University-industry collaborations: Possibilities to work together to reduce losses to FHB in cereals

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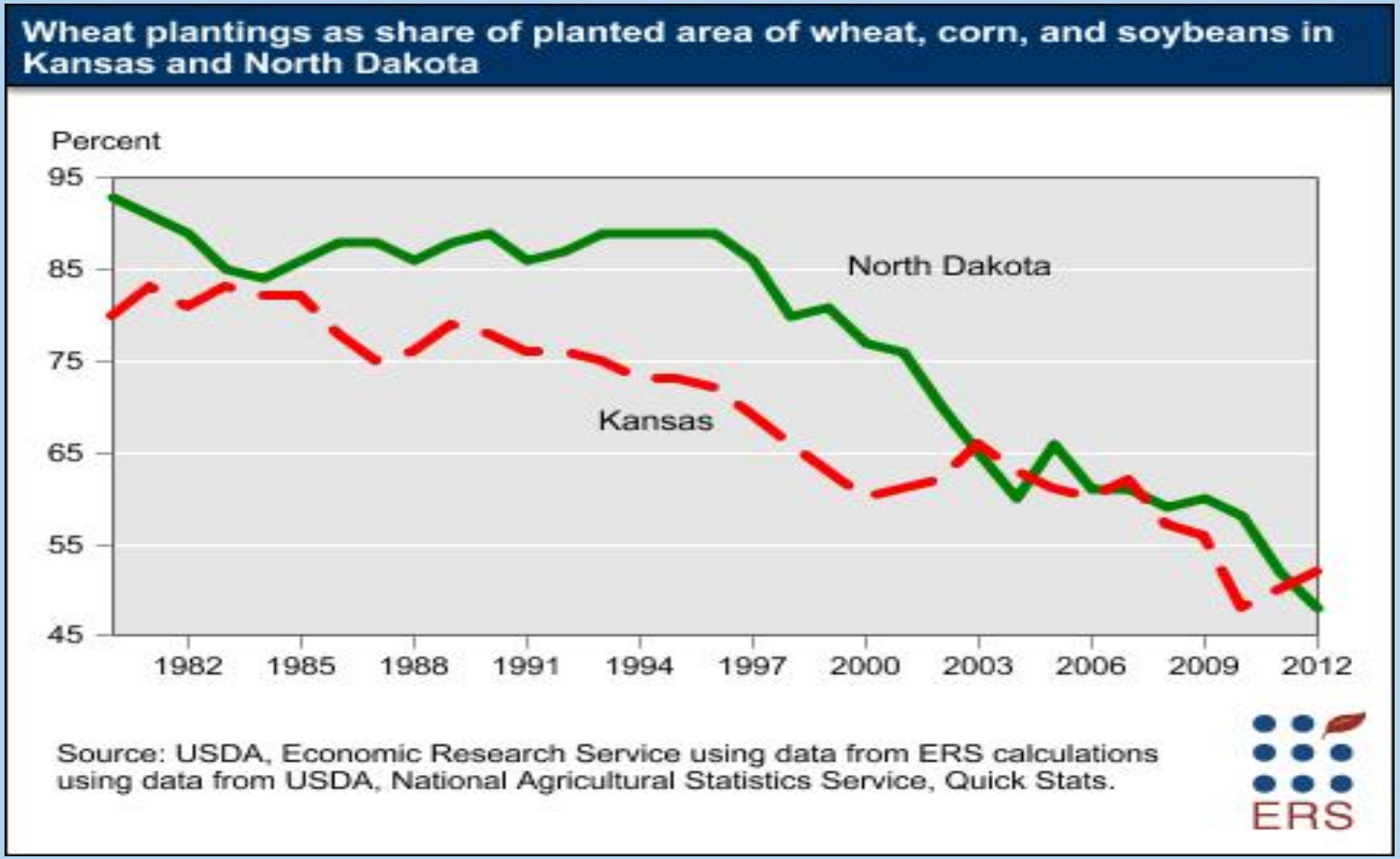
The *Real* Wheat Problem

(This is really the need for collaboration)

- It's not private - public competition!!



