



Sustainable Agriculture

Organized by

Mediterranean Agronomic Institute of Chania

Sustainable Agriculture

Scientific Coordinator: **Dr Ioannis LIVIERATOS**

MAI Coordinator: **Mr Alkinoos NIKOLAIDIS**

Objectives

To introduce the frame of the legal requirements and the methodological approach to certification systems of environmental friendly, sustainable and safe agrofood/production.

To specify the requirements of sustainability within the context of the new Common Agricultural Policy and the application of the quantitative methods for measuring the effect of sustainable production to environment.

To provide the agronomic knowledge of assessing the impact of the biotic and abiotic production inputs to sustainable production systems.

To present modern recycled soilless greenhouse production methods and their application to sustainable horticultural production.

To emphasise on case studies in organic and integrated production management on various horticultural crops.

The program is mainly addressed to graduates of Agricultural Engineering, or other related field.

In the second year, students who have successfully completed the first year develop a thesis based on research work and economic development study leading to a Master's of Science degree. The scientific results of graduate studies are usually announced in International Conferences and/or published in World Renowned Journals.

Part I

Post graduate specialisation program

The programme is organized in 6 sections

Tools ENGLISH, COMPUTERS

The Cycle includes introductory courses on Scientific English and use of Computer.

Section 1 BIOMETRICS

Most plant improvement programs in agricultural research involve experiments in which data are collected on genotype response across environments. Scientists must extract pertinent information from these data to make timely decisions on genotype recommendation, release or selection and on site selection for subsequent trials. The role of biometry in advancing knowledge in experimental design, analysis and interpretation of such data is of direct relevance to the economic viability of most rural industries. This cycle is devoted to the design of field experiments and the investigation of genotype-environment interactions for primary economic plant attributes (yield and quality).

Section 2 INTRODUCTION TO SUSTAINABILITY

This cycle is an introductory overview to sustainability. It is a thorough presentation of the ecological aspects of sustainability, the toxic effects of chemicals to the environment, the agro-environmental indicators and how they are used to measure impact to the environment, analysis of sustainable, organic farming systems and precision agriculture. In the last course of this module, the pertinent legislation used to certify quality assurance is presented.

Section 3 NATURAL RESOURCES MANAGEMENT

This cycle deals with the basic aspects of soil science and water management and how these resources can be used in a sustainable way. Soil properties and processes, soil as related to the environment and soil degradation problems and solutions. The water management course emphasizes on water balance of agricultural lands, agricultural water use efficiency and sustainable on-farm irrigation systems.

Section 4 ASSESSMENT OF GENETIC RESOURCES

Modern agriculture has a significant impact on agrobiodiversity. Equally, loss of biodiversity can have significant impacts on agroecosystems. Ways to measure and manage agrobiodiversity are essential tools of a sustainable agroecosystem. An important element of biodiversity conservation is the seed storage technology in seed banks. This technology requires knowledge on seed biology, seed germination and viability testing. Alternative technologies exist for germplasm that cannot be conserved with seeds such as recent advances in tissue culture and cryopreservation of vegetative material.

Section 5 CROP PROTECTION

This cycle is devoted to plant pest (fungi and bacteria, viruses, insects) and weeds management. Basic principles and techniques of integrated pest and weed management will be presented. Selected biotechnological approaches in crop protection.

Section 6 GREENHOUSE MANAGEMENT

This is a module on greenhouse management and hydroponic structures. The bioclimatology course will focus on energy balance and plant responses to environmental factors, while the crop modeling topic will emphasize on how and why is used as a tool and present several case studies. The second part emphasizes on greenhouse structures, the environment and equipment for climate control. In addition, topics dealing with energy saving technologies and renewable resources will also be covered extensively. The soilless culture course will cover hydroponic systems, their equipment, and water and nutrient management. Finally, disinfection strategies will be also introduced. Complementary to this topic is the subject of how the microclimate can influence crop growth and how the growth pattern can be assessed using computation and modeling.

CASE STUDIES CASE STUDIES ON INTEGRATED AND ORGANIC FARMING SYSTEMS

Case studies focused on the following crops will be presented: olives, grapes, citrus and vegetables. It includes day excursions to organic and integrated farms in combination with the theoretical background of integrated and organic farming systems. No credits will be awarded for this section.

