UNIVERSITY OF WISCONSIN–MADISON

How Do Advances in Corn Breeding Improve the Corn for Silage?

World Dairy Expo 2017

Dairy Forage Seminar Stage

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October 5th, 2017

Outline

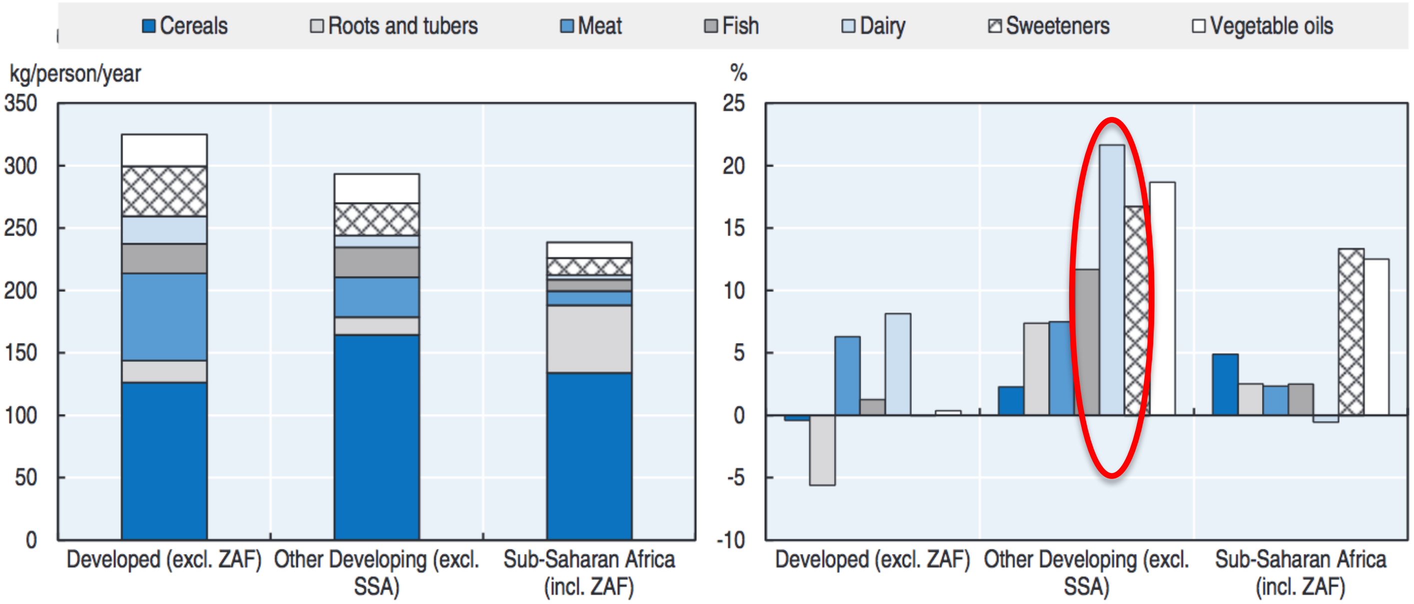
- Silage Breeding and the UW Program?
- Tools to Increase Breeding Outcomes
- Future Challenges

Demand for Silage?

- While income growth in emerging economies is projected to be weaker, increased global population is expected to increase demand for dairy products

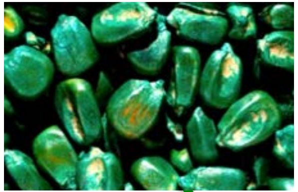
Figure 1.2. **Per capita food consumption by region**

Kg/cap/year in 2025 (left) and growth 2025 vs. 2013-15 (right)



