because of the high costs, mainly the fixed ones (Figure 18c) and the small size of some groves (Figure 18d). Initial results thus show that desired NS could not reached at this stage of the project. Consequently, either the FSO will be required, for optimising land and agrotechnology use and/or the farmers should work more co-operatively.

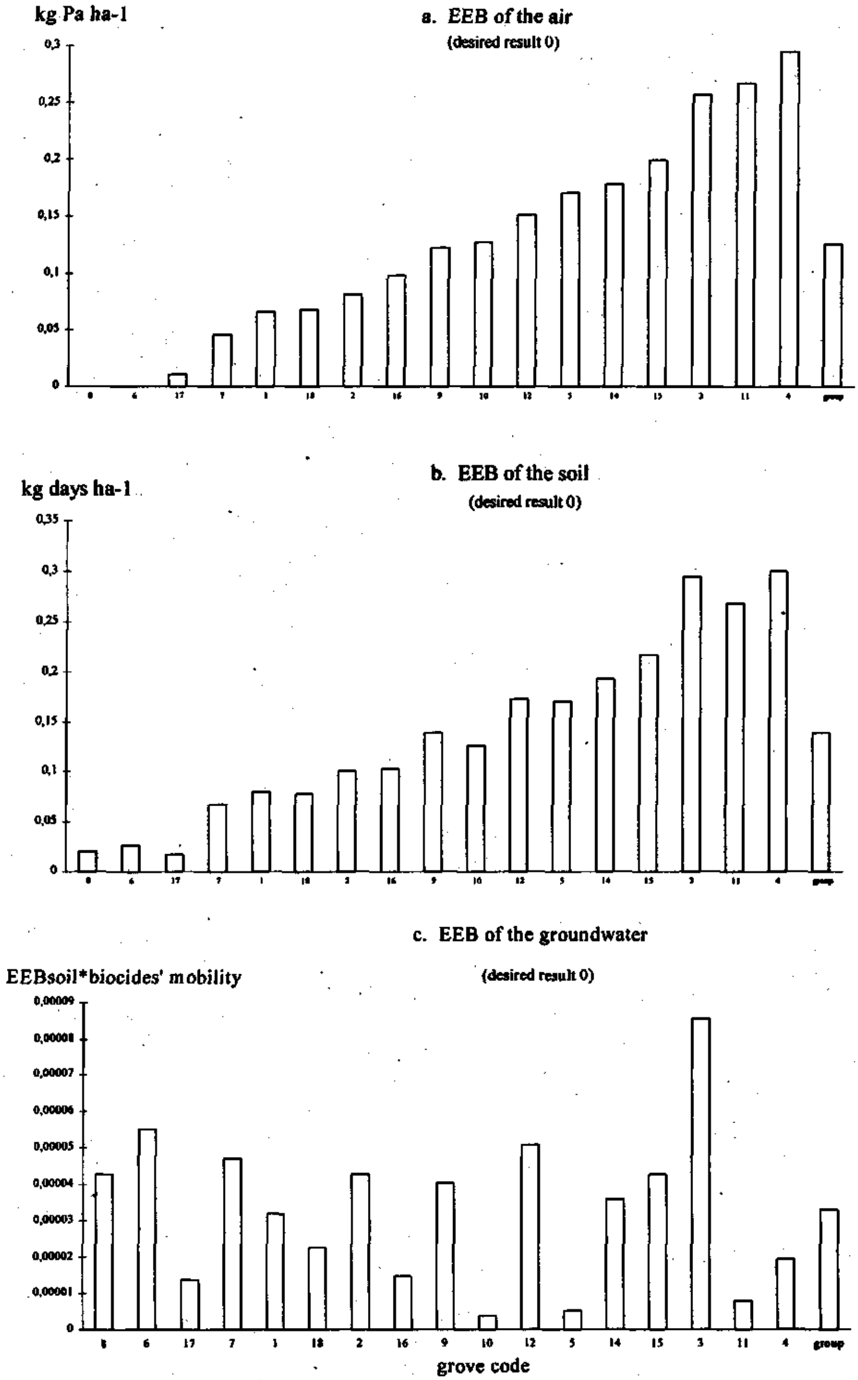


Figure 17. *Environmental Exposure to Biocides (EEB) by pilot grove, mean 1994-1995*

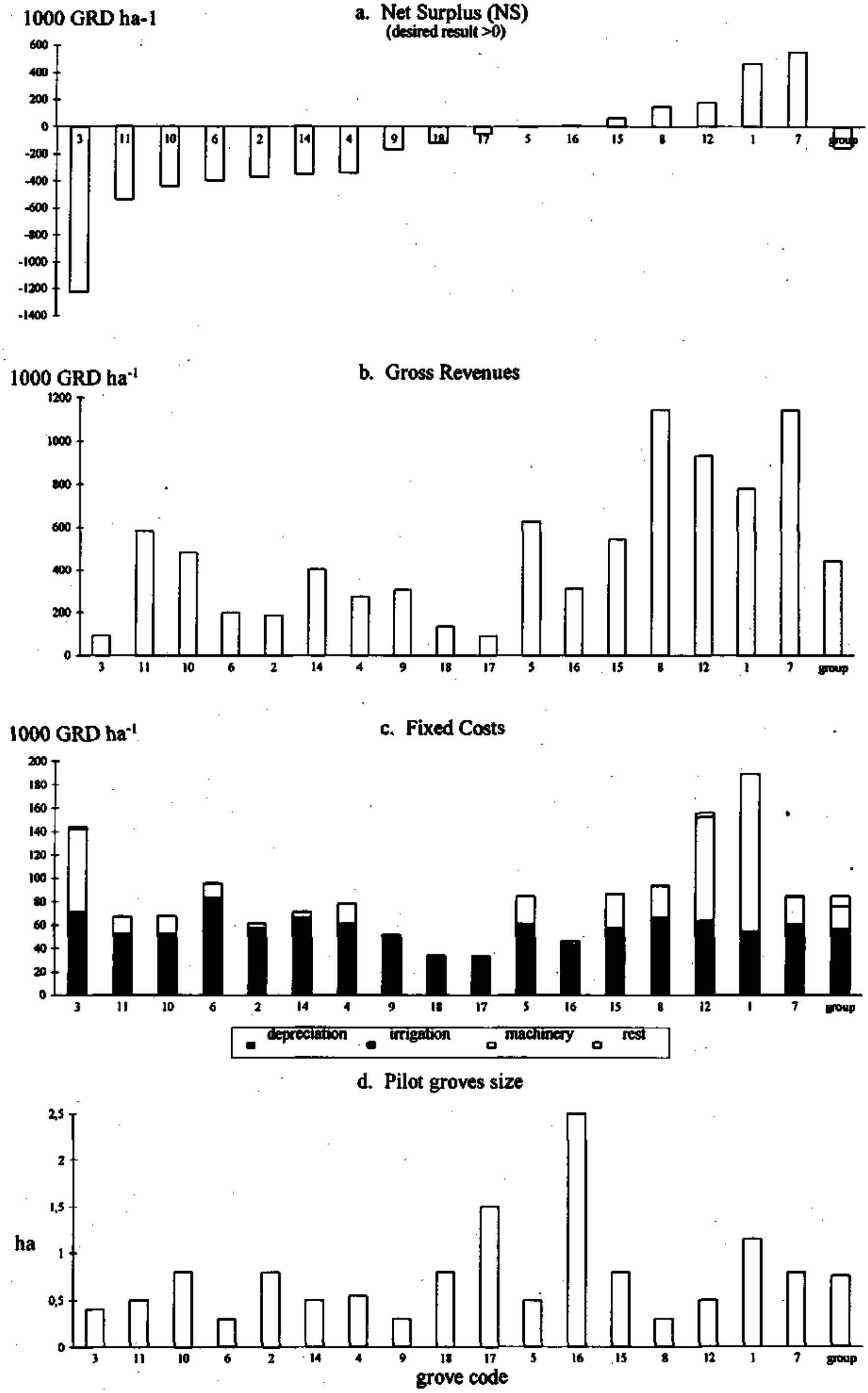


Figure 18. *Net Surplus (NS) by pilot grove, mean of 1994-1995*

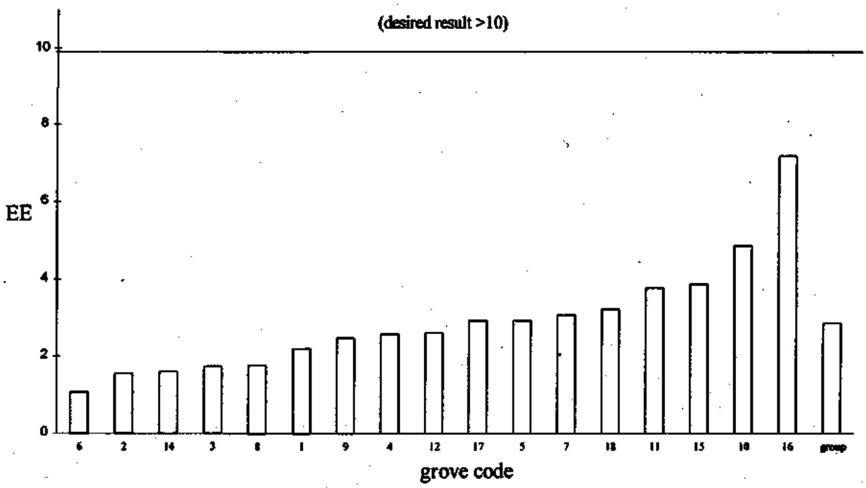


Figure 19. *Energy Efficiency (EE) by pilot grove, mean 1994-1995*

Figure 19 presents EEs throughout the pilot group. All the groves are below the desired result and this is due to the fact that energy use was not considered before. A main energy input is the fuel for transportation due to fragmentation of the farms with plots in several locations (see Figure 6). In Crete allocated farms are a current phenomenon. Energy consumption is also considerably enhanced by irrigation. EWM should therefore be optimised. Initial results of testing EE at pilot farms show that desired results for EE are not gained at this stage of the project. Consequently, FSO is required for further improvement and farmers should work more co-operatively.

The above parameters were used to check the economic and energy performance of the groves initially and to adjust the methods. In the future phase of this project FSO should be applied when all the methods designed for turning olive groves into ecological production systems fail to do so. That is important in particular, when prototypes are going to be disseminated at a large scale.

6.3 Improving the prototype

Improving the prototype is a matter of relating the shortfalls between achieved and desired results to the methods (Table 8 and Figure 20). Such shortfalls between achieved and desired results may arise from one or more of the following causes (Vereijken, 1995):

- the method(s) in question is not ready for use, or
- not manageable by the farmer, or
- not acceptable by the farmer, or

- not effective.

The methodical procedure of Vereijken (1995) is adopted in order to improve the prototype (Scheme 3). The first step is to establish which parameters show shortfalls between achieved and desired results (see Table 8 and Figure 20). The second step is to establish, using the theoretical prototype, which methods are involved (Figure 9). The third step is to establish which criteria are not yet fulfilled by these methods (Table 8). The next step is to establish targeted improvements of the methods to meet the criteria.. The last step is the laying out and retesting the prototype again. The prototype will be laid out and retested in the next stage of our project (see Chapter 1.3).

The process of interaction in 1994 and 1995 with the pilot grove for improving the methods had as follows: After annual application of the methods (see Chapter 5 and Appendix 3) and monitoring of the parameters, was examined with the pilot growers the:

- degree the objectives of the prototypes had been achieved;
- process of application, weaknesses, and opportunities to improve next year each method regarding readiness to use, manageability, acceptability, effectiveness. Then targeting improvements (i.e. timing of cultivation practices, type and use of machinery, used inputs, etc.) were decided for each farm and method;
- gaps between achieved and desired results of parameters related to application of methods and how targeting improvements of the methods could achieve the desired results of the parameters;
- overall performance of prototype and requirements for improvement.

The results of the above examination were presented to the members of Cretan Agri-environmental Group (CAG) and comments were received regarding the application of methods.

Table 8 highlights the initial testing results of Ecological Olive Production Systems (EOPS). The table specifies for any parameter the desired result and the main cause of a possible shortfall and in case the latter is a method, on which criterion it needs to be improved.

Figure 20 (as also Table 8) highlights the state of the art for Ecological Olive Production Systems (EOPS) at present. Parameters are presented as radii of the circle. Figure 20 shows the parameters, which quantify the objectives of the prototype, ranked clock-wise by increasing relative shortfalls between achieved and desired results. In this way, it shows which parameters and to what extent the prototype is completed or still to be improved. Figure 20 clearly shows that the prototype has not been agro-ecologically optimised regarding objectives of soil, basic income and profit and local flora and landscape. The state of the art presented at Figure 20 compared with the conventional production before

Table 8. *Initial testing results of Ecological Olive Production Systems (EOPS) over the pilot group, in 1994-1995*

multi-objective parameter	*unit of parameter measurement*	*desired result*	*achieved result*	*main cause of shortfalls*	*readiness of use*	*method to be improved regarding manageability*	*acceptability*	*effectiveness*
SER	t/ha, year	<1	not measured	-	-	-	-	-
OMB	output/input	1	not calculated	-	-	-	-	-
MB	output/input	>1		ENM		X		
• KB		• 1.4-1.7	• 2.4					
• PB		• 1.4-1.7	• 0.62					
• NB		• 1.4-1.71	• 1.43					
LR	%			ENM		X		
• KLR		• 0.7-0.9	• 1.01					
• PLR		• 0.09- 0.11	• 0.14					
• NLR		• 1.6-1.8	• 1.99					
EEB	/ha			EMIP	X			
• EEB air		• 0	• $1,19^{-19}$					
• EEB soil		• 0	• 0,139					
• EEB groundwater		• 0	• 3.319^{-15}					
NS	GRD/ha	>0	-151646	FSO	X			
SCI	soil cover/year	0.5	0.35	EMCW			X	
II	used/desired	≤1	1.31	EWM	X			
EII	share of area/desired	1	0,735	EIM		X		
TPSD	number of target plant species per 100 m / desired number			EIM				X
• TI		• 1	• 0.45					
• TS		• 1	• 0.42					
QPI		>0.95	0.77					
• QI	• achieved / top quality price	• >0.95	• 0.82	• FSO	X			
				• EMIP	X			
• PI	• marketed / on-field yield	• >0.95	• 0.932	• EWM	X			
EE	output/input	≥10	2.85	FSO	X			

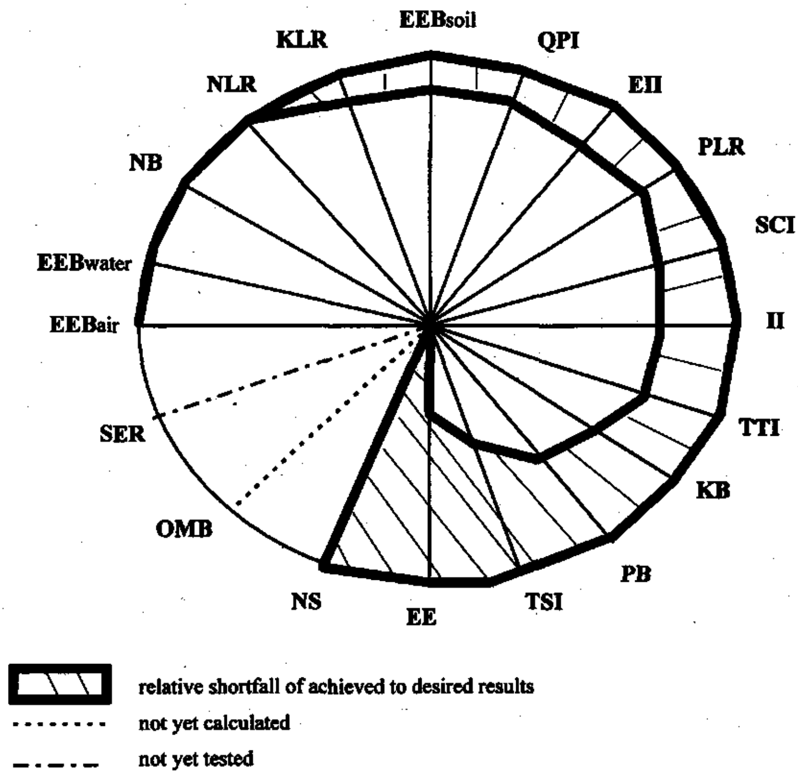


Figure 20. *State of the art for Ecological Olive Production Systems (EOPS)*

introducing the prototypes (Appendix 5; Figures 1.A5-4.A5) shows the improvements made during prototyping.

6.3.1 Improving the methods

The improvement of the prototype using the Vereijken's criteria for the method's performance is related to the incontrovertible decrease of the shortfalls between achieved and desired results (Figure 20) from the previous cycle of the prototype to the next one. Besides, improving the prototype presupposes also the improvement of knowledge, management, skills and agrotechnology related to the methods by researchers and growers. Furthermore, it implies the improvement of interaction and understanding between them.

