Outline

Alternative weed control background

Weed electrocution

Harvest weed seed control

Driver weeds in Kansas

- Palmer amaranth
  - Resistance to
    - HG’s 2, 4, 5, 9, 14, 27
    - 6-way
  - Waterhemp
    - Resistance to
      - HG’s 2, 5, 9, 14
    - 2-way
  - Kochia
    - Resistance to
      - HG’s 2, 4, 9
    - 4-way

Herbicide-resistance in the US

<table>
<thead>
<tr>
<th>Herbicide group (example herbicide)</th>
<th>Number of cases</th>
<th>Year (and state) of first report</th>
</tr>
</thead>
<tbody>
<tr>
<td>9, EPSPS inhibitor (glyphosate)</td>
<td>41</td>
<td>2005 (GA) 2007 (KS)</td>
</tr>
<tr>
<td>5, PSII inhibitors (atrazine)</td>
<td>10</td>
<td>1993 (TX) 1976 (KS)</td>
</tr>
<tr>
<td>27, HPPD inhibitors (mesotrione)</td>
<td>6</td>
<td>2009 (KS)</td>
</tr>
<tr>
<td>14, PPO inhibitors (fomesafen)</td>
<td>4</td>
<td>2011 (AR)</td>
</tr>
<tr>
<td>4, Growth regulators (2,4-D, dicamba)</td>
<td>3</td>
<td>2015 (KS) 1994 (MT)</td>
</tr>
<tr>
<td>15, VLCFA inhibitors (S-metolachlor)</td>
<td>2</td>
<td>2016 (AR)</td>
</tr>
<tr>
<td>10, Glutamine synthetase inhibitor (glufosinate)</td>
<td>1</td>
<td>2020 (AR)</td>
</tr>
</tbody>
</table>
**Metabolic resistance**

Herbicide converted to inactive forms before plant is killed
- Cytochrome P450s and glutathione S-transferases

We **must** rethink assumptions regarding herbicide resistance
- Reduced effectiveness of mixing and rotating herbicides
- Minimize weed seed bank
- Adopt alternative management strategies

**Harvest weed seed control can complement herbicides to manage seedbank**

**Why manage weed seed banks**

Seed rain year 1
Assume escapes of 100 plants per acre

\[
\text{seeds/acre} \times 15\% = \frac{52,500}{\text{viable seeds/acre}}
\]

Plants emerged year 2
52,500 seeds/acre \times 95\% = 5,025 plants/acre

Plants escaped year 2
10,500 plants/acre \times 95\% = 1,025 plants/acre

Seed rain year 2
525 plants \times 487 \text{ seeds/plant} = 255,639 seeds/acre

**Herbicide site of action introductions by year**

- **Group 1** fluazifop (Assure) 1981
- **Group 2** chlorsulfuron (Glean) 1980
- **Group 3** trifluralin (Treflan) 1963
- **Group 4** 2,4-D 1942
- **Group 5** dicamba (Diran) 1954
- **Group 6** bromoxynil (Moxy) 1965
- **Group 7** propachlor (Ramrod) 1965
- **Group 8** atrazine (Atral) 1965
- **Group 9** glyphosate 1971
- **Group 10** glufosinate (Liberty) 1981
- **Group 11** isoxaflutole (Balance) 1995
- **Group 12** fluprop (Fluprop) 1975
- **Group 13** clomazone (Command) 1982
- **Group 14** clodinafop (Patex) 1981
- **Group 15** propyzamide (Rynax) 1981
- **Group 16** tebuthiuron (Methoxy) 1965
- **Group 17** mefenacet (Mefenate) 1966
- **Group 18** ioxynil (Intox) 2004
- **Group 19** alachlor (Larson) 1963
- **Group 20** ethofumesate (Fomesate) 1975
- **Group 21** metolachlor (Ranger) 1969
- **Group 22** paraquat 1966
- **Group 23** clomazone (Mentex) 1983
- **Group 24** avadex (Avalon) 1971
- **Group 25** carfentrazone (Balance) 1992
- **Group 26** sethoxydim (Schiad) 1978
- **Group 27** imazaquin (Ravex) 1990
- **Group 28** metribuzin (Spear) 1978
- **Group 29** pyridate (Pylate) 2006
- **Group 30** cinmethylin 1981
- **Group 31** metribuzin (Spear) 1978
- **Group 32** mefenacet (Mefenate) 1966
- **Group 33** isoxaflutole (Balance) 1995

**Herbicide site of action introductions by year**

- **Group 1** fluazifop (Assure) 1981
- **Group 2** chlorsulfuron (Glean) 1980
- **Group 3** trifluralin (Treflan) 1963
- **Group 4** 2,4-D 1942
- **Group 5** dicamba (Diran) 1954
- **Group 6** bromoxynil (Moxy) 1965
- **Group 7** propachlor (Ramrod) 1965
- **Group 8** atrazine (Atral) 1965
- **Group 9** glyphosate 1971
- **Group 10** glufosinate (Liberty) 1981
- **Group 11** isoxaflutole (Balance) 1995

**Herbicide site of action introductions by year**

- **1940s** 1950s 1960s 1970s 1980s 1990s 2000s
Insanity is doing the same thing over and over and expecting different results.

Challenge

How will you change weed management to better steward current and future herbicides?

The Art of War

If you know the enemy and know yourself, you need not fear the result of a hundred battles.

If you know yourself but not the enemy, for every victory gained you will also suffer a defeat.