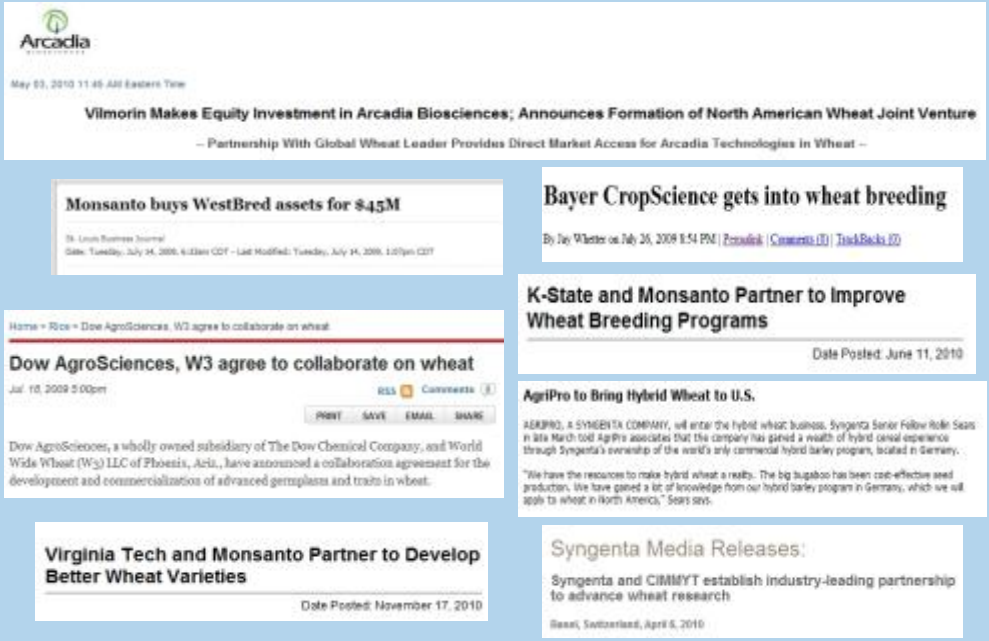
If that's not convincing enough, consider:

- The entire USWBSI was nearly cut for the present FY
- Loss of wheat acres to corn and soybean continues to reduce state check-off funds available for scab research
- FHB is a difficult disease, and it's one that affects the entire wheat community – producers, shippers/exporters, millers, bakers, and consumers

-- Thus, FHB demands a concerted ***and*** combined private-public research effort!

There is good news about support, but let's be realistic

- Industry is interested in wheat and wheat research like never before

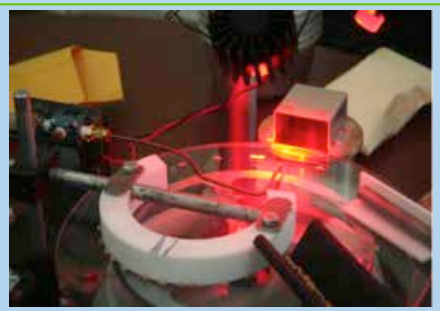


But

- Support will never be as high as compared with a devastating human disease
  - NCI* FY13 budget was approx. **$4.8 billion**
    *From http://www.cancer.gov/cancertopics/factsheet/NCI/research-funding (accessed 11/2013)
  - USWBSI FY13 budget was approx. **$4 to 5 million**

Areas of Collaboration

1) Imaging technologies (VDHR)



- Ø Accurately measure DON levels
- Ø Characterize mechanisms of resistance
- Ø Sort and select for resistance to FHB

2) Management practices (FSTU & MGMT)

- Ø Optimize genotype x fungicide treatments
- Ø Fine-tune genotype recommendations (ScabSmart)
- Ø Assure food safety

3) Breeding technologies (GDER & VDHR)

- Ø Identify and transfer new sources of resistance
- Ø Identify R-gene mechanisms and clone R-genes
- Ø Utilize genomic selection for resistance

