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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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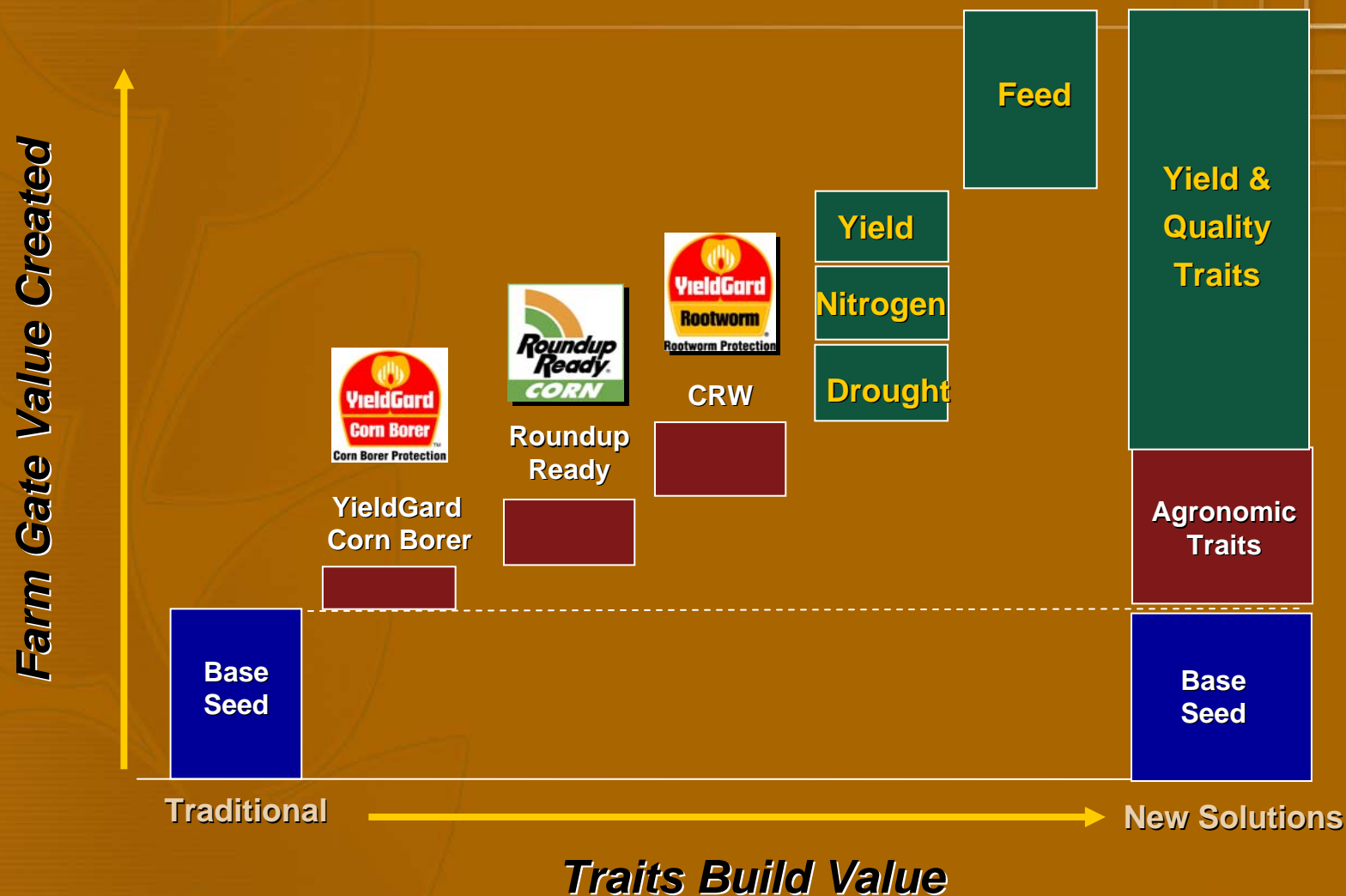
Topics

