Purdue Cooperative Extension Service

April 26, 2013 - Issue 4

In This Issue

Insects, Mites, And Nematodes

Managing Western Corn Rootworm Resistance to Bt on the Fringe - (*Christian Krupke*)

- Resistance to some Bt corn hybrids has been detected in Iowa and elsewhere.
- Growers in Indiana may be at reduced risk due to different cropping systems and low rootworm populations in recent years.
- The current situation and best management practices developed by corn entomologists are summarized in the linked document.

The first Bt toxin for rootworm control, Cry3Bb1, was sold in Yieldgard Rootworm hybrids in 2003, then combined with corn borer Bt traits and/or herbicide tolerance genes in YieldGard Plus, VT Triple, and Genuity VT Triple Pro. By 2010, Cry3Bb1 was part of a multi-trait pyramid in SmartStax (with Cry34/35Ab1) for rootworm control. The approval of pyramids led to a reduction in refuge from 20% to 5%. EPA also approved refuges in-the-bag for some traits. (To read more....click)

Results from severe rootworm feeding

Black Cutworm Adult Pheromone Trap Report
Week 1 = 4/11/13 - 4/17/13 Week 2 = 4/18/13 - 4/24/13

County	Cooperator	BCW Trapped		County	Cooperator	BCW Trapped	
		Wk 1	Wk 2			Wk 1	Wk 2
Adams	Kaminsky/New Era Ag	5	5	Knox	Bower/Ceres Solutions/Vincennes		0
Adams	Roe/Mercer Landmark	7	9	Knox	Hoke/SWPAC	3	1
Allen	Anderson/Syngenta Seed	0	3	Lake	Kleine/Kleine Farms	5	31*
Allen	Gynn/Southwind Farms	1	14*	Lake	Moyer/Moyer Seed Sales - Shelby	1	2
Benton	Babcock/Ceres Solutions	0	2	Lake	Moyer/Moyer Seed Sales - Schneider	4	5
Boone	Campbell/Beck's Hybrids	8	8	LaPorte	Barry/Kingsbury Elevator	1	0
Boone	Carrell/Lamb Farms Agronomy	2	0	LaPorte	Rocke/Agri-Management Solutions	2	3
Clay	Bower/Ceres Solutions - Brazil	0	0	Miami	Early/Pioneer	4	1
Clay	Bower/Ceres Solutions - Clay City	0	0	Newton	Moyer/Moyer Seed Sales	3	1
Clinton	Foster/Purdue Entomology		6	Porter	Leuck/PPAC	4	0
DeKalb	Hoffman/ATA Solutions	0	0	Putnam	Nicholson/Nicholson Consulting	2	2
Dubois	Eck/CES	4		Randolph	Boyer/DPAC	5	8
Elkhart	Kaufman/Crop Tech	4	1	Rush	Schelle/Falmouth Farm Supply	0	0
Fayette	Schette/Falmouth Farm Supply	0	0	Starke	Wickert/Wickert Agronomy Services	1	0
Fountain	Mroczkiewicz/Syngenta	2	4	Sullivan	Bower/Ceres Solutions - New Lebanon	0	2
Fulton	Jenkins/N. Central Coop - Rochester	2	5	Sullivan	Bower/Ceres Solutions - Sullivan W	10*	4
Fulton	Jenkins/N. Central Coop - Kewanna	5	1	Sullivan	Bower/Ceres Solutions - Sullivan E	2	0
Hamilton	Campbell/Beck's Hybrids	5	2	Sullivan	Bower/Ceres Solutions - Farmersburg	3	0
Hendricks	Nicholson/Nicholson Consulting	14	31*	Tippecanoe	Bower/Ceres Solutions	8	14*
Henry	Schelle/Falmouth Farm Supply	0	0	Tippecanoe	Nagel/Ceres Solutions	41*	23*
Jasper	Overstreet/Purdue CES	4	0	Tippecanoe	Obermeyer/Purdue Entomology	1	4
Jasper	Ritter/Brodbeck Seeds	0	0	Tippecanoe	Westerfeld/Monsanto	0	0
Jay	Shrack/RanDel AgriServices	3	7	White	Reynolds	0	11*
Jennings	Bauerle/SEPAC	0	0	Whitley	Walker/NEPAC	0	12
Knox	Bower/Ceres Solutions/Frichton	0	2				

*=Intensive Capture...this occurs when 9 or more moths are caught over a 2-night period

Weeds

How to Effectively Use the Corn and Soybean Herbicide Chart – (*Travis Legleiter and Bill Johnson*) –

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.

