CIHEAM
BARI

MASTER in

Innovative approaches and technologies for an IPM of Mediterranean fruit and vegetable crops

Academic Year 2022-2023

DESCRIPTION

The Master course aims at training a new generation of motivated students towards professional and academic careers that could promote integrated pest management (IPM) strategies for a sustainable intensification of tree and vegetable crops in the Mediterranean agroecosystems. The course deals with the management of plant pests and diseases with a focus on agroecological and food systems. Students will learn about the ecological and epidemiological traits of pests and pathogens, and how to apply innovative and smart technologies for diagnosis, monitoring and management of plant diseases. The course will launch innovative IPM strategies to cope with pests and diseases affecting the most important Mediterranean fruit and vegetable crops. In addition, risks connected to emerging transboundary pests and diseases will be highlighted and quarantine measures to prevent their introduction and possible establishment will be analysed.

At the end of the course, students will know how to:

- ✓ Analyse and build agroecosystems for a sustainable management of pests and diseases;
- ✓ Evaluate products for pests and diseases control and their relevant regulations;
- ✓ Develop tools for a rapid and timely identification, diagnosis and monitoring of pathogens and pests;
- ✓ Solve farm-related problems, using biodiversity policy, resistant cultivars, graft combination choices, rational application of pesticides and biological control methods;
- ✓ Plan and implement IPM strategies in different ecosystems;
- ✓ Exploit and apply preventive measures, i.e., plant quarantine measures and certification programmes for the control of important plant pests and diseases.

The program is organized in 8 Units and a Project, awarding a total of 60 credits (see details in the table below).

Units	Credits	Dates
Unit I - Sustainability and resilience in agriculture and food systems	6	03-28 Oct 2022
Unit II – Regulations, Guidelines and Tools for an IPM Implementation	6	7Nov- 2 Dic 2022
Unit III – Conventional and Advanced Control Strategies of Pests and Diseases	6	5 Dic -13 Jan 2023
Unit IV – Virus & Virus-like Diseases of Fruit Tree & Vegetable Crops	8	16 Jan- 17Feb 2023
Unit V – Bacterial & Fungal Diseases of Fruit & Vegetable Crops	8	20 Feb – 27 Mar 2023
Unit VI – Pests of Fruit Tree and Vegetable Crops	8	28 Mar-28 Apr 2023

Unit VII– Sustainable Post-harvest Control Strategies & Regulations	3	2 -19 May 2023
Unit VIII- Conventional Approaches & Smart Tools for the Monitoring & Surveillance of Plant Pests & Diseases	4	22 May - 12 Jun 2023
Project	11	16Feb- 16Jun 2023

UNIT I: Sustainability and Resilience in Agriculture and Food Systems

Food systems encompass all the elements (environment, people, inputs, infrastructures, institutions, etc.) and activities relating to production (cf. agriculture), processing, distribution, and consumption of food. They include the supply side and consumption elements as well as the food environment that shapes food access.

Over the last decades, food systems have been central in the debate on sustainable development (cf. Sustainable Development Goals - SDGs). Indeed, food systems are under an unprecedented confluence of pressures and lie at the centre of a global nexus of environmental, social and economic problems, as humanity faces the challenge of achieving sustainable food security confronted with ecosystem degradation and biodiversity loss, resource scarcity, human population growth, and climate change. Moreover, the COVID-19 pandemic has revealed the vulnerabilities and highlighted the flaws of the current food systems as well as the need to improve their resilience and sustainability.

On the one hand, food systems are among the main contributors to sustainability challenges such as land degradation, climate change, biodiversity loss, etc. On the other hand, they are dramatically affected by these challenges facing humanity. Moreover, the dysfunction of modern food systems is a major cause of several societal issues such as food insecurity and malnutrition, rural poverty and livelihoods vulnerability, social inequality. This has climaxed in different calls for the transformation of food systems and their transition towards more sustainability and resilience. Transition to sustainable and resilient agri-food systems is the objective of many policies, strategies and initiatives. While some initiatives focus on single stages of the food chain (e.g., sustainable agriculture, sustainable diets), others are more systemic and holistic (e.g., short food supply chains, alternative food networks). Food-related challenges are particularly pressing in the Mediterranean, where there is an urgent need for action.

