**TEACHING PROGRAM**

**MASTER 2**- **Semester 1**

L: Lecture / Cours magistraux (CM)

T: Tutorials / Travaux dirigés (TD)

PL: Practical Labwork / Travaux pratiques (TP)

**S-U02-4311 PLANT ECOPHYSIOLOGY (part 2)**

L 5h T 5h PL5h

**Teachers:** Laurent URBAN (AU), Hélène GAUTIER (INRAE), François LECOMPTE (INRAE)

* Introduction to ecophysiology: learning how physiological functions influence yield, quality of production and plant defenses (plant water relationships, metabolism and defenses, metabolism and quality of production).
* Photosynthesis from an ecophysiological perspective: learning how environmental factors influence photosynthesis and its components (photosynthetic capacity, photorespiration, respiration…)
* Oxidative stress and photooxidative stress: learning the importance of oxidative stress and its consequences for plant physiology, yield, quality and defenses
* Field tools for analyzing photosynthesis: getting familiar with actual tools used in ecophysiology and agronomy
* Metabolism and defenses: the objective of this course is to show how metabolic pathways are involved in plant responses to biotic stresses, and how the plant's environment (e.g. water availability, nutrients) contributes to a given metabolic status more or less adapted to an effective defense. A general lecture will be given to set metabolic processes in the overall defense cascade against pests and pathogens with different infection and virulence strategies, and illustrate the impact of the abiotic environment. In an interactive tutorial session, case-studies of metabolic switches towards defense will be examined.
* Metabolism and quality of production: learning how environmental factors influence plant phenology and physiology, assimilate partitioning, primary and secondary metabolism, and consequently the quality of production.

**S-U02-4312 PLANT BREEDING (parts 1 & 2)**

L 18h T 7h

**Teachers:** Emmanuel SZADKOWSKI (INRAE), Morgane ROTH (INRAE), Jean-Luc GALLOIS (INRAE), Juliette GOUSSOUPOULOS (INRAE), Rebecca STEVENS (INRAE), Benoit MOURY (INRAE)

* Introduction to plant breeding – back to the future? The presentation will cover history and prospects of breeding in the introductory course. We will approach new goals for sustainable agriculture and the challenges that they raise.
* The use of predictions in plant breeding (PB): The presentation will cover why we need predictions in PB, QTL mapping & GWAS for marker-assisted selection, genomic and phenomic selection.
* Opportunities for genome editing for plant breeding. The presentation will cover different uses of CRISPR technology to select new traits in crops.
* Management and maintenance of genetic resource collections: Short presentations are included on why diversity is important and how to maintain diversity. The Unit’s genetic resource collection will be presented including the rules for exchanging seeds. At the end of this section the students will answer questions related to seed conservation, screening of diversity and genetic resources for traits for plant breeding.
* Breeding for durable resistance. Presentation and discussion on: mechanisms of resistance breakdown by parasites; factors that influence breakdown risks; durable strategies of breeding and managing plant resistance.
* Fundamentals of evolution & population genetics of plant bioagressors (part 1). The presentation will cover evolutionary processes in phytopathology. The five basic forces of evolution will be described (Mutation, Genetic exchanges, Selection, Genetic drift, Migration). Evolutionary models of plant-parasite interactions will be shown.

**S-U02-4313 PLANT HEALTH**

L 5h T 10h

**Teachers:** Philippe NICOT (INRAE), Morgane ROTH (INRAE), Pierre FRANCK (INRAE), Clara TORRES (INRAE), Marc BARDIN (INRAE), Cindy MORRIS (INRAE)

* Principles and challenges of integrated pest management and integrated plant health management. Brief overview of and historical perspective on the concept of IPM/IPHM and the main tools that can be applied. Project: design an IPHM strategy based on the analysis of the existing state of the art for a crop and production system, identify key challenges that would require research work, and propose one detailed research action.
* Fundamentals of evolution & population genetics of plant bioagressors. This part will cover speciation mechanisms (speciation types and reproductive barriers) with a focus on plants. Expanding the topic to crops and crop health, this class will also present the mechanisms of plant domestication and will introduce some ways to measure and use plant genetic diversity for improving plant health. Most examples are chosen in Mediterranean plants.
* Biological control of plant diseases. The main types of biocontrol agents against diseases, their modes of actions and the key factors of their efficacy in the field.
* Debate: What is plant health/disease? Acknowledge the "paradox" that microbial symbionts and biocontrol agents deploy many of the same molecular strategies as pathogens. Understand that plant "health" and "disease" are subjective concepts. Discuss how this understanding could be useful in developing strategies to manipulate plant-microbe interactions for outcomes that are favorable for plant production.
* Frost damage: how a microorganism can cause abiotic damage. Learn about the processes involved in frost damage to plants and how it can be catalyzed by certain plant-associated microorganisms.