TRAINING SEQUENCE

Tools (4 ECTS) October	ENGLISH, COMPUTERS UNIT 1 – Scientific english (3 ECTS) UNIT 2 – Introductory computing (1 ECTS)
Section 1 (3 ECTS) October	BIOMETRICS Unit 1 – Crop experimentation (3 ECTS)
Section 2 (12 ECTS) November	INTRODUCTION TO SUSTAINABILITY Unit 1 – Agroecosystems and population dynamics (3 ECTS) Unit 2 – Ecotoxicology (3 ECTS) Unit 3 – Agro-environmental impact assessment and farm management (3 ECTS) Unit 4 – Quality assurance and good agriculture practice (3 ECTS)
Section 3 (9 ECTS) December	NATURAL RESOURCES MANAGEMENT Unit 1a – Soil properties and quality assessment (2 ECTS) Unit 1b – Compost technology (1 ECTS) Unit 2 – Nutrient management and soil fertility improvement (3 ECTS) Unit 3 – Optimal water use (3 ECTS)
Section 4 (9 ECTS) January	ASSESSMENT OF GENETIC RESOURCES Unit 1 – Agrobiodiversity (3 ECTS) Unit 2a – Seed production and quality management (2 ECTS) Unit 2b – Plant breeding (1 ECTS) Unit 3 – Biotechnological approaches to plant propagation (3 ECTS)
Section 5 (18 ECTS) February-March	CROP PROTECTION Unit 1 – Plant/Pest interactions and integrated pest management (3 ECTS) Unit 2 – Fungal and bacterial disease management (3 ECTS) Unit 3 – Detection and epidemiology of plant virus diseases (3 ECTS) Unit 4 – Insect management (3 ECTS) Unit 5 – Weed management (3 ECTS) Unit 6 – Biotechnological approaches to crop protection (3 ECTS)
Section 6 (9 ECTS) April-May	GREENHOUSE MANAGEMENT Unit 1 – Crop modeling and bioclimatology (3 ECTS) Unit 2 – Greenhouse technologies and climate control (3 ECTS) Unit 3 – Soilless culture (3 ECTS)
CASE STUDIES June	CASE STUDIES ON INTEGRATED AND ORGANIC FARMING SYSTEMS Case studies in organic and integrated production (olive, vineyard, citrus, vegetables)

Comprehensive oral or written examination (Modalities and dates)

During Introduction, participants attend classes on English TOEFL and Computers. They are also obliged to attend a 45-hour course in Scientific English, equally distributed during Sections, and take a written examination.

Participants take written examinations or submit projects for every unit within one section in the exam week which is scheduled at the end of every section, each unit being independently graded. Written exams consist of a set of questions that require a concise answer. Some of the questions are multiple choices. Lengthy questions are avoided.

Participants have the option of retaking course examinations of their preference equivalent of 9 ECTS credits during a weeklong retake period. There is no retake examination period for the last section.

A comprehensive oral examination conducted by an Examination Board takes place at the end of the academic year, representing 15% of the total grade.

Analytical syllabus

Tools ENGLISH, COMPUTERS

Unit 1 – Scientific english

Note-taking skills in order to better understand lectures; the study of scientific texts and their development; terminology related to the students' chosen field; a review of the fundamentals of English grammar with a view to studying advanced grammar skills for the purposes of writing a M.Sc. thesis; development of academic writing skills; public speaking, communication skills and theme-related discussions based on the students' chosen field of study. The final grade is awarded on the basis of the following:

- examination marks (based on grammar and scientific texts);
- presentation marks (based on oral and written presentations of students' own work);
- participation in classwork and attendance; homework assignments.

Unit 2 – Introductory computing

Computer hardware components, peripherals and controllers; architecture; operating systems. Interacting with computers Data communications and computer networks. The Internet; brief history, protocols, addressing and domain name service (DNS). E-mail, News-Groups, Telnet, Ftp, WWW (World Wide Web). Computer applications; word processing, spread-sheets, data-bases, graphics, scientific software, schedulers. Computer Service

Section 1 BIOMETRICS

Unit 1 – Crop experimentation

Practical experience in devising, executing, analyzing and interpreting experiments designed to answer specific crop production problems. The design of experiments, techniques of the analysis of randomized complete block designs, latin squares, factorial experiments and split-plot designs. Simple and multiple regressions, their use in modeling agricultural responses. Practical work uses the computer packages for statistical analysis of data.

