

Detailed description of the courses M2

Sustainable intensification of agricultural systems offered at University of Catania (Italy)

Common core (obligatory courses): 18 credits

Sustainable management of cropping systems	6
Sustainable management of animal production systems	6
Interdisciplinary field and laboratory activities	6

Subspecialisation: 12 credits (chosen by the students within thematic clusters of optional courses)

Thematic cluster 1: Horticulture and climate change	Mediterranean fruit tree crops	6
	Protected cultivation	6
	Sustainable pest management	6
	Applied environmental plant pathology	6
Thematic cluster 2: Land, soil and water management in a context of climate change	Natural treatment systems and use of reclaimed water	6
	GIS and remote sensing	6
	Restoration of degraded areas to green	6
	Soil conservation and control of desertification	6
Thematic cluster 3: Climate change and environmental policy	Environmental policy and biotechnology	6
	Economic valuation of environment and landscape	6

Master thesis: 30 credits

Detailed description of the courses

Obligatory courses

Sustainable management of cropping systems (6 ECTS)

Training objectives: Provide knowledge for the rational management of the soil in a climate change perspective, with regard to soil conservation, maintenance of fertility, improving of crop yields and acquire knowledge for a sustainable crop management. All these aspects will respect public health, plant health, animal welfare, non-renewable resources in order to respond to the needs of markets and community.

Contents: In the framework of the global warming and climate change, the following topics will be addressed: agro-meteorology, climate indices and meteorological services, soil degradation, erosion and its control, conservation tillage, sustainable agriculture, organic and biodynamic farming, weed management, crop physiology, simulation models, nutrient sources, fertilization and irrigation plans, compost and composting techniques, phytoremediation, bioenergy systems, agricultural biotechnology. All these aspects will be studied in a climate change context in order to investigate adaptation strategies to help producers better manage the risks associated with more variable and drier cropping seasons.

Pedagogical methods: Frontal lectures with particular insights to the results of scientific researches through the use of visual aids. Moreover will be encouraged the student's abilities to work as a team and their capacity to teach strengthening their speaking and communication skills.

Sustainable management of animal production systems (6 ECTS)

Training objectives: The course will be aimed at studying sustainable management of animal production systems focusing on ruminant feeding strategies such as: improving local pasture grazing and generally the use of forages also as hay or silage; improving the use of high fibre crop agroindustrial residues in replacement of cereal grains in order to reduce grains feeding competition between humans and animals, particularly in developing countries, and the environmental impact of residues waste management; using local legume seeds as protein supplement to reduce import of soybean and to improve organic livestock production systems coupled with maintaining soil fertility.

The course will improve the knowledge on the nutritional characteristics of feeding sources and on their management to avoid negative effects on animal performance and products quality (% of dietary inclusion, pasture management, secondary compounds characterization). Furthermore, the course will provide a scenario of organic livestock production systems and their effects on quality products and of some feeding strategies (tannin-rich plants feeding) to reduce greenhouse gases (GHG) emissions by ruminants and to cope with climate change.

Contents: Pasture management of small ruminants in Mediterranean areas (intake, herbage selection, pasture management, stocking rate); local legume seeds and agroindustrial residues (citrus pulp, carob pulp, olive cake, and others) nutritional characterization (proximate, fatty acid composition, secondary compounds, micronutrients) and their using in dietary formulation; effect

of using alternative feedstuffs and agroindustrial residues on product quality. Traceability of animal feeding systems. Feeding strategies to reduce GHG emissions in ruminants.

Pedagogical methods: The course will be shared between lectures and applied sessions (practical training and field study; LAB activities). The goal of practical training will be to estimate pasture intake according to animal requirements and pasture characterization; to characterize local feedstuffs and agroindustrial residues with an emphasis on their secondary compounds and fatty acids content measured according to LAB analytical procedures. Analysing product quality characteristics as affected by feeding strategies above mentioned. Moreover, students will experience technical farm visits in order to implement their theoretical knowledge through an interaction with farmers or agroindustrial and feedstuffs factories

Interdisciplinary field and laboratory activities (6 ECTS)

Training objectives: The course, aiming at describing some aspects of climatic change effects on agricultural processes, is designed with a multidisciplinary and an interdisciplinary approach to cope with the complexity of agricultural sector and to respond to the stakeholders demands in terms of methods and techniques. It also aims at evaluating the impact that humans have on our ecosystems, and to search solutions for future issues. All these strategies are adopted to improve the student awareness on climate change and boost their performance and speculative investigation.

