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Agricultural Outlook Forum

Presented: February 17, 2006

DROUGHT TOLERANT CORN: TURNING IMAGINATION INTO REALITY

Michael Stephens  
Corn Technology Team  
Monsanto

imagine

# Drought Tolerant Corn



Mike Stephens

Turning imagination  
into reality

Imagine  
Innovative  
agriculture  
that  
creates  
incredible  
things  
today.

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# Topics

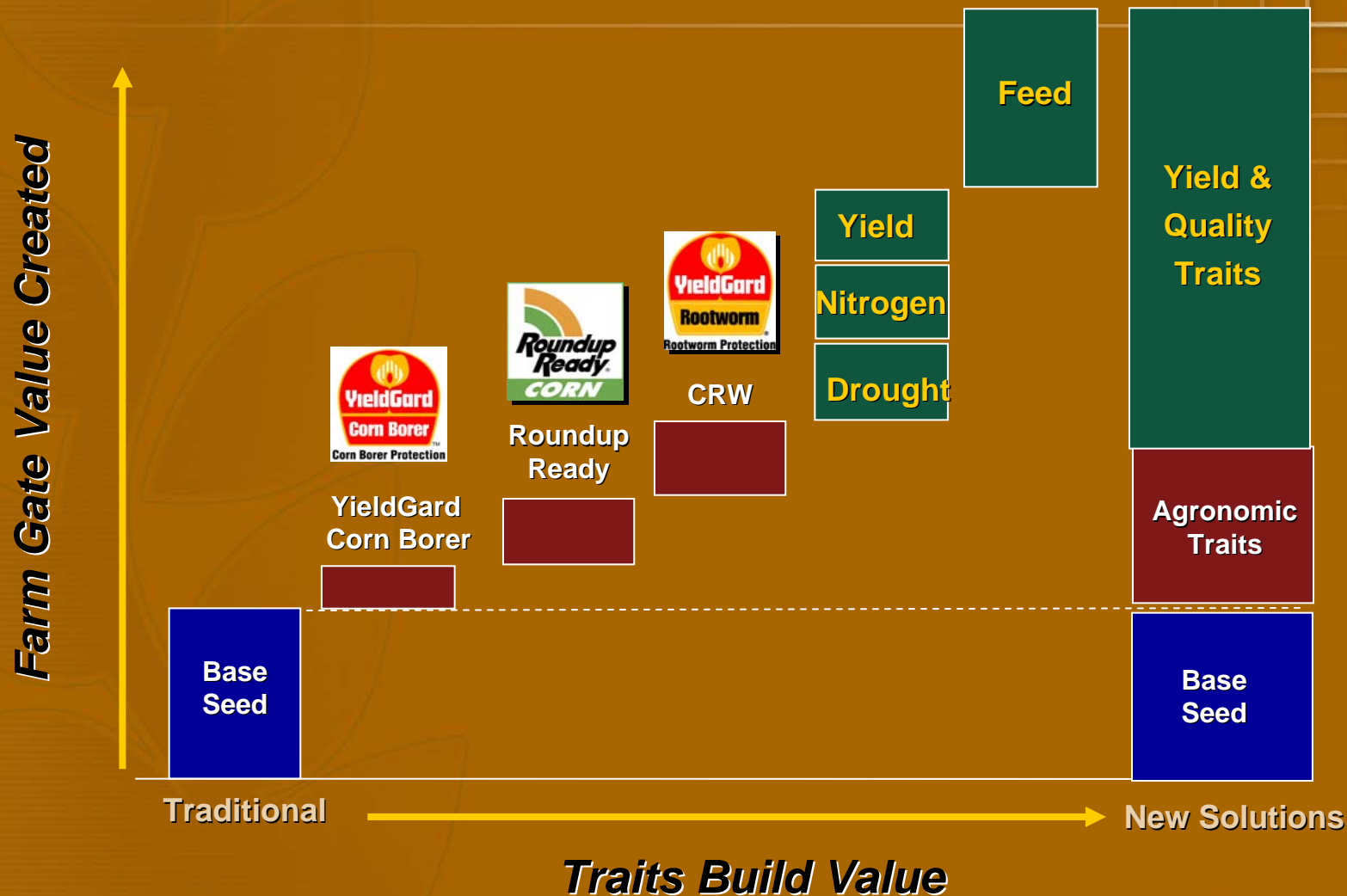
- **Product Concepts**
- **Example of Progress – Corn**
- **Summary - discussion**

