Current advances in wheat breeding at UC Davis

CWC Collaborators meeting October 17

Jorge Dubcovsky, Alicia del Blanco, Oswaldo Chicaiza, and Phil Mayo

- **Bread wheat breeder (HRS and HWS) Oswaldo Chicaiza**
- **Durum wheat. Alicia del Blanco**
- **Regional Testing Phil Mayo/ Diane Prato-Mayo/ Sam Fraser**

Funded by: California Wheat Commission/UC Discovery & CCIA

USDA-CSREES TCAP (Triticeae Coordinated Agricultural Projects)

New plot combine

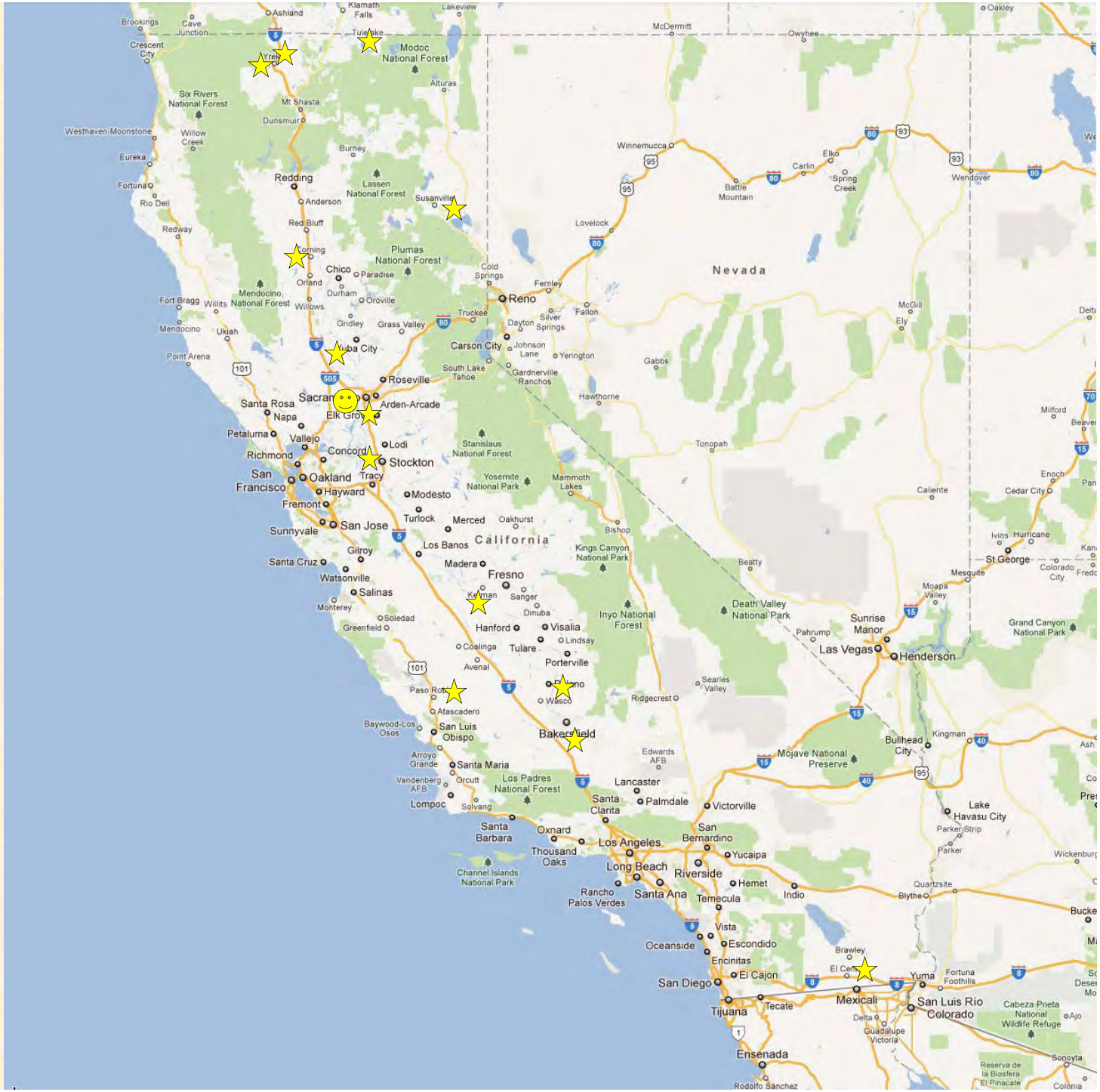
An example of a good partnership!

