

## Bayer CropScience Herbicide Features

Glutamine Synthetase Inhibitors — Group 10

HPPD Inhibitors — Group 27

Mitosis Inhibitors — Group 15

PPO Inhibitors — Group 14

EPSP Synthase Inhibitors (Glyphosate) — Group 9

PS II Inhibitors — Groups 5, 6, 7

Synthetic Auxin Herbicides — Group 4

ALS Inhibitors — Group 2

ACCase Inhibitors — Group 1

Integrated Weed Management

The Science of Weed Resistance

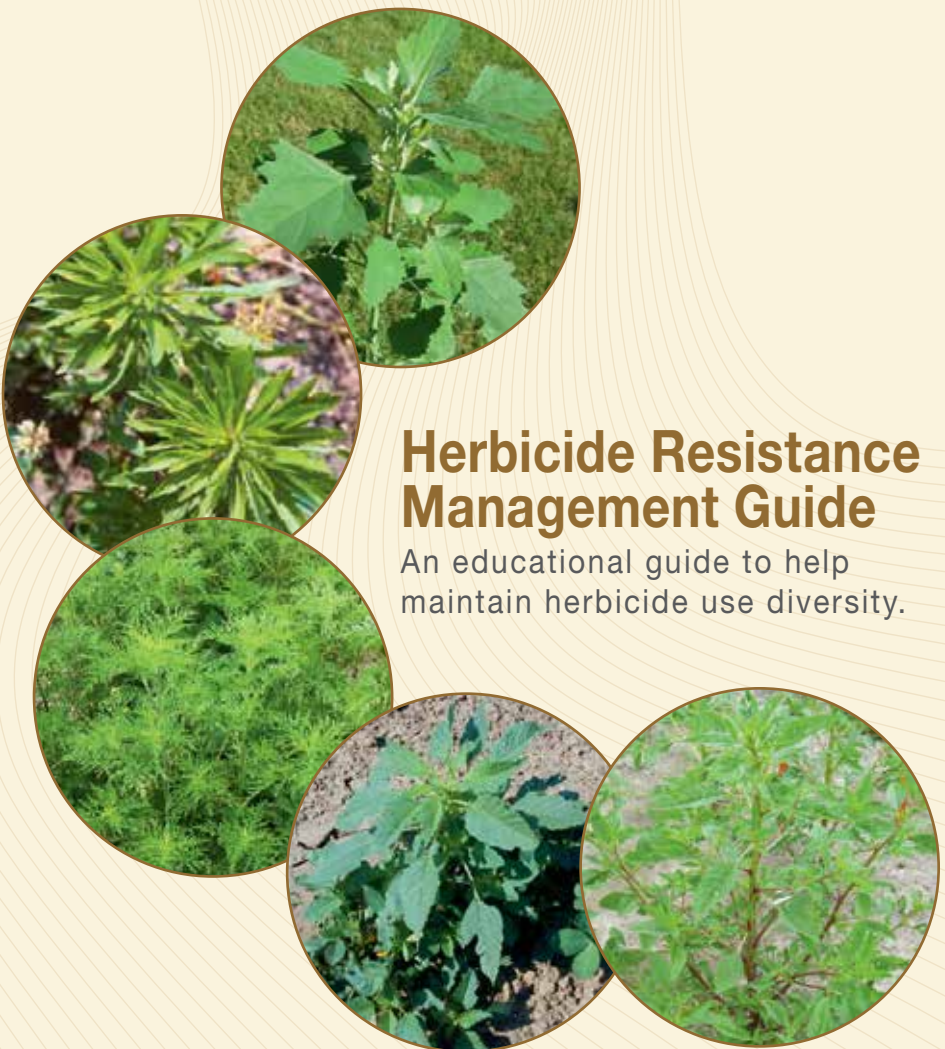
Development of Weed Resistance

Cellulose Biosynthesis Inhibitors — Group 29



## Herbicide Resistance Management Guide

An educational guide to help maintain herbicide use diversity.



Bayer CropScience



## Growing a Healthier World

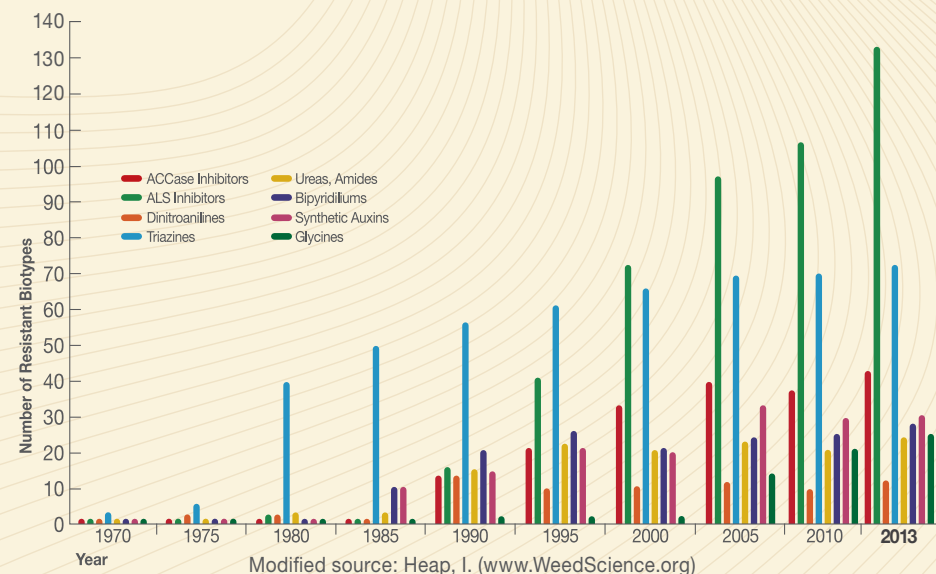
At Bayer CropScience, we are dedicated to uncovering the most sustainable solutions and best practices for today's global challenges. This has never been more important than it is now with the increase in the number of herbicide-resistant weeds.

Just like growers, we take weed management very seriously. Bayer CropScience works diligently with agronomists and university experts to study the science of weed management. As a leading provider of herbicide-tolerant trait platforms and crop protection products, it is our obligation to ensure growers have access to robust weed management programs that can carry their farms into the future.

But our responsibility goes beyond introducing new technologies. It includes giving growers effective weed management resources like this Herbicide Resistance Management Guide and our dedication to weed management, including the adoption of Integrated Weed Management (IWM) best practices and herbicide diversity through the rotation of crops, traits and modes of action.

By working together to preserve herbicide diversity and reduce herbicide-resistant weeds, all of us are protecting the planet and its resources, preserving agriculture's future for generations to come and providing healthier, more plentiful food for the world, one harvest at a time.

**Figure 1. The chronological increase in the global number of herbicide-resistant weeds for several herbicide sites of action (2013).**



return to cover

## Evolution of Weed Resistance

The use of herbicides in modern agricultural production systems has allowed growers to more effectively and efficiently control weeds, improve crop yields and increase profitability. Additionally, the adoption of herbicide-tolerant traits has allowed growers to apply herbicides over the top of crops, often with less tillage, fuel and labor. However, the evolution of herbicide-resistant weeds is an unfortunate side effect from the overuse of a single herbicide or mode of action (MOA)\*.

The occurrence of herbicide-resistant weeds worldwide is tracked on [www.WeedScience.org](http://www.WeedScience.org) and is sponsored by the Herbicide Resistance Action Committee (HRAC), an organization comprised of several pesticide manufacturers and the Weed Science Society of America (WSSA).

Cases of herbicide resistance are becoming increasingly common. Weeds have evolved resistance to 21 of the 25 known sites of action\*\* and to 148 different herbicides. Herbicide-resistant weeds have been reported in 66 crops in 61 countries. There are currently 403 unique cases (species X site of action) of herbicide-resistant weeds globally, with 218 species (129 dicots and 89 monocots). WeedScience.org reported a total of 145 herbicide-resistant weeds in the United States (October 17, 2013).

In the mid-1990s, there was a rapid increase in the number of reported weed biotypes resistant to ALS inhibitors, ACCase inhibitors and synthetic auxin inhibitors. And the advent of glyphosate-tolerant technology in the same period set the timer on resistance evolution for glyphines/glyphosate (Figure 1).

In the United States, some of the most widespread and increasingly important herbicide resistance problems in corn, cotton, soybeans and small grains, as well as tree fruit, nut and vine crops (TFNV), are associated with the following herbicide groups:

- ACCase inhibitors
- ALS inhibitors
- Photosystem II inhibitors (triazines)
- EPSP synthase inhibitors (glyphosate)

Several herbicide MOAs have recently gained broad acceptance in the marketplace, including:

- PPO inhibitors
- HPPD inhibitors
- Glutamine synthetase inhibitors (glufosinate)

If not managed correctly, these newer herbicide MOAs could also lose their effectiveness. To effectively manage the development of weed resistance, it is important to understand how herbicide resistance develops.