If you know neither the enemy nor yourself, you will succumb in every battle.

Know thy enemy

- Emergence and other lifecycle characteristics
- Method of pollination and other reproductive characteristics
- Canopy and root structure and other factors that influence competitiveness

Know thy enemy

Werle et al., 2014
“Alternative” can mean cultural

- Crop rotation
- Fertility
- Planting date
- Plant population
- Row spacing

“Dark is a good herbicide”

“Alternative” can mean physical/mechanical

- Cover crops
- Strategic tillage
- Flaming
- Electrocution
- Harvest weed seed control

Strategic tillage

![Graph showing weed count comparison between no-till, strategic tillage, and reduced tillage across different crop rotations.](image)

Obour et al. 2021

Strategic tillage

![Graph showing weed distribution across different tillage systems and crop depths.](image)

Farmer et al. 2017
Tillage/herbicide interactions
Stars indicate statistically greatest control Sept. 12, 2022

Electrocution
- Electricity transferred through copper boom
- Safety concerns

Electrocution
- Requires height separation between weeds and crop
  - More is better
- Multiple passes might improve control
- Main factors are voltage (=3 to 8 kV) and time (≈ 4 to 20 s)
- Greater weed density requires more energy
- Control increases as weeds mature

Palmer amaranth control 2 WAT

Response of Pigweed Species To Electrocution

What we think we’ve learned so far...
- This is NOT a weed management tool – it is a weed rescue tool
- Can be effective on troublesome resistant weeds
- Varies with Size, plant moisture, boom height – not soil moisture (in MO)
- Can reduce weed seed viability

Harvest weed seed control
- HWSC used on 80% of Australian farms
- Chaff lining (ideally in wheel tracks)
- Windrow burning
- Impact mills
  - Redekop
  - Seed Terminator
  - IHSD

*Bars followed by the same letter within a year are not different, LSD <0.05

Kevin Bradley

Walsh et al., 2017
**HWSC effects on Palmer amaranth seedbank at soybean harvest**

Seed bank decreased over time 3-pass herbicide program.
By year 3, all treatments reduced seedbank compared to no fall treatment.

"Rescue" option

---

**Palmer amaranth seed destruction in grain sorghum**

- No of samples collected = 4/strip
- No of passes = 4

<table>
<thead>
<tr>
<th>Category</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No damage</td>
<td>5</td>
</tr>
<tr>
<td>Slightly cracked</td>
<td>28</td>
</tr>
<tr>
<td>Moderately cracked</td>
<td>64</td>
</tr>
<tr>
<td>Fully pulverized</td>
<td>3</td>
</tr>
</tbody>
</table>

95% of total seeds were destructed

---

**Pigweed seed retention at soybean maturity**

<table>
<thead>
<tr>
<th>State</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seed Retention (%)</td>
<td></td>
</tr>
<tr>
<td>AR</td>
<td>99.98 ± 0.00</td>
<td>99.85 ± 0.05</td>
</tr>
<tr>
<td>IL</td>
<td>99.95 ± 0.03</td>
<td>--</td>
</tr>
<tr>
<td>NE</td>
<td>98.89 ± 0.23</td>
<td>99.93 ± 0.02</td>
</tr>
<tr>
<td>MO</td>
<td>99.98 ± 0.00</td>
<td>99.67 ± 0.20</td>
</tr>
<tr>
<td>TN</td>
<td>99.96 ± 0.01</td>
<td>--</td>
</tr>
</tbody>
</table>

**Waterhemp**

<table>
<thead>
<tr>
<th>State</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>IL</td>
<td>99.98 ± 0.01</td>
<td>94.98 ± 0.94</td>
</tr>
<tr>
<td>NE</td>
<td>99.99 ± 0.00</td>
<td>99.63 ± 0.10</td>
</tr>
<tr>
<td>MO</td>
<td>100.00 ± 0.00</td>
<td>99.84 ± 0.04</td>
</tr>
<tr>
<td>WI</td>
<td>99.96 ± 0.01</td>
<td>98.80 ± 0.30</td>
</tr>
</tbody>
</table>

**Harvest weed seed control**

Weed seeds buried overwinter

**Urbana-Champaign**
2015-16 (top):
Waterhemp, common lambsquarters, giant foxtail, velvetleaf, ivyleaf morningglory, giant ragweed, common cocklebur

**Beltsville**
2017-18 (bottom):
Smooth pigweed, common ragweed, jimsonweed, common lambsquarters, velvetleaf
Waterhemp density spring following treatment

Take aways
This is NOT a stand-alone weed control tool
Reduction in weed seedbank will take time, especially if initially large
Effectiveness influenced by weed seed retention, cutting height, weed seed getting to mill
Does result in added engine load and fuel use

Take aways
This is NOT a stand-alone weed control tool
Reduction in weed seedbank will take time, especially if initially large
Effectiveness influenced by weed seed retention, cutting height, weed seed getting to mill
Does result in added engine load and fuel use

3.33% where are all the places waterhemp could exit the combine?

Seed Terminator changes combine efficiency

Where are all the places waterhemp could exit the combine?
Future research on ‘alternative’ weed control in KS

On-farm studies
  Seed destructor in wheat
  IWM for tumble windmillgrass
  Weed Zapper?
  Row Shaver?

Small plot studies
  Cover crops
  Planting date/row-spacing interactions

slancaster@ksu.edu
@KStateWeedSci
K-State Weed Science
waragainstweeds.libsyn.com