Weed Management Strategies for 2015

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Lubbock, Texas

TEXAS A&M AGRILIFE RESEARCH

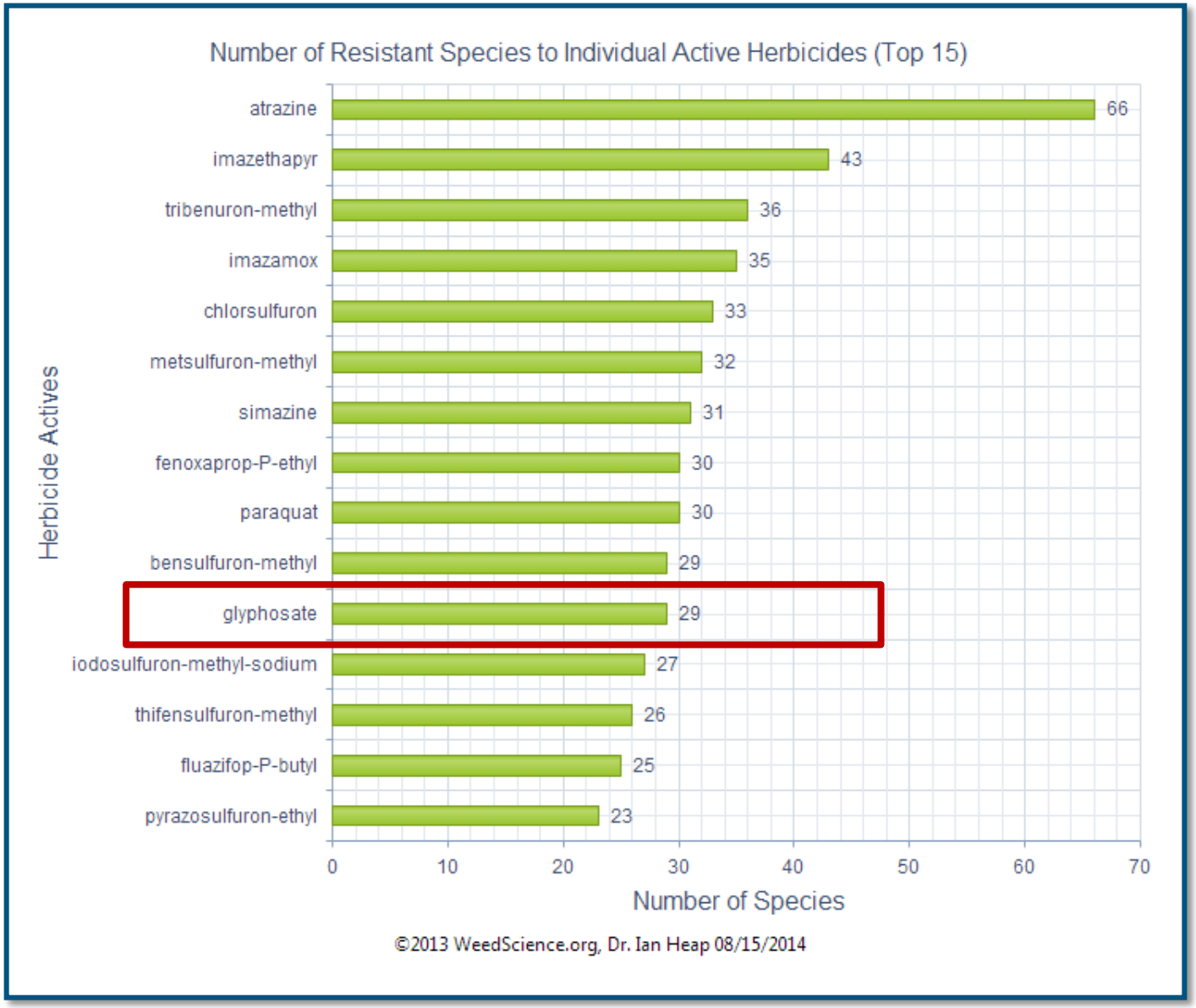
Overview

- Weed resistance – more than Palmer amaranth/glyphosate
- Palmer amaranth – past and present
- Strategies for managing resistant Palmer amaranth
  - Residual herbicides – PPI, PRE and POST options
  - POST options – Liberty®, Staple®
- New technology
  - Roundup Ready Xtend™ Crop System
  - Enlist™ Weed Control System

Herbicide Resistance in the U.S.

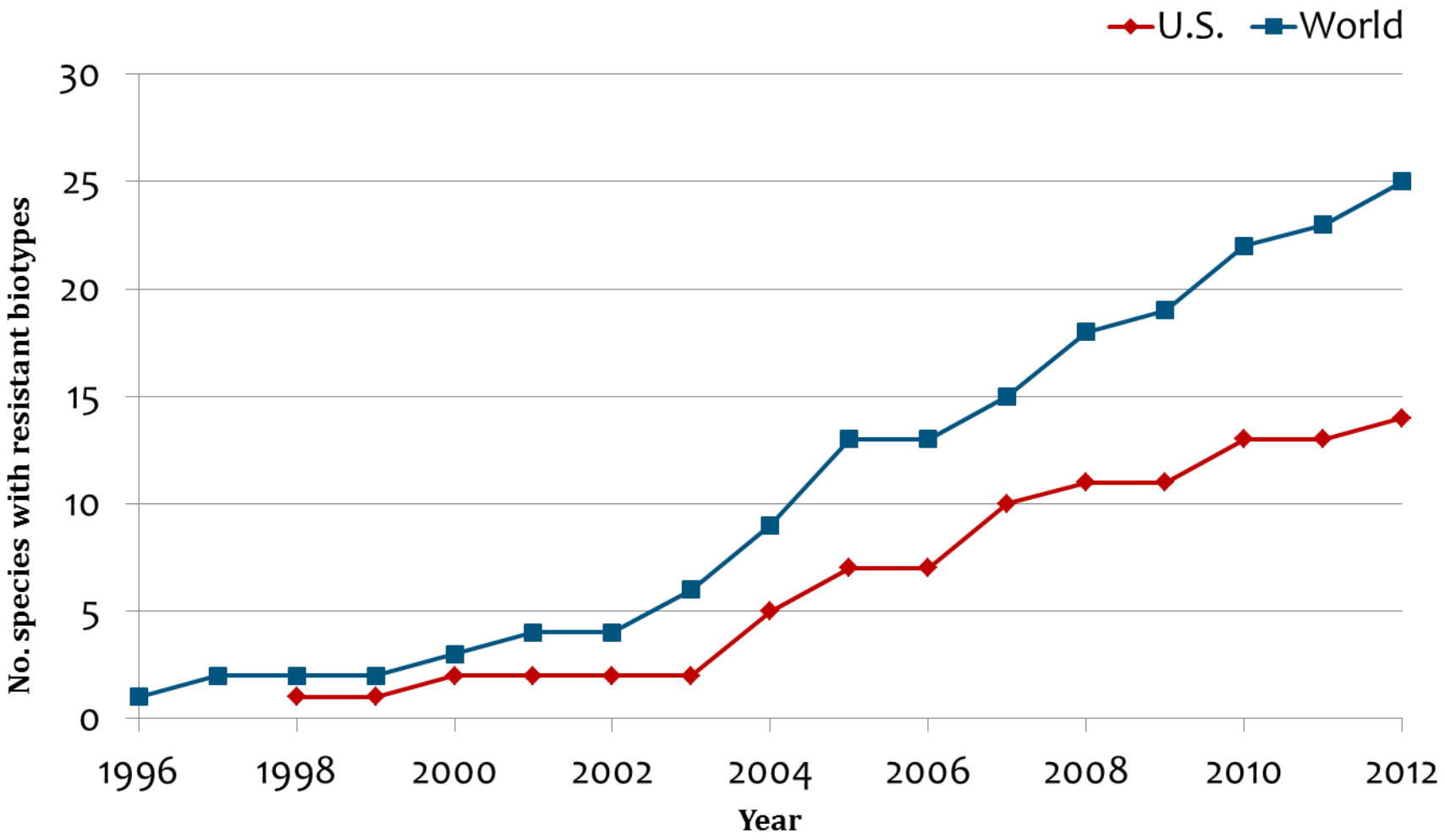
- 76 species with resistant biotypes
- 23 modes of action (MOA) with confirmed resistance
  - WSSA recognizes 25 MOAs
- 145 resistant species-MOA combinations

