GM in Small Grains

Presentation to
2011 Barley Improvement Conference & Barley CAP Meeting
KEEPING BARLEY COMPETITIVE THROUGH RESEARCH

American Malting Barley Association
San Diego

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Fargo, USA
List of Studies/References

- Wilson, W., W. Wilson, and B. Dahl. “Protein Demand in Hard Wheats.” *Australian Journal of Agricultural and Resource Economics*
Topics

- Background…
- Pressures to create GM Traits in Small Grains
- Entry of biotech into small grains
- Major Strategic Issues: Partners and Traits
- Varying presentations
  - NAWG
  - WIBC
  - National Academy of Sciences
  - Research: Gov of Canada
  - World Grain Forum (St Petersburg)
  - Hedge funds
  - Others
Background: What has changed in 6 years?

- Fundamental changes to Supply/demand: Ethanol, biodiesel, China etc
- Increase in acres planted to GM crops in worldwide
- Change in market regulations in several countries, e.g. Brazil
- New GM crops and traits: RR Sugar
- New (stacked) traits in corn, soybeans
  - Platforms emerging in competing GM crops, e.g. SmartStax
  - Growth in demand for special traits
- Australia emerging with GM crops including field trials in wheat and barley
- ABA reconsidering its position on GM wheat ABA
- Maturity of segregation systems
- Consumer concerns on “Food safety”
- China commercializing GM Rice and Corn; India on GM Vegetables
- US Growers pressure for development of GM wheat
- All major AgBiotech companies are/have entered into varying arrangements to facilitate development of GM Wheat
Demands and GM Markets: Domestic
Consumer attitudes: Summaries from US Consumer Research

• Biotech ingredients
  ◦ 70-80% of food products in US contain biotech ingredients (GMA)

• Most important to consumers are:
  ◦ sanitation, hygiene and foodborne illness (IFIC)
  ◦ < ½% identify food biotechnology as a food safety concern

• Labeling:
  ◦ 76% indicate there is no information they would like to see added to food labels
  ◦ <1% (and decreasing) want info on biotechnology
  ◦ Support for FDA policy to label food biotechnology has decreased
Likelihood to Purchase Biotech Wheat Products Produced Using Sustainable Practices

80% of Americans say they would purchase biotech wheat products if produced in a sustainable manner.

Source: IFIC, 2010
Risks:
- concern for biotechnology is relatively low compared to other food safety issues;

Trust in regulatory systems
- Americans have a higher degree of trust in regulatory authorities than Europeans
- Japanese and European consumers prefer international regulatory agencies and have less trust in national regulatory agencies than Americans or Canadians;

Labeling:
- consumers were generally not willing to pay more for labels (citing Angus Reid World Poll 2000).

Surveys are generally poor predictors of actual consumer behavior
- consumers often say one thing and do another.
Food Biotechnology: A Study of U.S. Consumer Attitudinal Trends, 2007 REPORT (IFIC—most recent study)

- **Awareness and perceptions of plant biotechnology are stable, with concerns about usage in food production low.**
  - 95% of consumers will not take any actions because of concerns they may have about food produced using biotechnology.
  - Among the remaining 5% who would take action, half would alter their purchasing behavior.
Food Biotechnology: A Study of U.S. Consumer Attitudinal Trends, 2007 REPORT (IFIC—most recent study)

- **What foods or ingredients have you avoided?**
  - Sugars/Carbs 54%
  - Fats/Oils/Cholesterol 38%
  - Animal products 21%
  - Salt/Sodium 15%
  - Snack Foods/Fast Foods/Soda 14%
  - Artificial/Additive 4%
  - Spices 2%
  - Processed Foods/Refined Foods 2%
  - Biotech 0%
Crop Competitiveness: *Longer-term impacts of GM in competing crops on supplies*

- Concerns on decreasing wheat competitiveness
- Impacts of GM in competing crops
  - Changing geography on production and displacing other crops, notably small grains
  - Changing technology growth rates
  - Improved technology in competing crops (RR2 Soybeans, DR corn), raises the opportunity cost of planting wheat (or other small grains)!
U.S. Biotech Crop Adoption