Section 2 INTRODUCTION TO SUSTAINABILITY

Unit 1 – Agro-ecosystems and population dynamics

The need for sustainable agriculture. An agroecological analysis. Concepts of sustainability - Sustainable agriculture systems. Agroecosystems - Populations in agroecosystems. The ecological role of biodiversity in agroecosystems - Agroecosystems diversification. Interaction between agroecosystems and natural ecosystems. Energy in agroecosystems – Emergy. Transition to sustainable food systems.

Unit 2 – Ecotoxicology

Basis of Ecotoxicology: I. Definitions. II. The pollutions. III. Classification of pollutants. IV. Fate of pollutants.

The pesticides: I. The pesticides. II. Physico-chemical aspects of pesticides. III. Pesticide treatments IV. Fate of pesticides in the V. Fate of pesticides in the organisms.

Effects of pesticides: I. Levels of action of pesticides II. Impacts of pesticides on agro- and ecosystems.

Unit 3 – Agro-environmental impact assessment and farm management

Environmental impact of agriculture, grouping environmental impact in different categories, such as "fossil energy and resource consumption", "climate change/global warming potential", "water quality", "soil strain", "eutrophication", "acidification", "human- and ecotoxicity", "biodiversity", "landscape image", "animal welfare", link categories with agri-environmental indicators; the life-cycle-assessment method (ISO 14040); using nutrient budgets at different levels as a farm management and an environmental impact weak point analyses tool; comparing the environmental impact of organic and conventional-integrated farming systems; agri-environmental policies and supporting programs (e.g. "cross compliance" of the EU); linking environmental impacts and productivity of farming systems; choosing the appropriate functional (reference) unit of an environmental impact; allocation, aggregating, ranking and weighting agri-environmental impacts.

Unit 4 – Quality assurance and good agricultural practice

Introduction: Increasing demand that agricultural products fulfill legal requirements, safe to the consumer, meet specifications regarding qualitative characteristics and quantities. Additional considerations include minimising environmental impacts and socially responsible labor practices. To achieve standardisation world wide there have been created Standards which cover primary production, sorting, packing and processing of agricultural products. Operations are then inspected, to ensure compliance with the Standards. Moreover, there have been create national and international initiatives for food safety, legality and quality. Examples include the EU farm to fork, the Global Food Safety Initiative et. al.

Overview of Legislation. Directive 93/43/EEC on food hygiene; Legislation concerning packaging materials; Legislation governing the licensing and use of plant production formulations and fertilisers; Legislation concerning pesticide residues; Codex Alimentarius Commission

Primary Production Standards. Organic Farming, Integrated Crop Management, Good Agricultural Practices; Standards created and recognised by wholesaler and retailer chains and organisations; The main aspects of each Standard will be described. Similarities and differences between them will be highlighted. When applicable (e.g. EUREP-GAP Option II), the links between primary production and sorting, packing and processing will be discussed.

Sorting, Packing and Processing Standards. HACCP and the various relevant Standards; ISO 9001:2000; The BRC (British Retail Consortium) Standard; The IFS (International Food Standard); ISO 22000; The main aspects of each Standard will be described. Similarities and differences between them will be highlighted. When applicable (e.g. EUREP-GAP Option II), the links between primary production and sorting, packing and processing will be discussed. Inspection and Certification Systems. The EN 45004, EN 45011 and EN 45012 Standards for bodies performing Inspections, Product Certification and System Certification, respectively; Accreditation of such Bodies; Product vs. system certification, correlation to the Standards presented in 3 and 4 above; Second and Third Party Audits; The necessary step-s to obtain certification.

Section 3 NATURAL RESOURCES MANAGEMENT

Unit 1a – Soil properties and quality assessment

Soil quality with regards to agriculture, chemical, compound behaviour. Surplus-limiting supplies of nutrients and contaminants, risk assessment protocols, fertilizer recommendations. Soil degradation: problems and solutions (acidification, salinity, erosion, soil conservation). Nutrient flows in soils / Dynamics of nutrients and contaminants: mobility, bioavailability, soil quality assessment / Pathways of nutrient inputs & exports / N, P, K cycles. Outline of the policy legislation.