Source: International Survey Herbicide Resistant Weeds



Source: International Survey Herbicide Resistant Weeds

Glyphosate-Resistant Weeds



Source: International Survey Herbicide Resistant Weeds

Herbicide Resistant Weeds—Texas

#	Year	Species	Site of Action	Activities
1	1989	*Lolium perenne* Perennial Ryegrass	ALS inhibitors (B/2)	sulfometuron-methyl
2	1991	*Echinochloa crus-galli var. crus-galli* Barnyardgrass	PSII inhibitor (Ureas and amides) (C2/7)	propanil
3	1993	*Amaranthus palmeri* Palmer amaranth	PSII inhibitor	atrazine
4	1998	*Kochia scoparia* Kochia	ALS inhibitors (B/2)	metsulfuron-methyl
5	2009	*Sorghum halepense* Johnsongrass	ALS inhibitor	imazethapyr, nicosulfuron
6	2006	*Amaranthus tuberculatus* (=*A. rudis*) Tall Waterhemp	EPSP synthase inhibitors (G/9)	glyphosate
7	2011	*Amaranthus palmeri* Palmer amaranth	EPSP synthase inhibitors (G/9)	glyphosate

Palmer amaranth

- Infests all cultivated cropland
- Emerges from May—September
- Prolific seed producer
- Can be controlled by wide range of PRE and POST herbicides in addition to glyphosate

Herbicide Application

Application Method	Acres Treated (%)
PPI	91
PRE	20
POST	1
Spot Treatment	40
Layby	1
Cultivation (3.1x)	98

Source: Smith, et al., 1996

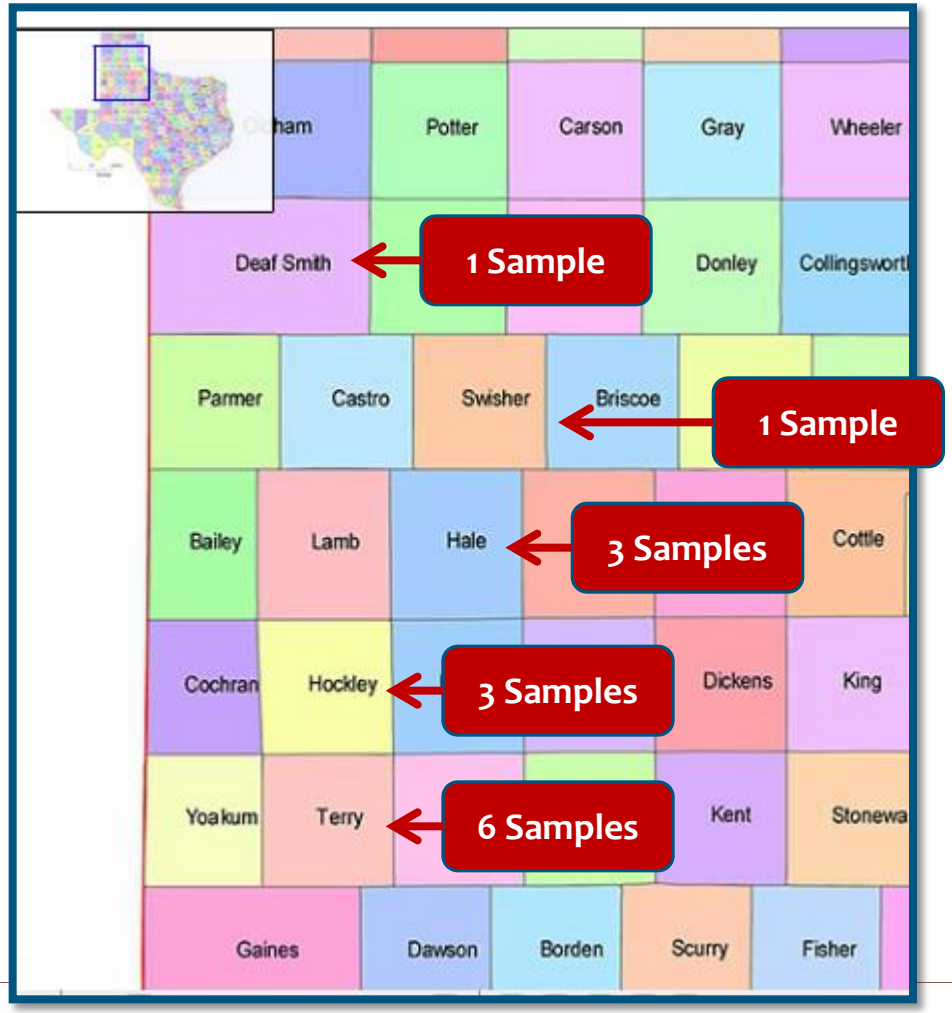
Pre-Emergence Weed Control
1950 - Lubbock, Texas

