Graduate level Course

HOS 6932 Survey of Breeding Tools and Methods

Graduate Level – 3 credit hours

Spring 2025

Coordinator Instructors:

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Module Instructor:

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- Dr. Esteban Rios: **estebanrios@ufl.edu**

Teaching assistants:

Office Hours: By appointment only. Email the instructor or teaching assistant

Location and time: Tuesday, period 2 (8:30 AM – 9:20 AM), Blueberry Building classroom 154.
Thursday periods 2 - 3 (8:30 AM – 10:25 AM), Blueberry Building classroom 154.

Zoom: For students and co-instructors in RECs, and for students not able to attend in person before authorization by the instructors. LINK will be share before classes start.

Prerequisite Basic knowledge of physiology, genetics, plant breeding and plant biology reproduction is required for all modules. Basic statistics and experimental design will be required for some modules.

Course Description

This course provides a short review of some important methods and techniques used in plant breeding. The intent of the course is to help students understand the breadth of disciplines in plant breeding. These will be taught by experts using these techniques and methods in their breeding programs. Frequent evaluations by topic will occur during the semester. Students are required to attend classes physically.

Intended Audience

The course is designed for graduate students working in plant breeding (e.g. agronomy, horticulture, environmental horticulture, and forestry), or any student in biological science who wants to deepen his/her knowledge about the methods and techniques and their applications in plant breeding.

Course Objectives

The course goal is to familiarize students with the application of diverse techniques used in plant breeding for cultivar development. By the end of the semester students should be able to acknowledge the existence and describe the methods cover in class. Students should be able to describe the advantages and disadvantages of the different methods covered in the course. Students should also be able to identify what method and what strategy should be applied depending on the crop species, the breeding goals, the population and the timeframe.

Evaluation

The evaluations for the student participation and performance will be determine by each of the instructors and communicated at the beginning of the section. These might include quizzes (in class or out of class), take-home exams, projects, hand-on activities, as well as paper discussions among others. Student feedback will be provided in writing and/or in class review of the responses.

Points	Type	Topic
11	Quiz	Plant Breeding
13	Quizzes	Genomic Selection
11	Quizzes	Artificial Intelligence
13	Quizzes	GS and Environmics
13	Quizzes	Phenomics
13	Quizzes	Chromosome Manipulations
13	Quizzes	Marker Assisted Selection
13	Quizzes	Gene Editing
100	**TOTAL**	

Letter Grade
A >90 B+ 85 to 89 B 80 to 84 C+ 75 to 79 C 70 to 74 D+ 65 to 69 D 60 to 64 E < 60

UF grading policies: https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Evaluation Description

Each module will be evaluated by quizzes, projects, and tests of material covered in class. Quizzes at the beginning of the class will last the first 5 min of the class. Feedback will be given usually the following class or the following week after the evaluation is performed.

Software
For some of the modules, you will need to bring your own laptop. The main software used will be the statistical software R which can be downloaded from www.r-project.org. **and** R-studio http://www.rstudio.com/. It is your responsibility to make sure that your computer has the latest version of R. Prior to the first day of class, please make sure you have removed all old versions of R, and have the most recent version installed.
There are numerous online resources available for R; however, if you would like a traditional textbook, The R Book, is widely available and comprehensive.

Crawley, M. J. (2012). The R book. John Wiley & Sons.

Required and Recommended Literature
This course does not have required nor recommended textbook.

Course Schedule and Topics (Tentative).

Week of semester Month/day	Module #: General Topic Description – Instructor in charge
Wk 1 01/14; 01/16	M0: Introduction, Plant Breeding – Dr. Patricio Munoz
Wk 2 01/21; 01/23	M1: Quantitative genetics and genomic selection – Dr. Felipe Ferrao
Wk 3 01/28; 01/30	M1: Quantitative genetics and genomic selection – Dr. Felipe Ferrao
Wk 4 02/04; 02/06	M2: Artificial intelligence – Invited Speaker
Wk 5 02/11; 02/13	M3: Marker Assisted Selection – Dr. Seonghee Lee
Wk 6 02/18; 02/20	M3: Marker Assisted Selection – Dr. Seonghee Lee
Wk 7 02/25; 02/27	M4: Phenomics – Dr. Kevin Wang
Wk 8 03/04; 03/06	M4: Phenomics – Dr. Kevin Wang
Wk 9 03/11; 03/13	M5: Integrating GS and environmics– Dr. Germano Costa-Neto
Wk 10 Spring Break	NO CLASS
Wk 11 03/25; 03/27	M5: Integrating GS and environmics– Dr. Germano Costa-Neto
Wk 12 04/01; 04/03	M6: Chromosome manipulation and mutagenesis – Dr. Esteban Rios
Wk 13 04/08; 04/10	M6: Chromosome manipulation and mutagenesis – Dr. Esteban Rios
Wk 14 04/15; 04/17	M7: Gene Editing – Dr. Kevin Begcy
Wk 15 04/22	M7: Gene Editing – Dr. Kevin Begcy

General description of module

Introductions and Plant Breeding

Plant breeding is a complex and dynamic system that requires the integration of multiple skills and knowledge. In this module I expect we become familiar with each other as well as the rationale of the course and each of the modules. The expectation is to discuss the broadness of the methods and techniques used in plant breeding while maintaining a breeding strategy and breeding goals.

