Managing around herbicide-resistant weeds

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Weed Science
Herbicide-resistant weeds are not new

Triazine-resistant c. lambsquarters

First herbicide-resistant weed confirmed in Michigan (1975)
Cases of herbicide-resistant weeds in Michigan

**Triazine Resistant**
- C. lambsquarters
- C. ragweed
- C. purslaneda
- Redroot pigweed
- Ladysthumb
- Horseweed
- Spreading orach
- Velvetleaf
- Late flowering goosefoot
- Eastern black nightshade

**Glyphosate Resistant**
- Horseweed (marestail) - 2007/2010
- Palmer amaranth - 2010
- Waterhemp - 2011

**ALS Resistant**
- Powell amaranth

Multiple-resistance to ALS-inhibitors has also been confirmed in our glyphosate-resistant weeds.
Why has Michigan traditionally lagged behind in glyphosate-resistant weeds?

- **MORE DIVERSITY**

- Traditionally extended crop rotations
  - Including herbicides with different modes/sites of action
  - More tillage in certain areas of the state

- Not a thoroughfare for railways, etc.
  - Weed seed dispersal mechanism
Palmer amaranth in Michigan
Palmer amaranth in Michigan

9 Counties
How did Palmer amaranth get to Michigan and how can it spread?
Resistance can be spread by feed and field operations.
How do we delay and/or manage herbicide- “glyphosate” resistant weeds?

By understanding herbicide site(s) of action
Herbicide Mode of Action vs. Site of Action

- **Mode of Action** - the physiological or biochemical process within the plant that is impaired or inhibited by the herbicide
  - *How* the herbicide works
Mode of Action examples

- Growth Regulators
- Pigment Inhibitors
Herbicide Mode of Action vs. Site of Action

- **Mode of Action** - the physiological or biochemical process within the plant that is impaired or inhibited by the herbicide
  - *How* the herbicide works

- **Site of Action** - the physical location within the plant where the herbicide binds
  - *Where* the herbicide works
Within herbicide Mode of Action groups there are Site of Action groups:

Mode of action
- Pigment Inhibitors

Site of action
- Diterpene Synthesis Inhibitors
- HPPD Inhibitors

Example herbicides
- clomazone (Command)
- isoxaflutole (Balance)
- mesotrione (Callisto)
- tembotrione (Laudis)
- topramezone (Armezon/Impact)
Why is important to know where a herbicide works?

- Continuous use of herbicides with the same "Site of Action" can increase the selection for herbicide-resistant weeds.

Once a weed is resistant to a site of action, herbicides within that same site of action will no longer work.
Importance of knowing *Site of Action* groups

**Group #**  

<table>
<thead>
<tr>
<th>Group</th>
<th>Site of action</th>
<th>Example herbicides</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>ALS Inhibitors</td>
<td>chlorimuron (<em>Classic</em>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>imazamox (<em>Raptor</em>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flumetsulam (<em>Python</em>)</td>
</tr>
<tr>
<td>9</td>
<td>EPSP Synthase Inhibitor</td>
<td>thiencarbazone (component of <em>Capreno</em>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>glyphosate (<em>Roundup</em>)</td>
</tr>
</tbody>
</table>

**Mode of action**

- Amino Acid Synthesis Inhibitors
Where can you find the Site of Action Group # of a herbicide?
Where can you find the Site of Action Group # of a herbicide?
Different publications
Herbicides are listed by:
- Mode of action
- Site of action group #
- Site of action
- # of herbicide resistant weeds
- Chemical family
- Active ingredient
- Trade names

Premixes are color-coded
- The more “distinct” colors a weed is exposed to, the less likely it will develop resistance
Corn and Soybean Herbicide Chart

Repeated use of herbicides with the same site of action can result in the development of herbicide-resistant weed populations.

This chart lists premix herbicides alphabetically by their trade names so you can identify the premix's component herbicides and their respective site of action groups. Refer to the Mode of Action chart for more information.

