Economics of Roundup Ready Crops: Farmer Benefits and the Impact of Weed Resistance

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Herbicide Tolerant Crops Have Become Very Popular

Source: http://www.ers.usda.gov/data/biotechcrops/

Data for each crop category include varieties with both HT and Bt (stacked) traits. Sources: 1996-1999 data are from Fernandez-Cornejo and McBride (2002). Data for 2000-09 are available in tables 1-3.
Wisconsin Farmers Following the National Trend

% Acres Planted in Transgenic Varieties

Source: http://www.ers.usda.gov/data/biotechcrops/
Weed Resistance: Clouds on the Horizon?

- Most of these herbicide tolerant crops are Roundup Ready
- Over reliance on a single herbicide/mode of action can lead to weed resistance/tolerance
- It’s happened for other herbicides and has happened for Roundup/glyphosate
Global Distribution of Glyphosate Resistance

Source: http://www.weedscience.org/glyphosate.gif
Glyphosate Resistance is a Growing Problem in the US.

Number of weed species with glyphosate resistant populations and number of states with glyphosate-resistant weed populations (Source: Hurley, Mitchell & Frisvold 2009; Heap 2009).
Weed Resistance is a Problem in Wisconsin, but not for Glyphosate

<table>
<thead>
<tr>
<th>Weed</th>
<th>Situation</th>
<th>Herbicide Mode of Action</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lambsquarters</td>
<td>corn</td>
<td>C1/5 - Photosystem II inhibitors (atrazine)</td>
<td>1979</td>
</tr>
<tr>
<td>(Chenopodium album)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth Pigweed</td>
<td>corn</td>
<td>C1/5 - Photosystem II inhibitors (atrazine)</td>
<td>1985</td>
</tr>
<tr>
<td>(Amaranthus hybridus)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kochia</td>
<td>corn, railways</td>
<td>C1/5 - Photosystem II inhibitors (atrazine)</td>
<td>1987</td>
</tr>
<tr>
<td>(Kochia scoparia)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velvetleaf</td>
<td>corn</td>
<td>C1/5 - Photosystem II inhibitors (atrazine)</td>
<td>1990</td>
</tr>
<tr>
<td>(Abutilon theophrasti)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Giant Foxtail</td>
<td>carrot, corn, onion, sweet corn</td>
<td>A/1 - ACCase inhibitors (fluazifop-P-butyl, sethoxydim)</td>
<td>1991</td>
</tr>
<tr>
<td>(Setaria faberi)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Crabgrass</td>
<td>carrot, onion</td>
<td>A/1 - ACCase inhibitors (fluazifop-P-butyl, sethoxydim)</td>
<td>1992</td>
</tr>
<tr>
<td>(Digitaria sanguinalis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kochia</td>
<td>roadsides</td>
<td>B/2 - ALS inhibitors (sulfoometuron-methyl)</td>
<td>1995</td>
</tr>
<tr>
<td>(Kochia scoparia)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common Waterhemp</td>
<td>soybean</td>
<td>B/2 - ALS inhibitors (imazethapyr)</td>
<td>1999</td>
</tr>
<tr>
<td>(Amaranthus rudis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Giant Foxtail</td>
<td>corn, soybean</td>
<td>B/2 - ALS inhibitors (imazethapyr, nicosulfuron)</td>
<td>1999</td>
</tr>
<tr>
<td>(Setaria faberi)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Foxtail</td>
<td>corn, soybean</td>
<td>B/2 - ALS inhibitors (imazamox)</td>
<td>1999</td>
</tr>
<tr>
<td>(Setaria viridis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern Black Nightshade</td>
<td>soybean</td>
<td>B/2 - ALS inhibitors (imazamox, imazethapyr)</td>
<td>1999</td>
</tr>
</tbody>
</table>

Source: Heap 2009
In Wisconsin, Glyphosate Resistance is not a Problem—At Least Not Yet!

- Chris Boerboom in summer 2009 started investigating giant ragweed in WI with suspected resistance to glyphosate
  - [WI Crop Manager June 18, 2009](http://ipcm.wisc.edu/Default.aspx?tabid=53)
- David Stoltenberg continuing the research
  - Seeds from plants surviving glyphosate applications being prepped (cleaned and cold treated) for greenhouse experiments taking place late this winter
  - Stay tuned for details
Questions Addressed in This Study

- What is the value of the benefits to farmers from RR Soybeans & RR corn?
- Do farmers think weed resistance is a problem?
- How does weed resistance affect the value of RR soybeans & RR corn?

