

Plant genetics, genomics and breeding

International Master of Science (120 ECTS)

2023/2025



Objectives

Plant breeding plays a key role in increasing crop yield and quality, by developing varieties that are adapted to the different environmental conditions, make better use of inputs and are integrated in environmentally and economically viable agricultural systems.

This discipline has evolved to a complex science, integrating new genetic, genomic, molecular, cellular and computer-based tools into classical selection methods. It is therefore necessary to train young professionals and scientists to meet the challenges of the agriculture of the future.

The main objectives of the Master are to provide:

(i) an understanding of the basics and principles of modern plant breeding, including molecular, genomic, phenomic, and biotechnological techniques; (ii) comprehension of the classical selection and breeding methods and criteria to assess the advantages and drawbacks of each according to the characteristics of crop species, the breeding objectives, the environmental conditions and the socioeconomic context; (iii) the skills necessary to integrate in a breeding programme the conventional and the most up-to-date techniques that contribute towards greater efficacy in the selection processes and in the development of new varieties; (iv) competence to design a breeding programme for a given crop species for the conditions of a country or region according specific objectives; (v) an introduction into research, and development of skills and competencies involved.

This Master programme is designed to train professionals in the field of plant breeding by integrating the advanced tools into classical selection methods. The specialization profile of this degree enables students to undertake technical responsibilities in this domain as well as to perform high-level scientific research.



Our innovative multidisciplinary programme trains plant breeding professionals for the future

Organization

The Master is mainly held in Zaragoza and is co-organised by the University of Lleida (UdL) and the International Centre for Advanced Mediterranean Agronomic Studies, in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA) and two Spanish research centres. One of them, the Center for Plant Biotechnology and Genomics (CBGP), has been granted the Spanish accreditation of Severo Ochoa Centre of Excellence. The other, Agrotecnio, belongs to the Catalan i-CERCA network of Centres of Excellence in Catalonia.

Why this MSc is unique

1. The students of today will be the professionals of 2050. The growing demand for food in the twenty-first century highlights the need to train specialists that can apply knowledge of genomics to guarantee a healthier and more sustainable food production.
2. An innovative programme that integrates the most advanced tools of plant genetics, data science for plant breeding, bioinformatics, structural and functional genomics, linkage maps and GWAS, marker enable prediction and selection and phenomics and analysis of omics data.
3. A multidisciplinary programme delivered by more than 80 highly qualified professionals from 13 countries, selected for their expertise.
4. A comprehensive teaching system combining lectures, practicals, individual and group work as well as visits to companies and research centres.
5. Introduction to research with a Master's thesis carried out in reputed institutions.
6. A multicultural environment shared with students and lecturers from over 30 countries.
7. An opportunity to establish a network of contacts and collaboration, a clear differentiating advantage in the professional field.
8. Official Spanish Master degree awarded by the UdL and Master of Science Degree awarded by CIHEAM. Postgraduate Specialization Diploma awarded by CIHEAM upon completion of the first year.
9. This Master is perfectly aligned with the SDGs.

Programme

1st year of the Master (60 ECTS)

The **first year** of the programme has a professional orientation and includes lectures, practicals, study, individual and group projects, and technical visits.

Unit 1: Agricultural systems and plant breeding (4.5 ECTS)

Historical perspective of agriculture and plant breeding. The plant breeding framework. Introduction to agricultural systems. Big data and digitalization in agriculture. Physiological determinants of crop production. Agriculture and climate change. Environmental characterization and crop modelling.

Unit 2: Plant genetics (6 ECTS)

Plant reproduction system. Genetic structure of plant populations. Genetic diversity and the domestication of crop plants. Detecting genetic diversity. Linkage analysis and genetic mapping. Essentials of quantitative genetics (D, R, H², breeding values). Gene identification and validation: forward and reverse genetics.

Unit 3: Structural and functional genomics (3 ECTS)

Plant genome sequencing, Genome structure. Reference genomes. Pangenomes. Transcriptomics and functional genomics.

Unit 4: Introduction to data science for plant breeding (7.5 ECTS)*

Scripting (BASH, R, Python). Experimental design. Introduction to multivariate methods. Genotype x environment interaction: adaptation, stability and resilience. Selection theory.

