AGRO-932
Biometrical Genetics and Plant Breeding
Spring 2020
University of Nebraska-Lincoln

I. Instructor

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II. Scope of the Course

Course Overview: Most economically important traits of crop species are complex and determined by polygenic factors. The goal of this course is to apply the biometrical methods to connect the phenotypic traits with high-dimensional genomic data to better understand polygenic traits for both prediction (i.e. plant breeding) and inference (i.e. gene mapping) purposes. In the course, we will discuss statistical methodologies for estimating heritability, genomic relatedness, best linear unbiased estimators (BLUEs) and best linear unbiased predictors (BLUPs). We will use real-world examples to learn and practice trait-associated variant mapping (i.e. genome-wide association study), genome-enabled prediction (i.e. genomic selection for plant breeding), multi-Omics data integration, and causal inference. Additional topics will be briefly touched upon, including genomic sequence data processing, population genomics modeling, transcriptomic and epigenetics data analysis. Through computational labs, students will establish the best practice for streamline code organization and collaborative data management. Students will also learn how to conduct biometrical genetics data analysis using High-Performance Computing (HPC) empowered by Holland Computer Center (HCC).

This course will meet two days (75 minutes per day) each week in Plant Sciences Hall (room 272). We will have a traditional lecture on the first day and a computer lab session on the second day. Handouts and reading materials (on Canvas and/or course website https://jyanglab.com/AGRO-932/) will be assigned ahead of the class with the expectation that students will study these materials before the class. Since this class contains a computer lab component, students will need to bring their computers for the lab session.

Prerequisites: Students should know about experimental design and have basic statistical analysis skills and are expected to have learned the introductory population and quantitative genetics. Therefore, the suggested prerequisites are AGRO 815A, 815B, and 815D, AGRO/ANSCI 931, and STAT 802, or their equivalents. The course will use basic bash language for bioinformatics analysis, slurm scripting language for high-performance computing, R/Rstudio software for statistical analysis, and github for version control. A

certain familiarity with these computing languages or tools is preferred but not required. Students are encouraged to contact Dr. Yang if they have questions about prerequisites or their readiness to take the course.

III. Textbooks and Materials

There is no required text for the course. Two important textbooks are listed below. I will be giving you supplemental material throughout the semester via Canvas or course website.

Textbooks

- Bernardo, R. 2020. **Breeding for quantitative traits in plants**. 3rd Ed. Stemma Press.
- Lynch, M. and B. Walsh. 1998. Vol. 1: **Genetics and analysis of quantitative traits**. Sinauer, MA

IV. Assignments, Exams, and Grading Policy

1. **Exams: Research project (2).** The two exams (one mid-term and one final exam) will be taking home exams to conduct a research project using simulated or publicly available datasets. For this research project, you will identify a species and a trait of interest and design an experiment using either the real-world or simulated datasets. For the mid-term exam, you will prepare a paper to introduce the background information, importance, experimental design, preliminary data analysis results, and future directions, etc. Two randomly selected anonymous reviewers will judge your paper. At the same time, you will also need to review two papers from your colleagues. For the final exam, you will refine your paper, incorporate more results, and prepare a final presentation about the whole project. Importantly, your final coding script will be judged and tested by two of your colleagues.

   You will be graded upon how well you leverage the course content to solve the research questions. Please keep in mind that quality, novelty, and reproducibility are highly crucial for this research project. This project is worth 300 points. Of those 300 points, 80 points for the mid-term paper, 20 points for judging others' work, 100 points for the final presentation (10 mins each), 80 points for the research code, and 20 points for judging others' code.

2. **Problems (3).** Throughout the semester, you will be given homework assignments after a particular subject matter has been covered in class. The assignments will reinforce subject matter covered in class. You will be given one week to complete these assignments. Please complete the homework assignments independently and do not compare your answers with other students. If a homework assignment is passed the due

date, the assignment will receive a zero score unless you have a valid excuse. It is anticipated that three problem sets, each worth 100 points, will be assigned.

3. **Class Participation.** Biometrical genetics can be learned only through study and practice at problem solving. While plant breeding will involve some levels of familiarity with the literature. At the end of the semester, we will be discussing new subjects (high throughput phenotyping and microbiome) and discuss how they can be used in plant breeding. Throughout the course, you are expected to read the assigned papers or course materials in advance of classroom discussions. Class attendance and participation during class are important to good understanding of the material. At the end of the semester each student will be given up to 100 points for classroom participation.

4. **Points.**
   a. Problems 300
   b. Exams: Research Project 300
   c. Class Participation 100
   TOTAL 700

5. **Final Grades.** The base minimum total points for each possible final grade are listed below. The instructors may assign a lower minimum for any of the grades.

