

Plant Breeding

Organized by

Mediterranean Agronomic Institute of Zaragoza

Plant Breeding

Jointly organized by: **CIHEAM-IAMZ and University of Lleida (UdL)**
Scientific coordinator: **Prof. Dr. Ignacio Romagosa**
IAMZ coordinator: **Dr. Ramzi Belkhodja**

The programme is held every two years. Next edition starts in October 2010.
This Master is also an official Master of the Spanish University system.

Aims: 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 into environmentally and economically viable agricultural systems. This discipline has evolved to a complex science, integrating molecular and cell biology and informatics tools into classical selection methods. It is therefore necessary to train young professionals and scientists to meet the challenges of future agriculture.

Learning outcomes:

- To understand the basis and principles of modern plant breeding, including new quantitative and molecular tools like genomics.
- To know the relevant methods and techniques contributing to a greater efficacy of the processes of selection and development of new varieties.
- To be able to integrate the different components of a breeding programme and to assess the advantages and drawbacks in the use of different strategies and methods, from a perspective of crop productivity, safety and quality improvement, and assuring the sustainability of agricultural systems.
- To know how to design, develop and assess breeding programmes in different situations and environments, according to the available materials, the established objectives and the agronomic, environmental and socioeconomic conditions.
- To assume the responsibility of planning and carrying out, under the supervision of a tutor, but in a manner that must be largely autonomous, a work of initiation to research in plant genetics and breeding, whose results may be potentially publishable.
- To prove knowledge of the scientific and technical information underpinning the research conducted, command of the techniques and methodologies relevant to such research, and capacity to objectively evaluate the significance of its results and conclusions.
- To know how to communicate the reasoning and conclusions of tutored works carried out in a group or autonomously, to develop skills in the preparation of informative and synthetic documents, and to acquire experience in the preparation and presentation of oral communications delivered and defended before an audience.

Part 1

Postgraduate specialization programme

The programme is organized in 9 Units (60 ECTS)

Unit 1

04-15 Oct. '10

PLANT GENETICS AND VARIABILITY (4 ECTS)

Content:

Historical perspectives of plant breeding
Plant reproduction systems
Plant genetics: from meiosis to gene structure
Plant genetic resources

Learning outcomes:

- To analyse the historical evolution of plant breeding, knowing which have been the key scientific and technical advances that have influenced its development or accelerated its results.
- To know the different plant reproduction systems, how they affect genetic variability and how they condition the strategies and processes of selection and breeding.
- To gain further insight into the genetic basis supporting plant breeding, from the individual gene to the complete genome.
- To consider the importance of plant genetic resources as a source of variability in plant breeding programmes, and to know the appropriate processes for their collection, conservation, evaluation and use.

Unit 2

13-26 Oct. '10 and
11-14 Jan. '11

STATISTICAL METHODS (5 ECTS)

Content:

Statistics and experimental design
Regression analysis
Genotype x Environment interaction

Learning outcomes:

- To know the statistical principles relevant to data analysis in plant breeding programmes.
- To adequately use the statistical methods, particularly those of experimental design and linear regression, to be able to interpret the results correctly.
- To be familiar with the operation of the computer software useful for statistical analyses.
- To gain practical experience in the analysis and interpretation of real data from experiments common to plant breeding.
- To assess the importance that genotype by environment (GE) interaction has as determinant of the adaptation properties of varieties to be developed in a plant breeding programme, and to be acquainted with the different GE analysis models, knowing how to interpret their results.

Unit 3

25-29 Oct. and
08-26 Nov. '10

QUANTITATIVE GENETICS AND GENETIC ANALYSIS (10 ECTS)

Content:

Population genetics
Components of variation
Response to selection
Molecular markers, gene mapping and QTL

Learning outcomes:

- To know how to determine the genetic structure of a population, to be aware of the changes that can be produced in it throughout time, and to know how to calculate the genetic distance between populations.
- To be able to assess the available phenotypic and genotypic variability and to determine which are the components of variation.
- To have a good command of the genetic basis of selection, and to know the different methods for simple-, correlated-trait- and multi-trait selection.
- To be familiar with the different types of molecular markers most used in genetic studies, and to gain experience in the construction and comparison of genetic maps.
- To understand the main applications of molecular markers in genetic studies and breeding programmes.
- To gain practical laboratory experience in DNA extraction and in the use of marker analysis methodology.
- To develop skills in the use of computer software for development of microsatellites, construction of genetic maps, interpretation of marker results and detection of QTL.