Contents: Relationship between abiotic and biotic stresses and climatic change. Morphological, physiological and biochemical modifications determined by climatic change in vegetables and in animals. Supply chain of products and environmental implications. Strategies to improve the sustainability of agricultural processes. Demands from stakeholders.

Pedagogical methods: Seminars, workshops and interactive lessons; focus group; SWOT analysis; practical laboratory and field exercises. Evaluation method: progress tests, written examination and presentation on specific topics.

Optional courses

Mediterranean fruit tree crops (6 ECTS)

Training objectives: Supply technical and scientific knowledge for a suitable and fruitful management of citrus, olive and grape crops. Students will be able to tackle and solve problems concerning choose of varieties and field management, adopting solutions suitable for specific conditions. Special attention will be paid to environmental condition constrains for the considered species as determined also by climatic changes.

Contents: Citriculture: 1. Citrus taxonomy, origin and diffusion; 2. Ecology, crop adaptation to different climatic conditions, morphology and physiology; 3. Varieties of the main citrus species; rootstocks; 4. Genetic improvement; 5. Propagation and cultivation techniques. Oliviculture: 1. Botany, diffusion; 2. Ecological and climatic requirements, organography and physiology; 3. Varieties; 4. Pruning and management; 5. Quality and product use. Viticulture: 1. Origin, diffusion and distribution of the crop; 2. Botany, organography and ampelography; 3. Ecology and physiology of the crop and its behavior in different climatic conditions; 4. Propagation and

planting: choice of rootstocks and varieties for wine and table grape; 5. Training systems, pruning and cultivation techniques

Pedagogical methods: The course is articulated in lectures and applied sessions (practical laboratory training and field study). Evaluation is performed through a final oral examination.

Protected cultivation (6 ECTS)

Training objectives: The course is aimed at training specialists capable to analyse problems and evaluate possible options to get production from crops produced under modified micro-climatic conditions. These figures will be able to put into practice the skills acquired with the purpose of planning and management of production processes through the use of appropriate protective equipment and suitable production techniques.

Contents: The protected cultivation in the world: general and historical figures, diffusion and economic importance. Presupposition and objectives of protected cultivations - biological: the needs of the crops; environmental: the climate and its variations; agronomic: quantity and quality of production, stability of yields. The microclimate under protected cultivation and its effects on crop response. Classification, agronomic meaning and management of mean, techniques and structures of protection. Choice of species and cultivars. Production scheduling. The most significant aspects of the agronomic technique under protected environment: soil preparation and interventions to change its characteristics; plant pruning and training; plant growth regulators; growing media; soilless cultivation. Specific aspects on the cultivation of the main greenhouse crops.

Pedagogical methods: The course will be articulated into: lectures, interactive training also aimed at facing with specific climatic and/or agronomical conditions, practical activity in the lab and in the field.

Sustainable pest management (6 ECTS)

Training objectives: Provide information on harmful arthropods and other pests in agricultural crops, forest ecosystems, green areas, parks and natural environments, in order to manage their population density and implement appropriate control strategies of their infestations, with special emphasis to problems deriving by invasive exotic species and their increasing importance in a context of climate change, as well as to planning plant protection and environmental restoration approaches taking into account local resources and operational factors in compliance with phytosanitary regulations.

Contents: Main pests in agricultural and forest ecosystems and in green areas: their biology and ecological requirements. Climate change and invasive pest species. Sustainable and low environmental impact control of pests in natural and cultivated ecosystems. Basic phytosanitary concepts to maintain ecological stability while designing green areas or cultivated lands. Impact of climate change on plant pests in temperate areas, with special reference to Mediterranean basin: the case studies of ornamental and forest plants.

Pedagogical methods: Lectures, supplemented by practical laboratory and field exercises. Evaluation through progress tests and a final oral examination. Team work spirit and communication skills will be stressed through the allocation of specific themes on which working groups, in the form of seminars, must be set up.

Applied environmental plant pathology (6 ECTS)

Training objectives: The main objective is to provide theoretical knowledge and skillfulness to diagnose biotic and abiotic plant diseases and evaluate their impact in agricultural and forestry ecosystems, green areas and parks as well as on landscape. Among abiotic causal agents of diseases, particular emphasis will be given to environmental pollution and climate changes. The course will provide the basic knowledge to plan sustainable disease management strategies, including bioremediation, in order to mitigate the effect of these disturbance factors. A brief outline on phytosanitary legislation will be supplied.