By Mode of Action (effect on plant growth)

This chart groups herbicides by their modes of action to assist you in selecting herbicides 1) to maintain greater diversity in herbicide use and 2) to rotate among herbicides with different sites of action to delay the development of herbicide resistance.

<table>
<thead>
<tr>
<th>Site of Action Group</th>
<th>Site of Action</th>
<th>Chemical Family</th>
<th>Active Ingredient</th>
<th>Product Examples</th>
<th>Trade Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ACCase Inhibitors</td>
<td>Arlyoxophenoxy propionate</td>
<td>fenoxaprop</td>
<td>component of Fusion Fusilade DX Select Arrow Poast, Poast Plus</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ALS Inhibitors</td>
<td>Sulfonilurea</td>
<td>chlorimuron</td>
<td>Classic Option Accent</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Amino Acid Synthesis Inhibitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Corn and Soybean Herbicide Chart**

Repeated use of herbicides with the same site of action can result in the development of herbicide-resistant weed populations.

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**By Premix**

This chart lists premix herbicides alphabetically by their trade names so you can identify the premix's component herbicides and their respective site of action groups. Refer to the **Mode of Action** chart for more information.

<table>
<thead>
<tr>
<th>Premix</th>
<th>Trade Name ©</th>
<th>Active Ingredient</th>
<th>Site of Action Group*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authority First</td>
<td>Spartan</td>
<td>sulfentrazone</td>
<td>14</td>
</tr>
<tr>
<td>Axiom</td>
<td>FirstRate</td>
<td>chloransulam</td>
<td>2</td>
</tr>
<tr>
<td>Basis</td>
<td>Define</td>
<td>flurenacel</td>
<td>15</td>
</tr>
<tr>
<td>Basis</td>
<td>Sencor</td>
<td>metribuzin</td>
<td>5</td>
</tr>
<tr>
<td>Basis</td>
<td>Harmony GT</td>
<td>thifensulfuron</td>
<td>2</td>
</tr>
<tr>
<td>Bicep II Magnum</td>
<td>Dual II Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Bicep Lite II Magnum</td>
<td>Dual II Magnum</td>
<td>atrazine</td>
<td>15</td>
</tr>
<tr>
<td>Boundary</td>
<td>Dual Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Boundary</td>
<td>Sencor</td>
<td>atrazine</td>
<td>15</td>
</tr>
<tr>
<td>Boundary</td>
<td>AATrex</td>
<td>azulfenocid</td>
<td>15</td>
</tr>
<tr>
<td>Breakfree ATZ</td>
<td>Breakfree</td>
<td>acetochlor</td>
<td>15</td>
</tr>
<tr>
<td>Breakfree ATZ Lite</td>
<td>Breakfree</td>
<td>azulfenocid</td>
<td>15</td>
</tr>
<tr>
<td>Buctril + Atrazine</td>
<td>Buctril</td>
<td>bromoxynil</td>
<td>6</td>
</tr>
<tr>
<td>Bullet</td>
<td>Micro-Tech</td>
<td>alachlor</td>
<td>15</td>
</tr>
<tr>
<td>Bullet</td>
<td>AATrex</td>
<td>atrazine</td>
<td>15</td>
</tr>
<tr>
<td>Camix</td>
<td>Callisto</td>
<td>mesotrione</td>
<td>28</td>
</tr>
<tr>
<td>Canopy DF</td>
<td>Classic</td>
<td>chlorimuron</td>
<td>5</td>
</tr>
<tr>
<td>Canopy EX</td>
<td>Classic</td>
<td>chlorimuron</td>
<td>5</td>
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<tr>
<td>Canopy EX</td>
<td>Express</td>
<td>tribenuron</td>
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<tr>
<td>Celebrity Plus</td>
<td>Clarity</td>
<td>dicamba</td>
<td>19</td>
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<tr>
<td>Celebrity Plus</td>
<td>Accent</td>
<td>nicosulfuron</td>
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</tr>
<tr>
<td>Cinch ATZ</td>
<td>Dual II Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Cinch ATZ Lite</td>
<td>Dual II Magnum</td>
<td>atrazine</td>
<td>15</td>
</tr>
<tr>
<td>Cinch ATZ</td>
<td>AA-Trex</td>
<td>atrazine</td>
<td>15</td>
</tr>
</tbody>
</table>

**By Mode of Action** (effect on plant growth)

This chart groups herbicides by their modes of action to assist you in selecting herbicides 1) to maintain greater diversity in herbicide use and 2) to rotate among herbicides with different sites of action to delay the development of herbicide resistance.