Source: https://lubbockarchive.tamu.edu

Roundup Ready® Flex or GlyTol® Cotton

- Weed Challenges
  - Russian thistle
  - Morningglory
  - Horseweed

Greenhouse Results Glyphosate-Resistant Palmer amaranth - 2011



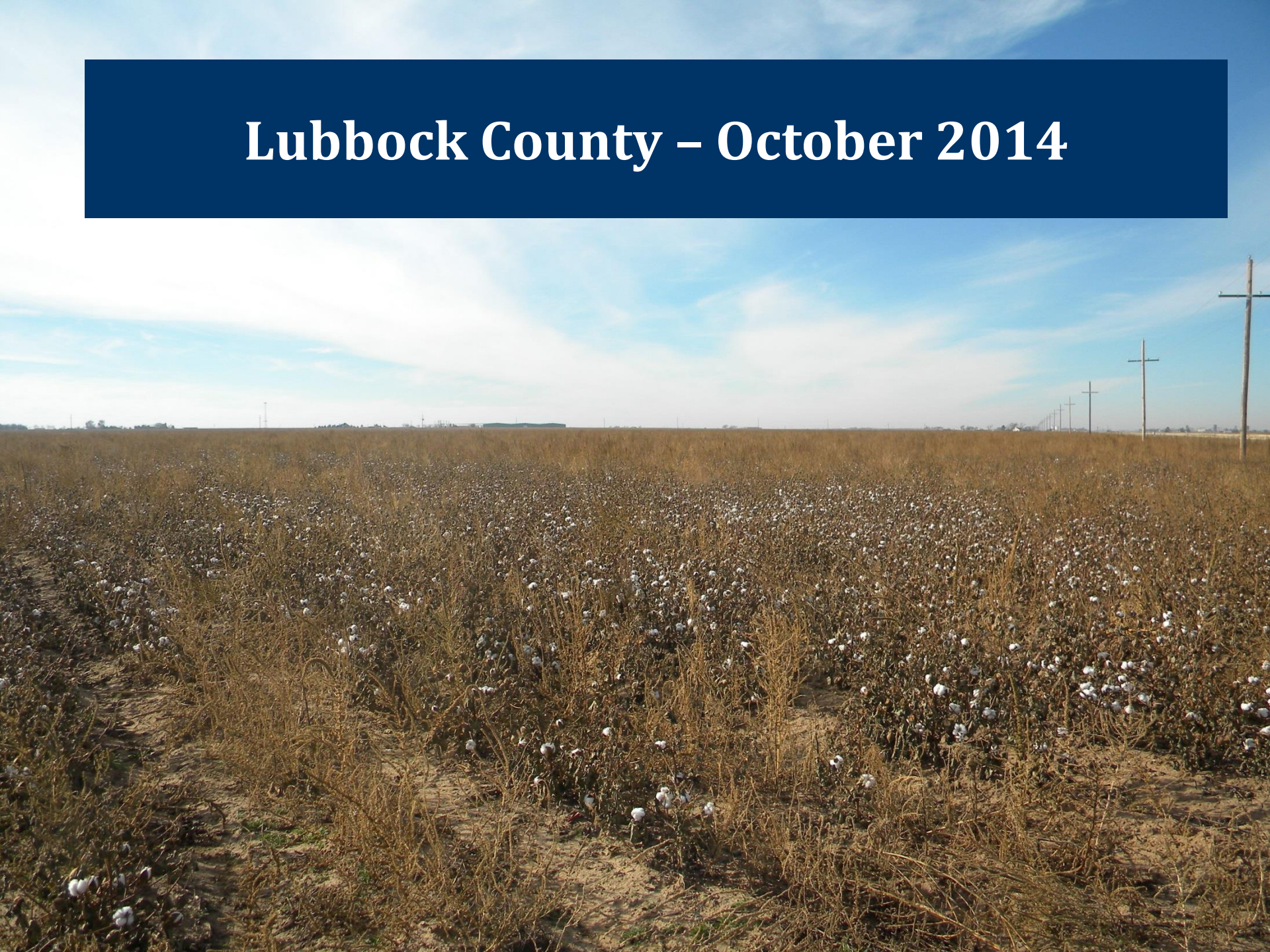
- Greenhouse study
  - Samples collected from field brought to greenhouse
  - Varying rates of glyphosate were applied
  - **8:12 samples exhibited some level of glyphosate resistance**

Texas A&M AgriLife Research

Southwest Lubbock County - 2013

TEXAS A&M AGRILIFE RESEARCH

Lubbock County – October 2014



Residual Herbicides

- Pre-plant Incorporated (PPI)
- Dinitroanilines (DNA): Trifluralin (generics), Prowl
  - Incorporation: tillage, irrigation
  - Control small-seeded broadleaf weeds, annual grasses
  - Rate related to soil type

Dinitroanilines – “Yellows”

- Low water solubility – no leaching
- Volatility: Trifluralin – most volatile; Prowl – less volatile
- Photodecomposition
- 2-pass mechanical incorporation – disk, spring-tooth harrow, field cultivator, rolling cultivator
- Incorporation by irrigation or rainfall – Prowl
- Trifluralin/Prowl combinations

- Valor® – Cotton – EPP
- 1.5 – 2.0 oz/A
- 21d interval prior to planting
  - 1” irrigation
- Tank-mix with 2,4-D or glyphosate
- Residual Control—Kochia, Russian-thistle, Palmer amaranth

