CURRENT STATE OF HERBICIDE RESISTANCE IN WISCONSIN

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What is Herbicide Resistance?

Resistance is defined as the inherited ability of a plant to survive and reproduce following exposure to a herbicide dose normally lethal to the wild type (WSSA, 2017). Two important points of this definition are that the resistance trait(s) must be heritable (passed on to progeny) and that the resistance response is compared to that of herbicide-susceptible plants ("the wild type").

Herbicide Resistance is a Global Problem

Herbicide resistance is an important weed management concern worldwide (Heap, 2017). Herbicide resistance is not a new problem, but has increasingly become a concern over time. The first case of herbicide resistance was confirmed in 1955. Since that time, the global occurrence of resistance has increased to 486 unique cases (weed species by herbicide site of action) by 2017, including 253 weed species with evolved resistance to one or more herbicide sites of action. Across all 486 unique cases of resistance, weeds have evolved resistance to 23 of the known 26 herbicide sites of action. Globally, ALS (acetolactate synthase) inhibitor resistance has been confirmed in the greatest number of weed species, followed by PSII (photosystem II) inhibitors, and third, ACCase (acetyl-coenzyme A carboxylase) inhibitors.

Occurrence of Herbicide Resistance is Increasing in Wisconsin

Herbicide resistance is not a new problem in Wisconsin either (Figure 1). The first confirmed case of herbicide resistance was PSII inhibitor (atrazine) resistance in common lambsquarters in 1979. Since then, 19 unique cases of herbicide resistance have been confirmed in the state, including 13 weed species with evolved resistance to one or more herbicide sites of action. Similar to that observed globally, ALS inhibitor resistance has been confirmed in more weed species than other types of herbicide resistance in Wisconsin, totaling eight weed species, most recently giant ragweed (Marion et al., 2013, 2017), common ragweed (Butts et al., 2015), and Palmer amaranth (Drewitz et al., 2016). In comparison, resistance to PSII inhibitors has been confirmed in four species (including common lambsquarters noted above). Resistance to ACCase inhibitors has been confirmed in only two species (giant foxtail and large crabgrass).

Glyphosate resistance in Wisconsin is a relatively recent occurrence compared to instances of PSII, ALS, and ACCase inhibitor resistance noted above. Glyphosate inhibits EPSP synthase (enolpyruvyl-shikimate-phosphate synthase), a key enzyme in the synthesis of aromatic amino acids. The first confirmed case of glyphosate resistance in Wisconsin occurred in 2011 in a giant ragweed population from Rock County (Glettner and Stoltenberg 2015; Stoltenberg et al., 2012). 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 resistance in waterhemp populations from Eau Claire and Pierce Counties (Butts and Davis, 2015a) and Palmer amaranth from Dane County (Butts and Davis, 2015b), glyphosate resistance concerns in Wisconsin have focused mostly on these pigweed species.

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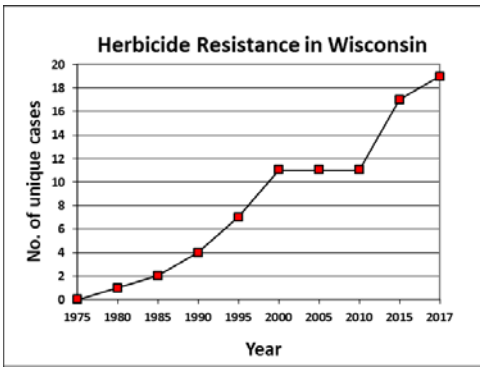

Figure 1. Herbicide resistance in Wisconsin 1975-2017. As of 2017, herbicide resistance has been confirmed in 19 unique cases (species by herbicide sites of action) including 13 weed species and a total of six herbicide sites of action.

The spread of waterhemp and Palmer amaranth has become an increasing concern in Wisconsin (Drewitz et al., 2016; Hammer et al., 2016). Both species are well-known for their competitive ability, abundant seed production, and propensity for developing herbicide resistance. Herbicide-resistant 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). In the short time since then, glyphosate resistance has been confirmed in waterhemp from 25 counties in Wisconsin (Figure 2). In addition to glyphosate resistance, multiple herbicide resistance (defined as resistance to more than one herbicide site of action) has been confirmed in waterhemp populations from four Wisconsin counties. In these instances, waterhemp was confirmed to be resistant to glyphosate and PPO (protoporphyrinogen oxidase) inhibitors (Figure 2).