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*Site of Action Group*:

1. ACCCase Inhibitors (acetyl CoA carboxylase)
   - Fenoxaprop
   - Fluazifop
   - Quizalofop
   - Clomazone
   - Cyclohexanedione

2. ALS Inhibitors (acetolactate synthase)
   - Sulfonylurea
   - Chlorimuron
   - Foramsulfuron
   - Halosulfuron
   - Iodosulfuron
   - Nicosulfuron

*Continued on next page...*
Corn and Soybean Herbicide Chart

Repeated use of herbicides with the same site of action can result in the development of herbicide-resistant weed populations.

By Mode of Action (effect on plant growth)

This chart groups herbicides by their modes of action to assist you in selecting herbicides 1) to maintain greater diversity in herbicide use and 2) to rotate among herbicides with different sites of action to delay the development of herbicide resistance.

By Premix

This chart lists premix herbicides alphabetically by their trade names so you can identify the premix’s component herbicides and their respective site of action groups. Refer to the Mode of Action chart for more information.

<table>
<thead>
<tr>
<th>Premix</th>
<th>Trade Name ©</th>
<th>Active Ingredient</th>
<th>Site of Action Group*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authority First</td>
<td>Spartan</td>
<td>sulfinpyrazone</td>
<td>14</td>
</tr>
<tr>
<td>Axiom</td>
<td>FirstRate</td>
<td>cloransulam</td>
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<tr>
<td>Axiom</td>
<td>Define</td>
<td>flurenzamid</td>
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<tr>
<td>Basis</td>
<td>Sencor</td>
<td>metribuzin</td>
<td>5</td>
</tr>
<tr>
<td>Basis</td>
<td>Sencor</td>
<td>metribuzin</td>
<td>5</td>
</tr>
<tr>
<td>Bicep II Magnum</td>
<td>Dual Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Bicep II Magnum</td>
<td>AAtrax</td>
<td>atrazine</td>
<td>6</td>
</tr>
<tr>
<td>Bicep Lite II Magnum</td>
<td>Dual Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Bicep Lite II Magnum</td>
<td>AAtrax</td>
<td>atrazine</td>
<td>6</td>
</tr>
<tr>
<td>Boundary</td>
<td>Dual Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Boundary</td>
<td>Sencor</td>
<td>metribuzin</td>
<td>5</td>
</tr>
<tr>
<td>Breakfree ATZ</td>
<td>Breakfree</td>
<td>aceclofop</td>
<td>15</td>
</tr>
<tr>
<td>Breakfree ATZ</td>
<td>Breakfree</td>
<td>aceclofop</td>
<td>15</td>
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<td>Breakfree ATZ Lite</td>
<td>Breakfree</td>
<td>aceclofop</td>
<td>15</td>
</tr>
<tr>
<td>Buctril + Atrazine</td>
<td>Buctril</td>
<td>bromoxynil</td>
<td>6</td>
</tr>
<tr>
<td>Buctril + Atrazine</td>
<td>Buctril</td>
<td>bromoxynil</td>
<td>6</td>
</tr>
<tr>
<td>Bullet</td>
<td>Micro-Tech</td>
<td>alachlor</td>
<td>15</td>
</tr>
<tr>
<td>Camix</td>
<td>Captan</td>
<td>mesotrione</td>
<td>28</td>
</tr>
<tr>
<td>Canopy DF</td>
<td>Classic</td>
<td>chlorimuron</td>
<td>2</td>
</tr>
<tr>
<td>Canopy EX</td>
<td>Classic</td>
<td>chlorimuron</td>
<td>2</td>
</tr>
<tr>
<td>Canopy EX</td>
<td>Classic</td>
<td>chlorimuron</td>
<td>2</td>
</tr>
<tr>
<td>Canopy EX</td>
<td>Classic</td>
<td>chlorimuron</td>
<td>2</td>
</tr>
<tr>
<td>Celebrity Plus</td>
<td>Clarity</td>
<td>dicamba</td>
<td>2</td>
</tr>
<tr>
<td>Celebrity Plus</td>
<td>Clarity</td>
<td>dicamba</td>
<td>2</td>
</tr>
<tr>
<td>Cinch ATZ</td>
<td>Dual Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Cinch ATZ</td>
<td>AAtrax</td>
<td>atrazine</td>
<td>6</td>
</tr>
<tr>
<td>Cinch ATZ Lite</td>
<td>Dual Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Cinch ATZ Lite</td>
<td>AAtrax</td>
<td>atrazine</td>
<td>6</td>
</tr>
</tbody>
</table>

