Removing Barriers to Weed Management
Diversification by Highlighting the Hidden Costs of Biological Time Constraints
TRENDS IN HERBICIDE USE IN MN
1990 - 2014

- Postemergence tactics were popular because it allowed farmers to decouple the time constraints of soil-applied herbicide application from planting date timing

- Decline of soil-applied residual herbicides was understandable considering that cool and wet soils in MN can delay crop planting and increase herbicide-induced crop injury and carryover to rotational crops

- In the mid-1990s, at the height of the ALS-herbicide market, reports of ALS-resistance became more common for: giant and common ragweed and common waterhemp

- These same species have now demonstrated resistance to glyphosate and multiple resistance is an issue
RATE OF ROUNDUP READY ADOPTION IN MN

- Sequential adoption of Roundup Ready soybean, corn and sugar beet in 1996, 1998 and 2008, respectively, expanded the rate of adoption of postemergence tactics and the decline of diversified weed management strategies.

- High percentage of MN acres are currently planted to:
  - RR soybean
    - Approximately 97% of acres are treated with glyphosate
    - Less than 25% of acres use a PRE herbicide
  - RR corn
    - Approximately 90% of acres are treated with glyphosate
    - Approximately 50% of acres use a PRE herbicide
  - RR sugar beet
    - Approximately 100% of acres are treated with glyphosate
    - Minimal use of PRE herbicides
<table>
<thead>
<tr>
<th>Year</th>
<th>Corn Area Applied PRE (%)</th>
<th>Area Applied w/ glyphosate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>50</td>
<td>85</td>
</tr>
<tr>
<td>2005**</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>2003</td>
<td>50</td>
<td>22</td>
</tr>
<tr>
<td>2002</td>
<td>43</td>
<td>11</td>
</tr>
<tr>
<td>1999</td>
<td>62</td>
<td>7</td>
</tr>
<tr>
<td>1996*</td>
<td>73</td>
<td>0</td>
</tr>
</tbody>
</table>

*ALS used on 33% of acres

**ALS used on 12% of acres
### MN SOYBEAN HERBICIDE USE TRENDS

<table>
<thead>
<tr>
<th>Year</th>
<th>Area Applied</th>
<th>Area Applied w/glyphosate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soybean Area Applied</td>
<td>(%)</td>
</tr>
<tr>
<td></td>
<td>PPI/PRE (%)</td>
<td></td>
</tr>
<tr>
<td>2009**</td>
<td>2</td>
<td>98</td>
</tr>
<tr>
<td>2004</td>
<td>15</td>
<td>85</td>
</tr>
<tr>
<td>2002</td>
<td>23</td>
<td>79</td>
</tr>
<tr>
<td>1999</td>
<td>39</td>
<td>48</td>
</tr>
<tr>
<td>1996</td>
<td>62</td>
<td>7</td>
</tr>
<tr>
<td>1994*</td>
<td>71</td>
<td>4</td>
</tr>
</tbody>
</table>

*ALS used on 70% of acres
**ALS used on <2% of acres
Impact of Herbicide Resistance to Weed Management Strategies

- ISU Reports waterhemp responses to labeled herbicide rates indicate:

How will you know the frequency of resistant populations in any given field?
SO WHAT DO WE DO ABOUT HERBICIDE RESISTANT WEEDS?

- After a >20 year emphasis on postemergence tactics with a herbicide that lacks soil weed control we have to reconnect with the biological principles that influence and inform durable weed management strategies.

- A higher level of weed management diversification needs to occur and a good place to start is by addressing:
  - Selection intensity, using the same weed management tactic again and again
    » Need for diversification of weed management tactics
  - Allowing weed population size to increase in the seed bank
    » Increases probability of a R-trait
    » Need to prevent pollen and seed production
EDUCATIONAL APPROACHES TO DEMONSTRATE THE BENEFITS OF DIVERSIFICATION

- Goal is to deconstruct current herbicide-based strategies in order to assess the hidden costs that weed biology, competition and time of weed removal have on weed control and crop yield.

- Focus on educational methodologies that will expose these hidden costs to farmers and remove some of the barriers associated with diversification of weed management.
Developed a Research and Education team to address these goals
- Weed Management Working Group
- Extension, IPM and Research & Outreach Center personnel

Weed Management Working Group’s Goals
- Maintain information links to agribusiness
- Develop educational methodologies that enhances extension activities and addresses specific farmer concerns
- Evaluate integrated management systems for efficacy, economic viability, degree of risk to the farmer and rate of adoption
ASSESSING THE “HIDDEN COSTS” OF BIOLOGICAL TIME CONSTRAINTS

- At the interface between weed biology and the economics of crop production lies a critical communication point between the weed scientist and farmer
  
  - How to align the farmer’s time and labor constraints with site-specific “biological time constraints” of weeds?

