

## MASTER 2- SEMESTER 1

### U02-4311 PLANT ECOPHYSIOLOGY (part 2)

L 5h T 5h PL5h

**Teachers:** Laurent URBAN (AU), H  l  ne GAUTIER (INRAE), Fran  ois LECOMPTE (INRAE)

- **Objectifs d'apprentissage :**

Students should be capable to understand how abiotic and biotic factors and agronomic practices, and their interactions influences yield, quality of production and plant defenses. Students should notably be able to explain how the global change will affect plant growth and development, and crop performance.

At the end of the course, students should have a comprehensive view of the major concepts and tools used in plant ecophysiology, as well as a first experience of them for research or field diagnosis.

Generally speaking, this course is designed to be a basis for courses of agronomy, crop protection and management of quality of production.

- **Description synth  tique des enseignements :**

- 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.

- **Travail attendu :**

Students will attend lectures, use computer simulations and participate in small trials, which objective is to make them acquainted with some of the tools used in plant ecophysiology.

- **Modalit  s de contr  le des connaissances :**

2 exams with the same coefficient (0.5 each)

- **Pr  requis :**

Basic concepts of plant physiology, plant pathology, biochemistry and biophysics

- **Comp  tences acquises :**

- **R  f  rences bibliographiques et ressources num  riques :**

Plant Physiology. Taiz and Zeiger (eds.). Sinauer (publisher)

### 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)

• **Objectifs d'apprentissage :**

- Understanding the need for plant genetic resources conservation and related techniques
- Understanding the major stakes of plant breeding
- Getting familiar with the major breeding methods relying on molecular biology, biostatistics and quantitative genetics
- Getting familiar with the forces ruling the evolution of live organisms (plants and their pathogens)

• **Description synthétique des enseignements :**

Ideal order in time:

1. Fundamentals of evolution & population genetics of plant bioaggressors (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.
2. 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.
3. 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.
4. 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.
5. Opportunities for genome editing for plant breeding. The presentation will cover different uses of CRISPR technology to select new traits in crops.
6. The use of predictions in plant breeding: The presentation will cover why we need predictions in PB, QTL mapping & GWAS for marker-assisted selection, genomic and phenomic selection.

• **Travail attendu :**

Active participation during the classes (questions, quiz), Journal Club and presentations of students

• **Modalités de contrôle des connaissances :**

Practical exercises and final exam of 2 hours

• **Prérequis :**

Solid knowledge in biology, especially in genetics

• **Compétences acquises :**

Seed biology and management of seed collections

Plant breeding strategies

Developing abilities to analyze complex problems

Biostatistics & quantitative genetics

Evolutionary biology

• **Références bibliographiques et ressources numériques :**

Will be provided during the class electronically

**U02-4313 PLANT HEALTH**

L 5h T 10h

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

- **Objectifs d'apprentissage :**

The objective of the course is to expose students to a range of advanced topics related to the complex factors intervening in plant health and their consideration when establishing integrated pest management of cropping systems. The students will have opportunities to debate and present critical evaluation of different types of plant health scenario and paradigms.

- **Description synthétique des enseignements :**

- 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 bioaggressors. 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.

- **Travail attendu :**

Attendance of class is mandatory. There will be 5 h of formal lectures. In addition, the students will be involved in individual and group work to be rendered as part of 10 h of debate and discussion on a range of subjects. Overall, each student will be part of teams that prepare presentations on about 3 subjects concerning evolution, ecology and general paradigms about what defines a plant pathogen and disease.

- **Modalités de contrôle des connaissances :**

Grades will be based on a 1h written exam and on the quality of presentations made in the classroom as well as on participation in discussion.

- **Prérequis :**

Undergraduate level courses about the fundamentals of plant biology, microbiology and agronomy. Knowledge of the basic principles of plant and population genetics and of evolution. A good level of oral and written skills in English.

- **Compétences acquises :**

The capacity to think critically about the wide range of factors to consider when conceiving and implementing integrated pests management and when identifying the knowledge gaps where further research is needed in this domain.

- **Références bibliographiques et ressources numériques :**

All reference materials will be available on the EDT platform of Avignon University

## **U02-4334 AGROECOLOGY**

L 4h PL 16h

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

### • **Objectifs d'apprentissage :**

The module Agroecology aims at an understanding of ecological interactions in agro-ecosystems, in particular interactions between crops, spontaneously occurring plants and arthropods. The major objectives are:

- (1) Learning to develop experimental protocols in order to analyse scientific questions,
- (2) Testing such protocols in the lab and in the field.

Such improved understanding allows the participants to develop skills in conservation biological control and environmental evaluation of agrochemical use.

### • **Description synthétique des enseignements :**

Lectures include the following topics:

- 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

In Agroecology Tutorials students analyse ecological interaction in crop fields and in the lab. Effects of crop management and surrounding habitats on arthropods are tested to evaluate biological control and ecotoxicological risks:

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

### • **Travail attendu :**

Relevés floristic and arthropod observation to analyse effects of field margin vegetation.

Arthropod trapping.