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Corn and Soybean Herbicide Chart

Repeated use of herbicides with the same site of action can result in the development of herbicide-resistant weed populations.

By Mode of Action (effect on plant growth)

This chart groups herbicides into specific actions to assist you in selecting herbicides to reduce the development of herbicide resistance. 1) To prevent resistance in one herbicide use and 2) to rotate among herbicides with different sites of action to delay the development of herbicide resistance.

<table>
<thead>
<tr>
<th>Site of Action Group</th>
<th>Site of Action</th>
<th>Number of resistant weed species in U.S.</th>
<th>Chemical Family</th>
<th>Active Ingredient</th>
<th>Product Examples (Trade Name ®)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ACCase Inhibitors (acetyl CoA carboxylase)</td>
<td>15</td>
<td>Aryloxyphenoxy propionate</td>
<td>fenoxaprop</td>
<td>component of Fusion Fusilade DX</td>
</tr>
<tr>
<td>2</td>
<td>ALS Inhibitors (acetolactate synthase)</td>
<td>38</td>
<td>Sulfonylurea</td>
<td>chlorimuron</td>
<td>Classic Option</td>
</tr>
</tbody>
</table>

continued on next page
Corn and Soybean Herbicide Chart

Repeated use of herbicides with the same site of action can result in the development of herbicide-resistant weed populations.

By Mode of Action (effect on plant growth)

This chart groups herbicides according to their mode of action to assist you in selecting herbicides with 1) diversity in herbicide use and 2) to rotate among herbicides with different sites of action to delay the development of herbicide resistance.

Giant foxtail

By Premix

This chart lists premix herbicides alphabetically by their trade names so you can identify the premix’s component herbicides and their respective site of action groups. Refer to the Mode of Action chart for more information.
# Corn and Soybean Herbicide Chart

Repeated use of herbicides with the same site of action can result in the development of herbicide-resistant weed populations.

This chart lists premix herbicides alphabetically by their trade names so you can identify the premix's component herbicides and their respective site of action groups. Refer to the **Mode of Action** chart for more information.

## By Mode of Action (effect on plant growth)

This chart groups herbicides into 15 site of action groups to assist you in selecting herbicides with diversity in herbicide use and 2) to rotate among herbicides with different sites of action to delay the development of herbicide resistance.