AIMS

- Explain the concepts of sustainability, sustainable development and resilience, and the way of applying them to agriculture and food systems (cf. sustainable agriculture, sustainable diets, sustainable food systems);
- Explore environmental, social, economic, and health-nutritional challenges affecting the sustainability of agriculture and food in the Mediterranean area and worldwide;
- Introduce examples of sustainability assessment approaches and show how they have been used in agriculture and food systems;
- Present policies, strategies, and initiatives to foster transition towards sustainability in agriculture and food systems in the Mediterranean, European Union and worldwide.

LEARNING OUTCOMES

By the end of the teaching unit, students will be able to:

- ✓ Understand the concepts of sustainability, sustainable development and resilience, and apply them to agriculture and food systems;
- ✓ Explain sustainability challenges regarding agriculture and food in the Mediterranean area and worldwide;
- ✓ Know how sustainability assessment approaches are used in agriculture and food systems with practical examples.

UNIT II: Regulations, Guidelines and Tools for an IPM Implementation

Global trade associated with the movement of goods and people increases the risk of introducing harmful organisms into new areas. These organisms, whether aliens or not, may become invasive and more harmful in evolutionary adaptation mechanisms in new host plants, in a favourable climate change context, and in the absence of adequate defence strategies.

The introduction and spread of these harmful organisms in newly cultivated areas may seriously compromise food security and safety, leading to severe economic, environmental, and social consequences on affected territories. These plant health crises, favoured by erroneous or weak management, and control strategies, can be avoided by implementing preventive control strategies and\or quarantine measures. The strengthening of preventive control strategies, i.e., the application of good agriculture practices, and the use of healthy certified plant propagating material, would greatly contribute to limiting the occurrence of plant pathogens/pests and possible pandemics, whilst increasing the security level of regions.

In this context, a successful integrated pest management (IPM) strategy is of key importance for the sustainable cultivation of fruit and vegetable cropping, However, the adoption of this approach needs strong and developed institutional and political frameworks and farmers.

This unit will provide basic tools to understand the IPM decision-making process and how to elaborate an IPM program to control economically important pests affecting the main Mediterranean fruit tree and vegetable crops, in accordance with the EU guidelines and regulations, finally learn how to incorporate IPM concepts and methods into a structural pest control business.

AIMS

- ❖ Provide basic knowledge on how to design and elaborate an IPM program to control economically important pests.
- ❖ Explain agroecosystem functioning.
- ❖ Examine the agroecosystems' complexities and challenges.
- ❖ Provide knowledge on the principles and strategies governing the international phytosanitary measures (ISPM) and quarantine systems (QS).
- ❖ Analyse and discuss the current quarantine legislation in the European Union.
- ❖ Provide concepts on the certification programs to produce healthy plant propagating material as the main pest prevention measure.

- ❖ Emphasise the importance of potential invasive harmful organisms for the Euro-Mediterranean area and plan possible countermeasures.

LEARNING OUTCOMES

At the end of this unit, students will be able to:

- ✓ Become knowledgeable about ecosystem functioning, principles of agroecology and related practices.
- ✓ Understand the basic principles and international agreements regulating trade between countries.
- ✓ Identify appropriate IPM strategies for preventing the introduction and spread of harmful and invasive pests in new areas.
- ✓ Assess pest threats in a new area through the elaboration of a Pest Risk Analysis (PRA) and propose an appropriate contingency plan.
- ✓ Intersect between scientific, legislative, and phytosanitary service activities for effective pests control strategies.
- ✓ Apply multidisciplinary approaches for implementing innovative sustainable IPM strategies for Mediterranean fruit tree and vegetable crops.