**\*Mode of action** describes how the herbicide controls the susceptible plant. It involves absorption into the plant, translocation or movement in the plant, metabolism of the herbicide and the physiological response of the plant.

**\*\*Site of action** refers to the specific biochemical site or process that is affected by the herbicide. Site of action is a more precise description of the herbicide's activity.

## The Science of Weed Resistance

### How do herbicides kill weeds?

Herbicides enter the plant at lethal dosages and interfere with crucial processes necessary for the plant to survive. The active ingredient often binds to a particular target site(s) within the plant, usually an enzyme or protein(s) essential to plant growth and development, creating a cascade of consequences that eventually lead to plant death. A few herbicides can act at multiple target sites.

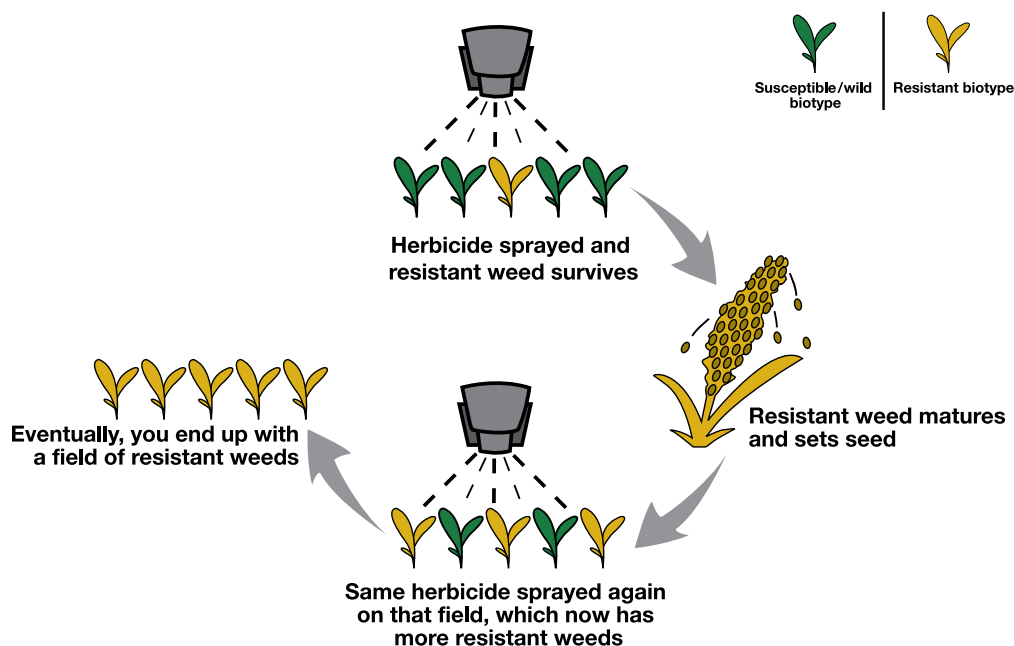
### What is resistance and how does it originate?

Resistance is a naturally occurring, inherited ability of some weed biotypes to survive a herbicide treatment that should, under normal use conditions, effectively control a weed population. Natural selection is the most common theory for the initial evolution of weed resistance within a weed population.

### How do resistant weed biotypes increase in number?

When a herbicide is applied to a sensitive population, most of the weeds in the population die as a result of the herbicide application. However, sometimes the initially rare resistant weed biotypes can survive, mature and produce seed. With repeated use of the same herbicide or family of related herbicides, or lack of diversity in the herbicide management program, the resistant weeds may eventually be "selected" from the population and dominate (Figure 2). Generally, the more effective the herbicide, the greater the selection pressure and the greater the probability that only resistant weeds will survive.

**Figure 2. Selection of resistant weed biotypes with repeated applications of the same herbicide or same mode of action herbicides.**



Modified source: J.L. Gunsolus. Herbicide-Resistant Weeds. 1998 North Central Region Extension Publication 468.

### What occurs within a resistant weed biotype that allows it to survive a herbicide application?

Some weeds naturally develop one or more mechanisms that allow them to survive a herbicide treatment. This generally occurs at a very low frequency in a population. The resistance mechanism is oftentimes controlled by a single gene. The two most common resistance mechanisms present within a weed population are:

#### Target-site resistance

- The herbicide reaches the target site at a normally lethal dose, but modification or amplification of the target site gene(s)/enzyme(s) limits herbicide binding, and thus its impact.

#### Nontarget-site resistance

- This occurs when any mechanism minimizes the amount of active herbicide reaching the target site (e.g., reduced uptake, reduced translocation, enhanced metabolism, sequestration, etc.).

Herbicides acting at a single target site are more likely to develop resistance than those that act at multiple sites. This occurs because alterations at a single target site are more likely, as compared to mutations simultaneously at several target sites.

### Can weeds be resistant to more than one herbicide or herbicide family?

Resistance can develop to more than one herbicide, herbicide family or MOA. Two terms commonly used to describe these forms of resistance include:

#### Cross-resistance

- Weeds are resistant to two or more herbicides with the same MOA by way of a single resistance mechanism (e.g., Weed A is resistant to both herbicides 1 and 2, each of which affects the same target site of the weed.).

#### Multiple resistance

- Weeds are resistant to two or more herbicides with differing MOAs because they possess two or more different resistance mechanisms (e.g., Weed A is resistant to herbicides 1 and 2, each of which affects different target sites in the weed.).

The difficulty of controlling weeds with various forms of resistance can be ranked as follows (least difficult to most difficult):

1. Resistance (one herbicide)
2. Cross-resistance
3. Multiple resistance

## The Science of Weed Resistance

### What actions increase the selection for herbicide resistance?

Weed management practices that can lead to increased selection intensity on weeds include:

- Using reduced rates of herbicides.
- Applying herbicides at inappropriate or delayed timing.
- Applying a herbicide(s) with the same MOA multiple times during a growing season without tankmixing with other modes of action or applying herbicides with long residual activity, thereby maintaining high selection pressure.
- Using one or multiple herbicides that act on a single site of action.
- Using the same herbicide without tankmixing any additional modes of action for several consecutive growing seasons.
- Using herbicides as the only weed control option.

Rotation of crops, herbicide-tolerant traits and herbicide MOAs, as well as the inclusion of mechanical and cultural control methods where possible, can play important roles in delaying the evolution of resistance or managing existing resistant weed populations.

### Indicators of potential weed resistance\* are:

- A patch of weeds occurs in the same area year after year and is spreading.
- Dead weeds appear next to surviving weeds after the same herbicide application.
- Many weed species are managed, but one particular weed species is no longer controlled.

\* These indicators are not definitive proof of resistance and are merely intended to act as a guide.

### What should you do if you suspect you have herbicide-resistant weeds?

Contact your local state Extension service, state weed specialist or local Bayer CropScience representative to have weed seeds collected and evaluated for potential resistance.

### What management practices delay the onset or control the spread of resistant weeds?

The best way to manage herbicide resistance and prevent the development of resistant weeds is to implement a diverse weed management program. The use of IWM strategies will help delay resistance and limit the selection pressure on weeds present in your fields. Growers who do not use IWM strategies risk resistant weeds and unnecessary herbicide costs. For example, a grower with a field full of glyphosate-resistant weeds should not tankmix glyphosate with another herbicide MOA, as the glyphosate will be ineffective against the resistant weeds.

## Respect the Rotation™

**Respect the Rotation™** is a weed management and stewardship program under the Bayer CropScience Weed Management Initiative that elevates the importance and grower adoption of herbicide diversity through the rotation of crops, traits and MOAs.



- **Rotate crops.** Crop rotation diversifies weed management.
- **Rotate herbicide-tolerant traits.** Alternate herbicide-tolerant (HT) traits and/or use HT trait stacks for more efficient rotation.
- **Rotate herbicide modes of action.** Use tankmix partners and multiple MOAs during both the growing season and from year to year to reduce the selection pressure of a single MOA.

The following Integrated Weed Management techniques are effective in reducing problems with herbicide-tolerant and/or herbicide-resistant weed biotypes. It is best to use multiple practices to manage or delay resistance, as no single strategy is likely to be totally effective.

- 1. Know your weeds, know your fields.** Closely monitor problematic areas with difficult-to-control weeds or dense weed populations.
- 2. Start with clean fields.** Effective tillage or the use of a burndown herbicide program can control emerged weeds prior to planting.
- 3. Stay clean—use residual herbicides.** Regardless of tillage system, a pre-emergence or early postemergence soil-applied residual herbicide should be used.
- 4. Apply herbicides correctly.** Ensure proper application, including correct timing, full-use rates and appropriate spray volumes.
- 5. Control weed escapes.** Consider spot herbicide applications, row wicking, cultivation, hand removal of weeds or other techniques to stop weed seed production and improve weed management.
- 6. Zero Tolerance—reduce the weed seed bank.** Do not allow surviving weeds to set seed, which will help decrease weed populations from year to year and prevent major weed shifts.
- 7. Clean equipment.** Prevent the spread of herbicide-resistant weeds and seeds.