OECD-FAO Agricultural Outlook 2016-2025

Seed to Seed: 800X Biomass Return



~30 kg seed/ha

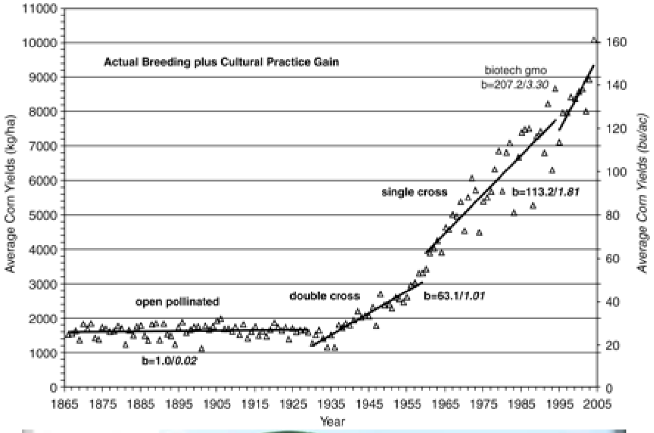
~ 75 days

~12 Mg/ha
vegetative biomass
at flowering

~ 45 days

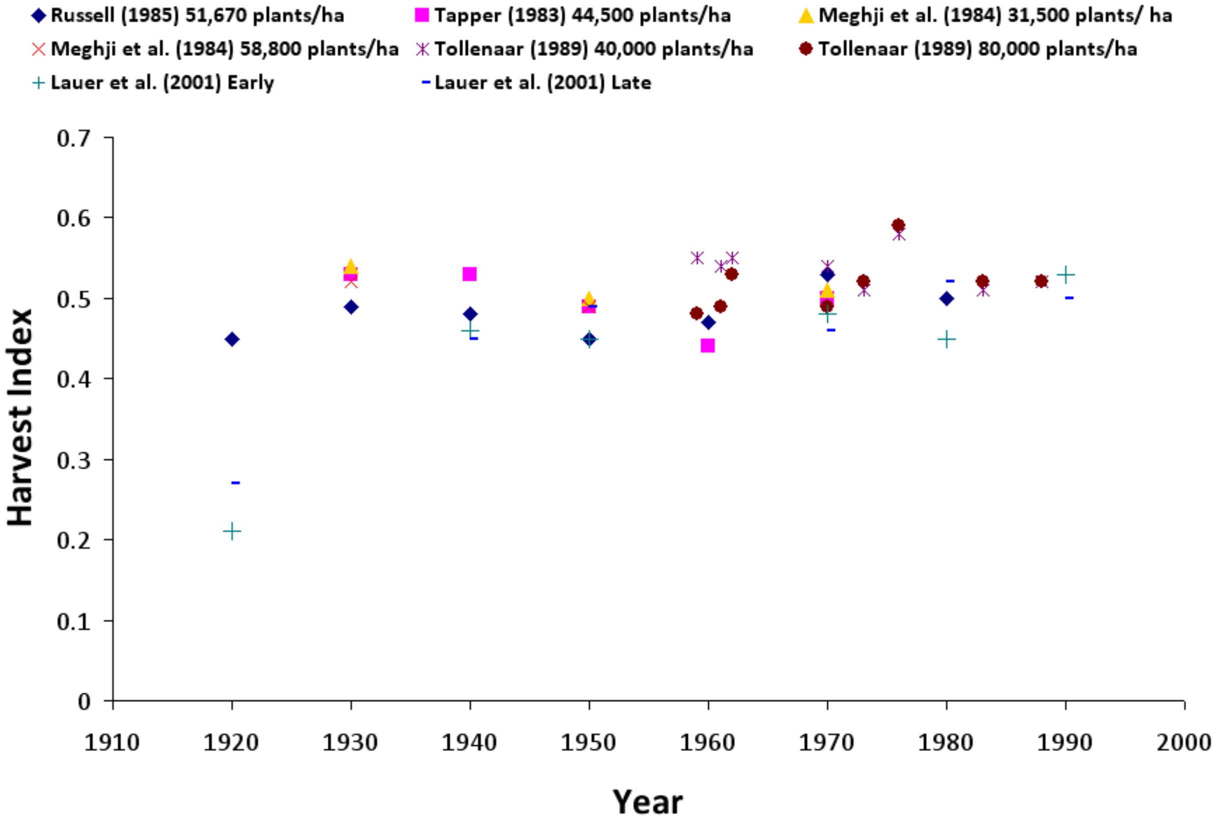
~12 Mg/ha
grain

Relative Contribution of Grain vs Stover

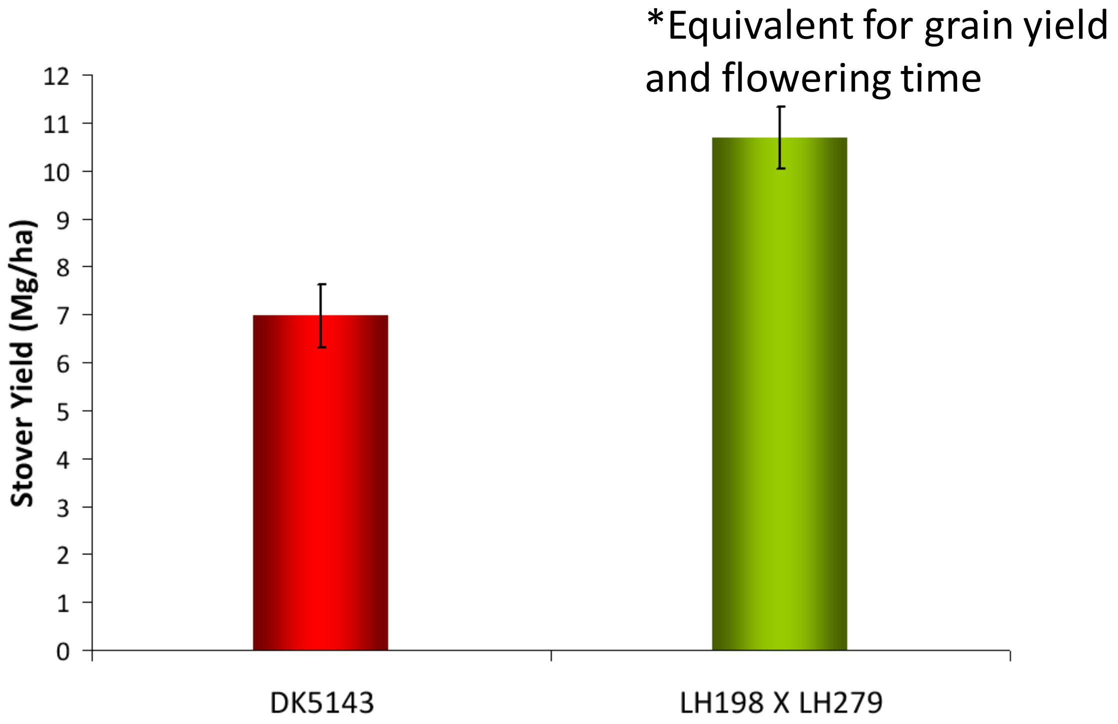


VS

Has Harvest Index Remained Constant in Corn?

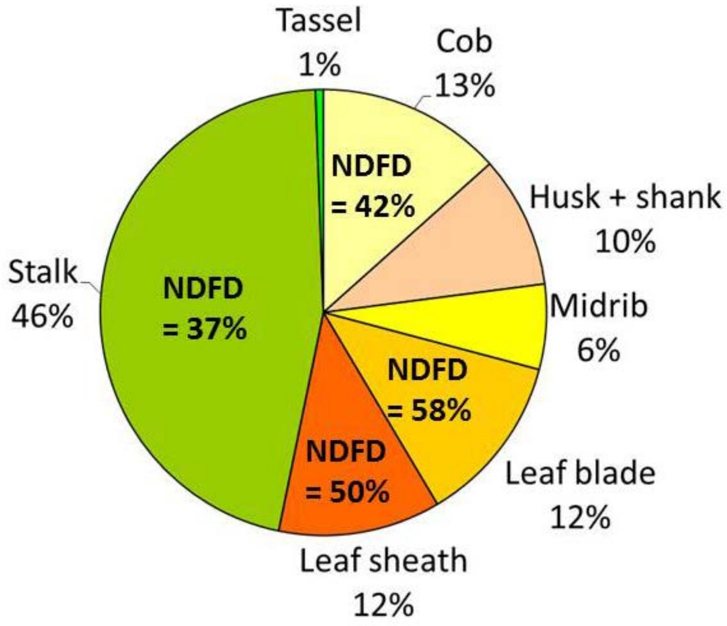


Variation for Stover Yield Among Elite Grain Hybrids



Lorenz et al 2009 - Crop Sci. 49:85–98

Where is Biomass Quality Coming From?