Grade	Base Minimum		Grade	Base Minimum		Grade	Base Minimum
A+	670		B	570		C-	470
A	645		B-	545		D+	445
A-	620		C+	520		D	420
B+	595		C	495		D-	395

V. Tentative Course Content

1. Estimate heritability and accuracy of selection
   a. Gain from selection
   b. Theory of heritability in plant breeding context
   c. Estimating broad-sense and narrow-sense heritability in traditional, simple way
   d. North Carolina Design

2. Estimation of breeding values
   a. Linear models to account for design factors and estimate phenotypic values

b. Best linear unbiased predictors (BLUPs)
c. Estimating marker effects and marker scores
d. Pedigree BLUPs
e. Genomic relationship matrix
f. G-BLUP and other forms of genomic prediction
g. Accuracy of genomic predictions
h. Resource allocation

3. Trait-marker association studies
    a. BSA and QTL mapping
    b. Population structure and GWAS
    c. Selection scan

4. Emerging technologies in plant breeding
    a. High throughput phenotyping
    b. Microbiome
    c. Omics data integration and causal inference

VI. Academic Dishonesty

Academic dishonesty can involve: cheating, fabrication or falsification of information, plagiarism - including copying of written materials or "cutting and pasting" from websites without proper referencing, destroying, defacing, stealing, or making inaccessible library or other academic resource material, complicity in the academic dishonesty of others, falsifying grade reports, or misrepresenting illness, injury, accident, etc. to avoid or delay an examination or the timely submission of academic work.

Consequences of academic dishonesty in Agronomy and Horticulture courses, depending on the degree of severity as interpreted by an instructor, may range from a warning to assigning an F for the course. The instructor may also choose to assign a zero or partial credit for a specific assignment or examination in which dishonesty was involved. Before imposing an academic sanction, the instructor shall first attempt to discuss the matter with the student. In all cases the instructor must document the instance(s) of student activity, which constitutes academic dishonesty. Documentation must be retained by the instructor for a minimum of one year and must be made available to appropriate department, college, and UNL authorities if cases of academic dishonesty result in disciplinary hearings and/or appeals at those levels. When an academic sanction is imposed that causes a student to receive a lowered course grade, the instructor shall file a written report outlining the facts of the case and of the academic sanction imposed against the student, to the Animal Science Department Head and the UNL Director of Student Judicial Affairs. The student shall be provided with a copy of this report. Further, the instructor may recommend the institution of CASNR or UNL disciplinary proceedings against the student for violation of the Student Code of Conduct if the instructor, in the exercise of his or her professional judgment, believes that such action is warranted.

If a student facing sanctions due to academic dishonesty in an Agronomy and Horticulture Department course wishes to appeal such a sanction, the following process must be followed. First the student must issue a written appeal to the chief instructor of the course. If resolution is not obtained, the student can appeal (in writing) to the Agronomy and Horticulture Department Head. The Department Head will refer the appeal to the Animal Science Curriculum Committee who will interview both the student and instructor, review all pertinent documentation, and issue a decision. If a member of the Agronomy and Horticulture Curriculum Committee is also an instructor of the course in which academic dishonesty has been reported, the Agronomy and Horticulture Department Head will temporarily appoint an alternative faculty member to the committee hearing the appeal. If a solution satisfactory to the student is not achieved at the department level, the student may then appeal through the CASNR Dean's office and the University Director of Student Judicial Affairs, in that order, and is subject to the processes and requirements of those offices.

VII. In the Event of an Emergency

Fire Alarm (or other evacuation): In the event of a fire alarm: Gather belongings (Purse, keys, cellphone, N-Card, etc.) and use the nearest exit to leave the building. Do not use the elevators. After exiting notify emergency personnel of the location of persons unable to exit the building. Do not return to building unless told to do so by emergency personnel.

Tornado Warning: When sirens sound, move to the lowest interior area of building or designated shelter**.** Stay away from windows and stay near an inside wall when possible.

Active Shooter:

Evacuate - If there is a safe escape path, leave belongings behind, keep hands visible and follow police officer instructions.

Hide out - If evacuation is impossible, secure yourself in your space by turning out lights, closing blinds and barricading doors.

Take action - As a last resort, and only when your life is in imminent danger, attempt to disrupt and/or incapacitate the active shooter.

UNL Alert: Notifications about serious incidents on campus are sent via text message, email, unl.edu website, and social media. For more information go to: http://unlalert.unl.edu.

Additional Emergency Procedures can be found at: http://emergency.unl.edu/doc/Emergency_Procedures_Quicklist.pdf

VIII. Special Needs

Students with disabilities are encouraged to contact the instructor for a confidential discussion of their individual needs for academic accommodation. It is the policy of the University of Nebraska-Lincoln to provide flexible and individualized accommodation to students with documented disabilities that may affect their ability to fully participate in course activities or to meet course requirements. To receive accommodation services, students must be registered with the Services for Students with Disabilities (SSD) office, 132 Canfield Administration, 472-3787 voice or TTY.