Characterization of multiple-resistant Palmer amaranth in Michigan

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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

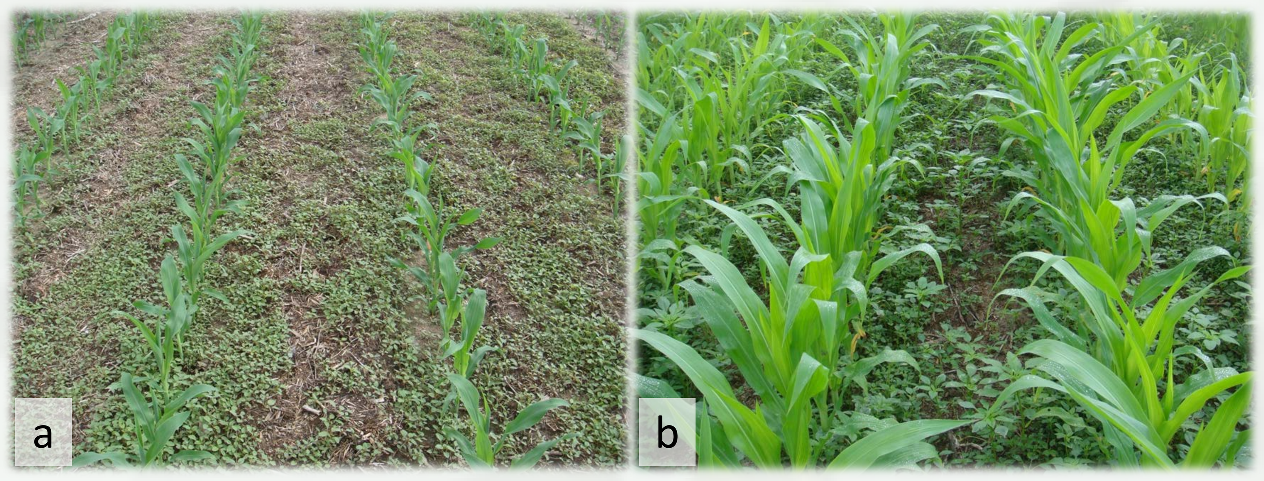

Figure 1. Palmer amaranth survival after atrazine was applied (a) PRE at 2.24 kg ha^{-1} 28 DAT and (b) POST at 1.12 kg ha^{-1} 14 DAT to a field in Barry Co., MI.

- The R^2 values for the fit of the data to the log-logistic equation ranged from 0.52 to 0.92 (*Table 1*).
- The lower R^2 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 (GR_{50}) for the Barry Co. population were always greater than the 1x rate for each herbicide, except atrazine POST (*Table 1*).