UCD Wheat Breeding Royalties	$ 19,389
Dept. of Plant Sciences	$ 19,389
College of Ag. & Env. Sci.	$ 38,777
Office of Research:	$ 38,777
CWC/CCIA	$ 38,777
	$ 155,108

UCDAVIS PLANT SCIENCES

Small Grains Regional Trials 13 locations

2013. Phil Mayo



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Small Grains website

http://smallgrains.ucdavis.edu/

- Cultivar performance
  - 13 locations
- Disease resistance notes
  - Stripe rust
  - Leaf rust
  - Septoria
  - BYDV
- Quality evaluations (CWC)
  - Bread quality
  - Pasta quality
- 2013 results available
  - 44 Tables organized by crop and location

The wheat breeding program

Objective: release wheat commercial varieties (CWC-CCIA funded)

Highlights: 26% of the CA common wheat acreage and 32% of the durum acreage in 2013 was grown with public varieties or varieties developed through UCD-industry collaboration.

Personnel: Oswaldo Chicaiza and Alicia del Blanco

Hard red spring	Hard White Spring	Desert Durum
Kern (2001)	Clear White (2004)	Desert King (2205)
Lassik (2008)	Patwin (2006)	Tipai (2010)
Expresso (WestBread)	Blanca Grande 515 (RSI)	Desert King-high protein (2011)
Summit 515 (RSI)	Patwin 515 (2012)	Westmore (APB)
	New Dirkwin (Baglietto Seeds)	Miwok (2013)
		Kronos Low Cadmium (APB)

Marker assisted selection information

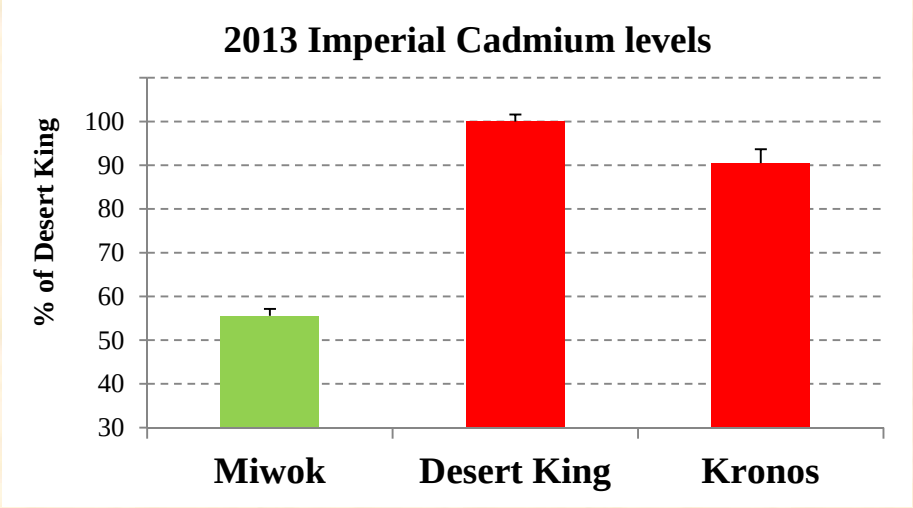
Objective: identify valuable alleles and develop markers and strategies to accelerate introgression into commercial varieties. T-CAP funded.

Highlights: we developed protocols for 62 disease resistance genes, 8 quality traits and 4 stress related traits. We generated a public web site for wheat MAS.