<table>
<thead>
<tr>
<th>Site of Action Group*</th>
<th>Site of Action</th>
<th>Chemical Family</th>
<th>Active Ingredient</th>
<th>Product Examples (Trade Name ®)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>ACCase Inhibitors (acetyl CoA carboxylase)</td>
<td>Aryloxyphenoxo propanate</td>
<td>fenoxaprop</td>
<td>component of Fusion, Fusilade DX, Assure II, Targa</td>
</tr>
<tr>
<td>2</td>
<td>ALS Inhibitors (acetolactate synthase)</td>
<td>Sulfonurea</td>
<td>chlorimuron</td>
<td>Classic, Select, Arrow, Poast, Poast Plus</td>
</tr>
</tbody>
</table>

## Giant foxtail

- Trade Name: Micro-Tech
- Active Ingredients: alachlor
- Site of Action Group: 15

## By Premix

- Bullet
  - Trade Name: Callisto
  - Active Ingredients: mesotrione
  - Site of Action Group: 28

- Camix
  - Trade Name: Dual II Magnum
  - Active Ingredients: s-metolachlor
  - Site of Action Group: 15

- Canopy DF
  - Trade Name: Classic
  - Active Ingredients: chlorimuron
  - Site of Action Group: 2

- Canopy EX
  - Trade Name: Classic
  - Active Ingredients: chlorimuron
  - Site of Action Group: 2

- Celebrity Plus
  - Trade Name: Clarity
  - Active Ingredients: dicamba
  - Site of Action Group: 4

- Cinch ATZ
  - Trade Name: Dual II Magnum
  - Active Ingredients: s-metolachlor
  - Site of Action Group: 15

- Cinch ATZ Lite
  - Trade Name: AAtrex
  - Active Ingredients: atrazine
  - Site of Action Group: 5

*continued on next page*
Corn and Soybean Herbicide Chart

Repeated use of herbicides with the same site of action can result in the development of herbicide-resistant weed populations.

By Mode of Action (effect on plant growth)

This chart groups herbicides by action to assist you in selecting herbicides and 2) to rotate among herbicides with different sites of action to delay the development of herbicide resistance.

By Premix

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</thead>
<tbody>
<tr>
<td>Authority First</td>
<td>Spartan</td>
<td>sulfentrazone</td>
<td>14</td>
</tr>
<tr>
<td>Axiom</td>
<td>FirstRate</td>
<td>chloransulam</td>
<td>2</td>
</tr>
<tr>
<td>Basis</td>
<td>Define</td>
<td>flurenzole</td>
<td>15</td>
</tr>
<tr>
<td>Basis</td>
<td>Sencor</td>
<td>metribuzin</td>
<td>5</td>
</tr>
<tr>
<td>Bicep II Magnum</td>
<td>Harmony GT</td>
<td>thifensulfuron</td>
<td>2</td>
</tr>
<tr>
<td>Bicep Lite II Magnum</td>
<td>Dual II Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Boundary</td>
<td>Dual Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Breakfree ATZ</td>
<td>Breakfree</td>
<td>acetoxychlor</td>
<td>15</td>
</tr>
<tr>
<td>Breakfree ATZ Lite</td>
<td>Breakfree</td>
<td>atrazine</td>
<td>15</td>
</tr>
<tr>
<td>Buctril + Atrazine</td>
<td>Buctril</td>
<td>bromoxynil</td>
<td>6</td>
</tr>
<tr>
<td>Bullet</td>
<td>Micro-Tech</td>
<td>alachlor</td>
<td>15</td>
</tr>
<tr>
<td>Camix</td>
<td>Callisto</td>
<td>mesotrione</td>
<td>28</td>
</tr>
<tr>
<td>Canopy DF</td>
<td>Classic</td>
<td>chlorimuron</td>
<td>2</td>
</tr>
<tr>
<td>Canopy EX</td>
<td>Classic</td>
<td>chlorimuron</td>
<td>2</td>
</tr>
<tr>
<td>Celebrity Plus</td>
<td>Classic</td>
<td>chlorimuron</td>
<td>2</td>
</tr>
<tr>
<td>Clarity</td>
<td>dicamba</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Accent</td>
<td>nicosulfuron</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Cinch ATZ</td>
<td>Dual II Magnum</td>
<td>s-metolachlor</td>
<td>15</td>
</tr>
<tr>
<td>Cinch ATZ Lite</td>
<td>Dual II Magnum</td>
<td>atrazine</td>
<td>15</td>
</tr>
<tr>
<td>AAtrax</td>
<td>atrazine</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

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Glyphosate/ALS-resistant Palmer amaranth
How many different Site of Action groups are in each program?