Contents: 1. Plants and pollution. 1.1 phytotoxic effects of polluting substances. 1.2 biological monitoring. 2. Impact of climate changes on plant diseases in the Mediterranean basin. 2.1 The Mediterranean region and the Mediterranean climate. 2.2 Olive diseases: a case study. 3. Bioremediation. 3.1 Fungi as a tool to detoxify soil and water. 3.2 Multitrophic interaction (plants, beneficial organisms and pathogens): *Trichoderma*, a case study. 4. Wood and root diseases and tree stability. 4.1 Diagnostic methods. 4.2 Public security: a case study.

Pedagogical methods: Lectures and interactive lessons with students; knowledge of prerequisites will be evaluated during classes and supplementary topics will be addressed to fill any gaps; progress tests will be scheduled to assess the learning level of students. Prerequisite: knowledge of morphology and physiology of plants, systematic botany of plants, biochemistry and general plant pathology. Evaluation method: progress tests, written examination and a power point presentation on a specific topic.

Natural treatment systems and use of reclaimed water (6 ECTS)

Training objectives: The main aim of the course will be the study of treatment technologies for urban and agro industrial wastewaters, mainly addressed to increase the resilience of rural areas to water stress due to climate changes by the use of reclaimed waters for agriculture and environment issues. The course provides criteria for the design and management of natural treatment systems (constructed wetlands, biological ponds, wastewater reservoirs) to promote the use of reclaimed water as means to increase water availability in areas affected by water stress. Furthermore, the course will deal with the main European legislation framework on treatment and reuse and with problems related to use of reclaimed water irrigation on soil, crops, equipment.

Contents: Wastewater characteristics and origin; decentralized wastewater treatment systems vs centralized systems; basics on design of wastewater treatment systems; design and management of treatment systems (constructed wetlands, biological ponds, wastewater reservoirs). Legislation on wastewater treatment and reuse. Effects of wastewater irrigation on soil, crops and irrigation equipment. Code of good practices for wastewater reuse for agriculture. Case-studies of wastewater reuse for agriculture and environmental issues.

Pedagogical methods: The course is articulated in lectures and applied sessions (practical training and field study). The aim of practical training is the gradual learning of the theoretical material by means of solving concrete problems on treatment and use of reclaimed water (making drafts, sketches and schemes, using appropriate techniques for calculations, etc.) Field study will develop the skills of implementing student theoretical knowledge on the design of a

natural treatment systems for a small settlements (such as: urban community, touristic resort, agro-industrial company, etc.).

GIS and remote sensing (6 ECTS)

Training objectives: The main objective of the course is to provide expertise for the development of professional and disciplinary skills in new technologies for the analysis of agricultural land and the environment, by means of concepts, methods and tools for the modern management of spatial information. To this aim theoretical knowledge related to Geographic Information Systems and knowledge needed to extract environmental information from remote sensing images to be used in Geographic Information Systems will be provided. The course will also provide basic knowledge on the use of GIS software (e.g., ArcGIS from ESRI, QGIS) for the management of geographic data in vector and raster formats, the performance of spatial analysis as well as data thematic representation and print.

Contents: 1. Introduction to GIS: definitions, components, functions. 1.1 Devices and file types in GIS. 1.2 The data and data sources in GIS. 1.3 The scale in GIS. 1.4 Georeferencing concepts. 1.5 The data model. 1.6 The concept of topology. 1.7 The DBMS. 2. The analysis of the data. 2.1 Spatial analysis and analysis based on attributes. 2.2. The thematic representation. 3. Practice using a GIS software: file management commands, commands to change settings, control data management, and attributes; management commands operations on the data, commands related to data analysis, controls related to thematic classifications of data, display commands, thematic data, commands related to printing data. 4. Remote sensing: concepts, principles and definitions; 4.1 Energy interactions in the atmosphere; 4.2 Multispectral, thermal, and hyperspectral sensing; 4.3. Sensors and satellites; 5. Introduction to visual interpretation and digital image interpretation and analysis related to agricultural land.

Pedagogical methods: The course involves lectures and applied activities. In lectures GIS concepts and tools are illustrated and linked with Remote sensing concepts and analyses. Applied activities include the guided use of the GIS software based on tutorials and case studies, with aim of using methods to collect, organize, analyze, and present spatial data.

The assessment methods will involve oral examinations, use of GIS software, and multiple choice tests. The following learning materials are provided: lecture notes and recommended reading, software tutorials and case studies related to agricultural land.