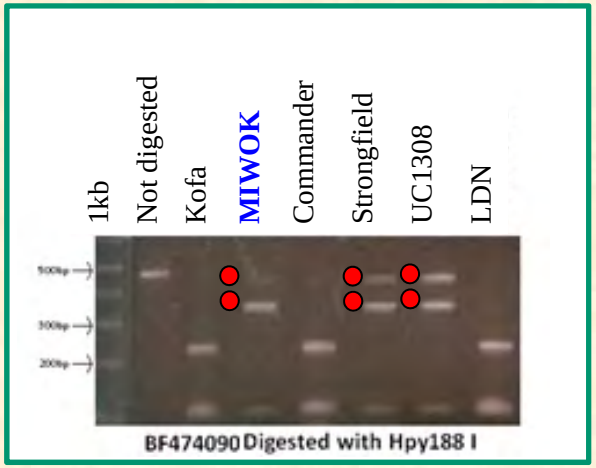
Personnel: Xiaoqin Zhang + multiple students / postdocs

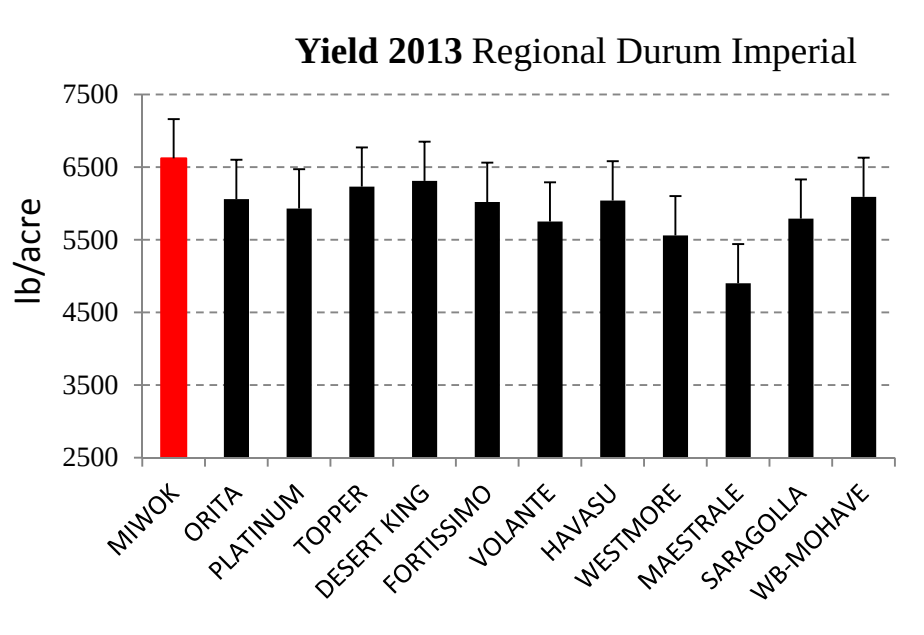
All protocols are publicly available at our website maswheat.ucdavis.edu