Program 1:
- Bicep II Magnum (s-metolachlor + atrazine)
  - fb.
- Laudis (tembotrione)
- Liberty (glufosinate)

Program 2:
- Capreno (thiencarbazone + tembotrione)
  - +
- AAtrex (atrazine)
  - fb.
- Roundup PowerMax (glyphosate)
  - +
- SureStart (acetochlor + flumetsulam + clopyralid)
How many different **Site of Action** groups are in each program?

**Program 1: = 4 SOA**
- **Bicep II Magnum**
  - (s-metolachlor + atrazine)
  - Group 15 5
  - fb.
- **Laudis**
  - (tembotrione)
  - Group 27
- **Liberty**
  - (glufosinate)
  - Group 10

**Program 2: = 6 SOA**
- **Capreno**
  - (thiencarbazone + tembotrione)
  - Group 2 27
  - +
- **AAtrex**
  - (atrazine)
  - Group 5
  - fb.
- **Roundup PowerMax**
  - (glyphosate)
  - Group 9
  - +
- **SureStart**
  - (acetochlor + flumetsulam + clopyralid)
  - Group 15 2 4
How many “effective” Site of Action groups are in each program?

**Program 1:**

- **Bicep II Magnum**
  (s-metolachlor + atrazine)
  
  - Group 15
  - Group 5

- **Laudis**
  (tembotrione)
  
  - Group 27

- **Liberty**
  (glufosinate)
  
  - Group 10

**Program 2:**

- **Capreno**
  (thiencarbazone + tembotrione)
  
  - Group 2
  - Group 27

- **AAtrex**
  (atrazine)
  
  - Group 5

- **Roundup PowerMax**
  (glyphosate)
  
  - Group 9

- **SureStart**
  (acetochlor + flumetsulam + clopyralid)
  
  - Group 15
  - Group 2
  - Group 4
How many “effective” Site of Action groups are in each program?

Program 1:= 4 effective SOA

Bicep II Magnum
(s-metolachlor + atrazine)

- Group 15
- Group 5

Laudis
(tembotrione)

- Group 27

Liberty
(glufosinate)

- Group 10

Program 2:= 2-3 effective SOA

Capreno
(thiencarbazone + tembotrione)

- Group 2
- Group 27

+ AAtrex
(atrazine)

- Group 5

fb.

Roundup PowerMax
(glyphosate)

- Group 9

+ SureStart
(acetochlor + flumetsulam + clopyralid)

- Group 15
- Group 2
- Group 4
Which program will provide the greatest control of *multiple-resistant* Palmer amaranth?

**Program 1:** 4 effective SOA

- **Bicep II Magnum**
  - (s-metolachlor + atrazine)
  - **Group 15 5**

- **Laudis**
  - (tembotrione)
  - **Group 27**

- **Liberty**
  - (glufosinate)
  - **Group 10**

- **Capreno**
  - (thiencarbazone + tembotrione)
  - **Group 2 27**

- **AAtrex**
  - (atrazine)
  - **Group 5**

- **Roundup PowerMax**
  - (glyphosate)
  - **Group 9**

- **SureStart**
  - (acetochlor + flumetsulam + clopyralid)
  - **Group 15 2 4**

**Program 2:** 2-3 effective SOA
Which program will provide the greatest control of *multiple-resistant* Palmer amaranth?
What would be the outcome of **Program A** overtime to manage glyphosate/ALS-resistant Palmer amaranth in continuous corn?

**Program A:**
- Roundup PowerMax (glyphosate)
- Callisto (mesotrione)
- Capreno (thiencarbazone + tembotrione)

Multiple “effective” sites of action are essential to manage and delay the development of herbicide-resistant weeds.

Development of HPPD-resistance (3-way) in an already multiple resistant population.
What about glyphosate/ALS-resistant Palmer amaranth management in soybean?
How many “effective” Site of Action groups are in each program?