4) Education

Example: Imaging Grain

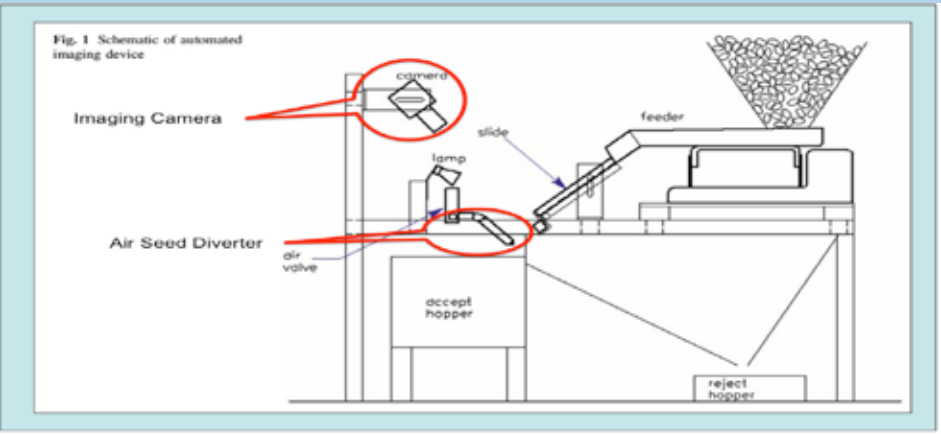
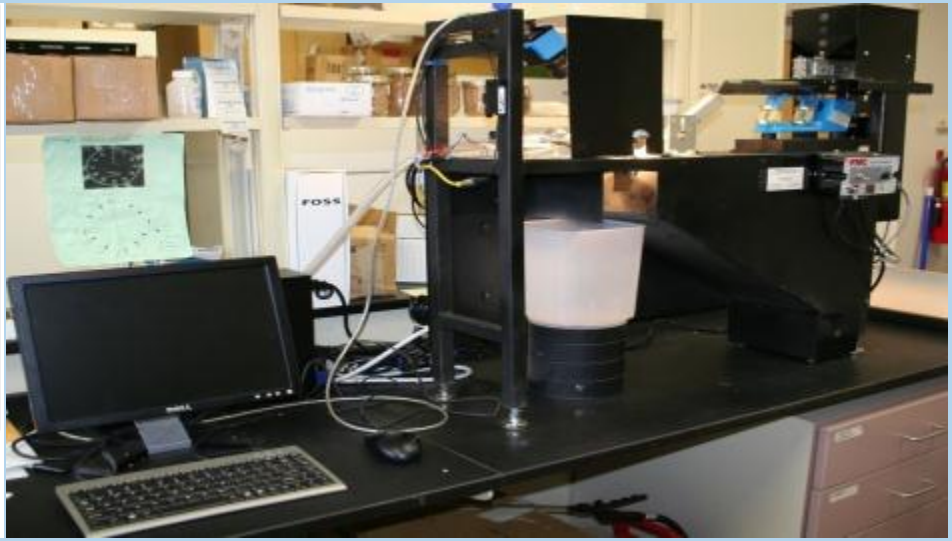


Fig. 1. Schematic diagram of optical sorter from Fig. 1 of Pearson, T., D. Brabec, and S. Haley. 2008. Color image based sorter for separating red and white wheat. Sens. Instrumen. Food Qual. 2:280–288



- Collaborate to improve imaging for DON content (Color, LED-NIR-SKNIR?)
- Collaborate to develop quality control measures to minimize DON in grain