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# New Biotech Yield Traits in the Pipeline Will Continue To Add Value To Corn

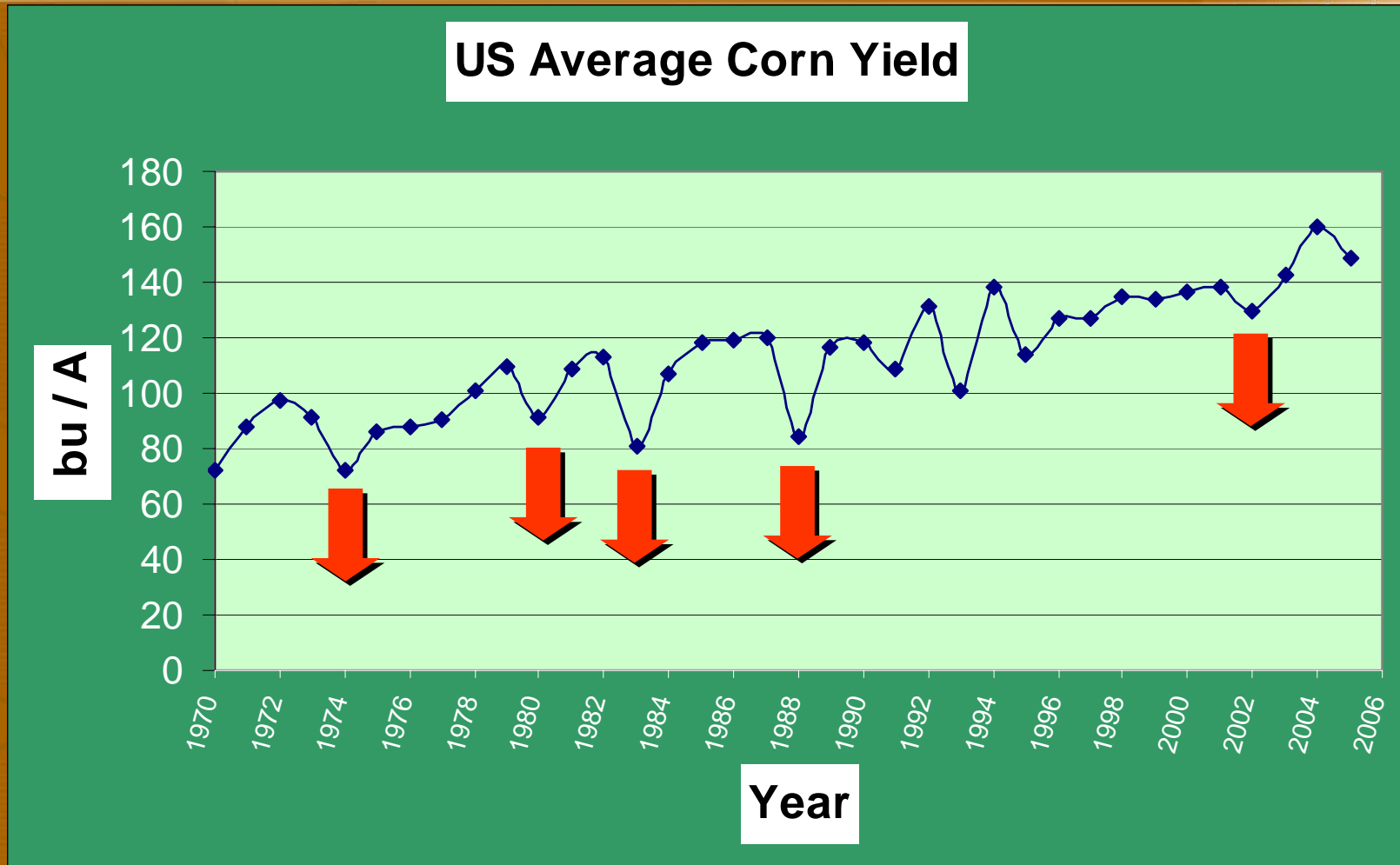


**Traits Build Value**

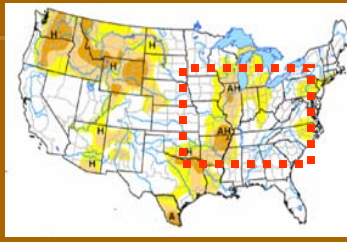
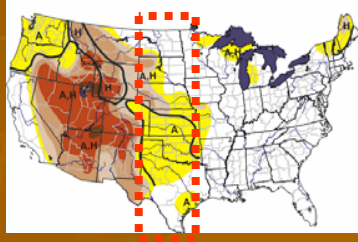
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# Increasing Yield Stability / Consistency



# Drought Tolerant Corn - Potential Product Concepts



**Product