AGRO/HORT 610
Advanced Crop Breeding
Spring 2022

Lecture: 12:00 – 1:00 PM, MWF Skeen Hall Rm W122

Laboratory: 2:30 – 4:30pm Tuesday, Skeen Hall W122 and/or Fabian Garcia/Leyendecker Farms

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Office hours: Wed/Thu/Fri, 2-4 PM, or by appointment (Zoom® or in person)
Zoom Personal Meeting ID: 248 297 3965

Class email: There is a dedicated email account for any course-related communication (e.g., scheduling appointment with the Instructor; submitting class requirements, requesting for an authorized absence from class, etc.): **agro610.nmsu@gmail.com**. Please use this email for these correspondences and expect a response within 48 hrs.

Literature: Assigned readings from the scientific literature – about 1 or 2 journal articles per class. **Recommended textbooks: (1) Breeding for Quantitative Traits in Plants by Rex Bernardo. 2020 (3rd ed). Stemma Press (order online: http://stemmapress.com/); and (2) Principles of Cultivar Development by Fehr (1991), Vol. 1**. Other general plant breeding textbooks are also suitable such as: **Essentials of Plant Breeding by Bernardo 2014, Stemma Press**. All readings, lectures, handouts, etc. will be posted on Canvas (https://learn.nmsu.edu/) unless otherwise indicated.

Course Goals: This course will demonstrate the application of breeding principles to crop improvement through a review of the scientific literature. Emphasis will be placed on breeding methodologies using conventional and modern techniques, including marker-assisted selection, genome-wide mapping, genomic selection, and biotechnology. Specific topics to be discussed include: (1) crop genetic resources; (2) breeding of self- and (3) cross-pollinated crops; (4) conventional and molecular concepts of inbreeding depression, epistasis and heterosis; (5) marker- assisted applications to crop improvement; (6) long-term selection; and (7) breeding behavior of polyploids. This course is designed to complement AGRO/HORT 670 (Biometrical Genetics and Plant Breeding), as well as AGRO/HORT 516 (Molecular Analysis of Complex Traits).

Laboratory Goals: The laboratory will review principles affiliated with accessing plant genetic resource databases; estimating components of phenotypic and genetic variation; influence of various breeding methods, mating designs, and testers on the partitioning and estimating genetic variance and its components; epistasis; and basic DNA marker-trait association strategies. Laboratory problem sets or reports will be periodically assigned to evaluate each student's understanding of key concepts.

Grading:

Journal article summaries	300 pts.	Laboratory problem sets/reports	240 pts.
Attendance and class participation	50 pts.	Student led discussions	50 pts.
Final presentations	140 pts.		

Journal articles: Students are encouraged to review pertinent chapters from a plant breeding textbook. **Students must read assigned journal articles and be prepared to discuss them in class.** For specified articles, students must prepare **a one to two-page** (Times Roman 12-point font, single line spacing, 1inch page margins) summary of each paper including: title, authors, journal/volume/pages, study objectives, materials & methods (e.g., experimental design and generations/traits evaluated), key results, and conclusions, in **MS WORD®**. At least 50% of each summary should be devoted to results discussion. **Summaries are due in class the day of discussion (-20% for each day late) at 12:00 noon via Email (agro610.nmsu@gmail.com).** Grading of article summaries will be based on clarity, critical thinking and analysis, and grammar. The free NMSU online writing center (http://web.nmsu.edu/~consult/) is available to assist students with their writing. Please DO NOT copy the abstract of the paper, you must use your own wording. Lastly, each student will be responsible for leading one journal article discussion during the semester (advanced notice will be given).

Final Presentations: Students will be given different job postings related to plant breeding, genetics, and genomics. Each student will select one position from the pool of positions available and will be required to put together a 20–30-minute PowerPoint® presentation based on the provided job description. Students are expected to integrate the different plant breeding and genetics concepts and tools learned from the class in their job talks. The instructor together with the other students in the class will serve as members of the search committee and will ask questions and give their evaluation after the presentation. Multiple students will be allowed to "apply" to the same position.

COVID-19 Safe Practices: Please maintain social distancing and wear your masks/facial coverings at all times while inside the classroom. Kindly read and sign the NMSU READY Crimson Commitment Classroom COVID-19 Safe Practices Acknowledgement Form (https://provost.nmsu.edu/faculty-and-staff-resources/syllabus/COVID-Classroom-Safety-Acknowledgement-Statement.pdf) and submit it to the Instructor within the first week of classes.

