Future Trends in Corn Genetics and Biotechnology

California Alfalfa & Forage Symposium

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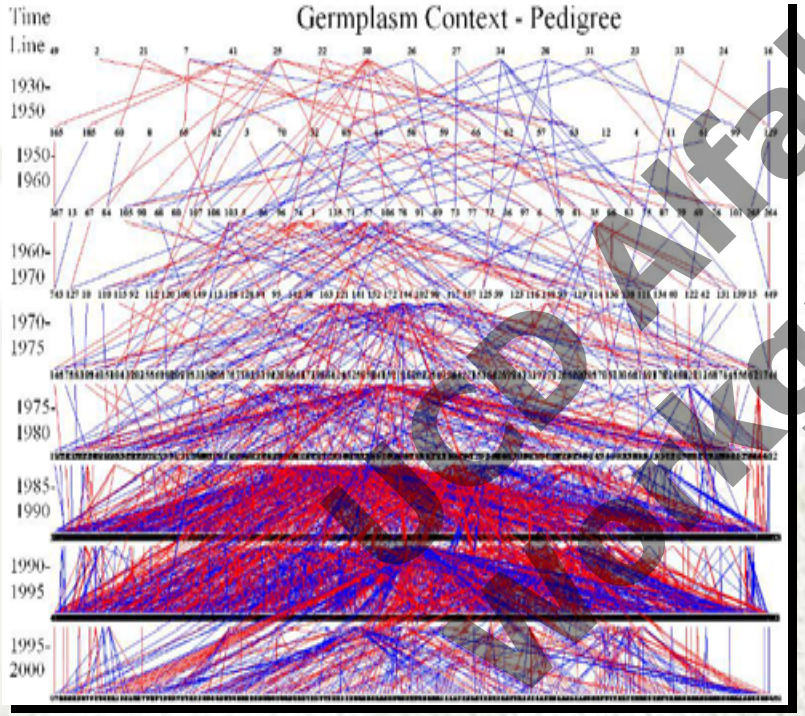
Plant Breeding

The art and science of genetic improvement of plants

Knowledge Rich Library



- Proprietary genetics library
- 75 years of documented performance data
- Genomic descriptions of best lines
- Unique advantage – can't be duplicated