Concept**

**Consistent Drought Stress Western US Dryland**

**Drought "Insurance"**

**Reduced Irrigation Costs**

**Broad Acre WUE**

**Market**

**KS, NE, TX, CO, SD**

**Central, E and S. corn belt**

**KS, NE, TX, CO**

**All corn acres**

**Opportunity for more crop choices for growers**

**More reliable / consistent yields**

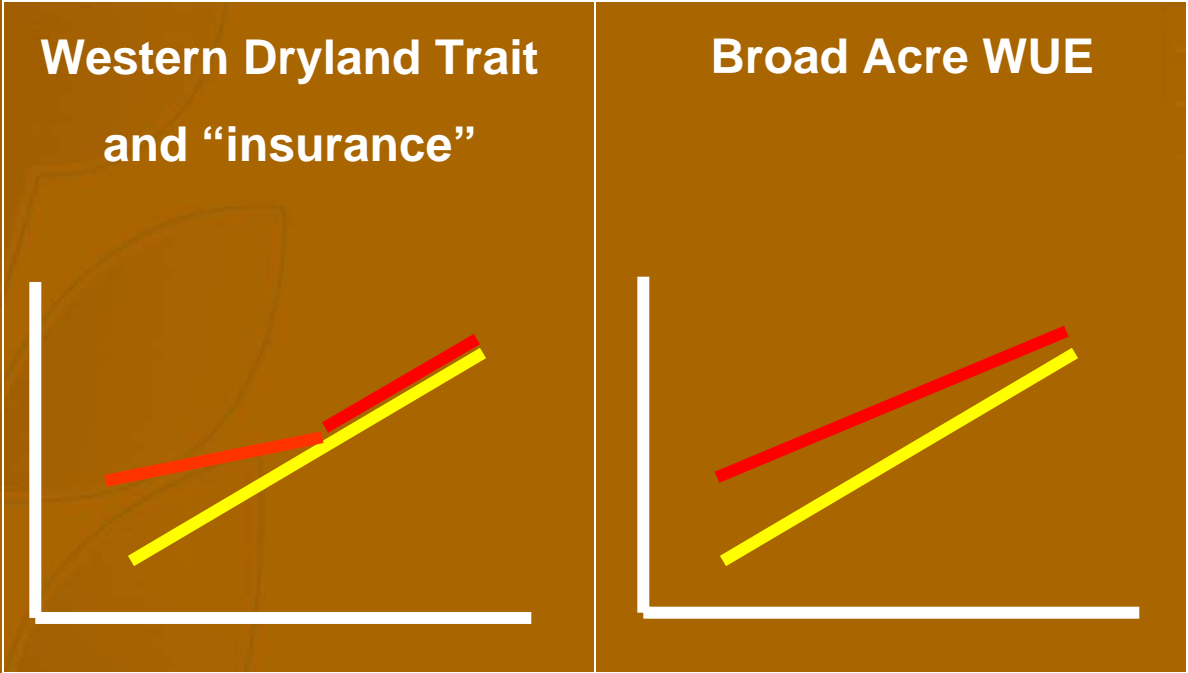
**Protect Aquifer water levels / reduce fuel consumption needed to pump water**

