emPLANT COURSE CATALOGUE

ERASMUS MUNDUS MASTER PROGRAMME IN PLANT BREEDING

Contents

Joint Courses

JOINT COURSES	Description, contents, learning outcomes	Prerequisites	Implementation:	ECTS
Pilot case	Semester 1 and 2: UniLaSalle, SLU Semester 3: UH, UPV, EgeU The pilot case is a case study to apply the project management tools to a breeding program. First students by group have to choose a species to be ameliorated. Then, find a character or several ones as goal for the breeding strategy. The students need to check the market potential for this new variety and verify that farmers will want to cultivate it. Secondly, students will define the potential market for their product (seeds), but also the market for the new variety (consumers). Thirdly, they need to create a structure to breed the new variety, and define the role of each student of the group in this structure (company, association...).	No prerequisites	The introduction to the Pilot Case will take place during the Joint Integration Week where the groups will be formed based on the specialty chosen by the students for Y2. During the first year the students will work in groups with their tutors and via telephone/video conference/email if group members are not located at the same site (LAS/SLU). During S3 the Pilot Case will be finalized with the tutors at the host university and by telephone/video conference/email among the group members. Two juries will be organized. The first jury at the end of S1 will evaluate the content and the form of the work and especially the project management content. At the end of S2 a written report will be evaluated. At the end of S3 a jury composed of the local tutors, the Coordinators for Y1 and an expert in Project Management will judge the defense of the Pilot Case. The students of S1 and S3 will be able to attend their respective presentations. The juries of S1 and S3 will be carried out on the same day for logistic reasons.	**S1: 3** **S2: 3** **S3: 2**
Intellectual Property & Plant Breeders' Rights	The two systems (plant patent and plant breeders' right) and implication for breeder rights will be studied. Breeder's exemption and farmer privilege will be analysed. From practical examples, lecturers from institutions and companies will analyse each system. Infringement cases and violations will be analyzed. UPOV origin and historical steps are presented. DCU and VCU notions. The transgenic varieties, the mutant and somaclonal variants will allow to introduce the notion of Essentially Derived Variety (EDV). Current and potential application of molecular markers and next generation sequencing will be discussed.	No prerequisites	This course will be offered in form of a UPOV (www.upov.int) online course. During one month, the student can access and complete 25h of online courses at their own rhythm. The course will be validated by a written online examination. SLU and LAS will nominate tutors who will accompany the students. In addition UPOV will nominate a contact person to accompany the students.	**S2: 2**
Bioinformatics	Biological databases, gene analyses, web-based analytical tools, Unix OS, functional genomics, molecular evolution, RNAseq expression analysis, annotation of new genomes	No prerequisites	This course will be offered via videoconference and tutorials and accompanied by tutors at the host universities. The class will be validated by a computer-based exam.	**S3: 2**

Big Data	Using big data in Plant breeding, Machine Learning Methods (10h lecture, 12h tutorials) Algorithmic/Software Development Clustering Random Forests K-Nearest Neighbors Method/ Kernel Methods Sparse Methods for high dimensional data Databases (Big data) Management (4h lecture 4h tutorials) Distributed file systems, Hadoop Parallel, distributed, massive data processing with Map Reduce NoSQL/NewSQL databases	Basic Statistics and Probability, Statistical Inference, Regression Models Database using Access	This course will be offered via videoconference and tutorials and accompanied by tutors at the host universities. The class will be validated by a computer-based exam.	**S3: 2**
Joint Summer Breeding Field Camp (at the end of Y1 (June))	The objective of this summer intensive program is to immerge students in two crops breeding chains. One week for a major crop such as corn or wheat and the second on a legume or fruit crop (green bean, apple). During each week students are going to visit the main actors related to breeding for the selected crop from farmers, to several breeders (diversity conservation, breeding, laboratory) or public research institutions involved in basic research , seed industry and seed multiplication farmers and even food industry to see the quality requirements for the specific transformation. To have a full panorama of the selected crop. The main learning objective is to have an integrated view of the food chain from the breeding till the final transformation of the product. Secondary objectives are to understand the different actions of breeding companies, how they integrate the requests of the consumer. To have a deeper knowledge on at least two crops which are managed differently, as are the cereals sand the vegetables. And understanding the importance of the seeds quality.	No prerequisites	All students will join the field camp after the first year.	**S2: 2**

