Glyphosate resistance confirmed in two Wisconsin common waterhemp (*Amaranthus rudis*) populations

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Introduction:

Common waterhemp (*Amaranthus rudis* Sauer) is an increasing threat to current agricultural production systems. Common waterhemp is a dioecious, small seeded, broadleaf weed species' known for its prolific growth characteristics and high competitive ability. It has exceedingly high growth and development plasticity, which elucidates the 0.16 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, common waterhemp can cause significant yield loss in corn (74%) and soybean (56%) when left unmanaged (Bensch et al., 2003; Steckel and Sprague, 2004).

Control of common waterhemp has become increasingly difficult due to its ability of evolving resistance to numerous herbicide sites-of-action. It has developed herbicide resistance to six different sites-of-action, with resistance to at least one site-of-action occurring in 17 states (Heap, 2014). Previously, Wisconsin had one confirmed ALS-resistant biotype of common waterhemp, but there are indications of further resistance problems throughout the state. 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. Five, ten, and six separate common waterhemp populations were identified for herbicide resistance screening in 2012, 2013, and 2014, respectively.

Materials and Methods continued:

To confirm herbicide resistance, seed heads from at least 30 mature plants were collected in situ, dried, and threshed for use in whole plant herbicide dose response bioassays. Twelve common waterhemp populations were screened for glyphosate resistance. Progeny were grown; and seven to ten plants per herbicide rate plus the appropriate adjuvants were sprayed when they reached four inches tall. Glyphosate (Roundup PowerMAX®) rates used for common waterhemp populations were 0, 0.22 (5.5), 0.43 (11), 0.87 (22), 1.74 (44), 3.48 (88), and 6.96 (176) 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 90% (ED_{90}) (Knezevic et al., 2007). Two separate screenings were conducted to confirm resistance in the common waterhemp populations.

Results and Discussion:

Two Wisconsin common waterhemp populations from Eau Claire and Pierce Counties clearly exhibited resistance to glyphosate. Progeny plants from the Eau Claire County collection were sprayed at the 0.87 kg ae ha^{-1} (22 fl. oz. ac^{-1}) rate. All plants survived and grew to an average of six times their spray date height at that rate. At the 1.74 kg ae ha^{-1} (44 fl. oz. ac^{-1}) rate, 95% survived and grew to an average of five times their spray date height (Figure 1) at that rate. The glyphosate ED_{90} for the Eau Claire County and susceptible populations was 3.91 and 0.40 kg ae ha^{-1}, respectively (Figure 2). This indicated a 10-fold level of glyphosate resistance in the Eau Claire County population.

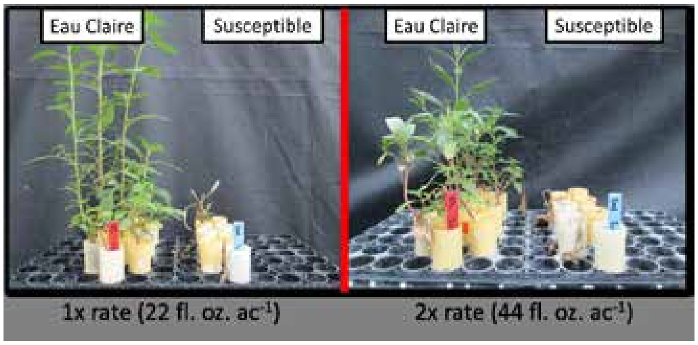

Figure 1. Comparison of ten Eau Claire County common waterhemp versus seven susceptible plants. Pictures taken at 14 days after application.