**Most corn experiences periodic water stress which limits yield**

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# Drought / WUE Product Concepts



Yield

Western Dryland Trait  
and "insurance"

Broad Acre WUE

Location Yield

(Decreasing Water Stress →)

- Transgenic
- Control

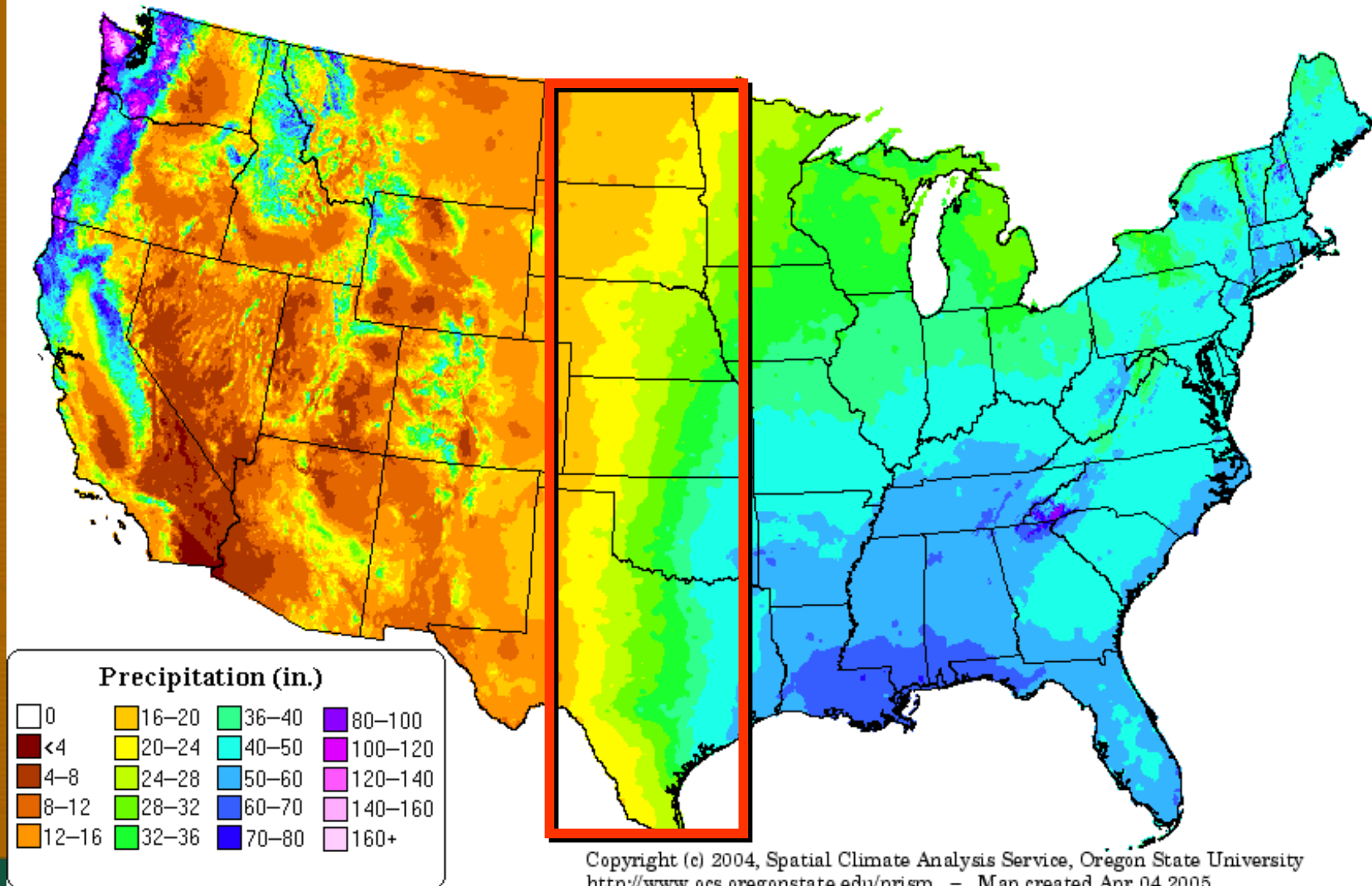
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# Annual precipitation in western plains can be 25-60% of the central corn belt