Unit 4

29 Nov.-03 Dec.
and
13-17 Dec. '10

SELECTION STRATEGIES AND VARIETY DEVELOPMENT (6 ECTS)

Content:

Pure line breeding
Population breeding
Hybrid breeding
Clone breeding

Learning outcomes:

- To know the different types of commercial crop varieties and the characteristics common to each of them.
- To analyse the factors determining the selection strategy to be applied to a particular breeding programme.
- To have a good command of selection methods, and to develop criteria to determine their appropriateness according to the breeding objectives, the crop reproduction system, the traits to be bred and the environmental conditions.
- To gain further insight into the particularities of the processes of breeding and development of new pure lines, populations, hybrids and clones.

Unit 5

17 Jan.-
04 Feb. '11

SPECIFIC BREEDING METHODS (5 ECTS)

Content:

In vitro techniques
Mutagenesis
Marker-assisted selection
Interspecific and intergeneric crosses

Unit 6
14 Feb.-
04 Mar. '11

Learning outcomes:

- To be familiar with the different *in vitro* culture techniques, to understand their application at the different stages of a breeding programme, and to gain practical laboratory experience.
- To assess the practical achievements of mutagenesis in the development of new varieties and materials of interest in genetic studies, and to know the methods to induce artificial mutations and the molecular bases of resulting changes.
- To gain further insight into the application of molecular markers in selection, as a tool contributing to assist new variety development.
- To know the *in vivo* and *in vitro* procedures and techniques used in interspecific and intergeneric crosses, and to assess their use in the transfer of genes of interest.

APPLICATION OF GENOMICS TO PLANT BREEDING. PLANT TRANSFORMATION (6 ECTS)

Content:

Plant genomes
Gene discovery
DNA sequence diversity
Genome databases and bioinformatics
Tools for dissecting complex traits
Plant transformation

Learning outcomes:

- To know the objective of genome analysis projects of certain model plant species, and the possibilities offered by their comparison with other important agronomic species.
- To understand the interest to identify genes, isolate them, determine their function and control their expression.
- To know how to identify genetic variability, locating gene regions linked with traits of interest for breeding, and determining the connexion between phenotypic and genotypic variability.
- To gain experience in the use of different available genomic databases and of the computer software specific to genomic analyses.
- To know how to apply classical and advanced tools for QTL analysis and for location and identification of complex traits of breeding interest.
- To gain further insight into the use of genetic transformation to obtain transgenic varieties resistant to particular biotic and abiotic stresses, varieties of superior end-use quality, especially nutritional, and molecules of industrial or pharmaceutical value, and to assess the advantages and drawbacks of the application of this methodology from a technical and social point of view.
- To be able to integrate these genomic advances in conventional breeding programmes to obtain specific objectives and enhance the efficacy of programmes.

Unit 7
14 Mar.-
01 Apr. '11

BREEDING FOR SPECIFIC OBJECTIVES (8 ECTS)

Content:

Abiotic stresses
Biotic stress
Compositional traits and added value

Learning outcomes:

- To know the causes determining crop stresses produced by abiotic factors, particularly drought and high temperatures, their physiological and biochemical grounds and crop adaptation mechanisms for these types of stress.
- To be familiar with the main types of crop pests and diseases, and to understand the plant-pathogen interaction, the diverse resistance mechanisms developed by crops and the genetic basis of such resistance.
- To understand, by means of case studies, the features determining crop and product quality, the components of such quality and the factors influencing it.
- To evaluate possible breeding strategies to obtain varieties of superior quality, resistant or tolerant to particular abiotic stresses, pests and diseases, by selecting appropriate quality/resistance sources, using adequate methods and techniques and incorporating genomic tools.
- To gain practical field and laboratory experience in measuring physiological parameters related to abiotic stresses, inoculating and interpreting infection results and assessing quality characters.