Semester 1 LAS

SEMESTER 1 LAS	Description, contents, learning outcomes	Prerequisite	ECTS

French as a foreign language	This language course aims at providing students with the necessary language tools to interact successfully in everyday life and in basic professional situations. After a 2 week intensive language course, students will continue to learn French at the rate of 3 hours per week. In addition to classroom instruction, students will realize interactive assignments, such as conducting surveys amongst their French peers. These assignments, are designed to familiarize students with cultural aspects in France and the French-speaking world. Introducing yourself and introducing someone else. Asking questions. Talking about your professional activities. Expressing preferences. Understanding an itinerary. Expressing an intention. Making appointments. Understanding a schedule.	No prerequisites	**2**
Spanish as a foreign language	This language course is targeted at students who chose UPV as Y2 destination and who still need to bring their Spanish to a B2 level for everyday life and professional situations. Students will learn Spanish at the rate of 2 hours per week. In addition to classroom instruction, students will realize interactive assignments. This course is carried out in close collaboration with UPV so as to ensure that the students obtain the language level needed.	B1	**Official certif.**
Interculturality & ethics	To raise awareness and develop skills around culture and its impact on behavior in international teams. Students will draw on their own experience of learning within a multi-cultural team immersed in a host culture. Reading - implementation of the method of ethics: analysis, explanation of the differentiated arguments of the ethical issue. Know how to comment - discern the positioning that appears to us most relevant and be able to account for it. Be able to justify and explain contradictory arguments. Program : 1) Culture: definitions, metaphors; key concepts. Culture as a source of intercultural errors. 2) Cross cultural communication : "Talk to me" 3) Managing an international team : “When in Rome . . . “ (case study; video) 4)Cultural perceptions of things: marketing, management, negotiation, hiring; 5) Student reports: results of expatriate manager interview 6) Student presentations of x-cultural training packages 7) Independent/group work on assignments and projects 8) Introduction - What is ethics? Distinction between ethics and ethics: stake, history, relevance. Ethics as a social or political dimension of morality which is personal: what is possible, desirable, and necessary in a given political, social, entrepreneurial body. 9) COMPOSITION and not RESOLUTIVE: composed of the Common Principles / Principles proper / Matter / circumstances / intention. From examples (flight to survive, revolution, tyrant ...) Explain the relative middle of the virtues and proportionality of the relations of justice / injustice.	No prerequisites	**1**
Introduction to seed business	Identify several factors going to impact the way of organizing companies on a regional and global scale such a long term activity as the breeding and the selection, in relation with transversal technologies and breeder’s profiles: technological traits, biotechnologies, markets, climatic changes, natural resource limitations, exchanges between countries and continents. Researchers and managers from seed companies and from agri-food industries will share their view of current status and prospective future of breeding activities and targets. 15 lectures followed by discussion, prepared in advance by students from keywords. 1 seminar to introduce the Pilot Case module “design a breeding project” guidelines will be given to student to follow.	No prerequisites	**4**

Introduction to algorithmics	Objectives : - Know how to use the fundamental structures of the algorithmics - Know how to analyze a problem and solve it with an algorithm - To implement an algorithm - To use a procedural language (C language) Contents : - Variables, data types, assignments - Conditional structure (« if » statement, loops) - Arrays - Functions, - Programming algorithms (C language)	No prerequisites	1
Statistics	This course introduces students to the basic theory behind the development and assessment of statistical analysis techniques in the areas of point and interval estimation and hypothesis testing. Topics include: Point estimation methods, including method of moments and maximum likelihood; Bias and variance; Mean-squared error and the Cramer-Rao inequality; Sufficiency, completeness and exponential families; the Rao-Blackwell theorem and uniformly minimum variance unbiased estimators; Bayesian estimation methods; Resampling estimation methods, including the jackknife and the bootstrap; Confidence interval construction methods, including likelihood-based intervals, inversion methods, intervals based on pivots and simple resampling-based percentile intervals; Highest posterior density and Bayesian credibility regions; Likelihood ratio tests and the Neymann- Pearson lemma; Power calculations and uniformly most powerful tests; Rank-based non-parametric tests, including the sign-test and Wilcoxon tests. Learning Outcomes Upon successful completion of the requirements of this course, students should have the knowledge and skills to: - Explain the notion of a parametric model and point estimation of the parameters of those models. - Explain and apply approaches to include a measure of accuracy for estimation procedures and our confidence in them by examining the area of interval estimation. - Assess the plausibility of pre-specified ideas about the parameters of a model by examining the area of hypothesis testing. - Explain and apply the idea of non-parametric statistics, wherein estimation and analysis techniques are developed that are not heavily dependent on the specifications of an underlying parametric model. - Understand the computational issues related to the implementation of various statistical inferential approaches.	Descriptive statistics, Probabilities, Linear model	2
Plant Reproduction systems	We will understand and appreciate differences in existing modes of reproduction. Sexual reproduction. Sexual life cycles. Structure of flower types. Gametogenesis. Pollination. Fertilization. - Sexual reproduction; Meiosis and fertilization; reproductive organs in flowering plants; plant sexual morphology. - Importance of reproductive systems for plant breeding. Distinction between cross-and self-pollination. Types of reproduction	No prerequisite	**2**

	- Autogamy (definition), mechanisms promoting or preventing autogamy, self-incompatibility systems and implications for plant breeding, male-sterility systems. Genotype conversion. Artificial pollination. - Allogamy (definition). Promoting mechanisms. Implications for plant breeding. Inbreeding depression and hybrid vigor. - Control of hybridization in a perspective of seed production. Dioecy, self-incompatibility, nuclear and cytoplasmic male sterility.		
Plant genetics 1	Introduction to genetics, genes and chromosomes, Mendel's laws, probabilities in Mendelian inheritance, sex chromosomes, genetic linkage, Tetrad analysis, extra chromosomal inheritance, epigenetics, population genetics	Basics in genetics	**3**
Plant genetic resources and diversity	At the end of this course student will understand the Importance of germplasm in breeding projects. The different types of evaluation of a collection, morphological, chemical, technological, molecular and their representations. Allelic richness, diversity structure. How to manage and use the genetic diversity: core collection and sampling strategies. Programme : - Teaching of most adopted tool for evaluation of genetic diversity and construction of core collection. - These tools will be defined morphological, biochemical, technological and molecular studies to assess genetic diversity in germplasms also allelic richness and construction of a core collection. - Evolution of phenotypic and genetic diversities of commercial varieties. - Conservation of germplasm: mechanisms and global maintenance. Genetic resources context in evolution.	No prerequisite	**4**
Introduction to plant pathology	The objective is to study the principals of the plant-microorganisms interaction. It introduces the major plant pathogen groups (viruses, viroids, phytoplasmas, bacteria, fungi, nematodes and the higher plant parasites) and the abiotic plant stresses (caused by environmental factors). It introduces also the importance of the beneficial microorganisms (e.g. PGPR, Plant-growth-promoting-rhizobacteria & AM, arbuscular mycorrhizae). Students study the scientific classification of theses microorganisms, their detection and quantification, and the general methods of control (chemical, biological & genetic). During the practical work, students follow experiments of the plant-PGPR-pathogen interactions under the greenhouse conditions. They prepare the bacterial and fungal inoculum, inoculate plants (resistant and susceptible genotypes), and follow disease progression (visual symptoms, molecular and microscopic diagnosis). They learn the different microbiological methods (preparation media, isolation of microorganisms, replication of bacterial and fungal cultures, using microscopes (classical and electronic), DNA extraction and real time quantitative PCR).	No prerequisites	**3**
Breeding Strategies and methods of selection	Students will be able to define the breeding goals in the midterm and long term, reasoning the breeding strategy adapted to the objectives, species, germplasm, traits to be selected according to the dimension of the breeding program, breeding tools and selection methods. Programme: A course will introduce the cultivar types, deriving from breeding strategies and methods of selection adapted to self-pollinated and open-pollinated species. Practical examples of breeding projects for yield, quality, and resistance to biotic and abiotic stress will be detailed by professionals. Examples will cover Seed and vegetatively propagated species. 1. Breeding objectives, program design and management; The choices a breeder has to make, like choice of parents, type and size of populations, change in allele frequencies by selection, effect of crop type on breeding program.	No prerequisites	**5**