Example: Imaging Grain

A Multispectral Sorting Device for Wheat Kernels

- Pearson et al. 2013. Amer. J. of Agric. Sci. Tech. 2: 45-60

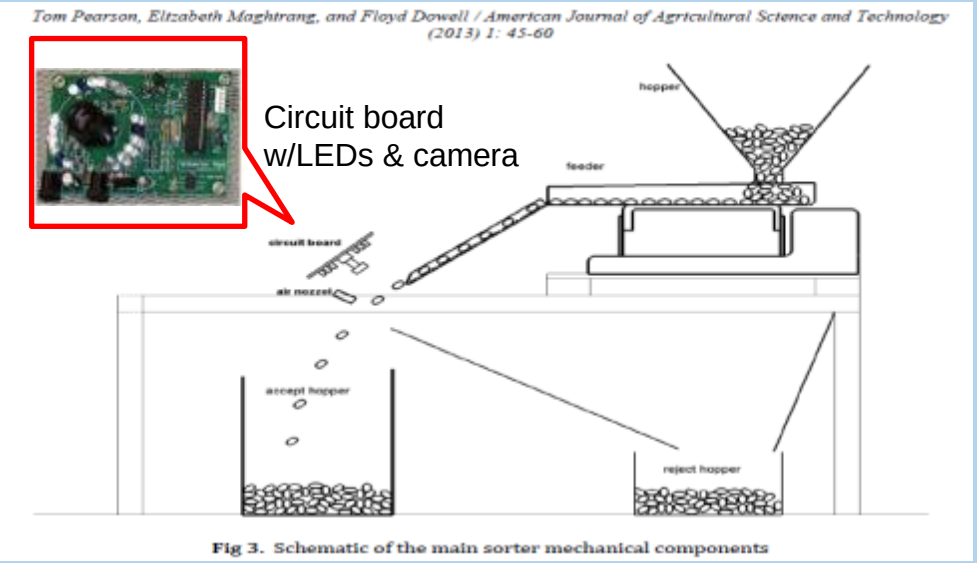


Fig 3. Schematic of the main sorter mechanical components

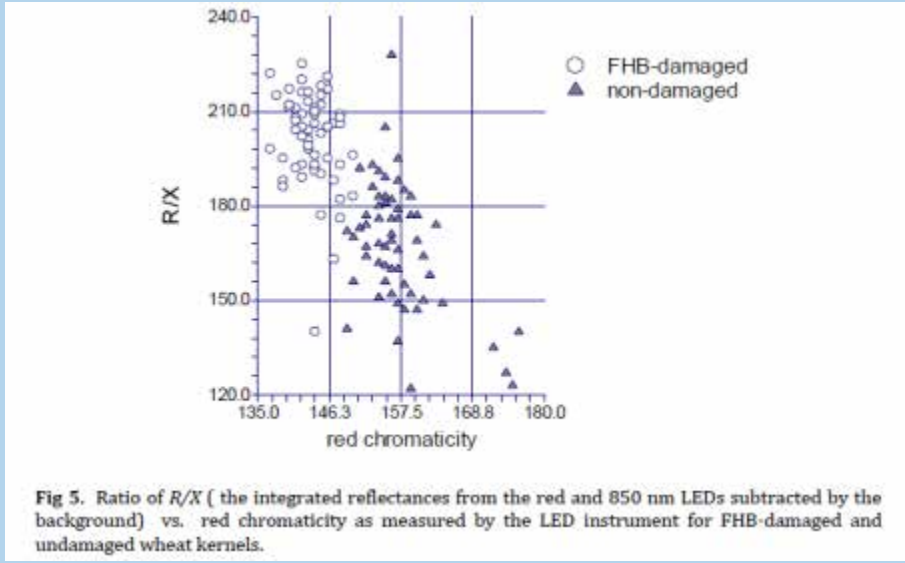
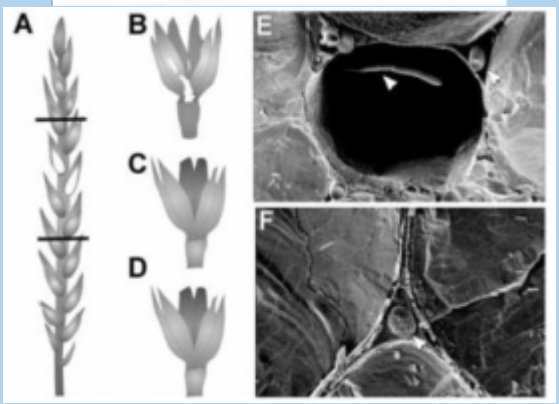


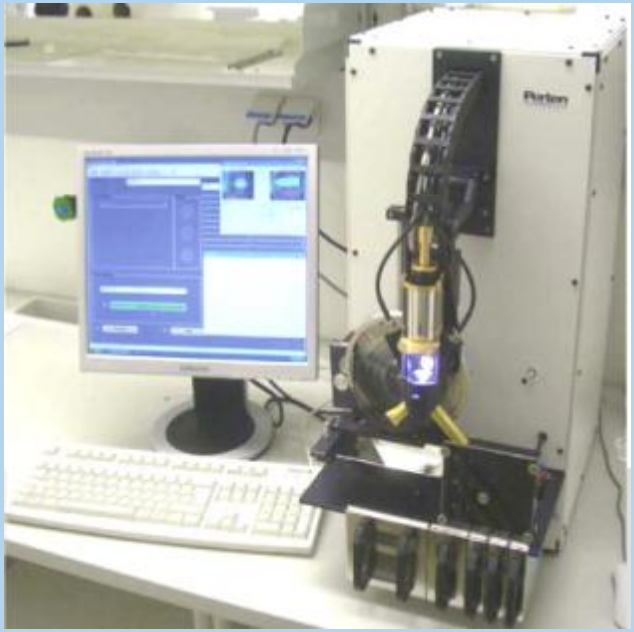
Fig 5. Ratio of *R/X* (the integrated reflectances from the red and 850 nm LEDs subtracted by the background) vs. red chromaticity as measured by the LED instrument for FHB-damaged and undamaged wheat kernels.

Ø Grain sorter with LED-NIR capabilities improved the sort of FHB-damaged vs. non-damaged kernels

Example: Imaging Plants



From: Molecular genetic approaches to explore Fusarium infection of wheat floral tissue. Urban and Hammond-Kosack (2013)



- Improve documentation of spike symptoms, optimize spray timing, characterize resistance mechs. (NIR, thermal or color imaging?)