- **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

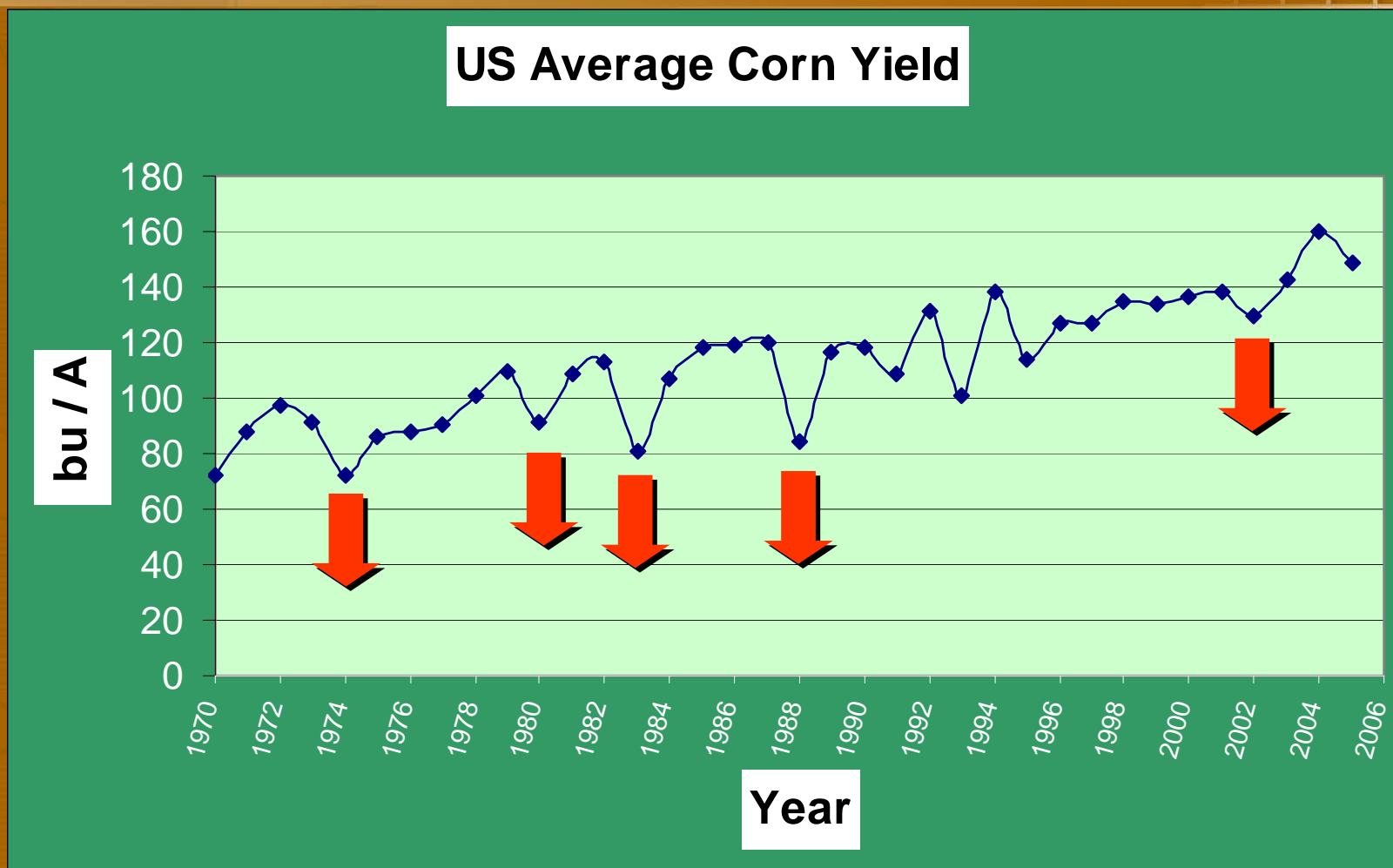


Traits Build Value

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Increasing Yield Stability / Consistency

