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Avoiding Herbicide Resistance in Weeds

A wise farmer once said, "If you do anything the same way long enough, it's wrong 'cause things are going to change." This is certainly true when speaking of weeds and herbicide resistance.

This publication will answer questions on herbicide resistance, help you understand the potential for resistance development based on herbicide chemistry, and give you strategies to avoid resistant weeds in your crops.

What are herbicide resistant biotypes?

Due to naturally occurring genetic diversity, a weed species population that was susceptible to a specific herbicide site of action at one time, is no longer susceptible to that site of action. These weeds are referred to as resistant biotypes.

How does resistance develop?

The mix of weed species in a field is based on the history of your crop and weed management practices. Because nature responds to changing conditions, it is natural for weed species to adapt. All weed management strategies, whether chemical, cultural or mechanical, select for weeds that are tolerant to those practices.

For instance, giant foxtail and common lambsquarters are very common in corn and soybean but rarely seen in wheat. This happens because the more adapted species will prevail in a given environment. Weeds developing resistance to a herbicide is similar.

Some individuals in a weed population are resistant to a specific herbicide site of action (i.e., the biochemical site where the herbicide acts). These produce seed, thereby increasing their percentage in the weed community.

" ... nature responds to changing conditions, it is natural for weed species to adapt."

The continual use of herbicides with the same site of action increases the percentage of the resistant weed to a level where control fails. It can take as few as six years of using herbicides with the same site of action for a resistance problem to appear.

Do you have resistance?

If you find situations where herbicide applications fail to control weeds, the following checklist can be followed to confirm if you have a resistant biotype.

- ❑ **Only one species has escaped.**
- ❑ **No known application errors.**
- ❑ **Favorable environment for herbicide performance.**
- ❑ **Confirm by respraying to a small test area.**

Contact a county extension agricultural agent to report confirmed cases of resistance.

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How big is the resistance problem?

Worldwide, there are now 284 herbicide resistant weed biotypes, found among 170 species. Fifty-nine countries have reported herbicide resistant weeds. The leading countries are the United States with 107, Australia with 41, Canada with 39, France with 30, and Spain with 26.

The 107 herbicide resistant weed biotypes in the USA occur in 46 states. California and Michigan lead the list with 16 and 15 biotypes, respectively each. Most states have reported at least two resistant biotypes. Only Alaska, Arizona, Nevada and West Virginia, have not reported any resistant biotypes.

Closer to home, Wisconsin, has confirmed 11 resistant biotypes:

- velvetleaf (PSII),
- smooth pigweed (PSII),
- common waterhemp (ALS),
- common lambsquarters (PSII),
- large crabgrass (ACCase),
- kochia (PSII & ALS),
- giant foxtail (ACCase & ALS),
- green foxtail (ALS),
- shattercane (ALS),
- giant ragweed (ALS),
- eastern black nightshade (ALS).

We also have a suspected biotype of common ragweed resistant to ALS inhibitors.

Once a field has a resistant biotype, how long will it remain?

Once established, herbicide resistant weeds remain a problem for a very long period of time, perhaps indefinitely. Rather than worrying how long a resistant biotype will remain, focus your efforts on delaying development of resistant weeds. Attention must be given to using herbicides with different sites of action, more diversified crop rotations, and row cultivators all of which lower the potential for resistance to develop.

Which sites of action are most susceptible?

Products that are highly active at a single site of action are the most likely to have resistant biotypes to appear. Inhibitors of acetolactate synthase (ALS inhibitors) and acetyl CoA carboxylase (ACCase inhibitors) are highly susceptible to resistance development. These two sites of action have been marketed since the early 1980's and already have the largest number (101) of resistant biotypes in the world. Photosystem II inhibitors are a close second with 63 resistant biotypes.

Considering these herbicides have been on the market for 40 years, this site of action is less susceptible to resistance development than either the ALS or ACCase inhibitors. Bipyridiliums (paraquat) and synthetic auxins (2,4-D) have fewer resistant weed biotypes with 23 and 21, respectively, worldwide. No resistance to shoot growth inhibitors has been reported in the USA. ■

How can I be sure to get herbicide resistant weeds?

The following six-step program can improve your chances of acquiring herbicide resistant weeds.

