HERBICIDE RESISTANCE UPDATE FOR WISCONSIN

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The first confirmed case of herbicide resistance in Wisconsin was atrazine-resistant common lambsquarters in 1979 (Heap 2015). Since then, herbicide resistance has been confirmed in 12 other weed species in Wisconsin. Resistance to photosystem II inhibitors such as atrazine and other triazine herbicides has been confirmed in smooth pigweed (1985), kochia (1987), and velvetleaf (1990), in addition to common lambsquarters in 1979. Resistance to ACCase inhibitors has been confirmed in only two species: giant foxtail (1991) and large crabgrass (1992). In contrast, resistance to ALS inhibitors has been confirmed in many species including kochia (1995) and eastern black nightshade, giant foxtail, green foxtail, and common waterhemp, all in 1999. More recently, resistance to ALS inhibitors has been found in giant ragweed (Marion et al. 2013; Stoltenberg et al. 2015) and common ragweed (Butts et al. 2015).

Glyphosate resistance in Wisconsin is a relatively recent occurrence compared to the instances of photosystem II inhibitor, ACCase inhibitor, and ALS inhibitor resistance noted above. The first confirmed case of glyphosate resistance occurred in 2011 in a giant ragweed population in Rock County (Glettner et al. 2012; Stoltenberg et al. 2015). Glyphosate resistance was subsequently confirmed in horseweed populations found in Jefferson County (Recker et al. 2013) and Columbia County (Recker et al. 2014). Following confirmation of glyphosate-resistant common waterhemp populations in Eau Claire and Pierce Counties (Butts and Davis 2015a, 2015b) and Palmer amaranth in Dane County (Butts and Davis 2015b, 2015c), glyphosate resistance concerns in Wisconsin have focused mostly on pigweeds (*Amaranthus spp.*). In 2015, there were 18 new reports of suspected glyphosate-resistant common waterhemp populations, bringing the total to 30 counties in which glyphosate resistance has been investigated since 2012 (Figure 1). In addition to the previously confirmed glyphosate-resistant common waterhemp in Eau Claire and Pierce Counties, molecular screening indicated glyphosate resistance in seven more counties in 2015. Glyphosate resistance in these seven cases has yet to be confirmed by whole-plant dose-response analysis at UW-Madison, but preliminary research indicates that whole-plant dose-response results are consistent with findings from molecular screening.

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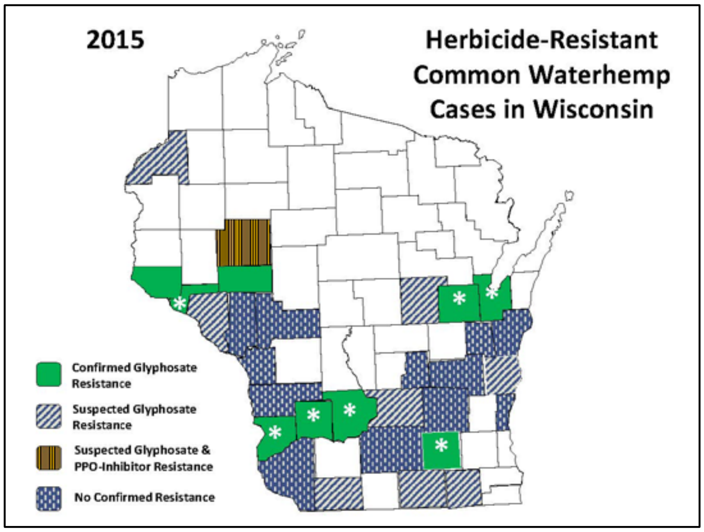

Figure 1. Herbicide-resistant common waterhemp cases in Wisconsin as of 2015. An asterisk (*) denotes that glyphosate resistance was indicated by molecular screening conducted at the University of Illinois Plant Clinic.

For example, recent results indicate that the waterhemp population from Outagamie County is 6.5-fold resistant to glyphosate compared to a known susceptible population based on ED_{50} values (Figure 2). Shoot dry biomass of the Outagamie County population was greater than that of the known susceptible population at glyphosate doses of 0.43 kg ae ha^{-1} or greater (Table 1).

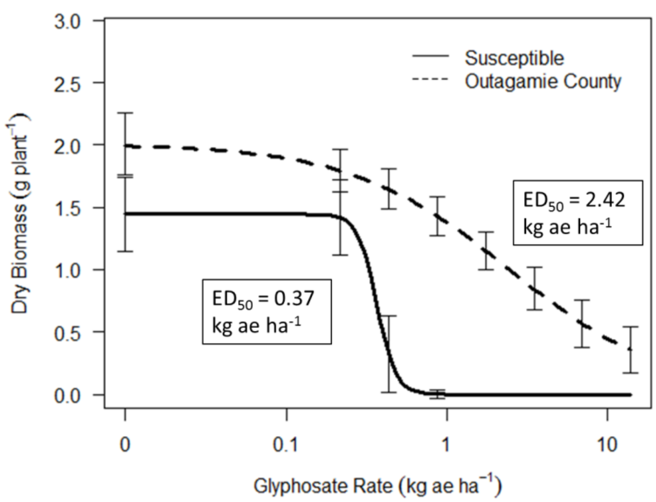

Figure 2. Shoot dry biomass of Outagamie County and known susceptible common waterhemp populations 28 days after treatment with glyphosate. Vertical bars represent standard error of mean values. The ED_{50} value is the effective glyphosate dose that reduced shoot dry biomass 50% relative to non-treated plants.