6.3.1.1Ecological management of cover crops and weeds

Improving Ecological Management of Cover crops and Weeds (EMCW) requires improving acceptability by the growers regarding the integration and use of animals for grazing, instead of incorporating or mulching the cover crops. Up to now farmers have not been confident that introduction of grazing animals in the groves would not cause damage and that there would be an effective way to manage them. Besides, they did not accept the idea of co-operating with livestock managers because of the extensive damage brought to their pastures and their carefulness regarding agroecosystem management. This should be improved by either using their own animals, which is difficult for most of the groves, or by making co-operatively precise agreements with livestock managers.

6.3.1.2Ecological nutrient management

Improving Ecological Nutrient Management (ENM) requires improving manageability of the method by the growers. Improving regards learning how to plan nutrient management, by using data form preceding soil analysis, and how to determine what fertilising materials are required by then. Up to now growers were not used to planning fertilisation well in advance, to use soil analyses, and to determine and find precisely the amount of required materials. Besides, they did not have the required machinery, like manure spreaders, and this made the method very laborious.

6.3.1.3Ecological infrastructure management

Improving Ecological Infrastructure Management (EIM) requires improving manageability of the method by the growers, regarding management of the ecological infrastructure and its diversification with target species. Up to the present time the growers were not used to managing a part of the grove as ecological infrastructure, as even if there are parts of the grove uncultivated they rarely manage them. Besides, they will have to plan activities (like sowing and planting species, taking care of them), costing finances and time, to manage the infrastructure. Furthermore, they need new tools and frequently careful execution of other cultivation practices in order to avoid destruction of the infrastructure. However, application of an ecological infrastructure within a grove and as a part of farmers' production system, does need experience on the basis of results. Farmers should see what introduction and conservation of new organisms on the farm (trees, shrubs, annual vegetation, animals) mean for their farm in the long term. Benefits of infrastructure require time to be visible.

6.3.1.4Ecological water management

Improving Ecological Water Management (EWM) requires improving readiness of use by the researchers. In the present stage of our project EWM was not ready for use. It will become so, when required background data become available. Furthermore, more knowledge should be established about irrigation (timing, dosage, water harvesting) which requires equipment like computers, software and tensionmeters. Farmers may afford them only when capital is on hand. Available agro-ecological data do not make sense at present. Most of such data are not determined in relation with our methods such as cultivation by cover cropping, ecological infrastructure and others (see Chapter 5.2 and Appendix 3). At the moment EWM is only ready for use in the next stage of the present project.

6.3.1.5Ecological management of insect pests and pathogens

Improving Ecological Management of Insect pests and Pathogens (EMIP) requires improving readiness of use by the researchers. The method was not ready for use as the required background data and know-how for the development of the method were not available. In particular it was not manageable because of the lack of pest prevention know-how and the required equipment, like computer software. Furthermore, agro-ecological factors had not been determined and their effect on the main pests, their biological cycle, their ecology and their predators and parasites in the area. At the moment the method is more comprehensive and objective to be used in the second stage of the project.

6.4 Conclusions

Considering the first stage for our project, a theoretical prototype for an ecological olive production system for the two different agro-ecological zones of the western part of Messara at Crete could be designed. It was possible to identify relevant farms for our project. Selection criteria (Scheme 4) were applicable.

Application of our theoretical prototypes in practise showed that farmers, however very much interested and involved, need a lot of experience and data. Initial results from 1994 and 1995 clearly show that our design needs further improvement by progressive retesting procedures. Initial results also show the impact of former conventional farming methods. Farmers got a lot of understanding about the damage which current agro-technological methods caused to relevant natural resources, as well to their future prospects of farming. Many retesting cycles are required to leach out such impacts simultaneously. But, it clearly appears that designing procedures improved considerably in farmers practises at present. Progress has been made, nevertheless the many shortfalls which farmers have to bridge before desired standards, identified for a properly functioning ecological olive production, are achieved.

Designing as done in the first stage of this project made clear that new methods are required, current methods become redundant, growers' experiences are as important as laboratory related data, growers are more than baskets into which scientists only have to pour their knowledge. Designing helps to bridge growers and scientists and prototyping according to the methodology of Vereijken brings ecological farming close to what policy makers and the society is requesting.

CHAPTER 7. A NETWORK FOR DISSEMINATION OF THE PROTOTYPE

Prototyping of an agricultural production system at a large scale involves three interrelated dimensions: agroecological, economical and social. In this book the agro-ecological dimension is mainly examined while the economical dimension is under study at the University of Wales, Aberystwyth, by Vassiliou. In this chapter the social dimensions of conversion from current to ecological farming systems in Crete on a large scale will be examined. Together the consequences for the institutional network will be touch upon when a theoretical prototype concerning ecological farming to be introduced.

7.1 Prototyping and dissemination network

Prototyping activities on a large scale requires a network of pilot groups to cover the different agroecological, economic and social conditions of the region. Those conditions vary from region to region. Therefore prototyping has specific characteristics region wise. So prototypes may differ from objectives to be achieved by the new system, but may also differ on parameters and farming methods. Farmers are important for adducing correct arguments and relevant aspects for designing a theoretical prototype that makes sense. Only such prototypes will get farmers interest. Without dissemination any farming method, however scientifically proved to be potentially sustainable, is useless. Farmers should feel that solutions for problems in farming have to do with themselves. Designing activities therefore require a network of farmers. Creation of Ecological Olive Production Systems (EOPS) in Crete therefore requires a network of co-operating institutions.

7.1.1 Prototyping network

Designing activities, bringing a theoretical prototype of olive production in Crete started in the western part of the Messara plain. Consequently EOPS have characteristics relevant for that particular area. The success of EOPS has a lot to do with the role of participating pilot growers of Messara. However, EOPS of Messara may not easily be introduced in other regions of Crete. Some kind of adaptation and redesigning by pilot groups of growers elsewhere in Crete is necessary. That is because of different:

- soil types;
- climatic conditions;
- landscape;
- animals and vegetation;

- cultural practices;
- socio-economic conditions.

Figure 21 represents schematically how the core group at the Messara plain triggers a network of other groups of intensive olive production farmers. All those groups should be considered as a part of the Cretan Agri-environmental Group (CAG). Within that network EOPS designed for the Messara area can be redesigned or adapted for the various conditions in other areas. Within the framework of CAG all different pilot groups may introduce harmonisation of standards, especially regarding social, economic aspects of conversion to EOPS and regarding marketing of products from EOPS all over Crete. That might avoid conflicts between various farmer groups.

Selecting growers for the pilot groups should be done with similar criteria as for the Messara pilot group (Scheme 5). The criteria for the selection of the pilot groves in these areas may be similar too (Scheme 4; page 67) and be modified in accordance to local agroecological conditions. For adaptation of the theoretical prototype in their situation, satellite groups may apply the same methodology described in this book in close interaction with the Messara group. This interaction will save them time and money, as they will gain by the experiences gained in the innovative project at Messara:

- on diagnosing the limitations of conventional system and setting objectives for the prototype;
- on choosing and measuring the right set of parameters for quantifying the objectives;
- on designing methods for achieving the objectives;
- on testing the prototype in interaction with pilot growers;
- on required agrotechnology to be developed for the methods' application.

For adaptation of the prototype to an area researchers should interact with the pilot growers, as well as with others in the farming community. The interaction should be done in all stages of prototype adaptation, as it was done for Messara (Figure 2). Pilot groups and research teams should interact also between them

Scheme 5. *Criteria for selection of pilot growers*
(1) Growers with a situation and management representative for the area
(2) Growers who are innovators and may lead the community into innovation
(3) Growers who have a family support for prototyping

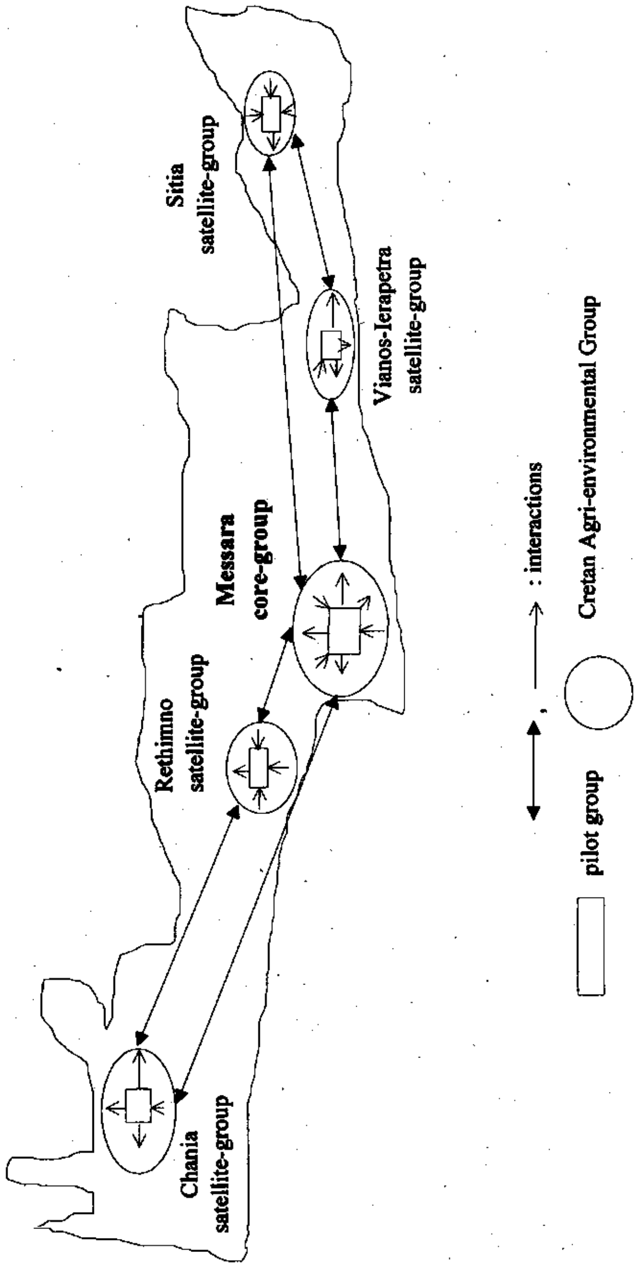


Figure 21. *Network for prototyping and dissemination of Ecological Olive Production Systems (EOPS) on Crete*

(Figure 21) for improving and optimising the prototypes of the region. Besides, a co-ordination unit should be established to facilitate the requirements of the network and develop basic common objectives, parameters and methods for the prototype. Besides, this unit may develop standards of production related to the prototype.

Growers participating in pilot groups should not be paid a fee for their activities. They should be stimulated to do their utmost in order to get premium prices for their better product. Further growers in Crete do trust scientists, since they still believe that research may help them to save money on the short and the long term. Apart from that, participation of farmers in pilot groups raises income, since they economise input supplies and low prices for collective purchases. Co-operation is also rewarded by getting free technological support, easy access to information and governmental support.

7.1.2 The network for dissemination

Dissemination of the prototypes takes place in several sequential stages. At first the prototype will be disseminated to neighbouring growers of a pilot grower and their groves, as also among the other farmers of the same village. The rest of the farming community, even if not participating in ecological production, pays attention and follows attempts, failures and successes of the pilot growers and of the pilot groves. Thus the selection criteria for the pilot growers and groves (see Scheme 5 and Scheme 4) and for pilot growers from different villages of the project area (see Map 1) are essential. Other growers from the same village can easily adopt and adapt the prototype to their farms, if no serious problems arise. Dissemination is easier and faster when is a concrete organisation exists here they can:

- participate
- interact with other farmers
- have administrative support regarding production standards
- gather technical, social and economic, information and assistance.

Later when dissemination within close circles around farmer is completed then the creation of satellite groups in other areas indicate the onset of a wider dissemination (Figure 21).

In the next stage every satellite agri-environmental group may achieve publicity of the prototypes and offer organisational assistance to new growers for a larger scale dissemination in their area. In this stage prototypes may be disseminated to the majority of the growers of the area of the group. Besides, at this stage, integration, that has been started earlier with contacts with other institutions and organisations (co-operatives, environmental groups, etc.) may be performed. This integration may lead gradually to the transition to a more ecological knowledge system in the area. At this stage the pilot growers with their pilot groves may participate in the dissemination by:

- acting as demonstrators and demonstration groves
- contributing in field days
- participating in meetings with farmers and giving presentations
- contributing to the production of material regarding the prototypes and their requirements for use.

Besides, other growers who have adopted the prototypes in the previous stage may participate and interact with others in the farmer community in the area. At this stage contacts with policy makers and formal institutions may be made for establishing a supporting policy for the prototypes. This will be possibly the best stage for farm structure optimisation as there will be enough neighbouring farms participating for it to be possible to readjust agricultural land, capital and labour activities among the farms.

The final stage will be the dissemination of prototypes in the whole region. This requires satellite groups which have completed (at least) the first stage of prototyping (see Chapter 1.3) and have tested the variants of the prototype for their area at least once. Of course farmers in the region may, and will, adopt the prototype methods but they will probably hardly meet the standards of production that each area specific prototype will require. If this happens, then the contribution of the prototype will be limited regarding the sustainability of the area. That might induce disappointments; once a farmer has been disappointed he never restarts co-operation related with innovative activities concerning sustainability. Distrust of scientists will start by then. For this regional scale dissemination the pilot groups of all areas should interact setting common standards of production for the region. This may be easier if one of them has the role of co-ordinator for the rest of the groups, facilitating the exchange of information and agrotechnology. Besides this core group will facilitate the interaction with networks of other regions.

7.2 Conclusions

Prototyping is a time consuming activity with a long time span. It requires few extra resources (human, natural, technological) while it optimises the existing ones. Consequently, it is economically profitable compared with other approaches of innovation and development. Once a production system has been prototyped successfully then it is easier to use existing experiences and networks to prototype other production systems. This is done easier than starting from scratch, as often farmers are farming more than one production system.

The agroecological criteria will be vital in the process of grove selection. The fragmentation of the farms in several locations may help also to select groves fitted in the agroecological criteria, although some times growers will propose or prefer to include other groves in the research.

Pilot growers should be highly motivated to convert to Ecological Olive Production Systems (EOPS) and to alter their cultivation practices and methods. Although at the beginning difficulties in interacting and organising study meetings should be expected they will be gradually overcome, as a result of better understanding and communication. It will be particularly important during the process of formation of the pilot groups to have technical information available for the problems they will face. A probable constraint can be the lack of experience on organic farming techniques of pilot groups, but on the other hand their transition from conventional to organic production will make them very willing to interact. Experiences from the core group at Messara may be valuable. It will help a lot if researchers come from and have previously worked in the area. Possible communication barriers will be limited as they will have experienced and probably understood the socio-economic context. Furthermore, they will be familiar with the existing cultivation practices, the problems and the phenology of groves, the nature and landscape. Besides, the size of the pilot group should cover the regional range of soil, agroclimatic conditions and management to answer the questions of feasibility, viability and competitiveness of the new designed systems.

Institutional and policy support will be crucial at final stage of dissemination as a large scale mobilisation of capital and human resources is required.

CHAPTER 8. FUTURE PERSPECTIVES OF PROTOTYPING AND DISSEMINATION

This work shows the importance of a methodical procedure of designing and on-farm research. It shows also the lack of research on farming systems including tree and perennial crops. Besides, it shows the need for synthetic research as well as farming systems research and design taking in consideration of the regional soil, climate, nature, landscape, agronomic and management conditions, and the social and economic conditions. Our designed prototypes raise a solution to main problems (agronomic, soil and land, nature and landscape) of olive production and offer a new production system for olive production. Dissemination of prototypes in a region contributes to eliminate the socio-economic problems of that region. It is important to establish a research station for prototyping ecological production systems because of the needs for institutional support and on-station research support, of organising a research team and facilitators, and for participating in European Union networks.

8.1 Research and pilot project circumstances

Agronomic circumstances for the pilot project were suboptimal at the first stage of the project as in 1991 until 1994 there was a drought and there were many pest outbreaks in the area. The latter because up until 1992 large scale bait air sprays were applied on the plain and the surrounding hills for the control of the olive fly. As a consequence a permanent residue of pesticides prevented outbreaks. However, after ceasing air spraying, many outbreaks of pests occurred. That might be due to imbalances between olive fly and its beneficials. All these problems were exacerbated by irrational fertilisation and water irrigation procedures (see Chapter 1.2 and Appendix 5).

There are increasingly problems with environmental pollution with oil mill wastes. Government subsidises replacement of oil mill's technology at the moment with new more environmentally friendly ones. There is no monitoring about the contamination of air, water and soil with agrochemicals and the depletion of groundwater reserves.

In recent years the general public has become aware about the contamination of food with toxic residues. Therefore, many farmers in the area also become more and more aware of the problems with conventional agriculture. Faced with increasing economic problems, farmers are susceptible to improvements on current production systems. Policy makers and formal institutions finally support the idea of the need for ecological food production.

Unfortunately there are no research teams concerning ecological production in Crete. Besides, the only research station in the area of the project had no human research capacity and was under-functioning. Consequently there was no background information on ecological production systems and any official support for the project. Otherwise, the two main research institutions in the region provide laboratory support for soil and plant analysis and some researchers were supportive, providing specific information. At the area and the region there were also no non-governmental organisations to offer any support. The project was based completely on voluntary work and it did not receive any financial support. The only economic contribution was from EU covering the travel costs for an agri-environmental visit of growers members of CAG in the Netherlands, in 1994.