Texas A&M AgriLife Research

Residual Herbicides

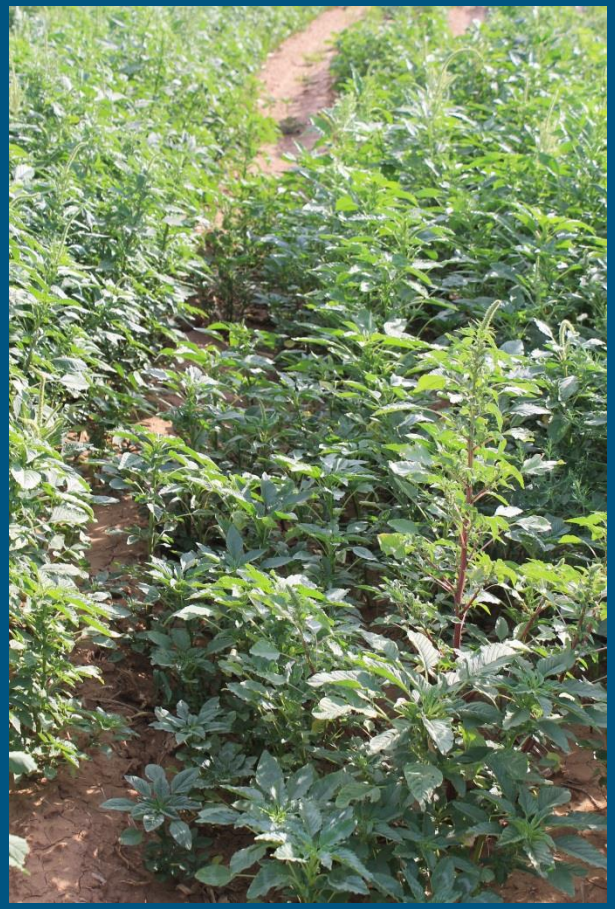
- PreEmergence (PRE)
- Caparol®, Direx®, Cotoran®, Dual Magnum®, Staple® LX
- Palmer amaranth/broadleaf annuals – broader spectrum than DNAs
- Dual Magnum® – grasses, yellow nutsedge
- Staple® LX – potential residue/rotation problems to sorghum or corn

Residual Herbicides

- PostEmergence Topical (POST)
- Dual Magnum®, Staple® LX, Warrant®, Prowl® H20, Envoke™
- Tank mix with Roundup®
- Residual Palmer amaranth control
- Staple® LX, Envoke™ – improved POST and residual morningglory control

Residual Herbicides

- PostEmergence Direct/Layby
- Caparol®, Direx®, Cotoran®, Layby™ Pro
  - Alone or with glyphosate
  - Residual Palmer amaranth and morningglory control
  - POST morningglory control
- Zidua®, Anthem® Flex (not-labeled on sandy soils)



Untreated

Trifluralin PPI + Caparol
PRE fb
Dual POST

Liberty® - POST

- Excellent activity on morningglory
- Effective burndown of perennials under active growing conditions
- Palmer amaranth control dependent on:
  - Weed size
  - Soil moisture
  - Weather
  - Growing conditions
- Glyphosate + Liberty® – tank mix
  - Antagonism can occur

ROUNDUP READY PLUS™
WEED MANAGEMENT SOLUTIONS

ROUNDUP READY® XTEND CROP SYSTEM

Bollgard II® XtendFlex™ Cotton

- 1st three-way herbicide tolerance stack in cotton with tolerances to dicamba, glyphosate, and glufosinate.
- Built on proven success of **Genuity® Bollgard II® with Roundup Ready® Flex** technology
  - In 2013, 10 out of the top 10 Cotton varieties planted in the US feature Genuity Roundup Ready Flex technology (USDA, 2013)
- Added choice in weed control options with triple mode-of-action herbicide tolerance available for pre-, at-, and post-planting
- Anticipated Introduction in Deltapine® Brand and select licensees

BOLLGARD II® XTENDFLEX™ COTTON

This information is for educational purposes only and is not an offer to sell Roundup® Xtend or Xtendimax™ herbicides. Roundup Xtend and Xtendimax are not yet registered or approved for sale or use anywhere in the United States.


Banvel


Clarity

Enhanced Chemistry Candidate Options for Roundup Ready® Xtend Crop System

- Upon registration, Monsanto's dicamba formulations will be labeled for use, before, at, and after planting with Roundup Ready® Xtend Crops
- Built with VaporGrip™ Technology
- By utilizing low volatility formulations, in combination with application requirements, growers can significantly reduce the potential for off-target movement

Roundup XTEND

Enhanced dicamba and glyphosate herbicide premix

XTENDIMAX™

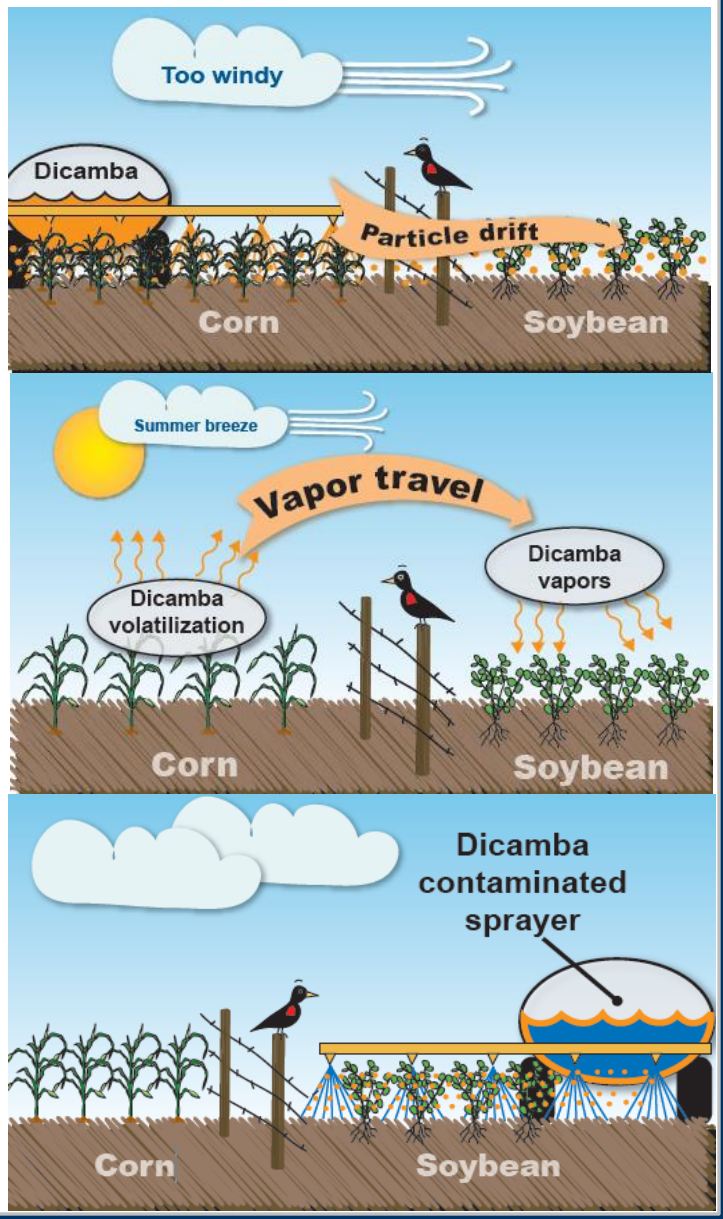
Enhanced dicamba herbicide that farmers can use as tank mix partner