	2. Main breeding strategies; Based on examples on different crops, we will review the main strategies: bulk breeding, pedigree breeding, backcross breeding, recurrent selection and synthetic varieties, hybrid breeding and hybrid production systems, mutation breeding, chromosome breeding. 3. Breeding strategies for quality and fitting with technological uses 4. Breeding strategies for yield increase 5. Breeding strategies for disease resistance, major resistance gene vs polygenic resistance. 6. Breeding strategies for tolerance to abiotic stress (drought tolerance, low nitrogen and phosphorus tolerance). 7. Breeding for low-input and for organic; Specific developments like evolutionary breeding for diversity and participatory breeding will be described. 8. Breeding for multiple purposes; we will analyse the importance of prioritizing selection among traits.		

Semester 2 LAS

SEMESTER 2 LAS	Description, contents, learning outcomes	Prerequisites	ECTS
French as a foreign language	This language course aims at providing students with the necessary language tools to interact successfully in everyday life and in basic professional situations. After a 2 week intensive language course, students will continue to learn French at the rate of 3 hours per week. In addition to classroom instruction, students will realize interactive assignments, such as conducting surveys amongst their French peers. These assignments, are designed to familiarize students with cultural aspects in France and the French-speaking world. Introducing yourself and introducing someone else. Asking questions. Talking about your professional activities. Expressing preferences. Understanding an itinerary. Expressing an intention. Making appointments. Understanding a schedule.	Course in S1	**Official Certif.**
Spanish as a foreign language	This language course is targeted at students who chose UPV as Y2 destination and who still need to bring their Spanish to a B2 level for everyday life and professional situations. Students will learn Spanish at the rate of 2 hours per week. In addition to classroom instruction, students will realize interactive assignments. This course is carried out in close collaboration with UPV so as to ensure that the students obtain the language level needed.	Course in S1	**Official Certif.**
Plant Microbe Interaction	The course is to study the breeding to plant resistance. The course describes the differences between the qualitative and quantitative resistance, methods of breeding, and their advantages and disadvantages. It explains the new methods of breeding using effectors, elicitors, and the beneficial microorganisms. It introduces the epidemiology of plant diseases, their interactions with other factors as insects and the actually projects and strategies treat the plant resistance. The course describes the molecular methods to identify the plant resistance gene markers and gene expression analysis. It introduces examples of the major economical plant diseases and the role of plant breeding in the control of these diseases.	Introduction to plant pathology	**5**
Phenotyping	Student will be introduced in traditional and modern methods of phenotyping. Diversification of phenotypic data will be illustrated. A focus will be on how to collect, store data safely, mobilize a large number of data, using notebook, excel and classic database. Programme:	No prerequisites	**4**

	Several visits and lectures will introduce classical and high throughput phenotyping tools and platforms as well as supporting technologies for aerial and root systems. Different database systems and their evolution (Excel, Access, mySQL) will be studied from practical examples.		
Plant Genetics 2	Basics for Quantitative genetics Definitions of qualitative and quantitative traits. Understanding major gene(s) vs polygenic control and inheritance. Analyse variance components of quantitative traits. Definition of heritability and estimates, genetic gain. Introduction to Molecular quantitative genetics and genomic selection. Programme : - From Population genetics to quantitative genetics - The different types of action of genes - Variance components of quantitative traits - Factors affecting heritability and methods of estimation - Consequences for selection methods - Response to selection and breeder equation - General and specific combining abilities - Association of DNA polymorphisms with phenotype variations of quantitative traits - Linkage disequilibrium - Genetic mapping and QTL detection - Marker assisted selection - Genomic selection - Incidence of polyploidy	No prerequisites	**5**
Seed and plant production and certification regulation guidelines	Importance of quality in seed and plant development and production. Notion of seed and plant certification. Comparison of certification processes and practical achievement in different regions. Program : - From practical examples, lectures and visits of official institutes (SNES, GEVES) and private companies, students will learn importance of physiological quality, sanitary conditions and genetic conformity for seed and plant productions. - Internal and official inspections guarantee quality for customers and are required for international exchanges. We will review some processes and analyse current national and international regulations, and their limits.	No prerequisites	**4**
INTERNSHIP + Minor Thesis	The minor thesis internship takes place in a company or research institution. It will familiarize student with a seed company and breeder position. Student have to make a minor thesis report.	Courses of Semester 1 and 2	**5**

