

Sustainability and Weed Management

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The introduction of glyphosate tolerant cropping systems has revolutionized the agronomics of weed management. The significant benefits of conservation tillage, increased productivity and flexibility of crop management over the last 16 years have driven herbicide tolerant crops to 94 million hectares or 59% of the total biotech trait hectares (James, ISAAA, 2011). The challenge of glyphosate resistant weeds make it clear that new and sustainable strategies must be implemented to maintain the agronomic gains of this technology. The incorporation of herbicide tolerant traits into the highest yielding germplasm for each region is a challenging task and one that Monsanto has made successful by using advancements in conventional and molecular plant breeding. For the next generation's crops to be most successful in this changing environment, they will need to grow with less water, less added nutrients. The next gen crops ability to tolerate higher planting densities will be a major tool in the weed management system. Combined with the most convenient herbicide tolerant trait systems the crops of the future will create a sustainable high yielding production of food, fiber and renewable energy. Every technology man has developed will be necessary to feed, clothe and sustain the 8.2 billion people predicted to exist in 2030. The presentation will summarize the view of Monsanto as a global seed company on the future of agriculture and weed management.

Keywords: herbicide ;resistant;glyphosate;sustainability;weed;

Future of Agriculture and its Impacts on Weed Science

6th International Weed Science Congress, Hangzhou, 17-22 June 2012



Sustainability and Weed Management

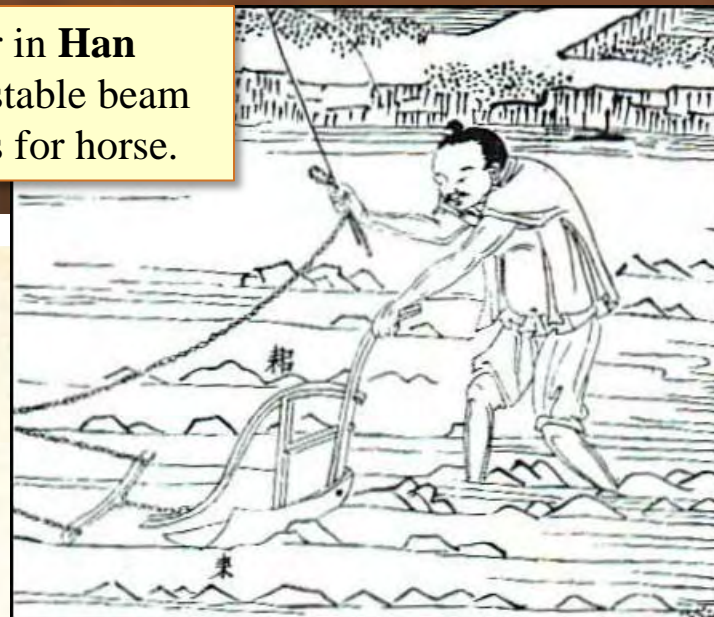
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4th Century B.C. popular in **Han Dynasty** including adjustable beam to set depth with harness for horse.

Row planting ~6th Century B>C.
Seed Drill 2nd century B.C.



“Chinese pest controls began in **Zhou Dynasty** (1000 BC), where *The Book of Songs* lists 20 insects: *Huang, Sheng, Zei*, etc. *Zhou Li Qiu Guan* records many official methods and *Guan Zi-Du Di* considers pest control one of five crucial national needs. It developed before *Chun Qiu* and *Zhan Guo* (800 BC) and improved over several millenia.”

PEST CONTROL METHODS IN ANCIENT CHINESE AGRICULTURE,
PENG, Shijiang, History Laboratory Researcher, South China Agricultural University, Guangzhou, PR China; (*Agricultural Archaeology* 1984(2):266-268. Transl. by Mingjie Zhang, ed. by B. Gordon

The oldest Chinese agricultural treatise is the *Xia Xiao Zheng* written circa the 16th century BC
Yu, Youtai 1987. Agricultural history over seven thousand years in China: In Sylvan Wittwer et. al. (eds.) Feeding a Billion: Frontiers of Chinese Agriculture: 19-33

"If you wish a pest-free new year, cut field weeds".












Systems Solutions Maximize Yield Potential

CHALLENGE:



Between planting and harvesting, many factors can limit yield.

OPPORTUNITY:

	Breeding	Biotech	Agronomic Solutions
WEED CONTROL			
INSECT CONTROL			
STRESS TOLERANCE			
DISEASE CONTROL			

Maximizing total yield potential



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Why are Biotech Traits on >380 million acres?