### What is herbicide classification by mode of action?

One simple way to delay or manage weed resistance is to use herbicides or herbicide tankmixes with differing MOAs in season and from year to year. Both the WSSA and HRAC employ easy-to-use herbicide classification systems by mode of action, using numbers and letters, respectively.

The WSSA groups products with similar MOAs together by an assigned **Group Number from 1 to 29**. The group number easily identifies products with differing sites of action. The Environmental Protection Agency (EPA) requests registrants voluntarily add a group number to the label showing the MOAs of the herbicide or herbicide premixes. A condensed version of the classification document is located at the back of this brochure.

Alternatively, HRAC references herbicide classes by letter, as does the International Survey of Herbicide-Resistant Weeds ([www.WeedScience.org](http://www.WeedScience.org)), the reporting body for confirmed resistant weeds. On the following pages, we include both classifications for your reference.



# ACCase Inhibitors Group 1

HRAC Group A



## What is a Group 1 herbicide?

- Inhibitor of acetyl-coenzyme A carboxylase (ACCase) enzyme.
- Inhibition prevents the production of fatty acids and lipid synthesis, leading to rapid cessation of plant growth at the growing point.
- Susceptible grasses generally die in 10 days to two weeks.
- Consists of products from three chemical families: aryloxyphenoxypropionate (FOPs), cyclohexanedione (DIMs) and phenylpyrazole (DENS).

## How do weeds evolve resistance to Group 1 herbicides?

- Involves both target-site and nontarget-site resistance mechanisms.
- Resistance is due to an altered ACCase binding site or enhanced metabolism of the herbicide.

## How many weeds have developed resistance to Group 1 herbicides?

- Globally: 43 weed species confirmed
- U.S.: 15 weed species confirmed

## Confirmed Group 1 Resistant Weed Species in the U.S.\*

- |                           |                         |
|---------------------------|-------------------------|
| • Barnyardgrass           | • Foxtail, robust white |
| • Brome, downy            | • Itchgrass             |
| • Canarygrass, littleseed | • Johnsongrass          |
| • Crabgrass, large        | • Oat, wild             |
| • Crabgrass, smooth       | • Ryegrass, Italian     |
| • Darnel, Persian         | • Sprangletop, Amazon   |
| • Foxtail, giant          | • Watergrass, late      |
| • Foxtail, robust purple  |                         |

\*Heap, I. The International Survey of Herbicide-Resistant Weeds. Available at [www.WeedScience.org](http://www.WeedScience.org). October 8, 2013.

## Common Group 1 ACCase-Inhibitor Herbicides

Use of Group 1 herbicides is most common in small grains and soybean production systems and to a much lesser extent in corn, cotton, and tree fruit, nut and vine (TFNV).

### Corn:

Poast<sup>†</sup>

### Cotton:

VLU

### Soybeans:

Assure<sup>®</sup> II

Fusilade<sup>®</sup> DX

Fusion<sup>®</sup> (P)

Select<sup>®</sup>

Select Max<sup>®</sup>

### Small Grains:

Axial<sup>®</sup> XL

Axial Star (P)\*

Axial TBC

Discover<sup>®</sup> NG

Foxfire<sup>®</sup> (P)

Wolverine<sup>®</sup> (P)\*

### Tree Fruits, Nuts and Vine Crops:

Poast

(P) = Premix product

(P)\* = Premix product containing at least one non-ACCase chemistry

VLU = Very little use

<sup>†</sup> = Herbicide-tolerant corn resistant to sethoxydim

## Bayer CropScience Herbicides for Management of ACCase-Resistant Weeds

### Corn:

Balance<sup>®</sup> Flexx (Group 27)

Capreno<sup>®</sup> (Groups 2, 27)

Corvus<sup>®</sup> (Groups 2, 27)

Liberty<sup>®</sup> (Group 10)

Laudis<sup>®</sup> (Group 27)

### Cotton:

Liberty (Group 10)

### Soybeans:

Liberty (Group 10)

### Small Grains:

Axiom<sup>®</sup> (Groups 5, 15)

Huskie<sup>®</sup> Complete (Groups 2, 6, 27)

Olympus<sup>®</sup> (Group 2)

Osprey<sup>®</sup> (Group 2)

Rimfire<sup>®</sup> Max (Group 2)

### Tree Fruits, Nuts and Vine Crops:

Alion<sup>®</sup> (Group 29)

Rely<sup>®</sup> 280 (Group 10)

Please refer to product labels for additional information on weeds controlled, application timings, precautions, restrictions and other important use information.



# ALS Inhibitors Group 2

HRAC Group B



## What is a Group 2 herbicide?

- Inhibitor of acetolactate synthase (ALS or AHAS) enzyme.
- Inhibition leads to depletion of key branched-chain amino acids necessary for protein synthesis and plant growth.
- Susceptible weeds may take several weeks to die.
- Consists of products from primarily four chemical families: imidazolinone, sulfonyleurea, sulfonylamino-carbonyl-triazolinone and triazolopyrimidine.

## How do weeds evolve resistance to Group 2 herbicides?

- Involves both target- and nontarget-site resistance mechanisms.
- The binding site on the AHAS enzyme is altered, and the ALS herbicide cannot attach itself to the protein. Additionally, enhanced herbicide metabolism has been shown as a resistance mechanism.

## How many weeds have developed resistance to Group 2 herbicides?

- Globally: 133 weed species confirmed
- U.S.: 47 weed species (both grass and broadleaf) confirmed

## Confirmed Group 2 Resistant Weed Species in the U.S.\*

- |                         |                             |                               |
|-------------------------|-----------------------------|-------------------------------|
| • Amaranth, livid       | • Foxtail, robust white     | • Ragweed, giant              |
| • Amaranth, Palmer      | • Foxtail, yellow           | • Redstem                     |
| • Amaranth, Powell      | • Horseweed (marestail)     | • Rice, flatsedge             |
| • Arrowhead, California | • Johnsongrass              | • Ryegrass, Italian           |
| • Bluegrass, annual     | • Kochia                    | • Ryegrass, perennial         |
| • Brome, downy          | • Lambsquarters, common     | • Ryegrass, rigid             |
| • Brome, Japanese       | • Lettuce, prickly          | • Sedge, smallflower umbrella |
| • Brome, rye (cheat)    | • Loosestrife, long-leaved  | • Shattercane                 |
| • Bulrush, ricefield    | • Marshelder                | • Sida, prickly               |
| • Chamomile, mayweed    | • Mustard, wild             | • Sowthistle, spiny           |
| • Chickweed, common     | • Nightshade, eastern black | • Sunflower, common           |
| • Cocklebur, common     | • Nutsedge, yellow          | • Thistle, Russian            |
| • Falseflax, smallseed  | • Oat, wild                 | • Wallflower, bushy           |
| • Flixweed              | • Pigweed, redroot          | • Waterhemp, common           |
| • Foxtail, giant        | • Pigweed, smooth           | • Waterhemp, tall             |
| • Foxtail, green        | • Ragweed, common           |                               |

\*Heap, I. The International Survey of Herbicide-Resistant Weeds. Available at [www.WeedScience.org](http://www.WeedScience.org). October 17, 2013.

## Common Group 2 ALS-Inhibitor Herbicides

Use of Group 2 herbicides is most common in small grains, corn and soybean production systems, and to a much lesser extent in cotton and TFNV.

### Corn:

Accent®  
Accent Gold® (P)\*  
Autumn™ Super  
Basis®  
Basis Gold (P)\*  
Capreno (P)\*  
Corvus (P)\*  
Hornet® (P)\*  
Instigate™ (P)\*  
Lightning® (P)  
Realm® Q (P)\*  
Require® (P)\*  
Resolve® (P)  
Resolve Q (P)\*  
Spirit® (P)  
Steadfast® (P)  
Steadfast ATZ (P)\*  
SureStart® (P)\*  
TripleFLEX™ (P)\*  
Yukon® (P)\*

### Cotton:

Envoke®  
Staple®  
Suprend® (P)\*

### Tree Fruits, Nuts and Vine Crops:

Matrix®  
Pindar™ GT (P)\*

(P) = Premix product  
(P)\* = Premix product containing at least one non-ALS chemistry

### Soybeans:

Authority® First (P)\*  
Autumn Super  
Canopy® (P)\*  
Canopy EX (P)\*  
Classic®  
Enlite® (P)\*  
Envive® (P)\*  
Extreme® (P)\*  
OpTill® Pro  
Pursuit®  
Pursuit Plus (P)\*  
Raptor®  
Scepter®  
Sonic® (P)\*  
Synchrony® XP (P)  
Valor® XLT (P)\*

### Small Grains:

Affinity® (P)  
Ally® Extra (P)  
Ally XP  
Amber®  
Beyond®  
Everest®  
Finesse® (P)  
Glean® XP  
GoldSky® (P)  
Harmony® (P)  
Harmony Extra (P)  
Huskie Complete (P)\*  
Maverick®  
Olympus  
Orion® (P)\*  
Osprey  
PowerFlex®  
Rave® (P)\*  
Rimfire Max (P)

## Bayer CropScience Herbicides for Management of ALS-Resistant Weeds

### Corn:

Balance Flexx (Group 27)  
Buctril® (Group 6)  
Capreno (Groups 2, 27)  
Corvus (Groups 2, 27)  
Liberty (Group 10)  
Laudis (Group 27)

### Cotton:

Liberty (Group 10)

### Soybeans:

Liberty (Group 10)

### Small Grains:

Axiom (Groups 5, 15)  
Huskie (Groups 6, 27)  
Huskie Complete (Groups 2, 6, 27)  
Wolverine (Groups 1, 6, 27)

### Tree Fruits, Nuts and Vine Crops:

Alion (Group 29)  
Rely 280 (Group 10)

Please refer to product labels for additional information on weeds controlled, application timings, precautions, restrictions and other important use information.



