Glyphosate-resistant Weeds. Coming soon to a field near you?

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GT Soybean Adoption Rate and Glyphosate Use

Herbicide Resistant Corn Adoption – 2006

Includes stacked with Bt

GT Corn and Soybean Acres Treated with Glyphosate

Source: NASS, USDA

Data provided by Doane Marketing Research, Inc. 2006

Source: Economic Research Service, USDA

Application and Average Usage Data provided by Doane Marketing Research, Inc. 2006

Data provided by Doane Marketing Research, Inc. 2006

Adoption Rate Source: Economic Research Service, USDA

Adoption Rate Source: Economic Research Service, USDA
**Development of Weed Resistance**

1. Resistant biotype exists within the natural population.
2. Repeated applications of herbicides with the same mode of action selects for the resistant weed biotype.

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**Confirmed Glyphosate Resistant Weeds in the U.S. (December 2006)**

- Horseweed (Marestail)
- Common Ragweed
- Italian Ryegrass
- Rigid Ryegrass
- Palmer Amaranth
- Common Waterhemp
- Giant Ragweed

Other Weeds Currently Under Investigation:
- Palmer Amaranth (more states)
- Lambsquarters

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**Glyphosate Resistant Weeds in the U.S.**

7 weeds in the U.S. are confirmed resistant:

- 2 Identified in Non-Roundup Ready System
  - Rigid Ryegrass - CA
  - Italian Ryegrass - OR
- 5 Identified in the Roundup Ready System
  - Marestail - several states
  - Common Ragweed - MO, AR
  - Palmer Amaranth – GA
  - Waterhemp – MO
  - Giant Ragweed – IN, OH

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**Investigations of Possible Glyphosate-Resistant Weeds**

- Common Lambsquarters in AZ, IN, NY, OH, VA and CA, WY
- Common Ragweed in KY and NC
- Giant Ragweed in AR and MO
- Palmer Pigweed in NC, SC, AR, TN, MS and LA
- Waterhemp in TX and OK
- Ryegrass in MS
- Common Cocklebur in SC
- Johnsongrass in LA
“Those who cannot remember the past are condemned to repeat it.”
—George Santayana
We’ve got 3. What Makes Us Different?

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Corn</th>
<th>Soybean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>11.4</td>
<td>10.1</td>
</tr>
<tr>
<td>Indiana</td>
<td>5.5</td>
<td>5.9</td>
</tr>
<tr>
<td>Iowa</td>
<td>12.5</td>
<td>10.4</td>
</tr>
<tr>
<td>Kansas</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Nebraska</td>
<td>8.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Missouri</td>
<td>2.75</td>
<td>5.3</td>
</tr>
</tbody>
</table>

----------- million acres -----------

Case 1: Glyphosate-Resistant Common Ragweed

Site History:
- Soybean-Wheat-Soybean Rotation
- RR soybean since 1996
- 1-2 applications of glyphosate/year

Greenhouse Dose-Response Experiments

*Approximately 10-times more tolerant of glyphosate than a susceptible common ragweed biotype.
Infested Area in 300 Acre Field

Initial confirmation of resistance in this 20 acre field.

GPS Locations of Plants Sampled

3200 ft
4269 ft
1805 ft
Results

- 17% of plants classified as susceptible
- 25% of plants classified as Low R
- 58% of plants classified as High R
- Resistant plants initially thought to be within a 20-acre area have been confirmed over a 132-acre area

Case 2: Glyphosate-Resistant Common Waterhemp

Common Waterhemp
Amaranthus rudis Sauer (AMATA)

- Troublesome annual weed that occurs throughout the Midwest
- Identified as the most common weed in Missouri corn and soybean production (Bradley 2003)
- Emergence pattern extends late into the season (Hartzler et al. 1999; Steckel et al. 2004)
- Typically produces at least 250,000 seed per plant (Sellers et al. 2003)
- Seed able to persist after several years of burial in the soil (Buhler and Hartzler 2001)

Glyphosate-Resistant Waterhemp

- Continuous soybeans > 15 years
- Continuous RR soybeans since 1996
- 1-2 applications of glyphosate/year

GR<sub>50</sub> of Waterhemp Biotypes
(Based on Fresh Weight Reduction in 2 Greenhouse Experiments)

- GR<sub>50</sub> = Glyphosate rate that results in 50% control of a waterhemp population
- Error bars represent the standard error of the mean

Common Waterhemp: A Weed With the Ability to Adapt

- Some populations with resistance to triazine herbicides in Missouri, Kansas, Nebraska, Iowa, and Illinois
- Numerous populations with resistance to ALS-inhibiting herbicides (Pursuit, Firstrate) throughout the Midwest
- Populations with resistance to protox-inhibiting herbicides (Reflex, Flexstar, Cobra, etc.) in Kansas, Illinois, and Missouri (Shoup et al. 2003; Li et al. 2004; Mager et al. 2002)
- 3-for-1: population with cross resistance to triazines, ALS inhibitors, and protox inhibitors has been identified in Illinois (Patzoldt et al. 2005)
- Biotypes with "variable" responses to glyphosate have previously been reported in Missouri and Iowa (Smeda and Schuster 2002; Zelaya and Owen 2005)
Influence of Glyphosate and Tank Mix Combinations on Glyphosate-Resistant Waterhemp Survival in Soybean