Productivity

44 million metric tons of additional soybeans, corn, cotton lint and canola in 2010



Economic Return

\$78.4 B global farm income benefit, 1996-2010

And everyone else gets:



Pesticide Reduction

- 438 million kg (-8.6%) reduction, 1996-2010



Greenhouse Gas Emissions

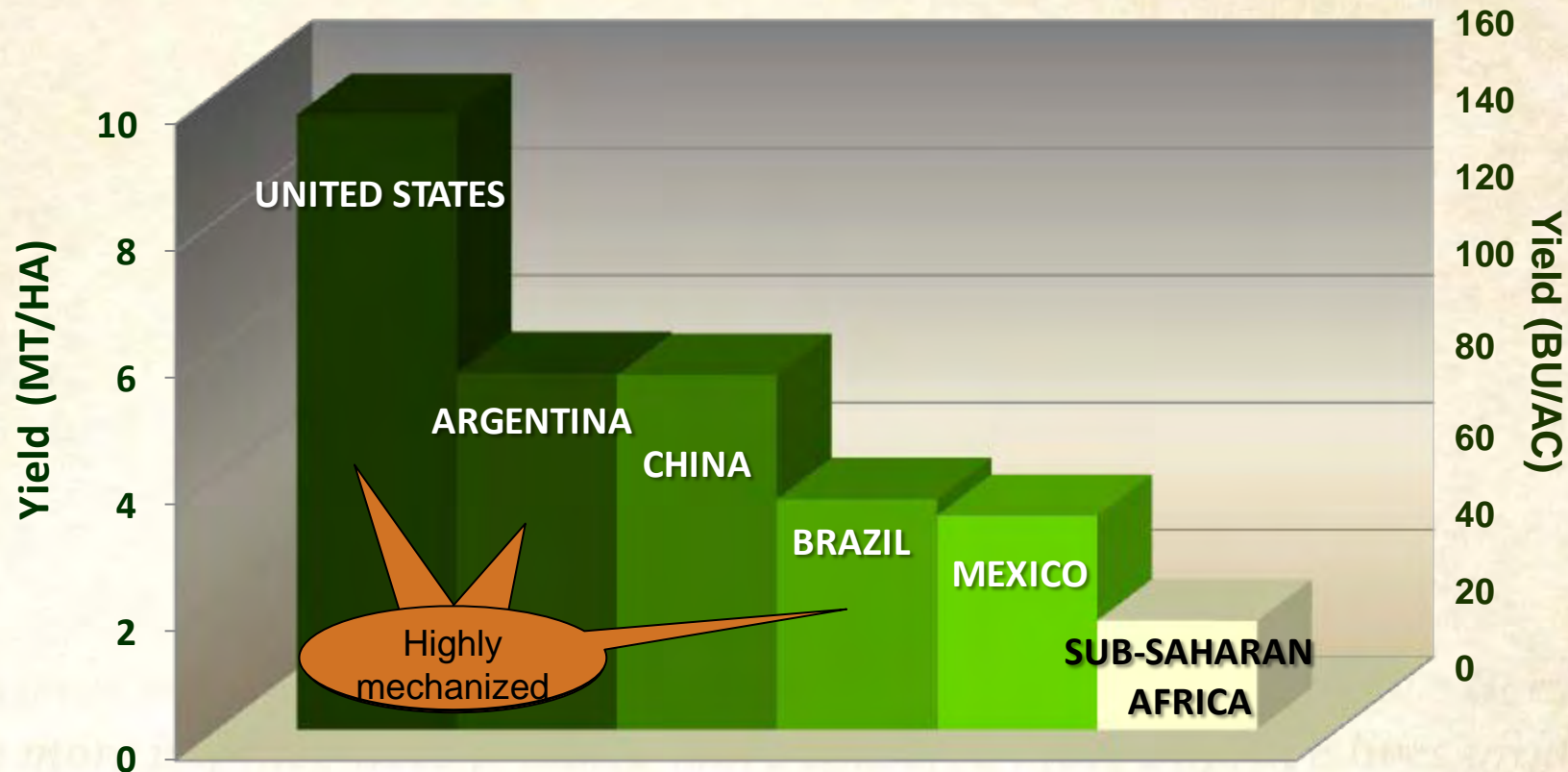
- Reduced CO₂ emissions equal to **removing ~8.6 M cars** from the road for a year in 2010

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Average Sub-Saharan African Corn Yields are Among the Lowest Globally

