HERBICIDE-RESISTANT COMMON WATERHEMP AND PALMER AMARANTH IN WISCONSIN

Nathan Drewitz, Devin Hammer, Shawn Conley, and Dave Stoltenberg[1]

Introduction

The spread of common waterhemp (*Amaranthus rudis*) and Palmer amaranth (*Amaranthus palmeri*) has become an increasing concern in Wisconsin (Hammer et al. 2016b). Both species are well-known for their competitive ability, abundant seed production, and propensity for developing herbicide resistance. Herbicide-resistant common waterhemp was first confirmed in Wisconsin in 1999, when a population was found to be resistant to ALS-inhibitors. More recently, glyphosate resistance was confirmed in two waterhemp populations in west-central Wisconsin (Butts and Davis 2015a).

The first occurrence of Palmer amaranth in Wisconsin was documented in 2013 (Davis and Recker 2014). This population was subsequently confirmed to be resistant to glyphosate (Butts and Davis 2015b). Since that time, Palmer amaranth has been found in three additional counties in Wisconsin. Responding to the increasing concern of Wisconsin growers, we have investigated several instances of suspected herbicide-resistant common waterhemp and Palmer amaranth. Our methods and findings are described below.

Methods

Seed heads of putative herbicide-resistant (R) plants were collected from 11 common waterhemp and two Palmer amaranth populations in several Wisconsin counties in 2014 and 2015. Six common waterhemp populations were sampled from Chippewa, Outagamie, Sheboygan, and Waupaca counties in 2014, and five populations were sampled from Crawford, Lafayette, and Walworth counties in 2015. Palmer amaranth populations were sampled in Iowa County in 2014 and Grant County in 2015. Seeds were dried, cleaned, stratified for 6 weeks (common waterhemp only), planted, and germinated in the greenhouse for whole-plant herbicide dose-response experiments.

Dose-response experiments included R and known herbicide-susceptible (S) populations treated with the herbicides specified below. All herbicide treatments included recommended adjuvants. The experimental design was a RCB with five to 10 replications. Experiments were repeated one or more times. Glyphosate was applied to 4- to 6-inch tall plants at eight rates ranging from 0 to 12.4 lb ae $acre^{-1}$ (16 times the labelled rate). Imazethapyr was applied to 4- to 6-inch tall plants (Palmer amaranth only) at six rates ranging from 0 to 6.25 lb ai ac^{-1} (100 times the labelled rate). Thifensulfuron was applied to 4-inch tall plants (Palmer amaranth only) at seven rates from 0 to 0.039 lb ai ac^{-1} (10 times the labelled rate). Tembotrione was applied to 4- to 6-inch tall plants (Palmer amaranth only) at seven rates from 0 to 0.82 lb ai ac^{-1} (10 times the labelled rate).

Shoot dry biomass was collected 28 days after treatment (DAT), dried, and weighed. Comparisons between R and S populations were made based on the effective herbicide dose that reduced shoot biomass by 50% (ED_{50}) using "R" statistical software. Some populations were

[1] Graduate Research Assistant, Graduate Research Assistant, Professor, and Professor, Dept. of Agronomy, 1575 Linden Dr., Univ. of Wisconsin-Madison, Madison, WI, 53706.

tested at the University of Illinois Plant Clinic (UIPC) using molecular screening methodology (Bell et al. 2013).

Results

Glyphosate resistance was confirmed in common waterhemp populations from 16 Wisconsin counties based on results from greenhouse dose-response experiments and screening results from UIPC (Figure 1). The majority of plants across these populations survived the labelled rate of glyphosate (0.77 lb ae acre^{-1}) (Hammer et al. 2016a). Responses of populations from Crawford and Lafayette counties are shown in Figure 2. The population from Monroe County was found to be resistant to glyphosate and PPO-inhibiting herbicides making it the first confirmed case of multiple resistance to these two herbicide sites of action (SOAs) in Wisconsin (Figure 1).

