Institute of Ag Professionals

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Minnesota Crop Production Retailers Association Trade Show

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Know Your Weeds:
Exploiting Seed-Bank Depletion and Emergence Patterns to Improve Herbicide- Resistant Giant Ragweed Control

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December 11, 2014
Herbicide Resistance

• Weeds have evolved resistance to 22 of the 25 known herbicide sites of action
  – 155 different herbicides
• 31 species resistant to glyphosate worldwide
• Threatens the use of herbicides for weed control
  – Herbicide resistant traits

(Heap, 2014)
Resistance Is Expensive

- Glyphosate-resistant *horseweed* in soybean increases production costs by $11.50 ac$^{-1}$

- Glyphosate resistant *palmer amaranth* in cotton increases production costs by $19.42 ac$^{-1}$ in Georgia and Arkansas

(Mueller et al. 2005; Norsworthy et al. 2012)
How can we manage resistant weeds???
What About Cultural Practices???

- Row Spacing
- Planting Date
- Crop Rotation
- Seed Bank Depletion
- Forages - Alfalfa

Giant Ragweed
Giant Ragweed (*Ambrosia trifida*)

- Native
- Difficult to control with PRE
  - Emerges early
  - Large seed allowing deeper emergence
- Multiple resistance
  - Resistant to ALS (B/2) and glyphosate (G/9)
- Widespread in Minnesota!!

(Heap, 2014)
21 Feet Tall!
From Texas...
Crop Rotation...

Seed Bank Degradation
Emergence Patterns
Prevent Weed Seed Production

= Weed Control

Life Cycle of Annual Weeds

From Chee-Sanford et al. (2006).
Crop Rotation Study

Herbicide resistant giant ragweed prevalent in a farmer’s field
Glyphosate applied to 8-10 inch weeds on June 22nd

3 weeks after application

Glyphosate (1x)  Untreated
FirstRate applied to 8-10 inch weeds on June 22\textsuperscript{nd}

3 weeks after application

ALS (FirstRate) (1x)  Untreated
# Crop Rotation Study

- **LibertyLink Corn and Soybean**
  - Resistant weeds
  - **Zero Weed Threshold**
    - to study the seed-bank
- **Roundup Ready Alfalfa**

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Corn</td>
</tr>
<tr>
<td>2</td>
<td>Corn</td>
</tr>
<tr>
<td>3</td>
<td>Corn</td>
</tr>
</tbody>
</table>

* Corn is SmartStax  
** Soybean is Liberty Link  
*** Alfalfa is Roundup Ready
Crop Rotation...

Seed Bank Degradation
Emergence Patterns
Prevent Weed Seed Inputs

= Weed Control

Herbicide Resistant Giant Ragweed

Emergence???

Life Cycle of Annual Weeds

From Chee-Sanford et al. (2006).
Seed Bank Degradation

- Emergence
- Seed Predators
  - Mice, crickets, birds
- Soil Microorganisms
  - Bacteria, fungi
- Crop Rotation:
  - Increases activity of microorganisms
  - seed degradation?

From Chee-Sanford et. al. (2006).

(Lonsdale, 1993; Chee-Sanford et al. 2006)
Measurements

- Weed seed bank samples
  - Beginning and end
  - Wet sieve soil to extract and count seed

