Weed Management
Strategies for 2015

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Weed Science and Cropping Systems
Lubbock, Texas
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
Number of Resistant Species to Individual Active Herbicides (Top 15)

- **Atrazine**: 66 species
- **Imazethapyr**: 43 species
- **Tribenuron-methyl**: 36 species
- **Imazamox**: 35 species
- **Chlorsulfuron**: 33 species
- **Metsulfuron-methyl**: 32 species
- **Simazine**: 31 species
- **Fenoxaprop-P-ethyl**: 30 species
- **Paraquat**: 30 species
- **Bensulfuron-methyl**: 29 species
- **Glyphosate**: 29 species
- **Iodosulfuron-methyl-sodium**: 27 species
- **Thifensulfuron-methyl**: 26 species
- **Fluazifop-P-butyl**: 25 species
- **Pyrazosulfuron-ethyl**: 23 species

Source: International Survey Herbicide Resistant Weeds

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Glyphosate-Resistant Weeds

Source: International Survey Herbicide Resistant Weeds
# Herbicide Resistant Weeds—Texas

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

<table>
<thead>
<tr>
<th>Application Method</th>
<th>Acres Treated (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPI</td>
<td>91</td>
</tr>
<tr>
<td>PRE</td>
<td>20</td>
</tr>
<tr>
<td>POST</td>
<td>1</td>
</tr>
<tr>
<td>Spot Treatment</td>
<td>40</td>
</tr>
<tr>
<td>Layby</td>
<td>1</td>
</tr>
<tr>
<td>Cultivation (3.1x)</td>
<td>98</td>
</tr>
</tbody>
</table>

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
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
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
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

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.
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

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

This information is for educational purposes only and is not an offer to sell Roundup Xtend™, XtendiMax™, Bollgard II® XtendFlex™ or Roundup Ready 2 Xtend™. These products are not yet registered or approved for sale or use anywhere in the United States.
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
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)
Trials conducted in 2013 and 2014:

- Seagraves
- Lubbock
- Halfway
## Treatments

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate (fl oz/A)</th>
<th>Application Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prowl H2O</td>
<td>32</td>
<td>PRE</td>
</tr>
<tr>
<td>Engenia</td>
<td>12.8</td>
<td>PRE, EPOST, MPOST</td>
</tr>
<tr>
<td>Roundup PM</td>
<td>28</td>
<td>EPOST, MPOST</td>
</tr>
<tr>
<td>Outlook</td>
<td>12</td>
<td>EPOST, MPOST</td>
</tr>
</tbody>
</table>

All treatments applied at 20 GPA using TTI 11002 at 50psi
Russian-thistle Control - Seagraves

LSD = 13
Palmer amaranth Control - Halfway

Prowl PRE fb Roundup POST
Prowl PRE fb Roundup + Engenia POST
Prowl PRE fb Roundup + Outlook POST
Prowl + Engenia PRE
Prowl + Engenia PRE fb Roundup POST
Prowl + Engenia PRE fb Roundup + Engenia POST
Prowl + Engenia PRE fb Roundup + Engenia + Outlook POST
Roundup POST
Roundup + Engenia POST
Roundup + Outlook + Engenia POST

LSD = 18
Field Bindweed Control - Halfway

LSD = 10
Crop Response

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

- 2,4-D ester: 5%
- 2,4-D amine: 4%
- 2,4-D choline: 1%

Up to 90% reduction in drift

When utilizing herbicides with Colex-D Technology and improved nozzles

XR Nozzles

<table>
<thead>
<tr>
<th>Glyphosate + Traditional 2,4-D</th>
<th>Enlist Duo™ Herbicide featuring Colex-D Technology</th>
<th>Enlist Duo™ Herbicide featuring Colex-D Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

AIXR Nozzles
New(er) Herbicides Evaluated in 2013/2014

- **Zidua®** – Pyroxasulfone *(BASF)*
  Post-directed in cotton and PRE in corn and wheat
- **Anthem® Flex** – Pyroxasulfone + Aim® *(FMC)*
  Post-directed in cotton
- **Fierce®** – Pyroxasulfone + 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

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>oz/A</th>
<th>Plant Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6”</td>
</tr>
<tr>
<td>Targa</td>
<td>5.0</td>
<td>99</td>
</tr>
<tr>
<td>Targa</td>
<td>8.0</td>
<td>100</td>
</tr>
</tbody>
</table>

Applied 30-May, 10-June and 18-June at 10 GPA with 1% COC
## Volunteer Corn Control 2014

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>oz/A</th>
<th>Plant Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6”</td>
</tr>
<tr>
<td>Targa</td>
<td>3.34</td>
<td>97</td>
</tr>
<tr>
<td>Targa</td>
<td>6.7</td>
<td>98</td>
</tr>
<tr>
<td>Targa</td>
<td>9.9</td>
<td>100</td>
</tr>
</tbody>
</table>

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