Current Status of Herbicide Resistance in Non-crop Areas

Fred Fishel
Professor, UF/IFAS Agronomy

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When Herbicides Don’t Work

- Improper plant/weed identification
- Incorrect herbicide dosage
- Improper application timing
- Herbicide isn’t absorbed by the target plant/weed
- Unfavorable environmental conditions
- Quality issues with mix water
- Use of the proper adjuvant if required
- *Pesticide resistance*
Improper Plant/weed Identification

Japanese climbing fern

Old World climbing fern
Depending upon product, rates can vary by 3X to 4X, or more, for different species.
Incorrect Herbicide Dosage

• Is equipment calibrated?
• Was herbicide properly measured?
• How long has the herbicide been sitting in the tank with carrier?
• Did you remember to add the herbicide to the tank?
Improper Application Timing

Arsenal:

Cut-stump Treatment

Dilute Solution. Spray or brush the solution onto the cambium area of the freshly cut stump surface. Ensure that the solution thoroughly wets the entire cambium area (the wood next to the bark of the stump).
Herbicide isn’t absorbed by the target plant/weed.
Unfavorable Environmental Conditions

Escort XP:

BIOLOGICAL ACTIVITY

Escort® XP Herbicide is absorbed primarily through the foliage of plants, and by the roots to a lesser degree. Plant cell division is generally inhibited in sensitive plants within a few hours following uptake. Two to 4 weeks after application, leaf growth slows followed by discoloration and tissue death. The final effects on annual weeds are evident about 4 to 6 weeks after application. The ultimate effect on perennial weeds and woody plants occurs in the growing season following application.

Warm, moist conditions following treatment promote the activity of Escort® XP Herbicide, while cold, dry conditions may reduce or delay activity. Weeds and brush hardened off by cold weather or drought stress may not be controlled. Weed and brush control may be reduced if rainfall occurs soon after application.
Quality Issues With Mix Water

• Water often comprises ninety-five percent (or more) of the spray solution
• Water quality can affect herbicide performance
• Water quality parameters affect herbicide performance:
  – pH
  – Dissolved minerals
  – Suspended solids
• Poor water quality
  – Reduce solubility
  – Decrease absorption
Quality Issues With Mix Water

Do you draw water from a pond or canal?

Suspended solids
Quality Issues With Mix Water

Suspended solids

- Pond and canal water....
  - Often has organic matter floating in it
  - This can tie up and deactivate almost any herbicide
  - Differences in clarity can impact the efficacy of the herbicide
Quality Issues With Mix Water

**Suspended solids**

**7.0 MIXING**

Roundup Ultra Label

Clean sprayer parts immediately after using this product by thoroughly flushing with water.

**NOTE:** REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS VISIBLY MUDDY WATER OR WATER FROM PONDS AND DITCHES THAT IS NOT CLEAR.
Quality Issues With Mix Water

Dissolved minerals

• Several herbicides (including 2,4-D, dicamba, and glyphosate) have an overall negative charge

• These herbicides can be influenced by hard water cations
  – Form precipitates
  – Lower probability of passing through plant cuticle
Quality Issues With Mix Water

Dissolved minerals

• The effects of hard water can be reversed with a water conditioner - commonly ammonium sulfate

• Add the water conditioner to the tank before you add the herbicide

\[
\begin{align*}
\text{Dissolved minerals} & \quad \text{Ca}^{2+} + \text{SO}_4^{2-} = \text{CaSO}_4 \\

\end{align*}
\]

7.4 Ammonium Sulfate

The addition of 1 to 2 percent dry ammonium sulfate by weight or 8.5 to 17 pounds per 100 gallons of water may increase the performance of this product, particularly under hard water conditions, drought conditions or when tank mixed with certain residual herbicides, on annual and perennial weeds. The equivalent rate of ammonium sulfate in a liquid formulation may also be used. Ensure that dry ammonium sulfate is completely dissolved in the spray tank before adding herbicides. Thoroughly rinse the spray system with clean water after use to reduce corrosion.
Use of the Proper Adjuvant

Escort XP:

ADJUVANTS
The use of a surfactant is recommended to enhance the control of susceptible plants, except where noted. Apply at a minimum rate (concentration) of 1/4% volume/volume (1 quart per 100 gallons of spray solution), or at the manufacturer’s recommended rate. Use only EPA approved surfactants containing at least 80% active ingredient. Certain types of surfactants, such as those incorporating acetic acid (i.e. LI-700), may not be compatible with Escort® XP Herbicide and may result in decreased performance. Certain surfactants may not be suitable for use on desirable plants, such as turf and conifers, listed on this label. Consult the surfactant manufacturer’s label for appropriate uses.
Terminology

- What does herbicide resistance mean???
- **Resistant:** Pest was originally susceptible to pesticide; over time control lost through the selection of resistant individuals.
- **Tolerant:** The inherent ability of a species to survive following a pesticide treatment – was never susceptible.
- **Biotype:** A group of individuals having the same genotype.
Terminology

- **Mode of action**: describes the biochemical processes by which the pesticide poisons the pest (for example, disrupting photosynthesis).

- **Target site of action**: the exact location of inhibition, such as interfering with the activity of a specific enzyme within a metabolic pathway.
Terminology

• *Cross resistance*: resistance to 2 or more pesticides that share the same mode of action.