  - Biological time constraints are time-dependent properties that influence weed management and would include:
    
    ▪ Periodicity of weed emergence
    ▪ Rate of weed and crop growth
    ▪ Crop sensitivity to early season weed competition
CONSIDER HOW RESIDUAL HERBICIDES CAN ADDRESS “HIDDEN COSTS” OF EARLY-SEASON WEED COMPETITION

Yield loss due to weeds is not always as visible to the farmer as is weed control, input costs and convenience

Expect:

- Residual herbicides to reduce timeliness issues associated with postemergence weed control
  - Periodicity of weed emergence – big impact on early-emerging weeds
  - Early season weed competition – “hidden costs”
  - Rapid weed growth and environment interactions = inconsistent control
  - Reduces weed density thus improving POST herbicide performance

- Residual herbicides do come with some risk to the farmer
  - Rainfall to activate the herbicide
  - Potential for early season crop injury (e.g. cold and wet weather)
  - Can limit crop rotations
## Biological Parameters

<table>
<thead>
<tr>
<th>Time of Emergence</th>
<th>Giant Ragweed</th>
<th>Lambsquarters</th>
<th>Common Ragweed</th>
<th>Waterhemp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>Early</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Late</td>
</tr>
<tr>
<td>10% by 150 GDD</td>
<td>10% by 150 GDD</td>
<td>10% by 300 GDD</td>
<td>5% by 150 GDD</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Duration of Emergence</th>
<th>Giant Ragweed</th>
<th>Lambsquarters</th>
<th>Common Ragweed</th>
<th>Waterhemp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short</td>
<td>Short</td>
<td>Moderate</td>
<td></td>
<td>Prolonged</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth of Emergence</th>
<th>Giant Ragweed</th>
<th>Lambsquarters</th>
<th>Common Ragweed</th>
<th>Waterhemp</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6 inches</td>
<td>&lt; 1 inch</td>
<td>&lt;2 inches</td>
<td></td>
<td>&lt; 1 inch</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relative Competitiveness (0 – 10)</th>
<th>Giant Ragweed</th>
<th>Lambsquarters</th>
<th>Common Ragweed</th>
<th>Waterhemp</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3</td>
<td>3</td>
<td></td>
<td>1.5</td>
</tr>
</tbody>
</table>

Our most competitive weed species
Weed Emergence Patterns

Spring Planting

POST Weed Control

Gi. foxtail
W. cupgrass
F. panicum
Velvetleaf
G. ragweed
Kochia
Morningglory
Waterhemp

Adapted from Sandell, Hartzler and Buhler. Iowa State University.
GLYPHOSATE TIMING AND CORN YIELD ACROSS LOCATIONS 2004 - 2006

Post – Roundup WeatherMax (22 oz/A)
Pre + Post - Harness (1.25 pt./A) / Roundup WeatherMax (22 oz/A) + AMS
Trt 11 – Harness PRE
Trt 12 – Roundup WeatherMax + AMS / Roundup WeatherMax + AMS at 3”/ 2-4” regrowth
Mean returns vs standard error of mean returns for corn treatments across locations in 2004-2006

Trt 5 – Harness (1.25 pt./A) / Roundup WeatherMax (22 oz/ A) + AMS at V 4 corn

Trt 12 – Roundup WeatherMax + AMS / Roundup WeatherMax + AMS at 3”/ 2-4” regrowth
WEED EMERGENCE PATTERNS AND
THE EFFECT OF TIME OF WEED REMOVAL
ON CORN

Lamberton, 3-4 inch weed removal date - June 18, 2005

204 bu/A
WEED EMERGENCE PATTERNS AND THE EFFECT OF TIME OF WEED REMOVAL ON CORN

Lamberton, 9-12 inch weed removal date – July 1, 2005

170 bu/A

In 13 days, 34 bu/A were lost
WEED EMERGENCE PATTERNS AND
THE EFFECT OF TIME OF WEED REMOVAL
ON SOYBEAN

Roundup PowerMax 30 fl oz/a + AMS 8.5 lb/100gal
Applied at V1 on May 18, 2012
As weed densities increase early season weed control becomes very critical.

As weeds get larger POST herbicide effectiveness decreases.