Research programmes currently concern technologically advanced olive production in Crete. In that system, farmers experience has been replaced gradually by knowledge raised in perfect or conditioned laboratory and plot experiments. That knowledge does not fit immediately in farmers' conditions. Introduction of ecological production systems in agriculture demand new kinds of knowledge. The meaning of ecosystem for food production is one of such kinds. System oriented knowledge instead of component raised knowledge is one of the other. Present institutions seem not ready for that at the moment. Also their research programmes are in conversion now. The research project described in this book could not be based therefore only on institutional help. The whole project had to be done by the farmers of Messara themselves. Valuable contribution regarding the research and the pilot project was obtained from the eco-team of AB-DLO in the Netherlands. Further, methodological support was received from the eco-team in relation to the EU research network on integrated and ecological arable farming systems. The design methodology of Vereijken and adapted by Goewie was the main route sign for Messara farmers.

8.2 Perspectives and recommendations

8.2.1 Perspectives for research and pilot project

Considering preceding chapters it is obvious that the project is only in its first phase. The designing methodology was shown to be a perfect way for converting olive production towards ecological ones. The formation of the grower pilot group and the role of Cretan Agri-environmental Group (CAG) was crucial for turning down new roads. Growers laid out the Ecological Olive Production Systems (EOPS), tested and disseminated the prototype at Messara. The next stage of the project is about to begin and will last at least for six years. The future of the project, providing that there is sufficient funding, shows to be most promising. Most Cretan olive growers became interested in that kind of finding sustainable approaches for their farming. They are eager to continue, evidenced by the fact that CAG was the only Greek farmer's organisation to participate in the First World Wide Organic Exhibition, August 1996, in Copenhagen, Denmark.

8.2.2 Recommendations for research and pilot project

The following recommendations can be made in the light of the results of the first stage of the innovative pilot project. Regarding the quantification of objectives with parameters:
- on-station support with necessary equipment for measuring parameters is required;
- on-farm and on-station research is required to establish genuine desired results;
- on-farm and on-station research is required to determine coefficients related to the calculations of the parameters;
- more labour is required for parameter-related measurements.

Regarding the methods for achieving the objectives on-farm research and on-station research and support is required for:
- selecting and developing appropriate machinery and equipment for the methods performance;
- selecting the best varieties for the cover crop species;
- selecting appropriate sheep breeds to be used in grazing the cover crops;
- determining desired ranges of soil nutrients for optimum nutrition of the groves' trees and for correlating soil and leaf reserves;
- determining release rates and availability of nutrients from animal manures and cover crops;
- selecting optimum species for the ecological infrastructure;
- studying the food chain in ecological infrastructure;
- choosing and developing equipment for managing species in ecological infrastructure;
- using computer programmes for irrigation planning and scheduling in the groves;
- improving water use by means of using equipment (e.g. tensionmeters) by the growers;
- determining predators, parasites, competitor species of the olive grove pests and determining their hosts, food chain and habitats;

- selecting and adapting computer programmes for determining favourable and unfavourable grove conditions that prevent the pests of the groves.

Regarding laying out of the prototype the following recommendations can be made:
- more rainfed, hilly groves should be included in the pilot groves during the formation of pilot groups in other areas, especially the mountainous, of the region;
- the agroecological criteria should be met in the selection of pilot groves in other areas.

Finally it is necessary to increase the research capacity of the pilot project in the second stage. More specifically at minimum are required:
- an expert on agricultural knowledge and information systems for acting as facilitator co-ordinating interaction between growers and researchers and dissemination in other areas
- an expert on agricultural data bases and data processing for organising administration, especially with the large scale dissemination
- two scientific assistants for supporting the research team and the growers and assisting teams in other areas.

Regarding the pilot project the following recommendations can be made:
- it is required to improve the organisation of CAG
- direct participation of the CAG members should be maintained
- the number of facilitators of the CAG should be increased
- the prototyping and disseminating network should be interactive
- CAG should facilitate the establishment of a regional data base on prototyping and dissemination, the exchange of information and the maintenance of production standards
- CAG should care for the use of the growers' money paid directly and indirectly to the state and for their regional use
- CAG should secure founding of the prototyping and dissemination network
- CAG should improve its lobbying and its participation in regional policy making
- CAG should more actively support and facilitate the process of transition to more ecological knowledge system at Crete.

Regarding the second stage and the establishment of a prototyping and dissemination network a research station should be devoted to provide the required on-station research and support, and to acting as co-ordinator for other institutions contributing in prototyping. The later should aim to the integration of disciplinary research and research information and the integration of extensionists in the pilot project.

8.3 Strengths, weaknesses, opportunities and constrains of prototyping and dissemination of ecological olive production systems

8.3.1 Strengths

Prototyping ecological olive production systems synthesises all available information regarding olive production. This synthesis using the agroecological principles of agroecosystem concentrates and utilises all accumulated information, experiences and knowledge for the components of the system. Information is adapted and used in designing ecological olive production systems without doing unnecessary experiments for data collection. Finally, the fact that information originates from not only literature but also from personal communication with experts and farmers is of major importance. Agricultural research is supposed to serve agriculture, not just analyse it. Its results prepare to work in a tangible way by an important industry, serving the basis of human life through nutrition.

The design and development of ecological olive production systems is in accordance with the agroecological principles of agroecosystems. This might result in more sustainable systems as a whole complex system is designed, avoiding emphasis on components of the system that may create negative side effects to other components. Designing of the theoretical prototype, and methods in its context should incorporate the agroecological principles.

Prototyping is done on working farms. This offers opportunities of incorporating farmers' experiences and knowledge in the designed new production system. Thus, time and money are saved while negative effects are avoided as these experiences and knowledge derive from centuries of trial and error experimentation on agroecosystem management. Prototyping on working farms offers the opportunity to study and design the whole production system in its socio-economic framework. Prototyping on working farms that takes account of farmers' management and that includes off-farm effects may also help researchers to design systems that are both more efficient and environmentally benign. Prototyping on working farms, integrates better researchers and farmers as they are working together. Researchers understand the problems and situation of farmers and their needs. Researchers who did not grow up on a farm may gain valuable experience and appreciation of farmers' constraints by working on the farm. Farmers and consumers may influence research on working farms more than they might on research elsewhere. Finally, agriculture occurs in commercial production enterprises. It is affected by powerful social, economic, and political institutions, from the local farming community to the global economy. Moreover, farming is more than a matter of agricultural science, technology and economics; farmers have knowledge, experties and strong traditions and values.

Prototyping improves farmers innovation and management. Farmers applying the theoretical designed methods may create innovations. Management is improved as they keep records on farm management, participate in evaluation of methods and interact with each other.

Farmers are self-motivated by participating in prototyping. They examine improvements of the prototype and solutions for problems related to the prototypes. Working with a research group and within an agri-environmental group with other farmers builds community ties and leads to more co-operation with neighbours, such as sharing information, labour and equipment.

Prototyping is easily used for demonstration and farmers' education. The results of prototyping on pilot groves are demonstrated to the rest of the farming community. Researchers' and pilot growers' experiences may be used for fellow farmers education as they learn to learn together from prototyping and transferring their experiences and knowledge. This happened with the members of the Cretan Agri-environmental Group (CAG).

8.3.2 Opportunities

Prototyping may assist the transition to an ecological knowledge system. Prototyping with a pilot group and dissemination with agri-environmental groups of ecological olive production systems may gradually lead to the transition to a more ecological knowledge system described by Rolling and Jiggins (1996).

Prototyping has the capacity to combine positivist and constructivist approaches. The combination of these approaches, described by Hamilton (1995), may optimise prototyping.

Prototyping may combine scientific disciplines. Prototyping requires the combination of different disciplines for the design of a theoretical prototype and methods in its context as it deals with the whole production system. Methods are covered by many different disciplines as their inputs are necessary. Furthermore, prototyping may lead to integration and synthesis of agricultural, ecological, economic and social fields as inputs from these fields are required as well as inputs to those fields are supplied.

Prototyping may assist reorganisation of institutions towards facilitation. Prototyping is effective and efficient when decentralised networks of institutions are involved (see Chapter 1.5 and Chapter 7.1).

Prototyping may stimulate collaboration among different kinds of groups such as farmers, consumers, environmentalists, safe food advocates, rural activists, etc. (see Chapter 1.5.1 and Chapter 7.1). In prototyping, even if farmers and especially pilot groups may be considered as groups with special knowledge and feeling for agriculture, also other interested in food systems groups with diverse views should be heard, especially on matters that extend beyond the production system, such as environmental protection, nature and landscape conservation, etc.

8.3.3 Weaknesses

The role of information and decision making is increased in prototyping. Large amounts of information for managing the agroecosystem are required by the farmers and the researchers. Often designed methods in prototyping are information-intensive farming methods and production techniques. Besides, information often replaces material inputs. This information is related to the agroecosystem processes and principles and even if often has not necessarily originated from experimentation it may not be available (i.e. farmers have lost traditional knowledge or their ability to follow natural phenomena and to understand the agroecosystem principles). In prototyping farmers and researchers often have to take more decisions while many options have to be examined before the decision making, selecting the most appropriate for the production system, without ignoring agroecosystem processes and principles.

Prototyping does not give quick results. Prototyping demands long term periods before completion, as many cycles of designing, testing and improving and many social actors are involved. Besides, as it is done on working farms it includes many more uncertainties that may cause delays before prototypes are optimised. This was also the case in the research project described in this book for example one member of the pilot group dyed in a car accident at the beginning of the project.

The methodical procedure for prototyping agroecosystems has not until now developed procedures for making a diagnosis of the existing conventional system and for transforming diagnosis to objectives of the prototype system. Besides, prototyping it does not include a procedure describing how methods for the achievement of the objectives of the prototype should be designed. Furthermore, it does not include a procedure describing the process of selection of parameters for quantifying the objectives of the prototype. Prototyping procedures at the moment do not describe either how the agroecological principles or the process of an agroecosystem are used in designing methods and selected appropriate parameters.

8.3.4 Constraints

Prototyping requires a considerable length of sufficient funding. Unfortunately, many times priority is given to short-term projects for several reasons (i.e. political rationale for highly visible projects showing tangible results or projects which avoid to risk large amount of money). Prototyping on the other hand, especially for perennial crops, needs to run through several cycles for designing, testing and evaluating. Besides, agroecosystems often respond slowly to management, based on agroecological processes, on low use of external inputs, or non-synthetic inputs.

Current institutional setting prevents prototyping. Institutions are often centralised, dominated by science and serving short term goals. Research institutions are often over specialised and fragmented not having a place for teams for prototyping. Often they are not interested in or prepared for co-operation or integration with institutes of different specialisation, which is a requirement for prototyping. Also, education institutes often educate agricultural students in accordance with very narrow specialisation and technical training with very little emphasis on social issues and concerns, communication and teamwork abilities and training in interdisciplinary research.

Prototyping is restricted by the professional reward system. The professional reward system often may be strongly rooted in the disciplinary rooting of research, related to the number of papers published in journals per year. These publications are often publications in one's own discipline and researchers in that discipline are the best judges of their value. The reward system suits mainly to highly specialised research and work that is not connected to agriculture as a production system and a human activity. Rarely does the professional reward system evaluates overall performance including for example presentations to farmers or non-technical audiences, effective dissemination work of research results, etc.

Prototyping requires an increase in sophisticated management. Management of the design methods by the farmers is usually more complex than the management of conventional methods (see Chapter 5.2). This is often because the farmer should have increased understanding of agroecological principles and a good ability to collect and to process information. Farmers may stop using synthetic or large amounts of external inputs only by becoming more sophisticated managers.

Prototyping requires economic incentives for the farmers. Also the adoption of new design methods includes an economic risk. Besides, many methods are environmentally beneficial but expensive as well for farmers. This incentives might be given by the consumers who share responsibilities for the food production and protection of air, soil and water resources as well as of nature and landscape.

Prototyping is restricted by weakness of fundamental research. Many times there is a considerable volume of specific research but with very little applicability in practice. Experimental research may have little or no practical use at all on working farms. This may prevent the design of methods or the quantification of objectives (see Chapter 4.2).

Prototyping is restricted by lack of appropriate computer software. Prototyping requires large databases for recording, storing and processing collected data. No such databases are readily available for the variety of farming systems and they have to build up. Additionally, it is laborious, demands experties for constructing them and requires a considerable amount of time.

Prototyping is a new type of research and there are few ongoing research projects in prototyping. Consequently comparable results and research are rarely available for reference.

A summary of the above strengths, weaknesses, opportunities and constraints is presented in Scheme 6.

8.5. Considerations for the future

It is difficult to compare the results with other research results as few other studies on prototyping are available. This was also a disadvantage for planning the research itself as there were no other comparable research results for reference.

The results of the present study suggest that the research must continue for another extended period to obtain a better view of the ecological methods and finally to be able to evaluate the research on ecological olive production systems with the parameters performance as well as the assumptions on which is based.

Scheme 6. *Summary of the strengths, weaknesses, opportunities and constraints of prototyping ecological olive production systems (EOPS)*

Strengths: • synthesis of available information; • development of farming systems in accordance to ecological principles; • research on working farms • integration of researchers - farmers; • greater influence of farmers and consumers on agricultural research; • incorporation of farmers experiences and knowledge; • improve farmers' innovation and management; • self-mobilisation of farmers; • cost effective research • learning of new production practices; • research easy to be used for demonstration and farmers education.	*Opportunities:* • combination of positivist and constructivist approaches; • transition to ecological knowledge system; • combination of scientific disciplines; • integrate and synthesise agricultural, economic and social fields; • reorganise institutions towards facilitation; • collaboration among different kind of groups.
Weaknesses: • increase role of information and decision making; • do not give quick results; • methodical procedure does not deal with diagnosis and its transformation to objectives; • methodical procedure does not deal with designing methods.	*Constraints:* • length of funding for research projects; • current institutional setting; • professional reward system favours disciplinary research; • management sophistication increases; • lack of economic incentives; • weaknesses of fundamental research; • lack of appropriate computer software; • lack of comparable research for reference.

REFERENCES

Altieri, M. A. 1995. *Agroecology. The science of sustainable agriculture.* Westview, Boulder, USA.

Alexandrakis, V. 1990. Effect of Dacus control sprays, by air or ground, on the ecology of *Aspidiotus nerii* Bouche (Hom. Diaspididae). *Acta Horticulturae,* **286**: 339-342

Allaya, M. (ed.) 1988. *The olive economy.* Proc. EC-ICAMAS Ceminar, Tunisia, 20-22 Jan. 1987. Options Mediterrannees, OQEH. Tunis, Tunisia.

Anagnostopoulos, P. T. 1951. The origins of olive tree. Athens, Greece. (In Greek)

Androulakis, I. and M. Loupasaki. 1990. Effects of synthetic fertilisers on soil fertility. In: GEO. C. G. *Agrochemicals and Environment.* Proc. GEO.C.G Workshop, Chania, Crete. 7-8 Dec. 1989. Chania, Greece. (In Greek.)

Carroll, C. R., J. H. Vandermeer, and P. M. Rossett (eds.) 1990. *Agroecology.* McGraw-Hill, New York, USA.

CEC, 1991. *Official Journal of the European Communities,* L 198/1, 22.7.91.

CEC, 1992. *CORINE - Soil erosion risks and important land resources in the southern regions of the European Community.* EUR 13233. Office for the Official Publications of the European Community. Luxembourg.

Centre of Planning and Economic Research, 1991. *Regional Policy.* CPER, Athens, Greece.

Chisci, G. and R. P. C Morgan 1988. Modelling soil erosion by water. In.: Morgan, R. P. C. and R. J. Rickson (eds.) *Agriculture, erosion assessment and modelling.* Commission of the European Community. EUR 10860 EN. Office for Official Publications of the European Communities, Luxembourg.

Cimato, A. 1990. Effect of agronomic factors on virgin olive oil quality. *Olivae* **31**: 20-32.

Cimato, A., and Fiorino, P., 1986. Influence of fruit bearing on flower induction and differentiation in olive. *Olea,* **17**:55-60

Civantos, M. 1995. Development of integrated pest control in Spanish olive orchards. *Olivae* **59**:75-81

Cox, W. G. and M. D. Atkins 1979. *Agricultural ecology: An analysis of world food production systems.* Freeman. San Francisco, USA.

Delrio, G. 1992. Integrated control in olive groves. In: J. C. van Lenteren, A. K. Minks and O. M. B. de Ponti (ed.) *Biological control and integrated crop protection: towards environmentally safer agriculture.* Pudoc, Wageningen, The Netherlands.

Dettori, S. 1987. Estimation by FAO methods of irrigation requirements of table-olive groves in Sardinia. *Olivae*, 6:30-35.

Dover, J. M. and L. M. Tablot 1987. *To feed the earth: Agro-ecology for sustainable development.* World Resources Institute. Washington, D. C., USA.