UNIT III: – Conventional and Advanced Control Strategies of Pests and Diseases

A wide number of pests can seriously affect fruit tree and vegetable crops in the field. As such, effective prevention, or control strategies to be applied all through the production chain is of paramount importance to reduce food losses that might have serious economic and nutritional consequences in producing countries. Although several conventional pesticides are available on the market; however, their over-reliance and improper use might have a negative impact on beneficial organisms and environment. Therefore, it is fundamental to increase knowledge in the sustainable use of conventional means and the chance of integrating safe alternatives as biocontrol agents, generally recognised as safe (GRAS) compounds, resistance inducers, etc. This strategy could count also on the use of plant genetic resources (*e.g.,* selecting resistant varieties), as well as on forecasting models for timely application of the control means, avoiding unneeded use and increasing the chance of success.

AIMS

- ❖ Exploring forecasting modelling as a tool for a more timely, proper, and successful use of control means.
- ❖ Reporting the most updated knowledge and regulations for a sustainable use of conventional pesticides.

- Researching possible alternatives to replace or integrate conventional control of pests by biocontrol agents, eco-friendly compounds, host genetic resistance, as well as specific inducers.
- Targeting for a product that is not only of high quality and very marketable, but also safe for consumers.

LEARNING OUTCOMES

At the end of this unit, students will be able to:

- ✓ Address basic principles of sustainable use of conventional control means to pests and pathogens in the field, thanks to a timely application by forecasting modelling and integration/replacement by biocontrol agents and eco-friendly compound.
- ✓ Broaden the current knowledge base pertaining to the resistance sources available in host germplasm and to the exploitation of similar mechanisms for their applications in protecting crops.

Implement the acquired theoretical knowledge into every-day practice with the aid of site/field visits and laboratory activities, as well as the elaboration of projects to address relevant issues to country of origin

UNIT IV: Virus and Virus-like Diseases of Fruit Tree and Vegetable Crops

Pathogens are responsible for direct yield losses ranging between 20 and 40% of the global agricultural productivity; whereas their indirect negative impact on consumers, public health, societies, environments, and farmers are much higher. A deep knowledge on the nature of plant pathogens, *i.e.*, viruses and viruses-like agents, together with efficient systems for their diagnoses, identification and control would save and above all avoid many losses at all levels of an agricultural supply chain. This unit will provide valuable information on the awareness of harmful pathogens and on the numerous key factors capable of offering the right methodologies to be followed for the identification, characterization, and management of such pathologies, using both conventional and advanced approaches. At the end of this unit, the students will also know the use of bioinformatics tools applied in the analysis of data on pathogens, being the new trend of modern research on data mining of pathogens in agriculture.

AIMS

- Provide in-depth knowledge on on viral and viral-like diseases affecting the Mediterranean fruit tree and vegetable crops.
- Acquire fundamental knowledge on the morphology, ecology, and epidemiology of plant pathogens, to propose adequate and sustainable control management.
- Get acquainted to the taxonomy normally associated with the classification and characterization of species and strains of pathogens.
- Understand the interaction existing between the host-pathogen-environment, for a better control strategy.

- Apply conventional and highly advanced technologies for pathogens' detection, identification, and characterization.
- Perceive the use of biotechnological approaches for creating resistance to plant pathogens and diseases.
- Learn how bioinformatics could support the research to understand some mystified infectious mechanisms induced by infection of pathogens.

LEARNING OUTCOMES

At the end of this unit, students will be able to:

- ✓ Identify diseases' etiologies and distinguish between disorders induced by biotic and abiotic factors.
- ✓ Propose the best strategies for detecting and controlling relevant pathogens and diseases.
- ✓ Apply different diagnostic techniques, at biological, serological, or molecular levels.
- ✓ Put in practice the acquired knowledge during field visits, laboratory activities, and analysis of specific case studies.
- ✓ Perceive new horizons of biotechnology in phytopathology.

