Late season weed escape survey identifies increasing numbers of herbicide-resistant *Amaranthus spp.* in Wisconsin

Thomas R. Butts, Ross A. Recker, & Vince M. Davis

Abstract

Herbicide-resistant weeds are a significantly increasing threat to current agricultural production systems. Pigweeds (*Amaranthus spp.*), specifically common waterhemp (*Amaranthus rudis Sauer*) and Palmer amaranth (*Amaranthus palmeri S. Wats.*), account for a large portion of these current challenges in the United States. These two weed species have developed herbicide resistance to more than five different sites-of-action, with resistance to at least one site-of-action occurring in 32 states. Wisconsin currently has 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 was to identify potential herbicide-resistant weeds. Fields containing potential herbicide-resistant weeds were identified through grower communication, field history, and in-field sampling. Five, ten, and six separate common waterhemp populations were identified as potentially herbicide-resistant in 2012, 2013, and 2014, respectively. Moreover, these surveys helped identify the first case of Palmer amaranth occurrence in Wisconsin in 2013, and identified a second population in 2014, both with suspected herbicide resistance. Twelve common waterhemp populations were tested for glyphosate resistance. Currently, one Palmer amaranth population is being screened for glyphosate resistance, while the second population is being screened for multiple resistances to glyphosate, tembotrione, and cloransulam-methyl herbicides. To screen for herbicide

resistance, seed heads from all populations were collected, dried, and threshed for use in whole plant herbicide dose response bioassays. Progeny were grown, and seven to ten plants per herbicide rate plus the appropriate adjuvants were sprayed when four inches tall. Glyphosate rates used for common waterhemp were 0, 0.22, 0.43, 0.87, 1.74, 3.48, and 6.96 kg ae ha^{-1}. Glyphosate rates used for Palmer amaranth were 0, 0.0087, 0.087, 0.87, and 8.7 kg ae ha^{-1}. Tembotrione rates used were 0, 0.023, 0.046, 0.092, 0.184, 0.368, and 0.736 kg ae ha^{-1}. Cloransulam-methyl rates used were 0, 0.00018, 0.0018, 0.018, 0.18, 1.8, and 9 kg ae ha^{-1}. For common waterhemp, two separate screenings were conducted, and plant dry biomass data were collected 28 days after application. The effective glyphosate dose needed to reduce plant dry biomass 90% (ED_{90}) was determined for the putative resistant and susceptible biotypes. Common waterhemp populations from Eau Claire and Pierce Counties in Wisconsin were confirmed glyphosate-resistant. The ED_{90} values for the Eau Claire County, Pierce County, and susceptible populations were 3.91, 5.16, and 0.40 kg ae ha^{-1}, respectively. This indicated a 10-fold resistance for the Eau Claire County population and a 13-fold resistance for the Pierce County population. Preliminary results for the Palmer amaranth populations from Dane and Iowa Counties in Wisconsin illustrate high potential for herbicide resistance. Visual control ratings were below 90% for the Iowa County population at both the 0.092 kg ae ha^{-1} rate and 0.018 kg ae ha^{-1} rate of tembotrione and cloransulam-methyl, respectively. Furthermore, visual control ratings of the Dane County population were below 90% and all ten plants survived the 0.87 kg ae ha^{-1} glyphosate rate. Further research will be conducted on the Palmer amaranth populations to investigate potential resistance within the state of Wisconsin.

Late season weed escape survey identifies increasing numbers of herbicide-resistant *Amaranthus spp.* in Wisconsin

Thomas R. Butts[1], Ross A. Recker[2], and Vince M. Davis[1]

University of Wisconsin-Madison[1], Monsanto Company[2]

Introduction

Herbicide-resistant weeds pose a significant threat to current agricultural production systems. Common waterhemp (*Amaranthus rudis Sauer*) and Palmer amaranth (*Amaranthus palmeri S. Wats.*) have established themselves at the forefront of this growing problem. The *Late Season Weed Escape Survey in Wisconsin Corn and Soybean Fields* aimed to identify these potential threats.

Objectives

- Identify potential herbicide-resistant common waterhemp and Palmer amaranth in Wisconsin
- Provide information on herbicide-resistant weed management to assist Wisconsin growers with weed management strategies

Materials & Methods

- Fields containing potential herbicide-resistant weeds were identified through grower communication, field history, and in-field sampling.
- Seed heads were collected, dried, and threshed for use in whole plant herbicide dose response bioassays.
- 12 common waterhemp populations and one Palmer amaranth population were screened for glyphosate resistance.
- A second Palmer amaranth population was screened for multiple resistances to glyphosate, tembotrione, and cloransulam-methyl herbicides.
- Progeny were grown, and seven to ten-plants per herbicide rate plus the appropriate adjuvants were sprayed when four inches tall.
- Visual control ratings and plant heights were taken once a week for four weeks after application for both the common waterhemp and Palmer amaranth screenings.
- Plant dry biomass data were collected 28 days after application for the common waterhemp populations. The effective glyphosate dose needed to reduce plant dry biomass 90% (ED_{90}) was determined for the putative resistant and susceptible biotypes.

Table 1. Rate structure used for each herbicide and weed species.