Unit 8

11-14 Apr.,
03-13 May and
23-May-
03 June '11

REVIEW OF APPLIED PROGRAMMES AND SEED AND PLANT PRODUCTION (9 ECTS)

Content:

Maize breeding
Wheat and barley breeding
Pepper breeding
Fruit tree breeding
Commercial seed and plant production

Learning outcomes:

- To widen the experience in the application of strategies, methodologies and techniques through the study of a series of cases concerning current breeding programmes of crops of interest.
- To contrast possible differences between strategies used in breeding conducted by public organisms and that carried out by private firms.
- To know the national and international legislation concerning registration of new varieties and the protection of intellectual rights, in particular breeder's rights.
- To be familiar with the procedures of production of certified seeds and plants, with seed processing and with the functioning of the seed marketing sector, as the final part of the breeding process.

Unit 9

4 Oct. '10-
10 June '11

DESIGN OF A PLANT BREEDING PROGRAMME (7 ECTS)

Content:

Throughout this first part, participants carry out an individual project of a breeding programme on a plant species of their choice applied to the specific conditions of their country of origin

Learning outcomes:

- To apply the principles and methodology presented throughout the different parts of the course to tackle the design of a breeding project of a certain crop according to the particular environmental and socioeconomic conditions and taking into account the established objectives.
- To develop skills in the search for technical and scientific information, as well as in its selective treatment.
- To be able to define and integrate the different components of a breeding programme and to plan its implementation, critically assessing the various traditional and molecular alternatives available.
- To develop skills in the preparation of documents of synthesis and in the presentation of results.
- To gain experience in the preparation and delivery of oral communications and in their public defence.

EXAMINATIONS

Participants take 7 written examinations, each unit being independently graded. Examinations are equally distributed over time. Written exams consist of a set of questions that require a concise answer. Some of the questions are multiple choice. Lengthy questions are avoided

Participants may retake failed exams once.

Participants present also written practical exercises in groups for the evaluation of the subjects "Genotype x Environment interaction" and "Fruit tree breeding" that complement the written examination on the corresponding unit. To evaluate the subject "Pepper breeding" participants present individual written reports on the greenhouse practicals. To evaluate Unit 9, participants must elaborate a written document that is presented and defended orally before a jury for its qualification.

LANGUAGE OF INSTRUCTION

The working languages are English, French and Spanish. Lecturers can teach in any of the three languages. Simultaneous translation into Spanish is provided when lecturers speak English or French, therefore participants should prove knowledge of Spanish at the start of the course. From the beginning of July to the end of September IAMZ organizes an intensive course of Spanish for those who require it. Participants can answer the exams in Spanish, French or English. In the selection of candidates, knowledge of English and French is nevertheless valued, as part of the documentation distributed may be written in either of these languages.

ACADEMIC STAFF

More than 65 invited lecturers from about 10 countries participate in each edition of the M.Sc. programme of which, 53% come from Research Centres, 35% from Higher Education Institutions, 9% from Private Companies and 3% from International Organizations.

Part 2

The Master of Science thesis

Project (10-12 months duration, 60 ECTS)

This part is organized in 2 Units

INTRODUCTION TO RESEARCH (30 ECTS)

The aim of this unit is to provide the prior knowledge, skills and attitudes necessary to carry out a research project in a particular topic in the speciality of plant breeding.

Learning outcomes:

- To improve skills in the search for information, as well as in its selective and systematic treatment.
- To develop criteria for defining the objectives of a particular research study.
- To know how to plan the research work in order to best achieve the objectives set and to optimise time.
- To develop skills in the use of techniques and methodologies relevant to the execution of a research project and to discern the advantages and disadvantages of each one for each particular project.
- To know how to integrate knowledge and to learn how to analyse and contrast results.
- To value the guidance received to plan and develop a research work, fostering dialogue, criticism and capacity to work as a member of a team.
- To develop skills for self-directed learning and autonomous work.
- To improve the capacity of response to unforeseen situations and the ability to reorient a research if need be.

MASTER THESIS (30 ECTS)

The aim of this unit is to apply previous education received throughout the Master programme to carry out original research in the topic chosen in the previous unit, that concludes with the elaboration of a written thesis.