Example: Management

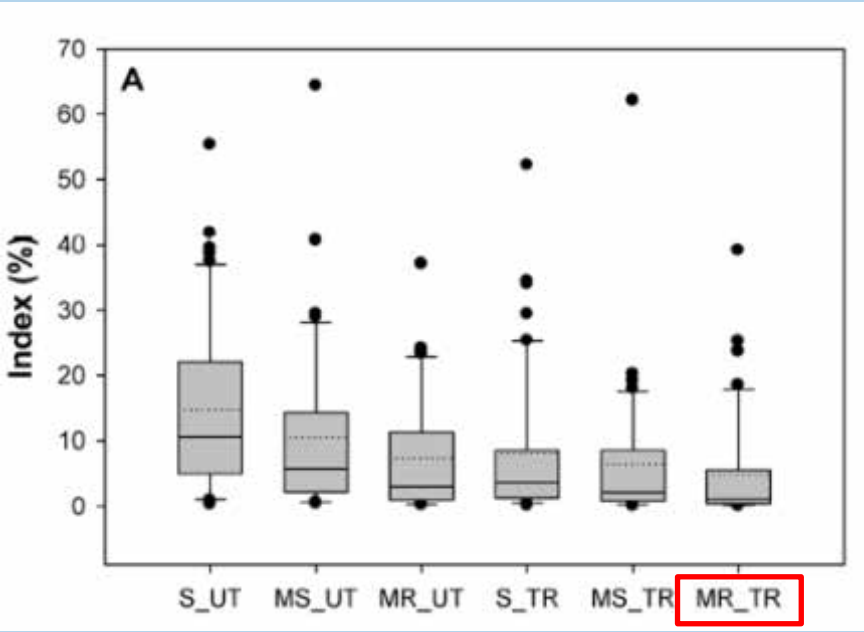
Efficacy and Stability of Integrating Fungicide and Cultivar Resistance to Manage Fusarium Head Blight and Deoxynivalenol in Wheat

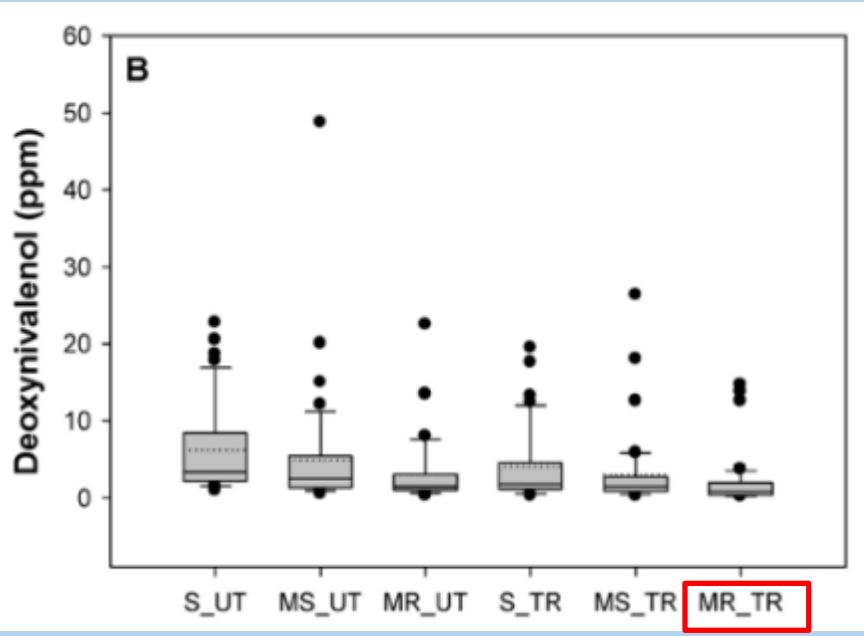
– Willyerd et al. 2012. Plant Dis. 96:957-967

- Examined efficacy of different host resistance + fungicide treatment combinations

- Moderately resistant genotype + fungicide tmt. was optimal compared to susceptible + no tmt. for reducing FHB index and DON

Example: Management





Integrated Management Treatment Combination

Fig. 1. From: Willyerd et al. 2012. Plant Dis. 96:957-967.