Doorenbos, J. A., and M.Kassam 1979. Yield response to water. *FAO Irrigation and Drainage Paper* 33:105-108. Rome, Italy.

FAO, 1972. *Study of water resources and their exploitation for irrigation in eastern Crete, Greece. Overall study of the Messara plain.* UNDP and FAO, Iraklion, Greece.

Francis, C. A., C. B. Flora and L. D. King. (eds.) 1990. *Sustainable agriculture in tempērate zones.* Wiley, New York, USA.

Gavalas, N. A. 1978. *The mineral nutrition and the fertilisation of the olive tree.* Benaki Phytopathological Institute. Athens, Greece. (In Greek.).

GEO. C. G, 1990. *Agrochemicals and Environment.* Proc. GEO.C.G Workshop, Chania, Crete. 7-8 Dec. 1989. Chania, Greece. (In Greek.)

GEO. C. G, 1993. *Management of the water resources of Crete.* Proc. GEO. C. G Workshop, Chania, Crete. 27-28 May. 1993. Chania, Greece. (In Greek.)

GEO.C.G, 1994. *Management of liquid waste from oil mills.* Proc. GEO. C. G 3rd International Conference on Management of Liquid Waste from Oil Mills, Sitia, Crete. 16-7 June. 1994, Sitia, Greece

Gliessman, R. S. (ed.) 1990. *Agroecology. Researching the ecological basis for sustainable agriculture.* Springer-Verlag. New York, USA.

Goewie, E.A. 1993. *Ecologische landbouw: een duurzamm perspecief?* Intreerede. Landbouwuniversiteit Wageningen. The Netherlands.

Goodman, D. 1987. The demography of chance extinction. In: M. E. Soule (ed.). *Viable populations for conservation*. Cambridge, New York. USA.

Grove, J. M., A. T. Grove, and O. Rackham. 1991. *Crete and the South Aegean Islands: effects of changing climate on the environment*. Unpublished Report. EC Contract EV4C-0073-UK.

Grove, J. M., and O. Rackham. 1993. Threatened landscapes in the Mediterranean: examples from Crete. *Landscape and Urban Planning*, 24:279-292.

Hamilton N. A. 1995. *Learning to learn with farmers. A case study of an adult learning extension project conducted in Queensland, Australia 1990-1995*. PhD thesis. Wageningen Agricultural University, The Netherlands

Haniotakis G., M. Kozyrakis, T. Fitsakis, and A. Antonidaki 1991. An effective mass trapping method for the control of *Dacus oleae* (Diptera: Tephritidae). *J. Econ. Entomol.* **84**,(2):564-569.

Hartmann, H. T., K. W. Optiz and A. J. Beutel. 1980. *Olive production in California*. Division of Agricultural Sciences, University of California, Davis, Leaflet 2474:45.

Hartmann, H. T. and C. Panetsos. 1961. Effect of moisture deficiency during floral development of fruitfulness in olives. *Proc. Amer. Soc.Hort. Sci.* **78**:209-217.

Hatfield, J. L. and D. L. Karlen. (eds.) 1993. *Sustainable agriculture systems*. Lewis. Boca Raton, USA

IFOAM, 1992. *Basic standards of organic agriculture*. Tholey-Theley, Germany.

ISPOT/IOOC, 1980. *Proceeding of the IIId International Congress on the biological value of the olive oil*. Institute of Subtropical Plants and Olive Tree, Crete. 8-10 Sep. 1980, Chania, Greece.

ISPOT/IOOC, 1991. *Olive oil quality improvement*. Proc. Institute of Subtropical Plants and Olive Tree International Seminar, Chania 26 Nov.-1 Dec. 1990, Crete, Greece.

Jardak, T. and M. Ksantini. 1996 Key elements of, and economic and environmental need for, a modified approach to olive crop care in Tunisia. *Olivae* **61**:24-33

Kabourakis, E., 1993. *Evaluation of the first year of ecological nutrient management in pilot farms.* MSc Thesis. Wageningen Agricultural University, The Netherlands.

Kedros, K., N. S. Margaris, and S. Chodzeas (eds.) 1988. *The olive groves of the Aegean Sea.* Proceedings of the scientific conference in Mitilini 25-27/2/1988. University of Aegean Sea, Ministry of Agriculture, District of Lesbos, Mitilini, Greece. (In Greek.)

Klein, I., and S. Lavee (eds.) 1977. *The effect of nitrogen and potassium fertilisers on olive production.* Proc. of the 13th colloquium of the Int. Potash Inst. pp. 295-305. The Int. Pot. Inst. Bern, Swiss.

Lande, R. 1988. Genetics and demography in biological conservation. *Science*, **241**:1455-1460

Lawrance, R., B. R. Stinner, and G. S. House (eds.) 1984. *Agricultural systems: unifying concepts.* Wiley, New York, USA.

Leone, G. F. 1993. Economic Appraisal of Technological Innovation - Environmental Problems in the Italian Olive Oil Sector. *Olivae* **47**: 15-20.

Lenza, X. 1991. Biocide residues in olive oil. A primary qualitative characteristic. (In Greek) *Elaiourgiki* **25**: 37-49.

Michelakis, N. 1986. *Olive tree behaviour under various irrigation conditions.* PhD Thesis. Agricultural University of Athens. Athens, Greece. (in Greek)

Malorgio, G. A, and M. Geenghini. 1990. Trade policies and international trade on olive oil market: the role of the Italian olive industry. *Acta Horticulturae* **286**: 473-476.

National Research Council, 1989. *Alternative agriculture.* National Academy Press, Washington, DC, USA.

Naveh, Z. 1993. Red books for threatened Mediterranean landscapes as an innovative tool for holistic landscape conservation. Introduction to the western Crete red book case study. *Landscape and Urban Planning* **24**: 241-247.

Ozyilmaz, H., and M. Ozkara. 1990. Determination of water consumption of the olive tree under field conditions. *Acta Horticulturae*, **286**: 279-282

Pansiot, F. P. and H. Rebour. 1961. Improvement in olive cultivation. *FAO Agric. Studies No 50.* Rome, Italy.

Papadakis, J. 1975. *Climates of the world and their potentialities.* Buenos Aires, Argentina.

Pastor, M. and J. Castro. 1995. Soil management systems and erosion. *Olivae*, **59**: 64-74

Pimentel, D. 1980. *Handbook of energy utilisation in agriculture.* CRC, Boca Raton, USA.

Pretty, J. N. 1995. *Regenerating agriculture. Policies and practice for sustainability and self-reliance.* Earthscan, London, UK.

Rolling, N. and J. Jiggins 1996. *The ecological knowledge system.* Proc. Second European Symposium on Rural and Farming Systems Research: Technical and Social Systems Approaches to Sustainable Rural Development, Granada, Spain, March 27-29, 1996. (In press.)

Rubio, J. L, and R. J. Rickson. 1990. *Strategies to combat desertification in Mediterranean Europe.* CEC, EUR 11175, Office for Official Publications of the European Communities, Luxembourg.

Sarrantonio, M. 1991. *Methodologies for screening soil improving legumes.* Rodale Institute, Pennysylvania, USA

Smith, M. 1992. CROPWAT: a computer program for irrigation planning and management. *FAO irrigation and drainage paper No. 46.* Rome, Italy.

Sfikas, G. 1989. *Animals and mammals of Crete.* Efstathiadis. Athens, Greece.

Sfikas, G. 1992. *Wild flowers of Crete.* Efstathiadis. Athens, Greece.

Taylor, D. C. 1990. On-farm sustainable agriculture research: lessons from the past, directions for the future. *Journal of Sustainable Agriculture* **1**(2):43-87.

Tivy, J. 1990. *Agricultural Ecology.* Longman, Harlow, UK.

Ugas, R. 1995. *Redesigning a vegetable farm in Peru to convert it to ecological agriculture.* MSc Thesis. Department of Ecological Agriculture. Wageningen Agricultural University. The Netherlands.

Vereijken, P. 1992. A methodic way to more sustainable farming systems. *Netherlands Journal of Agricultural Science* **40**:209-223

Vereijken, P. and H. Kloen, 1994. Innovative research with ecological pilot farmers. In: Struik, P. C., Vredenberg W. J., Renkema J. A. and J. E. Parlevliet (ed.) *Plant production on the threshold of a new century.* Proc. Wageningen Agricultural University Congress Jun. 28-Jul. 1, 1993. Kluwer, Dordrecht, The Netherlands.

Vereijken, P. 1994. *Designing prototypes.* Research network for EU and associated countries on integrated and ecological arable farming systems. Progress report 1. AB-DLO Wageningen, The Netherlands.

Vereijken, P. 1995. *Designing and testing prototypes.* Research network for EU and associated countries on integrated and ecological arable farming systems. Progress report 2. AB-DLO, Wageningen, The Netherlands.

Yassoglou, N. 1971. *A study of the soil of Messara valley in Crete, Greece.* Greek Nuclear Research Centre, Athens, Greece.

Summary

The olive sector in Crete, Greece, as in many other olive producing regions in Mediterranean European Union, faces agronomic, ecological and socio-economic problems. These problems to a large extent are due to one sided ways of production aimed at maximum levels of production while ignoring product quality, agroecosystem functions and processes, and environment. Besides, many problems are due to the gradual abolishment of price intervention by the European Union. Therefore, olive production in the future should become sustainable. The development of multi-functional olive production, marketed with an ecological label, is considered as the most promising solution. To explore this, an innovative research project has been established at the western Messara plain (Faistos area), southern Crete, Greece. This book presents the methodology, the theoretical prototype and the initial results of prototyping and dissemination of ecological olive production systems.

Chapter 1 of the book starts with a diagnosis of conventional olive production. Subsequently the methodology followed in the innovative research project aimed at prototyping (designing, testing and improving prototypes) ecological olive production is outlined. Two networks created to facilitate the achievement of the project objectives are described: (a) the foundation "Cretan Agri-environmental Group", for conversion from conventional to ecological production and for transition to an ecological knowledge system, and (b) the pilot group of olive growers, for interactive prototyping.

Chapter 2 provides the geographic (soils, climatic patterns, vegetation and animal life, and agroecological characteristics) and the socio-economic characteristics of the area. It emphasises the agroecological characteristics of the groves in the project area.

Chapter 3 outlines a process for establishing the objectives of ecological production, considering the agricultural, ecological and socio-economic circumstances and constraints of the region. Besides, it provides the procedure for making a hierarchy of objectives and the resulting objectives for ecological olive production systems in the project area.

Chapter 4 describes how the objectives of ecological olive production systems are transformed and quantified with appropriate parameters in order to establish desired results and to improve the prototypes until these results are achieved. It provides the quantification of objectives with twelve new parameters for olive production. Besides, this chapter presents the desired ranges for these parameters in the project area and the procedure of parameter quantification.

Chapter 5 outlines how appropriate farming methods for realising the objectives of the prototypes are designed. Six methods are initially designed in the framework of a theoretical prototype. They deal with the ecological management of cover crops, nutrients, ecological infrastructure, water, and insect pests and pathogens. These methods are described as well as their application under the specific conditions of the agroecological zones of the area.

Chapter 6 describes the layout of the prototype in three specific variants (hilly extensive groves, hilly intensive groves and plain intensive groves) and in seventeen pilot groves provided by the twelve pilot olive growers. The initial results of testing the prototype with ten parameters, in 1994 and 1995 are presented. These initial results are related to the introduction of the six multi-objective methods by the pilot growers. They show the progress made since the introduction of the prototype and during the conversion period to ecological agriculture. This chapter also discusses the improvement of the prototype in accordance with a methodical procedure and the required specific improvements of the methods in accordance with a set of criteria.

Chapter 7 outlines a network for preparing and disseminating the prototype at the regional scale. The network for area specific prototype groups is described as well as the principles of forming such groups. The dissemination of the prototypes is outlined, and the importance of pilot groups at the different areas of Crete is emphasised.

Finally in Chapter 8 the research and pilot project circumstances are revised. Future perspectives of prototyping and dissemination of ecological olive production systems are discussed, with emphasis on the required improvements considering the initial results. The strengths, weaknesses, opportunities and constraints of prototyping and dissemination are outlined in relation to the application of the new methodology that was followed.

Samenvatting

De olijventeelt in Kreta, Griekenland, heeft te kampen met agronomische, ecologische en socio-economische problemen. Deze problemen doen zich ook voor in vele andere teeltgebieden van olijven in de mediterrane landen van de Europese Unie en komen grotendeels voort uit eenzijdige produktiemethoden, gericht op maximalisering van opbrengst, waarbij overwegingen van kwaliteit, functionering van het agro-ecosysteem in zijn geheel, en milieu worden veronachtzaamd. Bovendien leidt de geleidelijke opheffing door de Europese Unie van prijs-interventie tot bijkomende moeilijkheden. Overgang naar een meer duurzame olijventeelt kan bijdragen tot de verlichting van deze problematiek. De ontwikkeling van multi-functionele produktie, op de markt gebracht met een ecologisch keurmerk, wordt gezien als de beste oplossing. Om dit nader te onderzoeken is een vernieuwend onderzoeksprojekt van start gegaan in de westelijke Messara-vlakte (Faistos gebied) in het zuidelijk gedeelte van Kreta.
Deze publikatie beschrijft de methodologie, het theoretische prototype en de eerste resultaten van prototypering en verspreiding van ecologische produktiesystemen.

Hoofdstuk 1 begint met een analyse van de konventionele olijventeelt. Verder wordt de methodologie beschreven van het vernieuwende onderzoeksprojekt voor prototypering (ontwerpen, toetsen en verbeteren van prototypes) van ecologische olijvenproduktie. Twee netwerken, tot stand gebracht om de doelstellingen te helpen bereiken, worden beschreven: (a), de stichting 'Agro-milieu groep van Kreta', voor konversie van konventionele naar ecologische productie en voor overgang naar een ecologisch kennis-systeem, en (b), de proefgroep van olijventelers voor interaktieve prototypering.

Hoofdstuk 2 verschaft de geografische (bodems, klimaat, flora en fauna, agro-ecologische aspekten) en de socio-economische kenmerken van het gebied in het algemeen en van de olijfgaarden in het bizonder.

Hoofdstuk 3 beschrijft een proces voor bepaling van de doelstellingen van ecologische productie met inachtneming van landbouwkundige, ecologische en socio-economische omstandigheden en beperkingen van het gebied. Ook geeft het de procedure weer voor definiëring van een hiërarchie van doelstellingen in het algemeen en van ecologische olijvenproduktie-systemen in het bizonder.

Hoofdstuk 4 geeft aan hoe de doelstellingen van ecologische produktiesystemen worden getransformeerd en gekwantificeerd met geëigende parameters om de gewenste resultaten tot stand te brengen en de prototypes te verbeteren totdat deze resultaten worden behaald. Kwantificering van doelstellingen wordt bewerkstelligd met behulp van twaalf nieuwe parameters voor olijventeelt. De gewenste mate van toepasbaarheid van deze parameters in het projektgebied en de procedure voor de kwantificering ervan wordt beschreven.

Hoofdstuk 5 geeft weer hoe geschikte methoden voor de prototypes ontworpen worden. Eerst worden zes methoden vastgesteld in het kader van een theoretisch prototype. Deze betreffen het ekologisch beheer van bodembedekkende gewassen, nutriënten, infrastructuur, water, en insektenplagen en pathogenen. Deze methoden worden beschreven alsmede de toepassing ervan onder de specifieke omstandigheden voor de agro-ecologische zones van het gebied.

Hoofdstuk 6 beschrijft het werkplan van het prototype in drie specifieke varianten en in achttien gaarden, ter beschikking gesteld door de dertien betrokken olijventelers. De eerste resultaten van de toetsing van het prototype aan de hand van tien parameters in 1994 en 1995 worden gepresenteerd. Deze eerste resultaten hebben betrekking op de introductie van de zes methoden met meervoudige doelstellingen door de telers en tonen de vooruitgang gemaakt sinds de invoering van het prototype en in de loop van de conversieperiode naar ecologische landbouw. De verbetering van het prototype volgens de methodologische procedure en de benodigde specifieke verbeteringen van de methodes volgens een combinatie van criteria worden ook besproken.

Hoofdstuk 7 presenteert een netwerk voor het maken en verspreiden van het prototype op regionale schaal. Het netwerk voor specifiek-plaatselijke groepen van prototypes wordt beschreven alsmede de principes voor het vormen van zulke groepen. De verspreiding van de prototypes en het belang van toetsgroepen in de verschillende gebieden van Kreta worden aangegeven.

In hoofdstuk 8 tenslotte worden de projektomstandigheden voor onderzoek en toetsing herzien. Vooruitzichten voor prototypering en verspreiding van ecologische produktiesystemen voor olijven worden besproken, met nadruk op de benodigde verbeteringen op grond van de eerste resultaten. Sterke en zwakke punten alsmede mogelijkheden en beperkingen van prototypering en de verspreiding ervan worden aangegeven in het licht van de toepassing van deze nieuwe methodologie.