10 – 4in Diameter holes (6 in deep)
Seed-Bank Densities

Starting Seed Bank

Ending Seed Bank

Scale Differences

<table>
<thead>
<tr>
<th>Seeds/ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.089</td>
</tr>
<tr>
<td>0.09 - 0.18</td>
</tr>
<tr>
<td>0.19 - 0.27</td>
</tr>
<tr>
<td>0.28 - 0.36</td>
</tr>
<tr>
<td>0.37 - 0.44</td>
</tr>
<tr>
<td>0.45 - 0.53</td>
</tr>
<tr>
<td>0.54 - 0.62</td>
</tr>
<tr>
<td>0.63 - 0.71</td>
</tr>
<tr>
<td>0.72 - 0.8</td>
</tr>
<tr>
<td>0.39 - 1.68</td>
</tr>
<tr>
<td>1.69 - 2.96</td>
</tr>
<tr>
<td>2.97 - 4.25</td>
</tr>
<tr>
<td>4.26 - 5.54</td>
</tr>
<tr>
<td>5.55 - 6.82</td>
</tr>
<tr>
<td>6.83 - 8.11</td>
</tr>
<tr>
<td>8.12 - 9.39</td>
</tr>
<tr>
<td>9.4 - 10.68</td>
</tr>
<tr>
<td>10.69 - 11.97</td>
</tr>
</tbody>
</table>

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Percent Depleted by Treatment

Overall Average: 96.9% of Seed Depleted

Emergence

Microorganisms?

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% Depleted</th>
<th>% Emergence Accounts For</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (CCC)</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>2 (SCC)</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>3 (CSC)</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>4 (SWC)</td>
<td>100%</td>
<td>96.7%</td>
</tr>
<tr>
<td>5 (SAC)</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>6 (AAC)</td>
<td>42%</td>
<td>96.7%</td>
</tr>
</tbody>
</table>
Summary: Seed Bank Depletion

• 97% seed depleted if NO weeds go to seed in 2 years

• 99% seed-bank depletion in AAC
  – Emergence only accounted for 42%
    • Increased depletion
      – Rodents, microorganisms
    • Seedling mortality
      – Lack of Tillage
Crop Rotation...

Seed Bank Degradation
Emergence Patterns
Prevent Weed Seed Inputs

= Weed Control

Herbicide Resistant Giant Ragweed

Emergence???

Life Cycle of Annual Weeds

From Chee-Sanford et al. (2006).
Measurements

- Monitor giant ragweed emergence
  - Weekly counts
  - 10 Weeks starting at onset of emergence

Count and Pull Emerged Seedlings
Starting Seed-Bank Density

Starting (2012) Seed-Bank

Yearly Emergence (Plants/ft²)

2012 Seed-Bank = Proportion of Seed Bank Emerging
Proportion of Seed Bank Emerging

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop Rotation</th>
<th>Emerging</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Corn-Corn</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Corn-Soybean</td>
<td>A</td>
</tr>
<tr>
<td>2013</td>
<td>Corn-Corn</td>
<td>AB</td>
</tr>
<tr>
<td></td>
<td>Soybean-Corn</td>
<td>BC</td>
</tr>
<tr>
<td></td>
<td>Corn-Soybean</td>
<td>BC</td>
</tr>
<tr>
<td></td>
<td>Wheat-Alfalfa</td>
<td>BC</td>
</tr>
<tr>
<td></td>
<td>Alfalfa-Alfalfa</td>
<td>C</td>
</tr>
</tbody>
</table>

Total Emergence

- Corn is SmartStax
- Soybean is Liberty Link
- Alfalfa is Roundup Ready

p<0.001
Crop Rotation...

Emergence Patterns

= Weed Control

Herbicide Resistant Giant Ragweed

Timing???

Emergence

Life Cycle of Annual Weeds

From Chee-Sanford et al. (2006).
Giant Ragweed Emergence (2013-2014)

Total Emerged: 77%

Tillage Before Planting: Relatively NO effect on emergence

Percent Emergence:
- 5% on 5/7
- 18% on 5/14
- 46% on 5/21
- 77% on 5/28
- 88% on 6/3
- 95% on 6/11
- 97% on 6/18
- 98% on 6/24
- 99% on 7/2
- 100% on 7/10

(2013 - 2014)
Giant Ragweed Emergence (2013-2014)

Increased Variability

30%

Percent Emergence

5% 18% 46% 77% 92% of Max Yield

Better Emergence = More Competitive

95% 97% 98% 99% 100%

Percent of Max Soybean Yield

Source: (Severson, 2013)
http://www.extension.umn.edu/agriculture/soybean/planting/soybean-planting-date-and-delayed-planting/
Increased Variability

Emergence (2013-2014)