2008/2009 CORN YIELDS BY COUNTRY



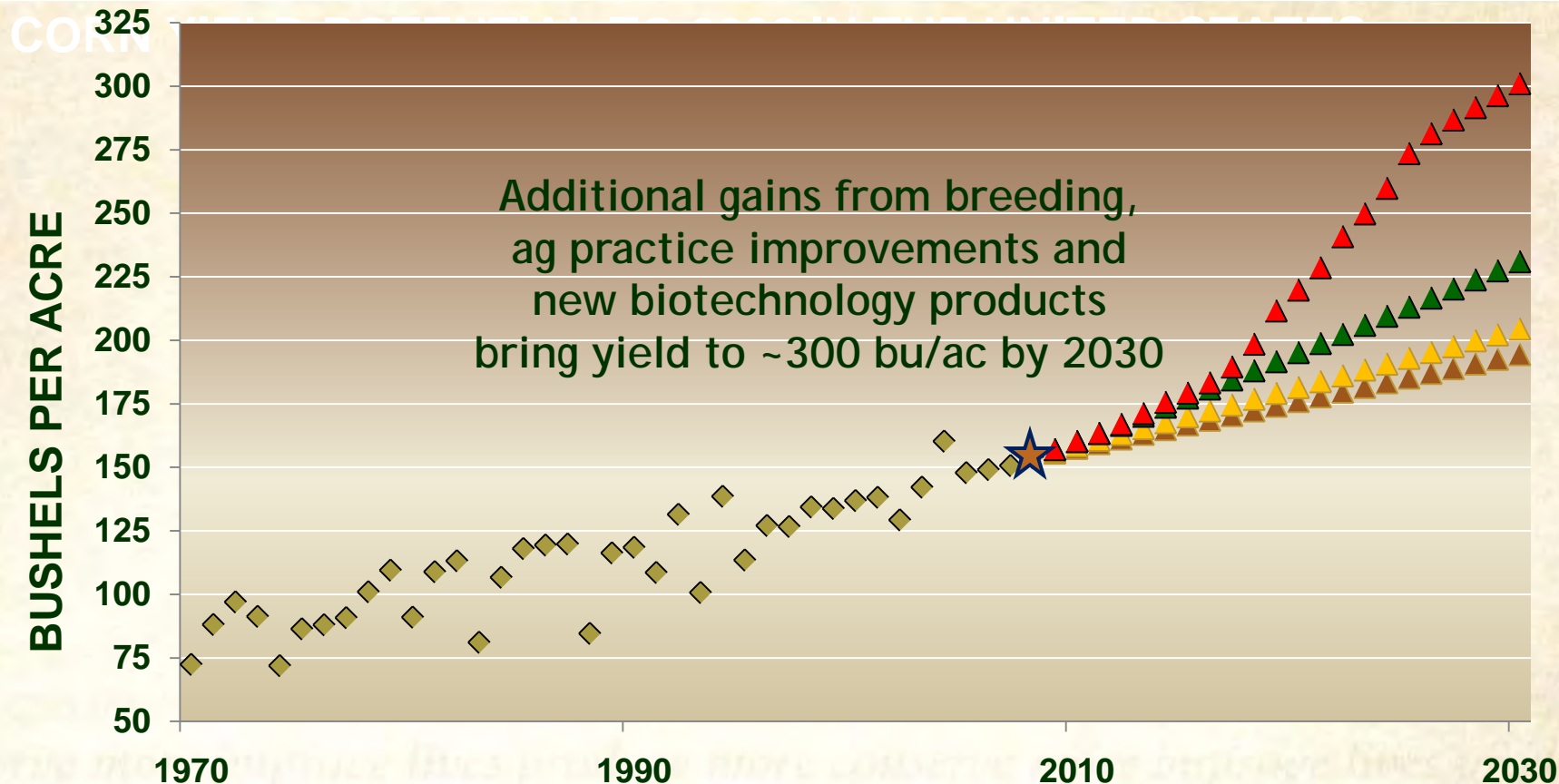
IMPROVED AGRONOMIC PRACTICES, BREEDING AND BIOTECH CAN ALL PLAY A ROLE

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Source: USDA, ERS, Oct. 2009