## Precipitation: Annual Climatology (1971–2000)



# 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**

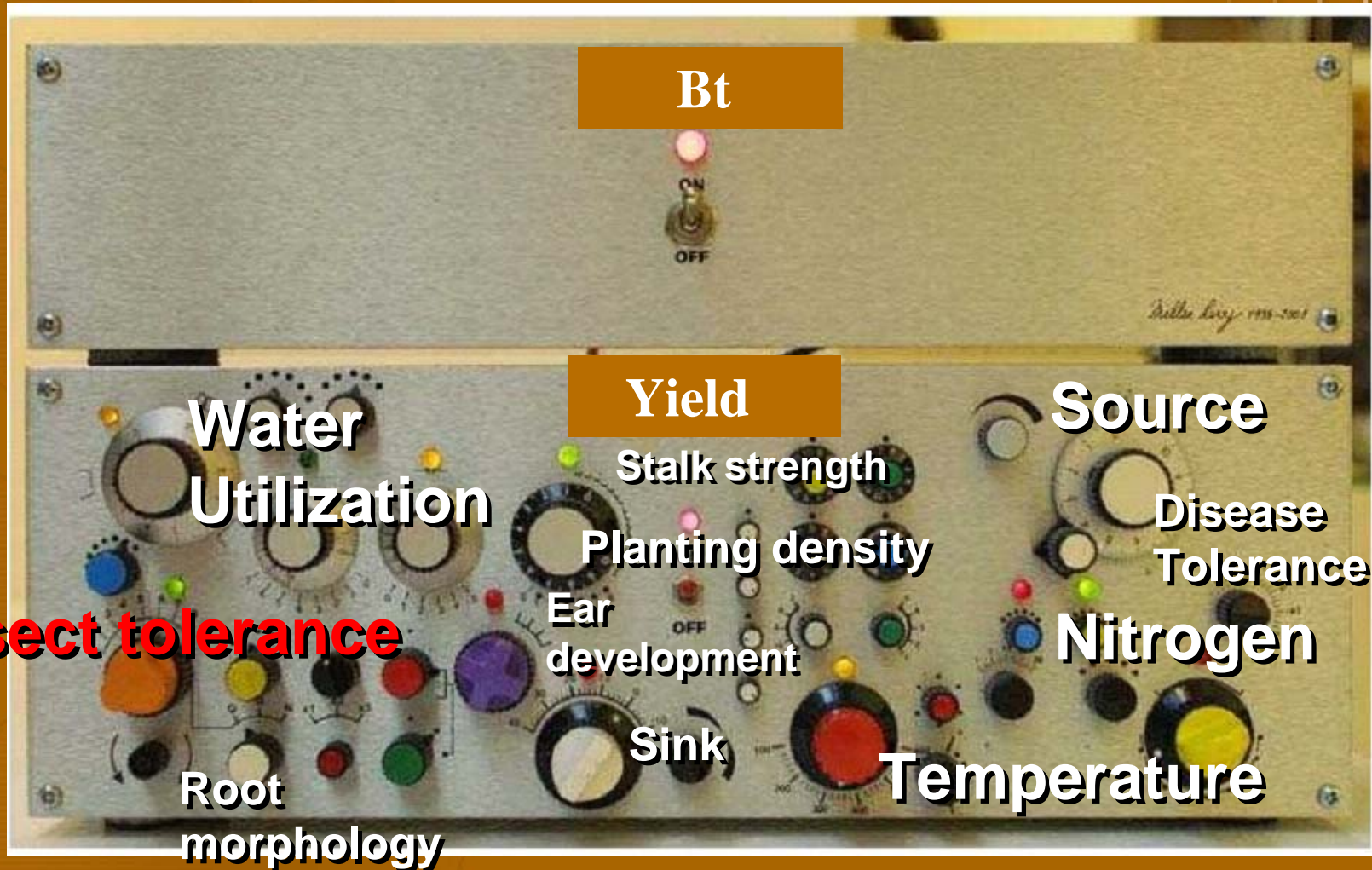
- **Summary - discussion**

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Yield is a complex quantitative trait but individual components affecting yield can be modified using single genes



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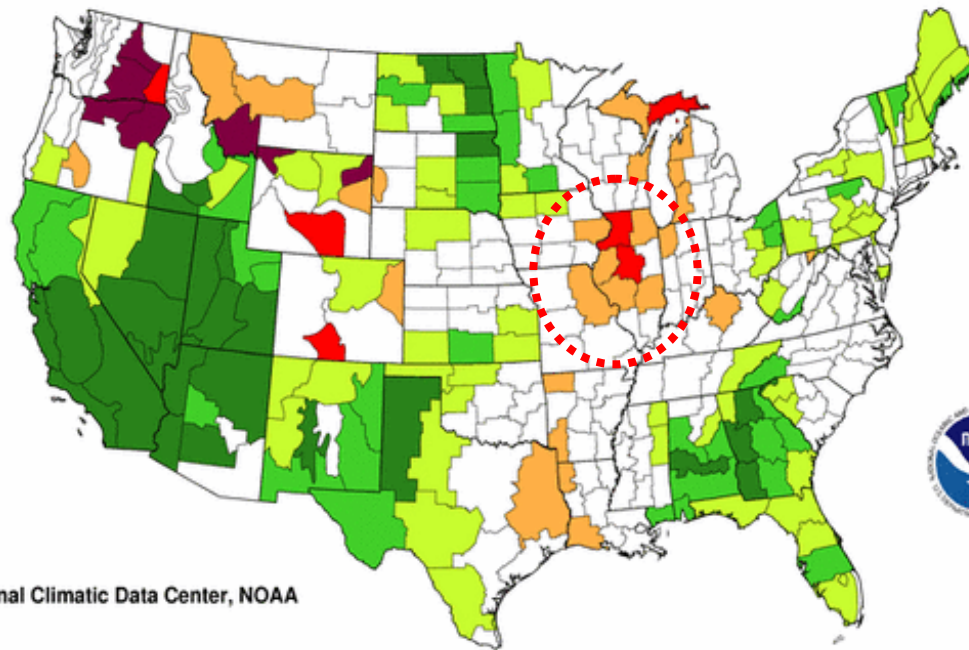




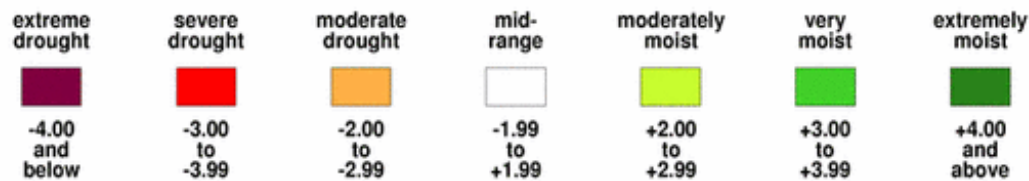
# Commercial Biotech traits already reduce risk during dry growing conditions

## Palmer Hydrological Drought Index Long-Term (Hydrological) Conditions

July 2005



National Climatic Data Center, NOAA



Palmer Hydrological Drought Index

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# Protecting roots - protects yield



