Resisting Resistance

Vince Davis, University of Wisconsin-Madison
vmdavis@wisc.edu
(608) 262-1392
Herbicide Resistance

What’s the Big Deal?
What’s the big deal?

Thoughts to consider:

• It’s not on my farm,.............it’s not my problem

• If I get it,.....................someone (industry) will give me new tools to fix it
What’s the Big Deal?

No new herbicide Modes-of-Action in the last 20 years
  • last new MOA was HPPD’s

Increasing concern and lack of availability of older herbicides (i.e. atrazine)
Why have no new herbicide modes of action appeared in recent years?

1. Glyphosate-Resistant (GR) crops have reduced the market potential for a new herbicide
2. GR crops led to significantly diminished herbicide discovery efforts
3. Company consolidations
4. The availability of more ‘generic’ herbicides
5. The best herbicide molecular target sites may have already been discovered

What is Resistance? Definitions

**Susceptibility:**
Plant injury/death caused by a herbicide at acceptable use rates – the inherent plant response to a herbicide

**Tolerance:**
The ability of a plant population to remain uninjured at the herbicide at acceptable use rates – *the inherent lack of plant response* to a herbicide

**Resistance:**
The *change in a plant population* from a population that is initially predominantly susceptible to a population that is predominantly “tolerant” – the loss of effectiveness of a herbicide due to the evolution of resistance in a weed population
Definitions

Resistance:
The change in a plant population from a population that is initially predominantly susceptible to a population that is predominantly “tolerant” – the loss of effectiveness of a herbicide due to the evolution of resistance in a weed population.

Cross Resistance:
Resistance develops to two or more herbicides with the same mode of action.

Multiple Resistance:
Resistance develops to two or more herbicides from different chemical families with different modes of action.
How do weeds become resistant?

A population equilibrates that exhibits...

• An altered site of action,
• Enhanced metabolism,
• Reduced uptake (foliar or root),
• Reduced translocation
  – Compartmentalization
  – Sequestration/conjugation
  – Other
• Other
Hypothetical Development of High-Level vs. Low-Level Resistance

www.weedscience.com
Timeline of herbicide resistance

• Before 1982 how many resistant weed biotypes?
  – Approx. 35 species

• Between 1982 and 1990 the number of resistant weed biotypes increased by what factor?
  – Tripled = 107 species

• From 1990 to 1995 the number of resistant weed biotypes increased by what factor?
  – Doubled = 214 species

• Presently – 372 weed species resistant to herbicides
The Chronological Increase in Unique Cases of Herbicide-Resistant Weeds Worldwide

Source: Dr. Ian Heap
http://WeedScience.com
Glyphosate-resistant weeds
Followed Glyphosate-resistant crops

Glyphosate-resistant (Roundup Ready®) released in 1996
• Clean fields were common
So what happened?

- Reduction in residual herbicide use
- Delayed postemergence herbicide applications
- No or minimal cost reductions
- Glyphosate-resistant weeds.....

Preplant residual herbicide advertisement in the 1980 (Volume 12) publication of Weeds Today
Evolving yield robbers....
Horseweed (Conyza canadensis)
Giant Ragweed
(*Ambrosia trifida*)
Common Waterhemp (*Amaranthus rudis*)

- Resistant to 5 herbicide Mode-of-Actions!
Palmer amaranth in cotton
Anyone looking for work?
Palmer amaranth (Amaranthus palmeri) is in Wisconsin Crop Production Fields.

Wisconsin Crop Manager article 10/13/11
Keep your eye on the ‘BALL’

• Not just concerned about glyphosate resistance
• Resistance to HPPD inhibitors !?!
• Callisto, Impact and Laudis
  – Newest mode of action (MOA) on market
• Latest MOA with confirmed resistance in U.S.
• HPPD resistant waterhemp in Iowa, Illinois
Resistance, what to look for

• Most of the time resistance is not detected until there is a large problem (more than one control failure)

• Early warning signs:
  – Only one weed species escapes control
  – Plants will have a wide range of response to the herbicide
    • often dead plants next to alive plants, especially look for large dead plants next to small, injured alive plants
    • Injured plants with rapid regrowth
  – Arrangement of weed escapes in the field do not match to field equipment widths
Of most concern in WI: Glyphosate-Resistant Giant Ragweed

- Others in the running
  - Lambsquarters
  - Waterhemp
  - Palmer amaranth?
  - Shattercane?
States with Confirmed Glyphosate-Resistant Giant Ragweed

Multiple resistance to glyphosate and ALS-inhibitors

(Heap 2012, www.weedscience.org)
Giant Ragweed
(*Ambrosia trifida*)
Sensitive

Noble county

0.75 lb ae/A – 21 DAT
Noble county  Sensitive
3.0 lb ae/A – 21 DAT
Is giant ragweed resistant to glyphosate in Wisconsin?
Is giant ragweed resistant to glyphosate in Wisconsin?
Rock County Giant Ragweed
July 2010
Dr. Dave Stoltenberg
Dose-Response Experiments

• Conducted under greenhouse conditions
• Grant County (GC) and Rock County (RC) giant ragweed
  – Suspected resistant (R) plants
  – Sensitive (S) plants
• Glyphosate applied at seven doses (rates) + AMS
  – 0.1 to 16.8 kg ae ha\(^{-1}\)
  – Non-treated check plants
  – 15 ± 5 cm-tall plants
• Shoot injury, height, and mass measured 4 WAT
• Experiment repeated