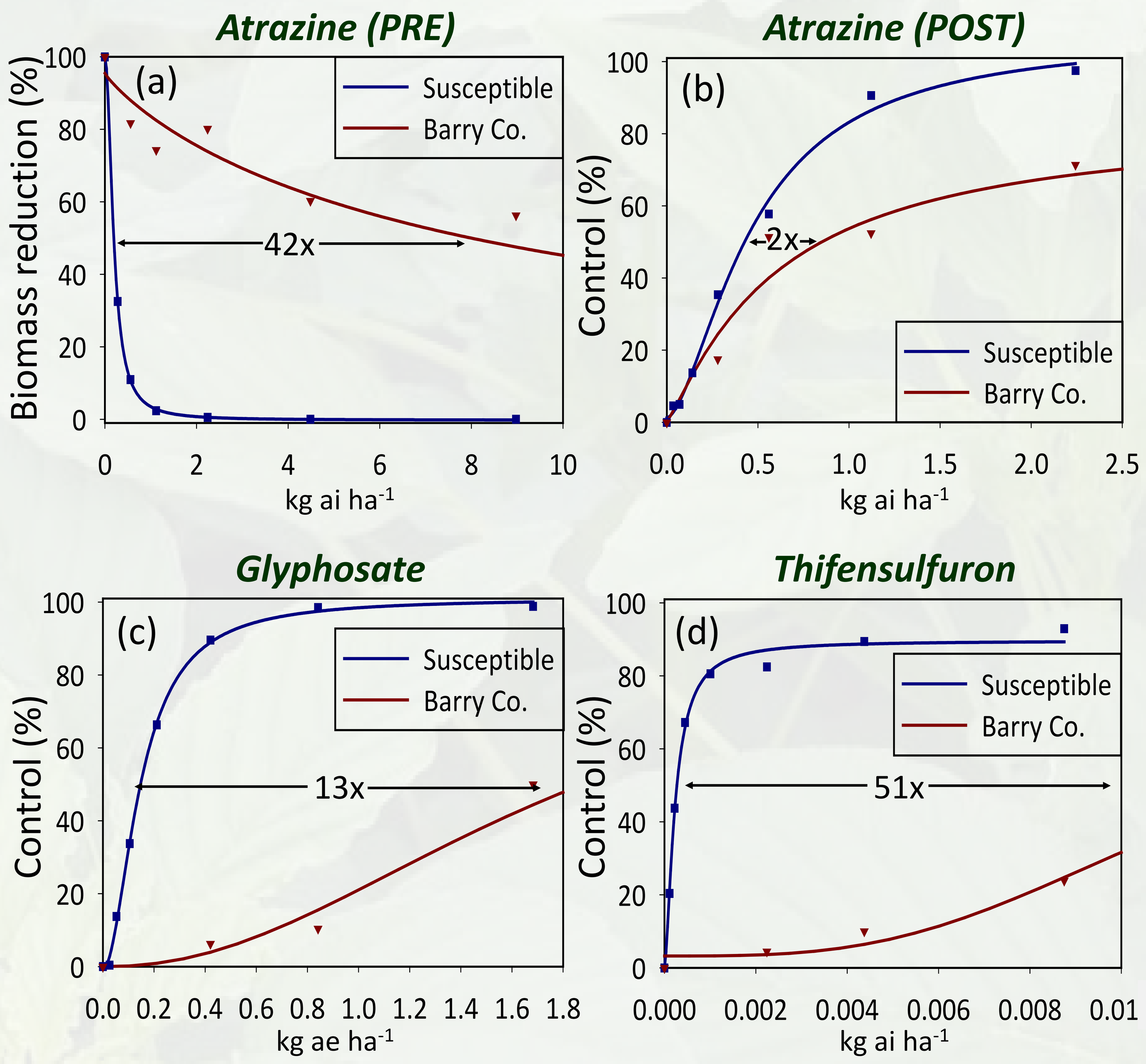

Figure 2. Dose-response curves for susceptible and suspected-resistant (Barry Co.) Palmer amaranth of: (a) atrazine PRE, (b) atrazine POST, (c) glyphosate POST, and (d) thifensulfuron POST.

Table 1. Dose response equations, R^2, and GR_{50} values for the susceptible and suspected-resistant Barry Co. populations of Palmer amaranth.

Herbicide	Population	Equation	R^2	GR_{50}
				– kg ha^{-1} –
Atrazine (PRE)	Susceptible	$y = 100/(1+(x/0.19)^{1.9})$	0.93	0.19
	Barry Co.	$y = 95/(1+(x/8)^{0.89})$	0.52	8
Atrazine (POST)	Susceptible	$y = 107/(1+(x/0.42)^{-1.6})$	0.91	0.42
	Barry Co.	$y = 84/(1+(x/0.84)^{-1.15})$	0.58	0.84
Glyphosate (POST)	Susceptible	$y = 101/(1+(x/0.14)^{-1.9})$	0.88	0.14
	Barry Co.	$y = 94/(1+(x/1.8)^{-2.1})$	0.90	1.8
Thifensulfuron (POST)	Susceptible	$y = 90/(1+(x/0.27)^{-1.56})$	0.92	0.00027
	Barry Co.	$y = 73/(1+(x/13.7)^{-3.2})$	0.78	0.014

- The magnitude of resistance (R:S ratio) for the GR_{50} 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*.