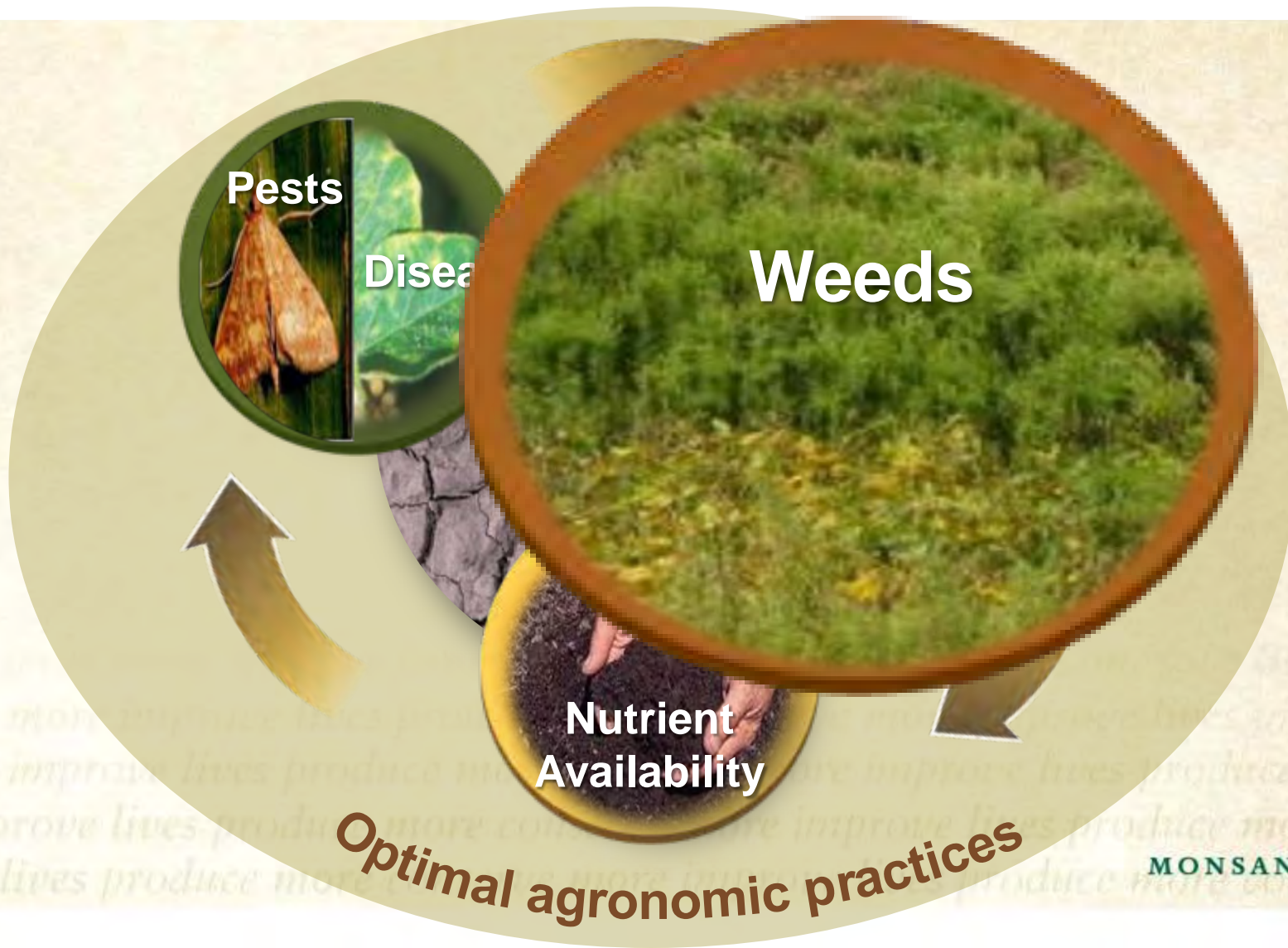
Corn Yield Components to 2030



◇ USDA Yield ▲ Historical Trend ▲ Agronomic ▲ Advanced Breeding ▲ Biotech



Farmers Face Many Agronomic Challenges; We Need A Systems Approach to Maximize Yield



“Trends link HT crops with conservation tillage” (Fawcett and Towery, 2002)