UNIT V: Bacterial & Fungal Diseases of Fruit & Vegetable crops

This unit provides in-depth knowledge of the most important fungal and bacterial diseases, together with the disorders induced by abiotic factors, which compromise the quality and quantity of Mediterranean fruit and vegetable production. Knowing how to identify and characterize the various species, strains and isolates of adverse pathogens offers a large benefit in the control, management and prevention pathogens affecting fruit tree and vegetable crops. This unit also provides biological, epidemiological, and ecological key elements necessary for analysing the pathogens\diseases relevance, distribution, and impact on farming systems. This knowledge will help set out rapid IPM interventions and strategies able to prevent crop and product losses, always ensuring the human and environmental health. Another thread if this unit is the forecasting and modelling systems able to identify the natural elements that can favourable the onset of diseases induced by biotic and abiotic factors in different environmental ecosystems. This prediction may involve phytosanitary intervention suitable to block the onset of diseases or risk factors.

AIMS

- Discriminate between groups of pathogens according to their biological, morphological, and physiological characteristics, with brief hints to their taxonomy.
- Identify the epidemiological mechanisms of disease and study the interaction between host-pathogen-environment.
- Develop specific IPM, tailored to the type of host-pathogen-environment context.
- Use the forecasting modelling for prediction the spread of infection

- Have un idea of the disorder caused by the abiotic factors.

LEARNING OUTCOMES

At the end of this unit, students will be able to:

- ✓ Identify the disease aetiology and discriminate between biotic and/or abiotic disorders\symptoms.
- ✓ Understand pathogens cycles, symptoms expression in infected plants and how to intervene for their control.
- ✓ Identify strategies for detecting and controlling relevant bacteria and fungi.
- ✓ Implement effective, safe, and secure strategies for controlling a disease by use different sustainable approaches.

UNIT VI: Pests of Fruit tree and Vegetable crops

Insects and nematodes are among the most important pests in agriculture, as they can seriously compromise food security and induce serious economic and environmental consequences for many crops and territories, as well as social destabilisation. Pests are responsible for direct yield losses estimated at around 20% of global agricultural productivity, although their indirect negative effects on consumers, public health, society, and the environment are much higher.

The correct and rapid identification of the pests responsible for crop damage based on their morphological characteristics or the symptoms they induce in host plants is a prerequisite for setting up an appropriate control strategy.

The need to significantly reduce the use of pesticides in agriculture in order to safeguard the environment and public health requires increasingly aware and rational methodological approaches to pest control. The realisation of predictive models of insect infestation successfully fulfils this need.

Insect and nematode infestations are significantly favoured by ecological conditions, but also by incorrect human behaviour.

AIMS

- Presenting a range of typical plant symptoms caused by different groups of insects or nematodes;
- Providing the basic elements to recognize the main groups of pests according to morphological and physiological characteristics, with brief hints to their taxonomy;
- Describing the main epidemiology mechanisms of plant pests and the relationship between host-pathogen-environment;
- Providing basic information for the realisation of forecasting models of pest spreading in the territory.

LEARNING OUTCOMES

At the end of this course students manage to:

- ✓ Identify on a morpho-physiological basis the main groups of insects and nematodes of agricultural interest;
- ✓ Understand the cycle of the symptomatological manifestation induced by the insect/nematode disorder and understand how to intervene for its control;
- ✓ Identify the best strategy for detecting and controlling relevant nematodes and insects;
- ✓ Implement in practise the acquired knowledge during field visits, laboratory activities, and analysis of specific case studies.

UNIT VII: Sustainable Post-harvest Control Strategies & Regulations

Nowadays, one of the main global challenges is to ensure food security for a world growing population whilst ensuring long-term sustainable development. According to the FAO, food production will need to grow by 70% to feed world population which will reach 9 billion by 2050. Therefore, there is a need for an integrated and innovative approach to the global effort of ensuring sustainable food production and consumption. In this context, a wide variety of post-harvest diseases severely affect fruit and vegetable crops, mainly in developing countries, reducing the quantity and the nutritional quality of food due to contamination by toxic compounds (pesticide residues and mycotoxins). As such, an effective prevention and control strategies are needed to apply throughout the production chain. This unit will provide knowledge on the post-harvest life of products, both in the field and after harvest, products that can be contaminated by toxic secondary metabolites of fungi and toxins. In addition, this unit will also provide information on to increase knowledge on the sustainable use of conventional means and the possibility of integration with safe alternatives such as biocontrol agents, generally recognized safe compounds (GRAS), genetic resistance to reduce contamination of fruits and vegetables.

