emPLANT+
master to sucseed

# COURSE CATALOGUE

# BOKU SEMESTER 3

# emPLANT+ COURSE CATALOGUE

# ERASMUS MUNDUS MASTER PROGRAMME IN PLANT BREEDING

## Contents

# Joint Courses

| JOINT COURSES | Description, contents, learning outcomes | Implementation: |
|---|---|---|
| Pilot case | The pilot case is a case study to apply the project management tools to a breeding program. First students by group o choose a species to be ameliorated. Then, find a character or several as goal for the breeding strategy. After, they check that there is a potential market for this new variety and verify that farmers will want to cultivate it and consumers too (1-week work) To be accomplished during all the first year. Secondly students are going to define the potential market for their product (seeds), but also the market for the new variety (consumers). Thirdly they need to create a structure who is going to breed the new variety, and define the role of each student on the group in this structure (company, association...) | 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. 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 and a second presentation more focused on the breeding schema 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 juries of S1 and S3 will be carried out the same day for logistic reasons. |
| Bio informatics | Biological databases; gene analyses, web-based analytical tools, Unix OS, functional genomics, molecular evolution, RNAseq expression analysis, annotation of new genomes. | 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. |
| Big Data | Clustering, Random Forests, K-Nearest Neighbors Method/ Kernel Methods, Sparse Methods for high dimensional data.<br>Databases (Big data) Management Distributed file systems, Hadoop, Parallel, distributed, massive data processing with Map Reduce<br>NoSQL/NewSQL databases | 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. |

## Semester 3 BOKU – Compulsory courses

| SEMESTER 3 BOKU (30 credits) | Objectives | ECTS |
|---|---|---|
| Molecular plant breeding | Structural genomics and functional genomics; molecular markers/fingerprinting tools: examples of techniques and methods; genetic mapping; transgenic plants; genome editing; mutations and genetic analysis, genome sequencing; QTL mapping, association mapping; marker assisted selection (MAS) and genomic selection (GS) | 3 |
| Molecular plant breeding practical | One-week lab training on: Gene transfer methods using model and crop plants (use of a fluorescent marker protein for subcellular localization; Fluorescence microscopy; Antibody extraction and purification from tobacco leaves.<br>DNA marker applications: DNA extraction; microsatellite markers (SSR); KASP SNP-markers; mutant discovery (TILLING) | 4 |
| Master seminar | Presentation, discussion and supervision of the master thesis projects.<br>The presentation of the master thesis (interim reports, preliminary final reports) will be held at the institute level in the context of regular events (e.g. lab-meetings, tutorials etc.). | 2 |
| Plant breeding - principles and methods | Diversity and mutations in the plant kingdom; propagation systems in the plant kingdom; genes and alleles in populations; genotypes and environments; breeder's selection for single and multiple traits, optimizing breeding selection gain; maintaining and utilizing genetic resources; needs of a plant breeder; breeding in different parts if the world, participatory breeding vs. expert breeding. | 3 |
| Plant breeding - principles and methods - practical exercises | Practical exercises on: mendelian inheritance; selection methods - inheritance and segregation of traits; Hardy-Weinberg equilibrium; phenotype vs. genotype; heritability; test crosses and combining ability; genotype by environment interaction; stability parameters; marker – trait associations. | 3 |
| German as a foreign language | | 3 |

