DROUGHT TOLERANT CORN: TURNING IMAGINATION INTO REALITY

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Monsanto
Drought Tolerant Corn

Turning imagination into reality

Mike Stephens
Topics

- Product Concepts
- Example of Progress – Corn
- Summary - discussion
New Biotech Yield Traits in the Pipeline Will Continue To Add Value To Corn

Traits Build Value
Increasing Yield Stability / Consistency

US Average Corn Yield

bu / A

Year

bu / A

0 20 40 60 80 100 120 140 160 180

### Drought Tolerant Corn - Potential Product Concepts

<table>
<thead>
<tr>
<th>Product Concept</th>
<th>Market Description</th>
<th>Benefits</th>
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<tr>
<td>Consistent Drought Stress</td>
<td>KS, NE, TX, CO, SD</td>
<td>- Reduced Irrigation Costs</td>
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<td>Western US Dryland</td>
<td>Central, E and S. corn belt</td>
<td>- Protect Aquifer water levels / reduce fuel consumption needed to pump water</td>
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<td>Opportunity for more crop choices for growers</td>
<td>- More reliable / consistent yields</td>
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<td>- Most corn experiences periodic water stress which limits yield</td>
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<td></td>
<td>KS, NE, TX, CO</td>
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<td></td>
<td>All corn acres</td>
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Drought / WUE Product Concepts

Western Dryland Trait and “insurance”

Broad Acre WUE

Location Yield

(Decreasing Water Stress →)

Yield

Transgenic
Control
Annual precipitation in western plains can be 25-60% of the central corn belt.
Traits that improve water utilization will make more productive use of water and potentially reduce irrigation costs.

Irrigation is responsible for 70% of water withdrawn.

Drought traits may eventually mitigate the effects of:

**Depletion of aquifers**
- Ogallala depleted at 1 - 5 ft / year. Affects river levels & increases conflict between users.

**Increasing restrictions on wells**
- Reduces volume and quality of water available.

**Higher pumping costs lower margin**
- Deeper wells require higher pumping costs and fuel costs are higher.

**Resulting in changes in farming practices**
- More conservation measures (tilling, irrigation).
- Movement from irrigated corn to other crops.
● Product Concepts

● Example of Progress – Corn

● Summary - discussion
Yield is a complex quantitative trait but individual components affecting yield can be modified using single genes.
Commercial Biotech traits already reduce risk during dry growing conditions

Palmer Hydrological Drought Index
Long-Term (Hydrological) Conditions

July 2005

Palmer Hydrological Drought Index
National Climatic Data Center, NOAA

-4.00 and below
-3.00 to -3.99
-2.00 to -2.99
-1.99 to +1.99
+2.00 to +2.99
+3.00 to +3.99
+4.00 and above
Approximately 25% of growers in the drought-stricken regions of IL experienced >30 bu/A advantage with YieldGard corn borer + YieldGard Corn rootworm versus YieldGard Corn Borer + Soil Insecticides.*

** U.S. Corn Belt Summary

10.9 bu/A**

Advantage with YieldGard Plus vs Conventional Hybrids with Soil Insecticides

**Source: 195 field trial head-to-head comparisons; grower on-farm and Monsanto trials, 2005.

* Source: 231 severe drought zone field trials; 278 moderate drought zone field trials.
Using Functional Genomics to Identify Lead Genes for Drought Tolerance

Current revenue re-invested in development of future traits

- High Throughput Greenhouse & Field Screens
- Detailed Physiology Trials
- Controlled Drought Field Yield Trials
- Multiple Location & Germplasm Yield Trials
Drought Stress Tolerance in Model plants

Arabidopsis

Rice
Drought Tolerant Crops Demonstrated in Greenhouse and Field

2003
- More kernels per ear and more ears harvested.
- Benefit is real
- May vary with environment & germplasm
Standard agronomic traits collected in yield trials:

- **Stand**
- **Greenness**
- **Flowering**
- **Plant Height**
- **Root & Stem Lodging**
- **Disease Ratings**
- **Grain Yield**
- **Grain Test Weight**
- **Grain Moisture**
- **Grain Quality Parameters**
2005 - Vegetative Phenotypes Repeated

Reduced Leaf Rolling

Reduced Leaf Temperature

With Trait

Without Trait

July 2005 -- during moderate drought stress

40 34 32°C
Results from 2005 trials
Multiple leads again showed yield benefit
Breeding for stress tolerance and Yield potential

Hybrid / trait combinations adapted for adverse growing conditions
- more stable and consistent -

Traits for Stress Tolerance (while maintaining yield potential)
- YGCB / YGRW
  - Drought
  - Nitrogen
  - Cold

Combination of traits & germplasm will provide options & the best stress mitigation packages for growers
A Trait that will Reduce Risk:

Drought tolerance is one of a set of traits that reduce risk for growers by mitigating the effects of abiotic and biotic stresses on crops.

In Development:

Researchers are developing biotech traits and germplasm that will enhance yield under drought stress for corn and other important crops.

Multiple Benefits:

Growers:

- Improve yield consistency, profitability, potentially reduce input costs (e.g. irrigation = energy) and potentially provide growers with more crop options.
- Provide more consistent supply of feed stocks for animals and ethanol plants

Combinations of Traits and Germplasm:

- To provide the best stress mitigation solutions these traits will need to be provided in elite adapted germplasm.