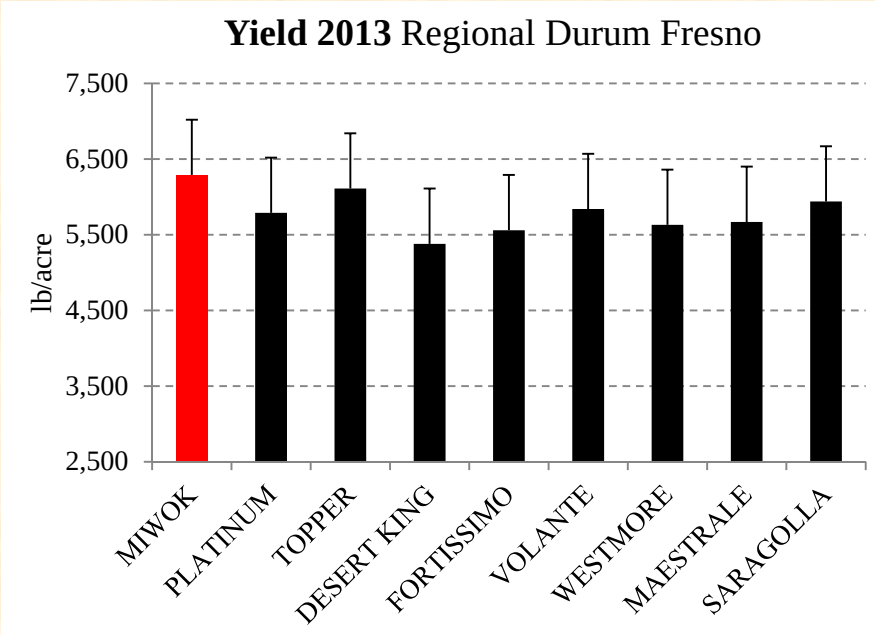
Durum low grain cadmium variety MIWOK



Marker for low Cd





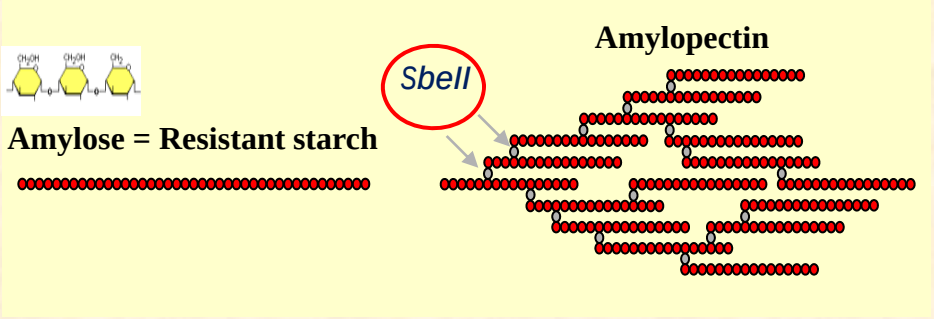


Miwok is the top yielding line in SJ Valley 2011-2013

Improving resistant starch in wheat

- RS consumption has benefits in the large intestine as well as systemic health benefits (reduced risk of diabetes, obesity, heart disease, and cancers of the colon and rectum)

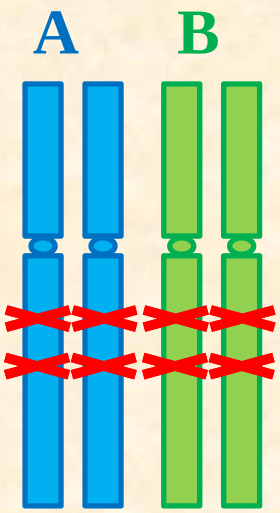
- Recommended dietary fiber
  - 19 to 38 g per day
  - <5% Americans consume this



- Recommended RS
  - No guidelines in US
  - Australia's Division of Human Nutrition: 20 g per day
  - Americans consume ~5 g RS per day

- Breads and cooked cereals/pastas contribute ~40% of RS intake
  - 2g of RS come from cooked cereals and pasta
  - A 10-fold increase in RS would satisfy the suggested 20g/d

Engineering the starch biosynthetic pathway



SbeIIa

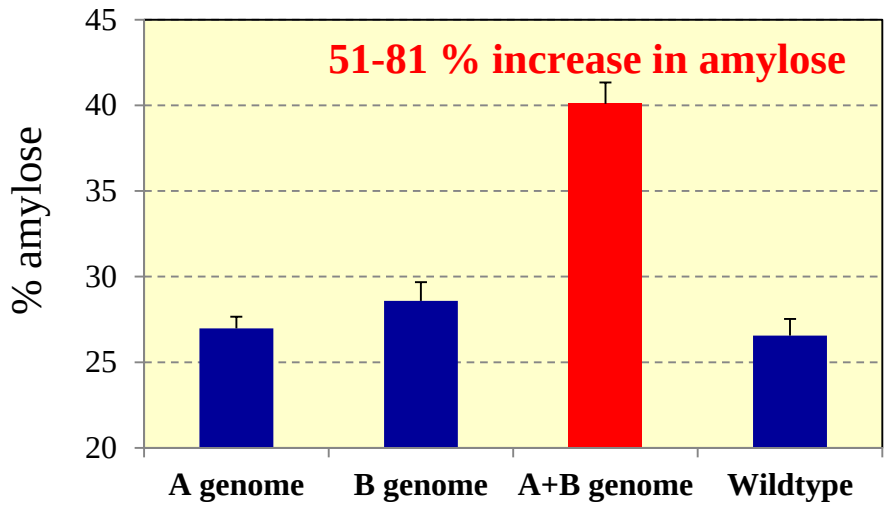
2012: Knock out ***SbeIIa*** alone — Crop Science. 2012 52:1754

- 22% increase in Amylose
- 2-fold increase in RS (115%)

