How to Manage Weeds More Successfully

with special reference
to giant ragweed
Weeds remain a problem for both conventional and organic farmers

- Herbicide resistance
- Off-site movement of herbicides in air and water
- Incomplete control with cultivation
- Complications due to weather
Durable improvements in weed management are based on:

• Understanding ecological principles and processes
• Learning the life history characteristics of problematic weed species
• Carefully considering and comparing management options
Weed population dynamics
Population dynamics equation

\[ N_t = N_{t-1} + B - D + I - E \]

- \( N_t \): the number of organisms at time \( t \)
- \( N_{t-1} \): the previous number of organisms
- \( B \): births
- \( D \): deaths
- \( I \): immigrants
- \( E \): emigrants
Life history of an annual weed

- Spring Seedbank
- Seedling recruitment
- Seedling survival
- Seedbank survival
- New seed survival
- Reproductive Adults
- Seed production
- New Seeds
Weed seedbank dynamics
Seeds in soil

Seedling emergence

Seed dormancy and persistence

Seed death in soil
  • pathogens
  • aging
  • fatal germination

Seed inputs

Seed loss to predators
Giant ragweed
Ambrosia trifida
Results of Survey of Certified Crop Advisors in the Corn Belt Regarding Difficulty of Managing Giant Ragweed
Key characteristics of giant ragweed contributing to its success in agroecosystems
Giant Ragweed Populations Resistant to ALS-inhibitors and/or Glyphosate
Glyphosate resistant giant ragweed in corn

Up to 82% corn yield loss on Ontario farms – Average 72%

Photos from P. Sikkema, https://twitter.com/psikkema1/status/703619310024073216
Giant ragweed male and female flowers

https://willowhousechronicles.wordpress.com/tag/giant-ragweed/
Large seeds with substantial energy reserves
Large cotyledons

Rapid leaf production and growth
Capable of overtopping crops
Early seedling emergence and cold tolerance
Giant ragweed seedling emergence patterns differ among locations and populations.

**Figure 3.** Emergence patterns of three giant ragweed biotypes.

- **Iowa agricultural field**
- **Ohio agricultural field**
- **Iowa non-agricultural field (flood plain)**

Source: Hartzler 2003
Distribution of emergence period of giant ragweed, in months
Extended periods of seedling emergence make giant ragweed control more challenging.
But giant ragweed has several vulnerabilities....

• High rates of seed consumption by predators (e.g., rodents, invertebrates, and birds)

• Short lifetime of seeds in and on the soil (i.e., it has a transient seedbank rather than a persistent seedbank)

• Relatively low rates of seed production (1,000s rather than 10,000s or 100,000s)
Seed Predators

Peromyscus maniculatus

Gryllus pennsylvanicus
Removal of giant ragweed seeds by predators

Cumulative seed removal (%)

Time after deposition (months)

Source: Harrison et al., 2003
About 60% of giant ragweed seeds were removed from the soil surface between November and May. Total seed predation over a 12-month period was 88%.
Fates of giant ragweed seeds buried at different depths over a four-year period

Source: Harrison et al. 2007
Most emergence of giant ragweed seedlings occurs within the first two years after seed deposition.

Source: Harrison et al. 2007
About 90% of giant ragweed seeds buried in the top 10 cm (four inches) of soil were eliminated after two years.
Giant ragweed seed production on field edges and in soybean

Source: Goplen 2015
Seeds are not dispersed from parent plants until late summer and fall

Source: Harrison et al. 2001
Situation analysis
Giant ragweed seed population density in the soil of a field in Minnesota

Figure A-2. Spatial distribution of starting seed bank density in experiment 1 at Rochester, MN taken in 2012. The krigging method of spatial interpolation was used to interpolate data and produce the seed density map.

100 seeds/m² = 404,686 seeds/acre

Goplen, 2015
How many weed seedlings does cultivation kill? (multiple passes in corn and soybean)

Gunsolus (1990): 92%
Renner & Woods (1998): 83%
Mohler et al. (1997): 68%
It can be hard to beat the numbers

- 100 seeds per square meter in the soil seedbank = 404,686 seeds/acre
- 30% of the seeds germinate and emerge $\rightarrow$ 121,406 seedlings/acre
- 90% effectiveness in cultivation $\rightarrow$ 12,140 plants/acre
- 1,400 seeds produced per plant $\rightarrow$ 16,996,812 seeds/acre
- 60% seed loss to predators $\rightarrow$ 6,798,725 seeds/acre added to the soil seedbank
Cropping systems and weed management
Consider two kinds of crops

(1) Row crops that can be cultivated, sprayed, and/or hand-weeded. Weed control may be less than 100% effective.

(2) Solid seeded crops that are harvested in mid-summer, mowed, and/or removed for fodder. *Cutting these crops in a timely manner can prevent reproduction by giant ragweed.*
Key questions for giant ragweed management

• How good does weed control need to be?
• Is the length of a crop sequence important?
• Is the sequence of crops within a given rotation important?
• How can hand-weeding supplement cultivation?
Consideration of weed management options using models
Management effects on life history

Seedlings → Reproductive Adults
Seedling recruitment
Seedling survival

Spring Seedbank → New Seeds
Seed production
New seed survival

New Seeds → Spring Seedbank
Seedbank survival
Spring Seedbank

Seedlings

Reproductive Adults

New Seeds

Cultivation, mowing, herbicides

Crop competition

Seed predation

Decay

Tillage
Key performance indicators

- Weed seed population density in soil
- Weed plant density
How good does weed control need to be?

3-Year Rotation, Solid-Row-Row

Control in row crops
- 90%
- 91%
- 92%
- 93%
- 94%
- 95%

Plant density, no. sq./meter

Years

0 3 6 9 12
How good does weed control need to be?

3-Year Rotation, Solid-Row-Row

96.3% control in row crops

Plant or seed density, no./sq. meter

Years

0.0 0.25 0.50

0 100 200

Mature plants

Seeds in soil
Is the length of a crop sequence important?

<table>
<thead>
<tr>
<th>Rotation length</th>
<th>Control required in row crops to prevent weed population increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year: Solid-Row-Row</td>
<td>96.3%</td>
</tr>
<tr>
<td>4-year: Solid-Solid-Row-Row-Row</td>
<td>90.2%</td>
</tr>
</tbody>
</table>
Is the sequence of crops within a given rotation important?

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Control required in row crops to prevent weed population increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid-Solid-Row-Row</td>
<td>90.2%</td>
</tr>
<tr>
<td>Row-Row-Solid-Solid</td>
<td>97.7%</td>
</tr>
</tbody>
</table>
How can hand-weeding supplement cultivation?
(solid-solid-row-row sequence)

<table>
<thead>
<tr>
<th>Control strategy</th>
<th>Control required in row crops to prevent weed population increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivate only</td>
<td>Cultivation: 90.2%</td>
</tr>
<tr>
<td></td>
<td>Hand-weeding: 0%</td>
</tr>
<tr>
<td>Cultivate + hand-weeding</td>
<td>Cultivation: 80.0%</td>
</tr>
<tr>
<td></td>
<td>Hand-weeding: 50.7%</td>
</tr>
</tbody>
</table>
Key points

• Minimize weed seed inputs
• Start new rotation sequences with weed suppressive crops and effective control practices
• Deplete the weed seedbank by allowing seedling emergence while preventing reproduction
• Encourage weed seed predation by leaving seeds on the soil surface as long as possible