

## Update on Herbicide Resistance in Wisconsin and Proactive Late-Season Weed Escape Survey Efforts<sup>1</sup>

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### Introduction

The potential increase of glyphosate-resistant weeds is a major threat to corn and soybean production across the nation and in Wisconsin. There are 14 glyphosate-resistant weeds confirmed in the United States, five of which occur in states that border Wisconsin (Heap 2012). A southern Wisconsin population of giant ragweed (*Ambrosia trifida* L.) was confirmed to be glyphosate-resistant and announced at this conference one year ago (Stoltenberg et al. 2012). Additionally, a different Wisconsin population of giant ragweed was also recently confirmed as resistant to cloransulam-methyl<sup>3</sup>. Integrated weed management tactics, including the use of multiple effective modes-of-action (MOA) against troublesome weeds are important to delay the onset of glyphosate resistance (Norsworthy et al. 2012). Identifying geographies that may be most vulnerable to glyphosate resistance development could help direct attention and pro-active resistance management tactics before wide-scale control failures occur (Davis et al. 2008). The objective of the late-season weed escape survey is to identify areas of Wisconsin for potential shifts to weeds that are more difficult to control with glyphosate and areas where glyphosate resistant weeds may first appear.

### Materials and Methods

An on-line survey was distributed to Wisconsin producers in June 2012 to generate sample locations with known crop history, herbicide use, tillage practices, and problematic weeds. The on-line survey was followed with an in-field survey of late-season weed escapes in corn and soybean fields throughout Wisconsin during late-July through early-September. The fields sampled were chosen from on-line survey participants that provided their contact information and agreed to participate. In-field sampling procedures were similar to methods previously described by Thomas (1985). The surveyor walked 100 paces along the edge of the field and then 100 paces into the field. From there, an inverted W pattern was followed, and individual weeds were counted at five, one m<sup>2</sup> quadrats evenly spaced along each arm of the W for a total of 20 quadrats per field. The spacing and angles were achieved by the surveyor walking 14 meters parallel to a row, followed by 14 meters perpendicular to a row, resulting in quadrats spaced approximately 20 m apart. Frequency data were calculated for each weed species according to Equation 1.

$$\text{Equation [1]} \quad \text{Frequency} = \frac{\text{number of fields where species occurred}}{\text{number of fields sampled}} \times 100$$

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<sup>1</sup> Funded by Wisconsin Corn Promotion Board

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Data are grouped separately by crop (corn or soybean), tillage (full, reduced, or no-till), and region based on National Agricultural Statistics Service (NASS) reporting districts described in Table 1. The tillage categories used are defined by the Conservation Technology Information Center (CTIC) [<http://www.ctic.purdue.edu/CTIC%20HOME/>]. The differences in frequency were subject to either a chi-square test or Fisher's exact test. Fisher's exact test was used when the expected weed species frequency was less than 5, and therefore chi-square may not have been a valid test.

Table 1. Region definitions based on NASS reporting districts

Region	NASS District
North Central (NC)	20
West (W)	40 & 70
Central (C)	50
South Central (SC)	80
East (E)	60 & 90

## Results & Discussion

There were responses describing 167 fields from the on-line survey. Problematic weeds as indicated by the survey respondents are presented in Table 2. Only weeds that were reported as the most problematic for five or more fields are shown for brevity. The problematic weeds reported most often were common lambsquarters, foxtail species (primarily giant and yellow), velvetleaf, giant ragweed, and pigweed species (primarily redroot pigweed and waterhemp).

Table 2. Problematic weeds as indicated by on-line survey respondents.

Common Name	Number of responses	Percentage of fields
Common lambsquarters	127	76.0%
Foxtails	90	53.9%
Velvetleaf	72	43.1%
Giant ragweed	57	34.1%
Pigweeds	51	30.5%
Yellow nutsedge	49	29.3%
Common ragweed	45	26.9%
Dandelion	23	13.8%
Crabgrass	19	11.4%
Quackgrass	18	10.8%
Woolly cupgrass	15	9.0%
Thistles	13	7.8%
Wild proso millet	13	7.8%
Common chickweed	12	7.2%
White cockle	9	5.4%
Fall panicum	7	4.2%
Curly dock	6	3.6%

The in-field survey consisted of sampling 151 fields. The number of fields in each categorical variable is displayed in Table 3. Sixty-four different weed species were documented in total, of which, 43 were broadleaf species and 21 were grass species or plants resembling grass species. The weeds that had the highest frequency in all fields sampled were common lambsquarters (58.3%), dandelion (57.6%), velvetleaf (32.5%), giant foxtail (24.5%), and yellow foxtail (22.5%). The frequencies of weed species found are summarized by crop, tillage practice, and region in Tables 4, 5, and 6, respectively. To be concise, only weeds that occurred in five or more fields of the total number of sampled fields are shown in Tables 4 – 6.