Percent Emergence

<table>
<thead>
<tr>
<th>Date</th>
<th>Percent Emergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/7</td>
<td>5%</td>
</tr>
<tr>
<td>5/14</td>
<td>12%</td>
</tr>
<tr>
<td>5/21</td>
<td>23%</td>
</tr>
<tr>
<td>5/28</td>
<td>30%</td>
</tr>
<tr>
<td>6/3</td>
<td>32%</td>
</tr>
<tr>
<td>6/11</td>
<td>36%</td>
</tr>
<tr>
<td>6/18</td>
<td>39%</td>
</tr>
<tr>
<td>6/24</td>
<td>42%</td>
</tr>
<tr>
<td>7/2</td>
<td>45%</td>
</tr>
<tr>
<td>7/10</td>
<td>47%</td>
</tr>
</tbody>
</table>

% Giant Ragweed Remaining

- 5/7: 95%
- 5/14: 99%
- 5/21: 99%
- 5/28: 92%
- 6/3: 85%
- 6/11: 81%
- 6/18: 72%
- 6/24: 65%
- 7/2: 55%
- 7/10: 40%

% of Maximum Yield

- 5/7: 100%
- 5/14: 99%
- 5/21: 97%
- 5/28: 92%
- 6/3: 85%
- 6/11: 81%
- 6/18: 72%
- 6/24: 65%
- 7/2: 55%
- 7/10: 40%

Source: (Severson, 2013)
http://www.extension.umn.edu/agriculture/soybean/planting/soybean-planting-date-and-delayed-planting/
Increased Variability

Emergence (2013-2014)

Percent of Max Soybean Yield

Percent Emergence


% Giant Ragweed Remaining

95%PRE, 82%

% of Maximum Yield

100% 99% 97% 92% 85% 81% 72% 65% 55% 40%

Source: (Severson, 2013)
http://www.extension.umn.edu/agriculture/soybean/planting/soybean-planting-date-and-delayed-planting/
Planting Soybeans on May 28\textsuperscript{th}...

- 92\% of Max Yield (50 bu/ac = \sim 4\text{bu}/ac loss)
  - 4\text{bu}/ac \times $10/\text{bu} = $40/\text{ac}
  - But... You have to control your weeds...

- 77\% of Giant Ragweed Emerged
  - Spring tillage
  - 77\% giant ragweed control for $40/\text{ac}
  - Fewer to control with herbicides etc.

\begin{itemize}
\item May 7\textsuperscript{th}...
  - 100\% of Yield
    (more yield variability?)
  - 100\% of Giant Ragweed
\item May 28\textsuperscript{th}...
  - 92\% of Yield
    (less yield variability?)
  - 23\% of Giant Ragweed
\end{itemize}
Summary: Emergence

- **97%** seed bank depletion in 2 years
  - **NO** Escape Weeds
- Fewer weed escapes in alfalfa and wheat treatments
  - Less total emergence
  - Competitive
  - Different Sites of Action
  - Harvest schedule
- Emerges early: 95% emergence by June 9th on average
  - Alter planting, tillage, and herbicide application schedules to better target giant ragweed
Crop Rotation…

Emergence Patterns

Timing in Different Crops??

Herbicide Resistant Giant Ragweed

Life Cycle of Annual Weeds

= Weed Control

From Chee-Sanford et al. (2006).
Giant Ragweed Emergence by Crop Rotation

All other Rotations

Alfalfa-Alfalfa

Treatment
(Previous – Current crop)
1 (Corn - Corn)
2 (Soybean - Corn)
3 (Corn - Soybean)
4 (Soybean - Wheat)
5 (Soybean - Alfalfa)
6 (Alfalfa - Alfalfa)

$R^2 = 0.860$

Logistic Model
Summary: Emergence Timing

• Emergence is prolonged in AAC
  – Differences in soil temperature and moisture
  – Resembles cool, wet spring
Crop Rotation...

Seed Bank Degradation
Emergence Patterns
Prevent Weed Seed Inputs

= Weed Control

Herbicide Resistant Giant Ragweed

Emergence???