**S-U02-4314 AGROECOLOGY**

L 4h PL 16h

**Teachers:** Pierre FRANCK (INRAE), Magali RAULT (AU), Joeffrey MOIROUX (AU), Armin BISCHOFF (AU), Olivier BLIGHT (AU)

*Lectures*: Understanding ecological principles of interactions in agro-ecosystems, in particular between crops, spontaneously occurring plants and arthropods.

* Control of pest insects, regulation by natural enemies, conservation biological control using agro-ecological infrastructures (wildflower strips, grass strips, hedgerows, etc.)
* Chemical control and the influence of agricultural practices
* Impact of agrochemicals on arthropods

*Practical Labwork*: Effects of crop management and surrounding habitats on arthropods: biological control and ecotoxicological risk assessment. Objective: learning to develop experimental protocols in order to analyse scientific questions, testing these protocols in the lab and in the field.

* Approaches to improve conservation biological control and methods to test its efficiency
* Impact of pesticides on non-target organisms and their ecological functions: from the molecule to population

**S-U02-4315 GREEN FOOD PROCESSING, CONSERVATION & TRANSFORMATION**

L 18h TP 7h

**Teachers:** Jean-Louis LANOISELLE (UBS), Farid CHEMAT (AU),Harish RAVI (PhD AU), Florence Charles (AU)

* Green and innovative food processing

- Sustainability in the food industry

- Instant controlled pressure drop technology; pulsed electric field; high pressure processing; supercritical fluids: process and procedure; applications in food processing; HACCP and HAZOP; environmental impact; up-scaling or numbering; success stories in food industry.

- Microwave technology; ultrasound processing; solar energy: process and procedure; applications in food processing; HACCP and HAZOP; environmental impact; up-scaling or numbering; success stories in food industry.

- How to create innovation and intellectual property for applied research.

* Conservation and transformation

Current postharvest research and innovations and sustainable technology

**S-U02-4326 FORMULATION OF FOOD PRODUCTS, VALORIZATION OF AGRO FOOD WASTES**

L 18h T 7h

**Teachers:** Pierre GUILLET (AU), Grégory DURAND (AU), Hélène FULCRAND (INRAE Montpellier), Cécile BARRON (INRAE Montpellier), CHAHINEZ AOUF (INRAE Montpellier)

- Particle characterization methods for food formulation and processing: the course will provide a comprehensive description of the dynamic light-scattering technique and its use for the characterization of self-aggregation in food processing. An experimental set-up will be presented.

- Nuclear Magnetic Resonance and Electron Paramagnetic Resonance for food formulation and analysis: the course will provide a comprehensive description of the two techniques. Applications in food formulation and processing through several examples will be provided.

Large quantities of wastes are generated every year from the agricultural and food processing industries. Producing energy and/or added-value products from the recycling of these wastes is a major challenge from both environmental and economic perspectives.

* Introduction to basic knowledge of bioeconomy, biorefinery and eco-design concepts. Illustration with winery by-products and distilleries.
* Dry fractionation of agricultural by-products and wood resources as a processing step to produce energy, molecules and materials.
* Sugar- and lipid-derived building blocks for the production of bioplastics. During interactive tutorial sessions, case-studies will be examined and a workshop will be prepared.