Step one. **Use the same herbicide year after year.**

Step two. **If using different herbicides, use herbicides with the same sites of action. Avoid tank mixes and premixes that have multiple sites of action. Steps one and two allow the build up of weeds resistant to that site of action.**

Step three. **Use herbicides that have high potential for resistance development. The high risk herbicides in Table 1 may help your selection process.**

Step four. **Use short crop rotations, or better yet, don't rotate crops at all. Weeds adapt easier in a cropping system that doesn't change.**

Step five. **Don't bother monitoring crop fields. If you don't see resistance, it's not going to happen.**

Step six. **Don't use mechanical weed control. Cultivation will control escaped weeds and would slow the build up of resistance.**

All kidding aside, do the OPPOSITE of each step to delay development of resistant weeds.

This publication is available from the NPM program, 608-265-2660, or on the web at **http://ipcm.wisc.edu**. Before publicizing, please call for publication availability.

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Table 1. Relative Risk of Developing Resistance to Common Agricultural Herbicides based on their Mode of Action

HIGH RISK of developing resistance

Amino Acid Synthesis Inhibitors (ALS Inhibitors)

- **Accent** (nicosulfuron)
- **Ally** (metsulfuron)
- **Basis** (rimsulfuron + thifensulfuron)
- **Beacon** (primisulfuron)
- **Classic** (chlorimuron)
- **Exceed** (primisulfuron + prosulfuron)
- **Express** (tribenuron)
- **FirstRate**, **Amplify** (cloransulam)
- **Harmony Extra** (thifensulfuron + tribenuron)
- **Harmony GT** (thifensulfuron)
- **Lightning** (imazapyr + imazethapyr)
- **Option** (foramsulfuron)
- **Peak** (prosulfuron)
- **Permit** (halosulfuron)
- **Plateau** (imazapic)
- **Pursuit** (imazethapyr)
- **Python** (flumetsulam)
- **Raptor** (imazamox)
- **Spirit** (prosulfuron + primisulfuron)
- **Steadfast** (rimsulfuron + nicosulfuron)
- **Synchrony** (chlorimuron + thifensulfuron)

Lipid Synthesis Inhibitors (ACCase Inhibitors)

- **Assure II** (quizalofop)
- **Fusilade DX** (fluazifop)
- **Fusion** (fluazifop + fenoxaprop)
- **Poast**, **Poast Plus** (sethoxydim)
- **Select** (clethodim)

MEDIUM RISK of developing resistance

Photosynthesis Inhibitors (Photosystem II)

- **Aatrex** (atrazine)
- **Basagran** (bentazon)
- **Buctril, Connect** (bromoxynil)
- **Buctril + atrazine** (bromoxynil + atrazine)
- **Evik** (ametryne)
- **Laddok S-12** (bentazon + atrazine)
- **Lorox** (linuron)
- **Princep** (simazine)
- **Sencor** (metribuzin)
- **Sinbar** (terbacil)
- **Spike** (tebuthiuron)
- **Velpar** (hexazinone)

Cell Membrane Disruptors (Photosystem I)

- **Diquat** (diquat)
- **Gramoxone Max** (paraquat)

Cell Membrane Disruptors (PPO Inhibitors)

- **Aim EW** (carfentrazone)
- **Authority, Spartan** (sulfentrazone)
- **Cobra**, **Phoenix** (lactofen)
- **Flexstar**, **Reflex** (fomesafen)
- **Resource** (flumiclorac)
- **Stellar** (lactofen + flumiclorac)
- **Ultra Blazer** (acifluorfen)
- **Valor** (flumioxazin)

Pigment Inhibitors (Isoprenoid Pathway)

- **Callisto** (mesotrione)
- **Command** (clomazone)

Seedling Root Growth Inhibitors (Cell Division Inhibitors)

- **Balan** (benefin)
- **Prowl**, **Pendimax** (pendimethalin)
- **Treflan** (trifluralin)

LOW RISK of developing resistance

Amino Acid Synthesis Inhibitors (EPSPS Inhibitor)

- **Roundup products**, **Touchdown**, and others (glyphosate)

Nitrogen Metabolism Inhibitors (Glutamine Synthetase Inhibitor)

- **Liberty** (glufosinate)

Growth Regulators (Synthetic Auxins)