Synthetic Auxins

Group 4

HRAC Group O



What is a Group 4 herbicide?

- Acts similar to auxin (IAA), similar to naturally occurring plant hormones.
- Primary action is to affect cell wall plasticity and nucleic acid metabolism, leading to uncontrolled cell division and growth, which cause vascular tissue destruction.
- Often produces epinastic-like symptoms (stem twisting, leaf malformations, etc.).
- Symptoms can often be seen within days of treatment.
- Consists of products from primarily four chemical families: benzoic acid, phenoxy carboxylic acid, pyridine carboxylic acid and quinoline carboxylic acid.

How do weeds evolve resistance to Group 4 herbicides?

- The specific cellular or molecular binding site has not yet been identified.

How many weeds have developed resistance to Group 4 herbicides?

- Globally: 29 weed species confirmed
- U.S.: 9 weed species confirmed

Confirmed Group 4 Resistant Weed Species in the U.S.\*

- |                        |                       |
|------------------------|-----------------------|
| • Barnyardgrass        | • Kochia              |
| • Bindweed, field      | • Lettuce, prickly    |
| • Carrot, wild         | • Starthistle, yellow |
| • Crabgrass, smooth    | • Waterhemp, common   |
| • Dayflower, spreading |                       |

\*Heap, I. The International Survey of Herbicide-Resistant Weeds. Available at [www.WeedScience.org](http://www.WeedScience.org). October 8, 2013.

Common Group 4 Synthetic Auxin Herbicides

Use of Group 4 herbicides are most common in corn and small grains with very little to no use in soybeans, cotton and TFNV.

Corn:

2,4-D (amine or ester)  
2,4-DB  
Banvel®  
Clarity®  
Distinct® (P)\*  
Hornet (P)\* WDG  
NorthStar® (P)\*  
Require Q (P)\*  
Shotgun® (P)\*  
Starane®  
Status® (P)\*  
Stinger®  
SureStart (P)\*  
TripleFLEX (P)\*  
WideMatch® (P)  
Yukon (P)\*

Cotton:

None

Soybeans:

2,4-D

Small Grains:

2,4-D (amine or ester)  
Banvel  
Clarity  
Curtail® M(P)  
MCPA (amine or ester)  
Orion (P)\*  
Pulsar™(P)  
Rage® D-Tech (P)\*  
Starane  
WideMatch (P)

Tree Fruits, Nuts and Vine Crops:

2,4-D  
Starane Ultra  
Stinger

(P) = Premix product

(P)\* = Premix product containing at least one nonsynthetic auxin chemistry

Bayer CropScience Herbicides for Management of Synthetic Auxin-Resistant Weeds

Corn:

Autumn Super (Group 2)  
Balance Flexx (Group 27)  
Buctril (Group 6)  
Capreno (Groups 2, 27)  
Corvus (Groups 2, 27)  
Liberty (Group 10)

Cotton:

Liberty (Group 10)

Soybeans:

Autumn Super (Group 2)  
Liberty (Group 10)

Small Grains:

Huskie (Groups 6, 27)  
Huskie Complete (Groups 2, 6, 27)  
Olympus (Group 2)  
Osprey (Group 2)  
Rimfire Max (Group 2)  
Wolverine (Groups 1, 6, 27)

Tree Fruits, Nuts and Vine Crops:

Alion (Group 29)  
Rely 280 (Group 10)

Please refer to product labels for additional information on weeds controlled, application timings, precautions, restrictions and other important use information.



# PS II Inhibitors Groups 5, 6, 7

HRAC Group C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>

## What is a Group 5, 6, 7 herbicide?

- Inhibitor of photosynthesis at Photosystem II.
- Inhibition causes electrons to accumulate on chlorophyll molecules. As a consequence, oxidation occurs in excess of what is normally tolerated by the cell, and the plant dies.
- Consists of products from 11 major chemical families: amide, benzothiadiazinone, nitrile, phenyl-carbamate, phenyl-pyridazine, pyridazinone, triazine, triazinone, triazolinone, uracil and urea.

## How do weeds evolve resistance to Groups 5, 6, 7 herbicides?

- Involves both target- and nontarget-site resistance mechanisms.
- A mutation occurs in the gene leading to an alteration at the site of the protein where triazine binding occurs. Additionally, enhanced herbicide metabolism has been shown as a resistance mechanism.

## How many weeds have developed resistance to Groups 5, 6, 7 herbicides?

- Globally: 98 weed species confirmed
- U.S.: 27 weed species confirmed

## Confirmed Groups 5, 6, 7 Resistant Weed Species in the U.S.\*

- |                              |                             |                               |
|------------------------------|-----------------------------|-------------------------------|
| • Amaranth, Palmer           | • Groundsel, common         | • Pigweed, redroot            |
| • Amaranth, Powell           | • Horseweed (marestail)     | • Pigweed, smooth             |
| • Barnyardgrass              | • Jimsonweed                | • Purslane, common            |
| • Bluegrass, annual          | • Kochia                    | • Ragweed, common             |
| • Fingergrass, swollen       | • Ladysthumb                | • Sedge, smallflower umbrella |
| • Foxtail, giant             | • Lambsquarters, common     | • Shepherdspurse              |
| • Foxtail, yellow            | • Nightshade, eastern black | • Smartweed, Pennsylvania     |
| • Goosegrass                 | • Orach, spreading          | • Velvetleaf                  |
| • Goosegrass, late flowering | • Pigweed, prostrate        | • Waterhemp, common           |



## Common Groups 5, 6, 7 PS II-Inhibitor Herbicides

Use of Groups 5, 6, and 7 herbicides is common in corn, cotton and TFNV production systems and to a lesser extent in soybeans and small grains.

### Corn:

Anthem™ ATZ (P)\*  
Atrazine  
Bicep II Magnum® (P)\*  
Callisto® Xtra (P)\*  
Cinch® ATZ (P)\*  
Degree XTRA® (P)\*  
Guardsman Max® (P)\*  
Harness® (P)\*  
Lexar® EZ (P)\*  
Lumax® EZ (P)\*

### Cotton:

Caparol®  
Cotoran®  
Direx®  
Diuron

### Soybeans:

Authority MTZ (P)\*  
Boundary® (P)\*  
Canopy (P)\*  
Metribuzin

### Small Grains:

Axiom (P)\*  
Huskie (P)\*  
Huskie Complete (P)\*  
Wolverine (P)\*

### Tree Fruits, Nuts and Vine Crops:

Atrazine  
Diuron  
Hyvar® X-L  
Karmex®  
Krovar®  
Princep®  
Simazine  
Sinbar®

(P)\* = Premix product containing at least one non-PS II chemistry

## Bayer CropScience Herbicides for Management of PS II-Resistant Weeds

### Corn:

Balance Flexx (Group 27)  
Buctril (Group 6)  
Capreno (Groups 2, 27)  
Corvus (Groups 2, 27)  
Liberty (Group 10)  
Laudis (Group 27)

### Cotton:

Liberty (Group 10)

### Soybeans:

Liberty (Group 10)

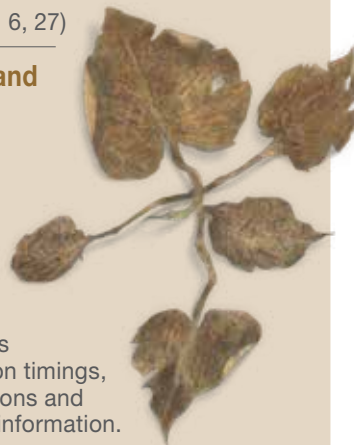
### Small Grains:

Axiom (Groups 5, 15)  
Huskie (Groups 6, 27)  
Huskie Complete (Groups 2, 6, 27)  
Olympus (Group 2)  
Osprey (Group 2)  
Rimfire Max (Group 2)  
Wolverine (Groups 1, 6, 27)

### Tree Fruits, Nuts and Vine Crops:

Alion (Group 29)  
Rely 280 (Group 10)

Please refer to product labels for additional information on weeds controlled, application timings, precautions, restrictions and other important use information.



\*Heap, I. The International Survey of Herbicide-Resistant Weeds. Available at [www.WeedScience.org](http://www.WeedScience.org). October 8, 2013.