Increasingly Erect Leaves

Left 1930s *Right 1990s*

Smaller Tassels

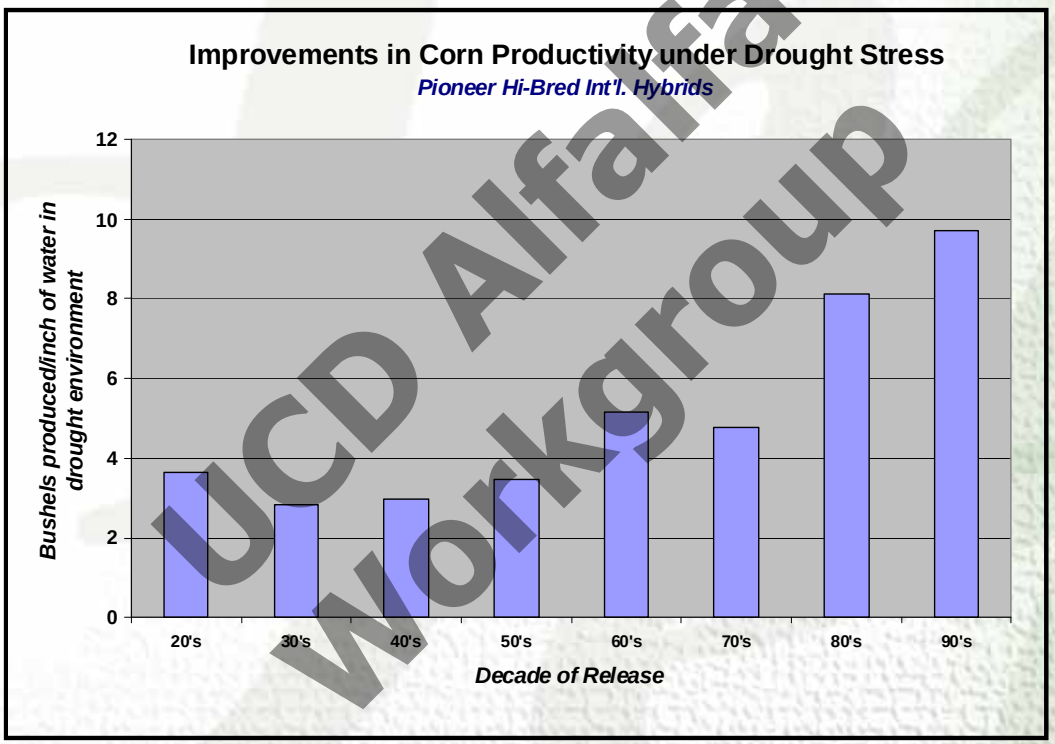
Left 1930s *Right 1990s*

Increased Flowering Synchrony

1930s

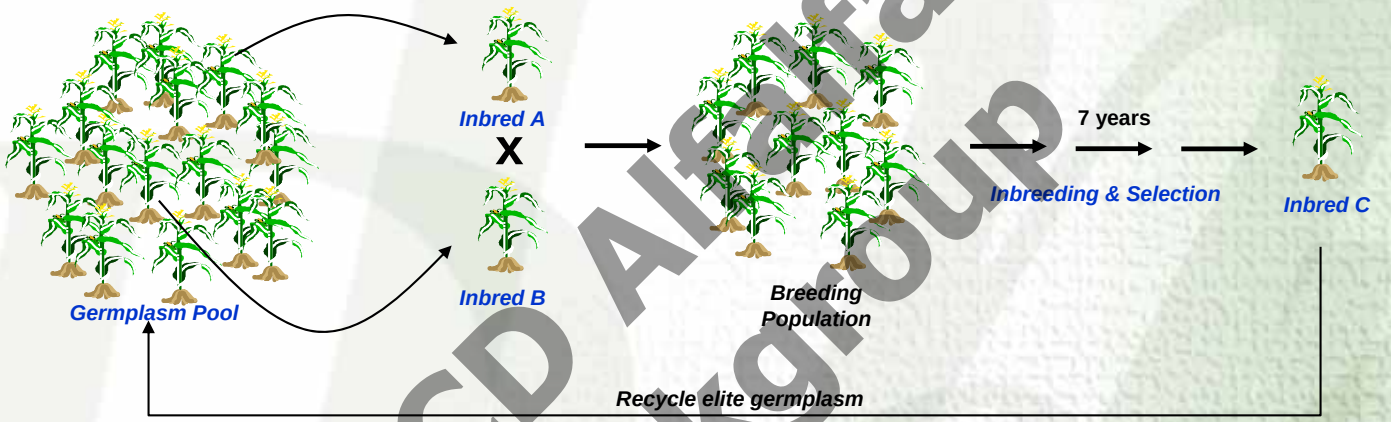
1990s

Historical Progress



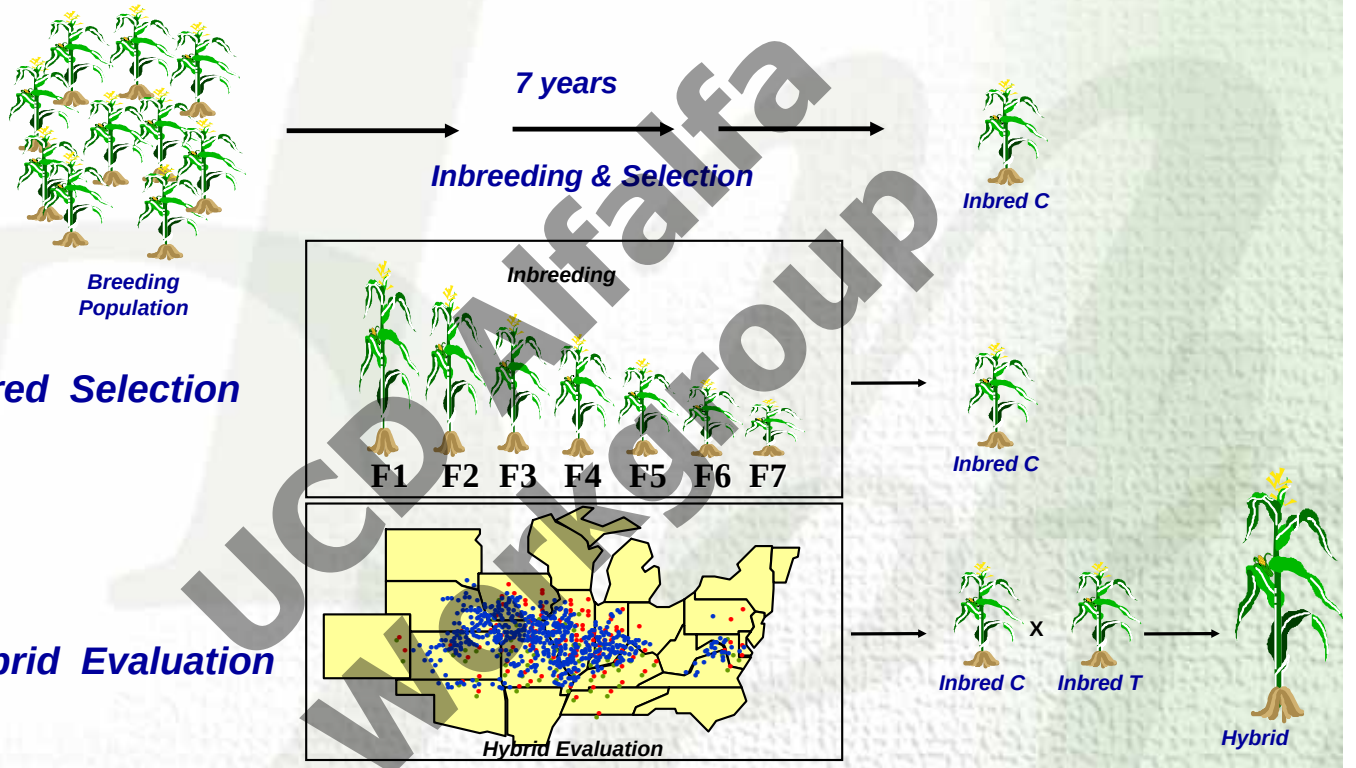
Traditional Breeding

Traditional Corn Breeding



- Germplasm Pool – The collection of inbreds and genes available for making new products
- Breeding Population – A cross between two or more inbreds to create variability
- Inbreeding & Selection – The process of selecting the best individual in a breeding cross
- Recycle elite germplasm – Once a new inbred is created it is added to our germplasm pool and serves a base of improved performance