Upon Registration

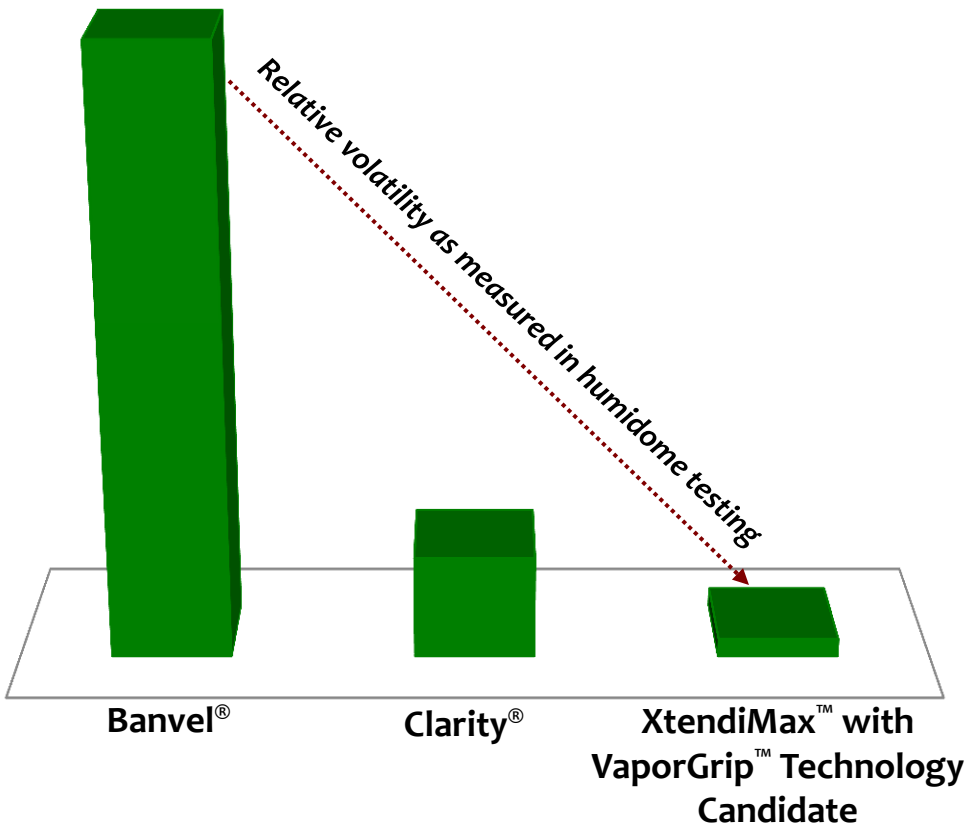
This information is for educational purposes only and is not an offer to sell Roundup 2 Xtend™, Bollgard II® XtendFLEX, Roundup Xtend or Xtendimax™ herbicides. These products are not yet registered or approved for sale or use anywhere in the United States.

Potential Routes of Off-Site Movement

- Spray Drift
  - Physical Particle Movement
- Volatility
  - Vapor Movement
- Spray Tank Clean-out
  - Direct application of herbicide to sensitive crops



Announcing VaporGrip™ Technology



New VaporGrip™ Technology

Coupled with application requirements will provide customers confidence in on-target application of dicamba.

Significant Reduction in Volatility Potential When Using Low Volatility Formulations and New VaporGrip™ Technology

"Applicators have the tools & responsibility to manage drift. The Roundup Ready® Xtend Crop System is developed around application methods proven to increase on target application."

Dr. Robert E. Wolf, Application Technology Specialist, Consultant and Professor Emeritus at Kansas State University

Use nozzles and operating pressures that produce very coarse to ultra coarse droplets to **minimize drift**

Spray weeds **less than 4 inches tall**

Maintain the required label buffer to **protect sensitive areas**

Make sure **ground speed** is less than 15 mph

Use low volatility formulations such as Roundup Xtend and XtendiMax

Use **triple rinse** tank clean-out procedure

Maintain boom height **20 inches above crop canopy**

Apply when **wind speed** is between 3-10 mph

Always read and follow label directions

Pending Regulatory Approval

July 2012

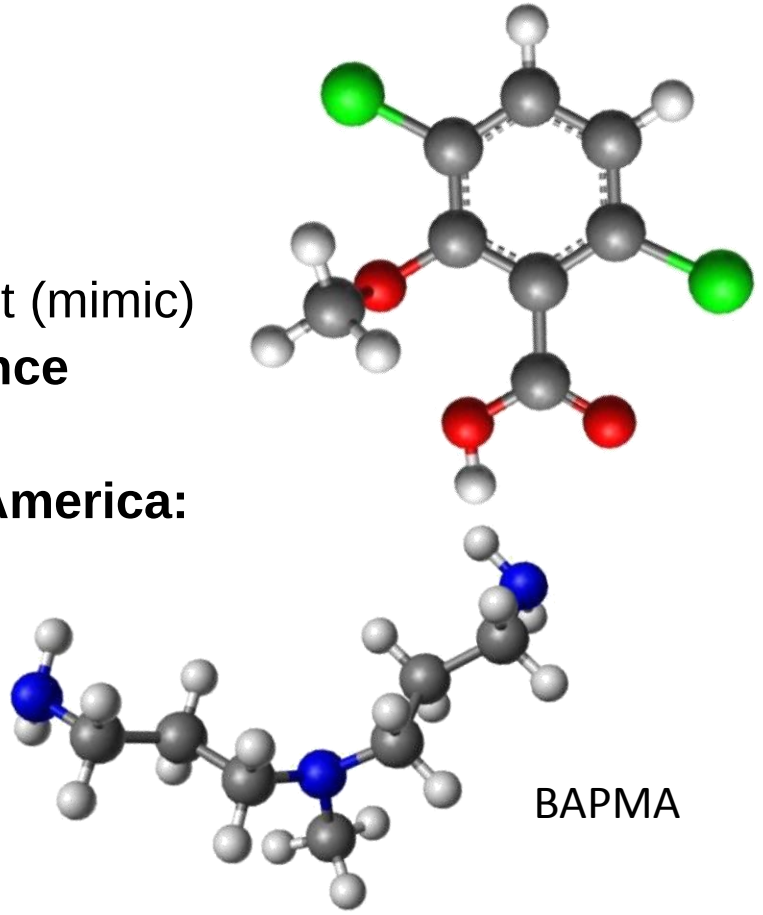
Engenia – Bollgard II XtendFlex Cotton

To evaluate Engenia™ herbicide as part of an overall weed management system in cotton for the Texas High Plains.