Biotech sugarbeets used on 95% of acreage in second year of widespread planting

USDA, National Agricultural Statistics Service; Sugar Industry Biotech Council
Corn Planted 1995

Corn 1995 (Acres)
- 0 - 20000
- 20000 - 50000
- 50000 - 100000
- 100000 - 200000
- 200000 - 397000

Corn Planted 2009

Corn 2009 (Acres)
- 0 - 20000
- 20000 - 50000
- 50000 - 100000
- 100000 - 200000
- 200000 - 397000
HRS Wheat Planted Area 1995

HRS Wheat Planted Area 2009

Hard Red Spring 1995 (Acres)

0 - 25000
25000 - 75000
75000 - 150000
150000 - 250000
250000 - 400000

Hard Red Spring 2009 (Acres)

0 - 25000
25000 - 75000
75000 - 150000
150000 - 250000
250000 - 400000
North Dakota Planted Area, 1980-2010

Planted Acres (000)

- Wheat Durum
- Wheat Other
- Spring
- Corn For Grain
- Soybeans
- Barley All
- Canola
North Dakota Minor Crop Planted Area, 1980-2010

[Graph showing the planted acres of various crops such as Sunflower All, Sunflowers Conf., Barley All, Beans Dry Edible, Canola, Flaxseed, Lentils, Oats, Peas Dry Edible, and Oats over the years from 1980 to 2010.]
Crop Rankings: Ret over Var Cost ND for 2011 (excl. impacts of risk (acceptance, discounts, etc.))

<table>
<thead>
<tr>
<th>Region</th>
<th>HRSW</th>
<th>Durum</th>
<th>Barley</th>
<th>Corn</th>
<th>Soybean</th>
<th>Drybean</th>
<th>Oil Snflr</th>
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2011 profit rank

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<th>NC</th>
<th>SC</th>
<th>EC</th>
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ND YIELD INDEXES

1992 to current
Corn       +82%
Soybean    +31%
HRS        +7%
Barley     +7%
Durum      +0%
Canada Acres for Durum, All Wheat, Barley and Canola, 1990-2010

- In past 20 years
  - Canola gained nearly 17.5 ma
  - Losses to
    - All wheat 15 ma
    - Barley 5 ma
- Outlook 2011
  - Canola to 19 ma
  - Canola beats mbly by $36/acre in Sask.

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Research Funding for Wheat and Barley Breeding
Public Wheat Breeding Research (nominal values) and Compare to Private R&D (other crops)

- Public sector research expenditures on small grains
  - No growth
  - Wheat: Translate to about $0.60/ac
  - Funding for public barley breeding has increased from about $1/acre to nearly $2.50/acre from 1998 to 2007 (reflective of reduced acres)
  - Per bushel expenditures for public barley breeding increased from 2 cents/bu to over 4.5 cent/bu in 2007
  - Implications
    - Nominal-nil yield growth rate
    - No increase in traits (differentiation)
    - Geographic market concentration in more stressed regions

- Private research expenditures
  - Rapid growth
  - Translate to about $8-10/ac (US Acres)
  - Increased
    - Yield growth rates
    - Number of traits (differentiation)
    - Geographic market expansion
Crop Improvement Technology:

**GM Tech and “Seeds and Traits”**

- Competing crop technologies have embraced
  - Marker-Assisted Breeding
  - GM technology
- Emergence of “Seeds and Traits” as business strategy
- Fundamental *Paradigm Shift* on Technology Distribution
Major Players: Crop Protection and Seeds and Traits 1990-2008: SEEDS and TRAITS!

- Bayer, Syngenta, BASF, DOW and DuPont were the firms that spent the most on Crop Protection R&D.
- Monsanto dominates the “seeds and traits” sector.
- Comparative R&D Expenditures
  - Wheat—about $0.70/acre/year
  - GM Row crops: $10/acre/year
  - Wheat improvement: about $20/acre
- Major point: Private firms have immense ability to spend capital on R&D
Following 1996 Monsanto's R&D on Seeds and Traits increased drastically from about $200 million/year to $600 million in 1998 and another peak in 2008 at over $800 million.

Other agbiotechnology companies increased spending on seeds and traits but did not do so until about the early 2000s.