Semester 1 SLU

SEMESTER 1 SLU	Description, contents, learning outcomes	Prerequisites	ECTS
Plant growth and development, (Uppsala University)	The course will focus on mechanisms that regulate the different phases of plant development at the molecular, cellular and organismal levels. It is based on recent research in plant physiology, molecular plant biology and developmental genetics. Plant growth and development is genetically regulated but governed in large also by integration of external signals. For example, many species do not flower until they have been exposed to a longer period of cold temperatures. Thus the course will deal with hormones as well as effects of for example light and temperature on plant development, throughout the plant life cycle. The course focuses on mechanisms on the molecular, cell and organism level that control the different phases in the development of the plant such as embryogenesis, germination, vegetative growth and reproductive growth.	120 credits including alternative A)/60 credits biology and 30 credits chemistry or 30 credits earth sciences; alternative B) 90 credits biology.	**15**
Genetic diversity and plant breeding	After completion of the course the student is expected to be able to: - Explain the concept of genetic diversity and how evolutionary processes and domestication affect genetic diversity - Explain concepts of quantitative genetics, breeding methods and regulations for the development of plant varieties - Understand principles of mapping quantitative traits in plant genomes and how to use this as a first step towards the identification of genes controlling phenotypic traits - Broadly explain next generation sequencing technologies and perform basic sequence analyses - Describe different biotechnological applications within plant breeding - Independently search, summarize and interpret literature within the topics covering genetic diversity and/or plant breeding and present this information in writing and orally - Conduct laboratory work to demonstrate genetic diversity at the molecular level, compile the results and write a lab-report. The course deals with issues within evolution, domestication and breeding. More specifically it focuses on different reproductive systems and their breeding strategies, on the use of next generation sequencing technologies to sequence whole genomes and their applications in breeding. Important qualitative and quantitative plant traits will be high-lighted both genetically and phenotypically. Practical exercises are parts of the course including both wet lab, phenotyping of plants and computer exercises. Application of molecular marker systems in selection processes as well as other methods in plant biotechnology constitutes a section of the course besides bioethical aspects. Legislation connected with variety production and the ownership of variety material will be discussed.	Knowledge equivalent to 180 credits including 90 credits Biology and English B from upper secondary school or equivalent. As an alternative to the above, equivalent to 120 credits including 60 credits Biology of which at least 5 credits Genetics and at least 5 credits Plant Biology/Plant Physiology must be included. English skills equivalent to English B from upper secondary school.	**12**
Swedish as a foreign language	The topics range from introducing and telling about oneself to greetings, family, food, shopping, weather and telling the time. The topics also include daily activities, living, transport and the immediate surroundings. The aim is to introduce students not only to the basic structures of Swedish, but also to the Swedish way of life. Simple everyday conversation is practised.	No prerequisites	**2**

Spanish as a foreign language	This language course is targeted at students who chose UPV as Y2 destination and who still need to bring their Spanish to a B2 level for everyday life and professional situations. Students will learn Spanish at the rate of 2 hours per week. In addition to classroom instruction, students will realize interactive assignments. This course is carried out in close collaboration with UPV so as to ensure that the students obtain the language level needed.	B1	**2**

Semester 2 SLU

SEMESTER 2 SLU	Description, contents, learning outcomes	Prerequisites	ECTS
Molecular plant-microbe interactions, (Stockholm University)	The course covers different interactions between plants and microbes, including recognition processes and signal exchange. Applied and ecological aspects of symbioses and pathogen defense are discussed. The use of organismal databases to identify genes involved in interactions will be taught. The course integrates lectures, student seminars, group discussions, method presentations, and laboratory work and data analysis. The course covers the molecular mechanisms that are the basis for both symbiotic and pathogenic interaction between plants and microbes, including recognition processes and signal exchange (bacteria, cyanobacteria, fungi and viruses). The balance between symbiosis and parasitism, as well as applied and ecological aspects of pathogen defense and resistance responses are discussed. The use of organismal databases in the internet to identify genes involved in interactions is taught. The course integrates lectures, student seminars, group discussions, method presentations, laboratory work and data analysis. The course includes the following elements 1) Theory 2) Literature Review 3) research Project	Admittance to the course requires knowledge equivalent to a minimum of 30 credits in Chemistry and a minimum of 90 credits in Biology or Molecular Biology. Additionally, it requires a minimum of 15 credits on advanced level in the area of Molecular Life Sciences. Swedish upper secondary school course English B/English 6 or equivalent.	**15**
Biology and production of agricultural plants	This is a course for you who want to obtain a deeper understanding of the processes that regulate crop yield and product quality and, how they are influenced by cultivation measures, environment and plant material. Through specialisation and synthesis of knowledge in crop production biology you will be trained in your professional role and also for possible third-cycle courses and study programs. The teaching is to considerable part based on project work, both individually and in groups. In the course, literature seminars and one by the student chosen advanced assignment are also included. The course is mainly directed towards crops adapted to tempered climates and offers a specialisation and synthesis of knowledge within crop production science. The course to a large extent gives a basis for continued research within the subject area but also a training of the professional role. In lectures is treated: - Individual crop species and their use, e g to food, feed and energy. - How environmental factors and cultivation measures influence yield in different crops - Experimental methods, planning and interpretation of experimental results Compulsory learning activities: Project work, seminars, study visits and exercises.	Knowledge equivalent to 180 credits of which 90 credits Biology	**5**

Ethics	This course aims to help students develop their understanding of ethical aspects in professional roles and decisions-making. Through this course students will develop their: - Theoretical framework for explaining ethical dimensions in professional and personal decisions, - Awareness of different general ethical arguments and perspectives, and - Ability to analyze, present and argue for decision outcomes based on ethical grounds.	Skills equivalent to 150 credits university studies. Skills equivalent to English B from upper secondary school.	**5**
Swedish as a foreign language	The topics range from introducing and telling about oneself to greetings, family, food, shopping, weather and telling the time. The topics also include daily activities, living, transport and the immediate surroundings. The aim is to introduce students not only to the basic structures of Swedish, but also to the Swedish way of life. Simple everyday conversation is practised.	Course in S1	**2**
Spanish as a foreign language	This language course is targeted at students who chose UPV as Y2 destination and who still need to bring their Spanish to a B2 level for everyday life and professional situations. Students will learn Spanish at the rate of 2 hours per week. In addition to classroom instruction, students will realize interactive assignments. This course is carried out in close collaboration with UPV so as to ensure that the students obtain the language level needed.	Course in S1	**2**