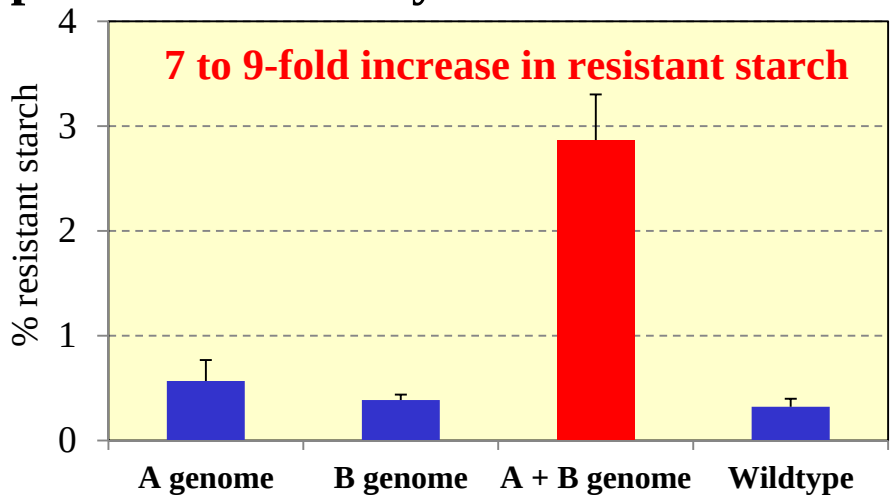
2013: Knock out **all *SbeII***

- Found mutations in *SbeIIb* genes
- Backcrossed 2 generations
- Combined the 4 mutations

Effect of *sbeIIa* + *sbeIIb* quadruple mutant on amylose and RS

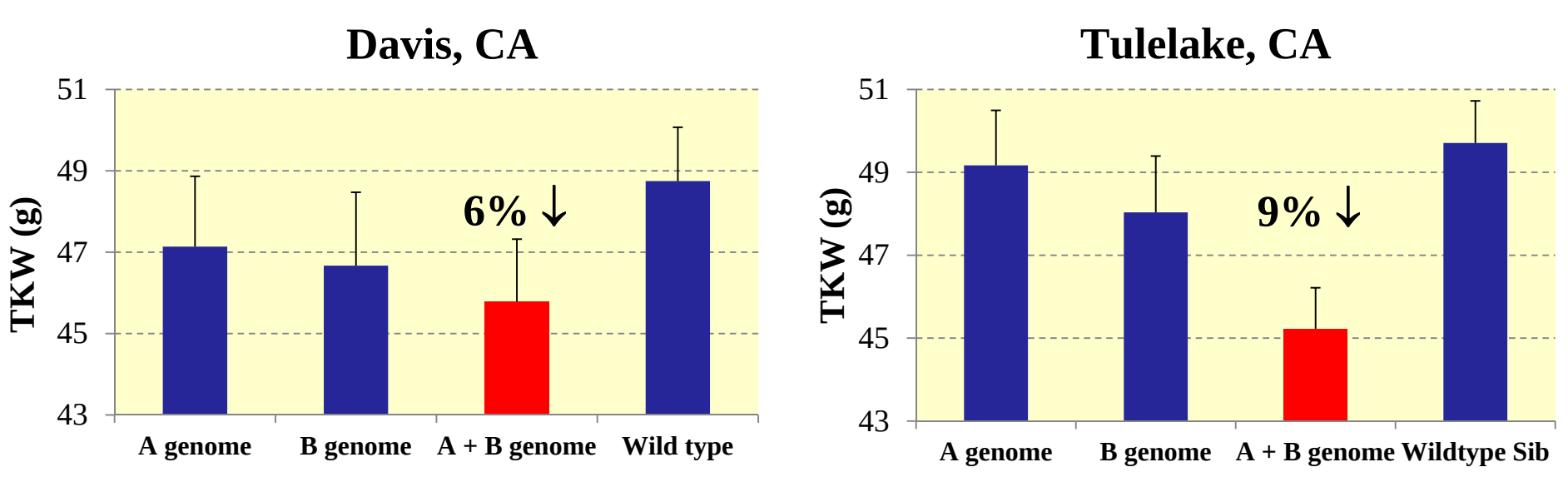


MUT: Davis 40% / Tulelake 54.4 % amylose



MUT: Davis 2.9%/ Tulelake 3.7% RS

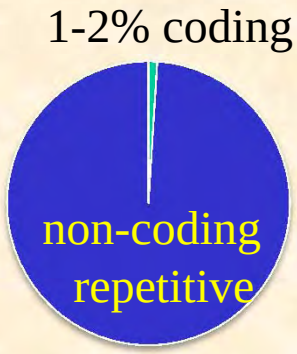
Effect of *sbeIIa* + *sbeIIb* mutations on TKW