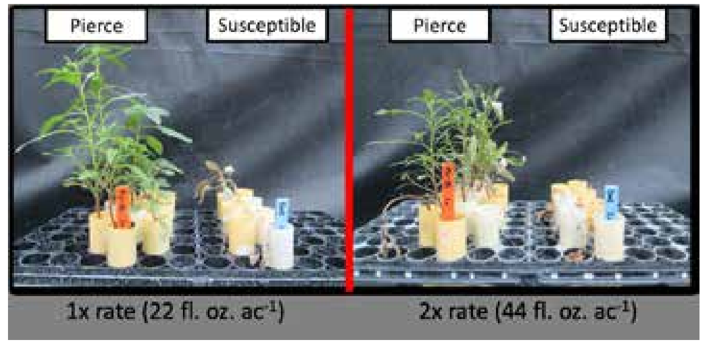

Figure 3. Comparison of ten Pierce County common waterhemp versus seven susceptible plants. Pictures taken at 14 days after application.

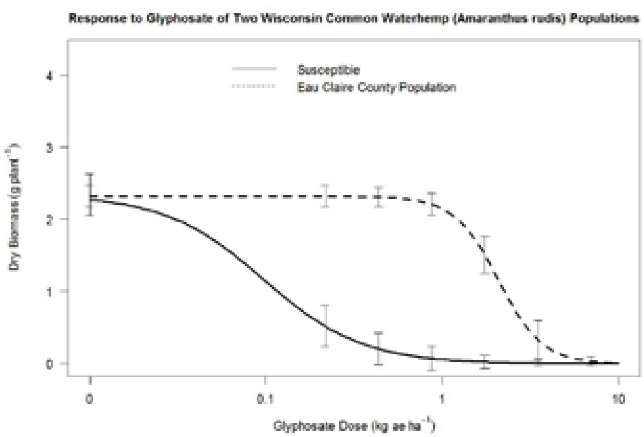

Figure 2. Glyphosate dose response models for two Wisconsin common waterhemp (*Amaranthus rudis*) populations. A three parameter log logistic function was used for analysis.

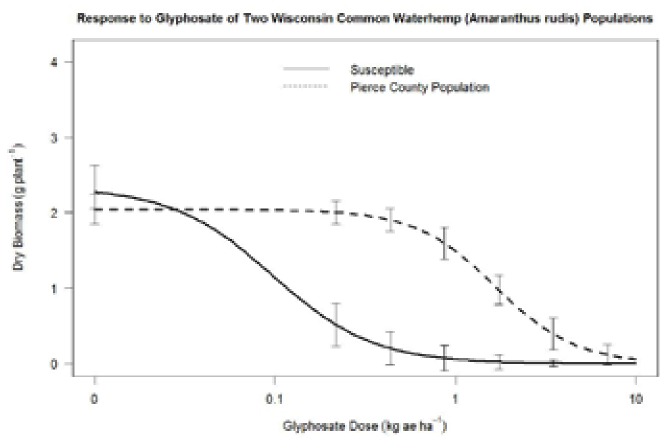

Figure 4. Glyphosate dose response models for two Wisconsin common waterhemp (*Amaranthus rudis*) populations. A three parameter log logistic function was used for analysis.

Results and Discussion:

Progeny plants from the Pierce County collection were sprayed at the 0.87 kg ae ha^{-1} (22 fl. oz. ac^{-1}) rate. All plants survived and grew to an average of six times their spray date height at that rate. At the 1.74 kg ae ha^{-1} (44 fl. oz. ac^{-1}) rate, 85% survived and grew to an average of four times their spray date height (Figure 3) at that rate. The glyphosate ED_{90} for the Pierce County and susceptible populations was 5.15 and 0.40 kg ae ha^{-1}, respectively (Figure 4). This indicated a 13-fold level of glyphosate resistance in the Pierce County population.

Conclusions:

In conclusion, two Wisconsin common waterhemp populations from Eau Claire and Pierce Counties have been documented as glyphosate-resistant with 10- and 13-fold levels of resistance, respectively.

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.

Conclusions continued:

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 taken 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 method possible.

For updates on Wisconsin weeds please visit the Wisconsin Crop Weed Science website at http://wcws.cals.wisc.edu/. Further information on controlling common waterhemp 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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