Περίληψη

Η ελαιοπαραγωγή στην Κρήτη, όπως και σε πολλές ελαιοκομικές περιοχές, αντιμετωπίζει αρκετά αγρονομικά, οικολογικά και κοινωνιο-οικονομικά προβλήματα. Τα προβλήματα αυτά οφείλονται στην μονόπλευρη κατεύθυνση της παραγωγής που στοχεύει στο μέγιστο των αποδόσεων αγνοώντας την ποιότητα της παραγωγής, τις λειτουργίες του αγρο-οικοσυστήματος και το περιβάλλον. Νέα προβλήματα αναμένεται να προστεθούν με την σταδιακή κατάργηση των επιδοτήσεων της παραγωγής από την Ευρωπαϊκή Ένωση. Συνεπώς, στο μέλλον η ελαιοπαραγωγή θα πρέπει να μετατραπεί σε αειφορική. Εκτενέστερα, η ανάπτυξη μιας πολύπλευρης οικολογικής ελαιοπαραγωγής, που θα διακινείται με ένα οικολογικό σήμα και που θα δίνει έμφαση στην λειτουργικότητα και στον ρόλο της υπαίθρου θεωρείται ως άριστη λύση. Για την διερεύνηση της ανάπτυξης αυτής ένα ερευνητικό πρόγραμμα καινοτομίας ξεκίνησε το 1993 στην πεδιάδα της Μεσσαράς, στη νότια Κρήτη. Το παρών βιβλίο παρουσιάζει την μεθοδολογία, το θεωρητικό πλαίσιο και τα αρχικά αποτελέσματα της πρωτοτυπίας και διάδοσης συστημάτων οικολογικής παραγωγής.

Το Κεφάλαιο 1 του βιβλίου αρχίζει με την διάγνωση της συμβατικής ελαιοπαραγωγής. Στην συνέχεια παρουσιάζεται η μεθοδολογία που ακολουθήθηκε στο ερευνητικό πρόγραμμα που στοχεύει στην πρωτοτυπία (σχεδιασμό, δοκιμασία, βελτίωση πρότυπων συστημάτων) της οικολογικής παραγωγής καθώς και τα δύο εμπλεκόμενα με το πρόγραμμα δίκτυα: (α) η εταιρία "Αγροτο-περιβαλλοντική Ομάδα Κρήτης", για την μετατροπή από την συμβατική στην οικολογική παραγωγή και για την μετάβαση σε ένα οικολογικό γνωστικό πεδίο, και (β) η ομάδα πιλότος οι οποία χρησιμοποιείται για την πρωτοτυπία.

Στο Κεφάλαιο 2 παρουσιάζονται τα γεωγραφικά (έδαφος, κλίμα, χλωρίδα και πανίδα, και αγροοικολογικά χαρακτηριστικά) και κοινωνιο-οικονομικά χαρακτηριστικά της περιοχής. Ιδιαίτερη έμφαση δίνεται στα αγρο-οικολογικά χαρακτηριστικά των ελαιώνων της περιοχής του προγράμματος.

Στο Κεφάλαιο 3 περιγράφεται η διαδικασία εγκαθίδρυσης στόχων για την οικολογική παραγωγή, λαμβάνοντας υπόψη την αγροτική, οικολογική και κοινωνιο-οικονομική κατάσταση, τους περιορισμούς και τις δυνατότητες της περιοχής. Παράλληλα, εξηγείται η μέθοδος ιεράρχησης των στόχων που πρόκειται να επιτευχθούν στα πλαίσια εφαρμογής των συστημάτων οικολογικής ελαιοπαραγωγής στην περιοχή του προγράμματος.

Το Κεφάλαιο 4 περιγράφεται αναλυτικά η διαδικασία με την οποία οι στόχοι των συστημάτων οικολογικής ελαιοπαραγωγής ποσοτηκοποιούνται με δώδεκα παραμέτρους. Παράλληλα παρουσιάζονται τα επιθυμητά εύρη τιμών των παραμέτρων αυτών. Οι παράμετροι χρησιμοποιούνται προκειμένου να συγκριθούν οι επιτυγχανόμενοι με τους επιθυμητούς στόχους.

Στο Κεφάλαιο 5 δίνεται ο σχεδιασμός κατάλληλων καλλιεργητικών μεθόδων για την εφαρμογή των στόχων των πρότυπων συστημάτων. Περιγράφεται πως έξι μέθοδοι αρχικά σχεδιάζονται στο πλαίσιο ενός θεωρητικού πρότυπου. Οι μέθοδοι αυτές σχετίζονται με την οικολογική διαχείριση της εδαφοκάλυψης, των θρεπτικών στοιχείων, της οικολογικής ενδοοργάνωσης, του νερού, και των εντόμων και παθογόνων. Εδώ περιγράφεται τόσο ο

γενικός σχεδιασμός των μεθόδων αυτών όσο και ο ειδικός σχεδιασμός τους για της αγροοικολογικές ζώνες της περιοχής.

Στο Κεφάλαιο 6 περιγράφεται η εφαρμογή των πρότυπων συστημάτων από δώδεκα βιοκαλλιεργητές ελαιοπαραγωγούς σε δεκαεπτά ελαιώνες, οι οποίοι ταξινομούνται σε: (α) εντατικούς λοφώδες ελαιώνες, (β) εκτατικούς λοφώδες ελαιώνες και (γ) εντατικούς πεδινούς ελαιώνες. Επίσης παρουσιάζονται τα αρχικά αποτελέσματα της εφαρμογής από το 1993 έως το 1995 των πρότυπων συστημάτων. Τα αποτελέσματα αυτά σχετίζονται με την εισαγωγή των έξι μεθόδων από τους ελαιοπαραγωγούς. Επίσης, επιδεικνύουν την πρόοδο που επιτεύχθηκε κατά την εισαγωγή των πρότυπων συστημάτων και την μεταβατική περίοδο στην οικολογική παραγωγή. Τέλος στο κεφάλαιο αυτό σχολιάζεται η βελτίωση των πρότυπων συστημάτων και οι απαραίτητες βελτιώσεις των καλλιεργητικών μεθόδων, σύμφωνα με ένα σύνολο κριτηρίων.

Το Κεφάλαιο 7 περιγράφεται η δημιουργία ενός δικτύου για την ανάπτυξη και διάδοση των πρότυπων συστημάτων σε περιφερειακή κλίμακα. Περιγράφεται η δημιουργία ενός δικτύου από ομάδες που στοχεύουν στην πρωτοτυπία κατά περιοχή καθώς και οι αρχές σχηματισμού τέτοιων ομάδων. Στο ίδιο κεφάλαιο σκιαγραφείται η διάδοση των πρότυπων συστημάτων καθώς και η σπουδαιότητα τοπικών ομάδων πιλότων στις διάφορες περιοχές της Κρήτης.

Τέλος στο Κεφάλαιο 8 επανεξετάζονται οι συνθήκες κάτω από τις οποίες σχεδιάστηκε και εφαρμόστηκε το πρόγραμμα καινοτομίας καθώς και οι μελλοντικές προοπτικές των πρότυπων συστημάτων και της διάδοσης των συστημάτων οικολογικής ελαιοπαραγωγής. Έμφαση δίνεται στις αναγκαίες βελτιώσεις λαμβάνοντας υπόψη τα αρχικά αποτελέσματα. Παράλληλα, όσον αφορά την νέα μεθοδολογία που ακολουθήθηκε στην έρευνα υπογραμμίζονται τα πλεονεκτήματα, οι αδυναμίες, οι περιορισμοί και οι δυνατότητες της πρωτοτυπίας και της διάδοσης των συστημάτων οικολογικής ελαιοπαραγωγής.

Appendices

Appendix 1 Cretan Agri-environmental Group

(text from the information leaflet of the foundation)

Cretan Agri-environmental Group

The foundation "Cretan Agri-environmental Group" is a registered (No 592/1994 Iraklion, Crete) non profit foundation established by farmers, agriculturists, researchers, and consumers in 1994.

The foundation aims at:

- the widespread of ecological farming methods and sustainable food systems,
- the promotion of labelled ecological products,
- the protection of the local agroecosystems, nature and landscape,
- the research and development of the local agroecosystems,
- the regional agri-environmental policy and education,
- the development of the local eco-agrotourism.

in the region of Crete.

Activities of the group to the present time have been:

- The Organic Olive Growers of Messara, which are the first group within "Cretan Agri-environmental Group" since 1993, have focused on organic olive tree cultivation and organic olive oil production, in accordance with Legislation (EEC) 2092/91. The organic olive growers of Messara have produced, standardised, bottled and promoted the first organic olive oil which has been produced in Crete.
- The core of the group, has participated for three years now in a research project that aims to design "ecological olive production systems". The research project takes place in Messara plain, Faistos area and the Legislation (EEC) 2092/91 is applied.
  The sustainable development of the region through participation in on-farm research and extension consists of one of the main interests of the foundation. Similar projects are prepared for other crops like vines, citrus and vegetables.
- The members of the group process, standardise and trade the olive oil themselves, activities that comprise the core element of the group's infrastructure.
- Finally, the participation in and the organisation of educational visits and training consist of another target of the group. In the frame of these activities, ten of its members visited The Netherlands, in 1994, under "The Agri-environmental Visits Programme".. Also, members of the foundation have participated in all kinds of activities related to organic farming (seminars, cross-meetings, scientific talks, training activities etc.). The

group participated to the First Organic World Exhibition in Denmark, in 1996.

- Cretan Agri-environmental Group aims at the establishment of a network of groups to cover all areas and production systems at Crete. It will attempt to create an ecological knowledge system in Crete.

***Appendix 2** Indicative chronology of the dynamic and continuous process for making an hierarchy of objectives for the ecological olive production systems (EOPS)*

1991				1992				1993			
		[illegible]									
[illegible]s and issues											
socio-econo[illegible] - situation of farmers											
		concepts, th[illegible] production									
							provisional hierarchy [illegible]ectives				
								hierarchy of obj[illegible]			

Appendix 3 Codes of practices for ecological olive production systems in Crete

CONTENTS

1. INTRODUCTION

The olive sector in Crete, as in many other olive producing regions in Mediterranean European Union (EU), faces agronomic, ecological and socio-economic problems. These problems to a large extent are due to one side ways of production aimed at maximum levels of production while ignoring quality of production, agroecosystem functions and processes, and environment. Besides, many problems are due to the gradual abolishment of price intervention by the EU. Therefore olive production in the future should become sustainable. We consider as optimal solution the development of multi-functional ecological olive production, marketing with an ecological label, and emphasising the functions of the countryside.

An innovative pilot research project aimed at designing, testing and improving ecological olive production is taking place at the western Messara plain (Festos area), southern Crete, Greece. Ecological olive production is based on a designed theoretical prototype and agroecosystem based farming methods that are applied and tested by a pilot group of growers. These methods have been disseminated to and are applied by the growers of the foundation "Cretan Agri-environmental Group". The foundation aims at the dissemination of ecological production systems and the re-establishment of an ecological knowledge system in the island of Crete. The pilot group, whose members comprise the core of the foundation, disseminates the agrotechnology which is produced to the foundation. All members of the "Cretan Agri-environmental Group" produce in accordance with Regulation (EC) 2092/91 for organic farming.

Designing ecological olive production systems requires a methodology for establishing the objectives of production, considering the biological, ecological and socio-economic circumstances and constraints of the region. These objectives have to be transformed and quantified with appropriate parameters in order to establish desired results and to improve the prototypes until these results are achieved. For the prototypes appropriate methods have to be designed, established and developed to achieve the objectives. These methods require a set of criteria for their development, testing and improvement. A pilot group of olive growers is needed for prototyping (designing, testing and improving the prototypes). Ecological olive growers are suitable members of such a pilot group. Their production should meet strict environmental and quality of production norms and be marketed under label (CEC, 1992; IFOAM, 1992). This implies shared responsibility of rural and urban populations, for the environment and nature, which we believe is the only sustainable solution. The prototypes should be tested and improved by co-operation with the pilot growers in the first step. In a second step prototypes are disseminated widely in the regional context. In Crete that is accomplished by the foundation "Cretan Agri-environmental Group". The whole process of participation of the pilot growers and the dissemination to the Agri-environmental Group of Crete is based on participated learning and continuous interaction between researchers and growers.

This innovative research project is still in an initial phase; three years ago a pilot group of thirteen olive growers was formed with a selection of eighteen pilot groves. Ecological agriculture was introduced in the project region and the growers started the conversion process to ecological agriculture, interacting with the multi-objective prototyping methodology. The multi-objective methods are gradually being introduced in the prototypes.

The principles of the farming methods for ecological olive production are simply described in codes of good agricultural practices in this article. The purpose is to assist farm advisors to disseminate them and to establish ecological olive production, and for the olive growers to apply them. In addition, we are looking for suitable patterns for establishing a Mediterranean network. These practices are valid in the western Messara plain, but can be adapted easily with the guidance of a farm advisor to meet the requirements of most olive producing areas around the world. This adaptation would be best done initially by a pilot group, which would develop the methods to be applied to the specific requirements of the area, and also would develop the required knowledge system.

The next chapter discusses the requirements for adjusting the olive grove to the agroecosystem functions. In addition, it gives the required guidelines for establishing new ecological groves. Chapter three discusses the regulation of olive tree size and its importance in ecological olive groves, giving the basic principles and techniques of pruning. Chapter four provides the principles and use of the ecological infrastructure. Chapter five provides the basic practices of the management of the grove floor for ecological olive production. Chapter six gives the principles of fertilisation in ecological production and the materials used. Chapter seven describes the main enemies of olive production in the western Messara plain, their prevention and control in ecological production. Chapter eight provides the requirements and practices for irrigation and rational water use in irrigated groves.

2. ESTABLISHING ECOLOGICAL OLIVE GROVES

Establishing an ecological grove means designing the new grove in such a way as to optimise the available resources on and of the farm. Consequently an assessment of natural, capital, human and technological resources available, taking in consideration short and long time trends, should be done before designing a new grove.

The design of the new olive grove should take in consideration the functions of an ecological olive grove and the contribution the groves make to the rural area. The first function is agronomic: the grove should be established for optimum production adjusted to the change in requirements from maximum to quality production and protection of the environment. The second is ecological: the grove should conserve the natural environment and landscape. The third function is socio-economic: the grove should not create unhealthy working conditions for the growers, but should maintain sufficient income and employment for the growers and economically vital rural communities, and provide healthy olive products to consumers. Consideration of the above functions may help to design a sustainable olive grove.

Old groves in the area in good condition, should be studied in regard to direction of planting, existence of terraces, stone walls, hedgerows and vegetation in the hedgerows.

Landscape must be assessed in order to determine the microclimate and its favourable and unfavourable characteristics related to parameters like humidity, aeration and shading. These parameters should be taken in consideration as they affect the physiological condition of the trees and the beneficial and harmful species (pests, vertebrates, "weeds"). Besides, basic characteristics of the landscape like old trees and old stonewalls should not be destroyed by earthworks. Draining of wildlife habitats should be avoided as these are species-rich. Furthermore, potentially stony, poor sites should be preserved as they are habitats for specific species.

For planning the new grove the soil may be assessed through soil analysis to determine if there are any site-specific problems regarding structure, primary nutrients, pH, or organic matter level. Besides, the existence of hard pans, or soil erosion signs like rills or gullies should be assessed. Furthermore, the soil biological activity, for example the existence and number of earthworms and vertebrates should be assessed at least visually. Considering these assessments the following will be decided:

- fertilisation plan to correct nutrient deficiencies,
- soil cover and mulching to improve soil,
- amount and dosage of water, if irrigation will be used.

Land levelling works should be planned in such a way that they do not maintain or even worsen soil problems. Practical tips are:

- Large stones that may make difficult the cultural practices and the use of equipment should be gathered and used for building stone walls. Stone walls should be built in a way that prevent topsoil losses and provide shelter to beneficial organisms.

- Terraces and earthworks should be made taking into consideration the requirements of equipment and machinery, especially when the olive trees grow to their full size. This will save time and money.

An initial decision should be made where to place a road for moving into the field, a water store if necessary and irrigation pipes using contours. After earthworks, cover crops should be used to avoid top soil losses. The appropriate seed mixture must be prepared well in advance.

A flora and fauna inventory should be compiled for the grove site and the surrounding area to assess target species regarding beneficial and non-beneficial species difficult to control, in order to prepare methods of management.

The variety(ies) selection should be done not only with the criterion of yields but also with additional criteria such as:

- weather requirements and adaptation to the microclimate of the area;
- resistance to insect pests and pathogens, which occur in the area;
- nutrient and water requirements related to their availability in the area.

Regarding planting density, the later development and the final size of the trees should be taken into consideration to avoid phenomena of shadow, insufficient air movement, competition for water and nutrients, insufficient sun, difficulties to use machinery, especially for management of the floor of the groves. Spacing of the trees is particularly important for plant protection and the levels of insect pests and diseases in ecological groves.

The design of the grove and its initial management are of critical importance for avoiding problems, since in case these are not done correctly, unbalances may occur, promoting harmful organisms instead of beneficial and preventing the good growth and development of the trees.

