What Have Transgenic Crops Meant to Farmers?

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Madison, WI
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Overview

● The “Grand Experiment”
  ✓ Yield progress versus yield protection

● What do transgenics crops mean for the farmer? Society?

● Performance of transgenics
A “Grand Experiment” is going on in the countryside …
Corn yield in Wisconsin since 1866

- Top Hybrid = 2.6 bu/A yr
- Arlington = 2.7 bu/A yr
- Marshfield = 2.6 bu/A yr
  source: UW Hybrid Trials

- 1866 to 1930 = 0.0 bu/A yr
- 1931 to 1995 = 1.4 bu/A yr
- 1996 to 2006 = 1.9 bu/A yr
  source: USDA Statistics

The yield march continues...

Open Pollinated Era

Hybrid Era

Transgenic Era
Corn Yield Progress in Wisconsin
(Top Producer in Category)

All = 3.6 bu/A yr
PEPS Cash Corn = 4.8 bu/A yr
PEPS Livestock Corn = 4.4 bu/A yr
NCGA Non Irrigated = 4.8 bu/A yr
NCGA No Till/Strip Till Non Irrigated = 4.5 bu/A yr
NCGA No Till/Strip Till Irrigated = 3.0 bu/A yr
NCGA Irrigated = 3.2 bu/A yr
NCGA Ridge Till Irrigated = 3.3 bu/A yr
NCGA Ridge Till Non Irrigated = 3.5 bu/A yr

Source: Data derived from grower yield contests (PEPS = 1987 to 2006; NCGA = 1983 to 2006)
“Biotech crops do not add to yield … they protect yield.”
Well managed normal hybrids can yield the same as transgenic hybrids. Transgenic hybrids yield at the top AND bottom of a performance trial.

Pros
● Efficacy
● Value of “ease of use”
  ✓ Sprayer cleanup
  ✓ Herbicide certification
● Crop safety
● Human safety
● Perceived risk decrease
  ✓ Biotech Yield Endorsement
● Potential for increased quality/ nutrition AND yield

Cons
● Potential development of resistance
● Unknown implications for the Midwest US (corn / soybean) cropping system.
● Cost: When is enough money enough?
  ✓ Research and Ramp-up expenses
  ✓ Patent expiration
Transgenic Events that have come (*and gone*) in the Wisconsin Corn Trials

<table>
<thead>
<tr>
<th>Insecticide Transgenes</th>
<th>Herbicide Transgenes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>● European Corn Borer</strong></td>
<td><strong>● Roundup Ready</strong></td>
</tr>
<tr>
<td>✓ <em>Bt176 (NaturGard Knockout)</em>: 1996-2001</td>
<td>✓ MonGA21 (RR1): 1998-</td>
</tr>
<tr>
<td>✓ Bt11 (AgriSure-CB): 1996-</td>
<td>✓ Nk603 (RR2): 2000-</td>
</tr>
<tr>
<td>✓ Mon810 (YieldGard-CB): 1997-</td>
<td><strong>● Liberty Link</strong></td>
</tr>
<tr>
<td>✓ <em>DBT418</em>: 1998-1999</td>
<td>✓ T25: 1997-</td>
</tr>
<tr>
<td>✓ TC1507 (Herculex I): 2003-</td>
<td><strong>● Tissue Cultured genes</strong></td>
</tr>
<tr>
<td><strong>● Corn Rootworm</strong></td>
<td>✓ IMI (IT and IR): 1993-</td>
</tr>
<tr>
<td>✓ MIR604 (AgriSure-CR): 2003-</td>
<td></td>
</tr>
<tr>
<td>✓ DAS591227 (Herculex II): 2006-</td>
<td></td>
</tr>
</tbody>
</table>

http://corn.agronomy.wisc.edu
Single, Paired, Triple and Quad Stacks
Making some Sense out of the Options!

● Often more complex to evaluate than normal hybrids. You need to know...
  ✓ Performance compared to other hybrids with similar trait, if others exist.
  ✓ Trade-off economics between pesticide tolerant trait and actual pesticide.
  ✓ Grain yield, output trait “yield” or quality, and other important characteristics.
  ✓ Finding comparative data in public or private trial reports may be difficult.
Rationale and Situation

- Corn is grown on 4 million acres in WI. A one bushel increase by farmers increases farm income $8 to $16 million dollars annually.