Unit 5: Bioinformatics (3 ECTS)*

Bioinformatics resources and databases. Data filtering, imputation, phasing, formatting and exporting. Alignment and mapping. Variant calling and effect prediction. Comparative genomics: orthology, collinearity.

Unit 6: Breeding methods and variety development (12 ECTS)*

Breeding methods. Germplasm diversity and development. Legal aspects of plant breeding. In vitro techniques. Double haploids. Juvenility management. Genetic transformation technologies.

Unit 7: Marker enabled prediction and selection (6 ECTS)*

IBD, IBS, genetic distance, population structure. QTL mapping and GWAS (estimation of positions and allelic effects). Evaluation of selection strategies. Cross validation, prediction error, training-test set construction. Penalized regression, ridge, GBLUP, Lasso. Dimension reduction, PCR, PLS. GxE, QTLxE, factorial regression, selecting environmental covariables for predicting phenotypes. Genomic prediction and GxE, genomic prediction for genotypic intercepts and sensitivities, Jarquin approach (double ridge); environmental classification, subdividing TPE.

Unit 8: Phenomics and analysis of -omics data (3 ECTS)*

Introduction to Phenotyping. Introduction to HTP data indoor & outdoor phenotyping. Data annotation and organization. Phenotyping VL – Spectral data LAB. Choosing the design for phenotyping experiments: Procedure and examples of indoor experiments designs. Feature extraction. Correcting for design factors and spatial modelling. Modelling dependence on environment gradients. Target trait prediction. Integrating phenotyping, machine learning, crop growth, modelling and satellite imagery in plant breeding programs.

Unit 9: Applied breeding programmes (9 ECTS)

Breeding crops on a climate change framework. Breeding for abiotic stress. Breeding for biotic stress. Quality and novel traits. Case studies: Maize, Winter cereals, Vegetables, Fruit trees.

Unit 10: Individual Project: Design of Plant Breeding Programmes (6 ECTS)

Individual design of a plant breeding project chosen by the student. This training activity provides the student with practical experience on planning breeding programmes with certain objectives and which respond to specific agronomic, environmental, social and economic conditions, by applying the principles and methodology presented throughout the different units of the course.

2nd year of the Master (60 ECTS)

The **second year** of the Master consists of tutored initiation to research or to professional activity in collaboration with governmental institutions, universities, research centres, ONGs, associations and private firms. CIHEAM Zaragoza coordinators will provide information about the activities of the centres where students will carry out their projects for a duration of 10 to 12 months. Students will choose a topic of their interest. They may also propose a project upon agreement with the host centres.

Unit 11: Introduction to research (30 ECTS)

Soft skills (6 ECTS) and Practicum (24 ECTS)

Unit 12: Master thesis (30 ECTS)

***Units 4 to 8 are also open for applicants who wish to take one or several units as independent modules and participants can attend face-to-face or online.**



Admission

The Master programme is targeted to graduates of agronomy, forestry science, biology, biotechnology and other related subjects. Basic knowledge of plant biology, genetics, genomics and statistics will be required and applicants should accredit B2 level of English.

The first part of the Master is held in morning and afternoon sessions.

Candidates must apply online at the following address: www.admission.iamz.ciheam.org

Dates and deadlines

The first year of the Master will be held from 2 October 2023 to 14 June 2024.

The second year will begin in September 2024 for a duration of 10 months.

Application deadlines* are as follows:

- Candidates that request a scholarship: 2 May 2023
- Candidates that do not request a scholarship or need a visa: 15 September 2023

*Non-European candidates should be aware of visa application deadlines.

Registration and scholarships

Registration fees are 1252,06 euro for each academic year of the Master. This amount covers:

- A) Cost of credits enrolled: 1107,6 euro*
- B) Administration fee: 144,46** euro

*This price is indicative and may vary ** official prices for credits of Master postgraduate programmes and determined at the UdL.

**This price includes records management, learning support service and compulsory insurance cover.

Candidates from CIHEAM member countries (Albania, Algeria, Egypt, France, Greece, Italy, Lebanon, Malta, Morocco, Portugal, Spain, Tunisia and Turkey) may request a scholarship to cover registration fees, accommodation and travel. Candidates from other countries seeking finance should apply directly to other national or international institutions. Preference will be given to non-European countries.

Degrees

- Postgraduate Specialisation Diploma (60 ECTS)
- Master of Science from the CIHEAM (120 ECTS)

More info:

www.masterplantbreeding.com



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