Strategies for managing the weed seedbank and encouraging weed seed predation

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1. How prevalent is weed seed return?
2. Does it matter?
3. What can we do about it?
Survey: weed seeds at harvest time

16 fields (8 corn, 8 sb)
30 samples/field

1. undispersed, standing
2. on soil surface
3. in soil seedbank
4. caught by combine
26 species total

- Giant foxtail
- Redroot pigweed
- Velvetleaf
Weed seedbank is persistent

Years required for X % reduction in seed number

<table>
<thead>
<tr>
<th>Weed type</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common lambsquarters</td>
<td>12</td>
</tr>
<tr>
<td>Velvetleaf</td>
<td>8</td>
</tr>
<tr>
<td>Common chickweed</td>
<td>3</td>
</tr>
<tr>
<td>Smartweed</td>
<td>4</td>
</tr>
<tr>
<td>Redroot pigweed</td>
<td>4</td>
</tr>
<tr>
<td>Common ragweed</td>
<td>2.5</td>
</tr>
<tr>
<td>Crabgrass, giant foxtail</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Kochia</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>
Weed seedbank is persistent

Years required for X % reduction in seed number

<table>
<thead>
<tr>
<th>Weed Type</th>
<th>50%</th>
<th>99%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common lambsquarters</td>
<td>12</td>
<td>78</td>
</tr>
<tr>
<td>Velvetleaf</td>
<td>8</td>
<td>56</td>
</tr>
<tr>
<td>Common chickweed</td>
<td>3</td>
<td>18</td>
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<tr>
<td>Smartweed</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Redroot pigweed</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>Common ragweed</td>
<td>2.5</td>
<td>10</td>
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<tr>
<td>Crabgrass, giant foxtail</td>
<td>&lt; 1</td>
<td>6</td>
</tr>
<tr>
<td>Kochia</td>
<td>&lt; 1</td>
<td>6</td>
</tr>
</tbody>
</table>
Seed germination (%)

Burial time (yr)

LOCATION
- Lincoln
- Scottsbluff

Burnside et al. 1996
Seed germination (%)

Burial time (yr)

LOCATION

- Lincoln
- Scottsbluff

Burnside et al. 1996
Why should we manage the weed seedbank?
Demographic sub-model

- seeds
- small seedlings
- large seedlings
- mature plants

Economic submodel

- control cost
- lost crop revenue

\[ s_s(1-g) \]
\[ g \]
\[ s_{cult} \]
\[ s_{hand} \]

\[ f^* s_{pred} \]

Liebman and Davis (2009)
Lower level parameter x

Cost ($/ha) in 5th yr

Physical control efficacy
Handweeding efficacy
Seedbank decline
Seed predation

= base value in model
= realistic parameter range

Liebman and Davis (2009)
Hand weeding intra-row weeds:

200-500 hours per hectare in carrot and direct sown onion and leek

Melander and Rasmussen, 2001
Relationship between weed density and time consumption for hand weeding

Melander and Rasmussen, 2001
Do seed escapes matter?
Wild proso millet fecundity in sweet corn had effects on following snap bean crop.

Yes.

Ecological management of weed seedbanks

- Cultural
- Physical
- Biological
Biological: I. Seed survival in soil seedbank

Chee-Sanford et al. (2006)
Fungal 18S principal component 1

Weed seed mortality (%)

\[ y = 40.4 - 3.3x \]
\[ R^2=0.27, \ P<0.05 \]

\[ y = 49.3 - 3.3x \]
\[ R^2=0.29, \ P<0.05 \]

organic 3-yr rotation

conventional 3-yr rotation

old field

conventional 4-yr rotation

reduced input 4-yr rotation

Davis et al. (2006)
Chemical:physical protection
(μg phenol g seed⁻¹/μm seed coat)

\[ y = 0.16 + 0.21/(0.0432 + x) \]
\[ R^2 = 0.99, \ P < 0.001 \]
Biological: II. Seed predation
Common predators of weed seeds…. We need more of these in our cropping systems!
Davis et al. (2003)
Annual rate of seed predation in field crops

Urbana, IL
2004-2008
Weed seed predation over time (giant foxtail)

CROP_05
- red: corn
- turquoise: soybean
- green: wheat/red cl

DAYS_ELAPSED

% Seed loss to predation
Weed seed predation over time
(giant ragweed)

% Seed loss to predation

DAYS_ELAPSED

CROP_05
- corn
- soybean
- wheat/red cl
Can we maintain high seed predation rates throughout the year by diversifying crops?

![Graph showing seed predation rates over seasons for different crops: corn, soybean, small grain + legume, alfalfa.](image)

- **Spring**: Corn, soybean show predation, small grain + legume and alfalfa show low predation.
- **Summer**: All crops show high predation.
- **Autumn**: Predation remains high for small grain + legume and alfalfa, lower for corn, soybean.
- **Winter**: Predation decreases for all crops.

**Question**: After Heggenstaller et al. (2006)
Day of Year

P_(seed predation)
$R^2 = 0.52$

$F_{1,10} = 11.46, P = 0.007$
beetle banks
Cultural: I. Cover crops and mulches
Cultural: II. Weed suppressive crop cultivars

crop yield loss:  

weed seeds:
Cultural: III. Crop population and spatial arrangement
Cultural: IV. Crop rotation and diversification
Physical: I. Improved intrarow control efficacy to reduce hand-weeding costs

Band-steaming reduced intra-row weeds in sugar beet

Melander & Jørgensen 2005
More physical and thermal tools: intrarow
Physical: II. Tillage as one-time rescue for massive seed input
Mohler (2001)
Physical: III. Stale seedbed
Physical: IV. Weed seed collection at harvest
Bibliography


*Scientific literature mentioned in presentation available upon request (contact Adam Davis: asdavis1@illinois.edu ) or John Masiunas: masiunas@illinois.edu *)