Unit 1b – Compost technology

Soil Nature of composts - Principles of solid state fermentation - Main factors controlling compost preparation. Compost technology: processing methodologies of agricultural, agro-industrial and urban wastes and by-products – infrastructure required for compost preparation – design of a composting site. Applications of composts and pertinent technologies in agriculture and environment protection: compost as conditioners of agricultural soils – compost and its effects on plant nutrition and productivity – compost suppressiveness against soil-borne plant diseases – use of composts in soil bioremediation, and bio-treatment of agro-industrial wastes and pollutants – compost for erosion control and landscape maintenance.

Unit 2 – Nutrient management and soil fertility improvement

Maintenance of soil's capacity to supply the nutritional needs of plants: Nutrient dynamics in soil and nutrient demand of crops, the problem of synchronization.

Organic matter: Importance of organic matter management; organic matter decomposition models. Overview on organic fertilizers available in different farm types and their effects on soils and crops: Farmyard manure, slurry, liquid manure, manure compost etc. Nutrient losses during manure storage and application, strategies for reducing them; Green manure, legume crops, intercropping etc.; Rock meal and rock phosphate.

Nitrogen input: Nitrogen input to the farm – cultivation of legume crops: Overview on species and types; Factors influencing the nitrogen input; Factors influencing nitrogen (nutrient) losses and strategies for reducing them; Use of legume N in the crop rotation.

Case studies: Tools to achieve sustainable nutrient management. Nutrient management of vegetables, olive trees, vineyard, citrus trees.

Unit 3 – Optimal water use

Introduction: Review of historical evolution of irrigation and drainage, Water resources in the world and water agricultural uses, Water-stressed countries and agriculture, Constraints in agricultural water planning, distribution and management, Examples of non-sustainable water management.

Water balance of agricultural lands: Scales of study, Basics of soil water balance, Basics of crop evapotranspiration, Control of water balance in the root zone, irrigation and drainage. Agricultural Water Use Efficiency: The WUE concept, How to increase WUE? Examples of WUE for some crops and irrigation strategies. Estimation of crop water requirements: Review of existing methods, The Penman-Monteith formula, Concept of crop coefficient Applications. Exercises). Sustainable on-farm irrigation: Irrigation efficiencies, Irrigation scheduling, Irrigation methods, Basics of localized irrigation, Examples of irrigation strategies for saving water. Applications. Exercises Sustainable drainage: Principles of agricultural drainage, Objectives and methods, Some examples of drainage systems.

Section 4 ASSESSMENT OF GENETIC RESOURCES

Unit 1 – Agrobiodiversity

Agro-biodiversity assessment and management

What is agro-biodiversity? Definitions and introduction to the concepts of landraces and crop wild relatives. Introduction to the principles of genetic, taxonomic and ecosystem diversity. Outline of the threats to agro-biodiversity and the need for conservation management. Introduction to the socio-economic aspects of agro-biodiversity conservation management. Outline of legislation in place for agro-biodiversity conservation, with emphasis on the Convention on Biological Diversity (CBD).

Assessing and understanding agro-biodiversity

Introduction to the basic principles of conservation genetics. Outline of methods for assessing and measuring agro-biodiversity at genetic, population, species and ecosystem levels. Brief review of the variety of life forms. Introduction to applied taxonomy and its importance in agro-biodiversity conservation.

Plant genetic resource (PGR) conservation

Overview of the conservation and use of PGR. Selection of target taxa and target regions for conservation. Introduction to plant conservation strategies and techniques, including complementary conservation. Overview of in situ conservation techniques (genetic reserve and on farm). Overview of ex situ conservation techniques, including germplasm collection, seed gene bank storage, field gene banks, botanic gardens, in vitro, DNA and pollen storage. Brief introduction to germplasm characterisation, evaluation and use. Highlight the issues of germplasm health, movement and quarantine. Introduction to participatory plant breeding and community involvement in domesticated species conservation.

Case study: Agro-biodiversity assessment and management in the Palestinian Authority.

Practical: Read handout on genetic engineering and GMOs, preparation of group presentations on the GMO debate.