Overview the Study and Summarize Results
Study of RR Benefits and Resistance

- Terry Hurley (U of MN), Paul Mitchell, and George Frisvold (U of AZ)
- Corn, soybean and cotton growers
- Telephone survey of 400 corn, 400 soybean and 400 cotton farmers from main states
  - At least 250 acres of target crop
  - Surveyed during Nov-Dec 2007
  - Questions on 2007 and plans for 2008
  - Weed management with RR focus
- Funded by Monsanto
Where are the Corn farmers from?

25 from WI
Where are the Soybean farmers from?

None from WI
Farmer Concerns about Resistance

- No where in the survey was weed resistance ever mentioned
- End of survey asked an opened question
  
  “What are your biggest concerns in regards to weed management?”

- Responses mentioning weed resistance
  - Concerned about weed resistance
    - 47% corn growers, 52% soybean growers
  - Mentioned having weed resistance
    - 3% of all growers (corn, cotton, soybean)
Concerned about weed resistance

0%
> 0% to 50%
> 50%
Mentioned having weed resistance
Number of weed species with suspected or confirmed resistance to glyphosate in 2006

Source: Monsanto
Estimating Farmer Benefits

- Farmers asked their planned 2008 RR and conventional corn/soybean acres and RR corn/soybean acres with a residual herbicide.
- How will these acreages change if the price of RR seed changed or the price of residual herbicide changed a few dollars per acre?
- From acreage shifts to (hypothetical) price changes, derive value of RR crop using “consumer surplus.”
- “Contextually stated preferences”
  - Farmers give more reasonable results than just asking them directly: “What’s RR corn/soybeans worth to you?”
For the next few questions, please think about how your current plans for the 2008 season might change if your cost for Roundup Ready [crop] seed increased by [$] per acre.

22a. If the cost for Roundup Ready [crop] seed increased by [$] per acre, would you plan to plant Roundup Ready [crop] next year in 2008?


22c. [If RR less than 100% of crop acres >> ask:] And, given this price change, how many acres of conventional herbicide [crop] would you plan to plant in 2008? That is, [crop] that is not Roundup Ready or LibertyLink or AgriSure?
Consumer Surplus

Area A + B = \( \frac{1}{2} \times 250 \times 10 = $1250 \) or $5/ac

Area A + B is “Consumer Surplus”

Dollar value a farmer gets from RR crop
What is the value ($/ac) of the benefits to farmers from RR Soybeans & RR corn?

<table>
<thead>
<tr>
<th></th>
<th>Corn</th>
<th>w/ residual</th>
<th>Soybean</th>
<th>w/ residual</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Median Benefit</strong></td>
<td>$16.74</td>
<td>$11.93</td>
<td>$8.44</td>
<td>$5.29</td>
</tr>
<tr>
<td><strong>90% Conf. Interval</strong></td>
<td>$11.44 to</td>
<td>$8.97 to</td>
<td>$7.47 to</td>
<td>$4.02 to</td>
</tr>
<tr>
<td></td>
<td>$32.34</td>
<td>$17.39</td>
<td>$9.77</td>
<td>$7.41</td>
</tr>
<tr>
<td><strong>Effect of Residual</strong></td>
<td>–$4.81 (–29%)</td>
<td></td>
<td>–$3.15 (–37%)</td>
<td></td>
</tr>
<tr>
<td>Herbicide</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Farmers find RR crops valuable, even if used with a residual. Using a residual decreases value of RR crops about 30%-40%
How does weed resistance affect the value of RR soybeans & RR corn?

- Used growers’ responses to open ended questions to code whether they are concerned about resistance
- Used Monsanto data to see if farmed in a county or a crop reporting district (CRD) with confirmed resistance

### % Change in Value of RR Crop

<table>
<thead>
<tr>
<th>Resistance</th>
<th>Corn</th>
<th>w/ residual</th>
<th>Soybean</th>
<th>w/ residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concerned</td>
<td>3.1%</td>
<td>0.3%</td>
<td>3.9%</td>
<td>25.2%</td>
</tr>
<tr>
<td>In County</td>
<td>−0.4%</td>
<td>−0.4%</td>
<td>−0.7%</td>
<td>4.8%</td>
</tr>
<tr>
<td>In CRD</td>
<td>−0.5%</td>
<td>0.5%</td>
<td>1.8%</td>
<td>−9.1%</td>
</tr>
</tbody>
</table>

Red values significant at the 10% level
How does weed resistance affect the value of RR soybeans & RR corn?