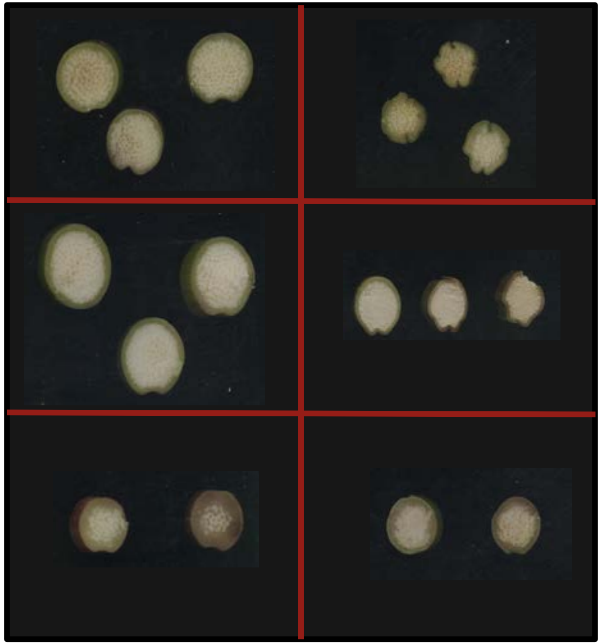
Hansey et al, 2010 - Bioenergy Research 3:28-37

- **Comparison:**
  - *bm3* (=COMT) vs isoline ~10 to 20% increase in NDFD
  - Increase blade sheath by 50% ~5% increase in NDFD

Relationship between Digestibility and Anatomical Traits

Genotypes with low sugar release

Genotypes with high sugar release



Silage Production and the UW Program

- Approximately 7% of the corn acreages harvested in the U.S. in 2016 were silage acres and WI is the largest producer with ~790,000 acres
- The UW program focuses on the development of corn varieties with enhanced compositional attributes and forage yield
  - High yield
  - High energy (high digestibility)
  - High intake potential (low fiber)
  - High protein
  - Proper moisture at harvest for storage





FOSS
NIRS™ DS2500

Scope of the Program

- Between 2,000 and 3,000 evaluation plots are dedicated to the silage breeding program yearly
- Evaluation includes two main locations – West Madison and Arlington, WI
- Advanced lines are evaluated by the UW Extension Program at an additional 3 to 4 location based on relative maturity
- Additional silage plots are dedicated to silage research activities which varies from year to year
- Release more than 8 breeding populations, UW NIRS silage quality prediction equations and 25 inbred lines since inception

Selection Criteria – MILK 2006

Milk/ton	Milk/acre
lbs	lbs

2005 EXPT WQS198 - Forage yield and nutritional evaluation (Madison and Arlington)

05No.	Entry	Dry matter %	Yield t/a	NDF %	IVD %	IVNDFD %	Protein %	Starch %	Milk/ton lbs	Milk/acre lbs
1	12004-1-4 X LH198	44.3	7.56	46.3	80.6	58.1	7.94	29.9	3244	24560
4	12021-3-4 X LH198	41.0	6.33	46.3	81.2	59.4	7.90	28.2	3258	20642
6	12028-3-1-5-1 X LH198	44.0	7.77	46.9	80.4	58.0	7.89	29.2	3225	25049
8	12028-3-2 X LH198	43.3	8.27	47.8	80.6	59.3	8.10	29.0	3224	26641
9	12028-3-3 X LH198	45.0	8.41	45.7	80.4	57.1	7.91	31.7	3242	27231
10	12028-3-4 X LH198	46.3	7.61	49.0	78.8	56.7	7.70	28.3	3118	23743
13	12057-1-1-2 X LH198	42.3	7.47	47.4	80.0	57.8	7.95	29.1	3199	23912
15	12057-1-5 X LH198	43.8	8.99	43.9	80.8	56.1	7.74	33.5	3281	29524
20	12135-3-1-3-1 X LH198	46.5	8.23	47.1	79.8	57.1	7.59	30.7	3192	26314

Milk 2006

University of Wisconsin Corn Silage Evaluation System

Randy Shaver, Dept. of Dairy Science *Patrick Hoffman, Dept. of Dairy Science*
Joe Lauer, Dept. of Agronomy
Jim Coors, Dept. of Agromomy

Sample values entered here must correspond to lab average and incubation time information entered in "UserInputGuide" Worksheet cells G25 and G27.

Critical Data Entry
Required Inputs
Calculated Outputs

		Form Input	Optional Starch Digestibility Tests			Lab Value	Lab Value	Lab Value	Lab Value	Lab Value	Lab or Book Value	Lab or Book Value	Field Measure	Calculated	Calculated	Calculated	Calculated
Field ID	Lab ID	Kernel Processed yes/no	KPS %	DSA %	IS-IV %	DM %	CP % DM	NDF % DM	NDFD % NDF	Starch % DM	Ash % DM	Fat % DM	DM Yield tons/acre	TDN-1x % DM	NE_L-3x Mcal/lb DM	Milk per Ton Index lb/ton DM	Milk per Acre Index lb/acre
"normal"	L001	no				35.0	8.8	45.0	59	27.0	4.3	3.2	7.0	69.7	0.68	3169	22182
1	L002	yes				35.0	8.8	45.0	59	27.0	4.3	3.2	7.0	71.0	0.70	3273	22910
						.	.	.	.	.	.	.	.	#VALUE!	#VALUE!	#VALUE!	#VALUE!
						.	.	.	.	.	.	.	.	#VALUE!	#VALUE!	#VALUE!	#VALUE!

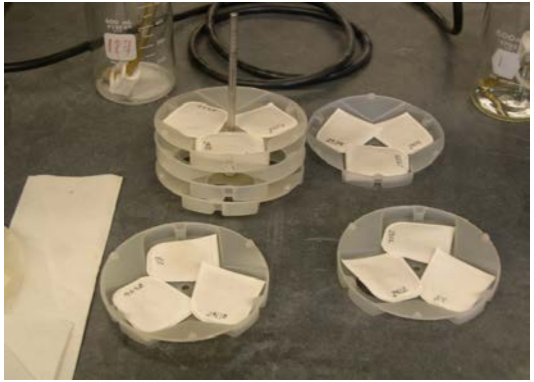
http://www.uwex.edu/ces/dairynutrition/documents/milk2006cornsilagev.xls