<table>
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<tr>
<th>Treatments*</th>
<th>Rate</th>
<th>Waterhemp Survival** (%)</th>
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</thead>
<tbody>
<tr>
<td>Rndup Omax</td>
<td>22 fl ozs</td>
<td>98 a</td>
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<tr>
<td></td>
<td>44 fl ozs</td>
<td>98 a</td>
</tr>
<tr>
<td></td>
<td>88 fl ozs</td>
<td>98 a</td>
</tr>
<tr>
<td></td>
<td>176 fl ozs</td>
<td>98 a</td>
</tr>
<tr>
<td>Rndup Omax + Phoenix</td>
<td>22 fl ozs + 0.8 ozs</td>
<td>94 a</td>
</tr>
<tr>
<td>Rndup Omax + Phoenix</td>
<td>22 fl ozs + 3 ozs</td>
<td>94 a</td>
</tr>
<tr>
<td>Rndup Omax + Ultra Blazer</td>
<td>22 fl ozs + 1.5 pts</td>
<td>95 a</td>
</tr>
<tr>
<td>Rndup Omax + Am</td>
<td>22 fl ozs + 1/4 fl oz</td>
<td>97 a</td>
</tr>
<tr>
<td>Rndup Omax + Phoenix</td>
<td>22 fl ozs + 0.3 ozs</td>
<td>99 a</td>
</tr>
<tr>
<td>Rndup Omax + Xylex</td>
<td>22 fl ozs + 2 ozs</td>
<td>98 a</td>
</tr>
<tr>
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</tbody>
</table>

*All treatments applied at RNDP at 2.5 fl oz.

**% of treated waterhemp plant/seedling (waterhemp) living 6 weeks after treatment.

Means followed by the same letter are not different (LSD 0.05).
More Sites?
- Screening of other waterhemp populations from around the state is currently being conducted.
- 7 of 9 samples have had RR soybeans continuously for 4 years or more and glyphosate as the only herbicide applied during that time period.

Who cares?
- Male and female flowers occur on separate plants. Pollen is wind-disseminated to females throughout the field. How far can it spread? Other types of herbicide resistance in waterhemp have been pollen-mediated.

Impact of Glyphosate-resistant Weeds?
- Waterhemp (1 m tall) and Corn (2 m tall) pollen dispersal distances are shown. Distance traveled depends on wind speed.

Glyphosate-resistant Waterhemp
- Best programs for management of glyphosate-resistant waterhemp in soybeans were $25 to $30 more per acre than current programs.
- PRE's in soybean are a must for this population, but best PRE-only program resulted in a return of 60.1 million waterhemp seed/A.

There is no going back
- Roundup Ready has allowed farmers to farm more acres with less equipment and less labor.
- Cultivators are in the weeds behind the equipment yard.

Widespread Glyphosate-resistant weeds will change how we do business
- Cotton will probably be affected the most; there are simply not enough alternatives/hybrids.
- Soybeans a close second; limited alternatives.
- Corn probably the least impact but where are we headed?
Understanding Glyphosate to Increase Performance

Biology and Management of Common Waterhemp

Moderately concerned. It

Biology and Management of Common Lambsquarters

Not concerned. All we

Biology and Management of Horseweed

Very concerned. I think it has the potential to be

Biology and Management of Wild Buckwheat

Somewhat concerned. I think we

Biology and Management of Common Ragweed

Very concerned. I think it has the potential to be

Biology and Management of Giant Ragweed

Not concerned. All we

Economic Implications of Glyphosate Stewardship

Very concerned. I think it has the potential to be

Biology and Management of Giant Pigweed

Somewhat concerned. I think we

Facts About Glyphosate Resistant Weeds

Moderately concerned. It

Biology and Management of Giant Pigweed

Somewhat concerned. I think we

How concerned are YOU as a crop consultant, retailer, etc. about the development of glyphosate-resistant weeds?

36% A. Very concerned. I think it has the potential to be devastating to our current cropping systems.

40% B. Moderately concerned. It’s an issue we can’t ignore.

14% C. Somewhat concerned. I think we’ll deal with it if it does occur.

2% D. Not concerned. All we’re seeing is a few isolated cases. These will not become wide-spread issues.

How concerned do you think farmers are about the development of glyphosate-resistant weeds?

16% A. Very concerned. I think it has the potential to be devastating to our current cropping systems.

25% B. Moderately concerned. It’s an issue we can’t ignore.

45% C. Somewhat concerned. I think we’ll deal with it if it does occur.

10% D. Not concerned. All we’re seeing is a few isolated cases. These will not become wide-spread issues.

Protecting Yields vs. Preventing Resistant Weeds

A new approach that should get us to the same place.

Weedsoft Yield Loss Calculator:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Height of Weeds When Controlled</th>
<th>Early Season Yield Loss</th>
<th>Profit Loss</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Growth Stage</td>
<td></td>
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</tr>
<tr>
<td>Soybean</td>
<td>V1 Less than 2”</td>
<td>0.2</td>
<td>$1.20</td>
</tr>
<tr>
<td></td>
<td>V3 4 to 8”</td>
<td>1.9</td>
<td>$11.40</td>
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<tr>
<td></td>
<td>V5 Greater than 8”</td>
<td>5.8</td>
<td>$34.80</td>
</tr>
<tr>
<td>Corn</td>
<td>V1 Less than 2”</td>
<td>0.8</td>
<td>$2.80</td>
</tr>
<tr>
<td></td>
<td>V3 4 to 8”</td>
<td>4.8</td>
<td>$16.80</td>
</tr>
<tr>
<td></td>
<td>V5 Greater than 8”</td>
<td>13.2</td>
<td>$46.20</td>
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http://weedsoft.unl.edu/