Field trip to agricultural area. General observation and discussion of agro-biodiversity issues *in situ*. Demonstration and practice in collecting herbarium specimens. Practice in collecting specimen and site data. Introductory practical training in field survey and sampling techniques.

Unit 2a – Seed production and quality management

Seed Biology: Seed anatomy, germination, water relations during germination, seed maturation and dormancy, desiccation tolerance, orthodox and recalcitrant seeds, seeds and biodiversity.

Seed quality: Improvement of seed quality by priming and sorting, different ways of seed storage, influence of storage on seed quality, Seed health, Detection of pathogens on seeds, seed production for organic farming.

Seed testing: Ways on how to address seed quality: measurement of seed germination characteristics, Use of Seed Calculator program to measure germination characteristics, different ways of testing the vigor of seed lots, prediction of the storage life of seeds, use of 'high tech' tests like microarray analysis, proteomics, fluorescence sorting, immuno-fluorescence

Unit 2b – Plant breeding

Seed legislation and policy: Testing for distinctness, uniformity and stability (DUS) in relation to variety registration and protection according to the guidelines of UPOV. Identification of varieties by conventional and novel methodology.

Genetic Resources and Diversity: Origin of natural genetic diversity and its utilization in plant breeding, development of usable genetic variation by classical and biotechnological approaches.

Plant Breeding: Breeding for yield, quality and resistance to biotic and abiotic stresses towards a sustainable Agriculture. Breeding for organic farming.

Unit 3 – Biotechnological approaches to plant propagation

Introductory history, laboratory equipment and requirements, general techniques, composition and preparation of nutrient media. Morphogenesis, organogenesis and embryogenesis. Haploid production (anther and pollen culture), protoplast isolation and culture, somatic hybridization and zygotic embryo rescue. In vitro cloning of various plant species. Somaclonal variation. Thermotherapy, meristem culture and production of virus-free plants. In vitro germplasm storage and cryopreservation.

Section 5 CROP PROTECTION

Unit 1 – Plant/Pest interactions and integrated pest management

Bio-interactions of pests, diseases and hosts: Relationship between predators and prey, parasitoids and hosts, pathogens and hosts, antagonists and hosts. Interactions between injurious and beneficial organisms. Multi-trophic interactions (indirect interactions among organisms from different trophic levels). Semio-chemicals (kairomones, synomones, pheromones).

Disease development and prediction modelling: Disease development: how pathogens attack plants - how plants defend themselves. Relation between injury, damage and loss - possibilities to predict the development of pests, diseases, antagonists and natural enemies.

Disease Resistance: Non host resistance, partial, polygenic, horizontal resistance – monogenic, R gene, vertical resistance, principles of breeding for resistance, "Boom & Bust" cycle.

Integrated Pest Management: Integrated pest management, and more in particular, biological control, genetic control and the new developments in these areas. Effects of cultural control measures (e.g. inter-cropping) on pest and disease development.

Unit 2 – Fungal and bacterial disease management

Alternatives to chemical control: Development of fungicide resistance and evolution of fungicide resistance. Alternatives to methyl bromide usage for the control of soil-borne pathogens. Biodegradable chemicals. Control of fungi and bacterial diseases: Physical, cultural and biological methods that eradicate, avoid or reduce the inoculum. Biological control: Fungal & bacterial antagonists (e.g. soil-borne fungi, soil-born fungi population dynamics). Suppressive soils. Resistance: Successful cases of plant resistance against fungi and bacteria. Case studies: vegetables, olive trees, vineyard, citrus trees.

Unit 3 – Detection and epidemiology of plant virus diseases

Detection of plant viruses and viroids: indicator hosts, cytological effects, serological assays, molecular assays. Transmission and epidemiology of plant viruses and viroids: mechanical, seed, insect, fungal, nematodes, pollen. Control of plant viruses and viroids: plant virus control based on their epidemiological properties, farming practices to avoid-reduce inoculum, physical methods of protection, cross protection, antiviral agents. Virus-free seed production, propagation and maintenance of virus-free plants. Case studies in the Mediterranean area.