3. REGULATION OF THE OLIVE TREE SIZE

The regulation of olive tree size in ecological groves is done exclusively with pruning, as chemical growth regulators are not used. Pruning of olive trees ("Koroneiki" and "Throubolia" varieties) is done by removing old unnecessary wood. Tree dimensions trimming should be carried out in a such a way that nutrients are distributed in balance to vegetation and flowering buds which will produce the fruits of the tree. Pruning, in conjunction with irrigation, fertilisation and plant protection, is a valuable contribution to the olive orchard's productivity.

In ecological farming, pruning is a vital cultural practice as it secures:

- regular fruiting and long productive life of the olive tree,

- olive tree adaptation to local conditions (temperature, humidity, sunlight, soil),
- a better balance between vegetative growth and flowering; besides, it regulates the alternate bearing of the trees,
- prevention of pests and diseases due to better aeration and easier control,
- water and humidity saving (as it reduces transpiration of foliage), essential because of the semi-arid conditions of the area and the long dry Mediterranean summer,
- regeneration of the trees,
- regulation of the nutrient requirements of the trees,
- easier mechanical harvesting for the "Koroneiki" variety.

Farmers in the Messara, as in every olive production region, apply three types of pruning: (a) shaping pruning, (b) fruiting pruning, and (c) regenerative pruning. These will be briefly described.

3.1 Shaping pruning

This type of pruning aims at giving a shape into the olive trees that has nothing to do with the "nice" appearance of the tree but with its sanitary condition and regular fruiting. In the agroclimatic conditions of Messara plain the most preferable shape is the hemispherical one in which the olive trees have the shape of an open umbrella. In this shape excessively vigorous shoots are removed, provided that large open spaces will not be created in the canopy of the tree. In case that this happens, the shoots are cut at the top to create axial shoots. If the outer side shoots are very dense then they are thinned out for correct aeration and illumination of the canopy of the tree.

Timing of pruning

Pruning must be done every year. In the "Koroneiki" variety, pruning can be done in combination with harvesting or after the end of harvesting. In the "Throubolia" variety, pruning is done at the end of winter or beginning of spring after the harvesting. In case of a serious infection from the olive knot (*Pseudomonas savastanoi*), careful cutting of the infected shoot is done in summer to prevent the spread of the disease in the rainfall period.

Technique

The key points of pruning for securing a good fruiting, flowering and good health condition of the tree relate to the following:
- The pruning should aim at the formation of many shoots of average length. This is because the fruiting zone of the olive tree depends on leaf area.
- In pruning:

- weak branches from the producing canopy of the tree should be removed so they can be replaced by stronger ones, preferably bending towards the ground.
- branches that are weak, dead, unhealthy or very dense, should be removed as they are infected easily by diseases.
- branches that create shading between the trees should be removed to improve aeration, and illumination in the whole fruiting zone of the tree.
- extremely fast growing or excessively vigorous shoots should be removed,
- the trunk and branches should not be left without any coverage by excessive removal of shoots and leaves.

Pruning must be repeated every year to avoid the need for a severe pruning which creates alternate fruiting, excessively vigorous shoots, problems from extreme temperatures, and sun burns of trunks.

3.2 Fruiting pruning

Because of the mechanical harvesting in the "Koroneiki" variety, the alternate bearing of the trees is desirable for reducing the harvest labour cost. For this reason the bearing of the trees is adjusted with a rather heavy biennial pruning. In a year with a heavy crop, the trees are also pruned in such a way so they again produce again a heavy crop the second year after pruning.

3.3 Regenerative pruning

Regenerative pruning is applied when the trees are old or when they are damaged by frost or harsh climatic conditions. As olive trees age, their capacity to produce productive shoots declines, and they should be rejuvenated to regain productivity. Even well spaced trees after many years shade out lower shoots and cause production to become confined to the top, which is difficult to harvest. After regenerative pruning, shoots need judicious spacing to rebuild the tree's shape. Besides, fertilisation and irrigation should be adjusted to discourage excessive growth.

It is important for pruning residues to be chopped and returned as organic material to the grove.

4. ECOLOGICAL INFRASTRUCTURE

Ecological olive growers create a framework of linear and non-linear elements in their groves to stimulate biological diversity, to re-establish agroecological balances and to buffer the cumulative effects of agricultural practices. An ecological infrastructure helps to promote beneficial insects and other animals as well as to protect the outstanding agricultural landscape of the Mediterranean olive producing areas. The latter is particularly important because of tourist activities in these areas.

Among other ways ecological infrastructure is established by taking care of the old stone walls, by not cultivating whole groves and grove margins, and by leaving corridors for the movement of beneficial organisms. Besides, in the plain, growers care for and manage the natural vegetation of the drainage ditches. Aside from the above conservation measures, growers plant species that host beneficial organisms and diversify the agroecosystem promoting biodiversity. These species are local varieties well adapted to agroclimatic conditions and are often used in traditional agriculture for production of fruits, vegetables and herbs. For example some species planted in Messara are:(a) trees such as almond tree and pear, (b) medicinal and aromatic plants such as *Ocimum basilicum* and *Laurus nobilis*, (c) wild flowers *Ebenus cretica* and *Thymus capitatus*. Understore cover crops contribute to a large extent to ecological infrastructure especially during the winter months. For the maintenance of the an ecological infrastructure within a grove, special measures should be taken to prevent fire during the dry summer months, especially in windy areas.

5. MANAGEMENT OF THE GROVE FLOOR

In ecological olive groves management of the grove floor is done by cover crops. They have a multi-functional role and contribute substantially to a rational and effective ecological management.

Among the functions of cover crops in ecological olive groves are:
- nitrogen source, when leguminous plants are included;
- improvement of nutrient cycling and prevention of soil born pests and diseases by improving soil structure, promoting soil micro-organisms activity and creating unfavourable environment in the top soil for pests;
- prevention of loss of the fertile top soil and of soil erosion;
- increased water absorption and storage efficiency by decreasing run-off;
- prevention and management of harmful plant species ("weeds") through competition;
- stimulation and conservation of beneficial insects, parasites, vertebrates and birds by providing shelter and food. Thus, they contribute to the prevention of insect pests and pathogens;
- conservation of threatened and endemic plant species.

Cover crops are used in ecological olive groves as:
- *green manures* (see next chapter)
- *mulches*. In this case the cover crops are chopped and the residues used as a mulch. Mulches minimise water losses, during the dry period, retain soil

organic matter content much better than cultivated soils, but are sensitive to fire during dry periods..

- *permanent crops* for grazing. In this case the undisturbed soil is a big advantage, while the danger of competition for water and nutrients between the cover crop and the olive trees is a disadvantage. Biodiversity and attractively are increased and food and shelter are available to beneficial organisms, all around the year.. The soil is enriched with fresh manure and thus biological activity is encouraged, while the economic benefits by reduced intervention costs and additional gains of animal feeds should not be underestimated. On the other hand, a prerequisite is the availability of grazing animals, mainly sheep, which graze without damaging the olive trees.

Green manures should be the first step in establishing cover crops as they have fewer risks and the growers learn gradually the new way of soil management. Later cover crops may be transformed to mulches or permanent cover, depending on the existing conditions. In the western Messara plain, the growers have been using green manures and now we have started experiments with the other forms, passing to the second stage.

A diversity of cover crops must be used since a number of different soils and orchard management requirements have to be satisfied. Plants used as cover crops can be:

- legumes. Although they are not so effective in improving soil structure and water penetration, they can contribute large amounts to the soil of nitrogen though dinitrogen fixation, while their residues are decomposed more rapidly.
- grasses. They provide large amounts of organic matter of slow decomposition. Because of their tasselled roots, they are useful in building up and improving soil structure, preventing erosion, improving water penetration and reducing nutrient losses and depletion. They can contribute to nitrogen management through non-symbiotic dinitrogen fixation in subtropical climates.
- other plant species. They increase diversity, can improve soil structure and offer food and shelter to beneficial insects and animals.

Usually mixtures of grasses, legumes and other species are used for cover-cropping, as their properties are thought to be complementary (see also green manures, next chapter). Cover crops can be annual or perennial plants, depending on soils, weather conditions, grove management and aggregate costs. Species and local varieties used in the traditional agriculture of the area are valuable as they are perfectly adapted to regional agroclimatic conditions. Species from elsewhere with dubious properties might turn to undesirable weeds soon, disturbing the balance of the grove and should not be introduced

Scheme 1.A3. Criteria for the selection of cover crop plant species

- nutrient and water requirements;
- temperature and light requirements;
- length of biological cycle;
- requirements for improvement of soil texture and structure (shallow or deep rooting);
- requirements for soil conservation;
- susceptibility to pests and diseases;
- interdependence of cultural practices (e.g. harvesting with nets for varieties like the "Throubolia" variety in west Messara plain);
- susceptibility to burning, especially in dry windy areas;
- feeding requirements of grazing animals;
- machinery requirements for their management, in chopping or incorporating operations;
- cost of seeds.

without previous research. Criteria we are using for the selection of the species are given in Scheme 1.

6. FERTILISATION

Fertilisation is an important aspect of grove management aimed at the maintenance of soil fertility and the increase of organic matter. The texture and structure of the soil directly affect the water holding capacity of the soil and aeration, affecting not only the development and distribution of the roots but also the activity of soil micro-organisms. Micro-organisms in their turn affect to a large degree the availability of nutrients originating from soil organic matter. Balanced nutrient management is required not only for maintaining a fertile soil, good yields and extended life of the olive trees but also for avoiding plant protection problems due to imbalance nutrition of the olive trees.

Green manuring and organic materials (animal manure, compost, processed seaweed, dust, leaves, wood residues, etc.) are used for fertilisation in ecological farming. The nutrient requirements of the grove and the availability of the materials in the area determine the selection of the organic materials used for fertilisation. Periodically it may be required to add minimal amounts of mineral fertilisers of phosphorus or potassium (such as rock phosphate and patend kali), depending on soil types and geology, and the supply of soil nutrients.

Fertilisation should aim at a fertile soil and thus the primary aim is not the plant macronutrient nutrition but the soil nutrient status and fertility. Fertilisation in ecological farming is done to maintain a high level of soil fertility and indirectly for olive tree nutrition. Fertilisation is necessary to start early in autumn during the rainy season as nutrients must be diluted in the soil water solution before being absorbed by the olive trees. As the nutrients of organic materials are slowly soluble and available to the olive trees and the trees do not absorb with the same rate all around the year, it should be ensured that there are continuously available nutrients for the trees' nutrition. This is secured with organic materials and plant residues which are transformed to organic matter in the soil.

The fertilisation plan must be done for increasing soil organic matter and soil fertility and for these reasons it must be combined with soil management related practices of the grove (irrigation and soil tillage). The efficiency of the fertilisation plan can be validated by the growers observing the soil fertility of the grove (soil structure, biomass of cover crops, etc.) and the productivity of the olive trees (fruit set, yield, vigour of shoots, leaf colour, etc.).

6.1 Green Manuring

Green manuring in the olive-groves is done for:
- fertilisation of the soil and the nutrition of the olive trees (manure)
- better absorption of rainfall and water conservation
- control of undesirable weeds,
- offering shelter and food to beneficial insects and parasites of the olive enemies,
- improvement of soil structure,
- prevention of soil erosion.

Timing

Green manure plants are sown after the first autumn rain when the soil is ready for cultivation (the time of sowing is the same as in the case of growing the same plants for fodder). They are incorporated before full flowering in advance of dry period (before the rains end of in spring). In the western Messara plain, green manures are incorporated at the end of March. The exact time depends on the field, the weather conditions (rainfall, temperature, sunshine hours) and the species used as cover crop.

Technique

Green manuring is carried out in frame of a five-year crop rotation plan which includes legume and graminae plants. The selection of species for crop rotation is based on the soil type, the weather conditions of the area and the nitrogen requirements. Species and local varieties used in the traditional agriculture of the area are valuable as these are perfectly adapted to the regional agroclimatic conditions. For example, in the agroclimatic conditions of Messara a green manure crop rotation can include the first year vetch, the second a mixture of vetch and barley, the third faba beans, the fourth lentils and the fifth barley. Sowing must be done when the soil has the appropriate amount of humidity using a cultivator (ripper) (the rotavator must be avoided due to negative effects which it has on the soil structure and the formation of a hard pan below 15 cm depth) between the trees. Deep cultivation under the trees should be avoided.

The amount of seed depends on the species, the variety and the desired percentage of ground coverage. For example 150-200 kg/ha of vetch for the conditions of the Messara are sufficient for a good ground cover.

Green manure is directly related to the management of the ground cover of the grove and the soil cultivation. Consequently management of plants which in conventional agriculture are considered as "weeds" is directly related to the ground cover. It is combined with minimum tillage and the competition and control of the "weeds".

6.2 Fertilisation with organic materials

Fertilisation with organic materials is done to provide the required nutrients to the soil and to provide the same positive effects that cover crops have on the soil.

Timing

In the western Messara, the distribution of organic materials in the olive grove is done before sowing of the green manure plants early in autumn (October-November depending on rainfall. It is important that the organic materials are ready for use early in autumn according to the fertilisation programme and their availability.

Technique

The organic materials are scattered around the olive trees and cover almost the whole ground surface in the grove in dense system of planting (200-300 trees per ha). In the traditional low density system the materials are scattered around the trees in a circle covering two times the diameter of the tree canopy. The organic materials are incorporated into the soil at the same time as the sowing of the green manure cover crop, with a cultivator.

If necessary (according to the results of soil analysis combined with the results of leaf analysis) natural mineral substances (allowed by Regulation (EC) 2092/91) can be used. The use of such products and their inclusion in the fertilisation plan must be done in co-operation with the farm advisor and the farm inspector.

The quantity of the applied organic materials depends on:
- the soil fertility of the grove (an indication is given by a laboratory soil analysis),
- the nutritional condition of the olive trees (which can be examined by leaf analysis of the trees),
- the yield of fruit,
- the species used as green manure,
- the organic materials used,
- the fertilisation plan of the grove.

Taking in consideration all the above, the type of organic materials to be used and their quantity are determined. The extensive irrational use of animal manure should be avoided as it can cause pollution of surface and groundwater with nutrients.

6. PLANT PROTECTION

The aim of plant protection in ecologically advanced olive production is to re-establish an agroecological balance. The establishment of this balance prevents pests and pathogens and keeps their populations below economic threshold levels. An agroecological balance is accomplished when the right cultural practices (pruning, fertilisation and irrigation) and the promotion and protection of beneficial predators and parasites are applied. A prerequisite is the application of only the really necessary control treatments. Biological agents (for example *Bacillus thuringiencis*) or insecticides (of mineral or plant origin) may be used when they are absolutely necessary and when they are in accordance with Regulation (EC) 2092/91. That kind of control is applied only in case there is a serious infestation in the grove. Before treatment, level of infestation, necessity and time of application are taken into consideration. In the transition phase control measures must be applied only after discussion with the farm advisor.

In the western Messara plain, plant protection aims in the first place at the prevention of problems primarily due to olive fly (*Bactocera oleae*) and secondarily due to black scale (*Saissetia oleae*) and olive leaf spot (*Spilocaea oleaginea*). It should be stressed here that except for the correct application of cultural practices, control measures are mainly necessary in groves in the transition phase, or in groves where ecological balance has not yet been established. More specifically, groves in the transition phase may, depending on the area, be infested by other secondary pests and pathogens, because of the lack of agroecological balance and wrong cultural practices (excessive fertilisation, irrational irrigation, insufficient pruning). In case of damage due to such insect pests and pathogens as wood insects (*Zeuzera pyrina, Cossus cossus, Phloeotribus scarabaeoides, Hylesinus olieipedra*), borer (*Coenorrhinus cribripennis*), green caterpillar (*Palpita unionalis*) olive thrip (*Liothrips oleae*), and *Euphyllura olivina,* the first thing to examine is the correct application of cultural practices. Extra control measures may be applied, if required, following the guidance of a farm advisor.

When production is threatened, extra control measures can be used through the advice of the farm advisor and the help of an inspector of the organic certification organisation.

Olive fly

Olive fly (*Bactocera oleae*) infests the olives, resulting in quantitative and qualitative reduction of the production. Protection against olive flies in ecological olive production is done with mass trapping. In case of severe infestation, due to wrong cultural practices, such as unbalanced fertilisation (excess of nitrogen), irrigation (high humidity), or pruning (insufficient air circulation and sunlight), or adverse climatic conditions (high temperature and humidity) extra control measures should be taken. For example those measures may include bait sprays with hydrolysed protein and insecticides like rotenone or pyrethrum.

Prays Oleae

Prays oleae infest the leaves flowers and fruits of the olive tree causing severe damage in olive groves. *Prays oleae* occurs mostly when the agroecological balance of the grove has been disturbed and predators or parasites do not exist. In the transition phase of the grove, when serious damages due to *Prays oleae* may occur, application of *Bacillus thurigiensis* is possible before flowering. Timing and correct application of cultural practices are very important. It must be noticed that in other olive producing areas, *Prays oleae* is a major insect pest.