## 2005 Drought Conditions U.S. Corn Belt

In Severe Drought

**YieldGard® Plus**  
*16.6 bu/A\**  
**Advantage**

over YieldGard Corn Borer  
with Soil Insecticides

In Moderate Drought

**YieldGard Plus**  
*11.5 bu/A\**  
**Advantage**

over YieldGard Corn Borer  
with Soil Insecticides

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



Maximum Insect Protection

\*\* 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***

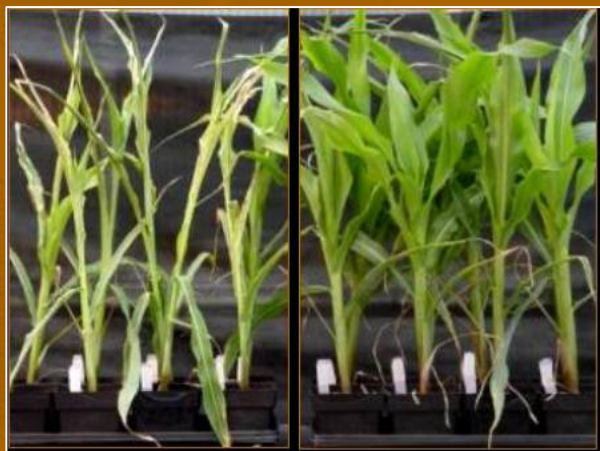




# Drought Tolerant Crops Demonstrated in Greenhouse and Field

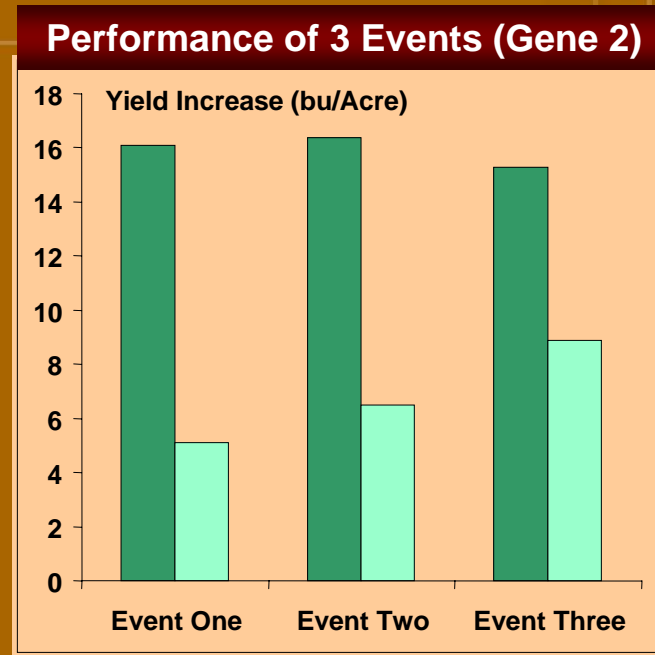
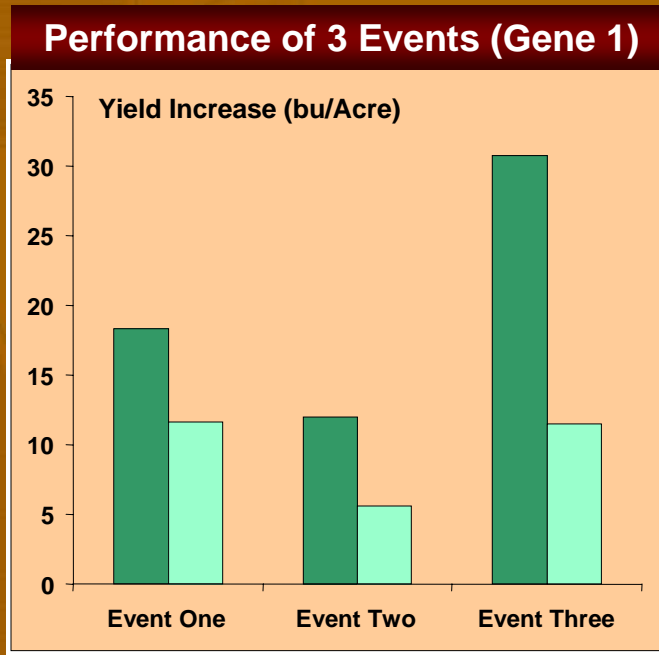