Weed	Herbicide	Rate						
		1	2	3	4	5	6	7
		kg ai (ae) ha^{-1}						
AMATA[a]	glyphosate	0	0.22	0.43	0.87	1.74	3.48	6.96
AMAPA[b]	glyphosate	0	0.0087	0.087	0.87	8.7	—	—
AMAPA	tembotrione	0	0.023	0.046	0.092	0.184	0.368	0.736
AMAPA	cloransulam-methyl	0	0.00018	0.0018	0.018	0.18	1.8	9

[a]Abbreviation: AMATA, *Amaranthus rudis,* common waterhemp
[b]Abbreviation: AMAPA, *Amaranthus palmeri,* Palmer amaranth

Results

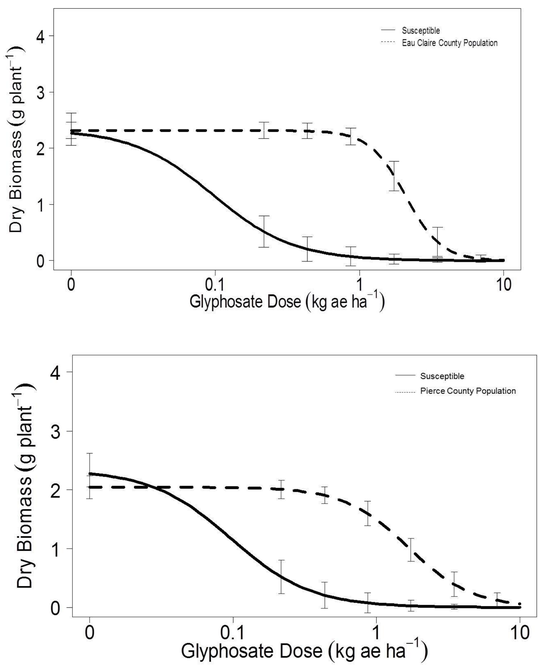

Fig. 2. Response to glyphosate of susceptible vs. Eau Claire County (top) and Pierce County (bottom), WI common waterhemp populations.

Table 2. Comparison of Palmer amaranth plants alive and average heights (cm) at 28 DAA across rates and herbicides.

	glyphosate						tembotrione				cloransulam-methyl			
	Dane County Population		Iowa County Population		Susceptible Population		Iowa County Population		Susceptible Population		Iowa County Population		Susceptible Population	
Rate[a]	P.A.[b]	H[c]	P.A.	H	P.A.	H	P.A.	H	P.A.	H	P.A.	H	P.A.	H
1	10	29.2	10	39.7	10	32.1	10	37.1	10	21.5	9	20.5	9	17.7
2	10	27.6	10	43.5	10	32.6	10	41.4	10	20.6	10	36.3	10	31.1
3	9	23.8	7	15.5	8	9.7	9	14.2	2	2.6	10	37.3	10	32.1
4	9	14	0	0	1	0.6	4	6.1	0	0	10	37.7	10	22.8
5	2	2	0	0	0	0	0	0	0	0	10	30.0	8	8.8
6	—	—	—	—	—	—	0	0	0	0	8	12.2	4	4.1
7	—	—	—	—	—	—	0	0	0	0	7	7.7	5	4.4

[a]Specific rates used can be found in Table 1. [c]Abbreviation: H, Average Height (cm)
[b]Abbreviation: P.A., Plants Alive

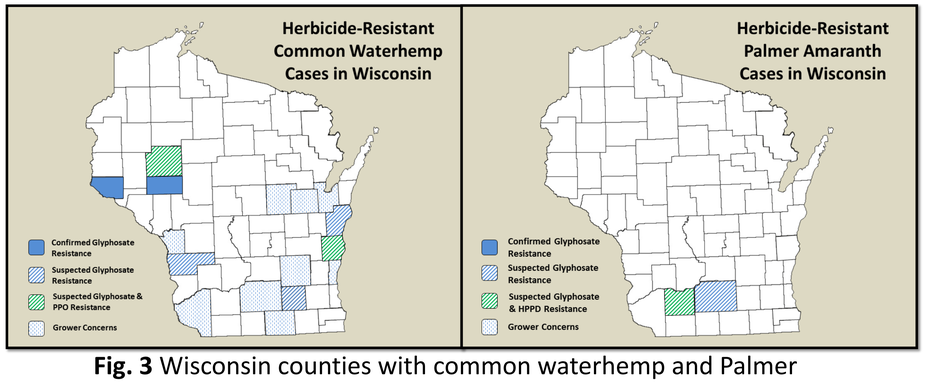

Fig. 3 Wisconsin counties with common waterhemp and Palmer amaranth herbicide resistance concerns identified through the survey.

Conclusions

Two Wisconsin common waterhemp populations were confirmed glyphosate-resistant. The ED_{90} values for Pierce County, Eau Claire County, and susceptible populations were 5.16 (*P=0.0267*), 3.91 (*P=0.0172*), and 0.40 kg ae ha^{-1}, respectively. This indicates the Pierce and Eau Claire County populations were 13-fold and 10-fold glyphosate-resistant, respectively. Preliminary Palmer amaranth data show indications of glyphosate, tembotrione, and cloransulam-methyl resistance in Wisconsin. As shown in Table 2, numerous plants survived recommended rates of each herbicide and grew taller than the susceptible population. More research will be conducted on the Palmer amaranth populations to further investigate the herbicide resistance potential.

Thank you to the Wisconsin Corn Promotion Board and United Soybean Board for funding this research, as well as the graduate and undergraduate research assistants who aided in this project.