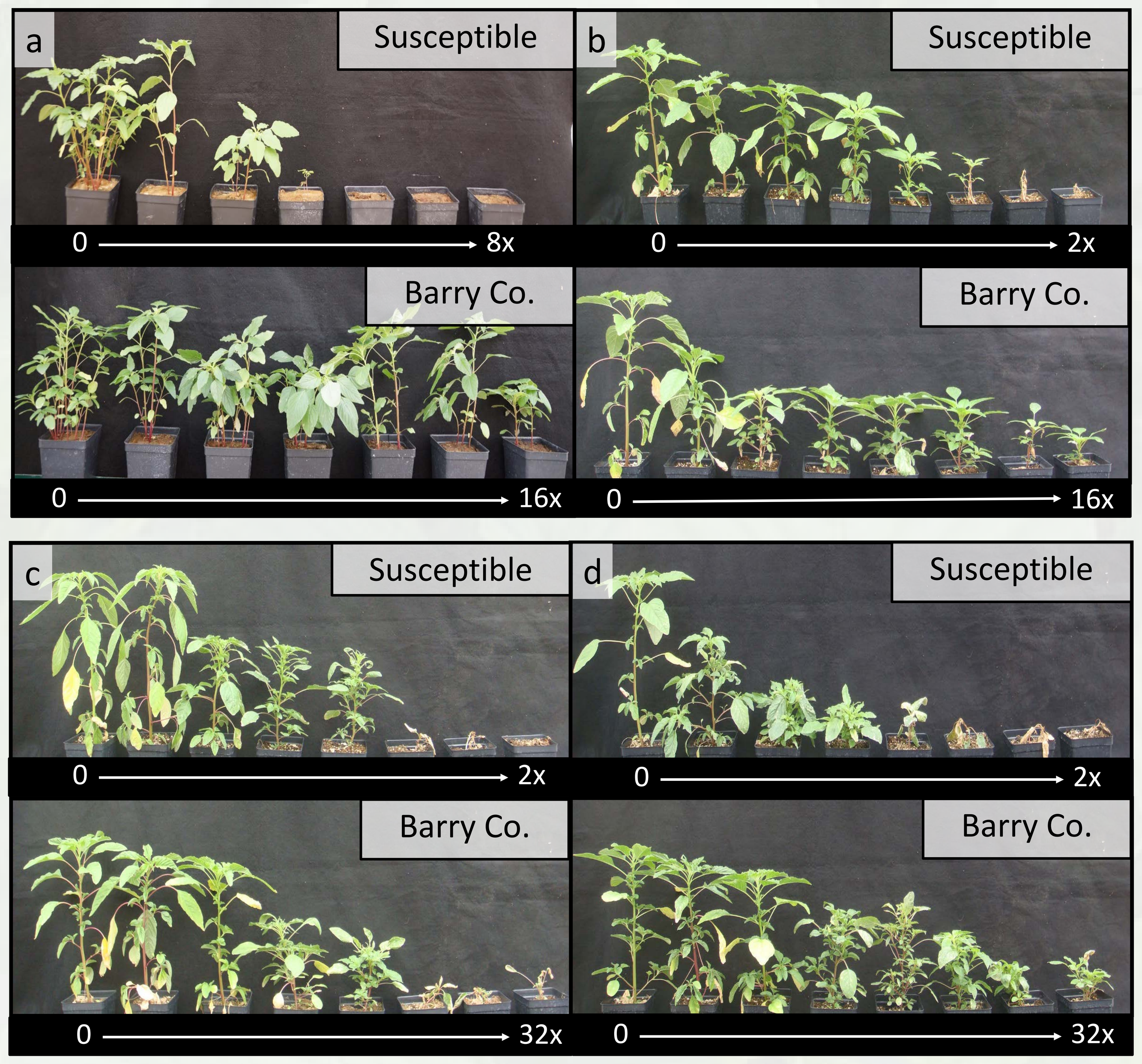

Figure 3. Control of susceptible and Barry Co. populations of Palmer amaranth with dose-responses of (a) atrazine PRE, (b) atrazine POST, (c) glyphosate POST, and (d) thifensulfuron POST.

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

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