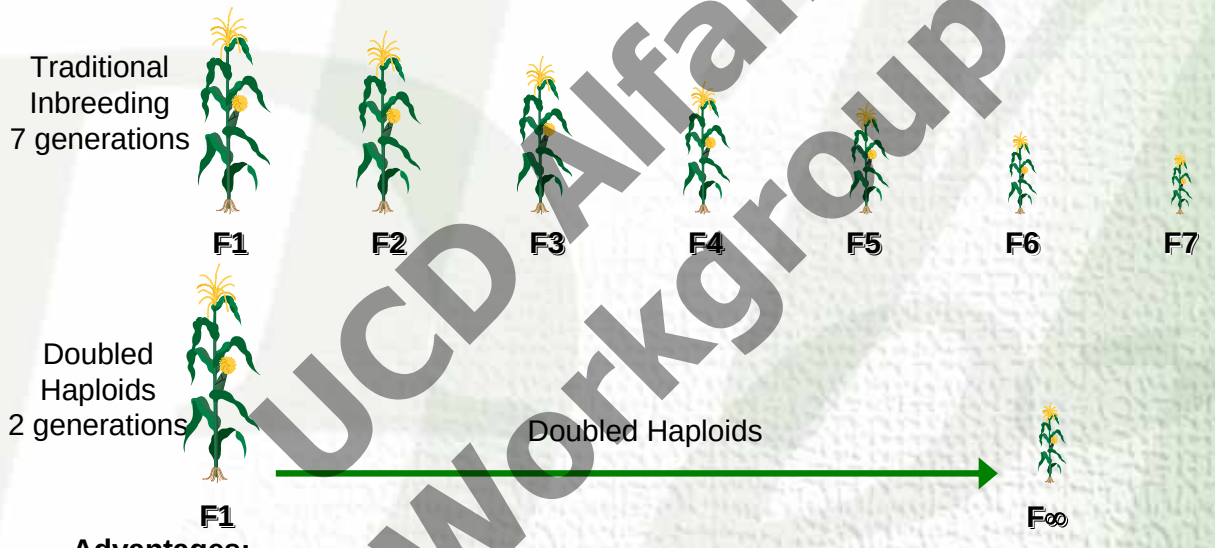
Inbreeding and Selection



- *Advance the inbred based on its hybrids performance in multi-location, multi-year field trials*

Doubled Haploids

Doubled Haploids – Instant Inbreds



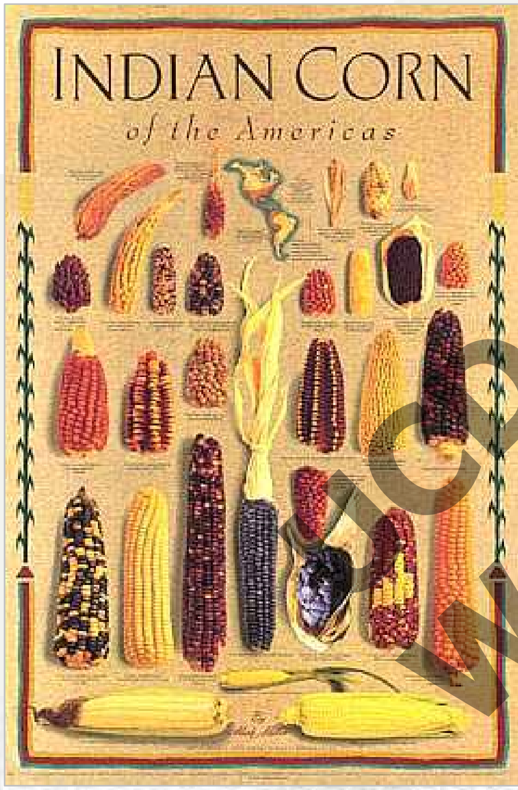
Advantages:

- **Increases precision of molecular markers**
- **Reduces hybrid development cycle time 1-2 years**
- **Increases options for per se selection (parent traits, disease, maturity)**
- **Breeding impact – more complex pedigree selection away from home nursery**

Doubled Haploid Lines

- **100% fixed, genetically uniform lines**
- **Improves breeding by…**
  - Increasing genetic differences between lines
  - Increasing uniformity
    - easier to measure traits
    - increases repeatability
  - Testing final product immediately
  - Reduces product development time

