Palmer amaranth (*Amaranthus palmeri*) confirmed glyphosate-resistant in Dane County, Wisconsin

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Introduction:

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is a highly adaptable and competitive broadleaf weed species. It is a dioecious, small seeded member of the pigweed (Amaranthaceae) family known for its prolific growth characteristics. It has exceedingly high growth and development plasticity, which elucidates the 0.21 cm per growing degree day growth rate (Horak and Loughin, 2000). Furthermore, it can produce over 250,000 seeds per female plant (Sellers et al., 2003). This intensifies the likelihood and speed that herbicide-resistant biotypes can increase in a population and transfer from one location to another through seed dispersal. Moreover, Palmer amaranth can cause significant yield loss in corn (91%) and soybean (79%) when left unmanaged (Bensch et al., 2003; Massinga et al., 2001).

Control of Palmer amaranth has become increasingly difficult due to its ability of evolving resistance to numerous herbicide sites-of-action. It has developed herbicide resistance to five different sites-of-action, with resistance to at least one site-of-action occurring in 25 states (Heap, 2014). Until now, Wisconsin had no confirmed herbicide-resistant Palmer amaranth biotypes; however increasing concerns and inquiries have become apparent. In 2012, the Late-Season Weed Escape Survey in Wisconsin Corn and Soybean Fields was initiated. One of the main objectives of this research was to identify herbicide-resistant weed species in Wisconsin and begin proactively educating growers about herbicide resistance management.

Materials and Methods:

The survey identified fields containing potential herbicide-resistant weeds through grower communication, field history, and in-field sampling. These surveys identified the first Palmer amaranth occurrence in Wisconsin (Dane County) in 2013 (Davis and Recker, 2014).

Materials and Methods continued:

To confirm herbicide resistance, a seed head from one mature plant was collected *in situ*, dried, and threshed for use in whole plant herbicide dose response bioassays. The Dane County Palmer amaranth population was screened for glyphosate resistance. Progeny were grown; and nine to ten plants per herbicide rate plus the appropriate adjuvants were sprayed when they reached four inches tall. Glyphosate (Roundup PowerMAX®) rates used for Palmer amaranth populations were 0, 0.0087 (0.22), 0.087 (2.2), 0.87 (22), and 8.7 (220) kg ae ha^{-1} (fl. oz. ac^{-1}). Plant dry biomass data were collected 28 days after application and analyzed using the dose response model package in R statistical software. Comparisons between our putative resistant and susceptible biotypes were determined by the effective herbicide dose needed to reduce plant dry biomass 50% (ED_{50}) (Knezevic et al., 2007).

Results and Discussion:

The Dane County Palmer amaranth population clearly exhibited herbicide resistance to glyphosate. This was determined by two efforts. First, leaf tissue samples were sent to Dr. Patrick Tranel at the University of Illinois where a polymerase chain reaction (PCR) technique detected a 3- to 20-fold amplification of the EPSPS gene indicating high likelihood of glyphosate resistance.

To confirm those results, a whole plant glyphosate dose response bioassay was conducted. Progeny plants from the Dane County collection were sprayed with a 0.87 kg ae ha^{-1} (22 fl. oz. ac^{-1}) rate. All plants survived and grew to an average of two times their spray date height (Figure 1) at that rate.

Due to high variance in biomass production of individual plants, dry plant biomass averages were used to compare putative resistant and susceptible ED50 estimates (Figure 2). This demonstrated an 18-fold level of glyphosate resistance validating previous results from the PCR technique.

