Characterization of multiple-resistant Palmer amaranth in Michigan

Jonathon R. Kohrt and Christy L. Sprague
Department of Plant, Soil, and Microbial Sciences, Michigan State University, East Lansing, MI

Introduction

• Palmer amaranth was first identified in Michigan in 2010.
• Palmer amaranth populations found in Michigan are thought to have been introduced from outside sources, such as cattle feed or equipment from other states.
• Several populations of Palmer amaranth in Michigan have been confirmed to be resistant to glyphosate (Group 9) and ALS-inhibiting herbicides (Group 2).
• In recent field trials in Barry Co., MI, both soil-applied (PRE) and postemergence (POST) applications of atrazine (Group 5) have failed to control Palmer amaranth that we initially thought was resistant only to glyphosate and the ALS-inhibitors (Figure 1).

Objectives

• To characterize the resistance profile of the suspected three-way resistant Palmer amaranth population from Barry Co., MI.
• To determine the magnitude of resistance for PRE applications of atrazine and postemergence applications of atrazine, glyphosate, and thifensulfuron.

Materials and Methods

• Greenhouse dose-response experiments conducted in 2014
• All herbicides were applied with a compressed air powered spray chamber at 187 L ha⁻¹
• Each treatment was replicated 6-7 times and each experiment was repeated in time

Preemergence Experiment

• Palmer amaranth seeds (25 per pot) of a known susceptible and the suspected-resistant populations were planted in pots containing field soil
• Atrazine was applied to the soil surface and immediately watered
• Atrazine (1.12 kg ai ha⁻¹ = 1x rate):
  • Susceptible population: 0, 1/4, 1/2, 1, 2, 4, 8x rate
  • Barry Co. population: 0, 1/2, 1, 2, 4, 8, 16x rate
• Germination counts were taken weekly and biomass was harvested 28 DAT

Postemergence Experiment

• Herbicide applications were made when Palmer amaranth was ~7.5 cm tall
• The rate structure for the susceptible population was the same for all herbicides: 0, 1/32, 1/16, 1/8, 1/4, 1/2, 1 and 2x rate
• The rate structures for the suspected-resistant Barry Co. population consisted of: 0, 1/4, 1/2, 1, 2, 4, 8, 16, 32x rates
  • Atrazine (1.12 kg ai ha⁻¹ = 1x rate)
  • Glyphosate (0.84 kg ae ha⁻¹ = 1x rate)
  • Thifensulfuron (0.0044 kg ai ha⁻¹ = 1x rate)
• Visual evaluations for weed control were made 7 and 14 days after treatment (DAT), biomass was harvested 14 DAT

Statistical Analysis

• All data were subjected to non-linear regression using the 3-parameter log-logistic model in SigmaPlot

Results and Discussion

Table 1. Dose response equations, R², and GR₅₀ values for the susceptible and suspected-resistant Barry Co. populations of Palmer amaranth.

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Population</th>
<th>Equation</th>
<th>R²</th>
<th>GR₅₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrazine (PRE)</td>
<td>Susceptible</td>
<td>y = 100/(1+(x/0.19)^3)</td>
<td>0.93</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>Barry Co.</td>
<td>y = 95/(1+(x/8)^1.29)</td>
<td>0.52</td>
<td>8</td>
</tr>
<tr>
<td>Atrazine (POST)</td>
<td>Susceptible</td>
<td>y = 107/(1+(x/0.42)^1.2)</td>
<td>0.91</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>Barry Co.</td>
<td>y = 84/(1+(x/0.84)^1.25)</td>
<td>0.58</td>
<td>0.84</td>
</tr>
<tr>
<td>Glyphosate (POST)</td>
<td>Susceptible</td>
<td>y = 101/(1+(x/0.14)^3)</td>
<td>0.88</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Barry Co.</td>
<td>y = 94/(1+(x/1.8)^1.2)</td>
<td>0.90</td>
<td>1.8</td>
</tr>
<tr>
<td>Thifensulfuron (POST)</td>
<td>Susceptible</td>
<td>y = 90/(1+(x/0.27)^1.5)</td>
<td>0.92</td>
<td>0.00027</td>
</tr>
<tr>
<td></td>
<td>Barry Co.</td>
<td>y = 73/(1+(x/13.7)^3.2)</td>
<td>0.78</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Figure 1. Palmer amaranth survival after atrazine was applied (a) PRE at 2.24 kg ha⁻¹ 28 DAT and (b) POST at 1.12 kg ha⁻¹ 14 DAT to a field in Barry Co., MI.

• The R² values for the fit of the data to the log-logistic equation ranged from 0.52 to 0.92 (Table 1).
• The lower R² values were found when the suspected-resistant Barry Co. Palmer amaranth population was treated with atrazine PRE or POST, suggesting that this population may still be segregating.
• None of the herbicides, atrazine (PRE or POST), glyphosate, or thifensulfuron provided complete control of the Barry Co. Palmer amaranth population (Figures 2 and 3).
• The dose required for 50% growth reduction (GR₅₀) for the Barry Co. population were always greater than the 1x rate for each herbicide, except atrazine POST (Table 1).

Figure 2. Dose-response curves for susceptible and suspected-resistant (Barry Co.) Palmer amaranth of: (a) atrazine PRE, (b) atrazine POST, (c) glyphosate POST, and (d) thifensulfuron POST.

• The magnitude of resistance (R:S ratio) for the GR₅₀ values were 42x for atrazine (PRE), 2x for atrazine (POST), 13x for glyphosate, and 51x for thifensulfuron (Figure 2).
• While the magnitude of resistance for atrazine applied POST was only 2x, there were still plants surviving at 18 kg ha⁻¹ (16x rate), Figure 3.

Figure 3. Control of susceptible and Barry Co. populations of Palmer amaranth with dose-responses of (a) atrazine PRE, (b) atrazine POST, (c) glyphosate POST, and (d) thifensulfuron POST.

Conclusions

• The Barry Co. population of Palmer amaranth is resistant to three herbicide sites of action: Group 2 (ALS-inhibitors), Group 5 (atrazine), and Group 9 (glyphosate).
• This is the second report of this three-way resistance profile in Palmer amaranth, the first case was in Georgia (Heap, 2015).
• The lower magnitude of resistance for atrazine applied POST may imply that this population is still segregating or that the resistance mechanism is metabolism based.
• Further research is needed to determine the actual mechanism of resistance to atrazine.

Acknowledgements

• To determine the magnitude of resistance for PRE applications of atrazine and postemergence applications of atrazine, glyphosate, and thifensulfuron.