Meeting the Challenge of Glyphosate-Resistant Palmer Amaranth in Conservation Tillage

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The Current Situation

“Weed resistance could have a significant impact on conservation tillage, which farmers have widely adapted not only as a cost-cutting measure but as a means to limit soil erosion and reduce chemical use. It could cause us to rethink our entire agronomic process.”

Delta Farm Press – Jan. 28, 2010
Uncontrolled Palmer Amaranth in Conservation Tillage Cotton
Weed Management

• Practical weed management consists of mechanical and chemical means.
• When herbicides are effective, the need for tillage and cultivation declines.
• When effective herbicides are not available, the need for tillage increases.
## Relative Growth Rates of Amanranths

<table>
<thead>
<tr>
<th>Week’s Growth</th>
<th>2</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmer amaranth</td>
<td>4</td>
<td>10</td>
<td>38</td>
</tr>
<tr>
<td>Red Root Pigweed</td>
<td>3</td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td>Common Waterhemp</td>
<td>2</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Smooth Pigweed</td>
<td>2</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Spiny Pigweed</td>
<td>1</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Tumble Pigweed</td>
<td>1</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

Rooting Depth of Palmer Amaranth
Glyphosate-Resistant Crop Acres

Million Acres

- Cotton
- Corn
- Soybean

Total Acres Exposed to Herbicide Modes of Action for Corn, Soybean, Cotton
Initial Discovery of Glyphosate-Resistant Palmer Amaranth
Glyphosate-Resistant Palmer Amaranth Found in Three Centers

2004
2005
2006
2007
Glyphosate-Resistant Palmer Amaranth Monitoring Documents Spread
Glyphosate-Resistant Palmer Amaranth Continues to Spread
Glyphosate-Resistant Palmer Amaranth Dominates Southeastern Coastal Plain and North Delta
Impacts of Glyphosate-Resistant Palmer Amaranth

• Increase Complexity and Costs of Weed Management in Cotton and Soybean
• Pose a Challenge to Conservation Tillage
• Increase Risk of a Resistance Cascade of Post Emergence Broad-Leaf Herbicides
## Herbicide Programs for Cotton - Georgia

<table>
<thead>
<tr>
<th>No Glyphosate-Resistant <em>Amaranthus palmeri</em></th>
<th>Glyphosate-Resistant <em>Amaranthus palmeri</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Fee - $42.18/acre</td>
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</tr>
<tr>
<td>Pendimethalin - $4.48/acre</td>
<td>Fomesafen + Pendimethalin - $18.62/acre</td>
</tr>
<tr>
<td>Glyphosate (2x) - $9.60/acre</td>
<td>Metolachlor + Glyphosate - $18.02/acre</td>
</tr>
<tr>
<td><strong>Total = $56.26/acre</strong></td>
<td>Diuron + MSMA - $3.46/acre</td>
</tr>
<tr>
<td></td>
<td><strong>Total = $82.28/acre</strong></td>
</tr>
</tbody>
</table>
Impact on Conservation Tillage Acres
Impact of Glyphosate-Resistant Palmer Amaranth in Central Georgia

 Practices

- Strip-tillage
- PPI Herbicides
- Glufosinate
- Cultivation
- Hand Weeding

Cotton Weed Management Systems

• **Conventional**
  – Full tillage, pre-plant incorporated and early and late post-directed herbicides; 2-3 cultivations

• **Glyphosate-Resistant Cultivars**
  – Conservation tillage, pre-plant burn down, two post emergence glyphosate applications, lay by

• **Glyphosate-Resistant Weeds**
  – Tillage (?); Cover Crops (?)
  – Pre-emergence residuals, glyphosate + residual early post, lay by, cultivations (?)
Experimental Design

Culpepper et al. 2009

Factorial:

2 deep tillage options

2 cover crop options

4 herbicide systems
Reduction in Palmer Amaranth Emergence

Non-treated: 620 plant/m2 in row.
No herbicides applied.
### Palmer Amaranth Response to Deep Tillage

<table>
<thead>
<tr>
<th>No deep tillage</th>
<th>Deep tillage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cover crop</td>
<td>No cover crop</td>
</tr>
</tbody>
</table>

**Herbicidal Treatments:**
- Staple + Reflex + Direx PRE
- Roundup Weather Max + Parrlay POST
- Direx + MSMA Lay by
<table>
<thead>
<tr>
<th>Palmer Amaranth Response to Cover Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>No deep tillage</td>
</tr>
<tr>
<td>No cover crop</td>
</tr>
<tr>
<td>No deep tillage</td>
</tr>
<tr>
<td>Rye cover crop</td>
</tr>
</tbody>
</table>

Staple + Reflex + Direx PRE
Roundup Weather Max + Parrlay POST
Direx + MSMA Lay by
<table>
<thead>
<tr>
<th>Palmer Amaranth Response to Deep Tillage and Cover Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No deep tillage</strong></td>
</tr>
<tr>
<td>No cover crop</td>
</tr>
<tr>
<td><strong>Deep tillage</strong></td>
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<tr>
<td>Rye cover crop</td>
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Staple + Reflex + Direx PRE
Roundup Weather Max + Parrlay POST
Direx + MSMA Layby
## Palmer Amaranth Response to Herbicide Systems

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<th>No deep tillage</th>
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</tr>
</thead>
<tbody>
<tr>
<td>No cover crop</td>
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<table>
<thead>
<tr>
<th>Staple + Reflex + Direx PRE</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Roundup Weather Max + Parrlay POST</td>
<td>Ignite + Parrlay POST</td>
</tr>
<tr>
<td>Direx + MSMA Layby</td>
<td>Direx + MSMA Layby</td>
</tr>
</tbody>
</table>
Rye 7 foot when killed, rolled, planted. Deep turn 12 inch in previous fall.
Herbicides: Direx + Reflex + Staple PRE; Roundup + Parrlay POST, Direx + MSMA at layby.
Glyphosate-Resistant Palmer Amaranth Control
Glufosinate Systems

Rye 7 foot when killed, rolled, planted. Deep turn 12 inch in previous fall.
Herbicides: Direx + Reflex + Staple PRE; Ignite + Parrlay POST, Direx + MSMA at layby.
Potential Weakness of High Residue Systems
Weed Control Down the Drill
Conservation Innovation Grant

• Cooperative Project of Auburn Univ., Clemson Univ., Univ. of Georgia, Univ. of Tennessee, and Cotton Incorporated.
• Two sites each in AL, GA, SC, and TN
• Three weed management programs:
  – Grower Standard
  – Fall Inversion followed by High Residue Management
  – High Residue Management
Herbicide Modes of Action

“The way an herbicide kills a plant”

Examples:

**ALS** – Acetolactate Synthase
- Cadre, Pursuit, Staple, Osprey, many others

**Gycine** – Glyphosate

**PPO** – Protoporphyrinogen Oxidase
- Valor, Reflex, Flexstar, Cobra, Goal
Glyphosate Resistant Palmer Amaranth

**Economic Threat to Cotton and Soybean**

Since protoporphrinogen oxidase (PPO) herbicides are not an over-the-top option, if acetolactate synthase (ALS) herbicides and glyphosate are compromised, there will be no selective post emergence options for cotton.

If ALS and glyphosate are compromised, then PPO herbicides are the only selective post emergence option for soybean.
Glyphosate-Resistant Palmer Amaranth

• Threatens Sustainability of Post Emergence Herbicides in U.S. Agriculture.

• If Protoprophrinogen Oxidase (PPO) herbicides are heavily used pre-emergence in cotton, and are the only post emergence option in soybean, what is their future?