Lecture 1
Introduction to Modern Plant Breeding

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Importance of Plant breeding

- Plant breeding is the most important technology developed by man. It allowed civilization to form and its continual success is critical to maintaining our way of life
- Problem: Feeding 9 billion (+) people with the same (or fewer) inputs
  - Same or less acreage
  - Same or less fertilizer, pesticides, water
  - Adapting to climate and environmental change

Goals of Plant breeding

- Increase the frequency of favorable *alleles* within a line
  - Additive effects
- Increase the frequency of favorable *genotypes* within a line
  - Dominance and interaction effects
- Better adapt crops to specific environments
  - Region-specific cultivars (high location G x E)
  - Stability across years within a region (low year-to-year G x E)

Objectives

- Development of pure (i.e. highly inbred) lines with high *per se* performance
- Development of pure lines with high hybrid performance (either with each other or with a testcross)
- Less emphasis on developing outbred (random-mating) populations with improved performance
- Development of lines with high regional G x E, low year G x E

Animal and tree breeding

- Similar goals, but since mostly outcrossing, the goal is to create high-performing *populations*, not inbred lines
- Generally speaking, inbreeding is bad in animals and many trees
- Focus on finding those parents with the best transmitting abilities (highest breeding values)
- Less of a G x E focus with animals, less of a focus on line and hybrid breeding

Special features exploited by plant breeders

- Selfing allows for the capture of specific genotypes, and hence the capture of interactions between alleles and loci (dominance and epistasis)
  - Homozygous for selfed lines
  - Heterozygous for crossed lines
- Often high reproductive output (relative to animal breeding)
- Seeds allow for multigeneration progeny testing, wherein individuals are chosen on the performance of their progeny, or of their sibs
  - Allows for better control over G x E by testing over multiple sites/years

Historical plant breeding

- Early origins
  - Creation of new lines through species crosses (allopolyploids)
  - Visual selection
  - Early domestication (selection for specific traits for ease of harvesting)
- Biometrical school
  - Using crosses to predict average performance under inbreeding or crossing or response to selection
  - Better management of G x E

Modern tools

- Molecular markers
  - Initially low density for QTL mapping, introgression of major genes into elite germplasm
  - With high-density markers, association mapping and MAS/genomic selection
- New statistical tools
  - Mixed model methods
  - Bayesian approaches to handle high-dimensional data sets
  - New methods to deal with G x E
- Other technologies
  - Better standardization of field sites (laser-tilled fields, GPS, better micro- and macro-environmental measurements)
  - High throughput phenotypic scoring
  - DH lines

Current Challenges

- Universities and NGOs playing a less important role in the development of new cultivars
  - Hence, more of an emphasis on short-term gains
  - Less movement of elite germplasm
  - Partition of diversity into lines from different companies
- Rapid movement by Universities and companies into molecular breeding at the cost of less strength in most classical approaches
  - Perhaps this is why you are here!

Diversity

- Plant breeders face the conundrum of using inbred lines to concentrate elite genotypes, but requiring a very large collection of such lines to store variation for further selection
- Landraces or local cultivars may be highly adapted to specific environments, but otherwise not elite
- Issue with keeping germplasm elite while introgressing genes/regions of interest.

Integrated Approaches

- How do we best combine the rich history of quantitative genetics and classical plant breeding with the new tools form genomics and other advances?
- Key: Quantitative genetics has all of the machinery needed to fully incorporate these new sources of information
- The goal of this and our next module is to show how this is done.