Unit 4 – Insect management

Resistance to pesticides: How resistance to pesticides develops in arthropods? Pesticide selectivity. Biological control: Types and methods - Natural enemies - Predators-Parasitoids - Protozoa, Fungi, Nematodes and Viruses as biocontrol against arthropods. Culture and colonization of beneficial arthropods - Population dynamics - Risk assessment of biological control of insects - Products available - Does biological control work in nature and farming practice? Successful cases of biological control in the Mediterranean area (olive, citrus, vegetables, grapevine)

Unit 5 – Weed Management

Factors affecting weed-crop interference. Integrating all available methods (soil and cultivation practices, crop rotation, choice of variety, crop establishment, crop nutrition strategy, and choice of herbicide application) for weed control. Management of weed resistance and aspects of using genetically modified crops with herbicide resistance. Incorporating Weed Management Strategies in the Integrated Pest Management System. How does herbicide resistance develops? When do we need to manage weed populations? Examples of allelopathy for the control of weeds. Rotation schemes to manage weeds. Case studies: vegetables, olive trees, vineyard, citrus trees.

Unit 6 – Biotechnological approaches to crop protection

Genetic engineering and biotechnology. Central dogma of the transfer of genetic information from DNA to RNA to protein. Molecular biology techniques for the identification of nucleic acids and proteins. Milestones in agricultural biotechnology. Practical Molecular Biology Techniques.

A. Pathogenicity and virulence genes in plant pathogens. Gene-for-gene interaction and genetics of resistance through the hypersensitive response. Identification and isolation of avirulent (*avr*) and resistance (R) genes. Characteristics of *avr* gene-coded proteins. Resistance genes in plants: classes and evolution. The guard hypothesis.

B. Signals in plant-microbe interactions. Genetic and pharmacological evidence of the role of salicylic acid (SA), jasmonic acid (JA) and ethylene (ET) in disease resistance. Cross-talk between defense pathway systems. Identification of induced genes. Defense signaling network in *Arabidopsis*.

C. Replication of plant RNA viruses and strategies for genome expression. Resistance sources against plant viruses: a. natural, b. virus itself (PDR), c. various other. Resistance mechanisms to plant viruses using pathogen derived resistance (PDR) (an overview). Post-transcriptional gene silencing (PTGS) and PTGS suppressors.

D. How and what gene to express for resistance against pathogens. Different strategies and promoters used for engineering increased disease resistance in plants.

E. Mode of action of *Bacillus thuringiensis* (*Bt*) crystal proteins. Biological considerations and genetic manipulation of *Bt*. Crystal protein resistance in insects.

F. Approaches to engineer herbicide tolerance: a. modification of the target of the herbicide action, b. detoxification of the herbicide. Strategies to engineer tolerance to glyphosate.

G. Potential direct and indirect impacts of transgenic crops on the environment. Risk quantification. Persistence or invasiveness of crops. Gene flow from crops to related species. Order and elements determining the likelihood and consequences of gene flow. Strategies to delay resistance (resistance management). Methods for the detection of GMOs.

Section 6 GREENHOUSE MANAGEMENT

Unit 1 - Crop modelling and bioclimatology

Bioclimatology:

Energy balance: radiative balance (radiation, spectrum, units, measurements, elementary laws of radiation physics, radiative balance), temperature (units, measurements), conductive heat transfer (mono-directional transfer law, transfer in soil), wind speed (units, measurements), convective heat transfer (definitions around convection and boundary layer, laws of convective fluxes, convective heat flux expressions), air water content (units, expressions, measurements) latent heat transfer (relation to evaporation), determination and use of energy balance, application to greenhouses.

Plant and crop responses to environmental factors: light and radiation (light and development and photosynthesis, optical properties, light extinction in crops, Monteith approach to production estimation), temperature (heat units, Q10, (radiative) frost action), water (definitions of evapotranspiration, potential and actual evapotranspiration, Penman and Penman-Monteith expressions, cropping coefficient definition and use).

General structure of crop models: elementary processes (photosynthesis, temperature effect integration, maintenance respiration), integrated processes (carbon balance, growth, organogenesis and organ ageing, assimilates partitioning, mineral uptake, water uptake), dry matter to leaf area conversion (SLA, LAR).

TOMGRO and TOMSIM, the greenhouse tomato case: details of the function expressions, experimental setup for calibration/validation, input/output data.

A case with soil: soil description, water fluxes, soil module calibration/validation experimental setup, input/output data, connection to the crop model.