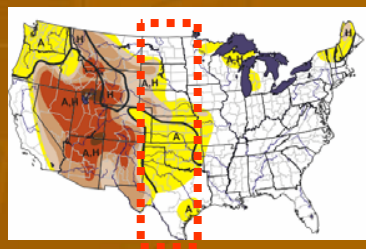


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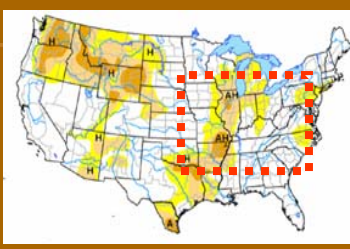


Drought Tolerant Corn - Potential Product Concepts

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**

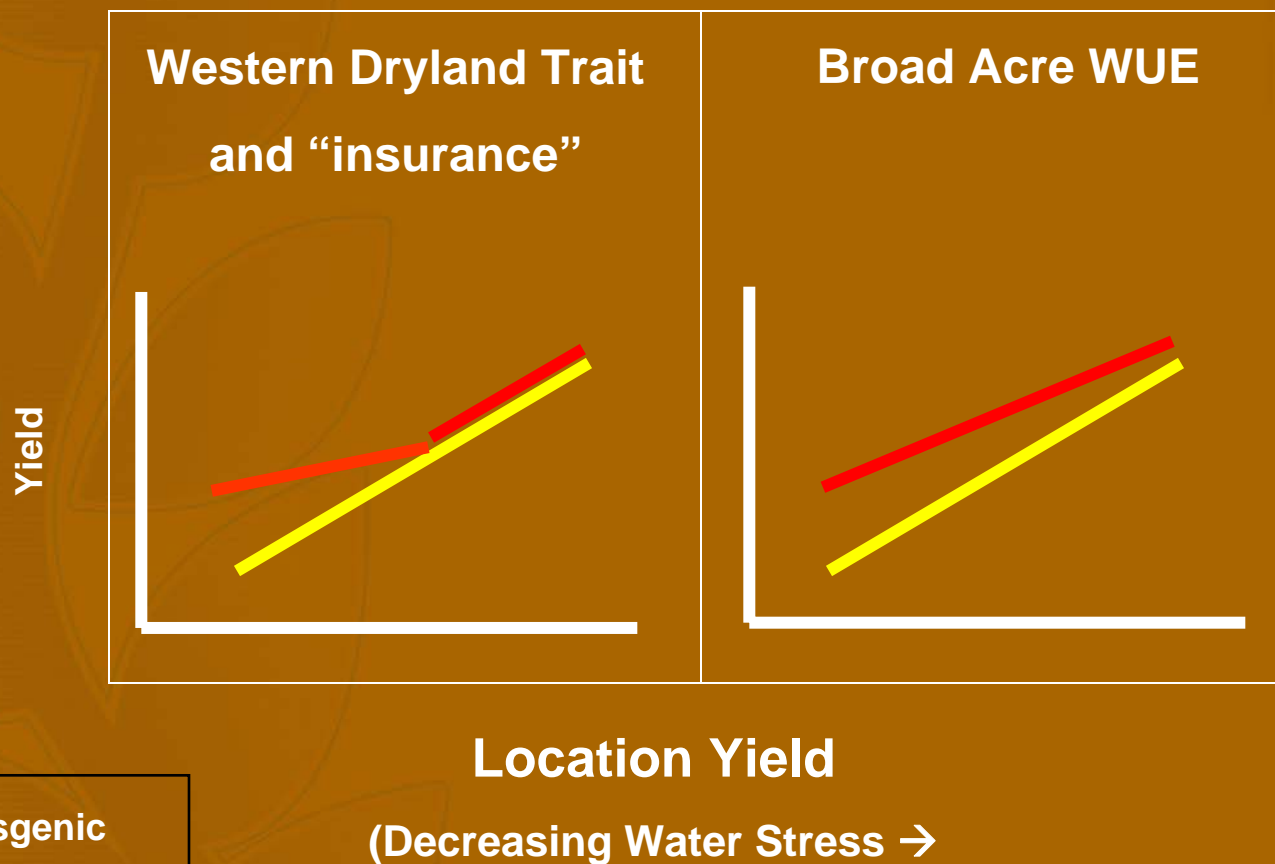
**Protect Aquifer
water levels /
reduce fuel
consumption
needed to pump
water**