- In 2008, 520 corn hybrids were tested at 14 locations.

Objective

- To provide unbiased performance comparisons of hybrid seed corn available in Wisconsin.
Non-transgenic corn hybrids ... there aren’t as many available ... they yield less than transgenic corn hybrids (~ 5 bu/A)

Source: Lauer (unpublished)
At the end of the day ...

How should you compare corn hybrids?
What is the control treatment?

- **Isoline comparison**
  - Preferred (CAST)
  - Problem: Backcross conversion
    - “Moving target”
    - Assumes conversion is clean
  - “Base genetics”, “families”

- **Within trials comparison**
  - Compare to trial average
  - Cohorts
    - Transgenic versus Non-transgenic
    - ‘Top’ hybrids (20%) cohort:
      More ‘real world’ since farmers have access to all hybrids
Insect Resistant Transgenic Corn Hybrids - European Corn Borer (*Ostrinia nubilalis*)

- First discovered near Boston in 1917. Damages >200 plants.
- Economic damage (Ostlie, 1997)
  - 1st generation = $7 /A
  - 2nd generation = $13 /A
  - Total = > $1 billion annually

Photos and map credit: Marlin Rice (ISU)

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Mon810 (n = 4858) advantage to non-transgenic (n = 8767) corn hybrids
Bt11 (n= 608) advantage to non-transgenic (n= 7840) corn hybrids

- All hybrids
- Top 20% of hybrids

Grain yield (bu/ A) advantage

Favors Transgenic
Favors Non-Transgenic

- Bt11 (n=60)
- Bt11+ IT (n=3)
- Bt11+ IT+ T25 (n=6)
- Bt11+ SytGA21 (n=4)
- Bt11+ T25 (n=501)
- Bt11+ T25+ MIR604 (n=21)
- Bt11+ T25+ MonGa21 (n=13)

Grain yield (bu/ A) advantage

-30 -25 -20 -15 -10 -5 0 5 10 15
TC1507 (n= 227) advantage to non-transgenic (n= 940) corn hybrids

Grain yield (bu/A) advantage

2003 (n=22)  2004 (n=44)  2005 (n=60)  2006 (n=101)  Average

Favors Transgenic
12  9  9  8

Favors Non-Transgenic

All hybrids
Top 20% of hybrids

-10 -5 0 5 10 15

Grain yield (bu/A) advantage

TC1507 (n=73)

TC1507+ T25 (n=140)

TC1507+ DAS591227 (n=3)

TC1507+ Nk603 (n=6)

TC1507+ DAS591227+ Nk603 (n=5)

Favors Non-Transgenic

Favors Transgenic

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Insect Resistant Transgenic Corn Hybrids -

Corn rootworm (*Diabrotica* sp.)

- **Annual economic damage=**
  - $800 million crop loss
  - $200 million in control costs

- **Current control strategies:**
  - Crop rotation
  - Insecticide

Photos credit: Marlin Rice (ISU)
Map credit: Ken Ostlie (MN)
Mon863 (n=940) advantage to non-transgenic (n=1116) corn hybrids

Grain yield (bu/ A) advantage

Source: Lauer

http://corn.agronomy.wisc.edu

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Herbicide Tolerant Transgenic Corn Hybrids

- **Glyphosate resistant** (Roundup Ready)
  - ✔ RR – MonGA21
  - ✔ RR2 – Nk603

- **Glufosinate resistant** (Liberty Link)
  - ✔ T25
Roundup Ready (n= 8481) advantage to non-transgenic (n= 6623) soybean varieties

Grain yield (bu/ A) advantage

-1 -2 -3 -4 -5

Favors Transgenic

Favors Non-Transgenic

1997 (n=56) 1998 (n=665) 1999 (n=1110) 2000 (n=804) 2001 (n=1187) 2002 (n=1250) 2003 (n=1179) 2004 (n=1150) 2005 (n=1080) Average