Sooty mold

Sooty mold is due to the fungi *Fumago vagans*, which develop on the sticky honeydew secreted by developing black scales (*Saissetia oleae*). For the prevention and control of sooty mold, balanced fertilisation and irrigation and good pruning for securing good air circulation and sunlight penetration are recommended. In case of severe infestation, extra control measures can be applied. These measures include spraying with Bordeaux mixture against the fungi and spraying with mineral oils or a solution of petroleum with soap against the scale.

Olive leaf spot

Olive leaf spot is due to the fungi *Spinalocaea oleaginea*, which develops in the leaves of the olives as a consequence of high humidity, bad air circulation and favourable temperatures in the grove. Control is done by limitation of its activity by means of intensive light and sun. So appropriate pruning, balanced irrigation and nitrogen management are essential in order to prevent infestation and development of the fungi. In case of severe infestation, extra control measures should be taken, including spraying with Bordeaux mixture. It has to be noticed that even if copper sprays are allowed by Regulation (EC) 2092/91, they must not be used extensively because copper residues affect animals that graze in fields heavily sprayed with copper compounds.

8. IRRIGATION

Irrigation is an important cultural method, related to nutrient uptake and nutrient losses. The total amount of water, dosage, timing and number of applications should be optimised to cover olive tree water requirements and to minimise the water losses during irrigation. The total amount of irrigation water depends on the microclimate of the grove, the weather, the soil type and the age of trees. Irrigation in ecological olive production systems aims at the maintenance of physical and chemical soil conditions and the conservation of water resources.

Irrigation frequency and water amount can be determined with computer programmes, using meteorological, soil data and data related to the ground cover of the grove (water budget method). An alternative is the determination of irrigation timing by examining soil humidity at 0-15 cm and by observing one or two control trees, that are used as indicators (feel method). Control plants in the ground of olive groves, such as *Malva silvestris,* can be used as indicators of soil humidity. Irrigation starts when those plants wilt. Tensiometers may also be used to determine water supply and when to irrigate.

In the Messara plain where groves are irrigated with drip irrigation, growers change the position of the emitters periodically to avoid local concentration of the root system and to prevent unavailability of nutrients due to this concentration.

Scheduling

The irrigation period starts at the end of flowering (May in the Messara) and continues till the end of September depending on the weather. Water is applied every week or every fortnight depending on the weather. In case of insufficient rainfall in autumn and when high yield is expected the coming year, then winter watering is recommended for promoting a good flowering in spring. Besides, in the end of winter when there is not sufficient rainfall then irrigation water is applied to increase nutrient availability. In this case also we water during flowering to increase fruit set. In all cases water applications must be related to pest, especially olive fly, population and potential damage. Irrigation should not create favourable conditions for fruit and tree infestation or the spreading of pests and diseases. Irrigation should be avoided during the appearance of a new pest generation, as observed by monitoring traps.

An indicative irrigation plan for Messara plain is as follows:

- When rainfall is low during winter, irrigation starts in February and March. This irrigation is required to maintain sufficient soil humidity and enhance flowering in the fruiting year.
- When rainfall is poor in March, irrigation increases nutrient availability and encourages sufficient flowering.
- Irrigation in April-May stimulates fruiting and avoids fruit abscission. In the first ten-day period of April, depending on weather and insect biology and the catches in the monitoring traps, we should avoid irrigation because this period coincides with the appearance of the adults of the first generation of the olive fly. In May the quantity of water per irrigation water is reduced and the frequency increased to avoid nitrogen leaching during the "critical period" of flowering.
- In June and July we irrigate regularly to avoid fruit abscission and to stimulate good fruit development. Around the first ten days of June, depending on weather and insect biology and the catches in the monitoring traps, irrigation quantities must be reduced and the frequency increased as this period coincides with the appearance of the second generation of the olive fly. Also, at the end of July, when the fruit stone is hard, irrigation quantities should be increased as the irrigation requirements of olive trees are greater.
- In August the irrigation should be adjusted to such a frequency and dosage that favourable conditions for the olive fly in the groves are avoided, especially the ones planted with the "Throubolia" variety and table olive varieties.
- In September and October the quantity and frequency of irrigation should further decrease, especially in oil producing varieties like "Koroneiki" and "Throubolia" when the weather is sufficiently humid.

- In November and December, when there is not sufficient rain, sufficient irrigation water should be applied to ascertain a good blooming next year, especially when a heavy crop is expected. Besides, drip irrigation should continue to dilute salts and to avoid their movement downward into the root zone.

Irrigation may contribute to heavy yields, but when it is applied incorrectly may appear to be useless or even damaging for the trees. Poor water management puts an orchard at risk and may result in significantly negative effect on revenue.

9. CONCLUSIONS AND PERSPECTIVES

All the cultural practices as described above are applied by the pilot group of olive growers, participating in the innovative pilot project for prototyping ecological olive production. Besides, they are applied by the organic growers of the Cretan Agri-environmental Group. The cultural practices and the methods are tested, evaluated and improved. Experiences and new insights from other areas are welcomed.

It is very important to stress that in ecological olive production no general recipes exist. Every grower has to follow the basic principles, methods and regulations of ecological agriculture after appropriate modification for his own soil, weather, cultural and management conditions and needs. This consideration requires the examination of the inter-links and the consequences of the individual cultural practices to the agroecosystem.

The perspectives of ecological olive production seem satisfactory as the initial results of our research show that costs do not increase. Besides, there are starting to be some market premiums on organic olive products and the market for organic products is growing fast. Furthermore, with the introduction of agri-environmental laws, like Regulation (EC) 2078/93, economic incentives are given to growers to farm ecologically.

We would like to establish a network for exchanging information, data and experiences and for setting up standards. Consequently, we welcome any correspondence.

10. REFERENCES

Anagnostopoulos, P. 1930. *The Helenic oliviculture*. Labropoulos, Athens, Greece (In Greek).

CEC, 1991. Official Journal of the European Communities, L 198/1, 22.7.91.

Elena, E. 1990. *Fungus's diseases of the olive tree in Greece.* Technical bulletin No. 11. Benaki Plant Protection Institute, Kifisia, Greece (In Greek)

Ferguson, L., G. S. Sibbett, and G. C. Martin. 1994. *Olive production manual.* University of California, Division of Agriculture and Natural Resources, Publication 3353.

Hartmann, H. T. and K. W. Opitz, 1966. *Pruning olive trees in California.* Univ. of California, Div. Agr. Sci. Leaf 2739.

IFOAM, 1992. *Basic standards of organic agriculture.* Tholey-Theley, Germany.

Kabourakis, E., 1993. *Nitrogen flows in olive groves with a leguminous and cereal green manure intercrop.* MSc Thesis. Wageningen Agricultural University, The Netherlands.

Kabourakis, E. 1995a. *Innovative research with a pilot group of olive growers.* Proc. 1st Greek National Conference for Organic farming, 4-6 November 1994, Kalamata, DIO, Greece. (In Greek)

Kabourakis, E. 1995b. *Designing ecologically advanced olive production.* Proc. 10th IFOAM Scientific Conference, Lincoln University, New Zealand, 11-16 December 1994, Lincoln University, New Zealand.

Kabourakis, E. 1995c. *Biological olive cultivation.* Agricultural Technology, January 1995 (In Greek).

Kabourakis, E. 1995d. *Practiche colturali per un'olivicoltura ecologicamente avanzata: l'esperienza di Creta.* Bioagricultura, July 1995 (In Italian).

Kedros, K., Margaris, N. S., and S. Chotzeas. 1988. *The olive groves of the Aegean sea.* Proc. Congress on olive growing in Greece, 25-27 February 1988, Mitilini, Lesbos, Greece. University of Aegean Sea, Ministry of Agriculture, Lesbos Prefecture, Mitilini, Greece (In Greek).

Michelakis, N. G. 1986. *Olive tree behaviour under various irrigation conditions.* PhD Thesis. Agricultural University of Athens, Athens, Greece (In Greek).

National Research Council, 1989. *Alternative agriculture.* Washington D. C., USA.

Pansiot, F. and H. Rebour. 1961. *Improvement in Olive Cultivation.* F.A.O Agr. Studies No 50.

Sarakamenos, D. 1920. *The Hellenic olive tree. Vol. 1 The olive tree of Corfu.* Sakelariou, Athens, Greece (In Greek).

Sfakiotakis, E. 1993. *Courses on olive growing.* Typo MAN. Thesaloniki, Greece (In Greek).

Vereijken, P. 1994. *Designing prototypes.* Progress report 1. AB-DLO. Wageningen, The Netherlands.

Vereijken, P. 1995. *Designing and testing prototypes.* Progress report 2. AB-DLO. Wageningen, The Netherlands.

Appendix 4 Potassium Available Reserves (KAR), Phosphorus Available Reserves (PAR) and Organic Matter Content (OMC)

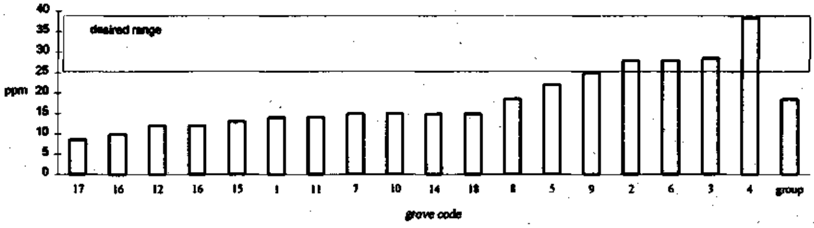


Figure 1.A4. *Potassium Available Reserves (KAR) by pilot grove, mean 1994-1995*

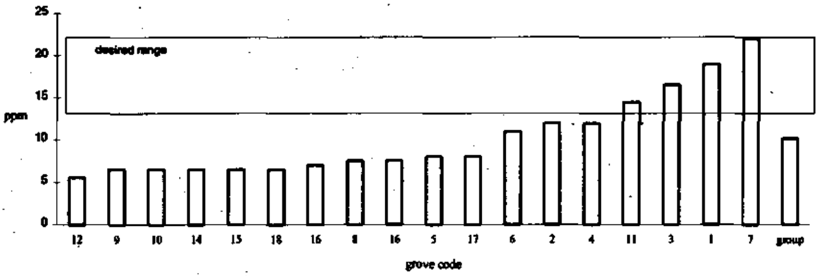


Figure 2.A4. *Phosphorus Available Reserves (PAR) by pilot grove, mean 1994-1995*

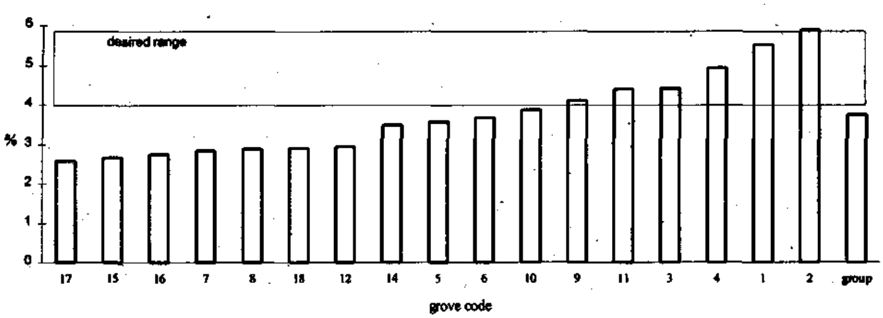


Figure 3.A4. *Organic Matter Content (OMC) by pilot grove, mean 1994-1995*

Appendix 5 Conventional management of the pilot groves before the introduction of the prototypes

Contents

1. INTRODUCTION

The conventional farming practices applied by the pilot growers before the introduction of the prototypes are described in this annex. These practices were also applied by the rest of the growers, members of the "Cretan Agri-environmental Group" who gradually adopted the prototypes. They are still applied by the rest of conventional growers in the area. Exact quantification of the inputs and practices used is difficult as growers did not keep any records.

There were not standard practices followed by the majority of the growers. The practices and the inputs used were not determined by a scientific sound way of managing the agroecosystem. Long term productivity was not considered, as the main consideration was maximum yields and maximum short term profits. The practices varied from year to year and from grower to grower depending on the cost of inputs and the recommendations made for inputs by dealers of agrochemical companies. Besides, the amount of inputs was also determined by the profits gained by a grower. Timing of practices was varied because farmers increasingly used machinery for soil cultivation and the application of inputs, especially for plant protection. Many farmers were unable to buy this machinery because of its cost. Machinery was hired, but it was not always available at the right moment for the cultivation practice. Growers involved in other activities and having other part time jobs usually they did not have available machinery at the right moment. Furthermore, these growers could not follow the natural cycles of the agroecosystems most of the time, due to their other activities and to their ignorance about these cycles.

State and co-operative extension services did not give recommendations and information on cultivation practices due to lack of personnel, funding and information. Besides, their personnel were overloaded and were dealing with administrative work for European Union (EU) and state subsidies and regulations.

At the beginning of the project, after an initial selection of the pilot group of growers all its members were individually interviewed. That informal semistructured interview took place over multiple sessions. In those semistructured interviews the following were discussed with the growers:

- agroecological criteria for the selection of the pilot grove (see Scheme 4, Chapter 6.1),
- history of the potential pilot grove, regarding year of establishment, density of plantation, yields, previous land use, soil type, etc.,
- phenology of the olive trees in the grove, regarding vegetative development, flowering, etc.,
- management of the grove, regarding labour, machinery, etc.,

- cultivation practices of the grove and their timing, like soil cultivation, fertilisation, irrigation, plant protection, etc.,
- amount of inputs used.

The data collected were checked and supplemented by visits to the pilot groves together and without the grower.

These interviews were taken in order to:

- select a representative grove fitting to the agroecological criteria,
- understand conventional cultivation methods used and learn the requirements the ecological methods to satisfy each pilot grove,
- to avoid misunderstandings regarding the proposed changes by the growers and the existing situation by the researcher,
- determine particular points that required attention,
- point out potential problems and avoid problems and mistrust in case losses of yield happened.

2. ESTABLISHMENT OF GROVES

The optimisation of available resources on- and of-farm was not taken into consideration during establishment of a new grove. Maximum yields were only considered. Long term ecological and socio-economic costs and effects were not taken into consideration.

An assessment of the field conditions was not done and the farmers planted the trees mainly as it was the current "fashion", often in very high densities (more than 280 trees per hectare). Subsoiling was often applied without existence of hardpan soils or any other reasons for it. Furthermore, land levelling works were extensive because of bas relief in the surrounding Messara plain hills. Unfavourable microclimate changes, promoting pests, and elevations of soil erosion were not considered. Besides, future results of nature and landscape disturbances were not taken into account. The criterion for the selection of a variety was its ability to use inputs and produce high yields. The planting density was many times too high (more than 280 trees/ha). These densities resulted, in combination with insufficient tree regulation, competition between the trees and problems, due to insufficient air movement, sun, etc., in later development of the trees. Widespread was among growers the notion that high density of trees combined with high inputs would give high yields and high profits.

3. REGULATION OF THE OLIVE TREE SIZE

Pruning of "*Koroneiki*" variety was done in the year of production in combination with harvesting. This pruning was mainly fruiting pruning. Growers did not take very much care for the shape of the trees. This in combination with the high density of the groves created favourable conditions for pests and pathogens due to insufficient aeration and illumination of the canopy of the trees. Besides, many times due to insufficient illumination, groves gave lower yields. "*Throubolia*" was not pruned at all, because of the size of the trees and the difficulties it created for the growers to prune. Regenerative pruning was not applied because of the fear of losses in yields in subsequent years. This resulted in the gradual reduction of yields due to insufficient illumination, outbreaks of diseases, and declined capacity to produce productive shoots. Growers were trying in this case to increase yields by excessive fertilisation and irrigation. These in their turns further aggravated the problems. Chemical growth regulators were not used in the pilot groves for the regulation of the olive tree size.

4. NATURE MANAGEMENT

Wild flora and fauna were considered unnecessary or even unwanted enemies by the growers, especially the young ones, who many times ignored their functions in agroecosystem. Extensionists promoted the idea many times that wild flora and fauna were sources of pests and should be eliminated. Their habitats were destroyed by extensive use of machinery on all the available land.

5. MANAGEMENT OF THE GROVE FLOOR

Management of the grove floor was done with continuous cultivation and/or herbicides. Usually the groves were ploughed with rotator, creating a hard pan below 15 cm depth and destroyed soil structure. Besides, often they used a plough, which was going more than 15 cm deep disturbing the surface root system of the trees. They plough at least three times per year. One in autumn when natural vegetation was developing, and one, two or more times in spring time, depending the weather conditions and the amount of biomass from natural vegetation. First they often plough and then they used additionally herbicides. The treatment of natural vegetation with herbicides was common, mainly on hilly groves because of the bas relief on hilly groves and the harvesting of '*Throubolia*' with nets. Herbicides were applied in autumn and sometimes additionally in spring time. The Soil Cover Index (SCI) (see Chapter 4.2.1) of the pilot groves before the introduction of the prototypes, based on our observations in the groves and the discussion with the growers, is presented in Figure 1.A5.