Table 3. The number of fields surveyed by crop, tillage practice, and region.

Fields Surveyed	Crop		Tillage Practice <sup>1</sup>			Region				
	Corn	Soybean	Full <sup>2</sup>	Reduced <sup>3</sup>	No-till <sup>4</sup>	NC	W	C	E	SC
	88	63	77	25	43	22	38	28	29	34

<sup>1</sup> Fields in which tillage was undetermined were not included

<sup>2</sup> Full: < 15% residue at planting

<sup>3</sup> Reduced: 15% to 30% residue at planting

<sup>4</sup> No-till: > 30% residue at planting

Table 4. Frequency of weeds that occurred in five or more fields displayed by crop. The statistics indicate whether weed presence was correlated with crop type.

Common Name	Type <sup>1</sup>	Weed frequency by crop			Chi-square test <sup>2</sup>
		Total	Corn	Soybean	
		----- % -----			P-Value <sup>3</sup>
Common lambsquarters	B	58.3	61.4	54.0	0.3635
Dandelion	B	57.6	61.4	52.4	0.2707
Velvetleaf	B	32.5	34.1	30.2	0.6108
Giant foxtail	G	24.5	30.7	15.9	<b>0.0370</b> **
Yellow foxtail	G	23.2	29.6	14.3	<b>0.0284</b> **
Yellow nutsedge	G	22.5	22.7	22.2	0.9416
Fall panicum	G	21.2	33.0	3.0	<b>&lt;0.0001</b> ****
Common ragweed	B	17.9	15.9	20.6	0.4549
Black nightshade	B	17.9	18.2	17.5	0.9092
Volunteer corn	G	15.2	8.0	25.4	<b>0.0033</b> ***
Large crabgrass	B	13.3	19.3	4.8	<b>0.0093</b> ***
Quackgrass	G	13.3	21.6	1.6	<b>0.0003</b> ****
Barnyardgrass	G	11.9	14.8	7.9	0.2011
Wild proso millet	G	11.9	15.9	6.4	<b>0.0738</b> *
Lady's thumb smartweed	B	11.3	8.0	15.9	0.1290
Green foxtail	G	11.3	13.6	7.9	0.2745
Redroot pigweed	B	9.9	11.4	7.9	0.4875
Giant ragweed	B	9.9	6.8	14.3	0.1303
Shepherd's-purse	B	9.3	12.5	4.8	0.1060
Common waterhemp	B	8.6	5.7	5.3	0.1296
Woolly cupgrass	G	8.6	11.4	4.8	0.1538
Smooth crabgrass	G	8.0	9.1	6.4	0.5391
Yellow woodsorrel	B	8.0	9.1	6.4	0.5391
					----- Fisher's exact test <sup>2</sup> -----
Broadleaf plantain	B	7.3	10.2	3.2	0.1221
Prostrate knotweed	B	6.6	6.8	6.4	1.0000
Wild buckwheat	B	6.0	3.4	9.5	0.1651
Smooth pigweed	B	5.3	8.0	1.6	0.1399
White clover	B	4.6	3.4	6.4	0.4517
Field bindweed	B	4.6	8.0	0.0	<b>0.0418</b> **
White cockle	B	4.0	4.6	3.2	1.0000
Eastern black nightshade	B	4.0	4.6	3.2	1.0000
Common chickweed	B	3.3	4.6	1.6	0.4013
Common milkweed	B	3.3	2.3	4.8	0.6497
Common burdock	B	3.3	5.7	0.0	<b>0.0755</b> *
All weeds		95.4	96.6	93.7	0.4517

<sup>1</sup> Type of weed: B=broadleaf species, G= grass species or plants resembling grass species

<sup>2</sup> P-Value Significance: 0 to 0.001 = '\*\*\*\*'; 0.001 to 0.01 = '\*\*\*'; 0.01 to 0.05 = '\*\*'; 0.05 to 0.1 = '\*'

<sup>3</sup> A significant p-value indicates a correlation between weed species frequency and crop type.

Table 5. Frequency of weeds that occurred in five or more fields, separated by tillage. The statistics indicate whether weed presence was correlated with tillage.