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

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Drought / WUE Product Concepts



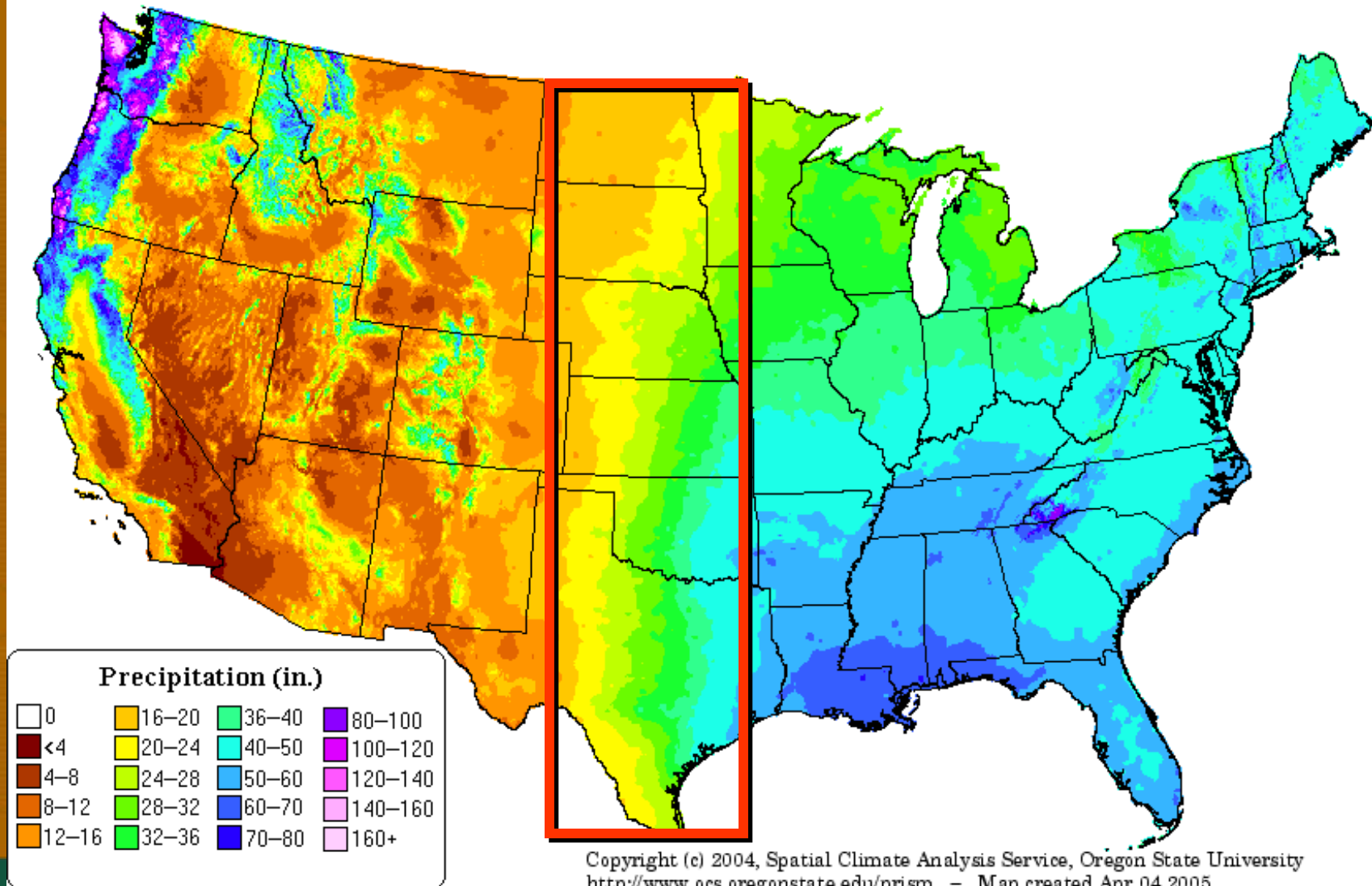
— Transgenic
— Control

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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