By 2006 each of the agbiotechnology companies has further accelerated their spending on seeds and traits.

Monsanto has a lead on its rivals by about 5-6 years.
Commercial View of Trait Development

- **Time for Development:** 8-10 years
- **Cost:** $80-100 million (incl. 20-40$ million in costs to conform to regulatory system)
- **Risks**
  - Technical feasibility—*proof of concept*
  - Regulatory Approval—US and ROW
  - Commercial acceptance—price discounts
    - US and ROW
    - Consumers vs. buyers
  - Prices for traits (i.e. values), and area penetrated
  - Competitor traits and technologies
Ag Biotech Product Development Process and Related Expense*

[Best Estimates: values used in empirical analysis below
Cost; timeline and probabilities]

Year 0        1         2         3         4         5         6         7         8          9        10

Discovery
Gene/trait identification 24-48 months

Phase I
Proof of concept 12-24 months

Phase II
Early development 12-24 months

Phase III
Advanced development 12-24 months

Phase IV
Regulatory submission 12-36 months

Spending

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<th>Spending</th>
<th>Probability of Success</th>
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(Probability of Success)

- High throughput screening
- Model crop testing
- Gene optimization
- Crop transformation
- Bio-evaluation
- Greenhouse and field trials
- Trait development
- Bio-evaluation
- Field trials
- Pre-regulatory data
- Large scale transformation
- Regulatory submission
- Seed bulk-up

*Numbers (time duration, spending, and probability of success) are all estimates. The actual for individual projects could vary.
Research and development lag

Gross Annual Benefits ($ per year)

Annual Costs (-$ per year)

Research Costs

Research and development lag

Adoption Process

Flows of Biotech Research and Development Benefits and Costs Over Time

Corn trait efficiency:  

Drought Resistance

- Potentially improve yields by 8-22% (15% average) under drought stress that reduces yields by 50%  
  - Reference (below) does not distinguish trait efficiency between GM technology and that from market assisted breeding.
- Monsanto (2008) indicated that  
  - yield improvements of 6-10% in water stressed environments.
  - Testing of first and second generation DT corn varieties ranges from  
    - 6.7 to 13.4% for first generation tests  
    - 9-15% for second generation  
    - 9-10% yield advantages were reported in low drought seasons and 15% in a high drought.
Distributions for Yields: Current Technology, Drought Tolerance with GM Trait Efficiency = .12 and .20
Northern Great Plains Region

- Suggests that yield advantages for drought stress traits increase as drought stress increases
- implies a rightward rotation of the distribution of corn yields relative to current technologies.
Drought: Trait efficiency—wheat

- Results to date:
  - Australia GM lines had yield 20 percent higher than conventional wheat varieties under conditions of drought stress (prospectively greater).
Distributions for Wheat Yields: Current Technology, Drought Tolerance with GM

Trait Efficiency = .20 and .25
### Corn: Base Case Results and sensitivities

**Greatest values for DR corn is**
- Prairie gateway, Northern Great Plains
- Value increases with increases in trait efficiency

<table>
<thead>
<tr>
<th>Trait Efficiency</th>
<th>Heartland</th>
<th>N. Crescent</th>
<th>N. Great Plains</th>
<th>Prairie Gateway</th>
<th>E.Uplands</th>
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### Wheat: Results and Sensitivities: Risk Premiums Regions

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<th>RRACs</th>
<th>Heartland</th>
<th>Northern Crescent</th>
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<th>Pr. Gate</th>
<th>Miss</th>
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<th>Fruitful Rim</th>
<th>Basin and Range</th>
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At 20 Percent Efficiency Gain (in $)

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<th>Pr. Gate</th>
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At 25 Percent Efficiency Gain (in $)
Wheat Drought Resistance: *Option Values*

Option Values Across Stages of Development
($in Millions, 20% Eff. Gain)

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<th>Stage</th>
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Option Values Across Stages of Development
($in Millions, 25% Eff. Gain)

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Efficiency gains: 20% and 25%.
New GM Traits and Competition

- Results of these expenditures in research is for
  - Emergence of new GM traits
  - An escalation in yield growth rates
Industry Corn Portfolio*
A Steady Pipeline of Events

VT Triple Pro (Monsanto)

