Course Syllabus
SOCR 720A – Advanced Plant Breeding Methods
Spring 2019 (2 Credits)

INSTRUCTOR

Dr. Scott Haley
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office hours by arrangement

MEETING TIME AND PLACE

11:00-11:55 AM – M, W, F
W-001 Plant Science Building
(until week 10-April 5)

COURSE PREREQUISITES

Introductory plant breeding (i.e., SOCR 460, or equivalent); three credits in statistics.

TEXTBOOK

There is no required textbook for this course. Textbook chapters and other reference materials will be made available via CSU's online educational platform – Canvas (http://canvas.colostate.edu).

LEARNING OBJECTIVES

- Students will develop an appreciation of some of the key historical achievements in plant breeding.
- Students will develop an understanding of genetic gain theory and strategies for optimizing genetic gain in plant breeding programs.
- Students will develop an understanding of breeding methods used in self-pollinated and cross-pollinated crop breeding programs.
- Students will use both classical and modern literature to foster improved understanding of plant improvement and disciplines contributing to plant improvement.

EVALUATION

- Two quizzes will be given during the semester, one about mid-way and the other near the end of the semester. Both of these will be take-home and open book, consisting of mostly short answer questions or problems.
- A term project activity will be done during the semester and oral reports of the project will be done during the 11th week of the semester. Complete details of the activity and evaluation expectations will be provided before the third week of the semester.
- Each student will be required to give a presentation of one research paper or topic during the semester. Students not presenting will be required to submit a review/critique of the paper. Expectations for the presentations and reviews/critiques will be provided.
- Two homework assignments will be given during the semester, both worth 20 points.
- Final assignment of grades will be according to a 90% A, 80% B, 70% C, 60% D, and <60% F scale:

Quizzes (2)	= 100 points
Term project	= 100 points
Paper presentation	= 50 points
Paper review/critique (9)	= 90 points
Homework assignments (2)	= 40 points
Total	= 380 points

Course Outline
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Week	Dates	Topic
1	Jan 23, 25	Plant breeding perspectives
2	Jan 28, 30, Feb 1	Reproduction and qualitative inheritance
3	Feb 4, 6, 8	Quantitative genetics and genetic gain
4	Feb 11, 13, 15	Quantitative genetics and genetic gain
5	Feb 18, 20, 22	Self-pollinated crop breeding methods
6	Feb 25, 27, Mar 1	Self-pollinated crop breeding methods
7	Mar 4, 6, 8	Self-pollinated crop breeding methods
8	Mar 11, 13, 15	Cross-pollinated crop breeding methods
9	Mar 25, 27, 29	Cross-pollinated crop breeding methods
10	Apr 1, 3, 5	Cross-pollinated crop breeding methods
11	Apr 8-12	Term project presentations

Academic Honesty and Integrity

The principles and practices of academic honesty and integrity will apply to all components of this course.

Academic Integrity – "The foundation of a university is truth and knowledge, each of which relies in a fundamental manner upon academic integrity and is diminished significantly by academic dishonesty. Academic integrity is conceptualized as doing and taking credit for one's own work. A pervasive attitude promoting academic integrity enhances the sense of community and adds value to the educational process. All within the University are responsible for and affected by the cooperative commitment to academic integrity. Faculty/instructors shall work to enhance a culture of academic integrity at the University."
(from CSU Catalog)

This course will adhere to CU's Academic Integrity Policy as explained at:
https://resolutioncenter.colostate.edu/conduct-services/academic-integrity/
http://catalog.colostate.edu/general-catalog/policies/students-responsibilities/#academic-integrity
https://resolutioncenter.colostate.edu/conduct-code/

Plagiarism is "the practice of taking someone else's work or ideas and passing them off as one's own. … If it is important to use the actual words of another author, they should be put in quotation marks and be clearly referenced." (Day et al., 2012. Biosystems Engineering 111:1)

Some links to information on academic integrity and plagiarism are as follows:

Practicing Academic Integrity: https://tilt.colostate.edu/integrity/

Understanding and Avoiding Plagiarism: https://writing.colostate.edu/guides/guide.cfm

Student Presentation Guidelines
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During the semester, we will spend part of our time reviewing and discussing research papers from the plant breeding and genetics literature. My intent with this is to allow us to explore the literature to a greater extent than would be possible with a typical lecture format and discuss some more current aspects of plant breeding and genetics.