Please visit* https://provost.nmsu.edu/faculty-and-staff-resources/syllabus/policies *for university policies and student services, including Discrimination and Disability Accommodation, academic misconduct, student services, final exam schedule, grading policies and more.

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Course Schedule (Lecture)

Week no.	**Date(s)**	**Section**	**Topics**	**Suggested Readings**
1	January 12 – January 14	Introduction to Plant Breeding, Genetic Resources, and Genetic Variation	Role of Plant Breeding in Agriculture	Fehr (1991), Chapter 1
	January 17	**Martin Luther King Jr. Day**	**NO CLASSES**	
2	January 18 – January 21	Introduction to Plant Breeding, Genetic Resources, and Genetic Variation	Crop Genetic Resources Parental Selection	Bernardo (2020), Chapter 4 Fehr (1991), Chapter 10
3	January 24 – January 28	Breeding Self-pollinated Crops	Pedigree method Single seed descent Doubled haploids Backcrossing Recurrent selection	Fehr (1991), Chapters 23, 25, 27, 28
4	January 31 – February 4	Breeding Cross-pollinated Crops	Recurrent phenotypic selection Mass selection and modified ear-to-row selection Recurrent selection based on half-sib, full-sib, and self-progeny performance	Bernardo (2020), Chapter 12 Fehr (1991), Chapter 15
	January 31- February 1	**New Mexico Chile Conference 2022**		
5	February 7 – February 11	Breeding Cross-pollinated Crops	Reciprocal recurrent selection Effective population size	
6	February 14 – February 18	Inbreeding Depression, Heterosis, and Epistasis	Inbreeding depression	Bernardo (2020), Chapter 13
7	February 21 – February 25	Inbreeding Depression, Heterosis, and Epistasis	Molecular analysis of heterosis Molecular analysis of epistasis	Bernardo (2020), Chapter 13 Fehr (1991), Chapters 8,9
8	February 28 – March 4	Genomics tools in Plant Breeding	Marker-assisted selection: Molecular markers	Bernardo (2020), Chapter 5; Collard et al. (2005), An

				introduction to markers, quantitative trait loci (QTL) mapping and marker-assisted selection for crop improvement
	March 7 – March 11	**SPRING BREAK**	**NO CLASSES**	
9	March 14 – March 18	Genomics tools in Plant Breeding	QTL mapping Genome-wide association studies Meta-QTL analysis	Bernardo (2020), Chapters 5 and 11
11	March 21 – March 25	Genomics tools in Plant Breeding	Genomic selection Targeted recombination Gene editing	
12	March 28 – April 1	Long-term selection	Estimating genetic improvement Response to selection	
13	April 4 – April 8	Long-term selection	Long-term selection experiments and sources of *de novo* genetic variability Genetic architecture of response in long-term selection experiments	
14	April 11 – April 14	Polyploidy in Plant Breeding	Polysomic inheritance versus disomic inheritance Polyploidization and bridging ploidy barriers using 2*n* gametes	
	April 15	**Spring (Easter) Holiday**	**NO CLASSES**	
15	April 18 – April 22	Polyploidy in Plant Breeding	Breeding behavior of autotetraploid alfalfa/potato Impact of allopolyploidization on gene expression in homeologous genomes	
16	April 25 – April 29	Polyploidy in Plant Breeding	Regulation of chromosome pairing in allopolyploid wheat	
	May 6	**FINAL PRESENTATIONS**	**The JOB TALK**	**Job postings from various academic, industry, and non-government research institutions will be provided, and**

				students will prepare presentations as job applicants accordingly.
	May 10	**FACULTY DEADLINE TO SUBMIT FINAL GRADES (5:00 PM)**		

AGRO 610 – Advanced Crop Breeding
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Course Schedule (Laboratory)

Week no.	Date	Topic	Assigned Reading
1	January 18	Considerations for becoming a successful plant breeder discussion. Introduction to the "National Plant Germplasm System & the Germplasm Resource Information Network. Please bring your personal laptop computer if you have one. If not, additional computers will be made available (Please let the Instructor know in advance if you need a computer).	
2	January 25	Genetic gain, heritability, and development of base populations for breeding programs.	Ray et al. 1999. Heritabilities of Water-Use Efficiency Traits… in Water-Stressed Alfalfa. Crop Sci. 39:494-498.
3	**February 1**	**New Mexico Chile Conference (No LAB but students are encouraged to participate in the conference)**	
4	February 8	Quantitative traits and the single locus model: Overview and Partitioning of additive and dominance variance among families upon inbreeding	
5	February 15	Partitioning of additive and dominance variance within families upon inbreeding	