EPSP Synthase Inhibitors (Glyphosate) Group 9

HRAC Group G

What is a Group 9 herbicide?

- Inhibitor of the chloroplast enzyme 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase.
- Inhibition leads to depletion of key amino acids that are necessary for protein synthesis and plant growth.
- Symptoms may take weeks to fully develop.
- Consists of one product from one major chemical family: glycine.

How do weeds evolve resistance to Group 9 herbicides?

There are three known mechanisms of resistance involving both target- and nontarget-site resistance: target-site resistance caused by EPSP synthase gene modification and amplification; and nontarget-site resistance caused by a reduced glyphosate translocation mechanism. A potential fourth mechanism, glyphosate metabolism, was recently identified.

How many weeds have developed resistance to Group 9 herbicides?

- Globally: 24 species confirmed
- U.S.: 14 species confirmed

Confirmed Group 9 Resistant Weed Species in the U.S.\*

- Amaranth, Palmer
  - Amaranth, spiny
  - Bluegrass, annual
  - Fleabane, hairy
  - Goosegrass
  - Horseweed (marestail)
  - Johnsongrass
- Junglerice
  - Kochia
  - Ragweed, common
  - Ragweed, giant
  - Ryegrass, Italian
  - Ryegrass, rigid
  - Waterhemp, common

\*Heap, I. The International Survey of Herbicide-Resistant Weeds. Available at [www.WeedScience.org](http://www.WeedScience.org). October 8, 2013.



Glyphosate-resistant waterhemp in soybeans.

return to cover



Common Group 9 EPSP Synthase-Inhibitor Herbicides

Use of Group 9 herbicides is most common in corn†, soybeans†, cotton†, and TFNV production systems. In small grains, Group 9 herbicides are used for burndown prior to planting or after harvest.

†Over-the-top use on glyphosate-tolerant crops only.

Corn:

Abundit™ Extra  
Buccaneer®  
Cornerstone®  
Credit®  
Durango®  
Gly-4™  
Glyfos®  
GlyStar®  
Halex® GT (P)\*  
Honcho®  
Roundup®  
Touchdown®

Soybeans:

Buccaneer  
Cornerstone  
Credit  
Durango  
Extreme (P)\*  
Flexstar GT (P)\*  
Gly-4  
Glyfos  
GlyStar  
Honcho  
Makaze®  
Roundup  
Touchdown

Cotton:

Buccaneer  
Cornerstone  
Credit  
Flexstar® GT (P)\*  
Gly-4  
Glyfos  
GlyStar  
Honcho  
Roundup  
Sequence® (P)\*  
Touchdown

Small Grains:

Buccaneer  
Cornerstone  
Credit  
Durango  
Gly-4  
GlyStar  
Honcho  
Roundup  
RT Master® II (P)\*  
Touchdown

Tree Fruits, Nuts and Vine Crops:

Alecto™ (P)\*  
Buccaneer  
Credit  
Cornerstone  
Gly-4  
Glyfos  
GlyStar  
Honcho  
Landmaster® BW (P)\*  
Makaze  
Roundup  
Touchdown

(P)\* = Premix product containing at least one nonglycine chemistry

Bayer CropScience Herbicides for Management of Glyphosate-Resistant Weeds

Corn:

Balance Flexx (Group 27)  
Capreno (Groups 2, 27)  
Corvus (Groups 2, 27)  
Liberty (Group 10)  
Laudis (Group 27)

Cotton:

Liberty (Group 10)

Soybeans:

Liberty (Group 10)

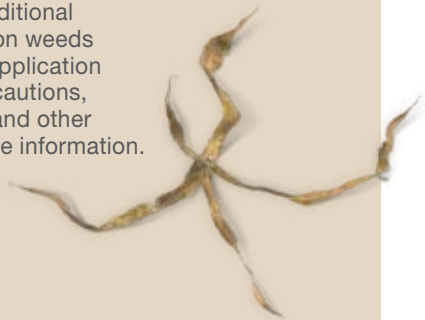
Small Grains:

Axiom (Groups 5, 15)  
Huskie (Groups 6, 27)  
Huskie Complete (Groups 2, 6, 27)  
Olympus (Group 2)  
Osprey (Group 2)  
Rimfire Max (Group 2)  
Wolverine (Groups 1, 6, 27)

Tree Fruits, Nuts and Vine Crops:

Alion (Group 29)  
Rely 280 (Group 10)

Please refer to product labels for additional information on weeds controlled, application timings, precautions, restrictions and other important use information.



PPO Inhibitors Group 14  
HRAC Group E

What is a Group 14 herbicide?

- Inhibitor of protoporphyrinogen oxidase (PPO) enzyme.
- Inhibition leads to a chain reaction resulting in the leaking of cell membranes.
- Symptoms from postemergence applications are observed within one day.
- PPO inhibitors are typically most effective on annual broadleaf weeds.
- Consists of products from eight chemical families: diphenyl ether, N-phenylphthalimide, oxadiazole, oxazolidinedione, phenylpyrazole, pyrimidinedione, thiadiazole and triazolinone.

How do weeds evolve resistance to Group 14 herbicides?

- This target-site resistance is conferred by an amino acid deletion in the PPO gene.

How many weeds have developed resistance to Group 14 herbicides?

- Globally: 6 weed species confirmed
- U.S.: 2 weed species confirmed

Confirmed Group 14  
Resistant Weed Species in the U.S.\*

- Ragweed, common
- Waterhemp, common

\*Heap, I. The International Survey of Herbicide-Resistant Weeds. Available at [www.WeedScience.org](http://www.WeedScience.org). October 8, 2013.

Iowa field treated with Corvus at 5.6 fl oz/A tankmixed with 1 lb atrazine.



Common Group 14  
PPO-Inhibitor Herbicides

Use of Group 14 herbicides is most common in soybean production systems and to a lesser extent in corn, cotton, small grains and TFNV.

Corn:

Aim®  
Anthem  
Anthem ATZ  
Cadet®  
Fierce® (P)\*  
Sharpen®†  
Rage (P)\*  
Resource®  
Verdict™ (P)\*†

Small Grains:

Aim  
Sharpen†

Tree Fruits, Nuts and  
Vine Crops:

Aim  
Chateau  
Galigan®  
Goal  
GoalTender®  
Oxyflo  
OxyStar®  
Pindar GT (P)\*  
Shark®  
Treevix®†

Cotton:

Aim  
Chateau®  
ET®  
Goal®  
Reflex®  
Sharpen  
Valor

Soybeans:

Authority (P)\*<sup>1</sup>  
Authority Elite  
Cadet  
Cobra®  
Enlite (P)\*  
Envive (P)\*  
Fierce (P)\*  
Flexstar  
Flexstar GT (P)\*  
Gangster® (P)\*  
Phoenix™  
OpTill (P)\*†  
OpTill Pro  
Resource  
Sharpen†  
Sonic (P)\*  
Ultra Blazer®  
Valor  
Valor XLT (P)\*

(P)\* = Premix product containing at least one non-PPO chemistry  
  
† = OpTill, †Sharpen, Treevix and Verdict are all powered by Kixor® herbicide  
  
<sup>1</sup> = Authority includes Authority Assist, Authority First, Authority MTZ and Authority XL

Bayer CropScience Herbicides for  
Management of PPO-Resistant Weeds

Corn:

Balance Flexx (Group 27)  
Capreno (Groups 2, 27)  
Corvus (Groups 2, 27)  
Liberty (Group 10)  
Laudis (Group 27)

Cotton:

Liberty (Group 10)

Soybeans:

Liberty (Group 10)

Small Grains:

Axiom (Groups 5, 15)  
Huskie (Groups 6, 27)  
Huskie Complete (Groups 2, 6, 27)  
Wolverine (Groups 1, 6, 27)

Tree Fruits, Nuts and Vine Crops:

Alion (Group 29)  
Rely 280 (Group 10)

Please refer to product labels for additional information on weeds controlled, application timings, precautions, restrictions and other important use information.





Mitosis Inhibitors Group 15  
HRAC Group K<sub>3</sub>

What is a Group 15 herbicide?

- Inhibits cell growth and division by interfering with development of very long-chain fatty acids (VLCFA).
- Typically affects susceptible weeds prior to emergence but does not inhibit seed germination.
- Oftentimes applied as a soil treatment for control of annual grasses and small-seeded broadleaf weeds.
- Consists of products from primarily four chemical families: acetamide, chloracetamide, oxyacetamide, tetrazolinone.

How do weeds evolve resistance to Group 15 herbicides?

- This target-site resistance appears to be due to an altered VLCFA synthase binding site.

How many weeds have developed resistance to Group 15 herbicides?

- Globally: 4 weed species confirmed
- U.S.: 1 weed species confirmed

Confirmed Group 15  
Resistant Weed Species in the U.S.\*

- Ryegrass, Italian

\*Heap, I. The International Survey of Herbicide-Resistant Weeds.  
Available at [www.WeedScience.org](http://www.WeedScience.org). October 8, 2013.