- **Banvel**, **Clarity** (dicamba)
- **Butyrac 200** (2,4-DB)
- **Crossbow** (triclopyr + 2,4-D)
- **Curtail** (clopyralid + 2,4-D)
- **Distinct, Overdrive** (diflufenzopyr + dicamba)
- **Garlon** (triclopyr)
- **MCPA** (MCPA)
- **Redeem** (triclopyr + clopyralid)
- **Thistrol** (MCPB)
- **Starane** (fluroxypyr)
- **Stinger** (clopyralid)
- **Weedmaster** (2,4-D + dicamba)
- **2,4-D** (2,4-D)

Seedling Shoot Growth Inhibitors (Multiple)

- **Define** (flufenacet)
- **Degree**, **Harness**, **Surpass**, **TopNotch** (acetochlor + safener)
- **DoublePlay** (EPTC + acetochlor + safener)
- **Dual II Magnum, Cinch** (s-metolachlor)
- **Eptam** (EPTC)
- **Outlook** (dimethenamid - P)
- **Micro-tech/Lasso** (alachlor)
- **Ro-neet** (cycloate)

Table 2. Agricultural Herbicides that Contain Two or more Different Modes of Action.

Amino Acid Synthesis Inhibitors (ALS Inhibitors) AND Growth Regulators (Synthetic Auxins)

Celebrity Plus (nicosulfuron + dicamba + diflufenzopyr)
Hornet WDG (flumetsulam + clopyralid)
NorthStar (primisulfuron + dicamba)
Accent Gold (nicosulfuron + rimsulfuron + flumetsulam + clopyralid)
Yukon (halosulfuron + dicamba)

Amino Acid Synthesis Inhibitors (ALS Inhibitors) AND Amino Acid Synthesis Inhibitors (EPSPS Inhibitors)

Extreme (imazethapyr + glyphosate)

Amino Acid Synthesis Inhibitors (ALS Inhibitors) AND Seedling Root Growth Inhibitors (Cell Division Inhibitors)

Pursuit Plus (imazethapyr + pendimethalin)

Amino Acid Synthesis Inhibitors (ALS Inhibitors) AND Cell Membrane Disruptors (PPO)

Ganster (cloransulam + flumioxazin)
Gauntlet (cloransulam + sulfentrazone)

Amino Acid Synthesis Inhibitors (ALS Inhibitors) AND Photosynthesis Inhibitors (Photosystem II)

Basis Gold (rimsulfuron + nicosulfuron + atrazine)
Steadfast ATZ (rimsulfuron + nicosulfuron + atrazine)

Pigment Inhibitors (Isoprenoid Pathway) AND Seedling Shoot Growth Inhibitors (Multiple)

Camix (mesotrione + s-metolachlor)

Photosynthesis Inhibitors (Photosystem II) AND Seedling Shoot Growth Inhibitors (Multiple)

Axiom (metribuzin + flufenacet)
Cinch ATZ (atrazine + s-metolachlor)
Cinch ATZ Lite (atrazine + s-metolachlor)
Bicep II Magnum (atrazine + s-metolachlor)
Bicep II Lite Magnum (atrazine + s-metolachlor)
Boundary (metribuzin + s-metolachlor)
Bullet (atrazine + alachlor)
Degree Xtra (atrazine + acetochlor)
Domain (metribuzin + flufenacet)
Field Master (atrazine + acetochlor + glyphosate)*
Fultime (atrazine + acetochlor)
Guardsman Max (atrazine + dimethenamid-P)
G-Max Lite (atrazine + dimethenamid-P)
Harness Xtra, Harness Xtra 5.6L (atrazine + acetochlor)
Lariat (atrazine + alachlor)
Lumax (atrazine + s-metolachlor + mesotrione)**
Keystone (atrazine + acetochlor)
Keystone LA (atrazine + acetochlor)

Photosynthesis Inhibitors (Photosystem II) AND Growth Regulators (Synthetic Auxins)

Marksman (atrazine + dicamba)
Shotgun (atrazine + 2,4-D)

Photosynthesis Inhibitors (Photosystem II) AND Nitrogen Metabolism Inhibitors (Glutamine Synthetase Inhibitor)

Liberty ATZ (atrazine + glufosinate)

Photosynthesis Inhibitors (Photosystem II) AND Amino Acid Synthesis Inhibitors (EPSPS Inhibitors)

Ready Master ATZ (atrazine + glyphosate)

** also Amino Acid Synthesis Inhibitors (EPSPS Inhibitors)*

*** also Pigment Inhibitors (Isoprenoid Pathway)*

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