6	February 22	Early generation selection in self-pollinated crops	St. Martin et al. 2000. Genetic gain in early stages of a soybean breeding program. Crop Sci. 40:1559-1564.
7	March 1	Choice of testers in recurrent selection programs: Impact on genetic variance	
	March 8	**SPRING BREAK- NO CLASSES**	
8	March 15	Estimating general & specific combining ability	Segovia-Lerma et al. 2004. Population-based diallel analyses... Theor. Appl. Genetic. 109:1568-1575.
9	March 22	Mating designs for tactical assessment of breeding populations	Rosulj et al. 2002. Nine cycles of mass selection …in two maize synthetics. Gen. and Mol. Biol. 25:449-461
10	March 22	Quantitative traits and the two-locus model: Epistasis	
11	March 29	Detecting epistatic effects using molecular markers	Yu et al. 1997. PNAS 94:9226-9231
12	April 5	Genomics-assisted breeding I: Gene specific marker development and genotyping by sequencing	
13	April 12	Genomics-assisted breeding II: DNA marker detection/genotyping & genetic mapping	
14	April 19	Genomics-assisted breeding II: Genomewide-association study and genomic selection	

ASSIGNED READINGS (Lecture)
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****** Indicates that one-two page summary is required in class on the specified date. Summary papers are due in class on the day of discussion.***

Section	Date	Article
Introduction to Plant Breeding Programs, Genetic Resources, and Genetic Variation	January 12	Duvick 1996. Plant breeding, an evolutionary concept. Crop Sci. 36:539-548.
	January 14	**Gepts, 2002. A comparison between crop domestication, classical plant breeding, and genetic engineering. Crop Sci. 42:1780-1790. *****
	January 19	Brummer et al. 2011. Plant breeding for harmony between agriculture and the environment. Frontiers in Ecology and the Environment 9:561-568.
	January 21	**Tanksley, 1997. Seed banks and molecular maps: unlocking genetic potential from the wild. Science. 277:1063-1066. ***** McCouch, 2004. Diversifying selection in plant breeding. PLoS Biology 2:1507-1511.
Breeding Self-pollinated Crops	January 24	Review: Mass, Bulk, Single Seed Descent, Pedigree, Early Generation, Backcross and Doubled Haploid breeding methods (Handouts)
	January 26	Schoener et al. 1979. Utilization of plant introductions in soybean breeding populations. Crop Sci. 19:185-188.
	January 28	**Peel et al. 2000. Improvement strategy for mature plant breeding programs. Crop Sci. 40:1241-1246. *****
Breeding Cross-pollinated crops	January 31	Weyhrich et al. 1998a. Responses to seven methods of recurrent selection in the BS11 maize population. Crop Sci. 38:308-321.
	February 2	Weyhrich et al. 1998a. Responses to seven methods of recurrent selection in the BS11 maize population. Crop Sci. 38:308-321
	February 4	**Weyhrich et al. 1998b. Effective population size and response to S_1-progeny selection in the BS11 maize population. Crop Sci. 38:1149-1158. *****
	February 7	Horner et al. 1989. Comparison of selection for S_2 progeny vs. testcross performance for

		population improvement in maize. Crop Sci. 29:868-874.
	February 9	Lee et al. 2003. Genetic components of yield stability in maize breeding populations. Crop Sci. 43:2018-2027.
	February 11	**Doerksen et al. 2003. Effect of recurrent selection on combining ability in maize breeding populations. Crop Sci. 43:1652-1658. *****
Inbreeding Depression, Heterosis, and Epistasis	February 14	Charlesworth 2009. The genetics of inbreeding depression. Nature Rev. Genet. 10:783-796.
	February 16	**Lu et al. 2003. Genetic basis of heterosis explored by simple sequence repeat markers in a random-mated maize population. Theor. Appl. Genet. 107:494-502. *****
	February 18	Stuber et al. 1992. Identification of factors contributing to heterosis in a hybrid from two elite maize inbred lines using molecular markers. Genetics 132:823-839. Yu et al. 2021. Molecular basis of heterosis and related breeding strategies reveal its importance in vegetable breeding. Horticulture Research https://doi.org/10.1038/s41438-021-00552-9
	February 21	**Graham et al. 1997. Characterization of a yield quantitative trait locus on chromosome five of maize by fine mapping. Crop Sci. 37:1601-1610. *****
	February 23	Schnable and Springer. 2013. Progress toward understanding heterosis in crop plants. Ann. Rev. Plant Biol. 64:71-88.
	February 25	Kaeppler. 2012. Heterosis: Many genes, many mechanisms - end the search for an undiscovered unifying theory. Intl. Schol. Res. Net. doi:5402/2012/682824. Yu et al. 1997. Importance of epistasis as the genetic basis of heterosis in an elite rice hybrid. Proc. Natl. Acad. Sci. 94:9226-9231.
Genomics tools in Plant Breeding	**February 28**	**Bernacchi et al. 1998. Advanced backcross QTL analysis in tomato. I. Identification of QTLs for traits of agronomic importance from Lycopersicon hirsutum. Theor. Appl. Genet. 97:381-397. *****
	March 2	Fridman et al. 2000. A recombination hotspot delimits a wild-species QTL for tomato sugar