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 belongs encloses and represents 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.

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:

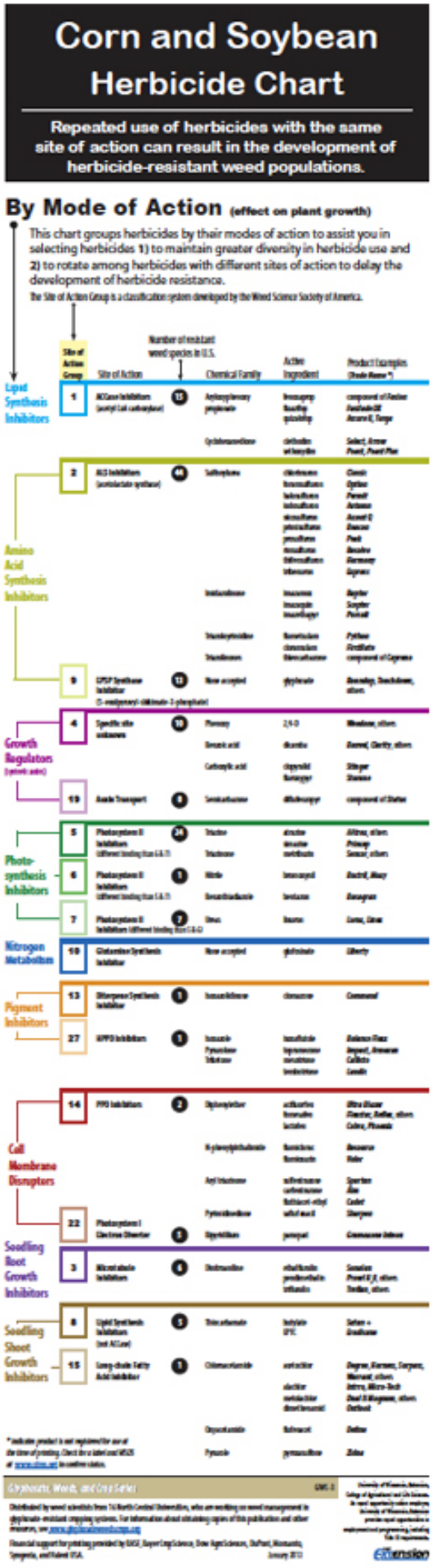
Permit's active ingredient is halosulfuron, which is part of the sulfonylurea chemical family that is part of the ALS Inhibitors (acetolactate synthase) site of action. The ALS inhibitors site of action has 44 resistant weed species in the U.S. and has been assigned the Site of Action group number 2.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