The Iowa County Palmer amaranth population displayed a high-level of resistance (> 150-fold) to imazethapyr (Figure 3) and a low-level of resistance (4.9-fold) to thifensulfuron (Drewitz et al. 2016). The Iowa County Palmer amaranth population was also found to have a low-level of resistance (7.0-fold) to tembotrione (Figure 3). These results confirm the first instance of multiple herbicide resistance in Wisconsin Palmer amaranth (Figure 1). The Iowa County population was sensitive to glyphosate. The Grant County population was sensitive to all herbicide SOA's tested.

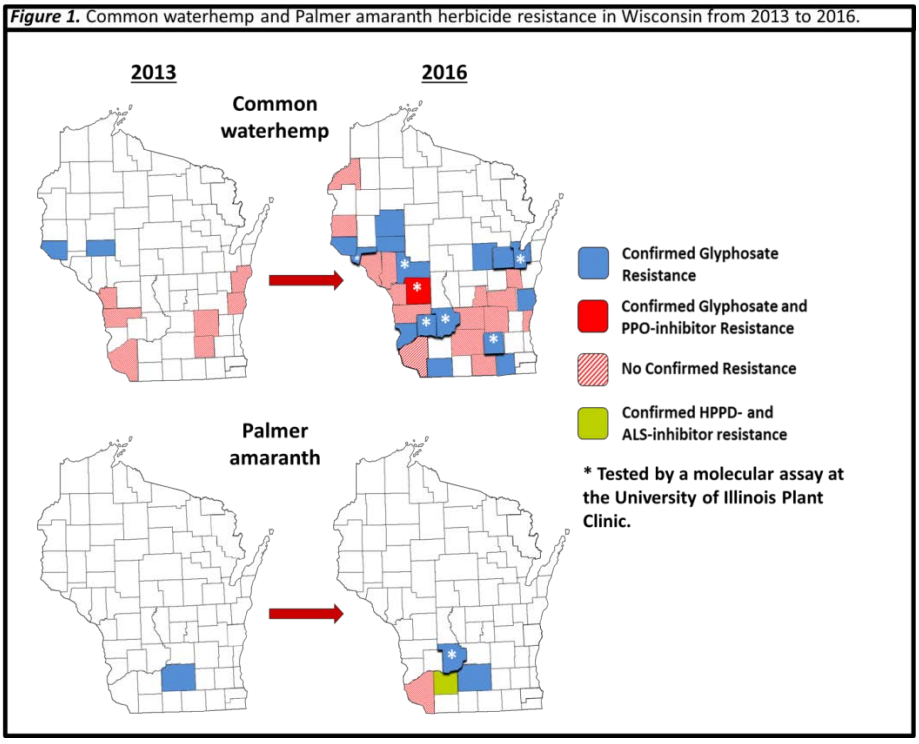


Figure 1. Common waterhemp and Palmer amaranth herbicide resistance in Wisconsin from 2013 to 2016.

Figure 2. Response of common waterhemp populations from Crawford and Lafayette counties to glyphosate 28 DAT. Plant response to glyphosate at the labelled rate (0.77 lb ae acre^{-1}) is shown in the photograph.