Drought Tolerance (Monsanto/BASF)

Broad Lep - MIR 162 (Syngenta)

Improved Feed (Pioneer/DuPont)

Higher Yield (Monsanto/Syngenta)

RW dual Mode of action (Syngenta)

Drought Tolerance (Syngenta)

Nitrogen Utilization (Monsanto/BASF)

Nitrogen Utilization (Pioneer/DuPont)

Improved Feed (BASF)

Novel Insect Traits (Syngenta)

Corn Amylase (Syngenta)

“Optimum” Herb.Tol. (Pioneer/DuPont)

Drought Tolerance (Syngenta)

Herbicide Tol. (Dow)

Increased Ethanol (Syngenta)

Increased Ethanol (Pioneer/DuPont)

“SmartStax (Monsanto/Dow)

“Optimum” Herb. Tol. (Pioneer/DuPont)

Increased Yield (Pioneer/DuPont)

Herbicide Tol. (Dow)

Increased Ethanol (Syngenta)

Triple-mode Herb.Tol. (Pioneer/DuPont)

Drought Tolerance (Pioneer/DuPont)

Nitrogen Utilization (Syngenta)

2009 2010 201X

Nitrogen Utilization (Pioneer/DuPont)

Increased Ethanol (Syngenta)

*Estimated commercialization pipeline of corn biotech events prepared by the U.S. Grains Council
Commercialization dependent on many factors, including successful conclusion of regulatory process
Industry Soybean Portfolio*
A Steady Pipeline of New Biotech Events Nearly Every Year

- **Omega-3** (Monsanto; Steadon Acid)
- **High Beta-Conglycinin** (Monsanto; Pioneer/DuPont)
- **Low Phytate** (Pioneer/DuPont)
- **Dicamba Tolerant** (Monsanto)
- **Feeding: High Protein Soybean** (Monsanto; Pioneer/DuPont)
- **Yield** (Monsanto; Pioneer/DuPont)
- **Rust** (Monsanto; Pioneer/DuPont)
- **Nematode Resistance** (Syngenta)
- **Herbicide tol.: 2,4-D** (Dow) and aryloxyphenoxy propionate

**2009**
- **High Oleic** (Pioneer/DuPont)
- **Liberty Link** (Bayer)
- **GAT/Glyphosate-ALS** (Pioneer/DuPont)
- **Glyphosate & isoxazole tol.** (Bayer)*
- **Processing: High Oil Soy** (Monsanto)
- **Modified 7S Protein FF** (Pioneer/DuPont)
- **HPPD Tolerant** (Syngenta)
- **Disease Resistance** (Syngenta)

**201X**
- **RR2Y** (Monsanto)
- **Low Sat** (Monsanto)
- **Bt/RR2Y** (Monsanto; Pioneer/DuPont)
- **Omega-3** (EPA/DHA)
- **Dicamba Tolerant** (Monsanto)
- **Yield** (Monsanto; Pioneer/DuPont)
- **Nematode Resistance** (Syngenta)
- **Antibody - containing** (against E. coli 0157:H)

New GM Traits and Competition

- A large number of traits are anticipated to be commercialized in the next 10 or more years.
  - Corn has 21 new GE traits
  - Soybean, has 22 new GE traits, respectively.
- Some of these are producer traits, some are processor traits and others are consumer traits.
  - Producer traits dominated early commercialization. As the market matures, focus of trait development has expanded to consumer and processor traits.
- Multiple developers: a number of these are being developed jointly by multiple developers.
- Dynamics of R&D competition are clear. As examples:
  - In many cases the forthcoming traits would result in competing solutions for the same problem.
  - several forms of HT being planned;
  - several forms of drought resistance being developed, with Monsanto potentially being first to market, followed by Syngenta and later by Pioneer/DuPont; and
  - Nitrogen use efficiency will be commercialized first by Monsanto, then Pioneer and Syngenta.
Double-X to single-X hybrids
Expansion of irrigated area, increased N fertilizer rates
Soil testing, balanced NPK fertilization, conservation tillage
Transgenic (Bt) insect resistance
Integrated pest management
Reduced N fertilizer & irrigation?

