HERBICIDE RESISTANCE UPDATE

Sarah Lancaster
Assistant Professor and Extension Specialist – Weed Management

OUTLINE

1 NEW PRODUCTS AND LABEL UPDATES

2 MORE HERBICIDE RESISTANCE

3 RESIDUAL PROGRAMS THAT WORK

XTEND CHALLENGES

- US District Court in AZ ruled the EPA violated FIFRA notice and comment mandates
  - Court did NOT find ESA violations
- The labels for XtendiMax, Engenia, and Tavium were vacated
- EPA issued cancellation order allowing sale and use of products already in the distribution system
  - Sell by May 31 (soy) or June 30 (cotton)
  - Apply by June 30 (soy) or July 30 (cotton)

Storen
Syngenta
Bicyclopyrone + metribun + pyroxasulfone + S-metolachlor
Postemergence (up to V8 corn or 3" weeds)
Silt application
COC or MSG before corn emergence; NS after corn emergence

All except Acuron applied with 0.75 lbs atrazine. No statistical differences among treatments (α = 0.05)
**Tarzec**

**Corteva**

Pyrossulam + halaxifen-methyl

Controls annual grasses (including cheatgrass and Italian ryegrass) and broadleaf weeds (including mustards)

Apply when wheat is 3 leaf to joint

Use 0.25% to 0.5% NIS or 1 to 1.25% COC when applied alone. See label instructions for tank mixing and applying in nitrogen fertilizer carrier.

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**ATRAZINE LABEL CHANGES**

Section 24(c) – Special Local Needs labels not renewed

Wheat-Fallow rotations only labeled non-crop use

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**WHAT IS THE ESA?**

Enacted in the 1973

- Protects listed species and their habitats

~1,800 listed species & 900 habitats

- Determined by FWS and National Marine Fisheries Service
  
  - Half plants
  
  - 40% in Hawaii

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**ESA COMPLIANCE REQUIRES COOPERATION FROM SEVERAL ENTITIES**

Agrichemical Companies

Seek registration

EPA, USDA

Evaluate risk; Approve registration

FWS, NOAA

Ensure no jeopardy from action

End Users

Judicious applications

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**MEAD'S MILKWEED**

By Jason Sturner; commons.wikimedia.org
ESA COMPLIANCE REQUIRES COOPERATION FROM SEVERAL ENTITIES

Agrichemical Companies

USEPA

End Users

THE CURRENT DILEMMA

Court removal of tools

Additional regulations

IS THERE PRECEDENT?

Focused on agricultural uses of conventional herbicides

Goals

- Reduce the likelihood of "jeopardy" or "adverse modification" findings
- Increase the efficiency of consultations with FWS

Final version should come out in August 2024

- Labels could start changing in 2025
Exemption from Mitigation

1. Follow recommendations from conservation specialist or certified expert to reduce runoff/erosion.
   - Characteristics of these recommendations or programs are currently under development
2. Field is more than 1,000 feet away from a terrestrial or aquatic habitat for listed species
3. Field has subsurface drainage or tile drains installed – runoff must be controlled

SPRAY DRIFT MITIGATION

Buffers
- Windbreak
- Hooded sprayer
- Coarse droplet size
- Using the minimum effective rate
- Lower %RH and wind speed

Additional mitigations

RUNOFF/EROSION MITIGATION

All labels:
- Do not spray if soil is saturated
- Do not spray if >50% chance of >1 inch rainfall within 48 hours

https://www.weather.gov/

Mitigation Menu of Options
Herbicides will require different mitigation points based on environment and use
Will use NRCS standards

Mitigations proposed in Draft Herbicide Strategy

<table>
<thead>
<tr>
<th>Field Characteristics</th>
<th>Application</th>
<th>Field Management</th>
<th>Adjacent to Field</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>West of I-35</td>
<td>Use lowest effective rate</td>
<td>Contour farming</td>
<td>Riparian area</td>
<td>Water retention</td>
</tr>
<tr>
<td>Sandy soil</td>
<td>Incorporation</td>
<td>Cover crop</td>
<td>Vegetated ditch</td>
<td></td>
</tr>
<tr>
<td>Slope &lt;2%</td>
<td>Filter strip</td>
<td>Filter strips</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced tillage</td>
<td></td>
<td>Terraces</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RUNOFF/EROSION MITIGATION
PESTICIDE USE LIMITATION AREAS (PULAS)

Applications in these areas will have additional restrictions

Based on species range maps from FWS

– Maps can be found at https://ecos.fws.gov/ecp/

WHAT DOES THIS MEAN FOR PESTICIDE USERS?