Semester 3 UH

SEMESTER 3 UH	Learning outcomes	Contents	Prerequisites	ECTS
Personal Study Plan (PSP)	After completing the study unit, the student has devised an individual plan for the Master's degree studies to be completed and a timetable for their completion	Student prepares a personal study plan where she/he reflects her/his strengths and areas of development, decides aims for her/his studies, and prepares a detailed study plan. A personal study plan can include elements related to career development. Study plan will be prepared independently after which it will be approved by the professor/student adviser on the study track		**0**
Breeding of crop plants (S3 in 2019 and in 2021)	The student will become acquainted with the practical breeding of agricultural and horticultural crop plants	Introduction to the practical breeding of agricultural and horticultural plants. Lectures by expert breeders. Presentations by students.	Basic knowledge in plant breeding or related disciplines.	**5**

Forest Tree Breeding (S3 in 2020)	The student will become acquainted with modern theories and practices in forest tree breeding	Recent results and theories concerning the physiological basis and restrictions of yield production implications for breeding. Patterns of adaptation and variation in forest trees with a special reference to northern environments	Basic course in statistics	**5**
Scientific Writing and Seminar	The student is able to reason using the scientific style of writing through the combination of analysis of a published paper and writing a preliminary version of part of the Master's thesis in an appropriate scientific style. The student can apply the principles of the structure of the scientific paper in his/her own Master's thesis. The student can give an oral presentation in a scientific style on the results she/he has obtained	Analysis of a published paper as a group work. Presenting results in tables, graphs and illustrations. Stepwise preparation of parts of a scientific paper (Introduction, Materials & Methods, Results, Discussion), with feedback from peers. Students will use part of their own MSc thesis data wherever possible, and a sample dataset will be provided for those who do not have their own data. MSc thesis seminars, preparation of an own seminar presentation as well as a task as an opponent in an MSc thesis seminar are included		**5**
Literature	After the course, the student is able to analyze and understand a defined topic of plant and forest breeding and biotechnology. She/he can apply theoretical knowledge to solve problems in the defined subject area	The student will choose a book from the field of plant and forest breeding and biotechnology, in consultation with the responsible teacher. The student will read the book independently, participate meetings and introduce the materials to other participants, seek further information when needed, prepare a learning diary describing the learning process and/or write a short summary of the contents of the book		**4**
Orientation Week	The aim of the orientation course is to familiarize students to the University of Helsinki, the Faculty of Agriculture and Forestry and the student's own MSc programme. After the orientation course the student will have knowledge of the necessary things to begin the studies in the MSc programme. Student is also acquainted with the study environment, the campus, lecture rooms and other important facilities within programme / campus. In addition the student becomes a part of the Faculty community, especially by getting to know fellow students and staff members of their MSc programme	The orientation course is meant for all new students of the Faculty. The course includes info sessions, tutoring sessions and program organized by the MSc programmes		**0**

Plants in Changing World	After completing the course the student • can identify her/his areas of interest in plant science that helps her/him in the selection of the most appropriate courses and course modules for the degree, and also a tentative topic for Master's thesis • gets an overview of plant science from molecules and cells to ecosystems and future plant and forest production • will appreciate the role and importance of basic research for practical applications in the various uses and production of plants • acquires a general view of the research topics and research groups within plant science, that form the Viikki Plant Science Centre at the campus, with a view to Master's thesis	This is a "showcase" course where plant science study modules offered in three Master's Programmes, as well as the respective research activities and groups at the campus, will be introduced. The course encompasses four main themes: • Plant diversity • Plant adaptation • Plant breeding and biotechnology • Changing use and production of plants		**5**

Plant Biotechnology and Molecular Biology	On this course students will acquire the following knowledge and skills • Understand how information encoded in DNA is used to shape the entire life of a plant. • Explain the various regulatory mechanisms in plant gene expression using examples from plant development, hormone or stress signaling. • Recognize the essential role of “next-gen” sequencing in modern plant molecular biology and biotechnology. • Be familiar with various methods to make genetically modified or genome edited plants. • Be able to discuss advantages and disadvantages on the use of genetically modified plants, and to support their opinions based on current legislation and risk assessment. • Produce an English text with arguments for or against the use of genetically modified plants. • Get a working knowledge of various online databases with plant genome, gene expression or other data, and be able to use this information to characterize a new unknown DNA sequence	Lectures will familiarize students with • structures and function of plant genomes • the Central Dogma in molecular biology • regulation of gene expression • molecular biology of *Agrobacterium*-mediated gene transfer • molecular basis of vegetative-reproductive transitions and flower development • molecular biology of hormone and signal transduction in plants • molecular basis of abiotic and biotic stress responses in plants • forest biotechnology • plant secondary metabolism • basics of plant gene isolation methods and gene transfer methods to plants • introduction to various methods in plant molecular biology including genome editing techniques (Crispr-Cas) • basics for legislation and risk assessment of plant biotechnology • introduction to applications and ethics of plant biotechnology • advantages and disadvantages of the use of genetically modified plants • introduction to plant bioinformatics related databases		**5**
Advanced Training in a Research Group	The student is able to work independently in a research group or other working group and knows the principles of scientific reporting of research results	Full-time working in a research group, organization or private company for 1 month. Student has her/his own project where she/he learns the skills required in research or other working group under a guidance of a supervisor. She/he will become familiar with the research question or relevant questions related to her/his tasks by studying the related scientific literature and discussing about them with the supervisor. At the end of working period she/he will write a short report which will be submitted to supervisor together with worksheet		**5**

