Institute of Ag Professionals

Proceedings of the

2005 Crop Pest Management Shortcourse

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Are populations of lambsquarters and giant ragweed becoming less sensitive to glyphosate?

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The Ohio State University
ALS-Resistant Weeds in Ohio by County
Through 2004

Legend

= amaranth, Powell (1)
= cocklebur, common (1)
= kochia (suspected) (1)
= lambsquarters, common (1)
= marestail (horseweed) (21)
= pigweed, smooth (1)
= ragweed, common (20)
= ragweed, giant (11)
= shattercane (1)
= waterhemp, common/tall (9)
1995-98 - ALS resistance gone wild

- Many species, many fields
- Some really weedy fields
- Would have become much worse

But

- Roundup Ready saves our ____
“THE COMPLEX TRANSFORMATIONS WHICH WERE REQUIRED FOR THE DEVELOPMENT OF GLYPHOSATE-TOLERANT CROPS WOULD BE UNLIKELY TO BE DUPLICATED IN NATURE TO YIELD GLYPHOSATE-RESISTANT WEEDS.”

— MONSENTO, 1995
Glyphosate-resistant marestail
Confirmed Cases of Glyphosate Resistant Marestail in IN & OH

- Counties confirmed glyphosate resistant
- Counties with no confirmed cases of glyphosate resistance OR not tested
Control of Multiple Resistant Marestail in the Field

28 DAT

Glyphosate - 1X

Glyphosate - 4X

FirstRate - 1X

FirstRate - 4X
FirstRate + glyphosate - 1X

Glyphosate + 2,4-D - 1X

FirstRate + glyphosate + 2,4-D - 1X
Glyphosate-resistant marestail in Ohio

- Developed first in continuous RR soybeans
  - Only glyphosate used
- Found following year in rotation of corn and RR soybeans
  - Only glyphosate used in soybeans
- So far, not found in fields with history of 2,4-D use in preplant burndown

- **Bottom line** - rotation away from glyphosate did not stop resistance unless another herbicide with activity on horseweed was also used
Glyphosate Resistant Weed Species

- Rigid ryegrass
  - 1996
  - Australia, South Africa, and CA
  - One biotype glyphosate, ALS, and ACCase resistant

- Goosegrass
  - Malaysia
  - Also resistant to ACCase herbicides

- Marestail/Horseweed
  - Many states East of the Mississippi River

- Italian ryegrass
  - Chile, Brazil, and OR (?)

- Hairy fleabane (closely related to marestail)
  - South Africa and Spain

- Buckhorn plantain
  - South Africa

- Common ragweed
  - 1 site in MO - also ALS resistant?
  - 10X resistant

- Palmer amaranth
  - GA and NC
  - high level of resistance

- Waterhemp
  - IA and MO
  - MO - high level
Erratic control of giant ragweed and lambsquarters in RR soybeans

Possible reasons:
- Plants too large, too old
- Some populations becoming less sensitive
- Glyphosate rates too low
- Late-emergers that escape POST treatment
- Stems infested with stalk-boring insects
- Sprayer tracks and dust
- Time of day
2001 POST – South Charleston
6-inch weeds - Roundup UMax – 20 oz
Consistency of Weed Control in Roundup Ready Soybean (6 years)
Michigan State University

1-pass program
POST (glyphosate)

2-pass program
PRE (residual) fb. POST (glyphosate)
2004 Glyphosate study - applied 1 day after cold front

<table>
<thead>
<tr>
<th></th>
<th>Lambsqtrs (% control)</th>
<th>Giant ragweed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rdup Wemax 16 oz</td>
<td>62</td>
<td>83</td>
</tr>
<tr>
<td>Rdup Wemax 22 oz</td>
<td>75</td>
<td>85</td>
</tr>
<tr>
<td>Rdup Wemax 33 oz</td>
<td>90</td>
<td>87</td>
</tr>
<tr>
<td>Rdup OriMax 16 oz</td>
<td>78</td>
<td>85</td>
</tr>
<tr>
<td>Rdup OriMax 16 oz + surfactant 0.25%</td>
<td>96</td>
<td>87</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

All applied with AMS - 17 lbs/100 gallons - 20 gpa
Lambsquarters - 2 to 3 inches tall
0.75 lb a.e. Touchdown Total on lambsquarters
Effect of surfactant rate - 4 sites
2003 Culp field study
glyphosate - 0.75 lb a.e.
4 - 6 and 10 - 12 inch plants
Glyphosate-resistant (?) lambsquarters populations

Hancock Co.
Darke Co.
Madison Co.
Morrow Co.
Sensitive
Untreated 0.75 lb ae/A 3.0 lb ae/A glyphosate
Tolerance vs Resistance vs Insensitivity

• Tolerance
  – Weed not well controlled from the start

• Resistance
  – Weed was controlled, but control decreased
  – Control failures implied
  – At least a 10X difference in response between S and R?