**RR Program:**
- Valor (flumioxazin)
- fb.
- Roundup PowerMax (glyphosate)
- +
- Prefix (s-metolachlor + fomesafen)

**LL Program:**
- Valor (flumioxazin)
- fb.
- Liberty (glufosinate)
- +
- Dual II Magnum (s-metolachlor)
How many “effective” Site of Action groups are in each program?

RR Program = 2 effective SOA

- Valor (flumioxazin)
  - Group 14
- Roundup PowerMax (glyphosate)
  - fb.
  - Group 9
- Prefix (s-metolachlor + fomesafen)
  - Group 15

LL Program = 3 effective SOA

- Valor (flumioxazin)
  - Group 14
- Liberty (glufosinate)
  - Group 10
- Dual II Magnum (s-metolachlor)
  - Group 15
Control of *multiple-resistant Palmer amaranth*
Challenges and potential issues with these programs

RR Program = 2 effective SOA

Valor (flumioxazin)
  fb.
Roundup PowerMax (glyphosate)
  +
Prefix (s-metolachlor + fomesafen)

- PRE needs adequate rainfall for incorporation for effectiveness
- Timing of POST applications are critical
- Rescue herbicide treatment would be another PPO herbicide (i.e., Cobra)
- Potential development of PPO resistance
LL Program = 3 effective SOA

- **Valor** (flumioxazin)
  - Group 14
  - fb.
- **Liberty** (glufosinate)
  - Group 10
  - +
- **Dual II Magnum** (s-metolachlor)
  - Group 15

Challenges and potential issues with these programs:

- PRE needs adequate rainfall for incorporation for effectiveness
- Timing of POST applications are critical
- Rescue herbicide treatment could be Liberty or a PPO herbicide (i.e., Flexstar, Cobra)
MSU’s Palmer amaranth recommendations in soybean

1. Consider planting LibertyLink soybean
2. Start clean
   - Tillage or effective burndown (Gramoxone or Liberty)
3. Effective PRE herbicides are essential
   - Valor (flumioxazin)-based herbicides
4. Timely POST herbicide applications
   - 3-inches tall or less
   - Liberty (29 fl oz) LL soybean, Flexstar (1 pt), or Cobra??
5. Residual product tank-mixtures with POST
   - Dual II Magnum, Warrant, or Outlook
6. Additional POST applications when needed
7. Hand-weed remaining plants
Scout for Palmer amaranth

- Focus scouting efforts in:
  - Areas where Palmer amaranth has been confirmed
  - Roundup Ready fields spread with manure the last couple years
  - Remove female plants prior to seed production
Prevention and early detection are essential!!
Protect your fields

DIVERSITY IN WEED MANAGEMENT IS KEY

- Start clean
- Use herbicide programs with multiple “effective” SOA against weeds prone to herbicide resistance
  - Residual herbicides (PRE) – full rates
  - Tank-mixtures
- Use practices that favor a competitive crop
- Manage weeds around field perimeters
- Prevent weed seed production – “Zero tolerance”
- Scout for changes in weed populations
Announcements

- 2013 Weed Control Guide for Field Crops (E-434) is now available online!
- NEW extension bulletin: Keys to distinguishing Palmer amaranth from other species.
- 2012 Economics for weed control in Non-GMO soybeans have been added.

Current Newsletters

Scouting Michigan fields for Palmer amaranth

Scouting will be key to stopping the spread of glyphosate-resistant Palmer amaranth in Michigan.

Upcoming Events

- Photos from the 2013 Weed Tour will be posted to the blog shortly!
- Photos from the 2012 Weed Tour are posted on the blog!

May 30, 2013
read »

2013 MSU Weed Tour

We invite you to make plans to attend the annual Michigan State University Weed Tour, beginning at the MSU Crops Field Lab on Wednesday, June 26th (Beaumont Road and Mount Hope Road on MSU Campus). Registration begins at 9:00 am, with the field tour kicking off at 9:30 am.