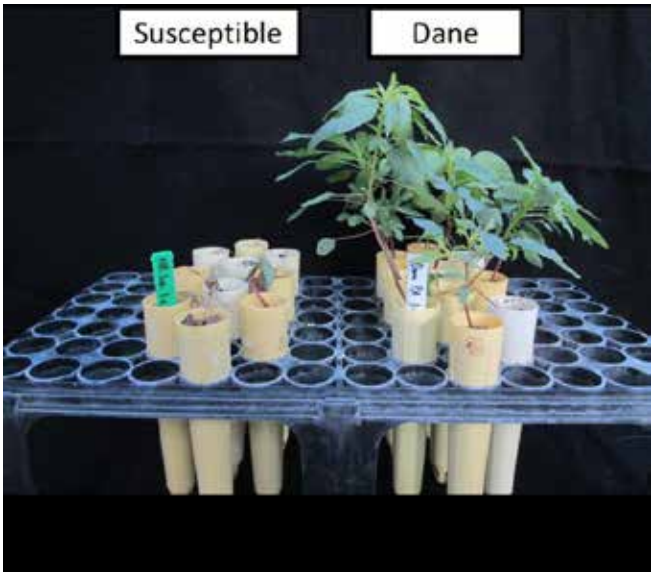

Figure 1. Comparison of ten susceptible plants versus ten Dane County Palmer amaranth plants. Pictures taken at 21 days after application.

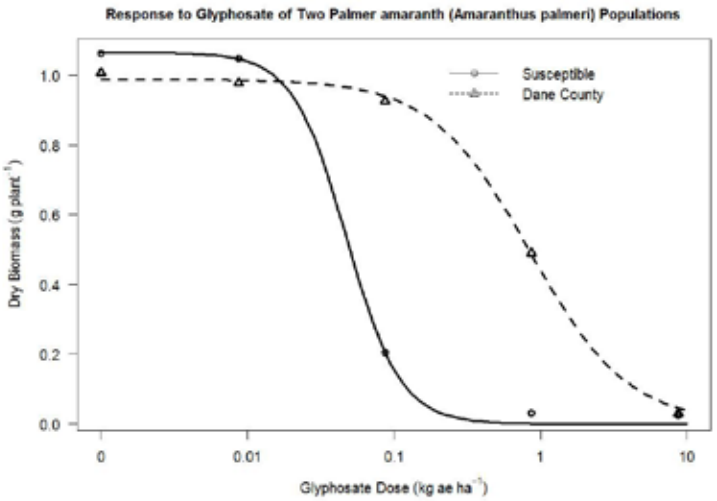

Figure 2. Glyphosate dose response models for two Palmer amaranth (*Amaranthus palmeri*) populations. A three parameter log logistic function was used for analysis.

Results and Discussion continued:

Furthermore, ANOVA showed significant differences in plant dry biomass between the Dane County and susceptible populations at the 0.087 and 0.87 kg ae ha^{-1} rates (Table 1).

Table 1. Comparison of plant dry biomass 28 days after application between the Dane County and susceptible Palmer amaranth populations at each glyphosate rate.

	Glyphosate Rate (kg ae ha^{-1})				
	0	**0.0087**	**0.087**	**0.87**	**8.7**
Significance	**NS**	**NS**	**	**	**NS**

*Significant at the P=0.05 probability level.
**Significant at the P=0.01 probability level.
***Significant at the P=0.001 probability level.

Conclusions:

In conclusion, the first occurrence of glyphosate-resistant Palmer amaranth in Wisconsin has been documented from a 2013 collection in Dane County.

There are several key components to an effective control strategy to combat herbicide-resistant weeds. The use of alternative herbicide sites-of-action and tank-mixing multiple herbicide sites-of-action will improve glyphosate-resistant weed control. An early planting date, coupled with the use of a preemergence residual herbicide, will allow crops to gain a competitive advantage over weeds. All herbicides should be applied at the correct timing, and in particular POST herbicide applications should occur when weeds are small and actively growing. To ensure the greatest efficacy, consult the herbicide label recommendations to apply before maximum weed size limits and to use appropriate rates. Furthermore, special care should be used to clean tillage and harvest equipment thoroughly as they can quickly spread weed seed among fields. The focus of these best management practices is to diversify weed control measures, reduce weed seed additions to the soil seedbank, and utilize control measures in the most effective methods possible.

For updates on Wisconsin weeds please visit the Wisconsin Crop Weed Science website at http://wcws.cals.wisc.edu/. Further information on controlling Palmer amaranth or other herbicide-resistant weeds can be found at: http://www.takeactiononweeds.com/. Finally, if you believe you may be facing herbicide-resistant weeds in your fields, please contact your local county extension agent.

References:

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