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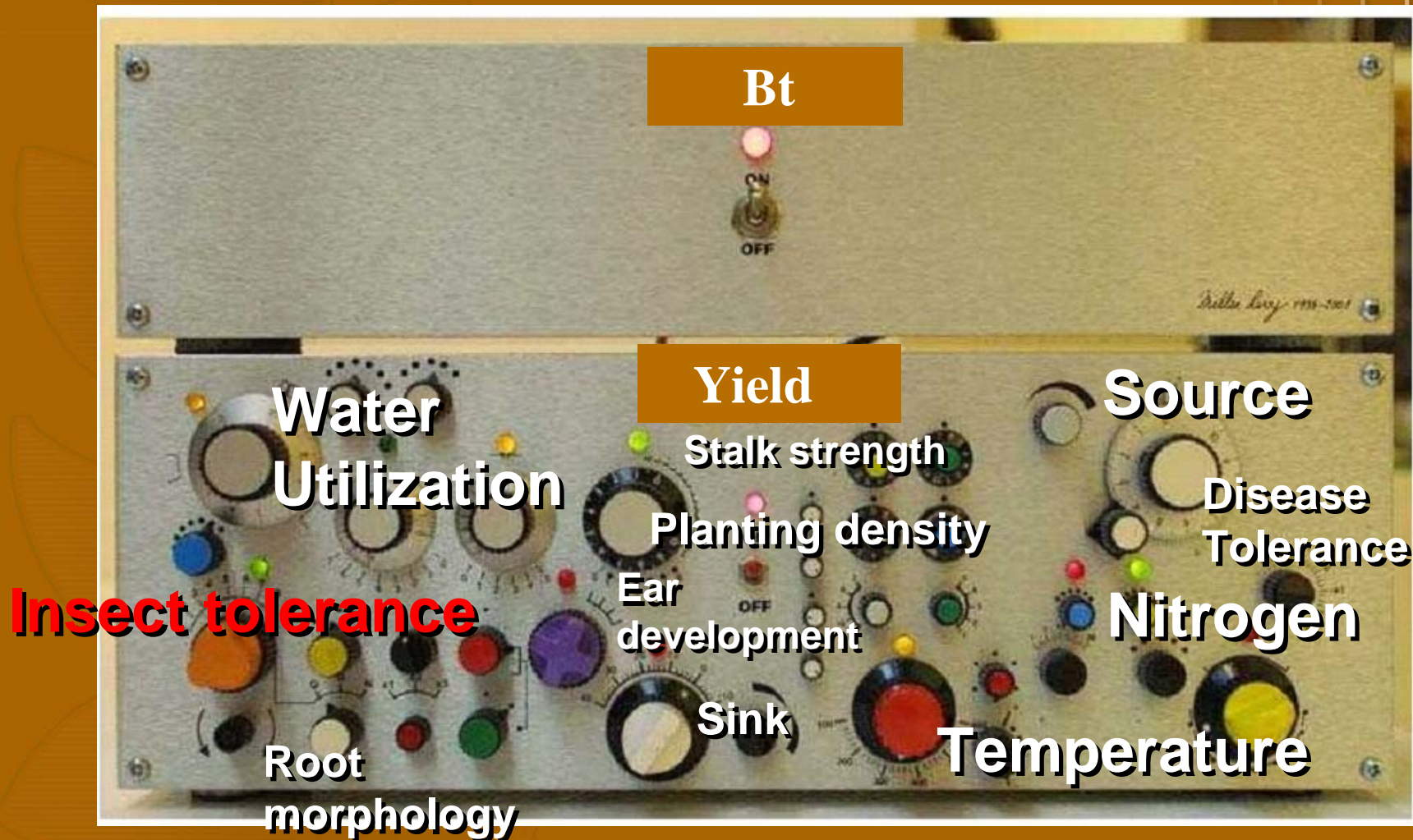