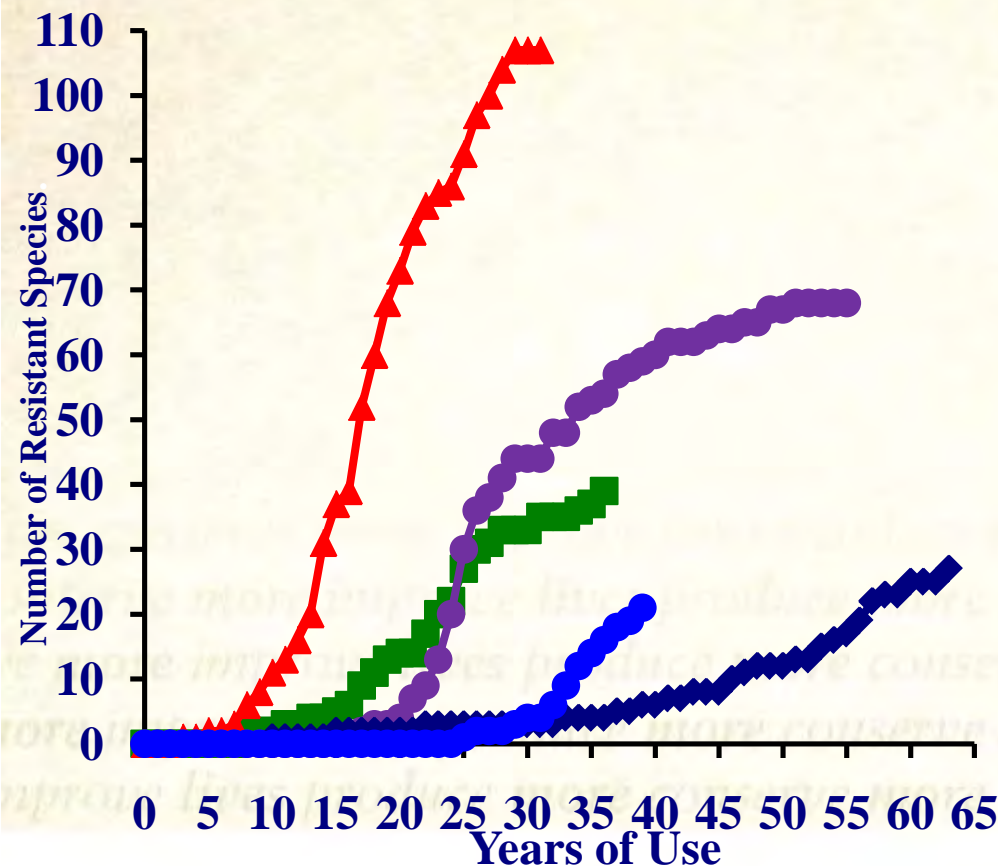
1. Improvements in weed control, including the adoption of HT crops , are important reasons for initial adoption and continuance of no-till.
2. Since 1994, nearly all the growth in no-till occurred in crops where HT technology is available.
3. There is a clear association between sustainable tillage practices and HT crops.
4. Farmers who don't use HT seeds are not as likely to engage in conservation tillage.

The key performance factor of glyphosate and glufosinate is the ability to control a broad spectrum of emerged weeds.



Resistance is a Concern and a Challenge to Herbicide Sustainability

Global Herbicide-resistant weeds since 1957 (2,4-D). Currently confirmed for 368 resistant biotypes in 200 weed species.



- **107** species **ALS-inhibitor (Group 2) herbicides**

- **68** species to triazine herbicides **Photosystem II inhibitors (Group 5)**

- **37** species to **ACCase-inhibitor (Group 1) herbicides** worldwide

- **30** species to **synthetic Auxin herbicides (Group 4)**

- **21** species to **Glyphosate-(Group 9)** worldwide

Factors Associated with Evolution of GR Weeds



Fallow

- Glyphosate only
- “Low rates”
- Reduced mechanical



•Orchards / Vineyards

- Glyphosate only
- “Low rates”
- Reduced mechanical



GT Crops (gly use)

- Glyphosate only
- “Low rates”
- Reduced mechanical

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Requirements for Sustainable Management (Profitable Yield at the Minimum Threshold)

Threshold depends on **Net Weed Seed Produced** (for each species)

- **Equal amount-** Minimum threshold- *fragile*
- **Less Seed dropped-** Progressive position- *durable*
- **More Seed dropped-** Not sustainable - *more inputs required*