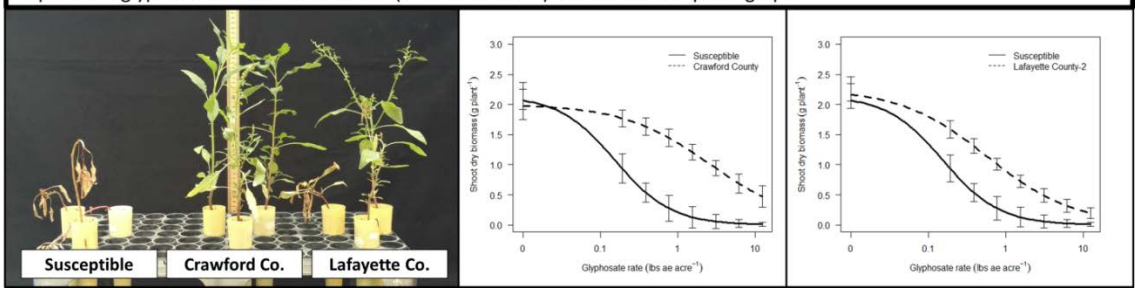
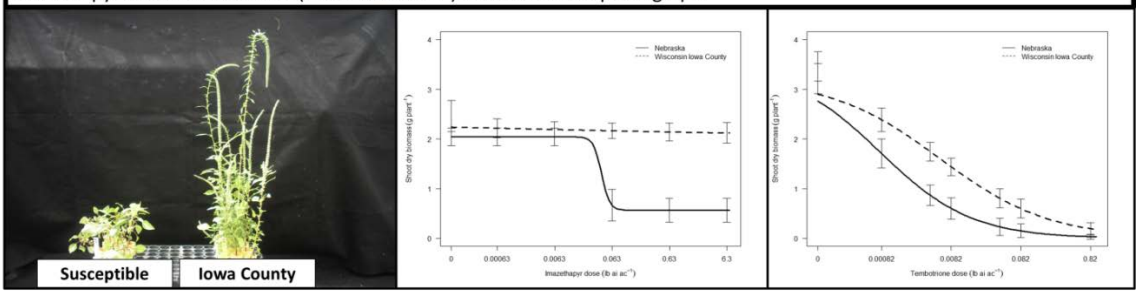


Figure 3. Response of Palmer amaranth from Iowa County to imazethapyr and tembotrione 28 DAT. Plant response to imazethapyr at the labelled rate (0.063 lb ai acre^{-1}) is shown in the photograph.



Conclusions

Our findings indicate that the distribution of common waterhemp and the occurrence of glyphosate resistance (including one population with multiple resistance to PPO-inhibitors) have increased rapidly in Wisconsin. Although the distribution of Palmer amaranth appears to be limited to four counties in southern and southwestern Wisconsin, the confirmation of glyphosate resistance in two populations, and multiple resistance to ALS- and HPPD-inhibitors in another population, have serious management implications for Wisconsin growers. It is critical that diverse resistance management strategies be implemented to reduce the spread, persistence, and impact of these and other herbicide-resistant species.

References

Bell MS, Hager AG, Tranel PJ (2013) Multiple resistance to herbicides from four site-of-action groups in waterhemp (*Amaranthus tuberculatus*). Weed Sci. 61:460-468

Butts T, Davis V (2015a) Glyphosate resistance confirmed in two Wisconsin common waterhemp (*Amaranthus rudis*) populations. http://wcws.cals.wisc.edu/wp-content/uploads/sites/4/2013/03/WCWS_207_waterhemp_resistance_WEB.pdf

Butts T, Davis V (2015b) Palmer amaranth (Amaranthus palmeri) confirmed glyphosate-resistant in Dane County, Wisconsin. Wisconsin Crop Manager. http://ipcm.wisc.edu/wcm/

Davis V, Recker R (2014) Palmer amaranth identified through the late-season weed escape survey. Wisconsin Crop Manager. http://ipcm.wisc.edu/wcm/

Drewitz N, Hammer D, Conley S, Stoltenberg D (2016) Multiple resistance to ALS- and HPPD-inhibiting herbicides in Palmer amaranth from Iowa County, Wisconsin. Wisconsin Crop Manager. 31:158-160 http://ipcm.wisc.edu/wcm/ Posted October 26, 2016

Hammer D, Drewitz N, Conley S, Stoltenberg D (2016a) Common waterhemp (*Amaranthus rudis*): Confirmed herbicide resistance and spread across Wisconsin. Wisconsin Crop Manager 31:161-163 http://ipcm.wisc.edu/wcm/ Posted October 26, 2016

Hammer D, Drewitz N, Davis V, Conley S, Stoltenberg D (2016b) Herbicide resistance update for Wisconsin. Proc Wisc Crop Management Conf. 55:25-28