Molecular Breeding



Genetic mapping
Map-based cloning

A	A	T	A	C	G	A		T
A	A	T	A	C	G	A		T
A	A	T	A	C	G	A		T
A	A	T	A	C	G	A		T
A	A	T	A	C	G	A		T
A	A	T	A	C	G	A		T
A	A	T	A	C	G	A		T
A	A	T	A	C	G	A		T
G	A	T	A	C	A	A	I/D	C
G	A	T	A	C	A	A	I/D	C
G	A	T	A	C	A	A	I/D	C
G	A	T	A	C	A	A	I/D	C
G	A	T	A	C	A	A	I/D	C
G	A	T	A	C	A	A	I/D	C
G	A	T	A	C	A	A	I/D	C
G	A	T	A	C	A	A	I/D	C
G	A	T	A	C	A	A	I/D	T
G	A	T	A	C	A	A	I/D	T
G	C	A	T	T	A	C		T
G	C	A	T	T	A	C		T
G	C	A	T	T	A	C		T
G	C	A	T	T	A	C		T
G	C	A	T	T	A	C		T
G	C	A	T	T	A	C		T
G	C	A	T	T	A	C		T
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G	C	A	T	T	A	C		T
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G	C	A	T	T	A	C		T
G	C	A	T	T	A	C		T
G	C	A	T	T	A	C		T
G	C	A	T	T	A	C		T

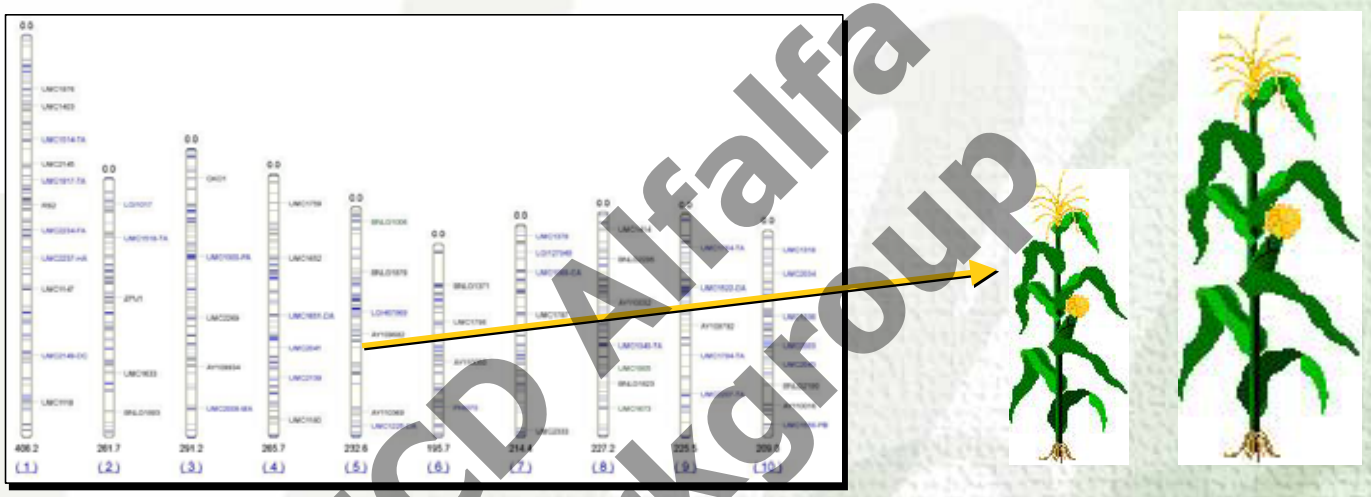
Molecular Breeding

- **Identify parents**
  - Load breeding pipeline with known genotypes
  - More predictive of performance
- **Select superior progeny**
  - Identify progeny with traits not expressed in testing environment (e.g. select for GLS where disease does not occur)
- **Test final products**
  - Predict performance in non-stress environments
  - Predict favorable new combinations of inbred parents based on complementary molecular profiles

Molecular Breeding

- **Enhance diversity of germplasm pool**
  - Move small segment of exotic chromosome into elite background without “drag”
    - Ex) move genes from teosinte or landrace into elite corn without having to do extensive backcrossing and repeated phenotyping to eliminate yield, maturity and adaptation drag
  - Scan corn genome for sequences of interest identified in other species
  - Move gene from other species into corn (transgenes)