Crop modeling in use: agricultural early warning (irrigation vs crop phenological stage prediction and/or potential evaporation, pesticide application vs pest development prediction).

Unit 2 – Greenhouse technologies and climate control

Greenhouse structures: Greenhouse types, cover and construction materials for greenhouses, design norms for greenhouse construction.

Greenhouse environment: Greenhouse energy and mass balances (radiation exchanges, sensible, latent and CO₂ fluxes). Evapotranspiration under cover. Climatic suitability of a region for protected cultivation.

Greenhouse equipment for climate control: Heating of greenhouses (estimation of heating requirements, heating systems, heat distribution networks)

Cooling of greenhouses: Natural Ventilation, Dynamic Ventilation, Fan and pad evaporative cooling system, Fog evaporative cooling system, Shading systems; Climate control systems.

Energy saving technologies: Thermal screens, windbreaks, thermal insulation of the greenhouses. Renewable energies sources (solar, geothermal, biomass) for heating greenhouses.

Emerging technologies for Sustainable Agriculture in greenhouses: Insect proofs, UV absorbing and anti-drop cover materials.

Unit 3 – Soilless culture

Introduction –Terminology

Substrates: Physical properties of substrates (bulk density, particle size distribution, porosity, water release curves, hydraulic conductivity, impact of physical properties on irrigation management in hydroponics). Chemical properties of substrates (pH, ion sorption, ion exchange). Substrate analysis (determination of water soluble and exchangeable nutrients, CEC, AEC, organic matter content, pH, EC). Description of substrates (sand, gravel, rockwool, expanded minerals, pumice, zeolite, pyroclastic materials, peat, coir, tree bark, sawdust, wood fibres).

Hydroponic systems: Systems involving solely water as a substrate (deep water culture, floating hydroponics, NFT, plant plane hydroponics, aeroponics). Systems involving an aggregate as a substrate (bag culture, container culture, trough culture, thin layer systems, various alternative systems).

Equipments in hydroponics: Installations used to prepare and deliver nutrient solution, sensors, equipment for the lay-out of the crop, equipment for irrigation and nutrient solution recycling.

Water and nutrient management in hydroponics: Irrigation control in hydroponics. Composition of nutrient solution, Effects of pH, EC and nutrient ratios on plant growth, yield and quality. Calculation of nutrient solutions for open systems. Management of nutrient solution in open systems. Introduction to nutrient solution recycling. Methods of nutrient solution recycling. Calculation of nutrient solutions for closed systems: concept of drainage solution plus fresh water, concept of uptake concentrations or uptake ratios.

Disinfection in hydroponics: Nutrient solution disinfection (heating, UV-irradiation, chemical treatments by means of ozone, hydrogen peroxide, chlorine, iodine, etc., membrane filtration, slow sand filtration). Disinfection of substrates (steaming, solarization, chemical sterilization, other techniques).

Hydroponics, product quality and integrated crop management in greenhouses.

CASE STUDIES

CASE STUDIES ON INTEGRATED AND ORGANIC FARMING SYSTEMS

Case studies in organic and integrated production (olive, vineyard, citrus, vegetable, cotton)

Part II

Masters of Science Program

Research Project (9 month duration)

Requirement : 60 ECTS credits

Laboratory techniques (Related to the subject of the Master Thesis)

Research Subject Areas:

(topics generally available for Master of Science thesis):

- Plant nutrition and hydroponics
- Greenhouse management
- Soil fertility and plant production
- Plant protection in horticultural crops
- Post-harvest quality of agro products
- Compost technology
- Plant virus detection & replication

INDICATIVE MASTER THESIS REALIZED WITHIN THE AREA

Title: Alternative Methods for Quality Preservation and Decay Control Caused by Botrytis Cinerea and Alternaria Alternata of Sweet Red Pepper (Capsicum Annum cv. Florinis), (2003)

Author: Semida Wael, Agronomist, Egyptian

Place of realization: Aristotle University of Thessaloniki, Greece

Thesis director: Evangelos Sfakiotakis

Title: Biodiversity of Soil-Dwelling Arthropods within an Organic, a Conventional and an Abandoned Olive Agro-Ecosystem on the Island of Crete, (2003)

Author: Issa Chahine, Lebanese

Place of realization: Agricultural Research Center of Heraklion, Greece

Thesis director: Emmaouil Kambourakis, Agricultural Research Center of Heraklion, Greece