Common Group 15  
Mitosis-Inhibitor Herbicides

Use of Group 15 herbicides is most common in corn and soybean production systems and to a lesser extent in cotton, small grains and TFNV.

Corn:

Anthem  
Anthem ATZ  
Bicep II Magnum  
Breakfree® ATZ (P)\*  
Bullet® (P)\*  
Cinch ATZ (P)\*  
Degree  
Degree XTRA (P)\*  
Dual II Magnum®  
Expert® (P)\*  
Fierce  
FulTime® (P)\*  
G-Max Lite™ (P)\*  
Guardsman Max (P)\*  
Hallex GT (P)\*  
Harness  
Harness XTRA (P)\*  
Intro®  
Keystone® (P)\*  
Lariat® (P)\*  
Lexar EZ (P)\*  
Lumax EZ (P)\*  
Micro-Tech®  
Outlook®  
SureStart (P)\*  
Surpass®  
TopNotch®  
TripleFLEX (P)\*  
Verdict†  
Warrant™  
Zemax®  
Zidua®

Cotton:

Dual II Magnum  
Prefix® (P)\*  
Sequence (P)\*  
Warrant

Soybeans:

Authority Elite  
Boundary (P)\*  
Cinch  
Dual II Magnum  
Fierce  
Intro  
Micro-Tech  
OpTill Pro  
Outlook  
Prefix (P)\*  
Sequence (P)\*  
Verdict†  
Warrant  
Zidua

Small Grains:

Axiom (P)\*

Tree Fruits, Nuts and  
Vine Crops:

None

(P)\* = Premix product  
containing at least  
one nonmitosis  
inhibitor chemistry

† = Verdict is powered  
by Kixor herbicide

Bayer CropScience Herbicides for  
Management of Mitosis-Inhibitor-  
Resistant Weeds

Corn:

Autumn Super (Group 2)  
Balance Flexx (Group 27)  
Buctril (Group 6)  
Capreno (Groups 2, 27)  
Corvus (Groups 2, 27)  
Liberty (Group 10)

Cotton:

Liberty (Group 10)

Soybeans:

Autumn Super (Group 2)  
Liberty (Group 10)

Small Grains:

Axiom (Groups 5, 15)

Tree Fruits, Nuts and Vine Crops:

Rely 280 (Group 10)  
Alion (Group 29)

Please refer to product labels for additional  
information on weeds controlled, application  
timings, precautions, restrictions and other  
important use information.

HPPD Inhibitors

Group 27

HRAC Group F<sub>2</sub>

What is a Group 27 herbicide?

- Inhibitor of 4-hydroxyphenylpyruvate-dioxygenase (HPPD) enzyme, which disrupts the formation of carotenoids.
- The lack of carotenoids results in the destruction of chlorophyll molecules by excessive light energy. This leads to characteristic bleaching of leaf tissue and rapid plant death (normally six to 14 days) after application.
- Symptoms often appear rapidly, but can be delayed by cloudy weather.
- Consists of products from four chemical families: triketone, isoxazole, pyrazole and pyrazolone.

How do weeds evolve resistance to Group 27 herbicides?

- Due to the recent discovery of HPPD resistance, researchers are investigating how this resistance develops.

How many weeds have developed resistance to Group 27 herbicides?

- Globally: 2 weed species confirmed
- U.S.: 2 weed species confirmed

How can Group 27 herbicides fit in my resistance management strategy?

By alternating and/or tankmixing HPPD inhibitors with multiple modes of action, these products can be key management options for control of weeds resistant to ALS, PPO, glyphosate, dicamba and triazine chemistries.

Confirmed Group 27  
Resistant Weed Species in the U.S.\*

- Amaranth, Palmer

• Waterhemp, common

\*Heap, I. The International Survey of Herbicide-Resistant Weeds. Available at [www.WeedScience.org](http://www.WeedScience.org). October 8, 2013.

Cellulose Biosynthesis Inhibitors

Group 29

HRAC Group L

What is a Group 29 herbicide?

- Inhibitor of cellulose biosynthesis (CBI).
- Inhibits meristem growth.
- Consists of products from one chemical family: alkylazines (indaziflam).

How many weeds have developed resistance to Group 29 herbicides?

- Globally: 1 weed species confirmed

How can a Group 29 herbicide fit into a resistance management strategy?

- With a new mode of action, products such as Alion (indaziflam) become a key management option for pre-emergent control of weeds resistant to ALS, glyphosate, triazine and other herbicide chemistries.

return to cover

Common Group 27  
HPPD-Inhibitor Herbicides

Use of Group 27 herbicides is most common in corn and small grain production systems and to a lesser extent in soybeans.

Corn:

Armezon®  
Balance Flexx  
Callisto  
Callisto Xtra (P)\*  
Capreno (P)\*  
Corvus (P)\*  
Halex GT (P)\*  
Impact®  
Instigate (P)\*  
Laudis  
Lexar EZ (P)\*  
Lumax EZ (P)\*  
Radius™ (P)\*  
Realm Q (P)\*  
Zemax (P)\*

Cotton:

None

Soybeans:

None

Small Grains:

Huskie (P)\*  
Huskie Complete (P)\*  
Wolverine (P)\*

Tree Fruits, Nuts and  
Vine Crops:

None

(P)\* = Premix product containing at least one non-HPPD chemistry

Bayer CropScience Herbicides for Prevention of  
Potential HPPD Resistance Development

Corn:

Autumn Super (Group 2)  
Buctril (Group 6)  
Capreno (Groups 2, 27)  
Corvus (Groups 2, 27)  
Liberty (Group 10)

Tree Fruits, Nuts and  
Vine Crops:

Alion (Group 29)  
Rely 280 (Group 10)

Small Grains:

Huskie (Groups 6, 27)  
Huskie Complete  
(Groups 2, 6, 27)  
Wolverine (Groups 1, 6, 27)

Cotton:

Liberty (Group 10)

Soybeans:

Autumn Super (Group 2)  
Liberty (Group 10)

Please refer to product labels for additional information on weeds controlled, application timings, precautions, restrictions and other important use information.

Common Group 29  
Cellulose Biosynthesis-Inhibitor Herbicide

Use of a Group 29 herbicide is registered only in TFNV.

Tree Fruits, Nuts and Vine Crops:

Alion

Bayer CropScience Herbicide for Prevention of Potential  
Cellulose Biosynthesis Inhibitor Resistance Development

Tree Fruits, Nuts and  
Vine Crops:

Rely 280 (Group 10)

Please refer to product labels for additional information on weeds controlled, application timings, precautions, restrictions and other important use information.



# Glutamine Synthetase Inhibitors    Group 10

HRAC Group H

## What is a Group 10 herbicide?

- Inhibitor of glutamine synthetase, a key enzyme in incorporating ammonium into amino acids.
- Blockage of this enzyme allows a buildup of phytotoxic ammonia.
- Consists of products from one chemical family: phosphonic acid (glufosinate).

## How do weeds evolve resistance to Group 10 herbicides?

- Researchers are investigating how glutamine synthetase inhibitor resistance develops.

## How many weeds have developed resistance to Group 10 herbicides?

- Globally: 2 weed species confirmed
- U.S.: 1 weed species confirmed

## How can Group 10 herbicides fit in my resistance management strategy?

- By introducing a new mode of action like a glutamine synthetase inhibitor, products such as glufosinate may become key ingredients and management options for control of weeds resistant to ALS, glyphosate, triazine and other herbicide modes of action.
- Additionally, LibertyLink® traits in corn, cotton, canola and soybeans allow over-the-top use of glufosinate.
- For a complete resistance management approach, rotate crops, herbicide-tolerant traits and herbicide modes of action.

**Confirmed Group 10  
Resistant Weed Species in the U.S.\***

- Ryegrass, Italian

\*Heap, I. The International Survey of Herbicide-Resistant Weeds. Available at [www.WeedScience.org](http://www.WeedScience.org). October 8, 2013.



Arkansas field of LibertyLink soybeans treated with Liberty.

[return to cover](#)

## Common Group 10 Glutamine Synthetase-Inhibitor Herbicides

Use of Group 10 herbicides is most common in corn, cotton, canola, soybean and TFNV production systems. All Group 10 products are manufactured by Bayer CropScience. Liberty is registered for over-the-top use on all LibertyLink crops including corn, cotton, canola and soybeans. Liberty also can be used for burndown prior to planting any corn, soybean, cotton, canola or sugarbeet crop. Rely 280 also can be used in registered tree fruit, nut and vine crops; berries; and for desiccation of potato vines.

### Canola\*:

Liberty

### Corn\*:

Liberty

### Cotton\*:

Liberty

### Soybeans\*:

Liberty

### Tree Fruits, Nuts and Vine Crops:

Rely 280

\*Over-the-top use on LibertyLink crops only.