Inbred Selection Using Molecular Markers

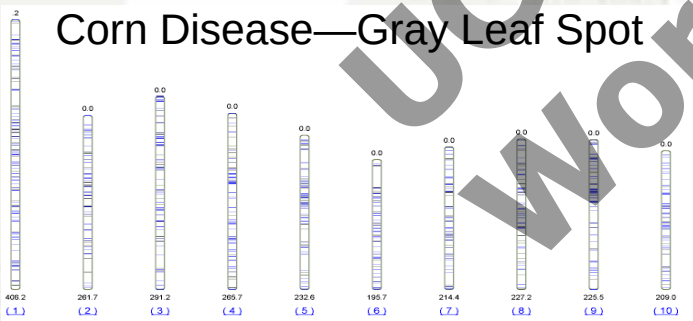


- **Molecular markers "tag" valuable chromosome segments**
- Quickly determine if inbreds and hybrids possess a gene for a target trait
- Aggressively profiling eight decades of germplasm to create a master genetic map

Drives agronomic performance gains (e.g., anthracnose, SCN)

Molecular Marker Based Selection

Corn Disease—Gray Leaf Spot



- **Phenoype = Genotype + Env + (Geno*Env)**
  - Not all genotypes are observed in all environments!
- **Markers allow for selection of genomic sections with known phenotypic effects in environments not conducive to phenotypic expression.**
- **Starting point of finding the underlying genes responsible for phenotype**

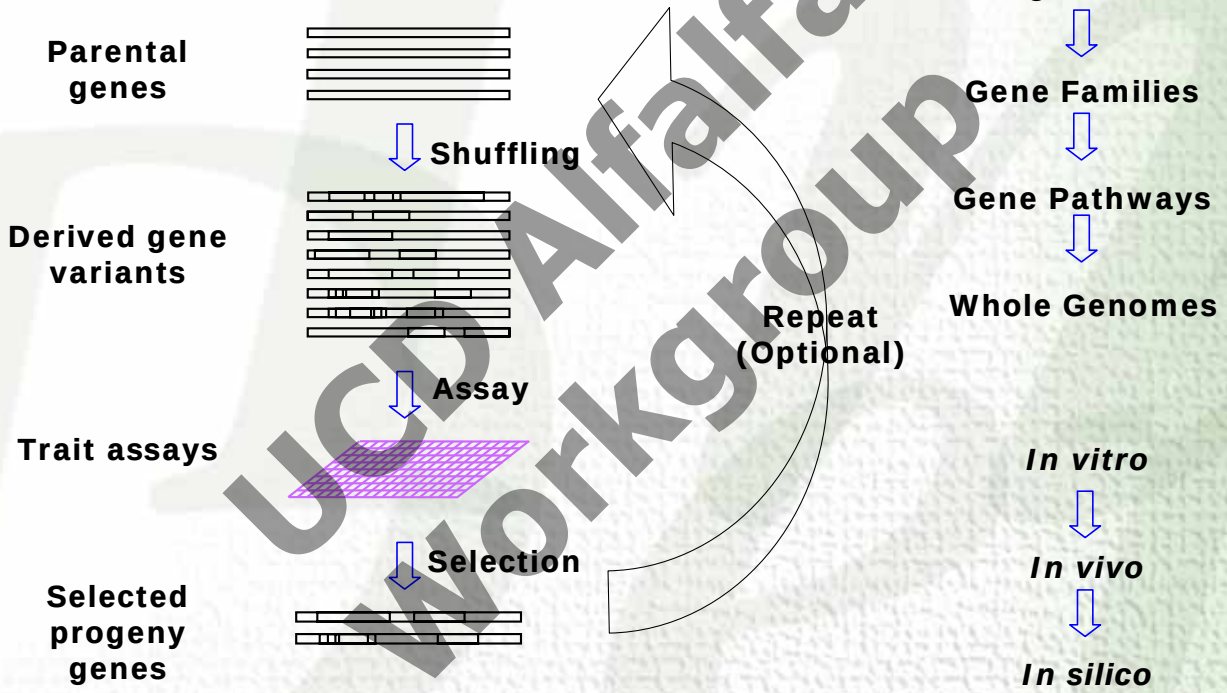
Current Uses

- **Understanding of Genetic Relationships**
- **Conversion Quality**
- **Corn Product Development**
  - Targeting “Key” Traits
  - Important tool in inbred/hybrid development
- **Germplasm protection**

