

Created: 4/18/2013



How to Effectively use the Corn and Soybean Herbicide Chart

The message from weed scientists to producers to rotate and include multiple modes of action and sites of action in their corn and soybean herbicide programs has intensified with the increasing number of acres infested with herbicide resistant weeds. Along with that message have come many tools to help farmers ensure the proper rotation of herbicides, including the Corn and Soybean Herbicide Chart from the glyphosate weeds and crops working group. This chart has been distributed by university weed scientists to aid producers in determining herbicide programs with optimal site of action rotation. The Purdue Weed Science program has noticed

that many producers would not use the chart if not properly instructed on how to use the chart. We emphasized instruction on how to use the chart at meetings this past winter. The following is an extension of this effort to explain the chart layout and how Purdue weed scientists are encouraging producers to use the chart when planning their weed management program.

Mode of Action vs. Site of Action

The first explanation to end some confusion is the difference between "mode of action" and "site of action". Sometimes the terms are thrown around and interchanged and can become confusing as to what is what.

- Mode of action: refers to the way in which the herbicide effects plant growth (visual symptoms on the plant) and eventual death at effective doses
- Site of action: refers to the specific enzyme site or pathway that the herbicide binds or inhibits to create the plant growth effects

In simplistic terms the sites of action are subsets of the broader modes of action. Several modes of action only have one site of action while others have two or three sites of action. To ultimately increase the number of chemicals available for use in a rotation, producers should focus on "Sites of Action" rather than "Modes of Action". The Corn and Soybean Herbicide Chart was designed around the Sites of action and WSSA assigned Site of Action group.



The Corn and Soybean Herbicide Chart PDF can be downloaded by clicking on the image above or going to: https://ag.purdue.edu/btny/weedscience/Documents/ Herbicide_MOA_CornSoy_12_2012%5B1%5D.pdf

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Corn and Soybean Herbicide Chart

April 18, 2013

Chart Layout

The chart actually contains two charts, "By Mode of Action" and "By Premix", which are linked by a color-coding system. The "By Mode of Action" chart would be the large chart under the large black header and the "By Premix" chart being the smaller chart on the far right.

"By Mode of Action"

The "By Mode of Action" table is a grouping of active ingredients and products containing single active ingredients into chemical families, sites of action and lastly modes of action. The single ingredient products and active ingredients are listed individually on the right of the chart and progress in their groupings to the left. Each column of the chart from the left to the right is explained below:

- Mode of Action: As explained previously, this is the broad grouping of herbicides by their effect on plant growth. Within this chart the Modes of action are separated by brackets and different colors
- Site of Action Group: The site of action group is a numerical value that has been assigned to each site of action by the Weed Science Society of America. The site of action group numbering system was designed for quick and simplistic recognition rather than using the complicated scientific names that can be cumbersome and confusing for producers. A colored box that corresponds to the mode of action that each site of action group number. Modes of action with multiple sites of action have different shades of the mode of action color representing each site of action (i.e. Site of action groups 5, 6, and 7 are all Photosynthesis-inhibitors and are represented by three shades of green.)
- Site of Action: The site of action as explained above is the site or physiological pathway that the herbicide binds or inhibits. Again the sites of action are subsets of the mode of action and should be the focus of herbicide program rotations. Each site of action will have a site of action number as described above.
- Number of resistant weed species in U.S. The numbers encircled in black dots represent the number of weed species that are resistant to each herbicide site of action.
- Chemical Family: The grouping of herbicides within each site of action by their chemical structures.
- Active Ingredient: The accepted common chemical name of the actual component that is responsible for growth effects, injury, and death of susceptible plants. This will be listed on the front of every herbicide label on the front panel under active ingredients.
- Product Examples (Trade Name®): The marketed or trade name of products that only contain only one active ingredient that is listed to the immediate left.



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The red boxes outline the two independent tables within the Corn and Soybean Herbicide Chart. The "By Mode of Action" chart is on the left and "By Premix" on the right.

Corn and Soybean Herbicide Chart

April 18, 2013



How to use the "By Mode of Action" Chart (Working from the right to left)

To find the details of the herbicide product "Permit" you would start by finding "Permit" in the Product Examples (Trade Names®) column. Then working back to the left column by column you would find the following:

Permit's active ingredient is halosulfuron, which is part of the sulfonylurea chemical family that is part of the ALS Inhibitors (acetolactate synthase) site of action. The ALS inhibitors site of action has 44 resistant weed species in the U.S. and has been assigned the Site of Action group number 2. The mode of action of Permit is amino acid synthesis inhibitors.

Producers using this chart to outline the sites of action used in their herbicide program will focus on the Example products (Trade Names ®), Active Ingredient, and Site of Action Group columns.