Quality Analysis Methods

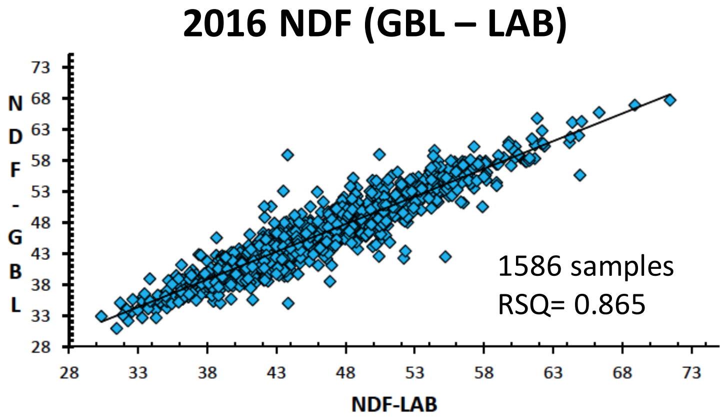
- **Neutral detergent fiber (NDF); Acid detergent fiber (ADF); Acid detergent lignin (ADL) and In vitro true digestibility (IVTD)** following Goering and Van Soest, 1970 with modifications (ANKOM system)

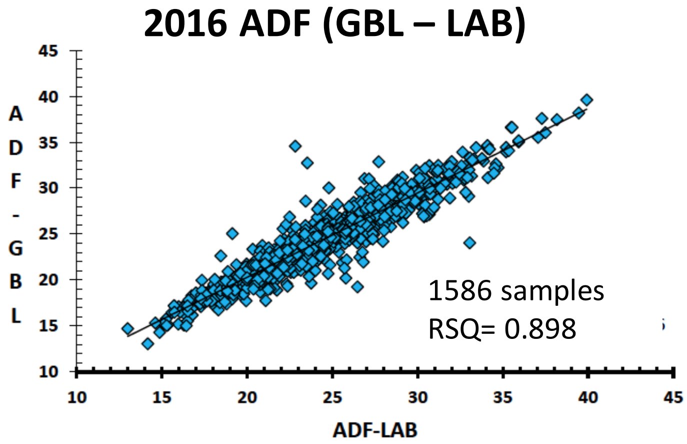
- **Protein** = Measure nitrogen using the Leco FP-528 nitrogen analyzer (N X 6.25)

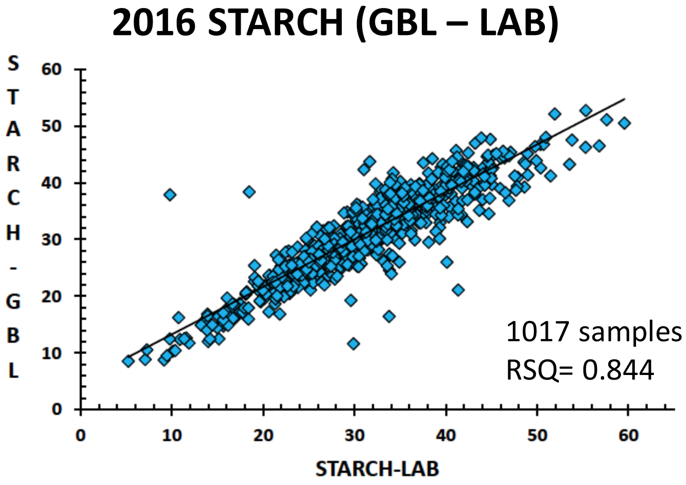
- **Starch** = Predicted using whole plant silage global NIRS equation