BLUP and Variance Components (S3 in 2019 and in 2021)	The student would understand the concept of breeding value, utilization of information on relatives and of genomic information in determining similarity among individuals, application of BLUP evaluation modelling for quantitative traits, estimation of genetic variation in important production and longevity traits and students would be capable to perform practical applications with R software	• Variances and covariances of random variables, statistical model, inverse of genetic relationship matrix, genomic relationship matrix, estimation of model parameters, mixed model equations, BLUP applications and genomic breeding value. • Simulation of data, characteristics of (co)variance component estimation methods: ANOVA, Maximum Likelihood, Restricted Maximum Likelihood, Bayesian procedures. • Utilization of genomic information in constructing covariance structures • Many topics are practiced with homework involving R program packages		**5**
Wood Structure, Growth and Differentiation	After the successful completion of the course the student knows • the structure of soft- and hardwoods and growth • many exceptional features of wood • the structure and biochemistry of the cell wall and its biosynthesis • the biotechnological possibilities for the use of woody material and its chemical components • the basic principles in the identification of wood species by their microscopical xylem structure • the making of cryomicrotome sections of woody material and their staining • the manufacture of permanent microscope slide	The central material of the course is the structure of soft- and hardwoods, growth and many exceptional features of wood, and the structure and biochemistry of the cell wall and its biosynthesis. The practical part consists of microscopical analysis of Finnish soft- and hardwoods and their differences as well as sectioning and staining of wood sections to produce permanent microscope slides. The course also includes a demonstration on wood strength properties. Students test bending and compression strength of two tree species and write a test report		**5**

Basic biotechnology applications in forestry	• Appreciation of diverse areas of biotechnology process that are relevant in Forestry • Understand the historical background on applied and modern biotechnology • Develop awareness on how biotechnology can impact on forestry practices in the coming decades • Identify key topic areas that might require immediate or long term intervention with biotechnology tools	• Biotechnology: history, processes and potentials in Forestry: An overview • Forest trees and their microbial partners: The potentials (Phytoremediation, biopulping etc) • Tree Health problems-an overview • Application of DNA/molecular techniques in fungal biodiversity analyses • Endophytes in biotechnology • Biological control: Principles and applications in tree health protection • Forest tree breeding • Fungal Biotechnology: secondary metabolites, lignocellulose bioconversion, first and second generation biofuel • Biodegradation and biodeterioration technology • Tree biotechnology-GM trees (concept, principles and applications) • Ethical and environmental implications of GM-trees: Impact of GM trees on Biodiversity, insect resistance, disease resistance, tolerance to environmental stress, sterility of GM trees, environmental release, regulatory framework, environmental and human health benefit of GM trees, Risk aspects of GM trees to human health and biodiversity • Excursions: to Biotechnology company, forest tree breeding station forest tree nursery etc	Basic background knowledge in forest sciences and biological sciences	**5**
Finnish course	The aim is to introduce students not only to the basic structures of Finnish, but also to the Finnish way of life. Simple everyday conversation is practised.	The topics range from introducing and telling about oneself to greetings, family, food, shopping, weather and telling the time. The topics also include daily activities, living, transport and the immediate surroundings.		*****

Semester 4 UH

SEMESTER 4 UH	Learning outcomes	Contents	Prerequisites	ECTS
Master Thesis	The students know and are able to apply ways of working within the process of scientific research, is familiar with the process of writing, are able to set research questions, find and compose more research, analyze and interpret research data and report the results.	The students orient themselves to the research question, draw up a research plan, determine the appropriate methods to solve questions, interpret the results using the scientific literature in the field, and learn presenting the results in a linguistically acceptable form, orally and in writing.	First year of the Master program	**30**
Laboratory Course in Plant Biotechnology (optional) *	The student will become acquainted with the basic techniques in plant cell culture and gene transfer	The laboratory practicals include relevant techniques in plant cell culture (callus and suspension cultures, haploid cultures, protoplast isolation and micropropagation) as well as techniques related to plant gene transfer methods (agrobacterium-mediated, particle bombardment, electroporation) and assays for gene expression (reporter genes encoding GUS, LUC, GFP)	Course in S3	**5**
Selection Theory (S4 in 2020 and in 2022) (optional) *	After the course students know the concept of breeding value and genetic correlation in quantitative traits. Students understand how to define the breeding goal and how to select for multiple traits simultaneously. Students can predict the selection response in a breeding program and control the risk (rate of inbreeding) in a breeding scheme	Before the course (period I) a possibility to take a briefing in matrix calculus and R-programming. Genetic (co)variances, heritability, genetic correlation, breeding value, breeding goal, total merit index, selection, mating systems, expected genetic response and controlling risk in the selection scheme	Course in S3	**5**
Finnish course	An ability to deal with simple, straightforward information and begin to express oneself in familiar contexts	The main topics are living and home, telling about yourself and your past, and making plans. The following grammar issues are discussed: possessive structure, object case marking, some infinite verb forms, and past tenses. The course includes exercises on everyday conversations.	Course in S3	**