## Semester 3 BOKU – Electives

| SEMESTER 3 BOKU (30 credits) | Objectives | ECTS |
|---|---|---|
| Experimental design and analysis of field and laboratory trials[1] | Work routinely with the R statistical environment (regression analysis, t-test, analysis of variance), perform analysis and understand the results of randomized complete block design (prelude to random blocks), incomplete block designs (augmented designs, α designs, p-rep, row-column designs), multi-factorial trial designs (genotype x environment interaction, split-plot designs, strip-plot designs). Optimization of trial designs (variance components, A-optimality, randomization theory) | 3 |
| Quantitative Genetics for Plant Breeders[2] | Quantitative genetic models, estimation of quantitative genetic parameters, (effects and variances), covariance among relatives, breeding values, combining phenotypes and genotypes, linear models, BLUPs, BLUES, genome wide prediction and selection. | 3 |
| Resistance breeding of crop plants (in Eng.) | Active student participation through student presentations; concepts, terms and definitions in relation to resistance breeding; examples for resistance to facultative pathogens; examples for resistance to obligate pathogens; methods and approaches for the identification of resistance genes; strategies and options for resistance breeding | 3 |
| Molecular mechanisms of fungal virulence and plant resistance | Effector proteins of fungi and oomycetes and their role in virulence; role of fungal secondary metabolites and their mode of action in plants; defense mechanisms in plants, signal transduction and role of induced proteins; Chemical inactivation of fungal metabolites by plant enzymes; novel approaches in fungal and plant genomics and metabolomics | 3 |
| Gene technology for plant pathologists | Use of transgenic plants to improve resistance of plants against pathogens and pests; discussion of the advantages and possible risks of using transgenic plants in agricultural systems. | 3 |

[1] Highly recommended for students who studied their first year at ULS or at SLU
[2] Highly recommended for students who studied their first year at SZIU or at SLU

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| Molecular evolution and phylogenetics | Analysis of high-density sequence data for measuring phylogeny, to assess evolutionary trends, and to study the changes within genomes over time. The lecture will provide insight into the molecular principles underlying the evolution of DNA, proteins and genomes. Different ways how to perform phylogenetic analyses will be discussed. Bioinformatics methods to study molecular evolution will be presented. | 1 |
| Global change and pest management | Climate change – basics, changes in atmospheric CO2, climate scenarios; effects of changes in atmospheric gases, temperature and precipitation on host plants, pests and their interactions; effects of climate change on natural enemies; effects of land use change on population dynamics of pest arthropods and biological control by natural enemies; neobiota as invasive pests – pathways, risk, approaches for control; effects of climate change on invasive pest species. | 3 |
| Plant metabolomics | Fundamentals of modern metabolomics research. The general concept will be illustrated with a practical example study on the metabolism of wheat. The lecture part will cover the basic principles of metabolism and the involved methodology. The practical section will be held in small student groups. You will carry out a complete metabolomics experiment involving plant treatments, sampling and sample preparation, PLC and mass spectrometry, data evaluation; biological interpretation of results | 5 |
| Aspects of product quality in plant production | Criteria of crop product quality; Crop composition (proteins, oils, carbohydrates, fibers, vitamins, toxic components etc.); analytical methods for crop quality determination; breeding for quality characters in selected crop species; environmental implications of crop quality; agronomy and quality;<br>Practical tool: introduction to near-infrared reflectance spectroscopy; breadmaking quality testing; rapid screening methods; molecular genetic methods of quality analysis (protein- and DNA-markers) | 4 |
| Bioinformatics lab rotation | Getting to know bioinformatics research is essential for students who wish to perform their master's thesis in a computational lab. This course gives an overview of the research directions in BOKU bioinformatics groups, and students will “rotate” through three labs. The participating faculty present their work in lectures based on which each student will select labs for carrying out a project. Each project comprises 16 hours of work, consisting of 90% practical work on the computer and 10% report writing. The rotation projects give the opportunity to get a first impression of the actual work in a particular lab and will provide an orientation to the students in which group to conduct their master thesis. | 2 |
| Genetics of diversity | Introduction to biodiversity; measuring genetic diversity; genetic variation and population size; genetic variation and population size – selection, migration, drift; effective population size; population subdivision; relatedness and inbreeding; inbreeding and inbreeding depression; pedigree measures of diversity; units of conservation-phylogenetic relationships; Conservation strategies in farm animal genetic resources; evaluation of genetic diversity using genomic data | 3 |
| Quantitative animal genetics | Simple genetic models (1- and 2-locus); estimation of heritability and genetic correlation in animal population; BLUP estimation of breeding values; QTL - genes of large effect; marker assisted and genome wide selection | 6 |