- **Product Concepts**
- **Example of Progress – Corn**
- **Summary - discussion**

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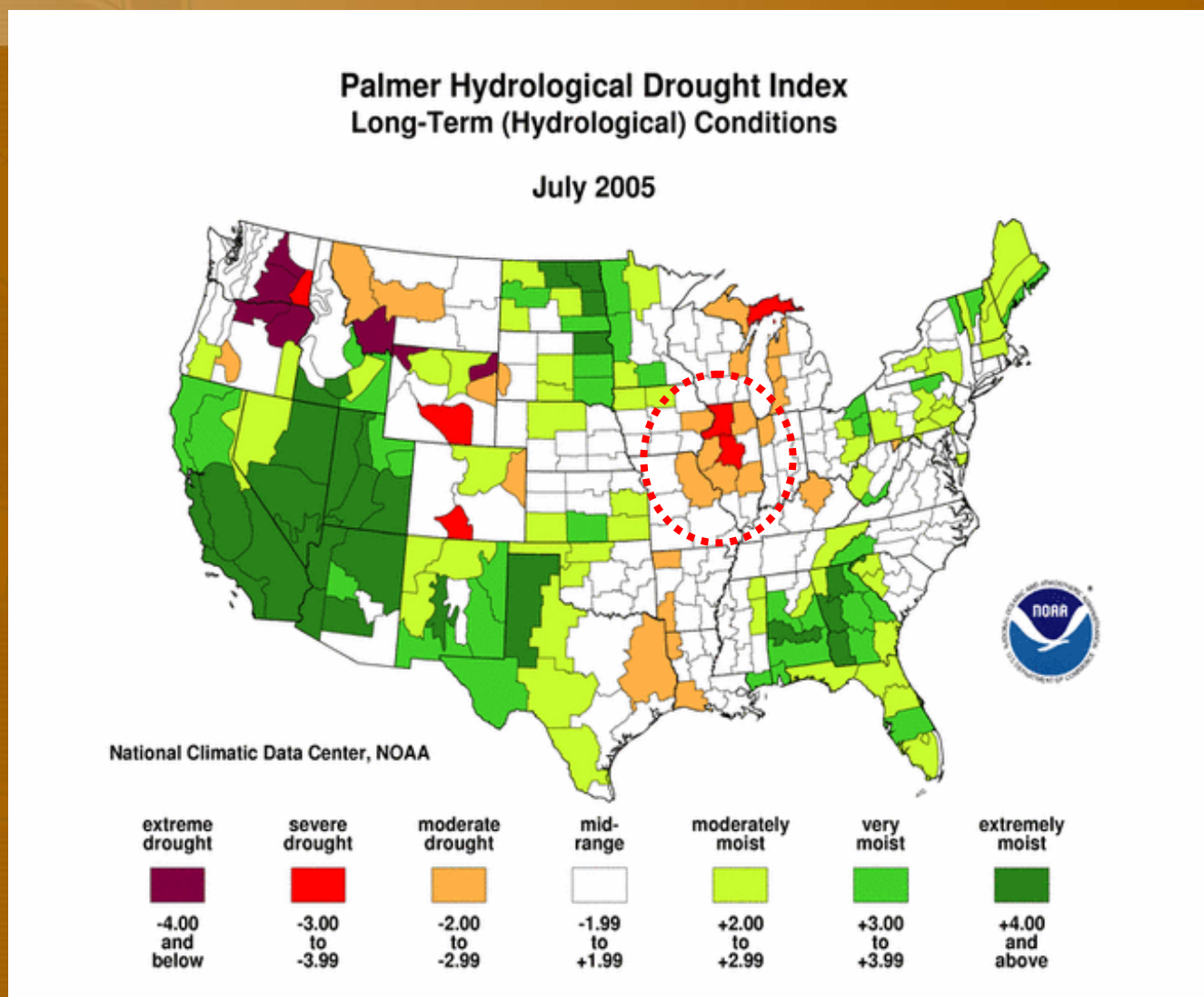
Yield is a complex quantitative trait but individual components affecting yield can be modified using single genes