Semester 3 UPV

SEMESTER 3 UPV	Description, contents, learning outcomes	Prerequisites	ECTS
Plant Breeding for resistance to stresses	Description: During the lectures breeding methods and special cases related to: i) viruses, ii) fungi, iii) bacteria, iv) pests and v) abiotic stresses (salt, drought, flooding, low-input conditions, low or high temperatures, etc.) are addressed Contents: Models of host-pathogen interaction. Mechanisms of resistance. Resistance genetics. Durability. Specific strategies and methods for improvement. Programs of improvement according to the source of variation (host, pathogen and others). Economic impact of abiotic stress alterations Physiological effects produced by different types of abiotic stresses. Resistance to water stress. Resistance To saline stress. Resistance to low temperatures. Resistance to high temperatures. Development of Parthenocarpic cultivars. Improvement to other types of stress. Learning outcomes: - Use knowledge in plant pathogen interactions and genetics in breeding programmes for plant resistance to pest and diseases. - Use knowledge in plant physiology and genetics in breeding programmes for plant resistance to abiotic stresses. - Locate, analyse, evaluate and synthesise information relevant to plant breeding for resistance to biotic an abiotic stresses. - Communicate conclusions, and reasons that support them, to specialized and non-specialized audiences in a clear and unambiguous way - Judge which plant breeding methods are appropriate for introducing resistance to plant varieties. - Carry out specific phenotyping activities within the resistance breeding (inoculations, stress experiments, stress response measurements…) - Use biotechnology advances in breeding for resistance Methods: The course will be delivered by the following means: Lectures (using flip teaching methods), case studies, Practical lab sessions, and home work. The assessment will be continuous.	Advanced Genetic analysis	**5**
Breeding for crop quality	Description: Factors involved in the quality of edible plant products and their breeding are studied. Bioactive compounds, cereals´ quality, sugars and acids, organoleptic quality, quality for industry traits (oil yield, fatty acids profile) etc. Contents: Concept of Quality. Components of quality. Organoleptic and nutritional quality. Difficulties in quality breeding. Analytical quality assessment. Genetic regulation of quality. Influence of the environment on the parameters of quality. Mathematical methods and techniques of analysis.	Quantitative genetics Advanced Genetic analysis	**5**

	Specific improvement for different crops. Learning outcomes: - Use knowledge in metabolic pathways and genetics in breeding programmes aimed at increase the nutritional/organoleptic/taste quality of the plants - Locate, analyse, evaluate and synthesise information relevant to quality plant breeding - Communicate conclusions regarding quality breeding, and reasons that support them, to specialized and non-specialized audiences in a clear and unambiguous way - Judge which plant breeding methods are appropriate for improving the plant internal quality. - Carry out metabolites analysis (sugars, polyphenols, vitamins, etc.) - Use biotechnological tools in breeding for quality Methods: The course will be delivered by the following means: lectures (using flip teaching methods), case studies, practical lab sessions, and home work. The assessment will be continuous.		
Tree species breeding	Description: Review of the specific traits, limitations and factors related to tree (fruit) species. Current genomic and genetic tools applied to their breeding. With particular emphasis on the most common ones in Spain: stone fruits a pip fruits, almond and olive trees, loquat, persimmon, and some shrubs. Contents: Methods of improvement in the short, medium and long term. Cloning in the selection and propagation. Design of mating and selection methods. Methods of improvement based on Hybridization and clonal selection. Selection of patterns and grafts. Biotechnology methods in improvement Of tree species. Genetic improvement of forest conservation. Learning outcomes: - Describe methods that are used in tree breeding - Use jointly conventional breeding methods and new biotechnologies to improve tree species - Use of plant genetic resources in breeding programs. - Carry out specific breeding activities, such as selection of parental germplasm, observation and recording of phenotypic variation and selection among progeny Methods: The course will be delivered by the following means: Lectures (using flip teaching methods), case studies, practical lab sessions, and home work. The assessment will be continuous.	Transgenic plants Breeding methods Plant genetic resources	**5**
Ornamental Plants Breeding	Description: Breeding procedures and examples of the most relevant ornamental species: roses, carnation, tulips, lily, cactaceae, etc. Contents: Specific breeding objectives. Generation of variation in ornamentals: intra and Interspecific, mutagenesis, somaclonal variation and others. Clonal propagation. Micropropagation. Methods of improvement. Learning outcomes:	In vitro culture	**5**

	- Describe methods that are used in ornamental breeding - Use jointly conventional breeding methods and new biotechnologies to improve ornamental species - Use of plant genetic resources in breeding programs. - Carry out specific breeding activities, such as selection of parental germplasm, observation and recording of phenotypic variation and selection among progeny. - Formulate and justify a plan for the application of plant breeding methods to achieve a specific objective. Methods: The course will be delivered by the following means: Lectures, practical lab sessions, and home work. The assessment will be continuous.		
Transgenic Plants	GMO technology and procedures. Steps in a GMO. Offspring management. Fields of application of GMOs. Current laws for GMOs. Phases of a genetic transformation program. Techniques usable in the various phases. Factors Conditioners of success. Genetic analysis and descent management. Fields of application of the Transgenic plants. Legislation and experimentation with transgenic plants. Description: GMO technology and procedures. Steps in a GMO. Offspring management. Fields of application of GMOs. Current laws for GMOs. Contents: Phases of a genetic transformation program. Techniques usable in the various phases. Factors Conditioners of success. Genetic analysis and descent management. Fields of application of the Transgenic plants. Legislation and experimentation with transgenic plants. Learning outcomes: - Describe transformation methods used for plant breeding - Formulate and justify a plan for the application of transgenesis in a breeding programme - Use of in vitro culture techniques in plant breeding - Judge the risk of using transgenic plants for human health and the environment - Describe the legal regulations on transgenic plants Methods: The course will be delivered by the following means: Lectures, practical lab sessions, and home work. The assessment will be continuous.	In vitro culture Molecular markers Genome function	**4**

Semester 4 UPV

SEMESTER 4 UPV	Description, contents, learning outcomes	Prerequisites	ECTS

Master Thesis I	During the initial part of the master thesis the student will identify the study crop and the trait to be improved. During this part of the Master thesis the student will collect information, design the experiments and start to grown plants if necessary. As learning outcomes we have: Ability to do scientific and market documentation Ability to design plant breeding experiments/programmes	First year of the master programme	**15**
Master Thesis	During the second part of the master thesis the student will perform and end the experiments and will analyze and report the results in a written and spoken manner. As learning outcomes it can be highlighted: Ability to write scientific reports and present them Ability to follow the scientific method and to use standardized protocols. Ability to perform plant breeding programmes	First year of the master programme	**15**