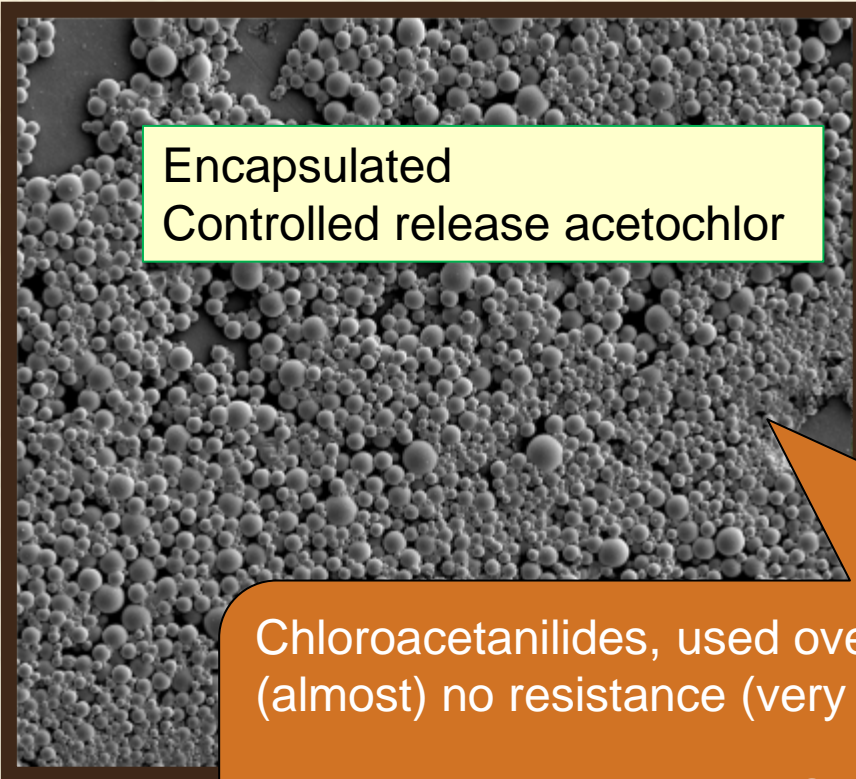
Two MOA's dramatically decreases success of selection
Simultaneous activity on the same plant

Reduce the weed stand count

- Start clean—residual Pre
- Tillage, cover crops, canopy etc



Warrant™ Provides Residual Control of Grasses and Small Seeded Broadleaves



Encapsulated
Controlled release acetochlor



Chloroacetanilides, used over 40 years with (almost) no resistance (very low risk)

Metabolism requires LOTS of GSH and GST (large seeds)

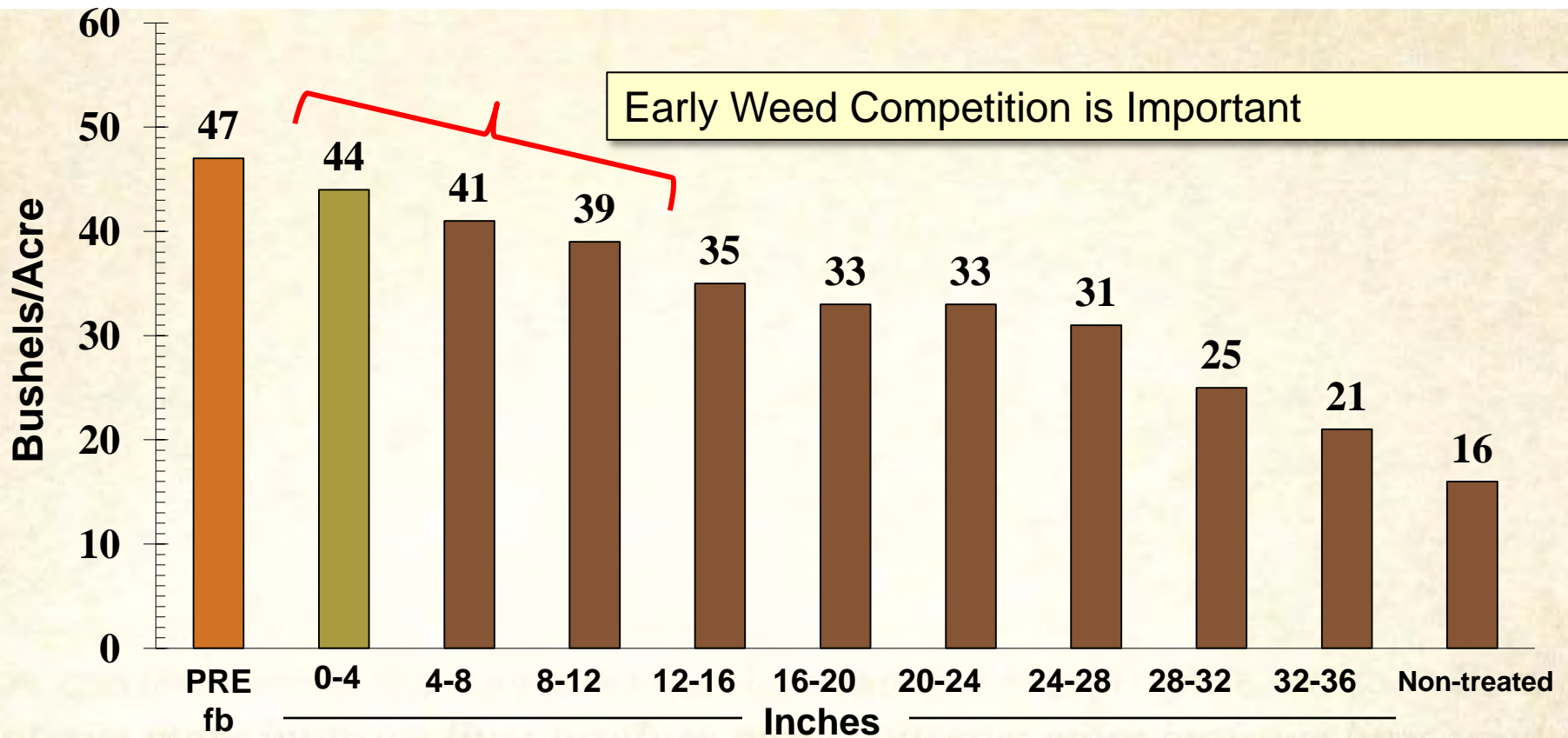
Roundup PowerMax™
+ 48 oz Warrant
Applied V3
20 DAT