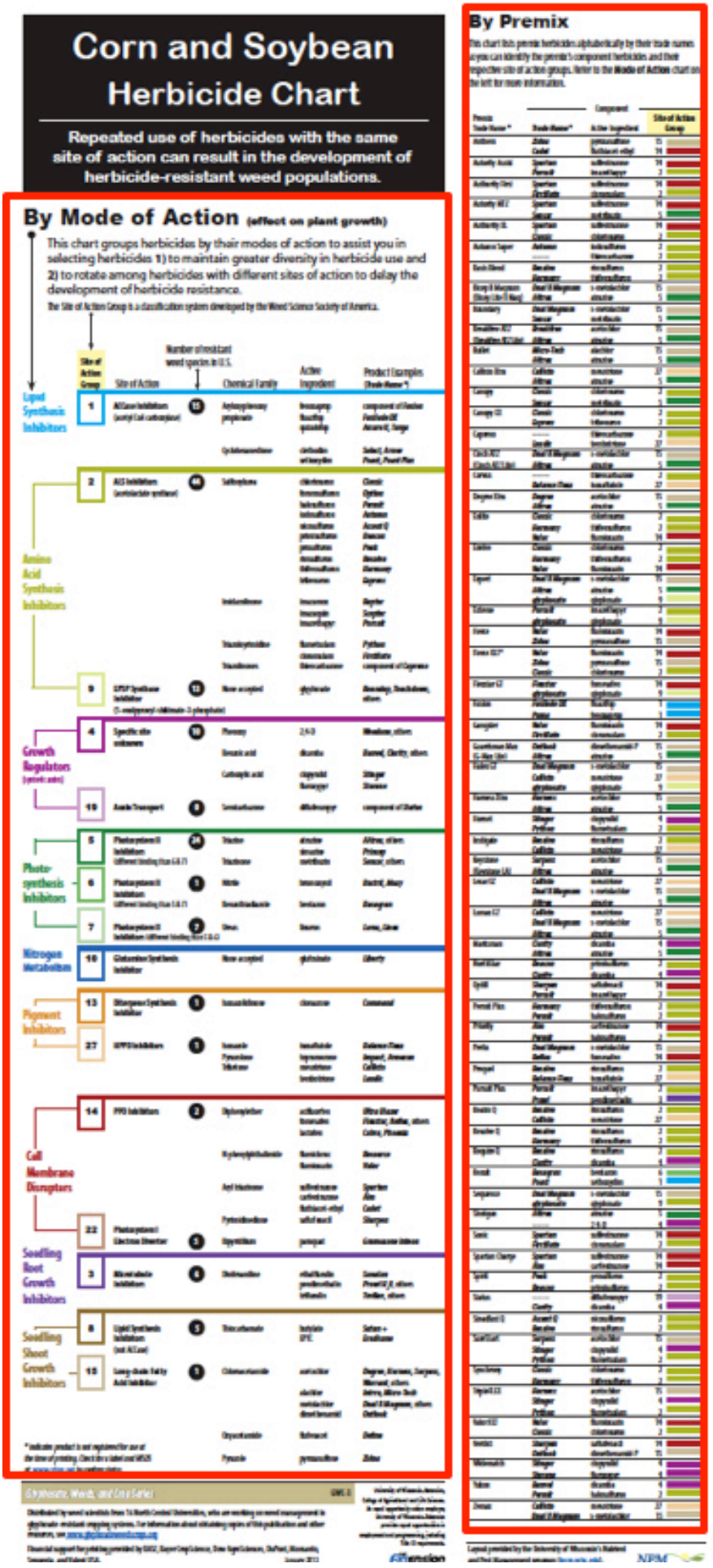
"By Premix" Chart

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 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.

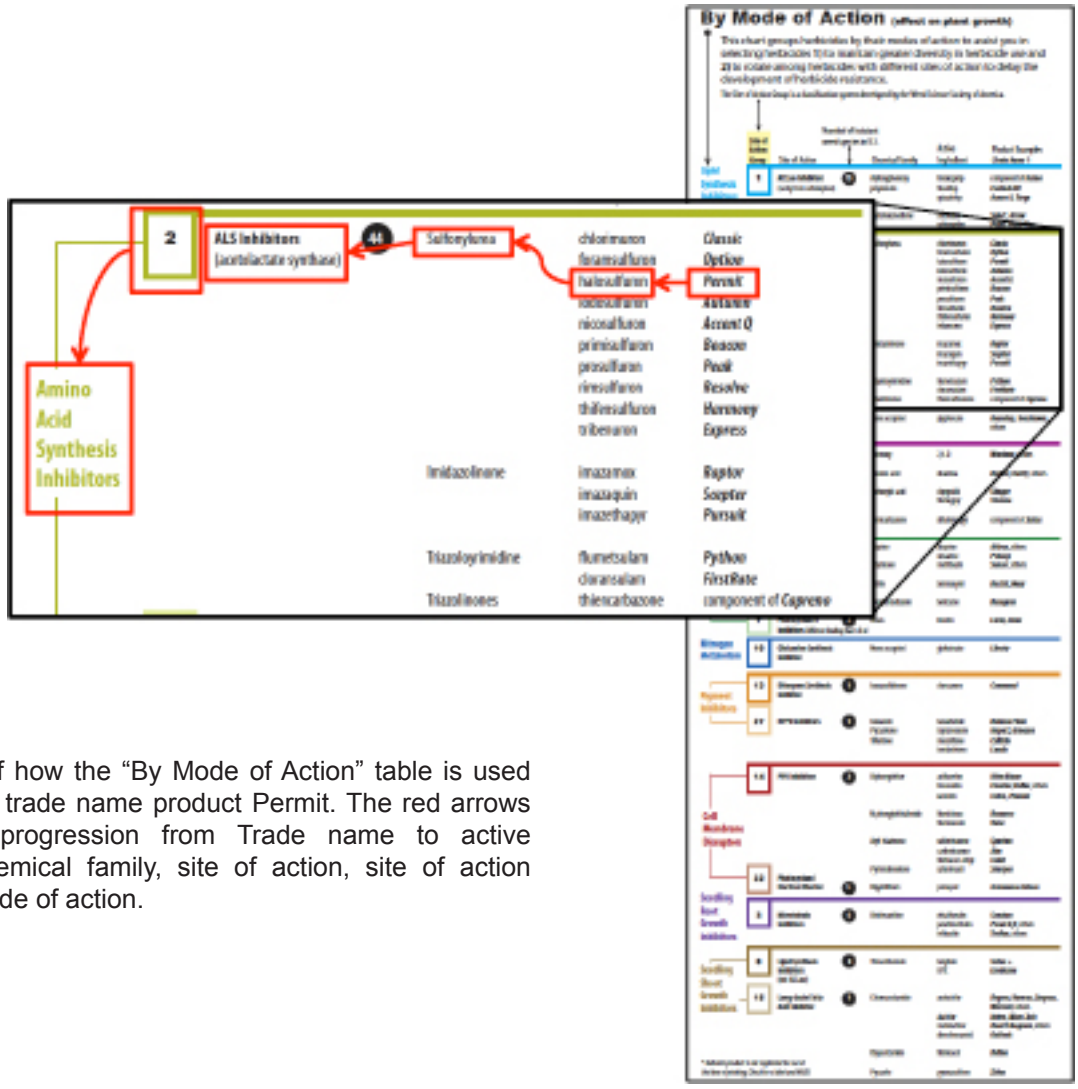
An example premix product would be Anthem that appears at the top of the chart. Anthem contains the trade name products Zidua and Cadet which contain the active ingredients pyroxasulfone and fluthiacet-ethyl, respectively. The two active ingredients belong to the site of action groups 15 and 14. A producer could obtain more information about