## Bayer CropScience Herbicides for Prevention of Potential Glufosinate-Resistance Development

### Corn:

Autumn Super (Group 2)  
Balance Flexx (Group 27)  
Buctril (Group 6)  
Capreno (Groups 2, 27)  
Corvus (Groups 2, 27)  
Laudis (Group 27)

### Small Grains:

Axiom (Groups 5, 15)  
Huskie Complete (Groups 2, 6, 27)  
Osprey (Group 2)  
Rimfire Max (Group 2)  
Wolverine (Groups 1, 6, 27)

### Soybeans:

Autumn Super (Group 2)

### Tree Fruits, Nuts and Vine Crops:

Alion (Group 29)

Please refer to product labels for additional information on weeds controlled, application timings, precautions, restrictions and other important use information.



On the left, glyphosate-resistant pigweed overtakes a soybean field, while on the right, Liberty herbicide on LibertyLink soybeans provides an option for growers to help manage or prevent resistance.



Bayer CropScience Herbicide Features



- Provides longer-lasting residual control of both grass and broadleaf weeds.
- Offers a new and unique chemistry that controls even resistant weeds.
- Delivers exceptional crop safety.



- Takes down the toughest weeds and keeps them down for a clean start prior to planting.
- Alternative mode of action to glyphosate that can help combat glyphosate-tolerant and -resistant weeds.
- Provides burndown of emerged weeds with residual.



- Provides consistent control of many grasses and certain small-seeded broadleaf weeds in wheat.
- Applied from germination up to 2-leaf stage of wheat.
- Offers a unique mode of action to fight ALS- and ACCase-resistant ryegrass in wheat.
- One active ingredient inhibits cell division while the second simultaneously stops the photosynthesis process, efficiently killing target weeds.



- Tough burndown of grass and broadleaf weeds with reactivation to kill late-emerging weeds.
- Tough enough to control glyphosate-resistant weeds at a low use rate.
- CSI™ Safener for excellent crop safety and flexibility.
- Perfect foundation herbicide for any two-pass program.



- Delivers season-long control of the toughest weeds for an amazing end-of-season clean.
- Offers the longest-lasting residual of any postemergence corn herbicide.
- Kills more than 65 grass and broadleaf weeds.
- Tankmix with glyphosate and atrazine for four modes of action to kill resistant weeds.



- Dependable one-pass performance at the 5.6 fl oz/A rate.
  - Burndown takes out early weeds. Residual prevents new weeds.
  - Reactivation gets late weeds.
- Convenient, low-dose formulation can be applied from pre-plant burndown through V2 corn.
- Tankmix with glyphosate and atrazine at pre-emergence for four modes of action to kill resistant weeds.



- Postemergence control of more than 50 broadleaf weeds.
- Controls the toughest broadleaf weeds with its unique mode of action.
- The most effective tankmix starts with Huskie.



- Powered by a unique MOA delivering complete cross-spectrum control of grass and broadleaf weeds.
- Helps manage weed resistance, including ACCase-resistant grasses and ALS-resistant broadleaf species.



- LibertyLink plus Liberty herbicide is highly effective against even the toughest weeds to help preserve the yield of high-performing varieties.
- The LibertyLink trait allows growers to spray Liberty in-crop for nonselective postemergence control of the toughest weeds, including Palmer amaranth, giant ragweed, waterhemp and marestalk.
- With a unique mode of action, spray Liberty early to control weeds quickly before they jeopardize yield potential.
- The high-performance LibertyLink trait is widely available across crops—canola, cotton, corn and soybeans—including leading brands such as FiberMax® and Stoneville® cotton, InVigor® canola and more than 100 brands of corn and soybeans.



- Delivers postemergence control of more than 65 grass and broadleaf weeds with unsurpassed crop safety on field corn, sweet corn, popcorn and seed corn.
- Tankmix with Liberty for the ultimate weed resistance management tool with residual control.
- Add to glyphosate to extend late postemergence control and kill resistant weeds.
- Add to glyphosate and Stratego® YLD for the safest and most convenient disease and weed management program.



- Cost-effective winter wheat herbicide that offers reliable postemergence control of tough grass weeds, including wild oats as well as a number of key broadleaf weeds.
- Provides consistent performance with a wide application window.
- Has no grazing restrictions.
- Spring and winter burndown.



- Offers broad-spectrum grass control, including Italian ryegrass and wild oats (including ACCase-resistant), and suppression of jointed goatgrass and *Bromus* in winter wheat.
- Full rotational crop flexibility and can be tankmixed with many broadleaf herbicides.



- Delivers rapid, nonselective control of emerged broadleaf and grass weeds, including those resistant to glyphosate and multiple herbicide classes.
- Provides excellent crop safety to mature trees and vines.
- Now more powerful and cost-effective than ever before.



- Offers spring wheat growers tough protection for control of changing weed populations.
- Two active ingredients work together to control the changing weed spectrum—weeds such as Japanese brome and Persian dandel.
- Effective control of wild oats and foxtails, including ACCase-resistant biotypes in wheat.
- Perfect tankmix partner with Huskie for an effective weed-control solution.



- The convenient postemergence solution for broad-spectrum grass and broadleaf weed control in wheat and barley.
- Controls 69 grass and broadleaf weeds—all at a single rate.
- Simplifies growers' spray operations by eliminating the need for tankmixing.



## Herbicide Classification by Site of Action

Group		Site of Action (Mode of Action)	Chemical Family	Active Ingredient Examples (AI)		Premixtures Containing AI Examples
WSSA	HRAC			Common Name	Trade Name	
1	A	ACCase Inhibition (Lipid Synthesis Inhibitors)	Aryloxyphenoxy-propionate (FOPs)	Clodinafop	Discover NG	
				Fenoxaprop-P	Puma®	Wolverine, Fusion
				Fluazifop-P	Fusilade DX	Fusion
				Quizalofop-P	Assure II, Targa®	
2	B	ALS/AHAS Inhibition (Amino Acid Synthesis Inhibitors)	Cyclohexanedione (DIMs)	Clethodim	Select, Select Max	
				Sethoxydim	Poast	Rezult®
			Phenylpyrazole (DENs)	Pinoxaden	Axial XL	Axial TBC
			Imidazolinone	Imazethapyr	Pursuit	OpTill, Authority Assist, Extreme, Pursuit Plus
				Imazamox	Raptor, Beyond	
				Imazaquin	Scepter	
			Pyrimidinyl thiobenzoate	Pyriithiobac-Na	Staple	
			Sulfonilamino-carbonyl-triazolinone	Flucarbazone	Everest	
				Propoxycarbazon-Na	Olympus	Rimfire Max
				Thiencarbazon		Corvus, Capreno, Huskie Complete
			Sulfonyleurea	Chlorimuron	Classic	Canopy, Enlite, Envive, Valor XLT, Authority XL, Authority Maxx
				Chlorsulfuron	Finesse	
				Foramsulfuron	Option®	
				Iodosulfuron		Autumn Super
				Mesosulfuron	Osprey	Rimfire Max
				Nicosulfuron	Accent, Accent Q	Steadfast Q, Steadfast ATZ
4	O	Synthetic Auxins (Growth Regulators)		Rimsulfuron		Basis, Require Q, Resolve Q, Realm Q, Steadfast Q, Prequel®
			Triazolopyrimidine	Chloransulam-methyl	FirstRate®	Authority First, Gangster, Sonic
				Florasulam		PowerFlex, GoldSky, Axial TBC
				Flumetsulam	Pythron®	Hornet WDQ, TripleFLEX, SureStart
			Benzoic acid	Dicamba	Banvel, Clarity	Distinct, Status, NorthStar, Require Q, Yukon
			Phenoxy carboxylic acid	2,4-D	Many	Rage D-Tech
				2,4-DB	Butyrac®	
				MCPA		Curtail M, Bronate®, Orion
			Pyridine carboxylic acid	Clopyralid	Stinger	WideMatch, Curtail M, Hornet WDQ, SureStart, TripleFLEX
				Fluroxypyr	Starane	GoldSky, Pulsar, WideMatch
				Picloram	Tordon®, Grazon®	
			Quinoline carboxylic acid	Quinclorac	Paramount®	
5	C <sub>1</sub>	Photosystem II Inhibition (PS II) (Photosynthesis Inhibitors)	Phenyl-carbamate	Desmedipham	Betanex®	Betamix®
				Phenmedipham		Betamix
			Pyridazinone	Pyrazon		
			Triazine	Atrazine	AAtrex®	Lexar EZ, Lumax EZ, Harness XTRA, Bicep II Magnum, Callisto Xtra, Guardsman Max
				Simazine	Princep	
			Triazinone	Metribuzin	Sencor®	Axiom, Authority MTZ, Boundary, Canopy
			Triazolinone	Amicarbazone		
				Uracil		
6	C <sub>3</sub>	Photosystem II Inhibition (PS II) (Photosynthesis Inhibitors)	Benzothiadiazinone	Bromacil	Hyvar XL	Krovat
				Bentazon	Basagran®	Storm®, Rezult
			Nitrile	Bromoxynil	Buctril	Buctril+Atrazine, Bronate, Huskie, Huskie Complete, Wolverine
7	C <sub>2</sub>	Photosystem II Inhibitor (PS II) (Photosynthesis Inhibitors)	Phenyl-pyridazine	Pyridate		
			Urea	Diuron	Diuron, Karmex	
				Fluometuron	Cotoran	
			Amide	Propanil	Stam™, Propanil	