Common Name	Type <sup>1</sup>	Weed frequency by tillage			Chi-square test <sup>2</sup>
		Full	Reduced	No-till	
		----- % -----			P-Value <sup>3</sup>
Common lambsquarters	B	53.3	76.0	53.5	0.1140
Dandelion	B	59.7	52.0	51.2	0.6047
Velvetleaf	B	35.1	28.0	25.6	0.5248
Giant foxtail	G	22.1	24.0	30.2	0.6083
Yellow foxtail	G	16.9	36.0	27.9	0.1044
Yellow nutsedge	G	28.6	8.0	23.3	0.1080
Fall panicum	G	26.0	12.0	20.9	0.3347
Common ragweed	B	16.9	24.0	16.3	0.6829
Black nightshade	B	13.0	32.0	16.3	<b>0.0898</b> *
Volunteer corn	G	14.3	8.0	23.3	0.2163
Large crabgrass	B	11.7	28.0	9.3	<b>0.0721</b> *
Quackgrass	G	16.9	12.0	9.3	0.4928
Barnyardgrass	G	16.9	12.0	4.7	0.1494
Wild proso millet	G	7.8	24.0	14.0	<b>0.0957</b> *
					Fisher's exact test <sup>2</sup>
Lady's thumb smartweed	B	11.7	16.0	4.7	0.2783
Green foxtail	G	6.5	16.0	14.0	0.2071
Redroot pigweed	B	13.0	0.0	9.3	0.1743
Giant ragweed	B	9.1	0.0	16.3	<b>0.0754</b> *
Shepherd's-purse	B	16.9	4.0	0.0	<b>0.0035</b> ***
Common waterhemp	B	6.5	8.0	14.0	0.3842
Woolly cupgrass	G	3.9	24.0	9.3	<b>0.0126</b> **
Smooth crabgrass	G	5.2	24.0	2.3	<b>0.0055</b> ***
Yellow woodsorrel	B	6.5	16.0	2.3	<b>0.1000</b> *
Broadleaf plantain	B	11.7	4.0	2.3	0.1647
Prostrate knotweed	B	7.8	0.0	7.0	0.5208
Wild buckwheat	B	9.1	0.0	0.0	<b>0.0504</b> *
Smooth pigweed	B	6.5	8.0	2.3	0.6230
White clover	B	5.2	4.0	4.7	1.0000
Field bindweed	B	3.9	4.0	7.0	0.8676
White cockle	B	5.2	4.0	2.3	0.8579
Eastern black nightshade	B	6.5	0.0	2.3	0.3912
Common chickweed	B	2.6	4.0	4.7	0.8422
Common milkweed	B	0.0	0.0	11.6	<b>0.0031</b> ***
Common burdock	B	2.6	0.0	7.0	0.3844
All weeds		96.1	100.0	90.7	0.2756

<sup>1</sup> Type of weed: B=broadleaf species, G= grass species or plants resembling grass species

<sup>2</sup> P-Value Significance: 0 to 0.001 = '\*\*\*\*'; 0.001 to 0.01 = '\*\*\*'; 0.01 to 0.05 = '\*\*'; 0.05 to 0.1 = '\*'

<sup>3</sup> A significant p-value indicates a correlation between weed species frequency and tillage.

Table 6. Frequency of weeds that occurred in five or more fields, separated by region. The statistics indicate whether weed presence was correlated with region.