Still much uncertainty

Pesticide labels will change for all

Additional measures will be required in key areas as noted in Bulletins Live Two

Continued opportunities for comments on re-registration decisions

HERBICIDE RESISTANCE IN PALMER AMARANTH

<table>
<thead>
<tr>
<th>Herbicide group (example herbicide)</th>
<th>Number of cases</th>
<th>Year (and state) of first report</th>
<th>Year of first report in KS</th>
</tr>
</thead>
<tbody>
<tr>
<td>9, EPSPS inhibitor (glyphosate)</td>
<td>44</td>
<td>2005 (GA)</td>
<td>2011</td>
</tr>
<tr>
<td>2, ALS inhibitors (Beyond, Harmony, Glean, Pursuit)</td>
<td>25</td>
<td>1993 (KS)</td>
<td>1993</td>
</tr>
<tr>
<td>5, PSII inhibitors (atrazine, metribuzin)</td>
<td>11</td>
<td>1993 (TX)</td>
<td>1995</td>
</tr>
<tr>
<td>27, HPPD inhibitors (Callisto, Laudis, Impact)</td>
<td>7</td>
<td>2009 (KS)</td>
<td>2009</td>
</tr>
<tr>
<td>14, PPO inhibitors (Reflex, Cobra)</td>
<td>5</td>
<td>2011 (AR)</td>
<td>2021</td>
</tr>
<tr>
<td>15, VLCFA inhibitors (Dual, Harness, Outlook, Zidua)</td>
<td>2</td>
<td>2016 (AR)</td>
<td>Not yet</td>
</tr>
<tr>
<td>16, Glutamine synthetase inhibitor (Liberty)</td>
<td>2</td>
<td>2020 (AR)</td>
<td>Not yet</td>
</tr>
</tbody>
</table>

*Weedscience.org
HERBICIDES FOR PALMER AMARANTH CONTROL IN CORN

Group 2
- Accent
- Beacon
- Harmony
- Resolve

Group 9
- Glyphosate

Group 5
- Atrazine

Group 11
- Liberty

Preemergence to weeds
Postemergence to weeds

HERBICIDES FOR PALMER AMARANTH CONTROL IN SOYBEAN

Group 2
- IMI
- Pursuit
- Beyond

Group 9
- Glyphosate

Group 11
- Liberty

Preemergence to weeds
Postemergence to weeds

HERBICIDE RESISTANCE IN WATERHEMP

<table>
<thead>
<tr>
<th>Herbicide group (example herbicide)</th>
<th>Number of cases</th>
<th>Year (and state) of first report</th>
<th>Year of first report in KS</th>
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</thead>
<tbody>
<tr>
<td>9, EPSPS inhibitor (glyphosate)</td>
<td>27</td>
<td>2005 (MO)</td>
<td>2006</td>
</tr>
<tr>
<td>2, ALS inhibitors (Beyond, Harmony, Glean, Pursuit)</td>
<td>27</td>
<td>1993 (IL, IA)</td>
<td>1995</td>
</tr>
<tr>
<td>5, PSII inhibitors (atrazine, metribuzin)</td>
<td>15</td>
<td>1994 (MO)</td>
<td>1995</td>
</tr>
<tr>
<td>14, PPO inhibitors (Reflex, Cobra)</td>
<td>12</td>
<td>2001 (KS)</td>
<td>2001</td>
</tr>
<tr>
<td>27, HPPD inhibitors (Callisto, Laudis, Impact)</td>
<td>6</td>
<td>2009 (IL)</td>
<td>Not yet</td>
</tr>
<tr>
<td>4, Growth regulators (2,4-D, dicamba)</td>
<td>3</td>
<td>2009 (NE)</td>
<td>Not yet</td>
</tr>
<tr>
<td>15, VLCFA inhibitors (Dual, Harness, Outlook, Zidua)</td>
<td>1</td>
<td>2016 (IL)</td>
<td>Not yet</td>
</tr>
<tr>
<td>10, Glutamine synthetase inhibitor (Liberty)</td>
<td>??</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WATERHEMP