1. Knockout of all four *SbeII* genes reduced TKW by 6-9%. Who will pay?
2. We are performing experiments this year to study effect on yield
3. We will have enough Kronos quadruple mutant in 2014 for pasta analyses
    1. Kronos — Ready seed increase and experiments in 2014
    2. Desert King — BC_2 (2^{nd} generation of 6)
    3. Tipai — BC_2 (2^{nd} generation of 6)
4. We are moving these linked mutations to hexaploid wheat
    1. Lassik — BC_3 (3^{rd} generation of 6)
    2. Patwin 515 — BC_3 (3^{rd} generation of 6)

New genomic tools

The wheat genome is huge but only 1-2% includes genes



We generated half-billion sequences of expressed wheat genes from Kronos and assembled the sequences of 80,000 wheat genes (Genome Biology 2013)

We used these sequences to create an exome-capture platform for wheat

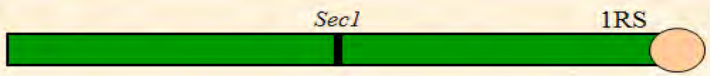
For $300 it is now possible to re-sequence 80,000 genes from a tetraploid wheat line!

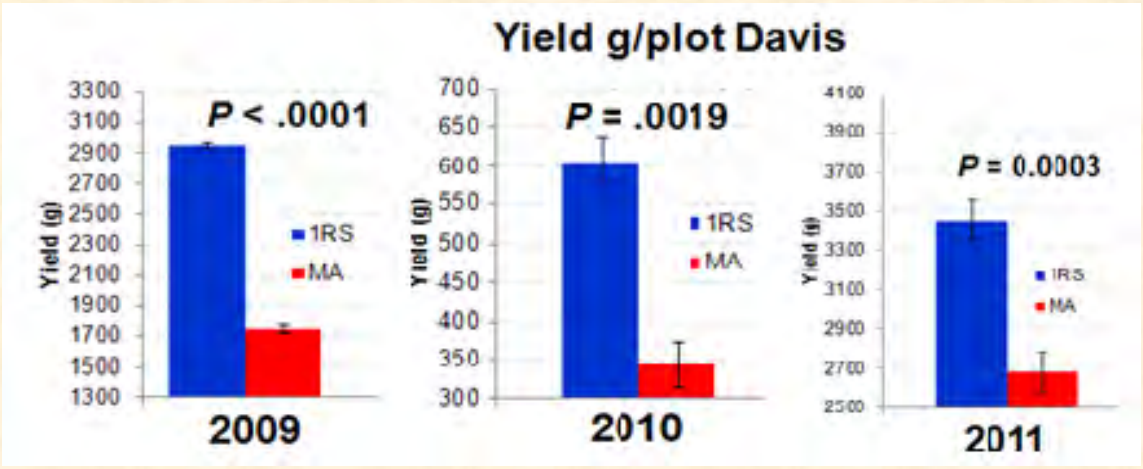
We are re-sequencing a collection of 1000 mutant lines that are expected to carry ~1000 mutations each in the gene regions: a public catalogue of 1,000,000 mutations in wheat!

We would be able to rapidly find mutations for any wheat gene.

