The Development of Herbicide Resistant Weeds

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Outline

- Herbicide Timeline
- Weed Management Update
- Weed Management Challenges in OK
- Strategies
- OSU Weed Science Extension Program
New Chemical Age

- **1944** – 2,4-D, discovered during WWII research
- **1951** – Substituted Ureas (Monuron, Diuron)
- **1955** – Triazine (Atrazine, Simazine)
1957 – 1st herbicide resistant weed

- 2,4-D on roadsides
- Wild Carrot
- Canada

- **GS inhibitors**: (glufosinate, contained in Liberty)
- **EPSP inhibitors**: (glyphosate)
- **ACCase inhibitors**: (fenoxaprop, included in Fusion)
- **HPPD inhibitors**: (Isoxaflutole, contained in Balance that was later commercialized in 1999)
- **PPO inhibitors**: (Lactofen, contained in Cobra)
- **ALS inhibitors**: (Imazethapyr, contained in Pursuit)
- **Carotenoid Synthesis inhibitors**: (Norflurazon, contained in Zorial)

Meanwhile

- **1970** – 1st herbicide resistant weed in the US
  - Simazine in Nurseries
  - Common Groundsel
  - Washington State
Herbicide Tolerant Crops

- **1993** – IMI Corn and Canola*
- **1995** – Bromoxynil Cotton
- **1996** – Roundup Ready Soybeans
- **1997** – Roundup Ready Canola, Glufosinate Corn and Canola
- **1998** – Roundup Ready Corn

*Not Transgenic*
Chemical Era/Herbicide Tolerant Crops

- Reliance on Chemical Only Weed Management
- Reliance on POST Only Herbicide Programs
- Products/MOAs/SOAs applied multiple times
- Herbicide application (rate, calibration, etc.)
- Movement away from other weed management practices
- No-till Movement
Selection for Herbicide Resistant Weeds
Mechanisms of Herbicide Resistance

- *Altered target site*
- Enhanced metabolism
- *Over-expression of target site*
- Reduced uptake
- Reduced translocation
- Compartmentalization
Altered Target Site

Buhler, 2016
Over-expression of Target Site

Susceptible Weed

Resistant Weed

Adapted from Buhler, 2016
Herbicide Resistance in the US
Herbicide Resistance

- PSII
- ALS
- EPSP
- PIGMENT
- CELL MEMBRANE
- GROWTH REGULATORS

http://weedscience.org/
Chemical companies are hard at work, but some time has been lost...
- Roundup Ready®
  - Herbicide discovery labs slowed down
  - Historically, weed science has trailed
  - A benefit of mergers = resources
New Technologies

Arysta LifeScience gains access to DuPont’s Rynaxpyr mixtures
FEB 08, 2017

The difficulty in understanding tariffs versus value-added taxes and a border tax issue
FEB 08, 2017

Resistance management even more critical with new herbicides

Herbicide-resistant weeds didn’t fall from the sky or rise from fields in a mutant mutiny, but they are here nonetheless. With new herbicide technologies going mainstream this season, growers must continue dogged
Throwing our Hands Up?

Weedy Adaptation

Increase in Unique Resistant Weed Cases for the USA

Number of Unique Resistant Cases

Year

Dr. Ian Heap, WeedScience.org 2015
<table>
<thead>
<tr>
<th>Application Method</th>
<th>Hectares Treated (%)</th>
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</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>

Smith et al. 1996

Back to the Drawing Board
We Have Tools!

**Biological**
- Mycoherbicide approach
  - Classic approach

**Chemical**
- Mobility
- Carry-over
- Timing
- Soil
  - Mode and Mechanism

**Physical/Mechanical**
- Till
  - Water smother
  - Harrow
  - Hoe
  - Heat
  - Mulch
  - Plow
  - Hand pull

**Cultural**
- Seed
  - Seeding density
- Crop variety
  - Crop rotation
  - Fertility
  - Row spacing
  - Seeding date
Successful weed management plans will require the use of more than one to be successful.

Yes, weed management plans will be more complicated.
Where can we Improve?
Chemical Weed Management Systems

WEEDS

BURNDOWN  ➔  PRE  ➔  POST  ➔  HARVEST AIDS

Gramoxone Roundup

Anthem Flex
Axiom
Prowl H₂O
Zidua

Axial XL
Beyond*
Metribuzin
Aim
Huskie
PowerFlex

Glyphosate

*Beyond can ONLY be used in Clearfield® varieties
## Tillage Practices in OK

<table>
<thead>
<tr>
<th></th>
<th>No-till Acres</th>
<th>Conservation Acres</th>
<th>Conventional Acres</th>
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</thead>
<tbody>
<tr>
<td>Oklahoma</td>
<td>35</td>
<td>18</td>
<td>47</td>
</tr>
</tbody>
</table>

US Census of Ag 2012
Physical/Mechanical Weed Management Strategies

• Tillage
  • ANOTHER TOOL
  • Seedbed prep
  • Burial and/or exposure of seeds

• Conservation tillage/no-till
  • Increased soil quality
  • Conservation of soil moisture
  • Decreased fuel and labor costs
Cultural Weed Management Strategies

- Prevention
- Proper land preparation
- Planting certified/clean seed
- Planting a competitive wheat cultivar
- Planting date
- Crop rotation
Livestock: a Challenge?

<table>
<thead>
<tr>
<th>State</th>
<th>Wheat for Grain</th>
<th>Cattle &amp; Calves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oklahoma</td>
<td>4,291,939</td>
<td>4,245,970</td>
</tr>
</tbody>
</table>

OSU 2017
US Census of Ag 2012
OSU 2017
What can we do in the Short-Term?

- START CLEAN!
- Plant certified/clean seed
- Use a PRE herbicide
- TIMELY POST applications
- Tank-mix when appropriate
- Rotate sites of action
- Thorough spray coverage
- Proper calibration
- Proper rates
What can we do in the Short-Term?

- Prevent weed escapes from going to seed/weed seed bank management
- Adopt physical, mechanical, and cultural practices
- Clean machinery
- **ROTATE CROPS**
OSU Weed Science Extension Program

- Weed Identification
- Herbicide Resistance Screening
- Incorporation of Preemergence Herbicides
- Making the Most of our Herbicide Applications
  - Timing, Adjuvants, Tank-mixes, etc.
- Crop Rotation
- New Technologies/Herbicidees
- Education
Questions?

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