2003



# 2004 - Quantitative Results From Field Tests

Relative to isogenic check



Hybrid background A



Hybrid background B

- More kernels per ear and more ears harvested.
- Benefit is real
- May vary with environment & germplasm

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## 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



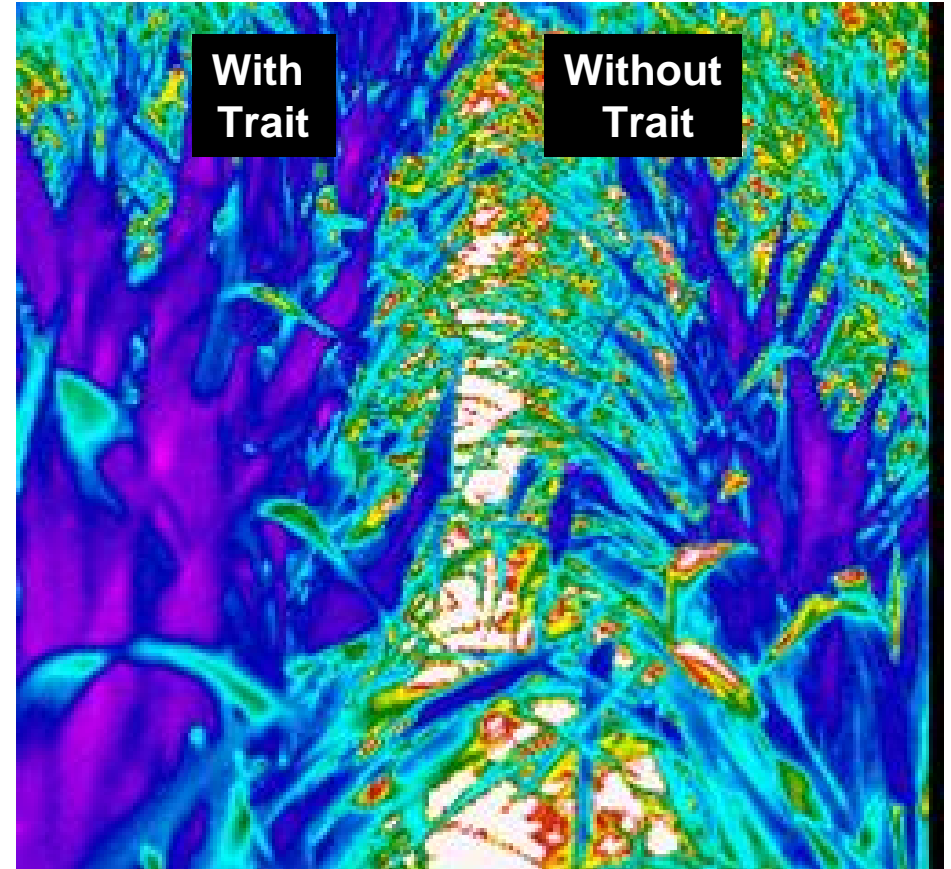
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# 2005 - Vegetative Phenotypes Repeated



Reduced  
Leaf Rolling



Reduced  
Leaf Temperature





# Results from 2005 trials

## Multiple leads again showed yield benefit

KS



Without  
Trait

With  
Trait

CA



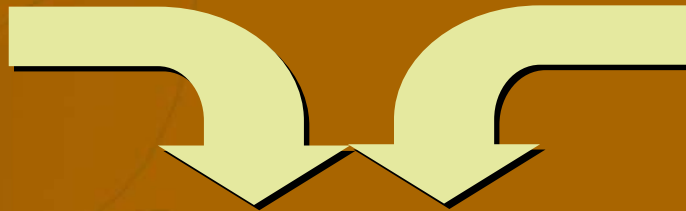
Without  
Trait



With  
Trait

# Combination of traits & germplasm will provide options & the best stress mitigation packages for growers

**Breeding**  
for stress  
tolerance  
and  
Yield  
potential



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

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

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# Summary – Drought Tolerant Corn

## ➤ 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.





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