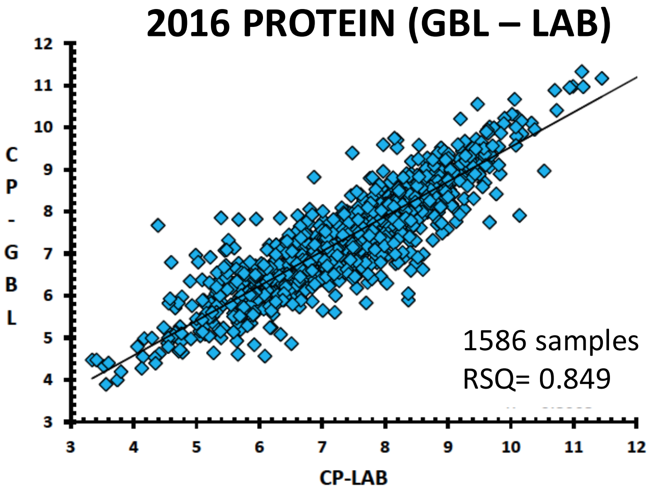


2016 NIRS Global Equation Calibration

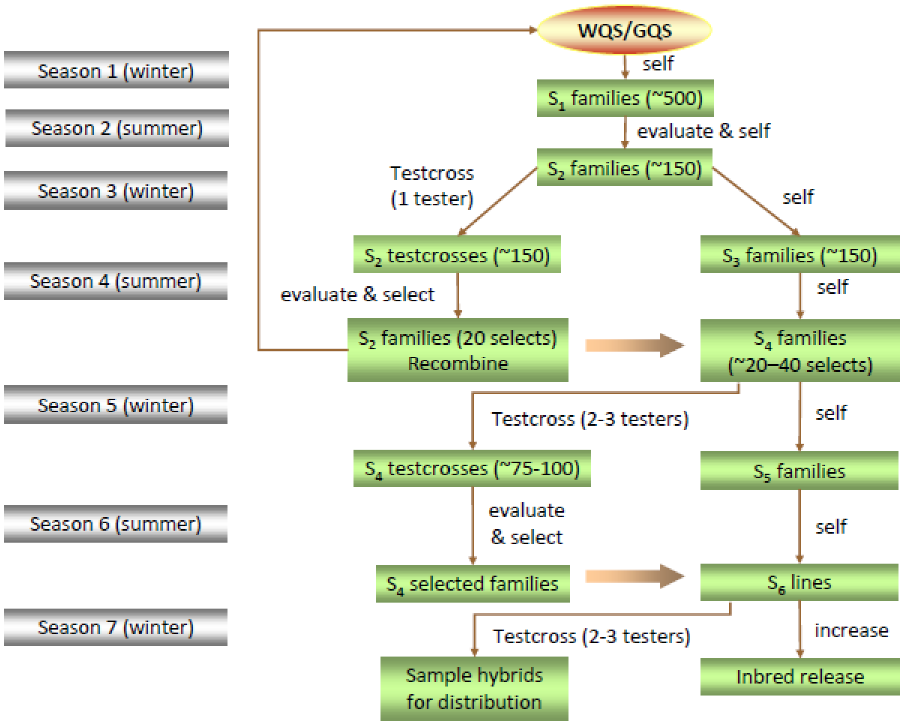








Selection Protocol

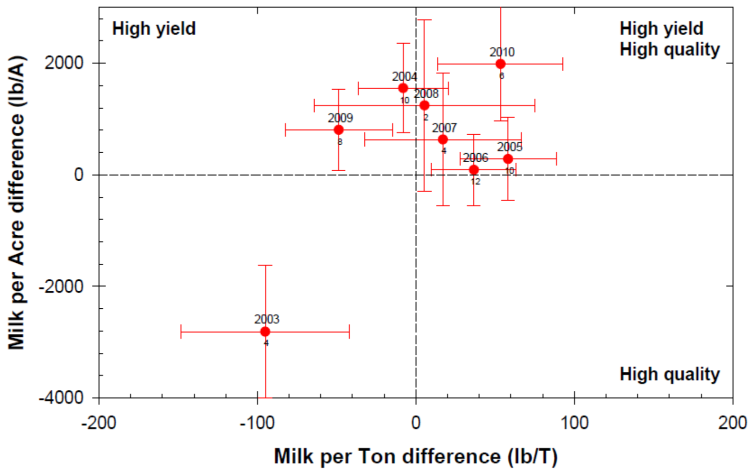


WQS - Broad-based high quality synthetic (low fiber, lignin and silica) then crossed by H99 and Mo17 (100 to 110RM)

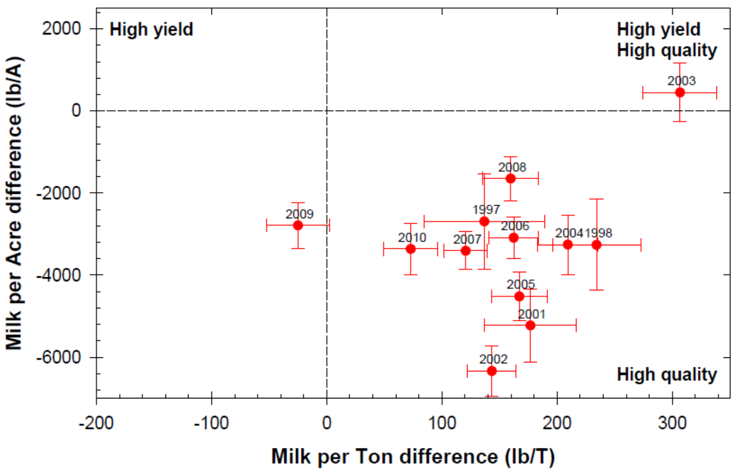
GQS - CUBA164:S1517 and CUBA117:S1520 populations are from the Stiff Stalk Synthetic background (75%)