S_UT = Susc. + Untreated
MS_UT = Mod. Susc. + Untreated
MR_UT = Mod. Res. + Untreated

S_TR = Susc. + Treated
MS_TR = Mod. Suc. + Treated
MR_TR = Mod. Res. + Treated

Example: Management

(A “natural fit” collaboration for chemical companies)

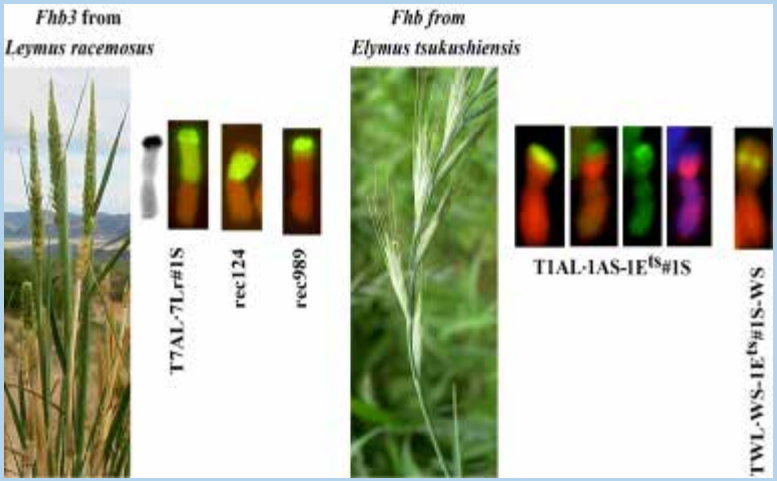
- Does the MR_TR combination give optimal control for all genotypes and chemistries?
- With the right combo, can one prolong the useful “lifespan” of otherwise excellent varieties?
- Which combination results in stable yields and is there any stay-green benefit to treatment combos?

Example: New Resistance Sources

Gene	Chromosome	Orig. Source
Fhb1	3B	Sumai-3
Fhb2	6B	Sumai-3
Fhb3	7Lr#1S	*Leymus* sp.
Fhb4	4B	Wangshuibai

From: Current Knowledge on the Genetics of Fusarium Head Blight Resistance in Wheat - Implications for Resistance Breeding – Buerstmyar 2010. et al.

- Can NSF I/UCRC involving KSU and CSU be a conduit to transfer new R-sources to industry and university wheat breeding programs?



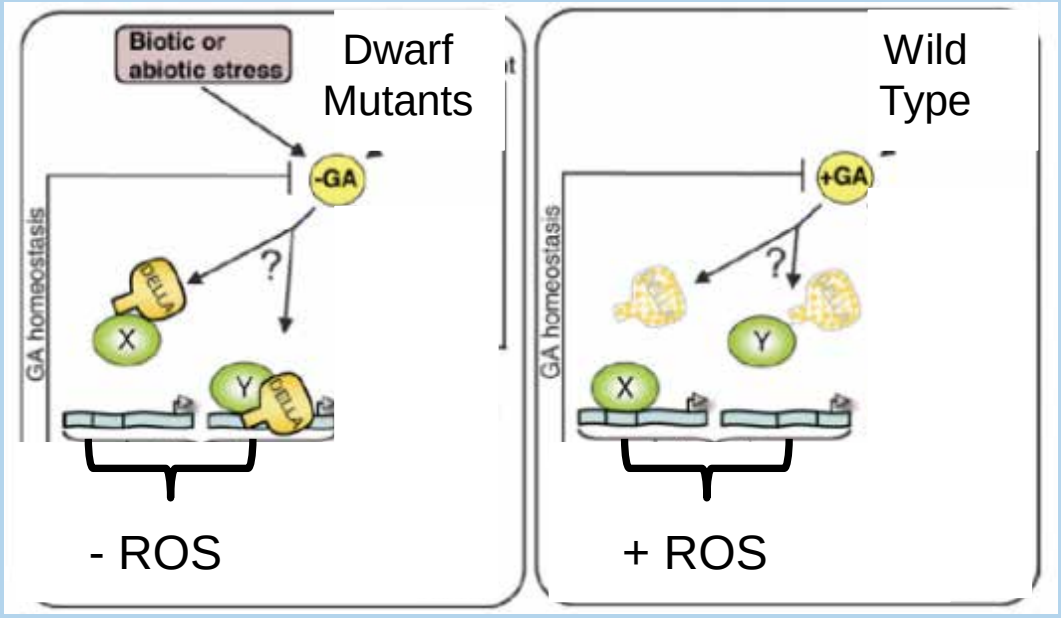
Compliments of B. Friebe (KSU)

Example: R-mechanisms

The 'Green Revolution' dwarfing genes play a role in disease resistance in *Triticum aestivum* and *Hordeum vulgare* - Saville et al. 2012. J. Exp. Bot. 63:1271–1283.