Untreated Check
Primary weeds
Tall Waterhemp
Common
Lambsquarters



Beresford, SD

Yield Benefit of a Pre in a Roundup Ready System



Timing of One application of Roundup (0.75 lbs ae/A)

Data courtesy of Southern Illinois University



The Roundup Ready® Xtend Crop SystemComing Soon*

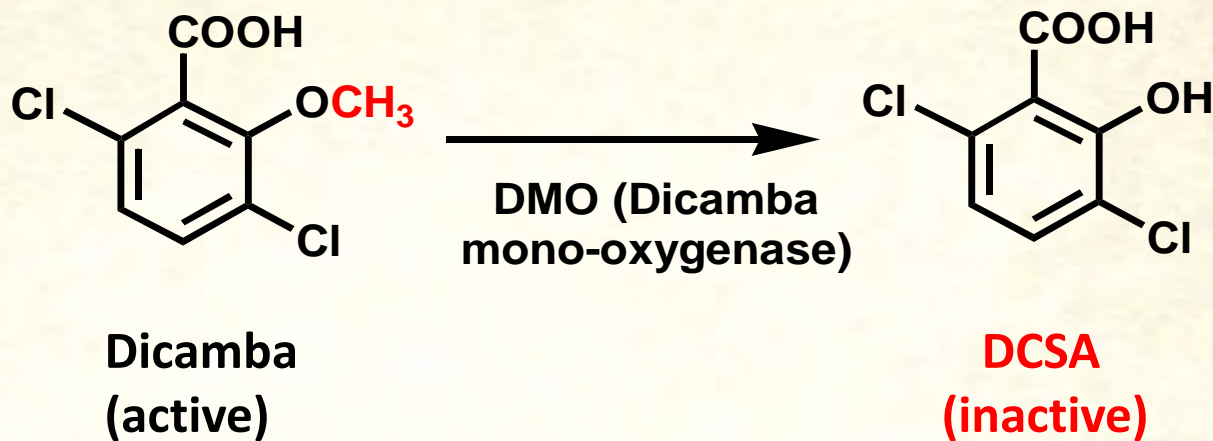


Biotech-stacked traits for herbicide tolerance to 2
MOA's; glyphosate and dicamba



Dicamba Crop Safety Based on Metabolism

- Grass weeds and crops naturally metabolize dicamba primarily to 5-OH dichloro anisic acid (HDCA) and much less to DCSA.
- DT crops use a bacterial gene to metabolize dicamba to DCSA



Characteristics, Auxin MOA

- Broadleaf weed control in corn, small grains, rangeland, pasture, etc.
- Broad spectrum control of annuals and perennials
- **7 to 10 days of soil residual activity**
- Resistant kochia and prickly lettuce in US



Dicamba + Glyphosate can control Resistant Palmer

2 applications Rdup (0.75 lb/A) + Clarity® (0.25 lb/A) at Pre & Early Post (6" Palmer) fb Rdup (0.75)



Mt Olive, NC, July 2008, Alan York



BioDirect Technology is a Next Step in the Evolution of Technologies for Solving Farmers' Challenges