Student presentations will generally be on Fridays, whereas Mondays and Wednesdays will be for instructor presentations. At random I have assigned you all specific dates for the presentation (see below), which will start in the 5th week of the semester. If you have a conflict and can't do the one assigned to you, you are responsible for switching with one of the other students and letting me know of the change. The guidelines for the presentations and paper critiques are as follows.

1) Each student will each give one presentation during the semester. The presentation will be worth 50 points. Students will be notified well in advance of the assigned paper or topic that I would like to use for the presentation. If you don't like my suggested paper, I would happy to hear your suggestions for an alternative.
2) Presentations will be 55 minutes total (the duration of our class period), which should include about 35-40 minutes for the presentation itself and 15-20 minutes for discussion and Q&A. You are encouraged to use the digital projector for the presentations (and the white board as you see fit). If you would like to use my laptop you must email me your file or bring it to class on a USB stick. Grading of the presentations will include aspects related to the presentation itself (i.e., clarity, organization, timeliness, etc.) as well as your ability to lead the discussion/Q&A.
3) The student presenting is not required to prepare the one-page review/critique of the paper being presented and discussed. Students not giving the presentation are required to thoroughly read the assigned paper and bring to class a one-page review and critique of the paper. Your review/critique could include: anything that you found particularly interesting (or not) about the paper; comment on the methods used or validity of the conclusions made; comment about things the authors failed to discuss; highlight difference of opinion you may have with the rationale, objectives, or conclusions of the paper; or questions/comments about the methodology used in the paper. This review should generally be about one full page of single-spaced typed text. Your review/critique will be graded (10 points each) based on how well you appear to have grasped the content and key points of the paper provided. You need to spend time reading the materials and thinking!

Week	Date	Presenter
1	Jan 25	Scott
2	Feb 1	Scott
3	Feb 8	Scott
4	Feb 15	Scott
5	Feb 22	Carl
6	Mar 1	Jeremy
7	Mar 8	Nick
8	Mar 15	Andrew
9	Mar 29	Brad
10	Apr 8	Yucong

Student Information Form
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Name _____

Phone _____

E-mail _____ Mobile _____

Degree sought, expected graduation date

What other courses are you taking this semester (include credits)?

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1) What do you hope to get out of this course?

2) List any and all prior courses in plant breeding, genetics, and statistics that you have had.

3) List any and all practical experience that you have had in plant breeding research.

4) On a scale of 1=no experience to 10=expert, describe the level of experience you have with R programming/statistics.

5) Do you have your own computer? YES NO (circle one)

If not, do you have good access to a computer? YES NO (circle one)

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Term Project Assignment

If plant breeding is about one thing and one thing only, it is about decision making. Breeders must choose the parents to include in a crossing program, what specific crosses to make among these parents, what breeding methods to implement, when and how to implement technologies such as DNA markers or genome-wide predictions, and how resources will be allocated to phenotyping. Breeders must also have some knowledge of the genetic architecture of key traits and how we might modify our breeding methods and approaches to optimize outcomes for these traits. The Breeding Games program provides an excellent tool to simulate each of these activities – in a setting where you will not be evaluated by your boss!

Installation

- Go to http://bernardo-group.org/books-and-software/ and click on the download link for Breeding Games. Note that there is also a link to a YouTube video, it's very worthwhile to watch this before you do anything, and also likely more than once.
- Open the .zip file by double clicking on the .zip file that's downloaded. On the Mac this seems to be done automatically. The "BreedingGames.exe" file is the program to open.
- In this directory, there are some .pdf files for installation and settings (including a file for running it in the terminal on a Mac), one that shows the parental values for the traits and a similarity matrix between the parents, and a player guide. Note that some instructions on installation on Windows are included in the player guide.