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MonGA21 (n=250) advantage to non-transgenic (n=5574) corn hybrids

MonGA21 (n=137) Favors Transgenic

MonGA21 + Mon810 (n=97) Favors Transgenic

MonGA21 + Bt11+T25 (n=13)

Grain yield (bu/A) advantage

1998 n=20 1999 n=12 2000 n=16 2001 (n=35) 2002 (n=69) 2003 (n=41) 2004 (n=23) 2005 (n=8) 2006 (n=26) Average

-17 -10 -14 -12 -14 -11 -10 -5 0 5 10 15
Nk603 (n= 1902) advantage to non-transgenic (n= 3703) corn hybrids

Grain yield (bu/A) advantage

All hybrids
Top 20% of hybrids

Favors Transgenic

Favors Non-Transgenic

1999 (n=15)
2000 (n=8)
2001 (n=35)
2002 (n=60)
2003 (n=183)
2004 (n=303)
2005 (n=512)
2006 (n=786)
Average (n=1902)

Nk603 (n=495)

Nk603+ Mon810 (n=1028)

Nk603+ Mon863 (n=80)

Nk603+ TC1507 (n=6)

Nk603+ Mon810+ Mon863 (n=288)

Nk603+ TC1507+ DAS591227 (n=5)

Grain yield (bu/A) advantage

Favors Non-Transgenic

Favors Transgenic

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T25 (n= 887) advantage to non-transgenic (n= 9909) corn hybrids

All hybrids
Top 20% of hybrids

Grain yield (bu/A) advantage

Favors Transgenic
Favors Non-Transgenic

1996 (n=6)
1997 (n=18)
1998 (n=54)
1999 (n=61)
2000 (n=82)
2001 (n=81)
2002 (n=62)
2003 (n=99)
2004 (n=107)
2005 (n=180)
2006 (n=137)
Average

T25 (n=84)
T25+ Bt11 (n=501)
T25+ Mon810 (n=33)
T25+ TC1507 (n=140)
T25+ Bt11+ IT (n=6)
T25+ Bt11+ MIR604 (n=21)
T25+ Bt11+ MonGA21 (n=13)

Grain yield (bu/A) advantage

-30 -25 -20 -15 -10 -5 0 5 10 15

Favors Transgenic
Favors Non-Transgenic

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Herbicide Tolerant Tissue Cultured Corn Hybrids

- Imidazolinone tolerant (Pursuit)
  - IT – “Clearfield”
  - IR

- Sethoxydim resistant (Poast)
IMI-IT (n= 257) advantage to non-transgenic (n= 8658) corn hybrids

Grain yield (bu/A) advantage

Favors Cultured/Transgenic

Favors Non-Transgenic

All hybrids
Top 20% of hybrids

IT (n=219)

IT+ Bt11 (n=3)

IT+ Bt176 (n=3)

IT+ Mon810 (n=9)

IT+ Bt11+ T25 (n=6)

-30 -25 -20 -15 -10 -5 0 5 10 15

Grain yield (bu/A) advantage

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Summary on Transgenic Performance

- Hybrids must stand on their own.
  - Pick corn hybrids and soybean varieties based upon individual performance.
  - DO NOT assume that performance is equivalent across a hybrid/variety family or ‘base’ genetics.
  - DO NOT assume you are getting a good deal because you got an extra trait.

- Grain yield of corn hybrids with CB transgenes (Bt11, Mon810 and TC1507) is better than nontransgenic hybrids.
  - Bt11, Mon810 and TC1507 stacked with T25, MonGA21 or Nk603 perform well.

- Herbicide resistant transgenes (T25, MonGA21, and Nk603, as well as IMI) do not add to yield.
  - Recommended for problem fields or difficult management situations.

- Care must be taken in selecting non-transgenic corn hybrids.

- Has the “Yield March” (genetic gain) come to an end?
  - Are we now just protecting yield?

- Roundup ready soybean varieties produce greater yield than normal varieties.

- CR transgenes ==> Yield lag or drag.