Dr. Dave Stoltenberg
Grant County (GC) and Rock County (RC)
Giant Ragweed Response to Glyphosate

Glyphosate dose (kg ae ha$^{-1}$)

Shoot dry mass (% of nontreated plants)

0.01 0.1 1 10 100

0
25
50
75
100
125

GC-R
GC-S
RC-R
RC-S

Shoot dry mass of non-treated plants for each accession relative to the mean of all non-treated plants

Dr. Dave Stoltenberg
Grant County (GC) and Rock County (RC)
Giant Ragweed Response to Glyphosate

Dr. Dave Stoltenberg
## Dose-Response Parameters for Giant Ragweed from Grant County (GC) and Rock County (RC)

<table>
<thead>
<tr>
<th>Accession</th>
<th>D</th>
<th>C</th>
<th>ED(_{50})</th>
<th>ED(_{50}) R:S</th>
</tr>
</thead>
<tbody>
<tr>
<td>GC-R</td>
<td>104.9 a</td>
<td>10.1 a</td>
<td>0.148 a</td>
<td>NS §</td>
</tr>
<tr>
<td>GC-S</td>
<td>96.0 a</td>
<td>9.1 a</td>
<td>0.073 a</td>
<td></td>
</tr>
<tr>
<td>RC-R</td>
<td>104.9 a</td>
<td>6.3 a</td>
<td>0.787 b</td>
<td>9.3</td>
</tr>
<tr>
<td>RC-S</td>
<td>103.7 a</td>
<td>9.4 a</td>
<td>0.085 a</td>
<td></td>
</tr>
</tbody>
</table>

\(\dagger\) D = upper asymptote  
C = lower asymptote  
ED\(_{50}\) = effective dose that reduced shoot mass by 50% relative to non-treated plants  
\(\dagger\) Means followed by the same letter do not differ at the 5% level of significance  
§NS = not significant

---

Dr. Dave Stoltenberg
Rock County Giant Ragweed
3.0 lb ae/acre glyphosate
4 WAT

Dr. Dave Stoltenberg
Rock County Giant Ragweed
3.0 lb ae/acre glyphosate
4 WAT
Of most concern in WI:
Glyphosate-Resistant Giant Ragweed

• IT IS NOW CONFIRMED!
Glyphosate-Resistant Giant Ragweed Confirmed in Wisconsin

Multiple resistance to glyphosate and ALS-inhibitors

Dr. Dave Stoltenberg
Additional site in 2011 with suspected glyphosate-resistant giant ragweed


Dr. Dave Stoltenberg
Is Wisconsin giant ragweed resistant to glyphosate?

- Grant County giant ragweed
  - Results do not suggest resistance at accession level
  - Variable response to glyphosate among plants
- Rock County giant ragweed
  - Nine-fold level of resistance to glyphosate
  - Current research determining sensitivity of enzyme target site (EPSPS) to glyphosate
- Columbia County giant ragweed
  - Seed collected in Fall 2011
  - Research initiated to determine plant response to glyphosate and ALS-inhibitors

Dr. Dave Stoltenberg
Giant ragweed management

• One-pass programs –WILL NOT WORK
• Start with clean field, Use a residual herbicide
• In soybean
  1. Use a PRE PPO + cloransulam (Authority First/Sonic; Gangster)
  2. Use a PRE PPO + imazethapyr (Authority assist, Optill) or PRE PPO + PSII (Authority MTZ or Lorox) or PRE PPO + seedling shoot inhibitor (Prefix)
• Follow all pre programs with TIMELY postemergence applications!
Giant ragweed management

• In corn
  Use a PRE triazine + acetanilide + HPPD
  Followed by: Glyphosate + .......
  HPPD and/or triazine and/or ALS and/or growth regulator (Callisto Xtra, Halex, Laudis, Capreno, Status, Northstar, Yukon)

• Spray postemergence applications TIMELY!
Giant ragweed management

- Spray postemergence applications TIMELY!

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate (per acre)</th>
<th>Giant ragweed height – Maximum (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roundup Powermax</td>
<td>22 fl oz, 32 fl oz</td>
<td>12, 18</td>
</tr>
<tr>
<td>Ignite 280</td>
<td>22 fl oz, 29 fl oz</td>
<td>6, 12</td>
</tr>
<tr>
<td>Callisto</td>
<td>3 fl oz, 24 fl oz</td>
<td>2, 10</td>
</tr>
<tr>
<td>Callisto Xtra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capreno</td>
<td>3 fl oz</td>
<td>6</td>
</tr>
<tr>
<td>Halex GT</td>
<td>3.6 pt</td>
<td>4</td>
</tr>
<tr>
<td>FirstRate</td>
<td>0.3 oz</td>
<td>10</td>
</tr>
<tr>
<td>Flexstar GT 3.5</td>
<td>3.5 pt, 4.5 pt</td>
<td>4 gly-sus, 2 gly-res, 6 gly-sus, 2 gly-res</td>
</tr>
</tbody>
</table>
Thanks for your attention!

Vince M. Davis vmdavis@wisc.edu