Other biotechnology applications

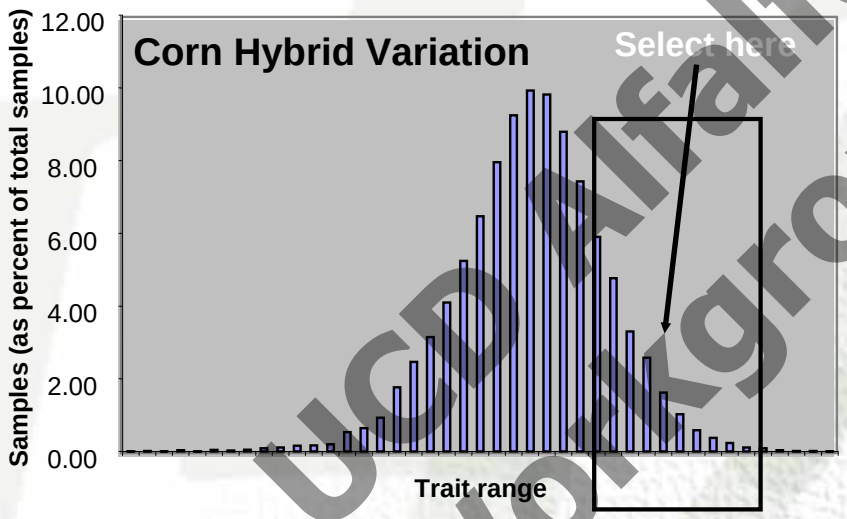
- **Transgenes**
  - European corn borer resistance (“bt”)
  - Corn rootworm resistance
  - Herbicide tolerance
- **Future potential**
  - Yield
  - Drought tolerance
  - N-use efficiency
  - Nutritional and industrial traits
- **Intellectual property**
  - DNA fingerprints
  - Protect investment to insure plant breeding future research
- **Gene discovery**
  - Genome sequencing
  - Gene expression
  - Understanding gene function

Gene Shuffling



Ultimate Goal of Breeding is:

- **Selecting for measurable improvements in traits**



- Trade-off
- Test for measured improvement
- Stay focused

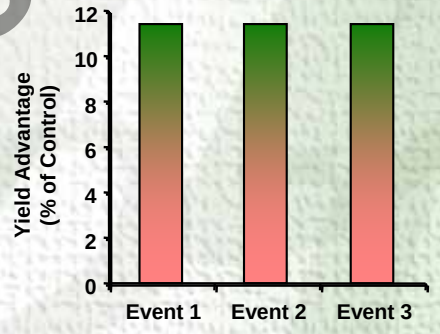
Is range broad enough to make meaningful progress?

Growing Value From Agronomic Traits

- **Drought tolerance**
  - Proprietary testing environments
  - Numerous early stage leads validated in multiple model crops
  - Average annual drought loss $8 billion globally
- **Nitrogen responsiveness**
  - Maintain yields using less nitrogen
  - Increase yields at current nitrogen levels
  - Industry-leading testing environments
  - Average nitrogen cost = $40/acre
- **Yield enhancement**
  - Farmers' No. 1 priority
  - Six soybean biotech events in advanced testing
  - Numerous corn leads undergoing inbred evaluation