- “Variation for grain yield exists among commercial transgenic corn hybrids and soybean varieties sold in Wisconsin.”
### Spreadsheet for Calculating Seed Costs

#### Crop Seed Price Calculator v1.2

Written by Joe Lauer, University of Wisconsin (September 2008)

<table>
<thead>
<tr>
<th>Hybrid / Variety</th>
<th>Hybrid A</th>
<th>Hybrid B</th>
<th>difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop Seed Price Calculator v1.2</td>
<td>150.00</td>
<td>150.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Predicted Field Yield (bu/A)</td>
<td>150</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>Economic advantage ($/acre)</td>
<td>Hybrid A = $150.00, Hybrid B = $160.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed Price ($/bag)</td>
<td>$150.00</td>
<td>$150.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Kernels/Seeds per bag (no/bag)</td>
<td>80,000</td>
<td>80,000</td>
<td>0.00</td>
</tr>
<tr>
<td>Seed Population (number/acre)</td>
<td>32,000</td>
<td>32,000</td>
<td>0</td>
</tr>
<tr>
<td>Potential plant death (%)</td>
<td>10</td>
<td>10</td>
<td>0</td>
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<tr>
<td>Acres per bag (acres/bag)</td>
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<td>2.27</td>
<td>0.00</td>
</tr>
<tr>
<td>Seed Cost ($/acre)</td>
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<td>$66.00</td>
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<tr>
<td>Herbicide Cost ($/acre)</td>
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<td>0.00</td>
</tr>
<tr>
<td>Insecticide Cost ($/acre)</td>
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<td>$0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Fungicide Cost ($/acre)</td>
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<td>0.00</td>
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<tr>
<td>Insurance Cost ($/acre)</td>
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<tr>
<td>Harvest Moisture (%)</td>
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<tr>
<td>Drying ($/point/bushel)</td>
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<td>$0.06</td>
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<tr>
<td>Drying Cost ($/bushel)</td>
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<tr>
<td>Handling Cost ($/bushel)</td>
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<tr>
<td>Hauling Cost ($/bushel)</td>
<td>$0.04</td>
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<tr>
<td>Trucking Cost ($/bushel)</td>
<td>$0.11</td>
<td>$0.11</td>
<td>0.00</td>
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<tr>
<td>Storage Cost ($/bushel)</td>
<td>$0.12</td>
<td>$0.12</td>
<td>0.00</td>
</tr>
<tr>
<td>Yield adjustment ($/bushel)</td>
<td>$0.56</td>
<td>$0.56</td>
<td>0.00</td>
</tr>
<tr>
<td>Yield adjustment ($/acre)</td>
<td>$84.00</td>
<td>$84.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total Input Cost ($/acre)</td>
<td>$150.00</td>
<td>$150.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Yield advantage bushel/acre</th>
<th>Crop Price ($/bushel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>$14.00</td>
</tr>
<tr>
<td>12</td>
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<tr>
<td>10</td>
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<tr>
<td>8</td>
<td>$8.00</td>
</tr>
<tr>
<td>6</td>
<td>$6.00</td>
</tr>
<tr>
<td>4</td>
<td>$4.00</td>
</tr>
<tr>
<td>2</td>
<td>$2.00</td>
</tr>
<tr>
<td>Hybrid A = (Hybrid B)</td>
<td>0.00</td>
</tr>
<tr>
<td>Hybrid A yields less than Hybrid B</td>
<td>2.00</td>
</tr>
<tr>
<td>Hybrid B yields more than Hybrid A</td>
<td>2.00</td>
</tr>
</tbody>
</table>

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It is an exciting time to be an agronomist ...

- The true impact of transgenic crops is unclear for the farmer ...
  - Economically = “Wash”
  - Trade-offs
  - Corn has “trained” man well.

- Transgenics are applying unprecedented pressure on Mother Nature ...

- Unclear implications for ...
  - Crop rotation
  - Tillage
  - Plant density
  - Seed treatment
  - Grain and silage nutritional quality. Biofuel quality?

- The “new” agronomics and economics of crop production ...
Thanks for your attention!
Questions?

2009 Corn Conferences

Waupaca
January 21

West Salem
January 20

Kiel
January 22

January 29-30, 2009
Kalahari Resort
Wisconsin Dells, WI