- Weed resistance and concerns about weed resistance do not seem to affect the value of RR corn. Farmers already commonly use multiple herbicides, so they have options they are used to using.

- Farmers concerned about weed resistance find RR soybeans more valuable than farmers not concerned about weed resistance, especially if they are using RR soybeans with a residual.
  - Proactively managing resistance is easier with RR soybeans, making RR soybeans more valuable.

- Soybean farmers in regions with weed resistance find using RR soybeans with a residual less valuable.
  - Value of RR crop reduced if “forced” to use a residual because of local development of resistance by others.
Farmer Use of Multiple Herbicides with different MOA by crop

- Corn farmers most likely to follow this practice
- Soybean farmers least likely to follow this practice
Summary of Findings

- Farmers are concerned about herbicide resistance: ~ 50%
- RR crops are valuable, even if used with a residual
  - Using a residual decreases value of RR crops about 30%-40%, but still substantial have value ($8 to $17/ac)
- Weed resistance & concerns about weed resistance
  - Seem not to affect the value of RR corn
  - RR soybeans more valuable if concerned about weed resistance, especially if using a residual
  - In regions with weed resistance, using RR soybeans with a residual is less valuable

**Recommendation**: encourage farmers to adopt weed resistance management BMPs
Weed Resistance BMPs

Scout fields before a herbicide application
Scout fields after a herbicide application

Start with a clean field, using a burndown herbicide application or tillage
Control weeds early when they are relatively small
Control weed escapes and prevent weeds from setting seeds
Clean equipment before moving between fields to minimize weed seed spread
Use new commercial seed that is as free from weed seed as possible

Use multiple herbicides with different modes of action during cropping season
Use tillage to supplement weed control provided by herbicide applications
Use the recommended application rate from the herbicide label

Source: http://www.weedresistancemanagement.com/stewardship.html (Monsanto)
Rotate between Roundup Ready and conventional crops or crops with other types of herbicide resistance.

Use Roundup Ready crops in your rotation where they have the greatest economic and management value.

Rotate glyphosate with other herbicide modes of action.

Rotate non-glyphosate herbicides over time as well.

Apply glyphosate at labeled rates at the correct stage of growth. If glyphosate is used as a burndown treatment and in-crop, tank mix the burndown treatment with another mode of action.

Use cultivation after in-crop applications of glyphosate when possible.

Scout fields regularly and identify weeds present. Respond quickly to changes in weed population.

Source: http://128.104.239.6/uw_weeds/extension/glyphosate%20white%20paper.pdf
### Boerboom’s examples of crop and herbicide rotations that promote glyphosate stewardship

<table>
<thead>
<tr>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
<th>YEAR 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tilled Corn/Soy</strong></td>
<td><strong>No-Till Corn/Soy</strong></td>
<td><strong>Alfalfa/Corn</strong></td>
<td><strong>Continuous Corn</strong></td>
</tr>
<tr>
<td>Conventional Corn Herbicides w/ non-glyphosate MOA</td>
<td>Conventional Corn <em>Burndown</em>: 2,4-D + glyphosate. <em>In-crop</em>: herbicides w/ non-glyphosate MOA</td>
<td>Alfalfa Glyphosate + 2,4-D in early fall</td>
<td>Conventional Corn Herbicides w/ non-glyphosate MOA</td>
</tr>
<tr>
<td>RR Soybean Glyphosate early postemergence</td>
<td>RR Soybean <em>Burndown</em>: 2,4-D + glyphosate. <em>In-crop</em>: glyphosate early postemergence</td>
<td>RR Corn Glyphosate early postemergence* Cultivate</td>
<td>RR Corn Plant only for specific weed problems Glyphosate early postemergence* Cultivate</td>
</tr>
<tr>
<td>Repeat rotation</td>
<td>Repeat rotation</td>
<td>Conventional Corn Herbicides w/ non-glyphosate MOA</td>
<td>Repeat rotation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alfalfa</td>
<td></td>
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</tbody>
</table>
Questions?

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www.aae.wisc.edu/mitchell/extension.htm