Pleiotropic effect of wheat Rht genes: DELLA Protein
= The nuclear "brake pedal" for growth and programmed cell death

-GA = Dwarf Mutant:
"Foot" on the pedal



+GA = Wild Type:
"Foot" off the pedal

No Cell Death **Cell Death**

Example: R-Mechanisms

Table 3. The effect of *Rht* alleles on Type 1 resistance to *Fusarium* Head Blight assessed as % Spikelets infected

Experiment	Genotype	% Spikelets infected	SEM	*P*-value
Field	*rht-tall*	11.7	±2.1	
	Rht-B1b	15.8	±2.1	0.185
	Rht-B1c	25.0	±2.1	<.001
Polytunnel	*rht-tall*	18.8	±0.9	
	Rht-B1b	24.2	±1.0	<.001
	Rht-B1c	35.9	±1.1	<.001

The 'Green Revolution' dwarfing genes play a role in disease resistance in *Triticum aestivum* and *Hordeum vulgare* - Saville et al. 2012. J. Exp. Bot. 63:1271–1283.

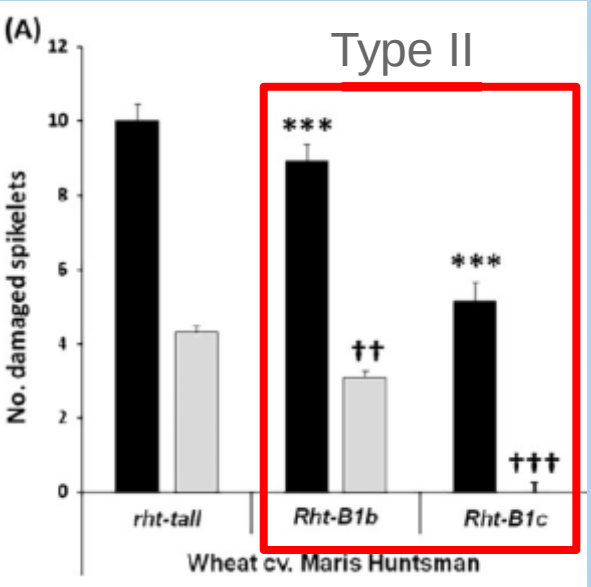


Fig. 5. The effect of GoF mutant alleles on resistance to Fusarium disease spread.

Note the differential effect of Rht alleles if Type I (*biotrophic* phase of FHB pathogen) vs. Type II (*necrophytic* phase of FHB pathogen)

Ø How can utilization of *Rht* allele combinations optimize FHB resistance?

Does this model help explain Type I *vs.* Type II resistance?

Digital Image Analysis of Primary Leaf Lesions on Wheat Seedlings of Frontana and Alsen Inoculated with Fusarium graminiearum – Evans and Pope. 2005. pg. 27. Proc. National FHB Forum

- Inoculated, detached leaves of Frontana expressed mean lesion size of 1.9%, which was significantly less than Alsen, with mean lesion size of 4.5%

Ø Can collaborative studies elucidate these mechanisms and help with the cloning R genes?

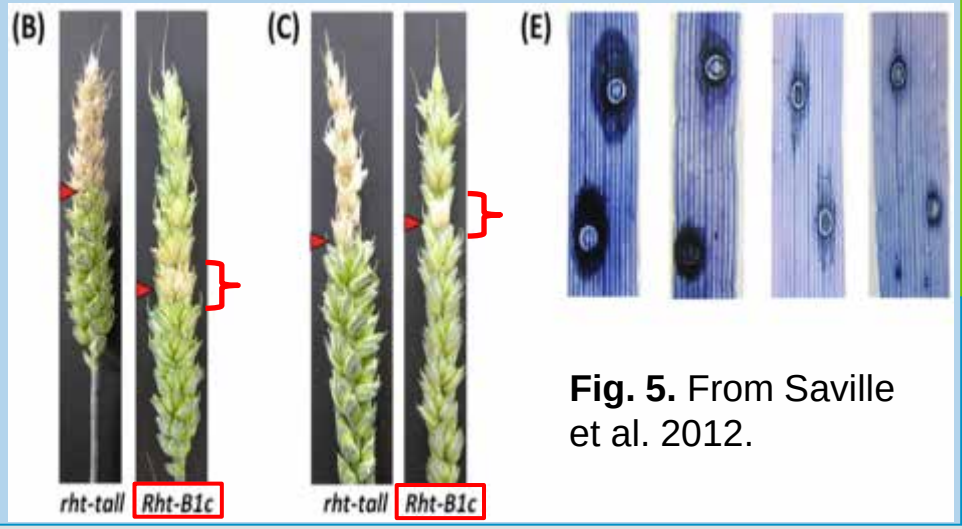


Fig. 5. From Saville et al. 2012.