Learning outcomes:

- To be able to apply previously acquainted knowledge, methods and techniques in a discerning manner.
- To develop skills in the analysis of problems and in the definition of objectives.
- To know how to design the diverse experiments included in the research project correctly.
- To be competent in data collection and analysis according to a pre-established research protocol.
- To gain experience in the analysis of results and the elaboration of conclusions that may contribute to clarify and find possible solutions to problems.
- To develop skills in the synthesis and presentation of contents and in the preparation of scientific texts.
- To gain practice in the preparation and presentation of oral communications and in their public defence.
- To acquire attitudes to favour exchange and collaboration with other researchers and professionals.

Research work is carried out in well-recognized institutions (universities, research centres or firms), generally throughout Spain or in the participant's country of origin, under the scientific supervision of a thesis director that must be a doctor of renowned prestige. Participants choose the topic according to their interest of training, which is approved by a Committee. If the participant so requires, the organizing institutions advise on the choice of the most appropriate thesis director and institution to carry out the desired project, and likewise propose topics related to their research activities or other topics of interest previously accorded with other institutions.

The assessment of acquired competences for both units is made by an examining board composed of representatives of the organizing institutions and external members selected

in each case for their expertise and prestige in the field of the research work. For the first unit, this assessment is based on: (i) an oral examination by the examining board; (ii) the evaluation done by the thesis director on the performance of the candidate; and (iii) the evaluation based on the reports presented periodically by the participant, with the support of the thesis director, on the development and progress of the research work. For the second unit, assessment is based on quality of the thesis and on its public presentation and defence.

Research activities: most common topics for Master of Science theses

- Application of genomics and other new technologies to variability characterization and crop breeding (marker/QTL analysis, genetic transformation, gene expression, mapping)
- Study of quality traits
- Pest/disease resistance
- Physiological factors related to crop yield
- Variety performance in particular environments

INDICATIVE MASTER THESES REALIZED WITHIN THE AREA

1. **Title:** Analysis of genetic diversity in a collection of Spanish autochthonous populations of *Brachypodium distachyon* and its evaluation as base material for pure line breeding and biotechnological applications (2008)
Author: Rifka Hammami, Agronomist, Tunisian
Place of realization: Departamento de Biología Celular y Genética, Universidad de Alcalá de Henares, and Departamento de Medio Ambiente, SGIT-INIA, Madrid, Spain
Thesis directors: Nicolas Jouve, Juan M. González Triguero and Consuelo Soler
2. **Title:** Effects and type of action of alleles of some vernalization and photoperiod genes in barley (2008)
Author: Abderrahmane Djemel, Agronomist, Algerian
Place of realization: Departamento de Genética y Producción Vegetal, Estación Experimental de Aula Dei, CSIC, Zaragoza, Spain
Thesis directors: Ana M. Casas and Ernesto Igartua
3. **Title:** Linkage map construction for Albacete x Barberousse DH population in barley (*Hordeum vulgare* L.) (2008)
Author: Alba Farré, Biotechnologist, Spanish
Place of realization: Departamento de Producción Vegetal y Ciencias Forestales, Universitat de Lleida, Spain
Thesis directors: Ignacio Romagosa and Hans Jansen
4. **Title:** Temporal and spatial variations in the transcriptome of maize scutellum during germination (2007)
Author: Hédia Tnani, Agronomist, Tunisian
Place of realization: Laboratorio de Genética Molecular Vegetal, Consorcio CSIC-IRTA, Instituto de Biología Molecular, Barcelona, Spain
Thesis director: Carlos M. Vicent
5. **Title:** Search for molecular markers linked to incompatibility in the Cristobalina cherry variety (2007)
Author: Ariana Mariela Cachi, Biotechnologist, Argentinian
Place of realization: Unidad de Fruticultura, Centro de Investigación y Tecnología Agroalimentaria, Diputación General de Aragón, Zaragoza, Spain
Thesis director: Ana Wunsch

Detailed additional information, in particular an analytical syllabus, is available in “ECTS information package” at IAMZ web site (www.iamz.ciheam.org/en/pages/paginas/pag_formacion8.htm)