GMO and agriculture: pest management and how the landscape has changed

Midwest and MidContinental Chapter of the Medical Library Association

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Introduction

• The adoption of GMOs is unprecedented in agriculture
• Currently most (all?) of the traits are designed to help manage pests
• Genetically engineered (GE) traits cannot be considered the same
  – GE traits for herbicide resistance do not have any influence on the weeds unless the herbicide is applied
  – GE traits for other pest resistances impact the pests continuously
• GMOs have significant pecuniary and non-pecuniary benefits
  – Cost of pest management
  – Type of pesticide used and environmental impact
  – Type of crop production system supported (i.e., no-till and impact on water quality)
Figure 1. Global Area of Biotech Crops, 1996 to 2015 (million hectares).
Source: Clive James, 2015.
Figure 2. Global Area of Biotech Crops, 1996 to 2015: Industrial and Developing Countries (Million Hectares)

Source: Clive James, 2015.
Figure 3. Biotech Crop Area as % of Global Area of Principal Crops, 2015 (Million Hectares)

Global Hectarages Data for 2015 (FAO, 2013)
Source: Compiled by Clive James, 2015.
Adoption of genetically engineered crops in the United States, 1996-2016

Data for each crop category include varieties with both HT and Bt (stacked) traits.
GE variety adoption and pesticide use, maize and soybeans in the United States, 1998–2011
Pest resistances in the Midwest

- Weeds with evolved resistance to herbicides is the most widespread issue
  - Waterhemp (Groups 2, 5, 9, 14, 27)
  - Horseweed/marestail (Groups 2 and 9)
  - Giant ragweed (Groups 2 and 9)
- Corn rootworm with evolved resistance to some insecticides including $Bt$ and crop rotation
  - Corn rootworm has a similar phenology as weeds
- Plant pathogens – given the current use practices, can resistance be considered likely?
Factors affecting evolved pest resistance

- Selective pressure(s)
  - For weeds, tillage is the most important selective factor followed by herbicides and cultural factors (e.g., crop rotation)
  - For insects, tillage, crop rotation, insecticides (including Bt) are important
  - Diseases and nematodes, crop rotation and fungicides and nematicides are important

- Frequency and effectiveness of the selection pressure
- Diversity or lack thereof of the system
- *All* tactics in crop production exert selection pressure on pests
- Pests *will* inevitably adapt to the selection pressures
Pest resistance management – general considerations*

• The evolution of pest resistance is not a herbicide problem
• The evolution of pest resistance is not a genetic engineering problem
• The evolution of pest resistance is a behavioral problem
Number of farms and average farm size – United State: 2007-2014
Example: Evolved resistance to herbicides

- Herbicide resistance is not synonymous with glyphosate resistance
- Issues with evolved herbicide resistance continue to escalate despite grower awareness
- Herbicide resistance is complex and encompasses agronomic, economic and sociological aspect of crop production
- Herbicide resistance is a “wicked” problem
Growers Reporting Resistant Species on Their Farm

Three species with a significant increase from 2014 to 2015 in the % of U.S. growers reporting resistance.

<table>
<thead>
<tr>
<th>Species</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maresta (horseweed)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Waterhemp</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Palmer amaranth (Pigweed)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Ragweed (all types)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Kochia</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Ryegrass</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

% of growers reporting

XX Significantly higher than previous year (90% confidence)
XXX Significantly lower than previous year (90% confidence)
Growers Reporting Glyphosate Resistant Weeds

% of Growers

- 0.0
- 0.1 - 20.4
- 20.5 - 45.2
- 45.3 - 70.1
- 70.2 - 90.3
- No Data

USA15 - Weed Resistance

Extension and Outreach
**Iowa, a case study: Estimated acres with resistance based on 2011 waterhemp population collections**

<table>
<thead>
<tr>
<th>Herbicide Group</th>
<th>Herbicide rate</th>
<th>Estimated herbicide resistance (95% Confidence Limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 2</td>
<td>1X</td>
<td>62% to 77%</td>
</tr>
<tr>
<td>Group 5</td>
<td>1X</td>
<td>44% to 51%</td>
</tr>
<tr>
<td>Group 9</td>
<td>1X</td>
<td>42% to 48%</td>
</tr>
<tr>
<td>Group 14</td>
<td>1X</td>
<td>10% to 12%</td>
</tr>
<tr>
<td>Group 27</td>
<td>1X</td>
<td>24% to 27%</td>
</tr>
</tbody>
</table>
## Assessment of responsibility for herbicide-resistant weed management*

<table>
<thead>
<tr>
<th></th>
<th>NO RESPONSIBILITY</th>
<th>LITTLE RESPONSIBILITY</th>
<th>SOME RESPONSIBILITY</th>
<th>MUCH RESPONSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FARMERS</strong></td>
<td>1.2</td>
<td>4.6</td>
<td>32.4</td>
<td>61.8</td>
</tr>
<tr>
<td><strong>PESTICIDE MANUFACTURERS</strong></td>
<td>2.4</td>
<td>5.2</td>
<td>38.9</td>
<td>53.4</td>
</tr>
<tr>
<td><strong>SEED COMPANIES</strong></td>
<td>2.7</td>
<td>8.3</td>
<td>44.4</td>
<td>44.7</td>
</tr>
<tr>
<td><strong>UNIVERSITY SCIENTISTS</strong></td>
<td>5.7</td>
<td>15.6</td>
<td>42.5</td>
<td>36.2</td>
</tr>
<tr>
<td><strong>PESTICIDE APPLICATORS (COMMERCIAL)</strong></td>
<td>5.4</td>
<td>16.9</td>
<td>44.7</td>
<td>33.0</td>
</tr>
<tr>
<td><strong>GOVERNMENT (E.G., EPA, USDA)</strong></td>
<td>12.5</td>
<td>24.5</td>
<td>40.8</td>
<td>22.2</td>
</tr>
</tbody>
</table>

*Adapted from Arbuckle Jr. (2014)
“Ideal” Integrated Pest Management

Current

Future (as appropriate)

Iowa State University
Extension and Outreach
Conclusions

• GMO dominate global agriculture
• The primary GE traits are for pest management
• There are notable benefits and risks attributable to GMO adoption
• The success or failure of GMOs will be a function of management decisions
• With regard to evolved pest resistance, diversity is key
Questions?