Advancement in Dicamba Formulation Technology

Experimental Results – Not Registered or Available for Sale

- **Engenia herbicide**
  - Chemistry: Dicamba BAPMA
    - BAPMA: N,N-Bis-[aminopropyl]methylamine
    - Tridentate amine provides strong performance
  - **Mechanism of Action:** Auxin Agonist (mimic)
  - **Generally low potential for resistance**
    - >50 years of use
  - **Resistance documented in North America:**
    - *Kochia*
    - *Sinapis* (wild mustard)
    - *Galeopsis* (common hempnettle)

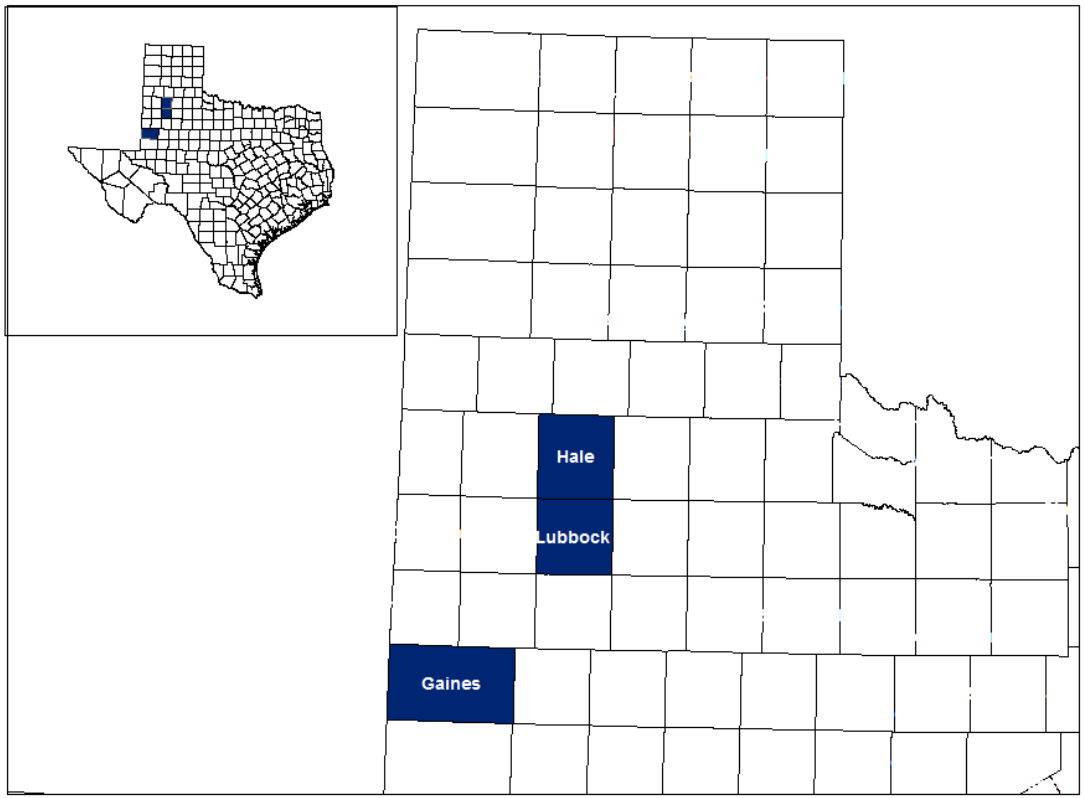


BAPMA

Field Trials

Trials conducted in 2013 and 2014:

- Seagraves
- Lubbock
- Halfway

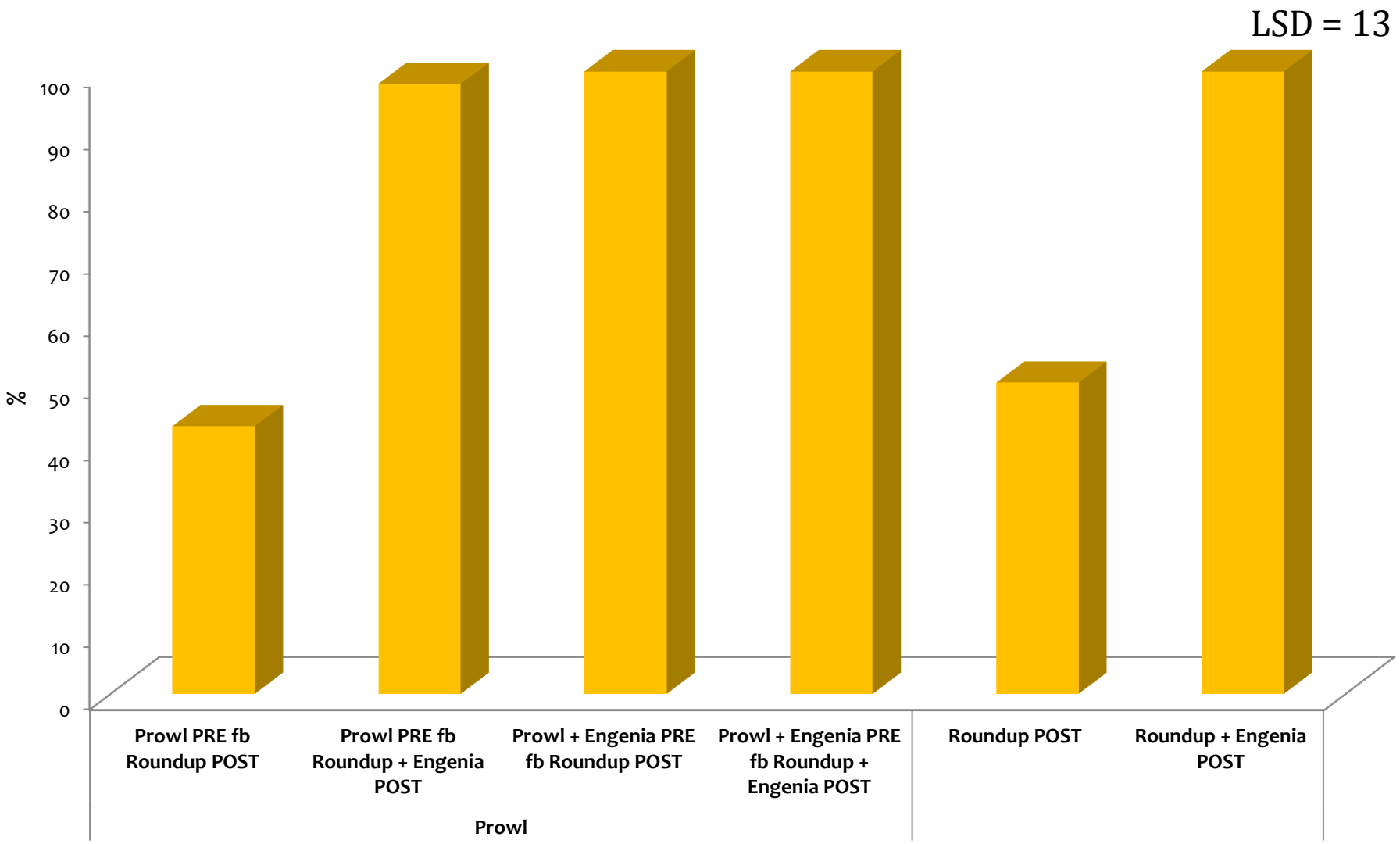


Treatments

Herbicide	Rate (fl oz/A)	Application Timing
Prowl H2O	32	PRE
Engenia	12.8	PRE, EPOST, MPOST
Roundup PM	28	EPOST, MPOST
Outlook	12	EPOST, MPOST