Quantitative Genetics and Genomic Selection

In this session, we will cover the motivation and intuition behind predicting phenotypic observations using genetic markers, with a particular focus on the use of frequentists and Bayesian approaches.

This module will consist of 4 classes covering the follow topics: (i) Introduction to quantitative genetics; (ii) Introduction to Genomic Selection and the use of mixed models; (iii) Genomic Selection and the Bayesian alphabet; (iv) Hands-on: genomic prediction in R. We will use open-sources R packages.

Marker Assisted Selection

This module will introduce students to theory and methods of the use of molecular markers with a focus on their applications in modern plant breeding. Students will have hands-on activities and experience on analyzing DNA/RNA sequencing data and designing molecular markers for target QTL and/or candidate genes of interest. Throughout the

module, students are expected to learn the various techniques of molecular markers and further practical applications for new cultivar development through marker-assisted selection.

Phenomics

In this session, we will examine different types of phenotyping systems, data processing, data management, and data utilization for decision making using HTPP in plant breeding, with case studies from multiple crop breeding programs. Development of HTPP systems, such as ground- and aerial-based mobile systems require evaluating the traits to be measured as well as the resources available. Data processing is the key component to convert raw data, such as sensor observations and digital images to plant parameters and ultimate trait values. Data management is also critical in the overall research process to provide efficient data access. Finally, examples of HTPP use within crop breeding and plant science are presented. This session provides an overview of the entire HTPP process from system conception to decision making within research programs based on phenomics data collected in high throughput.

Integration of GS and Enviromics

All phenotypes are the result of Genotype-by-Environment interactions (GxE). This fundamental concept in plant breeding recognizes that a plant's performance is determined not solely by its genetic makeup but also by its interaction with environmental conditions. The environmental influence has long been a challenge for breeders, as it complicates the selection and development of high-performing, stable cultivars across diverse growing conditions. In recent years, the field of enviromics has emerged as a powerful tool to enhance our understanding of GxE. Enviromics combines traditional environmental features with advanced analytics to create a comprehensive model of the "envirome" - the sum of all possible growing conditions for a crop in a given region or market. This approach recognizes that environmental variation constantly influences genetic gains, affecting everything from germplasm selection to multi-environment trials and product placement. By leveraging both hypothesis-driven and data-driven methods, enviromics aims to explore and understand this hidden environmental diversity, potentially turning what was once a problem into a strategic advantage. For students of plant breeding (or related fields), mastering these concepts is crucial, as they represent the cutting edge of efforts to develop more resilient and productive crops in the face of increasing environmental uncertainty. In this class, we will approach: (1) the influence of the environment on molecular breeding strategies; (2) what GxE is and whether we can escape from it; (3) envirotyping protocols (data collection and processing); and (4) examples of how to leverage enviromics for GxE using genomics.

Chromosome manipulation and Mutagenesis

This module is designed to introduce students to plant chromosome structures, polyploidy, complex plant genome composition, and the application of polyploidy and mutagenesis in plant breeding. Students will learn how chromosome number and structure variations are associated with abnormal inheritance patterns and disorders, and they will be able to identify appropriate cytogenetic and molecular techniques to study chromosome manipulations and random mutagenesis. The module will focus on the application of methods and techniques with the goal of generating genetic variation in plant breeding programs.

Gene Editing

This module will introduce the use of genetic engineering to manipulate genomes. We will cover basic methods as well as state-of-the-art literature on genome editing. Hands-on activities and lectures will be the teaching strategies used.

Attendance and Make-Up Work

“Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies that can be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx”

Online Course Evaluation Process
"Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at https://evaluations.ufl.edu. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at https://evaluations.ufl.edu/results/"

Academic Honesty
"UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class."

Software Use:
All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate.

Services for Students with Disabilities
"Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, www.dso.ufl.edu/drc/) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester."

Campus Helping Resources
Health and Wellness:

U Matter, We Care: If you or a friend is in distress, please contact umatter@ufl.edu or 352 392- 1575 so that a team member can reach out to the student.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc/Default.aspx, 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS) Student Health Care Center, 392-1161. University Police Department, 392-1111 (or 9-1-1 for emergencies). http://www.police.ufl.edu/