**S-U02-4318 plant food and phytochemicals, BIOAVAILABILITY AND HEALTH EFFECTS (part 2)**

L 15h T 5h

**Teachers:** Emmanuel REBOUL (INRAE-AMU), Patrick BOREL ((INRAE-AMU), Lourdes MOUNIEN ((INRAE-AMU), Jean-François LANDRIER ((INRAE-AMU), Jean-Charles MARTIN ((INRAE-AMU), Cyril REBOUL (AU)

Introduction to molecular mechanisms governing the absorption of vitamins and carotenoids and molecular mechanisms involved in the biological effects of bioactives. The approach will combine nutrigenetics, nutrigenomics, metabolomics and epigenetics.

* Intestinal fate and molecular mechanism for the absorption of fat-soluble vitamins and carotenoids
* Nutritional genomics of micronutrients
* Epigenetic regulation mediated by micronutrients
* From molecular targets to human health (molecular targets: cell and animal models, signaling pathways modulated by micronutrients; plant food and cardiometabolic diseases, a metabolomics approach.

**S-U02-4319 SAFETY IN THE PRODUCTION CHAIN OF FRUITS AND VEGETABLES (part 2)**

L 9h T 3h

**Teachers**: Frédéric CARLIN (INRAE), Pierre RENAULT (INRAE), Catherine DUPORT (AU)

For the safety control of fruits and vegetables, a worldwide traceability system has been implemented. The presentation will cover:

* Bacterial hazards: contamination routes and principles of control
* Microbiological hazard characterization. Bacterial toxins
* Applying mathematical model for risk assessment. Model for prediction of survival or growth. Models for environmental dispersion

**S-U02-4320 CONSUMER SCIENCE**

L 7h

**Teacher :** Sandrine COSTA-MIGEON (INRAE)

This presentation will explore how consumer behavior can be analyzed and utilized to advance healthy and sustainable nutrition. It will cover:

* Theories and methodologies developed in consumer science
* Interactions between “foodscape” and consumers, health consequences
* Determinants of consumers (individual, social and physical environments)
* Agri-food transitions and consumers (“Bio”): perceptions and attitudes
* Consumer, waste and losses
* Nudging and consumer changes

**S-U02-4321 DATA TREATMENT AND STATISTICS**

L 12h T 8h

**Teachers:** Florent BONNEU (AU), Céline LACAUX (AU)

Advances in digital technology in data processing are leading to changes in the mathematical tools available today, which must be part of the basic background of a student intending to do research.

In this presentation, students will learn about:

* Linear Mixed Models
* Data Analysis
* Parametric and non-parametric statistical tests

**S-U02-4322 MODELING**

L 12h T 8h

**Teachers:** Rachid EL-AZOUZI (AU), Florent BONNEU (AU), Gilles VERCAMBRE (INRAE), Bénédicte QUILOT-TURION (INRAE), Samuel BUIS (INRAE)

This presentation will cover:

* Graphs and Markov models
* Spatial processes and geostatistics
* Plant-Fruit eco-physiological modelling: objectives, development, calibration, use
* Integration of genetic control in process-based plant models: objectives, progress and perspectives
* Introduction to model uncertainty and sensitive analysis

**S-U02-4323 QUALITY CONTROL AND ANALYSIS, METABOLOMICS**

L 6h T 3h

**Teachers:** Raphaël LUGAN (AU), Jean-Charles MARTIN (INRAE-AMU)

Metabolomics is becoming the state-of-the-art method to analyze biological and environmental samples, aiming at detecting subtle and unexpected changes in their biochemical composition.

* Mass spectrometry metabolomics: sample preparation, chromatography, mass spectrometry, data analysis. Targeted and non-targeted approaches.
* Examples of MS metabolomics in the field of “foodomics”, functional genomics and clinical diagnosis.
* Application of MS metabolomics to monitoring health status: limitations of conventional clinical approaches, role of the metabolome to determine molecular phenotypes, statistical outlook, biomarkers searching and mechanistic insights, examples in nutrition, lipidomics overview, integration to multi-omics.

**S-U02-4324 IMAGING AND TECHNIQUES OF INTERNAL INVESTIGATION**

L 6h T 6h

**Teacher: Chahine ABBAS (AU)**

Imaging techniques, whether for illustrative or quantitative purposes, have become a significant lever in all fields of science and industry. Acquiring basic knowledge in this area is now essential for scientists. The course will give some basics in mathematical morphology and keys to facilitate the use of the open source *ImageJ* software in order to easily handle, filter and process images.