• Insensitivity
  – Variable control, generally more problematic
  – Difficult to determine exact reason
  – 2X to 4X difference in response between S and R
  – We should be able to affect the outcome??
Dose Response with Glyphosate on Lambsquarters

18 DAT

Untreated  1/100X  1/10X  1/4X  1X  4X  10X  100X

0.75 lb ae/A

Glyphosate
Dose Response - Common Lambsquarters to Glyphosate

- Col 1 vs Sensitive - Cos 03-04
- Col 1 vs Resistant?? - Mad 04-02F
- Col 1 vs Resistant - JC 03-04
- Col 1 vs Resistant - Han 04-04B

Sensitive - Cos 03-04 ($GR_{50} = 0.38 \text{ lb ae/A}$)
Resistant?? - Mad 04-02F ($GR_{50} = 0.72 \text{ lb ae/A}$; R/S ratio = 1.9)
Resistant - JC 03-04 ($GR_{50} = 1.25 \text{ lb ae/A}$; R/S ratio = 3.3)
Resistant - Han 04-04B ($GR_{50} = 1.52 \text{ lb ae/A}$; R/S ratio = 3.98)

Growth Reduction (% of Untreated)

Rates (X with 1X = 0.75 lb ae/A)
## Level of resistance to ALS-inhibitors and glyphosate

R/S = ratio of resistance to susceptible

<table>
<thead>
<tr>
<th>ALS resistance</th>
<th>R/S ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marestail</td>
<td>32 - 943</td>
</tr>
<tr>
<td>Common ragweed</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>Giant ragweed</td>
<td>&gt;1000</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Glyphosate resistance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Marestail</td>
<td>8 - 39</td>
</tr>
<tr>
<td>Common ragweed</td>
<td>10</td>
</tr>
<tr>
<td>Lambsquarters</td>
<td>3</td>
</tr>
</tbody>
</table>
2005 Large Plot Study Design - lambsquarters

Field length 160 ft

Roundup WeatherMax 22 oz/A

Followed By Roundup WeatherMax 44 oz/A

Followed By Roundup WeatherMax 22 oz/A

Roundup WeatherMax 44 oz/A

Followed By Roundup WeatherMax 44 oz/A

Roundup WeatherMax 44 oz/A

Followed By Roundup WeatherMax 44 oz/A

Roundup WeatherMax 22 oz/A

plus 0.25% surfactant
Lambsquarters surviving one glyphosate application
Lambsquarters surviving two glyphosate applications with seed
Hancock County - 2005

1 application
0.75 lbs glyphosate

1 vs 2 applications of glyphosate
Lambsquarters control in large-plot studies

<table>
<thead>
<tr>
<th>Site number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(% control - 3 WAT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1X</td>
<td>85</td>
<td>88</td>
<td>92</td>
<td>97</td>
<td>95</td>
<td>99</td>
</tr>
<tr>
<td>2X</td>
<td>94</td>
<td>99</td>
<td>96</td>
<td>99</td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>1X fb 2X</td>
<td>95</td>
<td>97</td>
<td>96</td>
<td>95</td>
<td>97</td>
<td>99</td>
</tr>
<tr>
<td>2X fb 1X</td>
<td>99</td>
<td>99</td>
<td>97</td>
<td>99</td>
<td>99</td>
<td>99</td>
</tr>
</tbody>
</table>

1X = 0.75 lb ae/A of glyphosate
Hypothetical Development of a Resistant Weed Population with Repeated Herbicide Applications

% Resistant Weeds

0 10 20 30 40 50 60 70

0 applications 0.0001
1st application 0.001
2nd application 0.02
3rd application 0.30
4th application 4.2
5th application 60.5
## Large Plot Results - 23 DAT vs 21 DAT Respray

<table>
<thead>
<tr>
<th>Treatment</th>
<th>23 DAT</th>
<th>21 DAT - Respray</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Control</td>
<td>% Dead Plants</td>
</tr>
<tr>
<td>WMax 22</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>WMax 44</td>
<td>80</td>
<td>49</td>
</tr>
<tr>
<td>WMax 22 + 1&lt;sup&gt;st&lt;/sup&gt; Rate .3</td>
<td>80</td>
<td>44</td>
</tr>
</tbody>
</table>
Large Plot Photos – 21 DAT Respray