• *Multiple resistance*: resistance to 2 or more pesticides with different modes of action.
History of Herbicide Resistance

• 1957 – weeds
  1. 2,4-D resistant dayflower in sugarcane field
  2. Triazine-resistant groundsel in late 1960s in a pine nursery
Herbicide Resistance Mechanisms

Sequestered in vacuole

Help! Get me outta here!

Please! Let me in!

I can’t do my job!

My key won’t fit!
Glyphosate Resistant Giant Ragweed (Ambrosia trifida) infesting Roundup Ready Corn. Photo: Dr. Bill Johnson

**PowerPoint Charts Available for Download**

High resolution PowerPoint charts available for presentations and extension publications. The PowerPoint contains charts made in Excel. [WSSA version (WSSA Group Numbers)](WSSA version (WSSA Group Numbers)) and [HRAC version (HRAC Group Letters)](HRAC version (HRAC Group Letters)).
Global Increase in Unique Resistant Cases

Number of Unique Resistant Cases

Year

Dr. Ian Heap, WeedScience.org 2016
More than 450 resistant biotypes globally
9 of the top 15 most common herbicides prone to resistance are ALS inhibitors.
Resistance Concerns

Circa mid-1990’s
Because glyphosate is non-selective, Monsanto has insisted that glyphosate resistant weeds will not appear with the use of this herbicide. With the imminent release of glyphosate resistant corn and soybeans, this hypothesis will soon be tested on potentially millions of acres. Resistant weed populations have been reported already in locations outside the USA.
Global Summary

- 479 unique cases of global herbicide resistance (species x site of action)
- 252 species (147 dicots and 105 monocots)
- Resistance documented in 23 of 26 known herbicide sites of action (161 herbicides)
- Resistance documented in 67 countries
# Common Non-crop Terrestrial Herbicide MOAs

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Class</th>
<th>Mechanism of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td></td>
<td>Synthetic Auxin</td>
</tr>
<tr>
<td>Aminocyclopyrachlor</td>
<td>4(^{(0)})</td>
<td>Acetolactate Synthase (ALS) Inhibitor</td>
</tr>
<tr>
<td>Aminopyralid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triclopyr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imazamox</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imazapic</td>
<td>2(^{(B)})</td>
<td>Acetyl CoA Carboxylase (ACCase) Inhibitor</td>
</tr>
<tr>
<td>Imazapyr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metsulfuron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluazifop-P</td>
<td>1(^{(A)})</td>
<td>Inhibitor of 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS)</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>9(^{(G)})</td>
<td>Inhibitor of Photosynthesis at Photosystem II Site A</td>
</tr>
<tr>
<td>Hexazinone</td>
<td>5(^{(C1)})</td>
<td>Inhibitor of Photosynthesis at Photosystem II Site A</td>
</tr>
</tbody>
</table>
If searched by crop, the following non-crop terrestrial sites may be selected: fallow, fencelines, forests, industrial sites, railways, and roadsides.
Global Herbicide Resistance - Fallow

• 12 species
• 3 countries
• 3 species in U.S., including resistant ragweed parthenium in Florida (glyphosate)
• Herbicides:
  – 2,4-D
  – Glyphosate
  – 1 case of multiple resistance
Global Herbicide Resistance - Fencelines

• 4 species
• 2 countries
• 2 species in U.S. – both in California
  – Horseweed
  – Junglerice
• Herbicides:
  – Glyphosate
Global Herbicide Resistance - Forests

- 7 species
- All cases are in Israel
- Herbicides:
  - Atrazine
  - Simazine
  - Chlorsulfuron
  - Sulfometuron
  - 2 cases of multiple resistance
Global Herbicide Resistance – Industrial Sites

- 5 species
- 5 countries
- 2 species in U.S., including resistant ragweed parthenium in Florida
- Herbicides:
  - Glyphosate, atrazine, simazine
  - 6 ALS inhibitors
  - 1 case of multiple resistance
Global Herbicide Resistance – Railways

- 15 species
- 11 countries
- 3 species in U.S., including resistant ragweed parthenium in Florida
- Many herbicides involved
  - 4 cases of multiple resistance
Global Herbicide Resistance – Roadsides

• 32 species
• 12 countries
• 15 species in U.S., including resistant ragweed parthenium in Florida
• Many herbicides involved
  – 3 cases of multiple resistance
## Herbicide Resistance in Florida

<table>
<thead>
<tr>
<th>Year</th>
<th>Species</th>
<th>Situation</th>
<th>Herbicide(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>American black nightshade</td>
<td>Tomato</td>
<td>Paraquat</td>
</tr>
<tr>
<td>1996</td>
<td>Goosegrass</td>
<td></td>
<td>Diquat</td>
</tr>
<tr>
<td>2001</td>
<td>Dotted duckweed</td>
<td>Aquatic</td>
<td>Fluridone</td>
</tr>
<tr>
<td>2002</td>
<td>Hydrilla</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Palmer amaranth</td>
<td>Cropland</td>
<td>Imazapic, pyrithiobac-Na, glyphosate</td>
</tr>
<tr>
<td>2014</td>
<td>Ragweed Parthenium</td>
<td>Non-crop</td>
<td>Glyphosate</td>
</tr>
</tbody>
</table>
Playing by the Numbers
Spraying by the Numbers

Metsulfuron: Group 2 ALS inhibitor
Spraying by the Numbers

To rotate to a different mode of action, choose a product with a different group number on its label.
Thank you for your attention!