Group		Site of Action (Mode of Action)	Chemical Family	Active Ingredient Examples (AI)		Premixtures Containing AI Examples
WSSA	HRAC			Common Name	Trade Name	
9	G	EPSP Synthase Inhibition (Amino Acid Synthesis Inhibitors)	Glycine	Glyphosate	Roundup, Touchdown	Halex GT, Sequence, Extreme, RT Master II, Flexstar GT
10	H	Glutamine Synthetase Inhibition (Nitrogen Metabolism Inhibitors)	Phosphoric acid	Glufosinate-ammonium	Liberty, Rely 280	
14	E	Protoporphyrinogen Oxidase (PPO) Inhibition (Cell Membrane Disrupters)	Diphenyl ether	Acifluorfen-Na	Ultra Blazer	
				Fomesafen	Reflex	Flexstar GT, Flexstar
				Lactofen	Cobra	
				Oxyfluorfen	Goal, Galigan	
			N-phenylphthalimide	Flumiclorac-pentyl	Resource	
				Flumioxazin	Valor, Chateau	Enlite, Envive, Fierce, Gangster, Valor XLT
				Oxadiazole		
				Oxazolidinedione	Pentoxazone	
				Phenylpyrazole	Fluazolate	
				Pyrimidinedione	Butafenacil	
					Saflufenacil	Sharpen, Treevix
					Thiadiazole	Cadet
					Fluthiacet	Anthem, Anthem ATZ
			Triazolinone	Carfentrazone	Aim	Rage D-Tech
				Sulfentrazone	Authority, Spartan®	Authority First, Authority MTZ, Authority Maxx, Authority Assist, Authority XL, Sonic
15	K <sub>3</sub>	Mitosis Inhibition (Seedling Shoot Growth Inhibitors)	Acetamide	Napropamide	Devrinol®	
			Chloracetamide	Acetochlor	Harness, Surpass, Warrant	Harness XTRA, SureStart, TripleFLEX
				Alachlor	Intro, Micro-Tech	
				Dimethenamid	Outlook	Guardsman Max, Verdict
				Metolachlor	Dual, Dual II Magnum	Bicep II Magnum, Lexar EZ, Lumax EZ, Boundary, Prefix, Halex GT, Sequence, Zemax
				Propachlor	Ramrod®	
			Isoxazoline	Pyroxasulfone	Zidua	Anthem, Anthem ATZ, Fierce
			Oxyacetamide	Flufenacet	Define®	Axiom, Radius
				Mefenacet		
			Tetrazolinone	Fentrazamide		
27	F <sub>2</sub>	4-Hydroxyphenyl-Pyruvate-Dioxygenase Inhibition (4-HPPD) (Pigment Inhibitors)	Callistemon	Mesotrione	Callisto	Callisto Xtra, Lexar EZ, Lumax EZ, Halex GT, Realm Q, Zemax
			Isoxazole	Isoxaflutole	Balance Pro	Balance Flexx, Corvus, Radius, Prequel
				Pyrasulfotole		Huskie, Huskie Complete, Wolverine
			Pyrazole	Topramezone	Impact	
			Triketone	Tembotrione	Laudis	Capreno
29	L	Cellulose Biosynthesis Inhibition	Alkylazine	Indaziflam	Alion	

Bayer CropScience commercial products are highlighted in [blue](#).

This table is a partial listing of WSSA, HRAC-approved group numbers or letters and a partial listing of active ingredients and products which may be contained within a chemical family. Group 29/L is a newly approved classification by WSSA/HRAC.

For a complete summary listing of herbicide mechanisms of action, refer to Summary of Herbicide Mechanism of Action According to the Weed Science Society of America (WSSA) available at [www.wssa.net/wp-content/uploads/WSSA-Mechanism-of-Action.pdf](http://www.wssa.net/wp-content/uploads/WSSA-Mechanism-of-Action.pdf).

For more information visit [www.BayerCropScience.us](http://www.BayerCropScience.us)

**IMPORTANT:** This bulletin is not intended to provide adequate information for use of these products. Read the label before using these products. Observe all label directions and precautions while using these products.



Bayer CropScience LP, 2 T.W. Alexander Drive, Research Triangle Park, NC 27709. Always read and follow label instructions. Bayer (reg'd), the Bayer Cross (reg'd), Alion®, Autumn®, Axiom®, Balance®, Betamix®, Betanex®, Bronate® Advanced™, Buctril®, Capreno®, Corvus®, CSI™ Safener, Define®, FiberMax®, Huskie®, InVigor®, Laudis®, Liberty®, LibertyLink®, Olympus®, Option®, Osprey®, Puma®, Radius®, Rely®, Respect the Rotation™, Rimfire®, Sencor®, Stoneville®, Stratego®, the Water Droplet Design (reg'd) and Wolverine® are trademarks of Bayer. AAtrex, Anthem ATZ, atrazine, Balance Flexx, Bicep II Magnum, Breakfree ATZ, Bullet, Callisto Xtra, Cinch ATZ, Corvus, Degree XTRA, Expert, FullTime, G-Max Lite, Grazon, Guardsman Max, Harness XTRA, Intro, Keystone, Lariat, Lexar, Lumax, Micro-Tech, Prequel, Radius, Shotgun, Steadfast ATZ and Tordon are Restricted Use Pesticides. Alion, Autumn, Autumn Super, Axiom, Balance Flexx, Balance Pro, Betamix, Betanex, Buctril, Capreno, Corvus, Define, Huskie, Huskie Complete, Laudis, Liberty, Olympus, Osprey, Puma, Radius, Rely 280, Rimfire Max, Sencor, Stratego YLD and Wolverine are not registered in all states. Cornerstone is a trademark of Agrilience LLC. GlyStar is a trademark of Agrisel USA Inc. Butyrac and OxyStar are trademarks of Albaugh Inc. Impact is a trademark of AMVAC Chemical Corporation. Banvel, Basagran and Everest are trademarks of Arysta LifeScience Corporation. Armezon, Basagran, Beyond, Clarity, Distinct, Extreme, G-Max Lite, Guardsman Max, Kixor, Lightning, OpTill, Outlook, Paramount, Poast, Pursuit, Raptor, Rezult, Scepter, Sharpen, Status, Treevix, Verdict and Zidua are trademarks of BASF Corporation. Glyfos is a trademark of Cheminova. Curtail, Durango, FirstRate, FullTime, Goal, GoalTender, GoldSky, Grazon, Hornet, Keystone, Pindar, PowerFlex, Pythron, Sonic, Starane, Stinger, SureStart, Surpass, TopNotch, Tordon and WideMatch are trademarks of Dow AgroSciences. Abundit, Accent, Accent Gold, Affinity, Ally, Assure, Basis, Breakfree, Canopy, Cinch, Classic, Enlite, Envive, Finesse, Glean, Harmony, Hyvar, Instigate, Krovat, Matrix, Prequel, Realm, Require, Resolve, Sinbar, Staple, Steadfast and Synchrony are trademarks of E.I. du Pont de Nemours and Company. Aim, Anthem, Authority, Cadet, Rage, Shark and Spartan are trademarks of FMC Agricultural Products. Targa and Yukon are trademarks of Gowan Company LLC. Makaze and Shotgun are trademarks of Loveland Products, Inc. Cotoran, Direx, Galigan and Karmex are trademarks of Makhteshim Agan of North America. Bullet, Degree XTRA, Harness, Honcho, Intro, Landmaster, Lariat, Maverick, Micro-Tech, Roundup, RT Master, TripleFLEX and Warrant are trademarks of Monsanto Technology LLC. ET is a trademark of Nichino America Inc. Credit and Ramrod are trademarks of Nufarm Americas Inc. Stam is a trademark of RiceCo LLC. Alecto is a trademark of Ritter Chemical LLC. AAtrex, Amber, Axial, Bicep II Magnum, Boundary, Callisto, Caporal, Discover, Dual II Magnum, Envioke, Expert, Flexstar, Foxfire, Fusilade, Fusion, Halex, Lexar, Lumax, NorthStar, Orion, Prefix, Princep, Pulsar, Rave, Reflex, Sequence, Spirit, Suprend, Touchdown and Zemax are trademarks of a Syngenta Group Company. Buccaneer is a trademark of Tenkoz Inc. Devrinol, Storm and Ultra Blazer are trademarks of United Phosphorous Inc. Gly-4 is a trademark of Universal Crop Protection Alliance. Chateau, Cobra, Fierce, Gangster, Phoenix, Resource, Select, Select Max and Valor are trademarks of Valent U.S.A. Corporation. For additional product information, call toll-free 1-866-99-BAYER (1-866-992-2937) or visit our website at [www.BayerCropScience.us](http://www.BayerCropScience.us)

CR1113MUL11A696V00R0

return to cover