"By Premix" Chart

The problem with listing example single ingredient trade name products is that many products contain multiple active ingredients and are often referred to as premixes. The "By Premix" chart allows users to quickly look up the active ingredients and sites of action in a premix product and link them back to the "By Mode of Action" chart for more details. The premix products are listed alphabetically by their trade names in the far left column. As you move across to the right you will see the break down of each premix by single ingredient

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trade name products, active ingredients, and site of action group numbers. Also on the far right is a colored bar that matches the color coding and shading of the mode of action and site of action in the "By Mode of Action" chart.

An example premix product would be Anthem that appears at the top of the chart. Anthem contains the trade name products Zidua and Cadet which contain the active ingredients pyroxasulfone and fluthiacetethyl, respectively. The two active ingredients belong to the site of action groups 15 and 14. A producer could obtain more information about these active ingredients by using the colors; light brown and dark red, to link back to the "By Mode of Action" chart. The user could also link back to the "By Mode of Action" chart with the site of action group numbers, active ingredients, and/or product examples (Trade Name®).

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Outlining Herbicide Programs Using the Corn and Soybean Herbicide Chart

The message that Purdue Weed Science has stressed to Indiana producers is to sit down with their planned herbicide program for this year and write out the site of action group(s) for each product using the Corn and Soybean Herbicide Chart. We have even challenged producers to write out two cropping years of their herbicide program. After writing out the sites of action there are a number of things that a producer should look for in their planned herbicide program, including:

- The overall number of site of action groups that are being used in the planned herbicide program.
- The number of site of action groups that are effectively controlling the weeds that are present in the field. i.e. Group 2 (ALS Inhibitor) herbicides would not be considered a site of action that is effectively controlling an ALS resistant weed species.
- Any repetition or reliance on a single site of action in the herbicide program. The use of a site of action more than two times in a growing season would be considered overreliance on that site of action and places significant selection pressure on that site of action

An ideal herbicide program would maximize the number of effective site of action groups without using any site of action more than two times in a growing season.

Example Herbicide Program Outlined

This program is for no-till soybean for control of an ALS and glyphosate resistant Palmer amaranth population. The table has the trade name products with their corresponding active ingredients and site of action groups.

Application Timing	Trade Name Product	Active Ingredient	Site of Action Group
Burndown	Gramoxone Inteon	paraquat	22
	Sencor	metribuzin	5
	Sonic	sulfentrazone	14
		cloransulam	2
Early Post	Prefix	fomesafen	14
		S-metolachlor	15
Late Post	Cobra	lactofen	14

After outlining the site of action groups in the program you can see that this program contains a total of 5 site of action groups, four of which are effectively controlling the target weed (Group 2 herbicides are not effective on ALS resistant weed species). The other thing to notice is the repetitive use of group 14 herbicides, for a total of 3 times in one growing season. In this program a significant amount of selection pressure is being place on the group 14 herbicides and an adjustment would be recommended such as the following.



Information listed here is based on research and outreach extension programming at Purdue University and elsewhere.

The use of trade names is for clarity and does not imply endorsement of a particular product, nor does exclusion imply non-approval. Always consult the herbicide label for the most current and update precautions and restrictions. Copies, reproductions, or transcriptions of this document or its information must bear the statement:

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	Sonic	sulfentrazone	14
		cloransulam	2
Early Post	Prefix	fomesafen	14
		S-metolachlor	15
	Liberty	glufosinate	10
	Dual II	S-metolachlor	15
Late Post	Cobra	lactofen	14
	Liberty	glufosinate	10

The replacement of the early and late post applications with Liberty (Group 10) relieves the pressure on the group 14 herbicides. However, if we apply Liberty twice during the growing season we are putting selection pressure for glufosinate resistance. We would recommend caution in using a program like this in consecutive years because of the increased selection pressure. It is encouraged for producers to use this chart to outline two years of their herbicide program to prevent recurring selection pressure over multiple years.

This is only one example of how to alleviate the selection pressure in this program. Many other options are available such as replacing the Sonic product with a non-group 14 herbicide with effective residual activity on ALS and glyphosate resistant Palmer amaranth and using one post pass of Liberty and one post pass of a group 14 (PPO inhibitor) herbicide.

In conclusion, use of this chart when planning weed management programs will be helpful in determining if you are over using specific sites of action and selecting for additional herbicide-resistant weed problems.



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Want more? Click on the graphic to see a aprox 25 min presentation of how to use the Corn and Soybean Herbicide Chart. You can also see the video by going to http://www.youtube. com/watch?v=fBegM4XcJ4Y.