Roundup WeatherMax 22 oz/A fb
Roundup WeatherMax 44 oz/A

Roundup WeatherMax 44 oz/A fb
Roundup Weathermax 22 oz/A
## Giant ragweed - small plot study - Licking Co.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>23 DAT#1</th>
<th>21 DAT#2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wmax 22 oz</td>
<td>56%</td>
<td>83%</td>
</tr>
<tr>
<td>Wmax 33 oz</td>
<td>62</td>
<td>80</td>
</tr>
<tr>
<td>Wmax 44 oz</td>
<td>69</td>
<td>87</td>
</tr>
<tr>
<td>Wmax 88 oz</td>
<td>79</td>
<td>94</td>
</tr>
<tr>
<td>Wmax + 1stRate - 22 + 0.3 oz</td>
<td>69</td>
<td>86</td>
</tr>
<tr>
<td>Wmax + Flexstar - 22 + 16 oz</td>
<td>69</td>
<td>87</td>
</tr>
<tr>
<td>1stRate 0.3 oz</td>
<td>75</td>
<td>97</td>
</tr>
<tr>
<td>Flexstar 21 oz</td>
<td>70</td>
<td>92</td>
</tr>
<tr>
<td>UTC (+ respray)</td>
<td>0</td>
<td>74</td>
</tr>
</tbody>
</table>

Respray (T#2) - 44 oz Wmax
## Giant ragweed - small plot study - Licking Co.

**Initial treatment** | **# plants with seed**
--- | ---
Wmax 22 oz | 17
Wmax 33 oz | 21
Wmax 44 oz | 8
Wmax 88 oz | 1
Wmax + 1stRate - 22 + 0.3 oz | 19
Wmax + Flexstar - 22 + 16 oz | 13
1stRate 0.3 oz | 3
Flexstar 21 oz | 1
UTC (+ respray) | 38

All treatments resprayed with 44 oz Wmax
Management of Roundup Ready soybeans matters!

10 yrs no-till soybeans
Glyphosate/2,4-D burndown
+ one post glyphosate app

Corn/soybean rotation
PRE herb followed by POST glyphosate

4 years of RR soybeans
One vs two post glyphosate apps
Solutions for giant ragweed, lambsquarters

Use tillage or an effective preplant burndown
  - include 2,4-D with paraquat or glyphosate

Include residual herbicides
  - Lambsquarters
    - Scepter, Python, Valor, Gangster, Sencor, Canopy,
      Synchrony, Prowl
  - Giant ragweed
    - Scepter, Canopy, Synchrony, Gangster, FirstRate,
      Amplify
Solutions for giant ragweed, lambsquarters

Managing POST glyphosate applications

- Apply to young, small plants
  - within 4 weeks after weed emergence
  - when plants are less than 6 inches tall
- Use the “right rate”
  - 6 inches or less - 1.1 to 1.5 lbs a.e.
  - more than 6 inches - 1.5 lbs a.e.
- Make a second POST application
  - controls late-emergers
  - completes control of injured plants
  - greatly reduces weed seed production
  - 0.75 to 1.1 lbs a.e.
Development of resistance over time
Reducing selection pressure

- Limit use of glyphosate-based systems
  - Continuous Roundup Ready crops?
- Start clean
  - Tillage or preplant herbicide treatment
- Integrate glyphosate with other herbicides
  - Goal - more than one site of action on all weeds every year
  - Apply with 2,4-D ester in preplant treatments
  - Use preemergence herbicides
  - Apply in combination with other POST herbs?
Why use PRE herbicides in RR systems?

Improved control, yield protection, risk management

• Early-season weed control:
  – Adds flexibility in POST application window
  – Time management
  – Reduces early-season competition
• Improves yield (or at least protects yield)
• Control of problem weeds - LQ, GRW
• Control of resistant weeds that might be developing
• Delaying onset of resistance
PRE/POST vs POST – RR soybean yield
POST = glyphosate 0.75 lb
South Charleston, OH

Yield (bushels/A)

Preplant herbicide

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>63</td>
<td>42</td>
</tr>
<tr>
<td>Canopy</td>
<td>67</td>
<td>50</td>
</tr>
<tr>
<td>Scepter</td>
<td>68</td>
<td>51</td>
</tr>
</tbody>
</table>
Managing POST glyphosate applications

- Goal - very few survivors, minimal seed produced
  - “Commercial” control good enough?
- Make first application to young, small weeds
  - Less than 6 inches tall, less than 4 weeks old
- Use the “right rate”
  - 0.75 lbs too low on tough weeds
  - 1.1 to 1.5 lbs
- Make second POST application to ensure effective control and prevent seed production
  - 0.75 to 1.1 lbs
- Mix with other POST herbs?
OSU Information Resources

• OSU C.O.R.N. Newsletter
  – corn.osu.edu

• OSU Weed Science
  – agcrops.osu.edu/weeds

• Weed Control Guide for Ohio and Indiana

• loux.1@osu.edu