Yield Trends in Corn: USDA View
(embodies tremendous technological innovation)

\[ y = 112.4 \text{ kg/ha-yr} \]

\[ [1.79 \text{ bu/ac-yr}] \]

\[ R^2 = 0.80 \]

New GM Traits and Competition

- Impact of advanced breeding with Marker assisted breeding and GM technologies
  - Emergence of new GM traits
  - Escalation in yield growth rates

Dept of Agribusiness & Applied Economics, NDSU, Fargo - 58102
After adoption of GMO seeds, and then stacked traits, the corn yield slope by decade has accelerated about 0.1 bushel per acre every year, and the trend for the period 2000-2009 is increasing at the rate of 2.9 bushels per acre per year.
RR2 in soybeans

- 7% yield advantage
- Value: 55$—70$/acre
  - this means *opportunity cost of wheat to produce these crops will escalate* $1.00b
    (For wheat at 37b/a)
  - or about 75c/b for barley
Summary

- **Consumer acceptance**
  - US consumers readily accept GM technology; and have a great deal of trust in the regulatory system
  - Results in other countries vary.
  - Inevitably, the prevailing result will be market segments including accepting of GM, those preferring non-GM and in organic
- **GM technology** on competing crops is eroding competitiveness of wheat and barley particularly in the US. Impacts:
  - Opportunity cost of producing wheat and barley is/has increased, and will continue to increase as new GM is developed
  - Supplies will evolve toward smaller stocks and greater emphasis on pre-planting contracts
## Emerging Competition in Wheat Technology

<table>
<thead>
<tr>
<th>AgBiotech Firm</th>
<th>Traits</th>
<th>Strategies Initiative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VABC (Australia)</strong></td>
<td>DR, NUE, Fungal, other</td>
<td>Developer in collaboration with private sector partners</td>
</tr>
<tr>
<td><strong>DOW</strong></td>
<td>Not specified</td>
<td>JV with World Wide Seed (2009)</td>
</tr>
<tr>
<td><strong>Bayer</strong></td>
<td>NUE, DR, yield, stress tolerance, improved utilization of phosphorus.</td>
<td>Collaboration with CSRIO in Austraila; Acquires US biotech company Athenix Corp.; $1 billion worldwide; Collaboration with U of Neb. and 2 programs in Ukraine; and several multinational initiatives for GM trait development</td>
</tr>
<tr>
<td><strong>Syngenta</strong></td>
<td>FR; Ug99, Stem rust</td>
<td>Partnership with CIMMyT; Hybrid breeding; Acquired Agpro seed (about 5 years ago); Resource Seeds (Calif.) Hybrid wheats in Ks.</td>
</tr>
<tr>
<td><strong>Monsanto/ BASF</strong></td>
<td>Drought Res., NUE, yield increase. 8-10 years out (2022)</td>
<td>Acquired Westbred seed and (August 2010) of 20% stake in Intergrain, W. Australia wheat breeding company. Agreements announced w/KSU and VT; and plans for NDSU and WSU(on-hold) Partner JV w/BASF</td>
</tr>
<tr>
<td><strong>Limagrain</strong></td>
<td>NUE, DR</td>
<td>For US Plans to bring GM wheat to market by 2016 and 2018 (5-7 years away). JV in Arg w/Don Mario to develop high tech wheat in S. America</td>
</tr>
</tbody>
</table>
Australia GM in Small Grains

- Traditionally, non-GM
  - Canola
  - Wheat, barley
- Factors are Changing Approach to GM Development
  - Canola moratoriums being lifted
  - Drought 2 years
- Victoria Department of Primary Industries (VABC)
  - Funding GM development (amongst others)
  - Drought and stress are critical to control; and without more efficient control, they will lose the industries
  - Traits: Drought tolerance: wheat and barley
  - Status:
    - Approved for 2008-2010; up to 50 GM wheat lines containing 15 different genes designed to improve drought tolerance; some seed will be retained for seed increase
- Strategy:
  - Partners fund (partial) development
  - VABC reserves right for marketing/distribution w/in Austr
  - Partner gets right for off-shore marketing and distribution, with Royalty to VABC
- Outlook:
  - Likely 5-8 years ahead of US companies
  - Will likely release prior to N. America and/or be a source of traits for N. America
Models of Commercialization and Agropolitical Acceptance