Drought Tolerance

Check Hybrid | *Pioneer Experimental Hybrid*



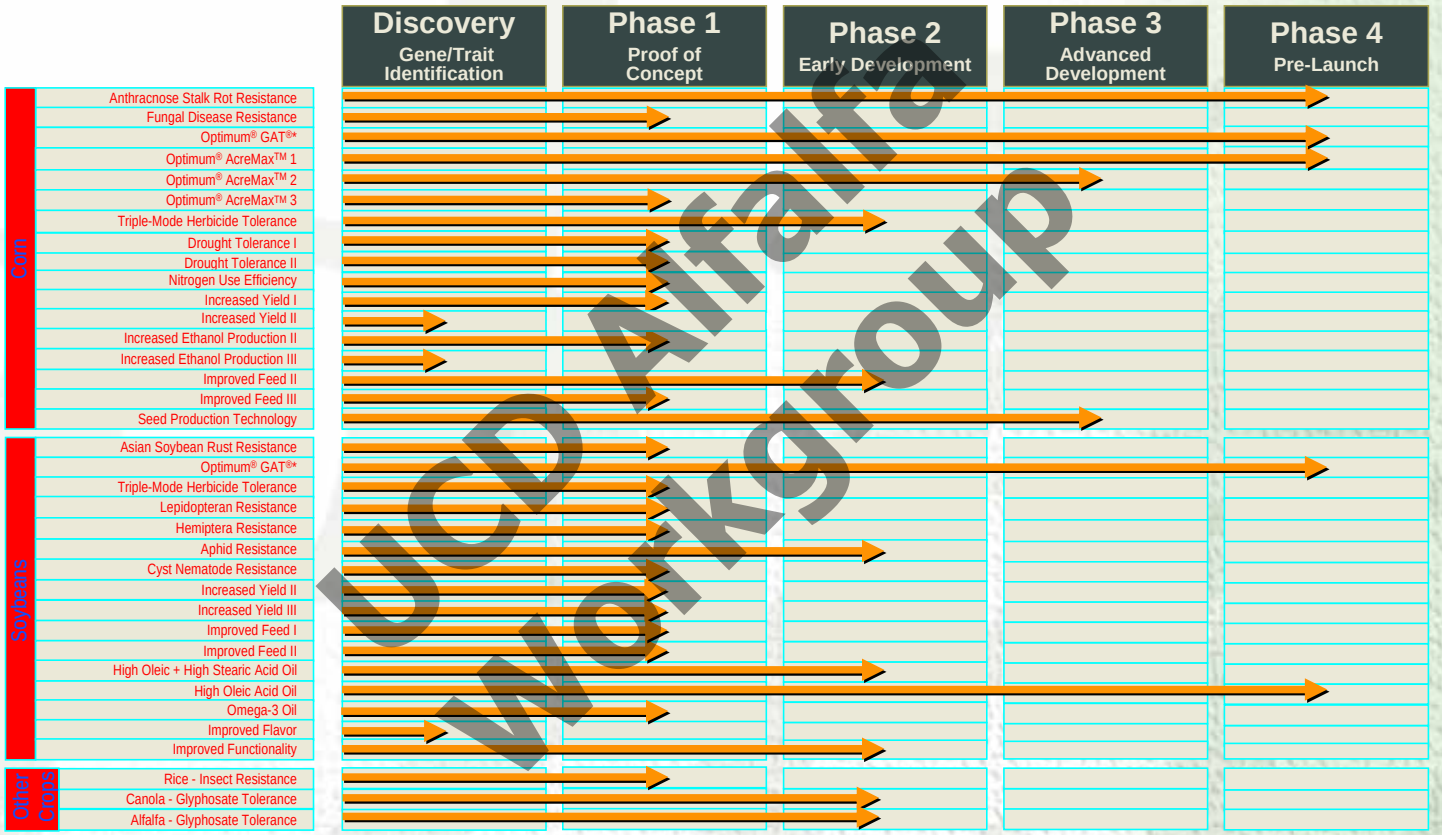
Average Soybean Yield Advantage Over Control Varieties During Past Two Years

Trait	Discovery	Phase 1	Phase 2	Phase 3	Phase 4
Drought Tolerance	→	→			
Nitrogen Responsiveness	→				
Soybean Yield Enhancement	→	→			

02/08

2008 Crop Genetics Pipeline

2/08



** Proprietary Pioneer Glyphosate + ALS Tolerance trait*

PIONEER
A DuPont Company

The miracles of science


Questions?
UCD Alfalfa
Workgroup