6. FERTILISATION

Fertilisation was done with the application of synthetic fertilisers. Farmers did not keep records of quantities for fertilisers they applied per grove. Routine fertilisation was done one year with application of 3 kg per tree of ammonium

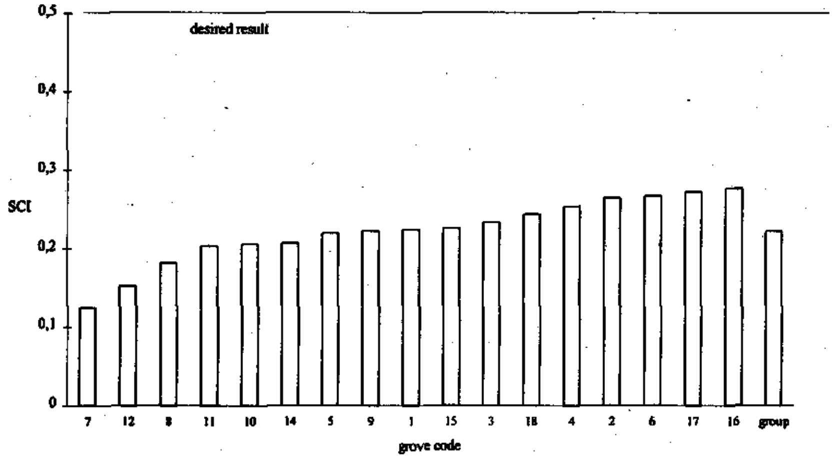


Figure 1a.A5. *Soil Cover Index (SCI) by pilot grove over the year, mean 1992-1993*

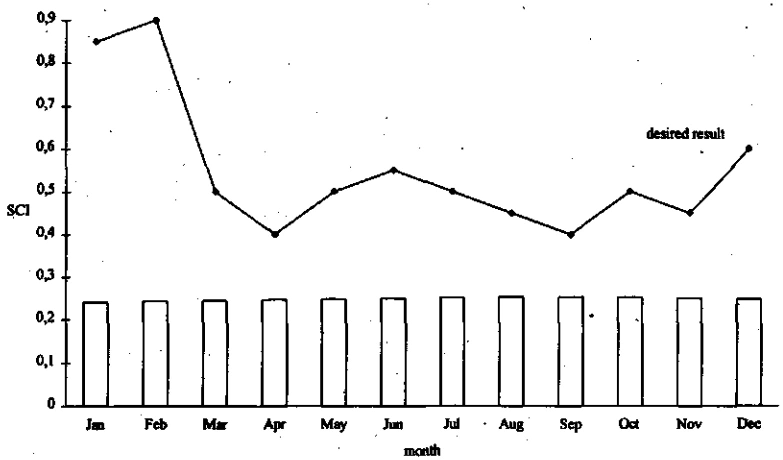


Figure 1b.A5. *Soil Cover Index (SCI) by month over the pilot group, mean 1992-1993*

suphlate fertiliser (21-0-0) and the next year with 3 kg per tree of a combined synthetic fertiliser (11-15-15) for "*Koroneiki*" variety. For "*Throubolia*" variety was used the same fertilisation plan in double quantities of fertilisers. The ammonium suphlate was applied usually on December - January and sometimes with warm weather on dry bare soil. The combined fertiliser was applied usually earlier on November - December. Soil or leaf analyses were not used for determining amounts of fertilisers. The quantities were varying and many times in years with lower prices of fertilisers or higher prices of olive products higher quantities were applied. The Macronutrient Balance (MB) (see Chapter 4.2.3) of the pilot groves before the introduction of the prototypes is presented in Figure 2.A5.

7. PLANT PROTECTION

Plant protection in the pilot groves was aimed at the control of pests and pathogens. No prevention measures were taken. The control was done with chemical biocides. The control was mainly done with routine sprays for the main pests and pathogens. These were the olive fly, the prays oleae, the sooty mold, the olive leaf spot and the olive knot.

The olive fly was controlled with 3-5 bait sprays by a state programme. Until 1992 the plain and the surrounding hills, when the bas relief permitted it, were air sprayed. In air sprays until August fenthion was used in a water solution of 0,1% of fenthion and 2% dacona or dacus bait food attractant. After August dimethoate was used in the same way. Ground sprays were done with the same solutions but with 0,25-0,3% fenthion and 2-3% food attractant, when bas relief did not permit air sprays. Except bait sprays 1-3 cover sprays were done with the same pesticides but without the food attractant. When fenthion was used the content was 0,125-0,150 % fenthion. When dimethoate was used the content was 0,04-0,05 % dimethoate.

Sooty mold was aggravated because of the high densities of the trees and the insufficient pruning. It was controlled with a cover spray on July with the use of methidathion in a water solution of 0,032-0,048 %.

The peacock spot is commonly found on the "*Throubolia*" variety. It was controlled with two cover sprays, one in autumn (around October) and one in spring time (on March). Bordeaux mixture (80% copper) was used in a water solution of 32% Bordeaux mixture. Besides, copper suphlate (99% copper) was used in a water solution of .0,99-1,485 copper suphlate and 1-1,5% lime.

Olive knot was commonly found in "*Koroneiki*" due to inappropriate pruning. Knots were not removed and pruning was done during rainy days. Besides, olive knot was spread with the mechanical harvesting during rainy days. Methidathion was used for control with one cover spray on July in a water solution of 0,032-0,048 %. Besides, Bordeaux mixture (80% copper) was used in a water solution of 32% Bordeaux mixture, in March.

The Environmental Exposure to Biocides (EEB) (see Chapter 4.2.11) of the pilot groves regarding olive fly control before the introduction of the prototypes is presented in Figure 3.A5.

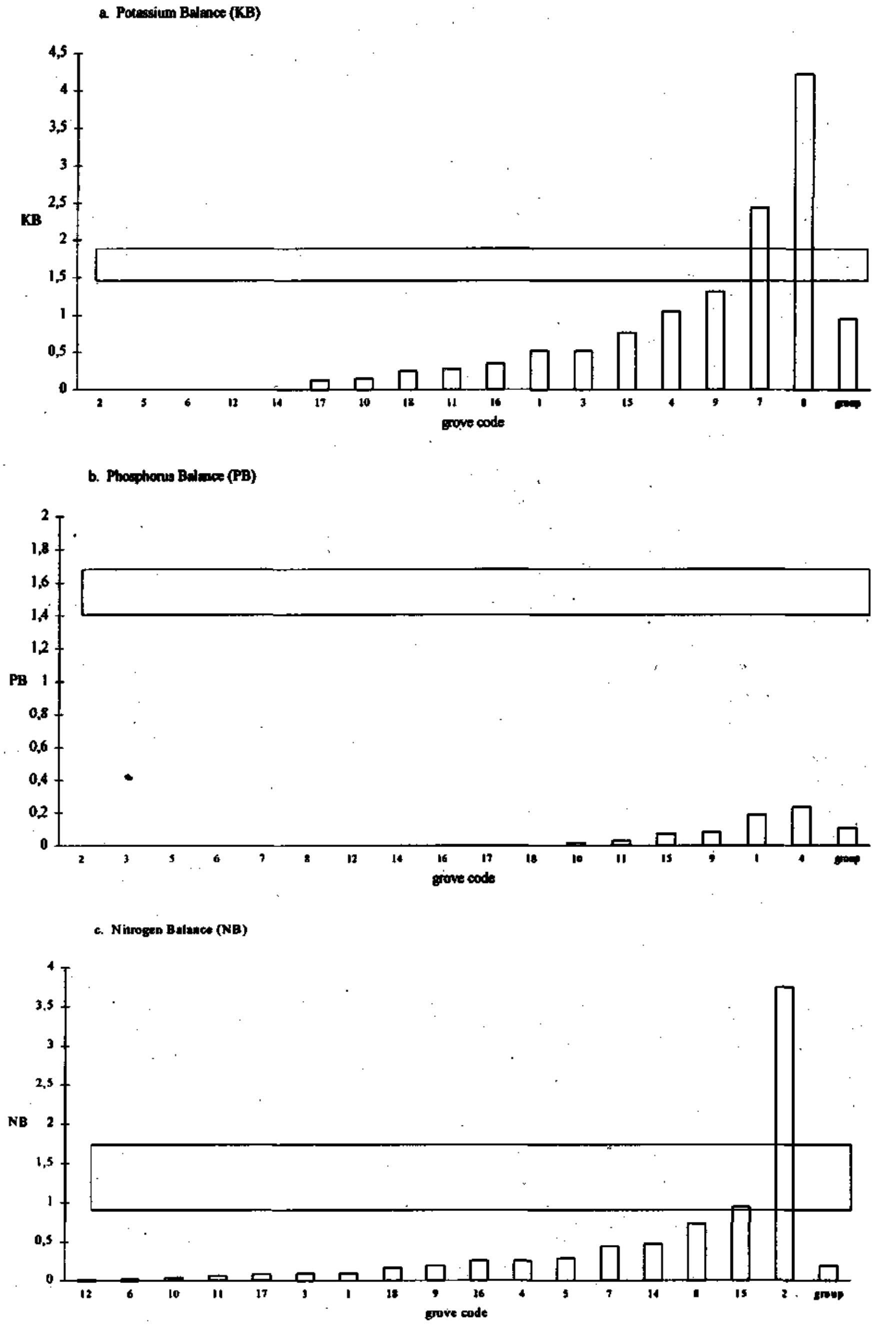


Figure 2.A5. *Macronutrient Balances (MB) by pilot grove, mean 1992-1993*

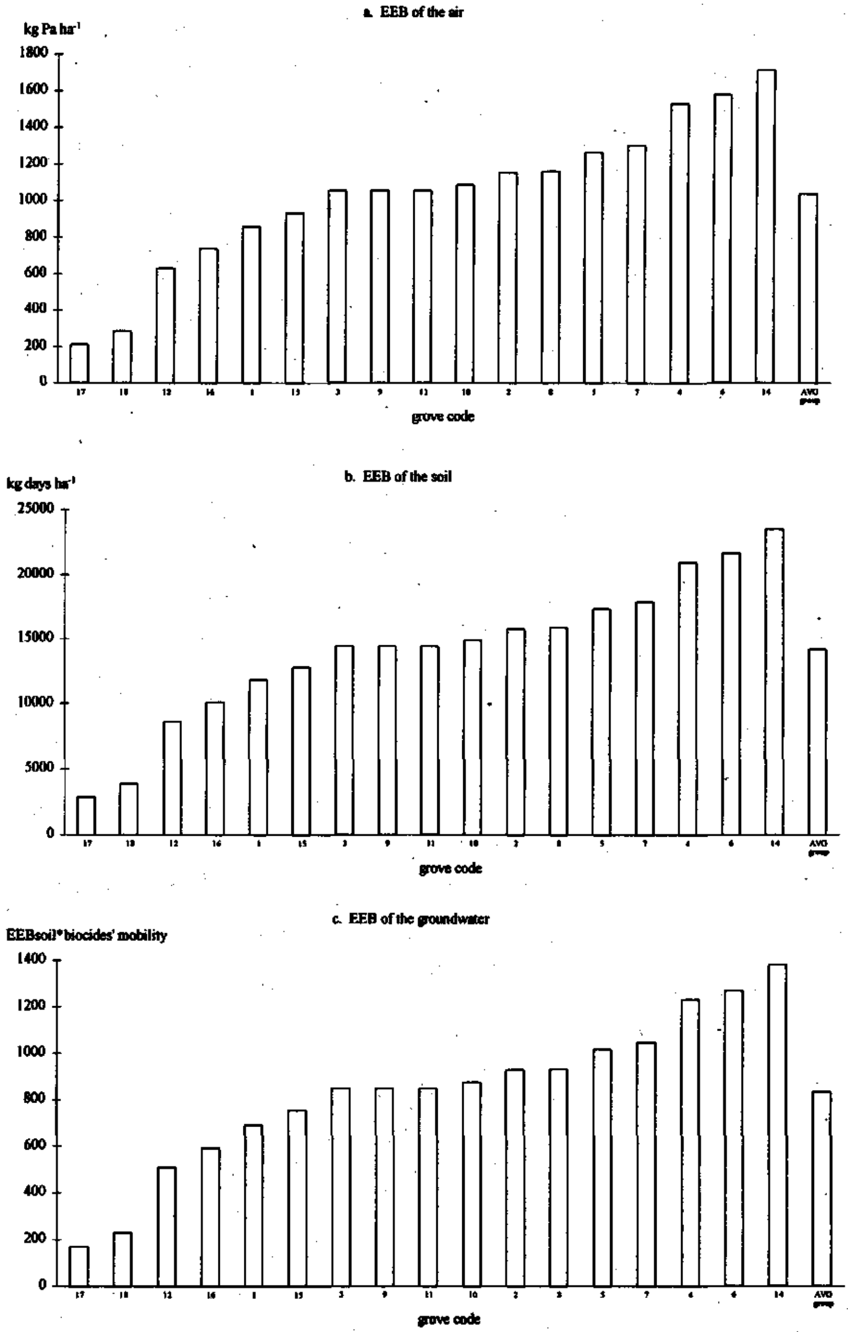


Figure 3.A5. *Environmental Exposure to Biocides (EEB) by pilot grove, mean 1992-1993*

8. IRRIGATION

Irrigation water was used without any scheduling and planning. Irrigation water was used from May until September. Growers irrigated the trees of "*Koroneiki*" variety every 10 days and the trees of "*Throubolia*" variety every 15 days. The applied quantity per irrigation and the total amount of irrigation water was varied accordingly the price of the water. "*Koroneiki*" variety was irrigated with around 1,5-2 m^3 of water per tree per irrigation in the plain (around 5500 -7500 m^3 per hectare per year), where water was cheaper, and around 0,5-1 m^3 of water per tree per irrigation in the hills (around 2000 - 3750 m^3 per hectare per year), where water was more expensive. "*Throubolia*" variety in the hills was irrigated with around 3 m^3 of water per tree per irrigation (around 1200 m^3 per hectare per year).

The Irrigation Index (II) (see Chapter 4.2.12) of the pilot groves before the introduction of the prototypes, based on our observations in the groves and the discussion with the growers, is presented in Figure 4.A5.

9. CONCLUSIONS

Figure 1.A4 - 4.A5 present the initial situation of the pilot groves. In these figures the data collecting at the beginning of the project regarding the conventional management were used to present the situation of the groves. For

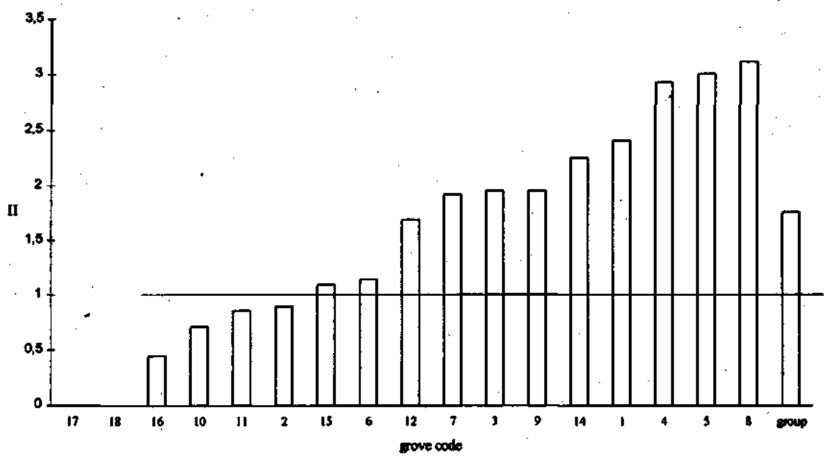


Figure 4.A5. *Irrigation Index (II) by pilot grove, mean 1992-1993*

this presentation the same parameters and desired results, when possible, were used as the ones used to quantify the objectives of the prototypes. Figures 1.A4 - 4.A5 in combination with Figure 20 indicate the differences of conventional and prototype systems regarding agroecosystem management.

Agroecosystem processes were completely ignored during conventional farming of the pilot groves. The only objective was maximum profit through maximum yields. There were not long term objectives and there were not objectives regarding environment, nature and landscape (see Chapter 3 for the objectives of the prototype system).

The results of conventional practices are described in the diagnosis of conventional olive production (Chapter 1.2).

ABOUT THE AUTHOR

Emmanouil Kabourakis was born in 1967, in Iraklion, Crete, Greece and grew up in a farm in Messara plain. He studied plant sciences, with a major in agricultural microbiology, in Agricultural University of Athens where from he obtained the MSc in Agricultural Sciences, in 1991. In 1991 he worked as extensionist, western Messara plain, in charge for plant protection of olive groves. He studied ecological agriculture in Wageningen Agricultural University and he obtained his MSc in Ecological Agriculture in 1993. Since 1993 he facilitates the innovative pilot project for prototyping and disseminating ecological olive production in the Messara. He organised, with the economic support of EU, an agri-environmental visit in the Netherlands in 1994, for ten members of the Cretan Agri-environmental Group. He organised the participation of the foundation Cretan Agri-environmental Group in the first world wide exhibition on organic farming in Denmark, in 1996.