Table 1. Comparison of shoot dry biomass of Outagamie County and known susceptible common waterhemp populations 28 days after treatment with glyphosate.

	Glyphosate rate (kg ae ha^{-1})							
	0	0.22	0.43	0.87	1.74	3.48	6.96	13.92
Significance	NS	NS	***	***	**	*	***	**

NS indicates not significant
* Significant at α=0.05
** Significant at α=0.01
*** Significant at α=0.001

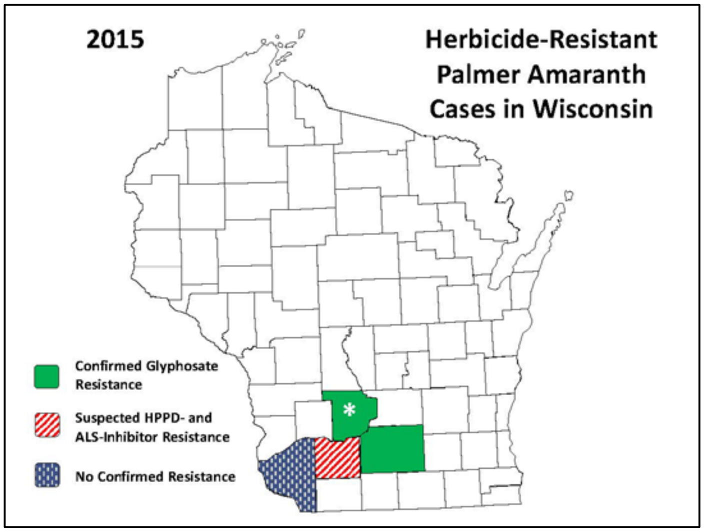

Figure 3. Herbicide-resistant palmer amaranth cases in Wisconsin as of 2015. An asterisk (*) denotes that glyphosate resistance was indicated by molecular screening conducted at the University of Illinois Plant Clinic.

In addition to the previously reported case of glyphosate-resistant Palmer amaranth in Dane County (Butts and Davis 2015b, 2015c), suspected glyphosate-resistant Palmer amaranth populations in Sauk and Grant Counties were reported in 2015 (Figure 3). Molecular screening indicated that the Sauk County population is resistant to glyphosate. Whole-plant dose-response experiments are currently being conducted at UW-Madison on the Palmer amaranth populations from Grant and Iowa Counties.

In conclusion, there were 18 new reports of suspected glyphosate-resistant common waterhemp populations in Wisconsin in 2015. To date, results from molecular screening and/or whole-plant dose-response experiments indicate that common waterhemp populations in seven of these 18 cases are resistant to glyphosate. Additional experiments are currently being conducted. It is important to note that results have shown no indication of glyphosate resistance in some suspected glyphosate-resistant common waterhemp populations, suggesting that factors other than resistance contributed to inadequate control. Even so, the high number of reports of suspected resistance is an indication of increasing abundance of common waterhemp in Wisconsin cropping systems. These developments along with confirmation of glyphosate-resistant Palmer amaranth in Wisconsin, and new reports of suspected herbicide-resistant populations of Palmer amaranth noted above, highlight the critical need for effective herbicide-resistance management.

Programs for herbicide-resistance management should consider use of all cultural, mechanical, and herbicidal options available for effective weed control in each situation and employ the following best management practices (Norsworthy et al. 2012).

1. Understand the biology of the weeds present.
2. Use a diversified approach toward weed management focused on preventing weed seed production and reducing the number of weed seed in the soil seedbank.
3. Plant into weed-free fields and then keep fields as weed free as possible.
4. Plant weed-free crop seed.

5. Scout fields routinely.
6. Use multiple herbicide mechanisms of action that are effective against the most troublesome weeds or those most prone to herbicide resistance.
7. Apply the labeled herbicide rate at recommended weed sizes.
8. Emphasize cultural practices that suppress weeds by using crop competitiveness.
9. Use mechanical and biological management practices where appropriate.
10. Prevent field-to-field and within-field movement of weed seed or vegetative propagules.
11. Manage weed seed at harvest and after harvest to prevent a buildup of the weed seedbank.
12. Prevent an influx of weeds into the field by managing field borders.

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