Palmer amaranth is a relatively recent arrival to Wisconsin cropping systems, being documented for the first time in 2011 (Davis 2011). This population was found in a soybean production field in south-central Wisconsin (Rock County). The good news is that the Rock County population did not demonstrate resistance to any of several herbicide sites of action. However, a second Palmer amaranth population was identified in Dane County in 2013 (Davis and Recker, 2014) and was subsequently found to be resistant to glyphosate (Butts and Davis, 2015b). Since that time, glyphosate resistance has also been confirmed in a Palmer amaranth population from Sauk County (Figure 3).

As with waterhemp, multiple herbicide resistance has also been confirmed in Wisconsin Palmer amaranth (Figure 3). In this instance, a Palmer amaranth population found in Iowa County displayed resistance to ALS inhibitors (imazethapyr and thifensulfuron) and the HPPD (hydroxyphenyl pyruvate dioxygenase) inhibitor tembotrione (Drewitz et al. 2016). This population did not display resistance to glyphosate.

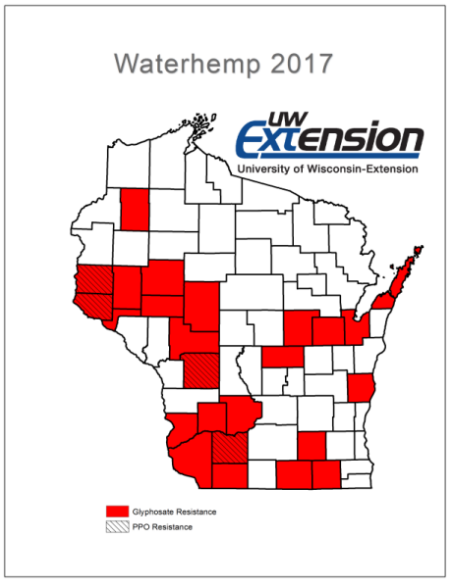

Figure 2. Confirmed herbicide resistance in waterhemp totaling 25 counties in Wisconsin as of 2017. Resistance was confirmed at UW-Madison and/or the University of Illinois Plant Clinic.

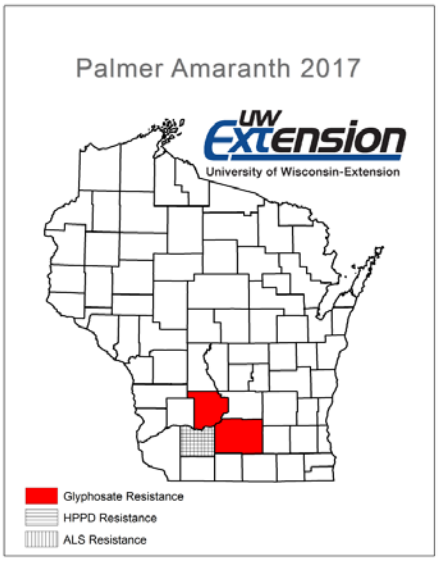

Figure 3. Confirmed herbicide resistance in Wisconsin Palmer amaranth as of 2017. Resistance was confirmed at UW-Madison and/or the University of Illinois Plant Clinic.

What Lies Ahead?

The occurrence of glyphosate resistance in waterhemp, and multiple resistance to glyphosate and PPO inhibitors, has increased rapidly in Wisconsin suggesting that waterhemp will likely increase as a management concern for many growers. Instances of multiple herbicide resistance to three, four, and five herbicide sites of action in waterhemp have been confirmed in neighboring states (Heap, 2017). Although the distribution of confirmed herbicide resistance in Palmer amaranth is currently limited to three counties in southern Wisconsin, glyphosate resistance in two populations, and multiple resistance to ALS and HPPD inhibitors in another population, also has 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 (Take Action, 2017). Multiple resistance is not limited to waterhemp and Palmer amaranth. Our current research is focusing on potential multiple herbicide resistance in common ragweed and giant ragweed in Wisconsin.

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