Analysis of field data using correlative statistics (regression analysis and statistical testing)

Ecotoxicological studies in the lab and data analysis

### • **Modalités de contrôle des connaissances :**

Report on interactions between flora and arthropods

Report on arthropod diversity

Report on ecotoxicological study

### • **Prérequis :**

Good command in Excel

Basic knowledge in test statistics using R

### • **Compétences acquises :**

See objectives

### • **Références bibliographiques et ressources numériques :**

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

L 18h TP 7h

**Teachers:** Jean-Louis LANOISELLE (UBS), Florence Charles (AU), Anne-Sylvie FABIANO (AU), Maryline VIAN (AU), Sandrine PERINO (AU)

### • **Objectifs d'apprentissage :**

To have the knowledge of food processing mainly food sustainability

### • **Description synthétique des enseignements :**

- 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

- Travail attendu :

A complete mastering about Green and sustainable food processing techniques.

- Modalités de contrôle des connaissances :

1 épreuve écrite 2H

- Prérequis :

To have the knowledge of food processing mainly unit operations

- Compétences acquises :

Green food processing (CO<sub>2</sub> balance, mass balance and energy balance).

- Références bibliographiques et ressources numériques :

F. Chemat, E. Vorobiev (Editors)

Green Food Processing Techniques: Transformation, Preservation and Extraction.

Elsevier, Amsterdam, 588 pages. 2019. ISBN : 978-0-12-815353-6

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

L 12h30 T 12h30

**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.

## **U02-4318 PHYTOCHEMICALS: BIOAVAILABILITY AND HEALTH EFFECTS (PART 2)**

L 15h T 5h

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

- **Objectifs d'apprentissage :**

The overall objective of this module is to bring general knowledge about the absorption of vitamins and carotenoids and molecular mechanisms involved in health effect of these molecules.

- **Description synthétique des enseignements :**

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.

- **Travail attendu :**

Attendance at lectures, critical analysis of one scientific article during practical teaching.

- **Modalités de contrôle des connaissances :**

1 épreuve écrite 1,5H

- **Prérequis :**

Basic knowledge in nutrition, metabolism, cell biology and molecular biology.

- **Compétences acquises :**

Fundamental knowledge about mechanisms of actions and absorption of vitamins and carotenoids. Article analysis

- **Références bibliographiques et ressources numériques :**

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

L 9h T 3h

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

- **Objectifs d'apprentissage :**

Knowledge is provided so that students are able to assess the risk in a food context, to model this risk using mathematical tools, and then to communicate on this risk.

- **Description synthétique des enseignements :**

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

- **Travail attendu :**

Active participation in lectures

- **Modalités de contrôle des connaissances :**

Written exam

- **Prérequis :**

Microbiology -Cellular biology, toxicology, epidemiology, modelling, biostatistics

- Compétences acquises :

Identify microbiological hazards throughout the food production chain.

Quantitatively assess microbiological risks.

Manage risks within companies in relation to regulatory constraints

- Références bibliographiques et ressources numériques :

## **U02-4320 CONSUMER SCIENCE**

L 7h

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

- **Objectifs d'apprentissage :**

The scope of this presentation is to provide basic knowledge of what influences consumer behavior, specifically food consumption, and to introduce the various ways to change consumer behavior.

- **Description synthétique des enseignements :**

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

- Travail attendu :

Interactive work during teaching, students are expected to be active. The exam requires a really good understanding of the lessons.

- Modalités de contrôle des connaissances :

2 épreuves écrite de 0,5H

- Prérequis :

None

- Compétences acquises :

Basic skills in understanding food purchase and consumption

- Références bibliographiques et ressources numériques :

Marketing des produits agroalimentaires, Philippe Aurier et Lucie Sirieix (2012). Dunod, Paris.

Solomon, M., Russell-Bennett, R., & Previte, J. (2012). Consumer behaviour. Pearson Higher Education AU.

## **U02-4321 DATA ANALYSIS & LINEAR MODELS IN AGROSCIENCES**

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 test

## U02-4322 MODELING

L 16h T 6h

**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

## U02-4323 QUALITY CONTROL AND ANALYSIS, METABOLOMICS

L 7.5h T 4.5h

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

- **Objectifs d'apprentissage :**

To discover the principles of metabolomic analysis by mass spectrometry.

Learn the principles of metabolomics applied to the quality analysis of plant productions.

- **Description synthétique des enseignements :**

2 séances de 3h de cours.

1- Metabolomics definition

2- Physico-chemical principles of metabolite extraction from complex matrices

3- Principles of liquid and gas chromatography

4- Principles of mass spectrometry: electron impact and electrospray ion sources

5- Methodological precautions to manage bias

6- Data structure and multivariate statistics for the analysis of large metabolomic data sets

7- Examples of metabolomic analyses applied to the determination of the loyalty of a product, its biochemical evolution during industrial transformation or to traceability, taken from the literature.

8- Visit to the 3A metabolomics platform, the Metaboscope.

- **Travail attendu :**

Students are given the entire course on video and are expected to familiarise themselves with it. The class sessions are used to review the key points and address any questions.

- **Modalités de contrôle des connaissances :**

MCQ

- **Prérequis :**

Bases de biochimie et biologie :

- Plant metabolism

- Analytical chemistry

- Statistics

- **Compétences acquises :**

Understanding of the basics of metabolomic analysis in the context of plant product qualification: fraud detection, sourcing, process monitoring (foodomics).

- **Références bibliographiques et ressources numériques :**

The entire course is available on ouTube

<https://www.youtube.com/watch?v=FaNSR4BLExQ&list=PLwo5e0jWFBluL2ZNBNaNfHBeEsfjYKOUv>



## **U02-4335 IMAGING AND TECHNIQUES OF INTERNAL INVESTIGATION**

L 4h 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.