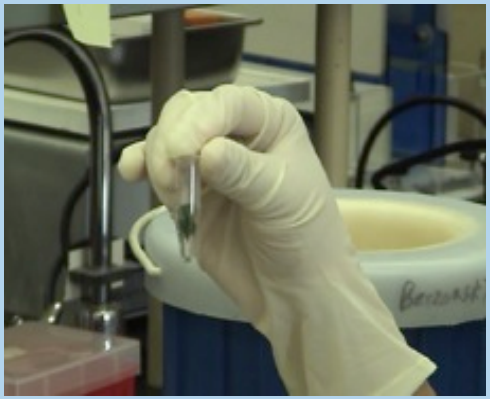
Example: Genomic Selection

Evaluation of Genomic Prediction Methods for Fusarium Head Blight Resistance in Wheat

- Rutkoski et al. 2012. The Plant Genome 5:51–61

- ØUS Coop. FHB Nurseries were used to develop prediction models for native FHB resistance
- ØMarker-based prediction models for DON resistance breeding could increase genetic gain
- ØCombining phenotypic trait information with QTL should improve prediction models

Example: Genomic Selection

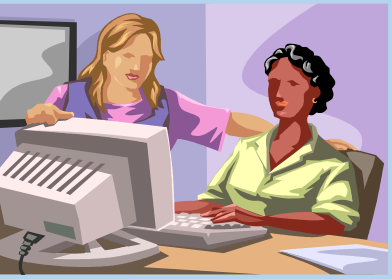


- Can cooperative FHB nurseries be expanded or sustained to include private and public participation to benefit GS?
- Can formation of a collaborative FHB genotype + phenotype database improve GS?

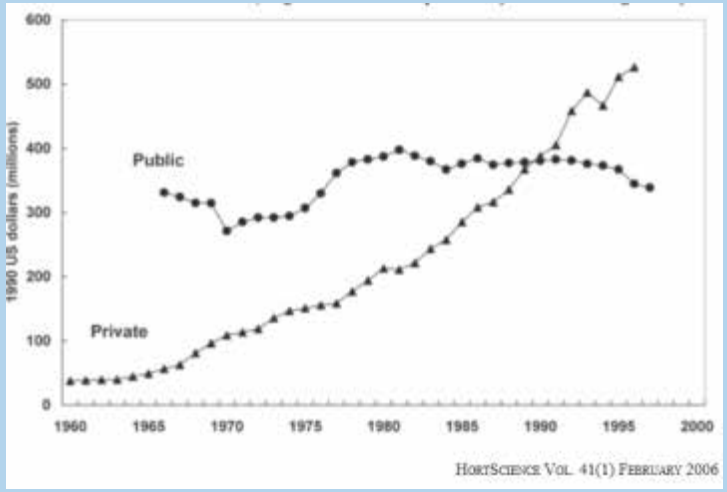
Example: Education
(A "Win-Win" Proposition)

- Ø Universities are in the business of educating students
- Ø Industry is in recruiting mode for wheat and barley students – various disciplines

Example: Education
(A "Win-Win" Proposition)



The Global Need for Plant Breeding Capacity: What Roles for the Public and Private Sectors? – Morris et al. 2006. Hortsci. 41:30-39.



Models & Opportunities:

- K-state I/UCRC (Involves Colorado State University)
- Industry internships (Ex. Monsanto Borlaug and Plant Breeding Fellowship Programs – *future vacuum?*)

What is an I/UCRC?

I/UCRC

Industry/**U**niversity **C**ooperative **R**esearch **C**enter

"…to conduct research that is of interest to both the industry and the university with which it is involved… centers rely primarily on the involvement of graduate students in their research projects…"

– From http://www.nsf.gov/eng/iip/iucrc/about.jsp

- It is a center partially supported by NSF, but intended to be sustained by its industry and university members
- One exists for wheat research involving KSU, CSU, and industry members

- Seem like an excellent model for the USWBSI to follow