Also germplasm from the Germplasm Enhancement of Maize (GEM) program

WQS Germplasm



WQS derived lines



brown midrib3 lines

Joe Lauer - Data from UW Extension - Corn Trial

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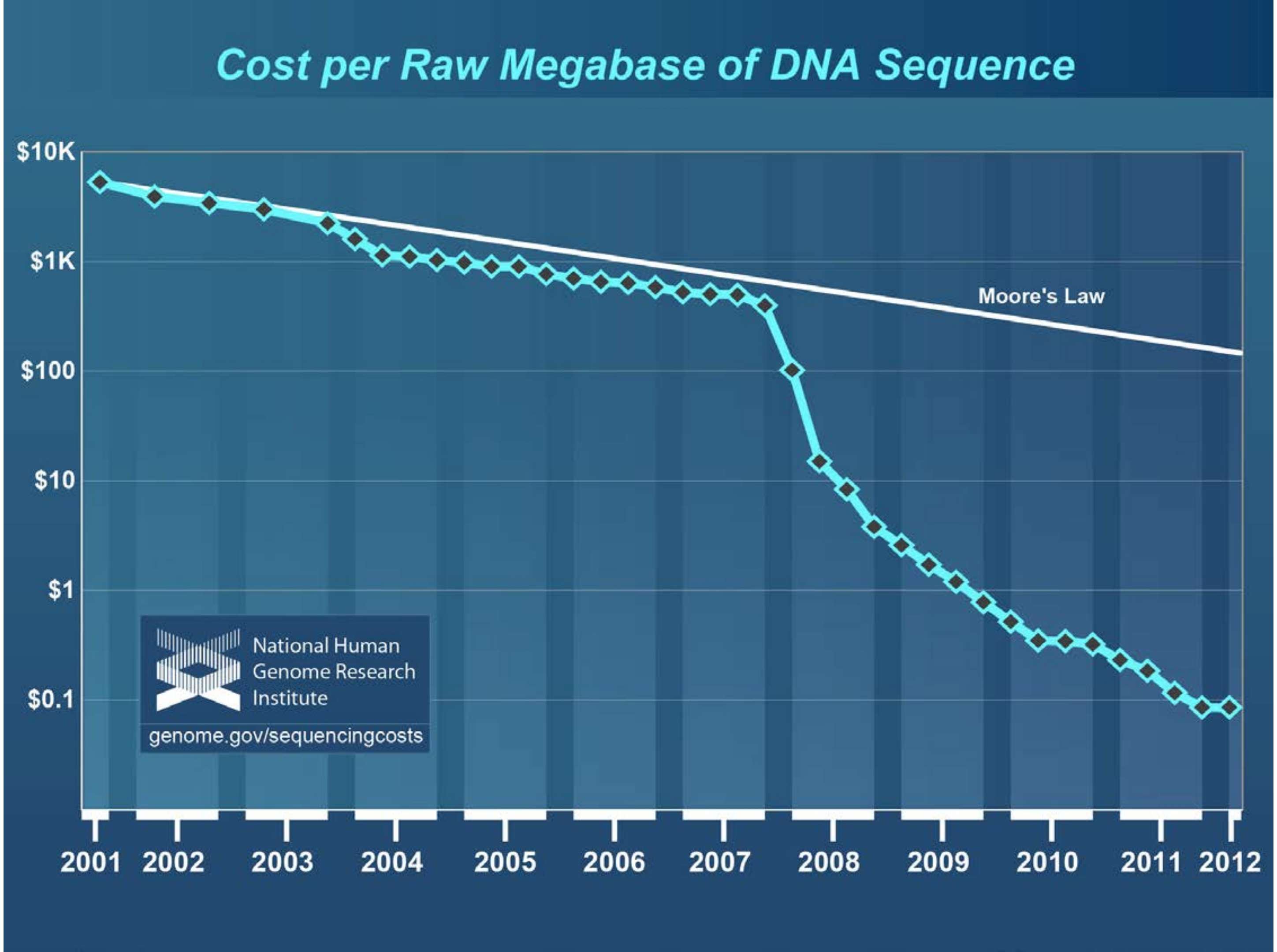
Cost per Raw Megabase of DNA Sequence
$10K
$1K
$100
$10
$1
$0.1
Moore's Law
National Human
Genome Research
Institute
genome.gov/sequencingcosts
2001
2002
2003
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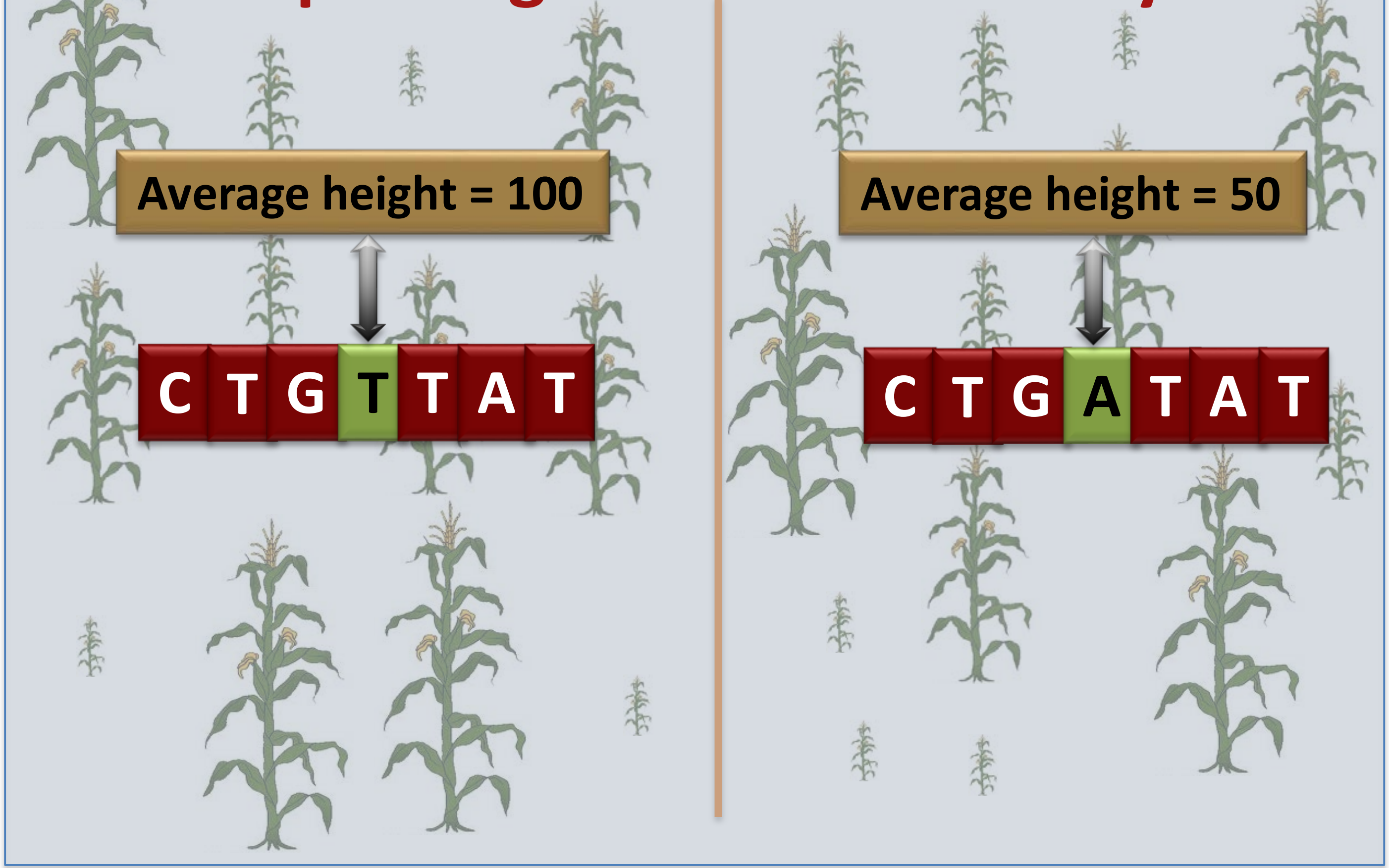
2012

