# .Plant Genomics for Sustainable Agriculture

## Prof. Matteo Busconi

***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

COURSE AIMS AND INTENDED LEARNING OUTCOMES

The course consists of 6 ECTS (42 hours) of frontal lectures and 2 ECTS (24 hours) of tutorials. The course is divided into 5 large macro areas designed to provide students with information and knowledge on the genetic improvement of plants, specifically: 1) Origin of cultivated species and Biodiversity; this area will focus on the domestication process of cultivated species, on biodiversity generated by the domestication process, and on how to preserve it for genetic improvement purposes; 2) Genetic improvement of mainly autogamous species and mainly allogamic species; the principal classical breeding methodologies developed after the rediscovery of genetics, starting from the early 1900s, will be presented; 3) In vitro cultures and propagation by regeneration of plants on artificial substrates; the different applications of in vitro cultures in support of plant genetic improvement will be presented; 4) Classical and new generation (NGS) DNA analysis methodologies. Development of molecular markers. Identification of genes useful for the varietal improvement process. Genomic selection and genetic improvement for resistance to biotic and abiotic stress; 5) Elements of genetic engineering, genetically modified plants (GMP) and Genome Editing; GMOs, methodologies for their development, legal aspects and answers to the main fears related to these varieties will be introduced. The most recent genetic modification approaches will be introduced, with particular reference to Genome Editing (CRISPR-Cas) and Cisgenesis.

With regard to the tutorials, 8 hours will be dedicated to educational visits to companies involved in plant genetic improvement through the application of DNA analysis, and 16 hours will be dedicated to practical laboratory activities during which DNA extraction, evaluation of the extracted DNA, and analysis by PCR and molecular markers for the evaluation of plant biodiversity will be performed.

INTENDED LEARNING OUTCOMES

At the end of the course, students will be able to:

1) Have a general picture of the genetic improvement of plants and its importance for the development of new cultivated varieties suitable for increasing the sustainability of agriculture;

2) Know that genetic improvement is actually an ancient practice that started with the domestication of cultivated species;

3) Explain why biodiversity is important and why it is essential to preserve it;

4) Explain why DNA analysis is not only a theoretical discipline but one with a high practical value, as it is fundamental for more efficient genetic improvements;

5) Explain what GMOs are and respond in a debate to the main fears and concerns about these varieties, and know the most modern approaches to modifying the plant genome without creating a GMO;

6) Select the most suitable classical methods of genetic improvement according to the pollination methods of the species to be improved.

COURSE CONTENT

|  |  |
| --- | --- |
|  | ECTS |
| Origin, domestication and evolution of cultivated species. Plant genetic biodiversity | 1.0 |
| Origin, domestication and evolution of cultivated species. Genetic erosion. Conservation of plant biodiversity. Valorisation of local varieties. Genetic structure of populations of: apomictic species and vegetative propagation; autogamous species; allogamous species. |  |
| Genetic improvement of autogamous and allogamous species | 1.5 |
| Genetic improvement in predominantly autogamous (biotic stress resistance) and allogamous species. Multiline varieties. Varietal constitution in allogamous species. Synthetic and hybrid varieties. Incompatibility. Male sterility: use of male sterility. QTL analysis. Marker assisted selection (MAS). |  |
| In vitro cultures | 0.5 |
| Micropropagation. Corn and cell suspension cultures. Somaclonal variation. Somatic hybridisation. Haploid plants. |  |
| Genome analysis and applications in plant genetic improvement | 1.5 |
| Classical methods of DNA analysis and development of molecular markers. New generation methods of genome analysis. Identification of genes useful for genetic improvement. Genomic selection. Improvements for abiotic and biotic stress resistance. |  |
| Genetic engineering and Genome Editing | 1.5 |
| Recombinant DNA technology. Sequencing. Induced mutagenesis, transgenic plants. Stable and transient transformation. Genome Editing (CRISPR-Cas) |  |
|  |  |
| Tutorials |  |
| Practical tutorials in the laboratory and educational visits to research centres. | 2.0 |

READING LIST

Barcaccia G. and Falcinelli M. *Genetica e genomica*. Vol 2 Miglioramento genetico, Vol 3 Genomica e Biotecnologie genetiche. Liguori Editore, Naples, 2012.

Lorenzetti F., Albertini E., Frusciante L., Rossellini D., Russi L., Tuberosa R., Veronesi F. Miglioramento genetico delle piante agrarie, Edagricole, 2018

PowerPoint presentations will be made available during the course at the beginning of each new macro area.

TEACHING METHOD

1) Theoretical frontal lectures and dialogues in the classroom, during which the key concepts of classical and modern plant genetic improvement will be presented;

2) Laboratory tutorials, during which an analytical experiment will be carried out on plant biodiversity, beginning with DNA extraction, then PCR reactions, and final an evaluation of the results;

Educational visits to two areas of interest for plant breeding: a) ISI Sementi, an Italian company engaged in the establishment of new varieties of vegetables through the integration of classic and innovative breeding approaches; b) CREA Research Centre for Animal and Plant Genomics and Post-Genomics (GPG) in Fiorenzuola d'Arda, to investigate the genetic improvement of cereal crops with particular reference to barley.

ASSESSMENT METHOD AND CRITERIA

An oral exam in the form of an interview, which will be used to evaluate the student's knowledge in relation to the subjects taught. The exam consists of three questions on the main topics presented in class. This interview will be structured to cover the entire range of course topics in a representative way. Each question will be assigned a mark from 1 to 10. The mark attributed to each answer will depend, in addition to the level of knowledge shown, on the student's presentation clarity, appropriate use of specific terminology, and ability to reason on the topics being discussed.

NOTES AND PREREQUISITES

Participation in lectures and tutorials is highly recommended.

For a correct understanding of the course contents it is important, but not fundamental, that students have taken a course in basic genetics during their Bachelor's Degree.

Information on office hours available on the teacher's personal page at http://docenti.unicatt.it/.