Welcome to the WSU Wheat Academy
Herbicide Resistance is a Case Study on Natural or Artificial Selection
Progression of Weed Resistance

Weed resistance progresses logarithmically

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% Resistant Weeds in Population</th>
<th>Weed Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Application</td>
<td>.0001</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Year 0

Credit: Mike DeFelice

Herbicide-resistant biotype

Seed pool or seed bank in soil

First application of herbicide to initial population to produce resistant individual.
Progression of Weed Resistance

Weed resistance progresses logarithmically

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<td>0 Application</td>
<td>.0001</td>
<td>Excellent</td>
</tr>
<tr>
<td>1st Application</td>
<td>.00143</td>
<td>Excellent</td>
</tr>
<tr>
<td>2nd Application</td>
<td>.0205</td>
<td>Excellent</td>
</tr>
<tr>
<td>3rd Application</td>
<td>.294</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Herbicide resistance cannot be reversed in a practical time frame. In many cases, the seed pool is unlikely to change back because there is no fitness penalty.

Credit: Mike DeFelice
Factors Affecting Speed of Selection

The length of time for selection of resistance varies by:

- Cultural practices
- Frequency of herbicide use
- Herbicide mechanism of action
- Biology of weed species
- Frequency of resistant biotypes among weed species
Chronological Increase in Resistant Weeds Globally
Number of Herbicide-Resistant Species by crop (top 10)

- Wheat: 84
- Corn (maize): 65
- Rice: 54
- Soybean: 53
- Roadside: 36
- Winter wheat: 34
- Spring barley: 31
- Orchard: 29
- Canola: 23
- Cotton: 18
## Current Status of Herbicide Resistance in the PNW

<table>
<thead>
<tr>
<th>Species</th>
<th>MOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Groundsel</td>
<td>Group 5 (simazine), Group 6 (bromoxynil)</td>
</tr>
<tr>
<td>Prickly Lettuce</td>
<td>Group 2 (ALS), Group 4 (synthetic auxins)</td>
</tr>
<tr>
<td>Kochia</td>
<td>Group 2 (ALS), Group 4 (synthetic auxins), Group 9 (glyphosate),</td>
</tr>
<tr>
<td>Russian Thistle</td>
<td>Group 2 (ALS), Group 9 (glyphosate)</td>
</tr>
<tr>
<td>Mayweed Chamomile</td>
<td>Group 2 (ALS)</td>
</tr>
<tr>
<td>Redroot Pigweed</td>
<td>Group 5 (photosystem II)</td>
</tr>
<tr>
<td>Spiny Sowthistle</td>
<td>Group 2 (ALS)</td>
</tr>
<tr>
<td>Common Lambsquarters</td>
<td>Group 5 (photosystem II)</td>
</tr>
<tr>
<td>Yellow Starthistle</td>
<td>Group 4 (synthetic auxins)</td>
</tr>
<tr>
<td>Downy Brome</td>
<td>Group 1 (ACCase), Group 2 (ALS), Group 9 (glyphosate)</td>
</tr>
<tr>
<td>Italian Ryegrass</td>
<td>Group 1 (ACCase), Group 2 (ALS), Group 15 (flufenacet), Group 9</td>
</tr>
<tr>
<td></td>
<td>(glyphosate), Group 10 (glufosinate)</td>
</tr>
<tr>
<td>Wild Oat</td>
<td>Group 1 (ACCase), Group 2 (ALS), Group 3 (pronamide), Group 8,</td>
</tr>
<tr>
<td></td>
<td>Group 26 (difenozoquat, triallate)</td>
</tr>
</tbody>
</table>

weedscience.org
How Do We Avoid or Delay Herbicide Resistance in Weeds?
Integrated Weed Management

Sanitation

Mechanical

Chemical

Biological

Cultural
General Principles of Integrated Weed Management

- Use agronomic practices that limit the introduction and spread of weeds
  - “Prevent weed problems before they start”
- Help the crop compete with weeds
  - Help crop “choke out” weeds
- Use practices that keep weeds “off balance”
  - “Do not allow weeds to adapt”
Prevent Weed Problems Before They Start

- Use clean seed
- Tarp grain loads
- Control weeds on field edges
- Remove or cut weeds before seed set
- Compost livestock manure
- Manage weed seed at harvest and after harvest
Help Crop “Choke Out” Weeds

- Fertilizer placement and/or timing
- High seeding rates
- Narrow row spacing
- Shallow and uniform seeding
- High quality seed
- Well prepared seedbed
- Competitive crop varieties
Do Not Allow Weeds to Adapt

- Crop rotation
  - Select crops with varied seeding dates
  - Select crops with varied life cycles
  - Alternate crops with varied competitive abilities
Winter Annual Grass Weeds in Winter Wheat
Jointed Goatgrass Seed Longevity

Viable seed (%)

Years in seedbank

0 20 40 60 80 100
1 2 3 4 5

Jointed Goatgrass Seed Longevity
Crop Rotation Effects on Weed Densities

Weed densities (plants/yard$^2$)

Jointed goatgrass

- 9.6
- 17

Feral rye

- 1.2
- 4.7

Legend:
- WW-Ft
- WW-Fh
- WW-F-F
- WW-SF-F
- WW-PM-F
Do Not Allow Weeds to Adapt

- Crop rotation
  - Select crops with varied seeding dates
  - Select crops with varied life cycles
  - Alternate crops with varied competitive abilities
- Rotate and/or combine herbicides with different mechanisms of action
- Rotate use of Herbicide-Resistant Crops
- Rotate tillage practices
## Risk of Resistance on a Per Species Basis

<table>
<thead>
<tr>
<th>Management Option:</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicide mix or rotation in cropping system</td>
<td>&gt; 2 modes of action</td>
<td>2 modes of action</td>
<td>1 modes of action</td>
</tr>
<tr>
<td>Weed control in cropping system</td>
<td>Cultural, mechanical, and chemical</td>
<td>Cultural and chemical</td>
<td>Chemical alone</td>
</tr>
<tr>
<td>Use of same mode of action per season</td>
<td>Once</td>
<td>More than once</td>
<td>Many times</td>
</tr>
<tr>
<td>Cropping system</td>
<td>Full rotation</td>
<td>Limited rotation</td>
<td>No rotation</td>
</tr>
<tr>
<td>Resistance status to mode of action</td>
<td>Unknown</td>
<td>Limited</td>
<td>Common</td>
</tr>
<tr>
<td>Weed infestation</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Control in last 3 years</td>
<td>Good</td>
<td>Declining</td>
<td>Poor</td>
</tr>
</tbody>
</table>

Moss 1998
The Weed Seedbank

Figure 2. Flow chart for the dynamics of weed seeds in the soil (Harper 1977)
Questions?