EVOLUTION: AG PLATFORMS DRIVING YIELD

NEXT INFLECTION POINT

Monsanto's leading genomics and agronomics systems capability are key catalysts: data and insight enables multiple, complementary R&D platforms

GENOMICS

NEW

NEW

ADVANCED BREEDING

AG BIOTECHNOLOGY

SYNTHETIC AGRICULTURAL CHEMICALS

AG BIOLOGICALS

INTEGRATED FARMING SYSTEMS (IFS)

1980s

1990s

2000s

2010s

BioDIRECT

Monsanto's Biological Ag Solutions Technology

CREATING BREAKTHROUGH AG BIOLOGICAL PRODUCTS
WITH BIODIRECT TECHNOLOGY

MONSANTO



A New Class of Agricultural Biologicals Delivering Effective Plant and Beneficial Species Protection

MONSANTO's AG BIOLOGICALS PLATFORM FOCUS AREAS

BioDirect™ TECHNOLOGY



WEED MANAGEMENT

INSECT MANAGEMENT

VIRUS CONTROL

BEE HEALTH

Precision in design and targeting of products, leading to effective, highly specific control of a pest (plant, insect or virus).

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Early Testing Indicates BioDirect™ Technology Could Improve Performance and Control of Resistant Weeds

NEW BioDirect™ TECHNOLOGY

WEED-CONTROL RESEARCH

MONSANTO RESEARCH LAB TRIALS



GLYPHOSATE-RESISTANT WEEDS SPRAYED WITH GLYPHOSATE ALONE



GLYPHOSATE-RESISTANT WEEDS SPRAYED WITH *BioDirect* + GLYPHOSATE

Example: Glyphosate-Resistant Weed Control

Early testing indicates that BioDirect technology can be used with Glyphosate to target resistant weeds and provide more effective control of problem weeds

MONSANTO RESEARCH LAB TRIALS



SPRAYED WITH HPPD CHEMISTRY ALONE

BioDirect + HPPD CHEMISTRY



SPRAYED WITH ALS CHEMISTRY ALONE (RESISTANCE EVIDENT)

BioDirect + ALS CHEMISTRY

Example: Better Weed Control Performance

Early testing indicates BioDirect technology can be used with multiple other herbicides for weed control:

- Improve performance
- Provide more effective spectrum of control of problem weeds

SUPPLEMENT TO EXISTING HERBICIDES FOR IMPROVED PERFORMANCE

Sustainable Agriculture



Sustainable Weed Management

Source: www.aplu.org/NetCommunity/Document.Doc?id=1842

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Legals

- **Monsanto Company is a member of Excellence Through Stewardship® (ETS).** Monsanto products are commercialized in accordance with ETS Product Launch Stewardship Guidance, and in compliance with Monsanto's Policy for Commercialization of Biotechnology-Derived Plant Products in Commodity Crops. This product has been approved for import into key export markets with functioning regulatory systems. Any crop or material produced from this product can only be exported to, or used, processed or sold in countries where all necessary regulatory approvals have been granted. It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted. Growers should talk to their grain handler or product purchaser to confirm their buying position for this product. Excellence Through Stewardship® is a registered trademark of Biotechnology Industry Organization.
- **Commercialization is dependent** on multiple factors, including successful conclusion of the regulatory process. **The information presented herein is provided for educational purposes only, and is not and shall not be construed as an offer to sell, or a recommendation to use, any unregistered pesticide for any purpose whatsoever.** It is a violation of federal law to promote or offer to sell an unregistered pesticide.
- **Individual results may vary**, and performance may vary from location to location and from year to year. This result may not be an indicator of results you may obtain as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible.
- **ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS.** Roundup Ready® crops contain genes that confer tolerance to glyphosate, the active ingredient in Roundup® brand agricultural herbicides. Roundup® brand agricultural herbicides will kill crops that are not tolerant to glyphosate. **Tank mixtures:** The applicable labeling for each product must be in the possession of the user at the time of application. Follow applicable use instructions, including application rates, precautions and restrictions of each product used in the tank mixture. Monsanto has not tested all tank mix product formulations for compatibility or performance other than specifically listed by brand name. Always predetermine the compatibility of tank mixtures by mixing small proportional quantities in advance. Genuity and Design®, Genuity Icons, Roundup Ready 2 Yield®, Roundup Ready PLUS™, Roundup Ready®, and Roundup® are trademarks of Monsanto Technology LLC. Banvel® and Clarity® are trademarks of BASF Corporation. All other trademarks are the property of their respective owners. ©2012 Monsanto Company.