- **Corn/Beans/Cotton/Canola:**
  - Purely commercial
  - Seeds and Traits bundled and dominated by tech provider

- **Wheat:** Apparent strategies
  - Public/private partnerships of varying forms
    - MON, BCS
  - Private initiatives
    - Limagrain, DOW
  - Joint industry group and tri-lateral support for commercialization

- **Sugarbeets:** highly successful model
  - Joint industry group
RR Sugar Beets

- RR Sugarbeet developed in 1990s
- Shelved in 2000 due to consumer concerns as expressed by consumer-food processors
- FDA approval August 2004
- Demonstration Plot conducted in Idaho, 2006
- Commercialized 2007 with sales of seed in Wyoming in 2007
- Commercialized in 2008
  - 2008 59%
  - 2009 95%
  - Fastest penetration of a GM trait ever.
Individual companies decided to adopt GM sugarbeets,
- Wyoming Sugar 2000 of 12000 acres in 2007,
- Crystal Sugar decided July 2007 to adopt GM in 2008
- Other sugar companies announced tentative plans to adopt GM in 2008 with limits on seed availability
- Minn-Dak will allow up to 50% GM for 2008
- 2009: Widespread adoption of nearly all sugarbeet acres.
Sugar Industry Biotech Council
- formed in 2003
- represent all constituents in the US and Canada
  - Sugarbeet and sugarcane growers, sugar processors, sugar industry associations, seed and technology companies

The purpose of the SIBC is
- to provide science-based information regarding technological advances in both sugarbeet and sugarcane crops and the broad range of environmental and consumer benefits of these advances, including sugar products derived from technologically enhanced sugarbeet and sugarcane.
Sugar Industry Biotech Council

- **Leadership includes:**
  - American Sugarbeet Growers Association
  - Beet Sugar Development Foundation (Processors)
  - National Sugarcane Research Effort
- **Membership includes All:**
  - North American sugarbeet grower associations
  - North American sugarbeet processors/marketers
  - North American sugarbeet seed companies
  - North American beet by-product marketers
  - North American cane sugar growers and refiners
  - Sugar industry marketing organization
  - Technology providers
Sugarbeet: Summary and Outlook

- Evolutionary Lessons
  - End-users misrepresented consumer concerns initially (perhaps strategically to assure lower technology fees)
  - Commercialization forestalled
  - Substantial cost savings and adoption

- Role of Industry Coalitions
  - Critical in facilitating successful commercialization
  - Represent all interests
  - Respond to allegations constructively and based on scientific evidence

- Future
  - Further adoption, applications refinements and pricing games
  - Induce investment in other GM technologies that can reduce production costs in sugarbeets (i.e. disease issues)
GM Wheat: Process

- Joint Biotech Committee
  - NAWG, US Wheat, NAMA
  - Joint goal to foster development of GM Wheat
  - Committee modeled after SugarBeet regarding membership and function

- Trilateral support for GM Wheat
Barley:

- Alternatives for barley: Specialty crop (welcome to the club!)
  - Increase costs (by up to 25%) based on projected yield increase in wheat (not counting other crops technologic growth)
  - Increase dependence on contracting
    - Pre-planting (or, more likely pre-agronomic decisions on competing crops)
    - Buyers absorbing a greater share of production risks
    - Farmer contract performance issues
    - Intensified inter-firm rivalry related to uncertainty w.r.t. rivals’ contracting position
  - Reduced stocks, increased volatility, periodic dependence on imports

- Opportunities
  - Improve technology and make barely competitive w/other crops.
  - Improve yields, reduce costs, increase area planted and supplies
  - Prospect of exploring desired end-use traits (e.g., reduced fusarium, amongst others)
  - Increased incentives for private-sector research
  - Increase in yields, profitability relative to competing crops
  - Traits most valuable likely:
    - FR, DR, cold (frost) tolerance, Yield, other disease, pre-harvest sprout and prospective end-use/processing traits
    - Stacked platform essential

- Challenges
  - Small acres
  - Identifying traits of sufficient value
  - Create a coalition that speaks with a consistent message
Thank you.....

.............................................Questions?