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Commercial Biotech traits already reduce risk during dry growing conditions



Palmer Hydrological Drought Index

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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

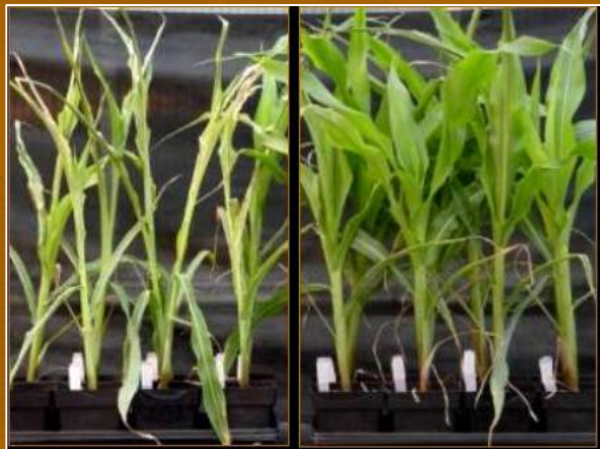


Rice



Drought Tolerant Crops Demonstrated in Greenhouse and Field

2003

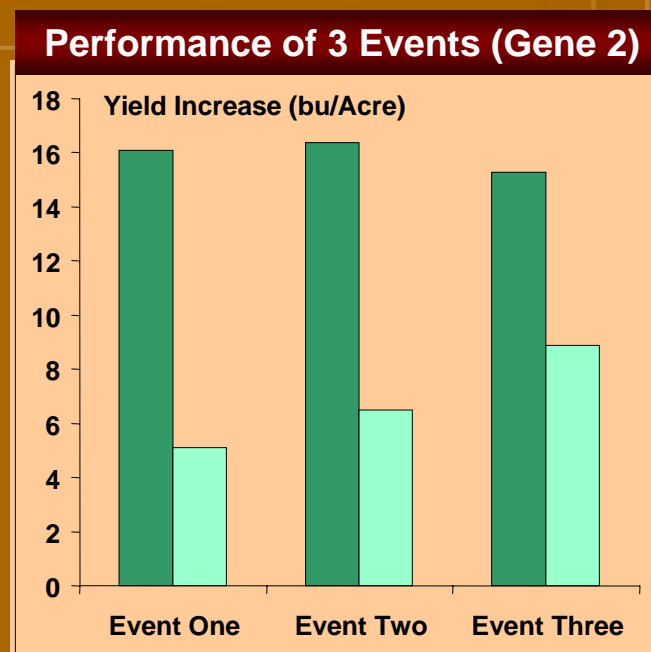
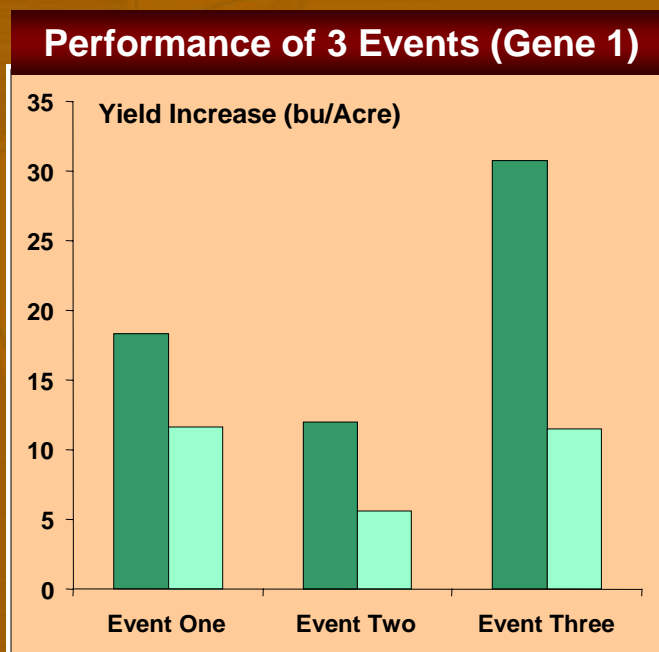