Common Name	Type <sup>1</sup>	Weed frequency by region					Chi-square test <sup>2</sup>
		NC	W	C	E	SC	
		----- % -----					P-value <sup>3</sup>
Common lambsquarters	B	63.6	55.3	60.7	55.2	58.8	0.9642
Dandelion	B	77.3	55.3	53.6	58.6	50.0	0.3338
Velvetleaf	B	31.8	26.3	7.1	55.2	41.2	<b>0.0021</b> ***
Giant foxtail	G	13.6	29.0	10.7	37.9	26.5	0.1080
Yellow foxtail	G	18.2	21.1	28.6	20.7	26.5	0.8830
Yellow nutsedge	G	27.3	26.3	17.9	13.8	26.5	0.6415
Fall panicum	G	22.7	23.7	14.3	14.3	26.5	0.7706
Common ragweed	B	13.6	2.6	32.1	27.6	17.7	<b>0.0171</b> **
Black nightshade	B	4.6	15.8	32.1	27.6	8.8	<b>0.0340</b> **
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							Fisher's exact test <sup>2</sup>
Volunteer corn	G	4.6	18.4	7.1	31.0	11.8	<b>0.0669</b> *
Large crabgrass	B	9.1	15.8	28.6	3.5	8.8	<b>0.0718</b> *
Quackgrass	G	31.8	13.2	10.7	3.5	11.8	<b>0.0776</b> *
Barnyardgrass	G	22.7	2.6	14.3	6.9	17.7	<b>0.0853</b> *
Wild proso millet	G	4.6	5.3	17.9	10.3	20.6	0.2020
Lady's thumb smartweed	B	13.6	5.3	14.3	20.7	5.9	0.2541
Green foxtail	G	0.0	2.6	3.6	24.1	23.5	<b>0.0011</b> ***
Redroot pigweed	B	31.8	10.5	3.6	3.6	8.8	<b>0.0041</b> ***
Giant ragweed	B	0.0	26.3	0.0	0.0	14.7	<b>0.0001</b> ****
Shepherd's-purse	B	22.7	2.6	3.6	10.3	11.8	<b>0.0944</b> *
Common waterhemp	B	4.6	10.5	0.0	10.3	14.7	0.2545
Woolly cupgrass	G	0.0	5.3	10.7	17.2	8.8	0.2529
Smooth crabgrass	G	18.2	2.6	21.4	3.5	0.0	<b>0.0022</b> ***
Yellow woodsorrel	B	9.1	7.9	14.3	3.5	5.9	0.6619
Broadleaf plantain	B	31.8	0.0	0.0	10.3	2.9	<b>&lt;0.0001</b> ****
Prostrate knotweed	B	4.6	5.3	3.6	10.3	8.8	0.8486
Wild buckwheat	B	13.6	0.0	14.3	6.9	0.0	<b>0.0104</b> **
Smooth pigweed	B	0.0	2.6	3.6	13.8	5.9	0.2678
White clover	B	9.1	5.3	7.1	0.0	2.9	0.5466
Field bindweed	B	0.0	0.0	0.0	6.9	14.7	<b>0.0104</b> **
White cockle	B	0.0	2.6	3.6	6.9	5.9	0.8125
Eastern black nightshade	B	13.6	2.6	0.0	3.5	2.9	0.2011
Common chickweed	B	4.6	7.9	0.0	0.0	2.9	0.3774
Common milkweed	B	0.0	2.6	0.0	3.5	8.8	0.4194
Common burdock	B	4.6	5.3	0.0	0.0	5.9	0.5912
All weeds		95.5	92.1	100.0	93.1	97.1	0.6232

<sup>1</sup> Type of weed: B=broadleaf species, G= grass species or plants resembling grass species

<sup>2</sup> P-Value Significance: 0 to 0.001 = '\*\*\*\*'; 0.001 to 0.01 = '\*\*\*'; 0.01 to 0.05 = '\*\*'; 0.05 to 0.1 = '\*'

<sup>3</sup> A significant p-value indicates a correlation between weed species frequency and region.

**Crop:** Weed species which were correlated with crop type ( $\alpha = .1$ ) were found more often in corn with the exception of volunteer corn found in soybean. Seven of those nine species associated most often with corn were grass weed species. Interestingly, giant ragweed was the 11<sup>th</sup> most often found weed in soybean fields, but it was only the 25<sup>th</sup> most frequently found weed species in corn fields.

**Tillage:** Six of the ten weed species which were correlated with tillage type ( $\alpha = .1$ ) were more often found in fields where reduced tillage practices were used. On the contrary, giant ragweed frequency was dependent on tillage practice and occurred in 9.1%, 0%, and 16.3% of full, reduced, and no-till fields, respectively.

**Region:** Velvetleaf frequency was correlated to region and was highly variable ranging from 55.2% in the east region to 7.1% in the central region. Common ragweed was found least often in the west region (2.6%), and most often in the central (32.1%) and east regions (27.6%). Redroot pigweed occurred in 31.8% of fields sampled in the north central region. Giant ragweed escapes were only found in the west and south central regions with 26.3 and 14.7%, respectively.

#### Summary of 2012 results

It is likely that late-season weed escapes were present in 2012 Wisconsin corn and soybean fields for a variety of reasons. Several of those reasons may be attributed to droughty weather conditions. A lack of rainfall in 2012 resulted in poor herbicide performance in many systems. This includes inadequate soil moisture for soil applied herbicide activity, inadequate vegetative crop growth causing slow canopy closure to aid weed suppression, and a deficient in postemergence herbicide translocation of systemic herbicides like glyphosate created by low moisture conditions. These results will be further analyzed for correlation to herbicide resistance indication factors, and these late-season weed survey efforts will continue in the late-summer of 2013. If you did not participate in 2012 but would be willing to participate in 2013, please contact us at [recker@wisc.edu](mailto:recker@wisc.edu) or [ymdavis@wisc.edu](mailto:ymdavis@wisc.edu).

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