21 DAA

Nontreated

64 fl oz Liberty
**HERBICIDES FOR WATERHAMP CONTROL IN CORN**

Preemergence to weeds

- **Group 2**
  - Accent
  - Beacon
  - Classic
  - Harmony
  - Resolve

Postemergence to weeds

- **Group 9**
  - Amidazon
  - Zidua

**Group 11**

- Liberty

**Group 27**

- Callisto
- Laudis
- Pyrazon
- Impact
- Shielder

**Group 3**

- Prowl

**Group 14**

- Valor

**Group 15**

- Liberry
- Isoxaflutole
- Balance
- Triketone
- Callisto

**Group 27**

- Isoxazole
  - Balance

**Group 3**

- Prowl

**Group 15**

- Liberry
- Triketone

**Group 27**

- Isoxazole

**Group 3**

- Prowl

**Group 15**

- Liberry

**Group 14**

- Valor

**PREEMERGENCE HERBICIDE OPTIONS IN CORN**

<table>
<thead>
<tr>
<th>Herbicide (Product)</th>
<th>Group</th>
<th>Rate</th>
<th>Rating*</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrazine</td>
<td>5</td>
<td>0.75 to 2 lbs</td>
<td>Better</td>
<td></td>
</tr>
<tr>
<td>Pyroxasulfone (Zidua)</td>
<td>15</td>
<td>2.5 to 6.5 fl oz</td>
<td>Best</td>
<td>0.5&quot; rain</td>
</tr>
<tr>
<td>S-metolachlor (Dual)</td>
<td>15</td>
<td>1 to 2 pts</td>
<td>Good</td>
<td>0.5 to 1&quot; rain</td>
</tr>
<tr>
<td>Acetochlor (Harness)</td>
<td>15</td>
<td>1.25 to 3 pts</td>
<td>Good</td>
<td>0.25 to 0.75&quot; rain</td>
</tr>
<tr>
<td>Dimethenamid-P (Outlook)</td>
<td>15</td>
<td>12 to 21 fl oz</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Mesotrione (Callisto)</td>
<td>27</td>
<td>3 to 7.7 fl oz</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Isoxaflutole (Balance Flexx)</td>
<td>27</td>
<td>3 to 6 fl oz</td>
<td>Better</td>
<td>Applied with atrazine</td>
</tr>
</tbody>
</table>

*Assuming a susceptible population

**PREEMERGENCE HERBICIDE OPTIONS IN SOYBEAN**

Preemergence to weeds

- **Group 9**
  - Glyphosate

Postemergence to weeds

- **Group 14**
  - Valor

**Group 2**

- IMI
  - Pursuit

**Group 15**

- Liberty
- Zidua
- Dual
- Outlook

**Group 27**

- Triketone

**Group 3**

- Prowl

**Group 14**

- Valor

**HERBICIDE APPLICATION CALENDAR**

- **Fall**
  - Control emerged winter annuals

- **EPP**
  - If no fall applications
  - Spend your money HERE

- **PRE**
  - Plan to apply 21-28 days after PRE
  - Include a Group 15 product

- **EPOST**
  - SCOUT

- **LPOST**
  - Emphasize residual herbicides
## Preemergence Herbicide Options in Soybean

<table>
<thead>
<tr>
<th>Herbicide (Product)</th>
<th>Group</th>
<th>Rate</th>
<th>Rating*</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metribuzin</td>
<td>5</td>
<td>0.5 to 1 lb</td>
<td>Better</td>
<td></td>
</tr>
<tr>
<td>Pyroxasulfone (Zidua)</td>
<td>15</td>
<td>2.5 to 6.5 fl oz</td>
<td>Better</td>
<td>0.5&quot; rain</td>
</tr>
<tr>
<td>S-metolachlor (Dual)</td>
<td>15</td>
<td>1 to 2 pts</td>
<td>Good</td>
<td>0.5 to 1&quot; rain</td>
</tr>
<tr>
<td>Acetochlor (Warrant)</td>
<td>15</td>
<td>1.25 to 3 pts</td>
<td>Good</td>
<td>0.25 to 0.75&quot; rain</td>
</tr>
<tr>
<td>Dimethenamid-P (Outlook)</td>
<td>15</td>
<td>12 to 21 fl oz</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Flumioxazin (Valor)</td>
<td>14</td>
<td>2 to 3 fl oz</td>
<td>Best</td>
<td></td>
</tr>
<tr>
<td>Sulfentrazone</td>
<td>14</td>
<td>4.5 to 12 fl oz</td>
<td>Best</td>
<td></td>
</tr>
</tbody>
</table>

*Assuming a susceptible population

Basic formula: Group 15 + Group 14 + metribuzin (or other)

## Herbicide Mixtures Are the Key!

“A second major conclusion is that rotation of herbicides…is markedly inferior to the use of herbicides in combination, and is not superior to the “expend and swap” approach…”

Diggle et al. 2003

## Herbicide Mixtures Are the Key?

“This conclusion is contingent…on the assumptions…that both herbicides achieve efficacy that is high enough to ensure “redundant kill”…and have different modes of action…”

“For large population size there is very little effect of pattern of herbicide application.”

Diggle et al. 2003

## Are 3 AIs Really Necessary for a Preemergence Application?

Weed control in corn 4 or 6 WAT at 1 or 2 site/years in Wisconsin

Silva et al. 2023
TAKE HOME MESSAGE

1. FEW HERBICIDES, MANY REGULATIONS
2. HERBICIDE RESISTANCE CONTINUES TO SPREAD
3. MIXING HERBICIDES IS OUR BEST DEFENSE

LET’S CONNECT

slancaster@ksu.edu
@KStateWeedSci
K-State Weed Science
War Against Weeds podcast