All treatments applied at 20 GPA using TTI 11002 at 50psi

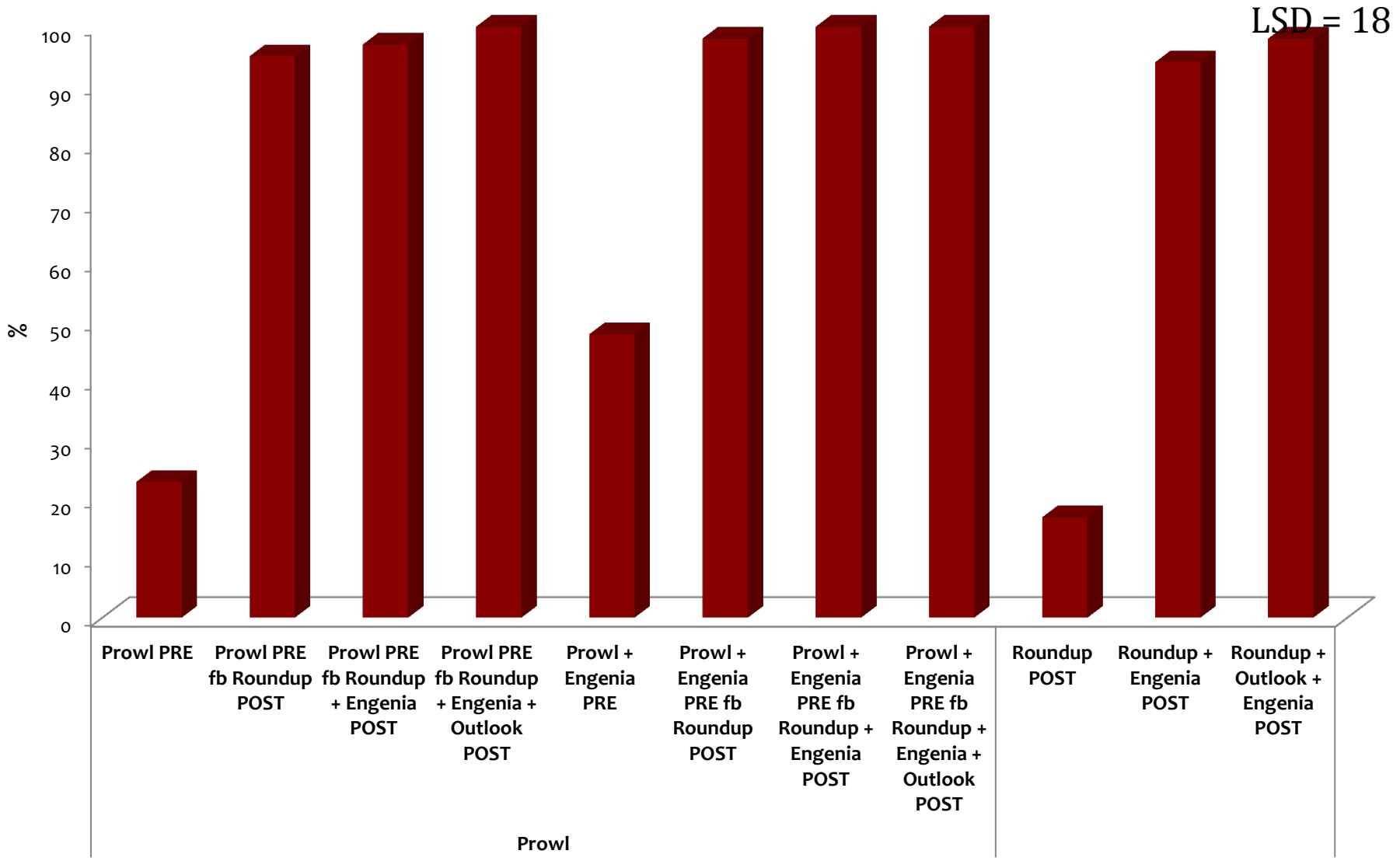
Russian-thistle Control - Seagraves



Untreated

Treated

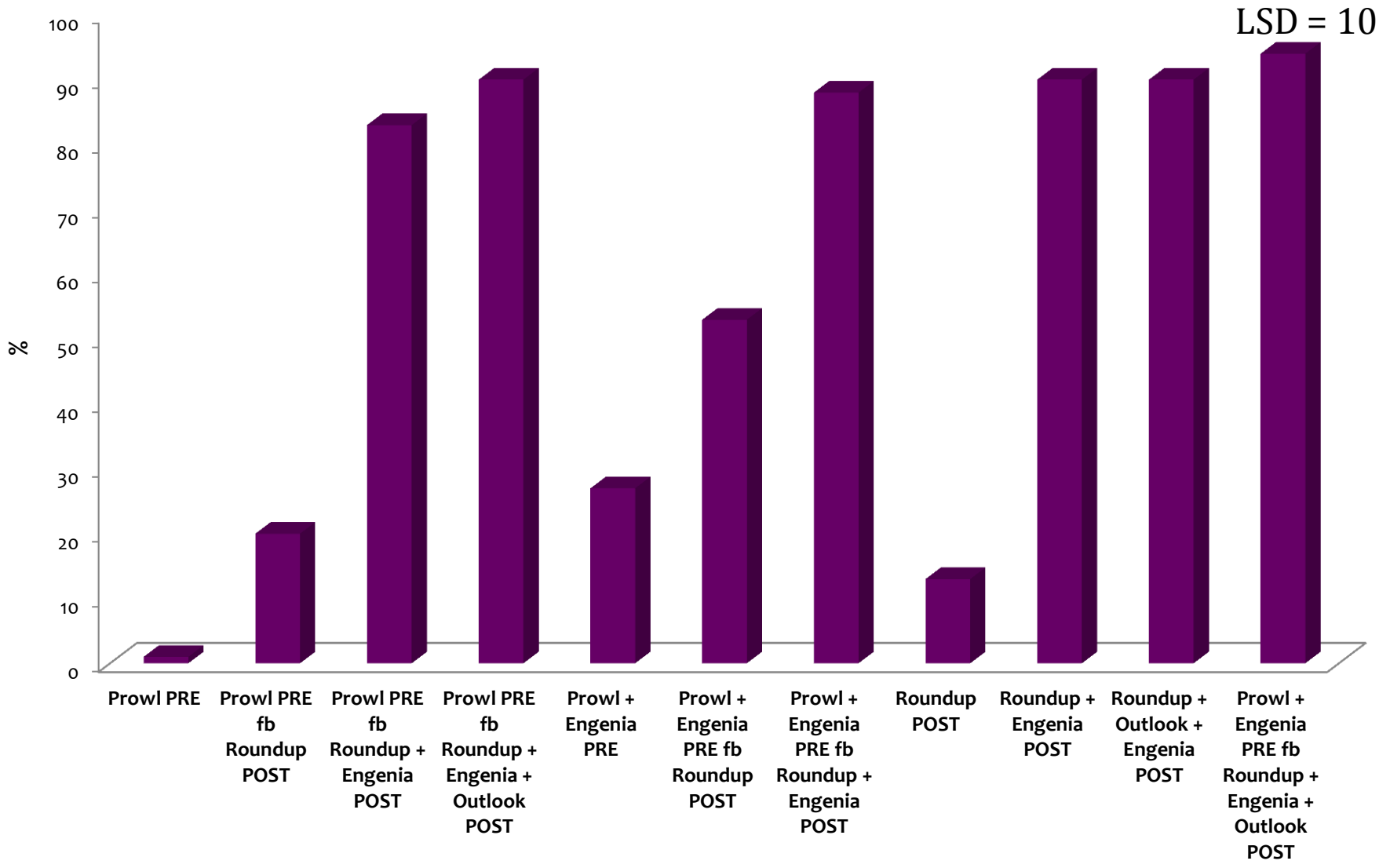
Palmer amaranth Control - Halfway



Untreated

Treated

Field Bindweed Control - Halfway



Untreated

Treated

Crop Response

Engenia (12.8 fl oz/A) + Roundup (28 fl oz/A)

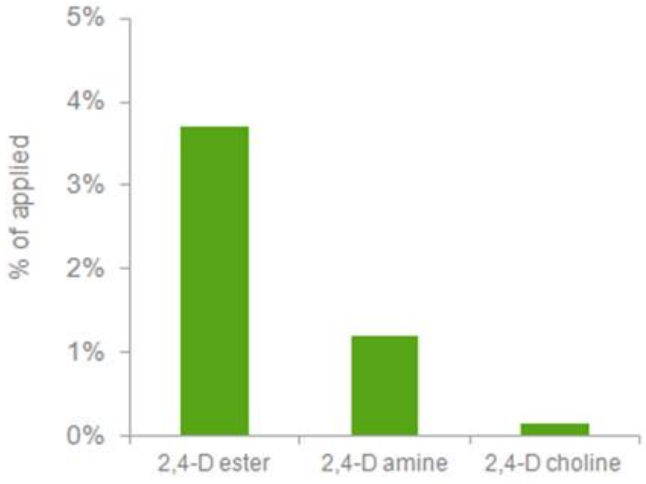
Untreated

Enlist™ Weed Control System

- New herbicide tolerant traits that provide robust tolerance to 2,4-D
- Will be stacked with glyphosate tolerant technologies
  - Will provide an additional mode of action without changing the farming system that growers have adopted
- Enlist™ will include a new and innovative 2,4-D choline based herbicide
- Enlist herbicides will also feature technology to reduce off-target movement

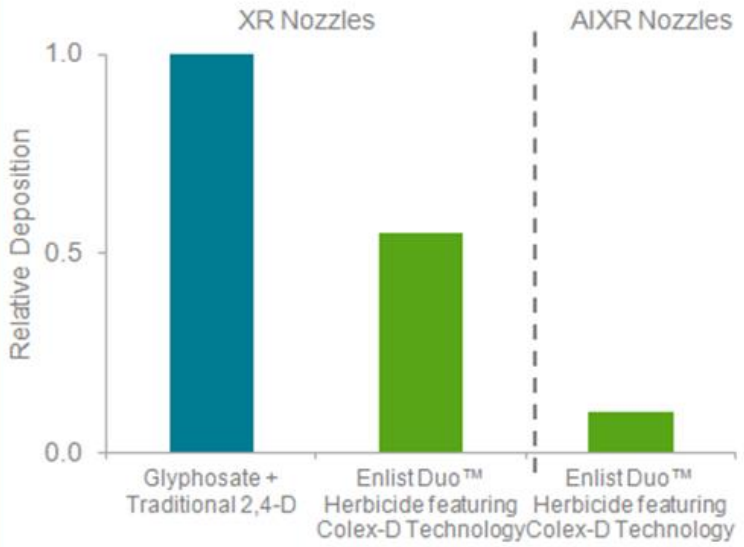
Field-scale trials validate Colex-D™ Technology attributes

87% to 96% reduction in volatility[2]



Up to 90% reduction in drift[2]

When utilizing herbicides with Colex-D Technology and improved nozzles



New(er) Herbicides Evaluated in 2013/2014

- **Zidua®** – Pyroxasolfone **(BASF)**
  Post-directed in cotton and PRE in corn and wheat
- **Anthem® Flex** – Pyroxasolfone + Aim® **(FMC)**
  Post-directed in cotton
- **Fierce®** –Pyroxasolfone + Valor ® **(Valent)**
  Post-directed in cotton
- **Targa®** – Quizalofop-P-Ethyl – 0.88 lb a.i./Gal **(Gowan)**
  Grass and volunteer corn

Volunteer Corn Control 2013

Herbicide	oz/A	Plant Height		
		6”	12”	18”
Targa	5.0	99	92	75
Targa	8.0	100	98	92

Applied 30-May, 10-June and 18-June at 10 GPA with 1% COC

Volunteer Corn Control 2014

Herbicide	oz/A	Plant Height		
		6”	12”	18”
Targa	3.34	97	96	92
Targa	6.7	98	100	99
Targa	9.9	100	100	100

Applied 19-May, 2-June and 10-June at 10 GPA with 1% COC