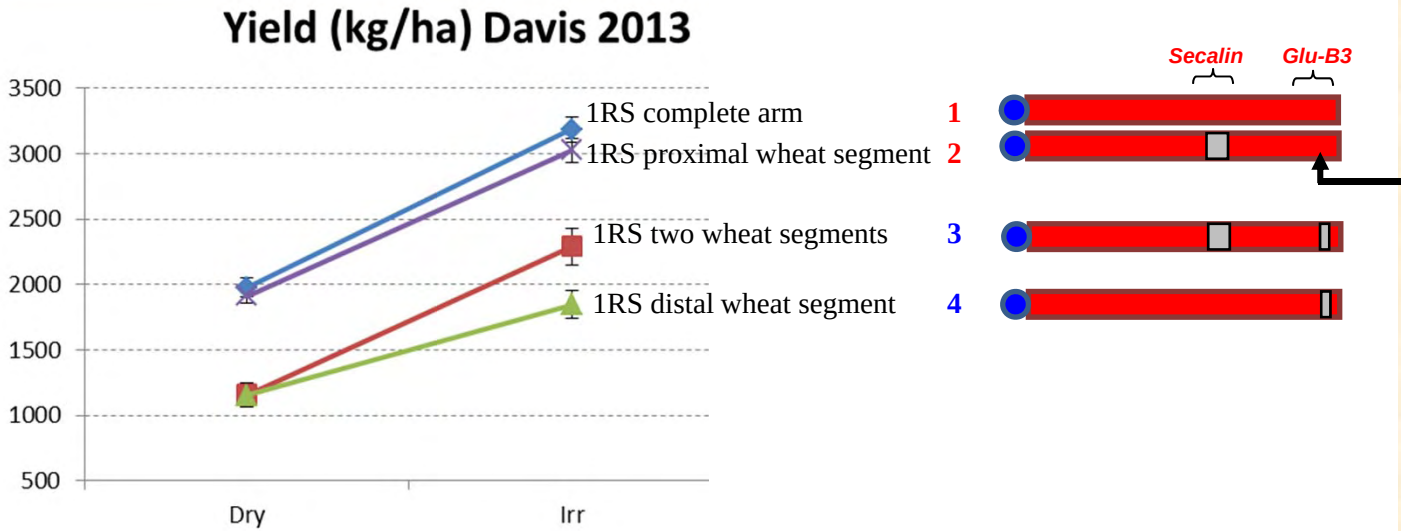
Should we tackle the epitopes for gluten intolerance?

Molecular markers for drought tolerance

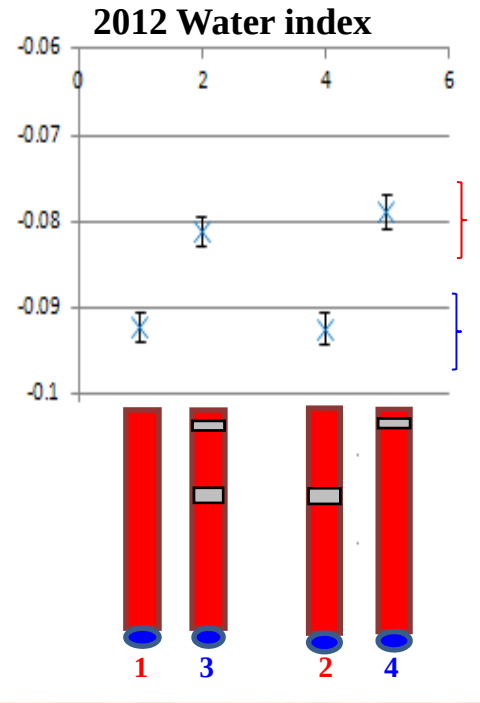




Molecular markers for drought tolerance



From the 2012-2013 yield and water status data we concluded that the distal 1RS segment is important for yield under drought

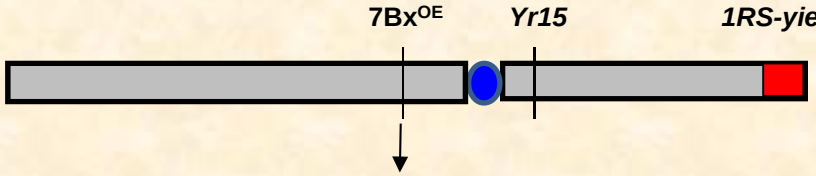


Susceptible to drought
Worse water index

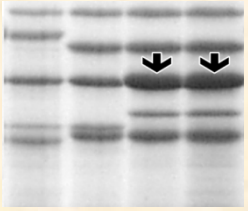
Drought tolerant
Better water index

We engineered a new chromosome including

- distal 1RS for yield
- *Yr15* for stripe rust resistance
- 7Bx^{OE} for strong gluten



Duplication of the 7Bx subunit



To compensate for the loss of Glu-B3