Semester 3 EgeU

SEMESTER 3 EgeU	Description, contents, learning outcomes	Prerequisites	ECTS
Hybrid breeding	The aim of this course is to provide students with information on genetic principles of F1 Hybrid Cultivar development, to make them understand the basics and practice of new F1 Hybrid variety development, and to teach breeding techniques and methods used in plant breeding. Course content: - Definition, history, significance, aim of F1 hybrid cultivar breeding - Development of segregating populations and pure lines - Analyzing combining abilities - Performing and evaluating dilallel analysis - Developing cytoplasmic-genetic male sterile lines - hybrid breeding for resistance to stress - hybrid breeding for quality - Tissue culture techniques - Recombinant DNA techniques and its applications in F1 hybrid cultivar development	Basic knowledge in plant breeding and genetics	**3**
Vegetable breeding	This is an introductory course designed for students directly or indirectly involved in vegetable breeding. Students who will finish this course are expected to understand the basic principles of vegetable breeding. - Traits of interest. Breeding trends in the past and future. - Designing plant architecture. - Breeders' own knowledge and the need for collaboration. - The flower. Sexually propagated vegetables will be introduced.	Basic knowledge in plant breeding and genetic sources	**4**

	- Inbreeding-outbreeding. Mechanisms leading to outbreeding will be explained and examples given from vegetables and their wild relatives. - Introduction to variability in vegetable crops. Vegetable genetic resources such as wild relatives, closer relatives, domestic landraces will be explained. - Introducing variability. Collection missions and gene banks will be taught. The importance of exotic vegetables will be outlined. A discussion will be made on a production with landraces and old cultivars by considering in-situ, ex-situ and on-farm conservation strategies. - Creating variability. Mutation breeding, hybridization will be outlined as possible sources of variability. - Assessing variability. Observed variability in vegetables will be classified by a hierarchical method. A comparison will also be made between molecular and morphological variability		
QTL analysis	The aim of this course is to teach the principles of genetic mapping in plants, to teach molecular linkage analysis and the use of quantitative genetic mapping in plant breeding program. Content - Meiosis, Mendel's Laws and recombinations - Genetic variations in the populations - Molecular basis of allelic variations - Bulk Segregant Analysis - Mapping populations - Molecular markers - Linkage analysis and software - Principle of quantitative traits analysis - Marker data and phenotypic data for QTL - QTL analysis methods and software	Basic knowledge on molecular markers and genetics	**3**
Fruit breeding/genetics	This course aims to teach genetics and breeding methods in some fruit species - the aim of fruit breeding - Cytology of fruit species - Flower and fertilization biology - Fruit breeding program - Fruit breeding program on stone fruits, pome fruits, nuts, citrus species	Basic knowledge in plant breeding and genetics	**3**
Grapevine breeding/genetics	The aim of the course is to teach the grapevine genetics and breeding. Contents - grapevine genomics - functional genomics, - Breeding for new varieties, and rootstocks - resistance to biotic and abiotic stresses	Basic knowledge in plant breeding and genetics	**4**

Gene Technologies and Biosafety	The aim of this course is to teach the basic principles of plant biotechnology and apply principles of molecular biology/biotechnology in plant production and Biosafety. Content: Gene, genome, Protein synthesis, gene transfer techniques, PCR, recombinant DNA technology, genetic markers, transgenic plant production and analysis, Risks and Benefits Associated with Genetically Modified Plants and Biosafety rules.	Basic knowledge on molecular biology	**4**
Biochemical changes during fruit maturation	Teaching the fundamentals of biochemical changes of fruit development and ripening metabolism. Contents. - Fruit Development And Rıpenıng Metabolism - Fruit Set - Sugar Accumulation And Transport in fruit - Hormonal Control Of Fruit Rıpenıng - Water content in fruit - Potassium - Organic Acids - Nitrogen In Fruits - Phenolics In Fruits - -Amino Acid Composition - pH and Proton Pumps - Polyamines and fruit Set	Basic knowledge on molecular biology and genome function	**3**
Turkish course	This language course aims at providing students with the necessary language tools to interact successfully in everyday life and in basic professional situations. The course takes 12 weeks in a term. Turkish grammar, reading, writing, speaking and listening are offered in the level of A1 (basic level) to C1 (advanced level) every weekday. Contents: Introducing yourself and introducing someone else. Asking questions. Talking about your professional activities. Expressing preferences. Understanding an itinerary. Expressing an intention. Making appointments. Understanding a schedule.	No prerequisites	**2**

Semester 4 EgeU

SEMESTER 4 EgeU	Description, contents, learning outcomes	Prerequisites	ECTS
Master thesis	To enable the graduate student to study with the aims of gathering, assessing and interpreting data to solve a specific problem current in the field in which the student study within ethical limits. Contents Master thesis covers the independent study by the student following theoretical and applied courses under supervision of an advisor. The student surveys, gathers and assesses the data, analyzes the data and presents the outcomes in written manner under supervision of the advisor.	First year of the master programme	**30**

Turkish course	This language course aims at providing students with the necessary language tools to interact successfully in everyday life and in basic professional situations. The course takes 12 weeks in a term. Turkish grammar, reading, writing, speaking and listening are offered in the level of A1 (basic level) to C1 (advanced level) every weekday. Contents: Introducing yourself and introducing someone else. Asking questions. Talking about your professional activities. Expressing preferences. Understanding an itinerary. Expressing an intention. Making appointments. Understanding a schedule.	Turkish Course S3	**2**