AIMS

- ❖ Give an overview of postharvest diseases that cause quality losses and their conventional and alternative means of control.
- ❖ Highlight safety issues related to mycotoxin contamination, consequences on product marketability, and control strategies.
- ❖ Report the most up-to-date knowledge and regulations for the control of contaminants in agricultural products and for the sustainable use of conventional pesticides.
- ❖ Guide toward obtaining a product that is not only of high quality but also safe for consumers, thus highly marketable.

LEARNING OUTCOMES

At the end of this unit, students will be able to:

- ✓ Address the basic principles of sustainable use of conventional means of post-harvest control through integration/replacement with biocontrol agents, eco-friendly compounds, and exploitation of host resistance.

- ✓ Discuss the risks of contamination by toxic compounds such as mycotoxins and possible strategies to preserve food quality and safety through sustainable management throughout the production chain.
- ✓ Deepen the theoretical knowledge acquired in daily practice with the help of seminars and laboratory activities, as well as the development of projects to address issues relevant to the country of origin.
- ✓ Increase their ability to adapt to the changing requirements of production, handling, and storage environments.

UNIT VIII: Conventional Approaches & Smart Tools for the Monitoring & Surveillance of Plant Pests & Diseases

Trade intensification associated with the movement of goods and people increases the risk of introducing harmful organisms in new areas. These organisms, whether aliens or not, may become invasive and more harmful in evolutionary adaptation mechanisms in new host plants, in a favourable climate change context, and in the absence of adequate defence strategies. The introduction and spread of these harmful organisms in new areas may seriously compromise food security and safety, leading to severe economic, environmental, and social consequences on affected territories. These phytosanitary risks can be avoided by implementing preventive control strategies using advanced pest surveillance technologies such as Remote Sensing (RS), Geographic Information Systems (GIS), Decision Support Systems (DSS), forecasting, modelling, etc., which would greatly contribute to limiting the occurrence of plant pathogens and possible pandemics, increasing the security level of the regions.

AIMS

- ❖ Emphasize the importance of phytosanitary monitoring and surveillance.
- ❖ Introduce cartography, Geographic Positioning System and Remote sensing concepts and approaches.
- ❖ Present the newest modern approaches and tools available in the geomatic, geoscientific and informatics fields that can be useful for the early detection, control, and eradication of quarantine pests.
- ❖ Learn and apply the Geographic Information System in Agriculture.
- ❖ Introduce key elements for a timely intervention and Decision Support System.

LEARNING OUTCOMES

At the end of the Unit, students will acquire:

- ✓ Basic concepts, principles, methods, and practical applications of the Cartography and Geographic Information System (GIS).
- ✓ Fundamental concepts of remote sensing for the surveillance phytosanitary.
- ✓ Notions on the Decision Support System (DSS).

- ✓ Capacity of exploit the technological innovations for and better disease control.
- ✓ Intersect between scientific, legislative, and phytosanitary service activities for effective control strategies of pests and pathogens.

RESEARCH-BASED PROJECT ACTIVITY

With the academic year ending, students will be asked to carry out at CIHEAM Bari a research-based project activity, dealing with a topic introduced during the units' lectures. The topic can deal with various phytosanitary aspects, i.e., diagnostics, control, monitoring, surveillance and management of plant pests and pathogens. Once the topic is identified, students must conduct small-scale research activity for a period of 14 days, assisted by the mentor who proposed the topic. Once the research activity is over, students shall present (PowerPoint slide show) their topic and relative results to an examination board which will assess the scientific content and knowledge acquired by the students during that period.