Restoration of degraded areas to green (6 ECTS)

Training objectives: Provide the necessary knowledge to restoration of degraded areas in view to establish new “landscape design” in Mediterranean” region. Analysis will consider: the causes of landscape degradation, the biological characteristics of the Mediterranean crops and wild species and the sustainable growing methods and techniques in view to restore degraded areas finalizing their environmental roles. Several degraded areas typologies will be analyzed in view to individuate technical solution to rehabilitate them by the choice of the wild species in relation to their functional traits and of the sustainable techniques to use for establishing and for maintaining along the time the new green areas and the landscape design in Mediterranean region.

Contents: Analysis of the characteristics of several typologies of degraded sites and of the influences that some sub-optimal conditions (salt and water stress, soil-water-air pollution and related pollutants, marginal pedoclimatic conditions, etc..) can affect plant performances and floral/crop associations during the time. Deepening on the plant bio-morphological traits of the main wild species diffused in the Mediterranean region and on their floral association and on functional crops of interest for restoring degraded areas with sustainable methods and techniques.

Pedagogical methods: Lectures and applied activities on some cases of study in field and in laboratory. Assessment by oral examination and preparation of a power point presentation on the individual case of study agreed.

Soil conservation and control of desertification (6 ECTS)

Training objectives: The aims of this course are to enable students: 1) to understand the principle of climate change impacts on Agriculture 2) evaluate changes and trends in crop production systems; 3) adopt appropriate agronomic strategies for soil fertility conservation and agro ecosystems adaptation maintain crop yields with a special focus on Mediterranean agro-ecosystems conditions.

Contents: Brief outline on climate change and characteristics of the Mediterranean climate; Agricultural and agro-ecosystems principles and basic concepts; agronomic concept of soil fertility. Role and protective functions of organic matter, herbaceous crops and soil microorganisms for soil conservation. Factors affecting the phenomenon of loss of soil fertility: erosion, compaction, salinization, sodification; indicators of the desertification process. *General mitigation measures:* conservation agriculture (CA); Cropping patterns accompanied by organic soil management: cover crops, intercrops, polycultures, improved fallows; water management practices for agriculture: use of poor quality water for irrigation and water conservation/harvesting (collection of runoff); enhancement of agrobiodiversity, analysis of agricultural case-studies and a brief outline on elements of agroforestry.

Pedagogical methods: The achievement of learning objectives will be pursued through lectures, seminars, tutorials, and possible field trips. The lectures and seminars will be presented through the use of slides and documents, which will be made available to the students. To evaluate attainment of course goals, students' learning and performance will be assessed through progress tests and a final test. Teamwork spirit and communication skills will be stressed through assessing specific group work.

Environmental policy and biotechnology (6 ECTS)

Training objectives: The course is designed to give participants a thorough grounding in relevant regulatory aspects and policies of agricultural biotechnology products. It covers a number of issues related to agricultural biotechnology associated with biodiversity, environment, and human health.

Contents: 1.Biotechnology impacts on agriculture and social acceptance; 1.2.UE regulatory framework and international agreements for biodiversity protection;1.3. environmental policies and sustainability. 2.Use of biotechnology in agriculture and genetically modified organisms (GMO): 2.1.regulation of biotechnology in Europe and in the United States; 2.2.trans-atlantic

differences; 2.3. multilateral trade agreements; 2.4. multilateral disputes over the regulation of GMO; 2.4 negotiation and harmonization of GMO regulation. 3. Relationship between science and technology: 3.1. knowledge transfer and dissemination, 3.2. public policies and innovation, 3.3. merchantability and protection of intellectual property rights.

Pedagogical methods: Lectures and tutorial. Assessment through oral examination.

Economic valuation of environment and landscape (6 ECTS)

Training objectives: The goal is to prepare students to conduct valuation studies, analyze the data, and to expose students to the literature on non-market valuation.

Contents: Reasons to value environmental resources. The natural capital as a capital asset. Principles of welfare economics. The Total Economic Value paradigm. General overview of economic valuation methods. Valuation methods based on revealed preferences: the travel cost method (single sites and multiple sites approaches). The hedonic price method. The defensive behavior and damage cost method. Valuation methods based on stated preferences: contingent valuation and choice experiments. Combining revealed and stated preference methods. Secondary methods: the benefit transfer method. Natural Resource Damage Assessment and Equivalence Analysis. Discussion and analysis of selected non-market valuation case-studies.

Pedagogical methods: The class will be conducted mostly in a discussion format. In-class-midterm written exam, and final oral examination.