Ineffective control with POST herbicides increases the probability of selecting for herbicide-resistance.
2013 & 2014: Do you Plan to Use a Preemergence Herbicide in ....?  
IPM Assessment Survey – Stahl et al.

Soybean  
(636 & 568 responses)  

Corn  
(785 & 570 responses)  

~25% Yes in 2011  
~50% Yes in 2011
2013 & 2014: For Weed Control I Primarily.......?
IPM Assessment Survey – Stahl et al.

2013
(713 responses)

2014
(679 responses)

- Use POST glyphosate only
- Use POST herbicides only (> 1 SOA)
- Use a PRE herbicide for at least 1 crop
- Use a PRE herbicide for all my crops
- Use a PRE herbicide for all my crops and >1 SOA POST
BARRIERS TO COMMUNICATION

- Impact of herbicide mode of action on weed management
  - Herbicide site of action
  - Systemic versus non-systemic herbicides

- Exponential rate of change
  - Not an intuitive concept and negatively influences timing of weed management decisions at the population and individual plant level.
WHEN PLANNING WEED MANAGEMENT
PROGRAMS, DO YOU PURPOSELY UTILIZE
DIFFERENT HERBICIDE SOA’S?

- Yes: 75%
- No: 14%
- Don’t know: 11%
HOW ARE HERBICIDE SOA’S CLASSIFIED?

- Don’t have a clue: 66%
- II, IV, IX, XIV: 10%
- 2,4,9,14: 14%
- B, D, I, N: 11%
Is Glyphosate (the active ingredient in Roundup) a contact or systemic herbicide?

- **Systemic herbicide**
  - 2011: 39
  - 2010: 28
  - 2009: 38
  - 2008: 41

- **Contact herbicide**
  - 2011: 61
  - 2010: 72
  - 2009: 62
  - 2008: 59
BARRIERS TO COMMUNICATION

- Impact of herbicide mode of action on weed management
  - Herbicide site of action
  - Systemic versus non-systemic herbicides

- Exponential rate of change
  - Not an intuitive concept and negatively influences timing of weed management decisions at the population and individual plant level.
EXPONENTIAL RATE OF CHANGE IS NOT INTUITIVE AND NEGATIVELY INFLUENCES TIMING OF WEED MANAGEMENT DECISIONS AT THE POPULATION AND INDIVIDUAL PLANT LEVEL

Farmer becomes aware of problem

Unless alternative weed management practices are taken, the change to resistant biotypes can occur quickly

Adapted from Gunsolus. U. Minn. 1993.
NOTE PALMER’S RAPID GROWTH RATE

Waterhemp on left, Palmer amaranth on right, both planted on the same day
TIME OF POSTEMERGENCE WEED CONTROL IS A FUNCTION OF TIMING THE DIFFERENCE OF 2 DAYS!

Flexstar (SOA # 14) on 6” Palmer

Flexstar (SOA # 14) on 3” Palmer

Steckel 2010
INTEGRATED WEED MANAGEMENT IS MORE THAN INTEGRATED HERBICIDE MANAGEMENT

Herbicide Inputs
- Move away from Total Post & One-Pass
- Post with delayed PRE
- Start with a PRE
- Post – target max. of 3-inch weeds

Cultural Control
- Inter-row cultivation
- Increase crop seeding rate
- Work fields closer to planting date
- Delay planting if targeting early-emerging weeds
- Develop weed maps

Crop Rotation
- Goal is to reduce the seed bank

Crop Competition
- Via Crop Rotation
- Focus on early-season weed control
- Narrow rows

Weed Management
Do you map Weedy Spots and infestations in your fields?

- Sometimes: 17
- No: 59
- Yes: 24
WEED MANAGEMENT WORKING GROUP

Research & Outreach Centers
Tom Hoverstad – Waseca
Greg Johnson - Waseca
Travis Vollmer- Lamberton

Integrated Pest Management
Fritz Breitenbach – Rochester
Bruce Potter - Lamberton

Extension Regional Educators
Lisa Behnken - Rochester
Ryan Miller – Rochester
Dave Nicolai – Farmington
Liz Stahl - Worthington

Project Scientists
Brad Kinkaid – St. Paul Campus
Doug Miller – St. Paul Campus

Summary
- In-field, hands-on, educational methodologies that address the hidden costs of biological time constraints has been an effective teaching tool
- Field studies need to be very visual and treatments should make comparison of tactics readily identifiable
- If possible allow “open access” to these studies
- Addressing biological time constraints has helped farmers reframe their risk/benefit analysis
Pest resistance is not a major concern because new technologies will be developed to manage them.