Title: Impact of Conventional and Organic Management on the Nutritional Status and Economic Performance of Olive Orchards in Crete (2002)

Author: Efriyam Krishkov, Bulgarian

Place of realization: MAICH, Greece

Thesis director: Ioannis Metzidakis, Institute of Subtropical Crops and Olive Tree, Greece

Title: Emergy Analysis of Organic and Conventional Production of Olive and Olive Oil in Crete, Greece (2001)

Author: Dalia Khalaf, Egyptian

Place of realization: MAICH, Greece

Thesis director: Evangelos Sfakiotakis, Aristotle University of Thessaloniki, Greece

Title: Old And Endangered Organically Cultivated Greenhouse Tomatoes. Effect Of The Harvest Time On The Flavour Ingredients And Consumer Acceptance (2005)

Author: Vasilios Gkisakis, Greek

Place of realization: MAICH, Greece

Thesis director: Ulrich Koepke, IOL (Univ. Bonn), Germany and A. Krumbein, Inst. F. Zierpflanzen, Germany

Title: Reverse Transcription-Polymerase Chain Reaction (Rt-Pcr) Amplification, Cloning Expression And Purification Of Cucurbit Yellowing Stunting Disorder Virus (Cysdv) P22 And P25 Proteins (2007)

Author: Eleftheria Stavridou, Greek

Place of realization: MAICH, Greece

Thesis director: Ioannis Livieratos, MAICH, Greece

Title: Reverse Transcription-Polymerase Chain Reaction (Rt-Pcr) Amplification, Cloning Expression And Purification Of Cucurbit Yellowing Stunting Disorder Virus (Cysdv) P22 And P25 Proteins (2007)

Author: Eleftheria Stavridou, Greek

Place of realization: MAICH, Greece

Thesis director: Ioannis Livieratos, MAICH, Greece

Title: Reverse Transcription-Polymerase Chain Reaction (Rt-Pcr) Amplification, Cloning Expression And Purification of Tomatoe Chorois Virus P22 Protein (2007)

Author: Farhan Khaled, Jordanian

Place of realization: MAICH, Greece

Thesis director: Ioannis Livieratos, MAICH, Greece

Title: A Yeast Two-Hybrid System Approach To Identify Tomato Proteins Interacting With Pepino Mosaic Virus (Pepmv) Proteins (2007)

Author: Rita Veiga, Portugese

Place of realization: MAICH, Greece

Thesis director: Ioannis Livieratos, MAICH, Greece

REFERENCES OF THE MAIN ACADEMIC STAFF TEACHING WITHIN THE M.SC.

More than 25 invited lecturers from about 4 countries participate in each edition of the M.Sc. programme of which, 40% came from Research Centres, 60% from Higher Education Institutions.

GREECE

Higher Education Institutions

- E. Tjamos, D. Savvas, E. Paplomatas, G. Skarakis, Agricultural University of Athens
- K. Kittas, I. Tsitsipis, University of Thessaly
- N. Katis, A. Economou, V. Keramidas, I. Eleftherochorinos, Aristotle University of Thessaloniki
- E. Kapetanakis, Professor, Technical Educational Institute of Crete, Heraklion
- G. Markakis, Professor, Technical Educational Institute of Crete, Heraklion

Research Centres

- I. Vlachoiannis, IDS Institute, Athens
- E. Kambourakis, NAGREF, Heraklion
- G. Zervakis, NAGREF, Kalamata
- I. Livieratos, MAICh, Chania

GERMANY

Higher Education Institutions

- G. Haas, Institute for Organic Agriculture, University of Bonn
- U. Koepke, Institute for Organic Agriculture, University of Bonn

THE NETHERLANDS

Higher Education Institutions

- W. Ligterink, Laboratory of Plant Physiology, Wageningen Agriculture University

FRANCE

Research Center

- M. Tchamitchian, Horticultural Cropping Systems, INRA, Avignon
- L. Belzunces, Environmental Toxicology, INRA, Avignon

GREAT BRITAIN

Higher Education Institutions

- C. Correira, Agrobiodiversity, University of Birmingham

SPAIN

Research Center

- A. Baille, ETSIA, Dept. of Food Engin. & Agric. Equipment