		content to 484bp within an invertase gene. PNAS. 97:4718-4723.
	March 4	Bouchez et al. 2002. Marker assisted introgression of favorable alleles at QTL between maize lines. Genetics 162:1945-1959.
SPRING BREAK	**MARCH 7 – MARCH 11**	**NO CLASSES**
Genomics tools in Plant Breeding	**March 14**	**Eathington et al. 2007. Molecular markers in a commercial breeding program. Crop Sci 47(S): S154-S163. *** **
	March 16	Breseghello et al. 2006. Association analysis as a strategy for improvement of quantitative traits in plants. Crop Sci. 46:1323-1330.
	March 18	Begum et al. 2015. Genome-Wide Association Mapping for Yield and Other Agronomic Traits in an Elite Breeding Population of Tropical Rice (Oryza sativa). PLoS ONE 10(3): e0119873
	March 21	Desta & Ortiz. 2014. Genomic selection: genome-wide prediction in plant improvement. Trends Plant Sci. 19: 592-601. Hsu et al. 2014. Development and Applications of CRISPR-Cas9 for Genome Engineering. Cell. http://dx.doi.org/10.1016/j.cell.2014.05.010
	March 23	Spindel et al. 2015. Genomic selection and association mapping in rice (Oryza sativa) ... PLoS Genet. 11(2):e1004982 doi:10.1371/journal.pgen.1004982
	March 25	**Bernardo. 2020. Reinventing quantitative genetics for plant breeding: something old, something new, something borrowed, something BLUE. Heredity (2020) 125:375–385**
Long-term selection	March 28	Lamkey et al. 1987. Performance and inbreeding depression of populations representing seven eras of maize breeding. Crop Sci. 27:695-699.
	March 30	Morrison et al., 1999. Physiological changes from 58 years of genetic improvement of short-season soybean cultivars in Canada. Agron. J. 91:685-689.
	April 1	Dudley. 2007. From means to QTL: The Illinois long-term selection experiment as a case study in quantitative genetics. Crop Sci. 47(S3) S20-S31.
	April 4	Dudley. 2007. From means to QTL: The Illinois long-term selection experiment as a

		case study in quantitative genetics. Crop Sci. 47(S3) S20-S31.
	April 6	**Laurie et al. 2004. The genetic architecture of response to long-term artificial selection for oil concentration in the maize kernel. Genetics 168:2141-2155.*** **
	April 8	Lozada et al. 2020. Gains through selection for grain yield in a winter wheat breeding program. PLoS ONE. 15(4): e0221603. https://doi.org/10.1371/journal.pone.0221603
Polyploidy in Plant Breeding	April 11	Overview of important concepts associated with polyploid crops (notes)
	April 13	**Ray et al. 1992. Cytology of 2n pollen formation in diploid crested wheatgrass. Crop Sci. 32:1361-1365.*** **
SPRING (EASTER) HOLIDAY	**April 15**	**NO CLASS**
Polyploidy in Plant Breeding	April 18	Sattler et al. 2016. The polyploidy and its key role in plant breeding. Planta 243:281–296
	April 20	Bingham et al. 1994. Complementary gene interactions in alfalfa are greater in autotetraploids than diploids. Crop Sci. 34:823-829.
	April 22	Adams et al. 2003. Genes duplicated by polyploidy show unequal contributions to the transcriptome and organ-specific reciprocal silencing. PNAS 10:4649-4654.
	April 25	Greer et al. 2012. The Ph1 locus suppresses Cdk2-type activity during premeiosis and meiosis in wheat. Plant Cell 24:152-162.
	April 27	Baker et al. 2017. Polyploidy and the relationship between leaf structure and function: implications for correlated evolution of anatomy, morphology, and physiology in Brassica. BMC Plant Biology. 17:3 DOI 10.1186/s12870-016-0957-3.
	April 29	**The Modern-Day Plant Breeder: Lessons Learned from Plant Breeding and Genetics for Trait Improvement**