Basic Idea

Users are tasked with creating a set of crosses to make with the intention of ultimately identifying an improved barley variety that combines high yield with grain protein concentration and Fusarium head blight (FHB) resistance within the targets specified. The first decision points to be made are a) choosing a set of parents and combinations of these parents for making a group of biparental crosses and b) the starting F2 population size for each cross.

Following establishment of these parameters (in the "Crosses.csv" file), the user then must choose among three options: a) making selections based on a DNA marker for FHB resistance, b) performing genome-wide predictions (and potentially selection) for each trait, or c) delaying these evaluations and advancing the population via single seed descent (SSD). After homozygous lines (recombinant inbred lines, RILs) are developed via SSD, the user must then choose among different options for phenotyping the lines (over locations and years) and making selections based on the observed phenotypes and genome-wide predictions. With each of these tasks, the results dumped into the "Results.csv" file which the user can then open and make selections.

A very important part of the program is that every activity in the game carries a monetary cost which must be considered in strategic ways to prevent you from going over budget.

Some Potentially Useful Tips

1) Plant breeders often cross "good x good" (i.e., high yield x high yield) as these crosses will have higher mean performance for that trait. If the parents of a good x good cross are more genetically distant there will be a greater opportunity to identify and recover individuals that are better than the parents for the trait (i.e., transgressive segregates).

2) The distribution of F2 and RIL trait values from "good x good" crosses will be wider when the genetic distance between the two parents is greater (i.e., the marker similarity values in the file provided).
3) Larger populations will improve the degree to which transgressive segregates may be identified and selected. Plant breeding is a numbers game.
4) Genome-wide selection allows prediction of trait phenotypes at lower cost than conventional phenotyping, but the accuracy of such predictions may not be very high for some traits.
5) Trait phenotyping is required to validate selections made with genome-wide prediction, but the costs of phenotyping large numbers of individuals can be great. Also, the accuracy of phenotyping (reflected in the heritability values provided and the least significant difference values reported in the "Results.csv" file) is greater for some traits than others.
6) The accuracy of trait phenotyping increases with increasing numbers of trial locations, but testing large numbers of genotypes over a lot of locations can be costly. Refer back to the "funnel" diagram in the Glenn paper we discussed in class.
7) The proportion of the total genetic variance among individuals that is due to additive genetic effects (which is modelled by the genome-wide prediction) is greater among inbred lines than it is among F2 individuals.
8) Some traits targeted by breeders are negatively correlated, which complicates breeding especially when trying to select for multiple traits simultaneously. It might be useful to plot some graphs (may help to visually identify outliers) or do some calculations based on the data reported in the "Results.csv" file (as Rex Bernardo demonstrated in his YouTube video).
9) A tip from Rex Bernardo: It could be useful to perform selection for each trait individually first and then with a second trait to gain a better understanding of how breeding gets more difficult with more traits. In this case, you would need to ignore the "Congratulations!" and "Try again" messages at the end of the program, and instead look in the "Results.csv" file to see if any lines meet the criteria.

Teams

Students will be divided up into three groups of two students each. I have made the following assignments based on my understanding of your experience in plant breeding from my interactions with you and your responses on the student info form I asked you all to fill out:

Team 1 – Carl and Yucong Team 2 – Nick and Andrew Team 3 – Brad and Jeremy

Evaluation – 100 points total

Ability to document breeding decisions made and their outcomes	25 points
Ability to describe rationale for alternative breeding decisions made	25 points
Met goals of developing a variety that meets the targets	10 points
Budget used to meet goals	10 points
Time required (i.e., number of years of phenotyping)	10 points
Clarity of presentation	10 points
Things missing in Breeding Games program, or how it could it improved?	10 points

Extra credit – 10 pts for highest yielding variety, 5 pts for second highest, 0 pts for third