Life Cycle of Annual Weeds

From Chee-Sanford et al. (2006).
Harrington Seed Destructor

Ray Harrington – Farmer / Inventor

(Walsh et al, 2012)
Integrated Seed Destructor
Crop Rotation...

Prevent Weed Seed Inputs

Herbicide Resistant Giant Ragweed

Weeds Must Retain Seed...

Timing

Life Cycle of Annual Weeds

From Chee-Sanford et al. (2006).
Approach

• Catch seed using collection traps
  – 3ft diameter funnel
• Monitor seed rain weekly
  – In Rosemount, MN
  – September-October
• Counted Seed
Approach

• Catch seed using collection traps
  – 3ft diameter funnel
• Monitor seed rain weekly
  – In Rosemount, MN
  – September-October
• Counted Seed
Locations:

FieldMargins

ManagedSoybeanField
Fence Row Weeds

Resistant Giant Ragweed

Resistant Giant Ragweed

30ft
Giant Ragweed Seed Production

• Produce 1,548 seeds / plant
  – No difference between soybean field and fence-rows
• 68.8% of the seed is hard (potentially viable).
Cumulative Percent of Seed Shattered

Soybean Harvest

No difference between fence-line and soybean field
Seed Fate on November 1st

Percent of Seed Going Through Combine

Year

Percent Retained on Plant

2012

2013

2014
Summary

- Most seed goes through combine
  - Varies with year
  - Seed could end up in grain
- Be mindful to prevent spread of seed
- Seed destructor could be effective

From Chee-Sanford et. al. (2006).
Summary

- Most seed goes through combine – Varies with year

From Chee-Sanford et al. (2006).

1,600 Seeds 30ft

1,600 Seeds 3ft

November 1st 62%
Take Home Message

• **Zero Weed Threshold** = 97% seed bank depletion in 2 years in any crop rotation.

• How to maintain Zero Weed Threshold?
Take Home Message

How to maintain Zero Weed Threshold?

1. **Crop Rotation:**
   a) Fewer weed escapes in alfalfa and wheat treatments
      • Less total emergence
      • Competitive
      • Different Sites of Action
      • Harvest schedule

2. **Alter Timing**
   a) Change planting, tillage, and herbicide application schedules to better target giant ragweed.
   b) 95% of giant ragweed emerged by **June 9th**
      • Emergence is prolonged in AAC

3. **Giant Ragweed retains seed well into the fall**
   a) Be mindful of seed retention: Mow your **Fence-lines**
   b) Something like Seed Destructor could work if need be
Integrated Weed Management

Game of Percentages

How much to rely on Herbicides??

Planting

Emergence???

95% 82% 54% 23% 12% 5% 3% 2% 1% 0%
% Giant Ragweed Remaining

TILLAGE
PRE
POST

Cultivation

Life Cycle of Annual Weeds

From Chee-Sanford et al. (2006).
Integrated Weed Management
Game of Percentages
How much to rely on Herbicides??

From Chee-Sanford et al. (2006).
Integrated Weed Management
Game of Percentages

How much to rely on Herbicides??

From Chee-Sanford et al. (2006).
**Integrated Weed Management**

**Game of Percentages**

**How much to rely on Herbicides??**

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**Emergence**

- Kochia
- Giant ragweed
- Common lambsquarters
- Common ragweed
- Burcucumber
- Pennsylvania smartweed
- Common sunflower
- Eastern black nightshade
- Common cocklebur
- Velvetleaf
- Giant foxtail
- Jimsonweed
- Field sandbur
- Barnyardgrass
- Woolly cupgrass
- Green foxtail
- Yellow foxtail
- Fall panicum
- Shattercane
- Sacred mallow
- Redroot pigweed
- Common waterhemp
- Ivy leaf morning glory

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**TILLAGE**

- Pre-Planting
- Cultivation

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**Werle et al. (2014)**

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**From Chee-Sanford et al. (2006)**

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**Not So Simple**

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**GDD (T_{base} = 9 C; Starting January 1)**

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