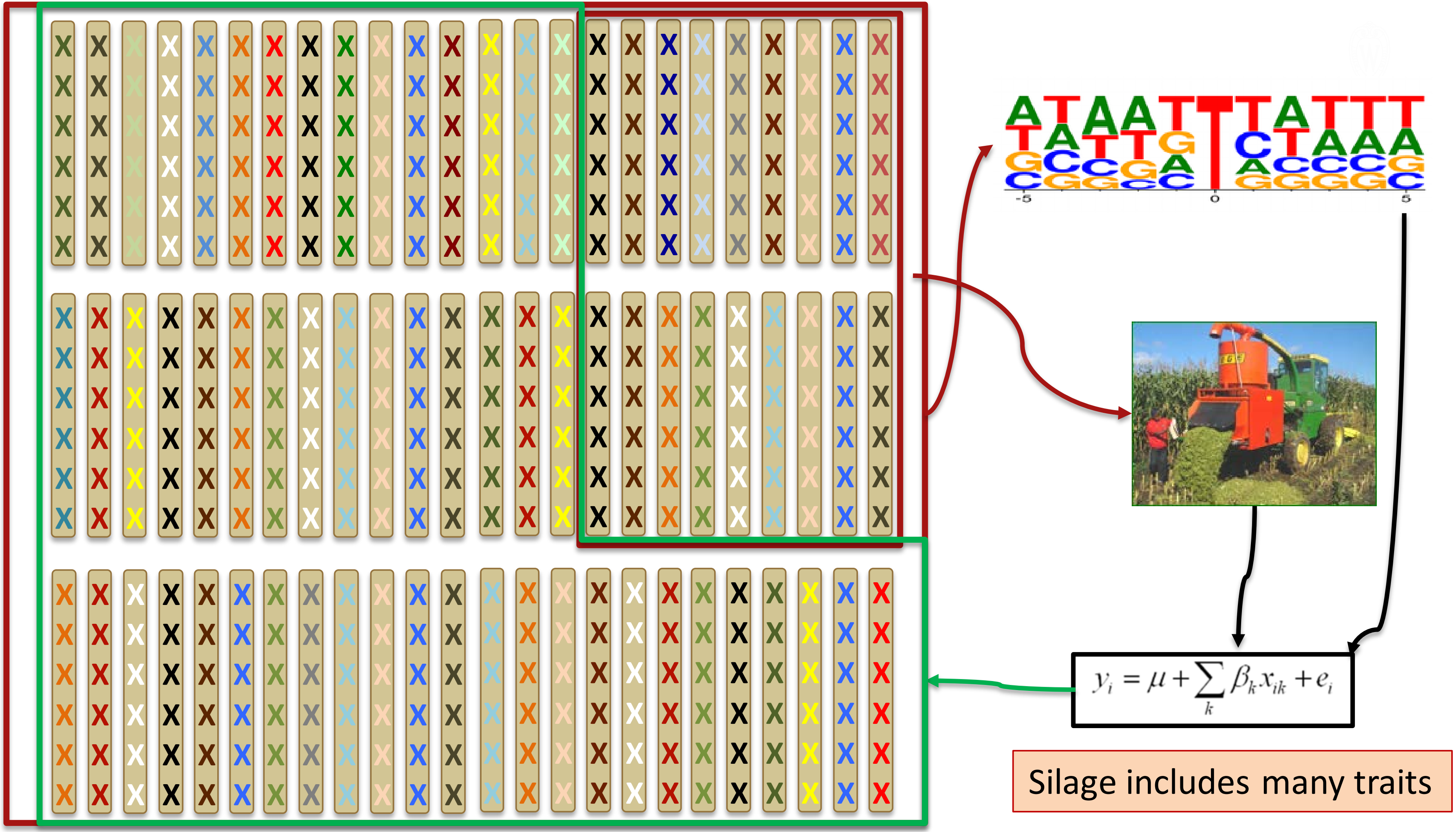
Exploiting Genetic Variability



Phenotypic Selection

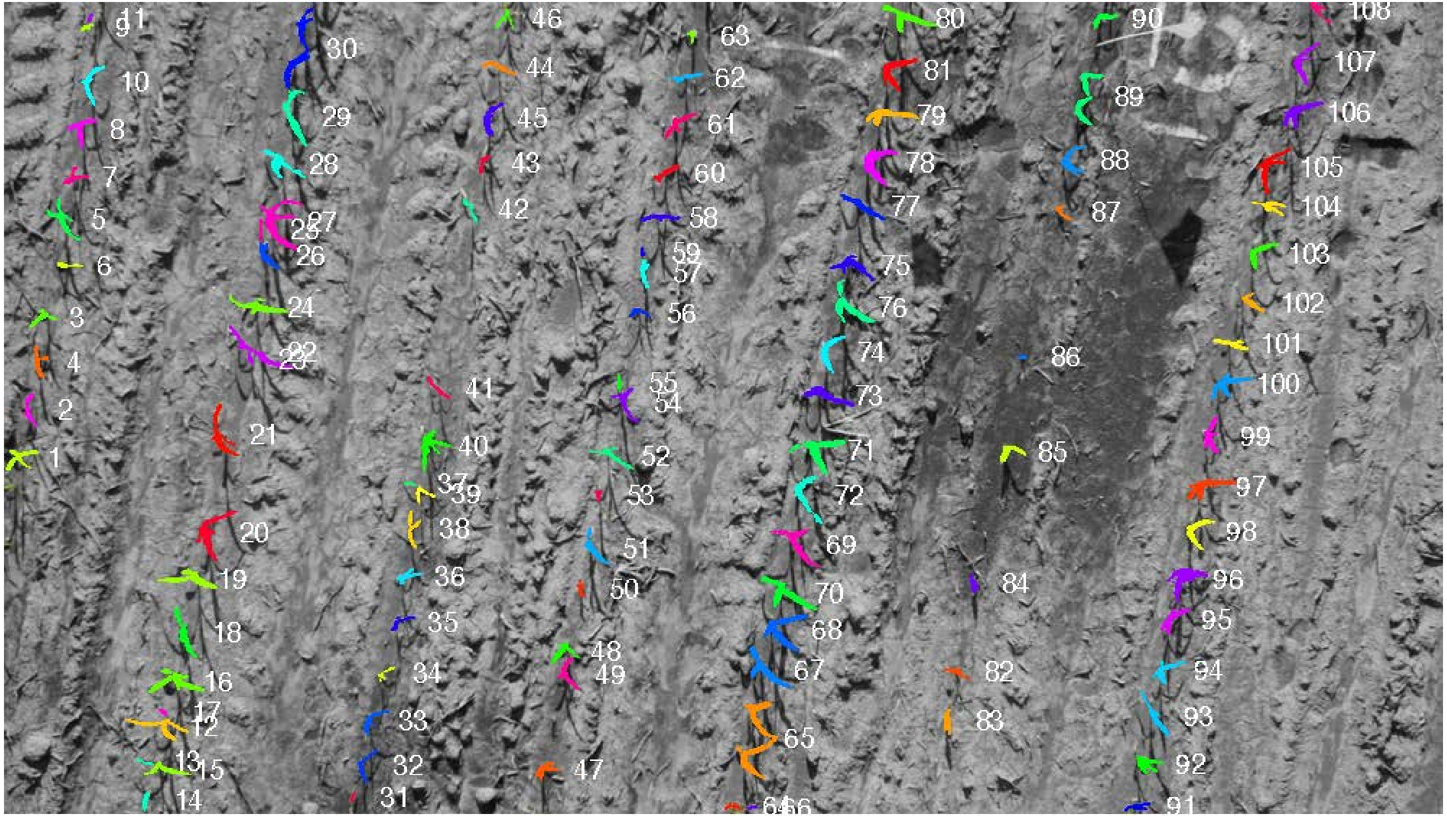
Genomic Selection

http://b4fa.org/bioscience-in-brief/plantbreeding/what-is-plant-breeding/

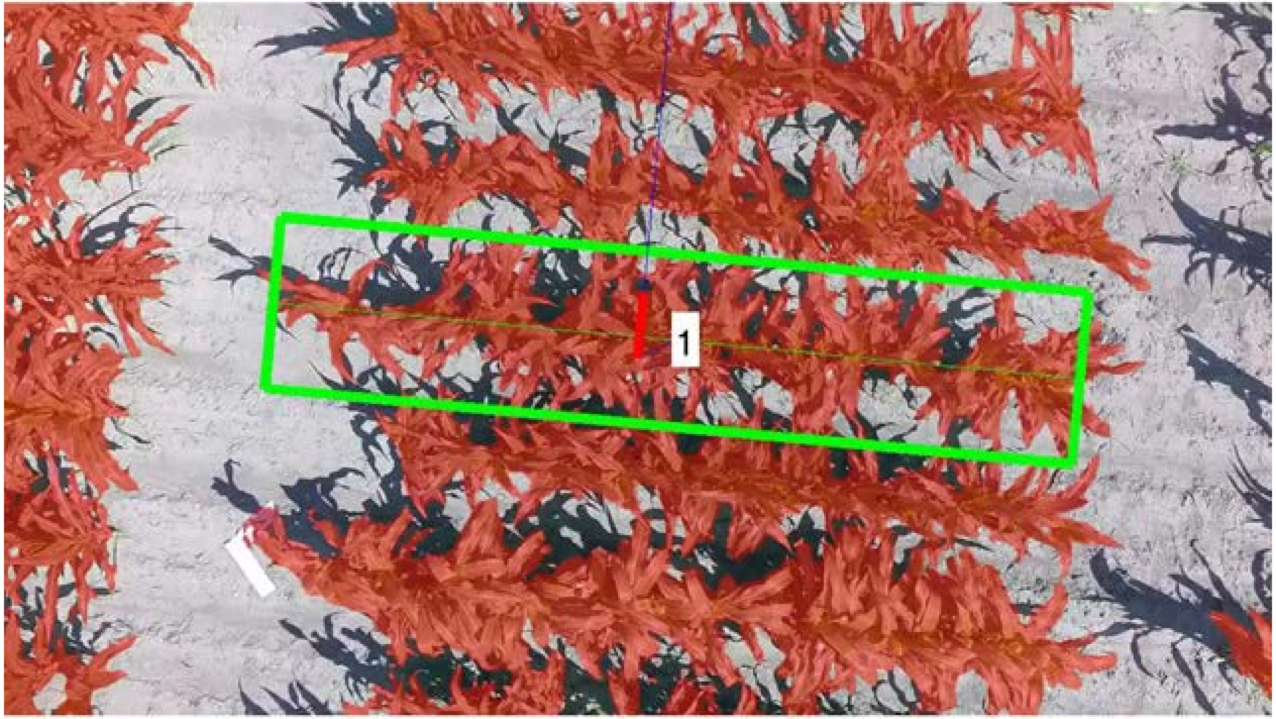

$y_i = \mu + \sum_k \beta_k x_{ik} + e_i$
Silage includes many traits

Phenotyping

Stand Counts



Growth Rate and Tasseling



Nathan Miller
Spalding Lab

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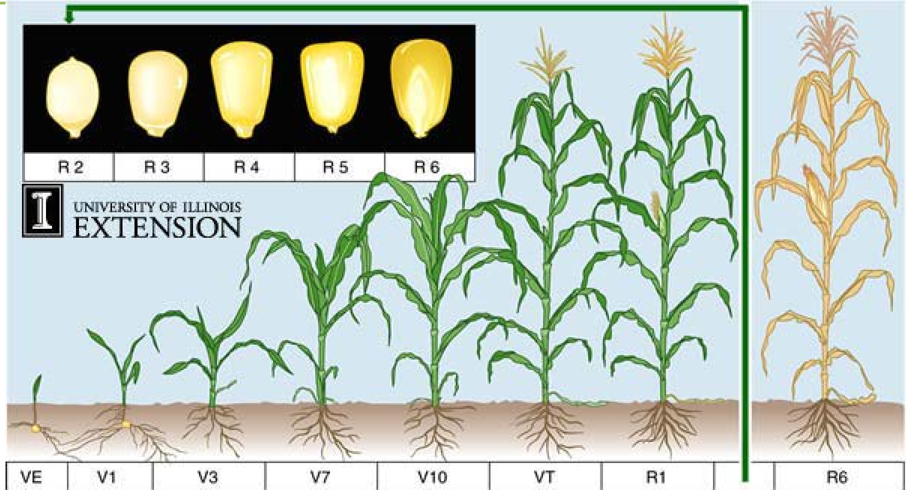
Phenotypes are Modified by the Environment over Time

Factor	VE	V6	V12	V18	R1	R6
Frost (< 28 F)	0	100	100	100	100	0
Hail (max)	0	53	81	100	100	0*
Drought/Heat (%/day)	--	--	3	4	7	0
Flooding (<48 h)	severe	severe	0	0	0	0

* Assuming no ear dropage

http://corn.agronomy.wisc.edu/Management/L011.aspx




Day 1
Day 2
Day 3
Day 4
Day 5

Edgar Spalding
UW Madison

What Our Eyes Cannot See

Take Home Message:

- ✧ Need for varieties with improved silage characteristics is expected to continue to increase due to international demand
- ✧ Equipment and management tools have helped research
- ✧ Genotypic information is cheap, meaningful, high-throughput phenotyping is the bottleneck
- ✧ Interdisciplinary developments are needed to increase efficiency of phenotyping (current bottleneck)
- ✧ The UW Corn Silage Breeding Program continues to serve as a source of germplasm, research and a tool for training of students

Acknowledgements:

U.S. DEPARTMENT OF ENERGY

GREAT LAKES BIOENERGY RESEARCH CENTER

JGI JOINT GENOME INSTITUTE DEPARTMENT OF ENERGY

NSF

USDA United States Department of Agriculture National Institute of Food and Agriculture

USDA-Hatch

IOWA CORN GROWERS ASSOCIATION

MONSANTO

DUPONT PIONEER

THANK YOU.

- Shawn Kaeppler and UW Group
- Edgar Spalding group – UW Madison
- Robin Buell group – Michigan State
- Candy Hirsch – Univ of MN