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2004 - Quantitative Results From Field Tests

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



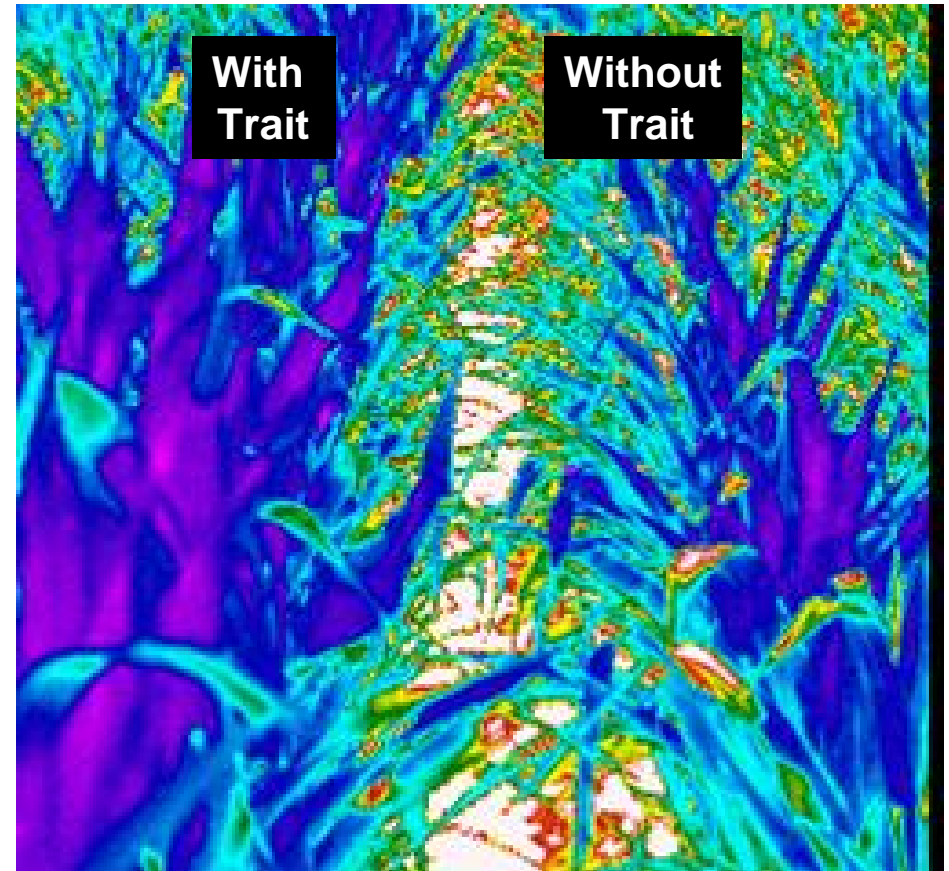
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2005 - Vegetative Phenotypes Repeated



Reduced
Leaf Rolling



Reduced
Leaf Temperature



Results from 2005 trials

Multiple leads again showed yield benefit

KS



Without
Trait

With
Trait

CA



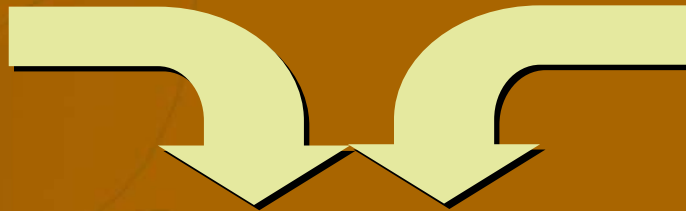
Without
Trait



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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