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



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 the “By Premix” on the right.



An example of how the "By Mode of Action" table is used to look up the trade name product Permit. The red arrows indicate the progression from Trade name to active ingredient, chemical family, site of action, site of action group, and mode of action.

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®).

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.

After outlining the site of action groups in program 1 you can see that this program contains a total of 5 site of action

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

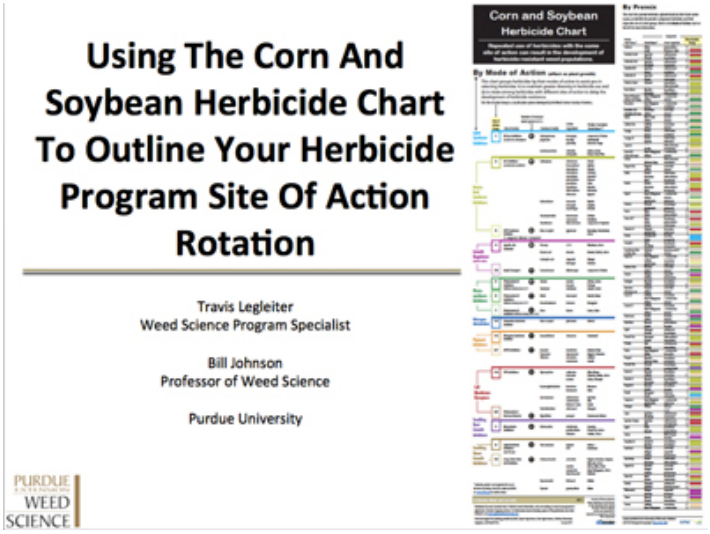
groups, four of which are effectively controlling the target weed (Group 2 herbicides are not effective on ALS resistant weed species). The other thing to notice is the repetitive use of group 14 herbicides, for a total of 3 times in one growing season. In this program a significant amount of selection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

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



Want more? Click on the graphic to see an approximate 25 minute 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>.

Agronomy Tips

Plentiful Winter and Spring Precipitation – Nitrogen Carryover Unlikely for Most of Indiana – (*Jim Camberato*[1])

Last year's drought and reduced corn yield in Indiana resulted in considerably more nitrogen (N) being left in the soil at the end of the growing season than normally occurs. Most of the leftover N was in the nitrate form which is subject to loss with excess soil moisture, both by drainage to the water table and via tile drains to the ditches and to the air through a process called denitrification[2].

A dry winter and spring would have allowed some of the nitrate to carry over to the upcoming corn crop. Unfortunately in most of Indiana the winter and early spring have been anything but dry.

Precipitation totals from late October through April (Fig. 1, upper panel) show that almost all of Indiana received more than 15 inches of precipitation during this 180 day span. Most of Indiana (except the southeast) received more precipitation than normal (Fig. 1, lower panel). Large areas of Indiana have received precipitation as much as 4 to 8 inches of above normal.

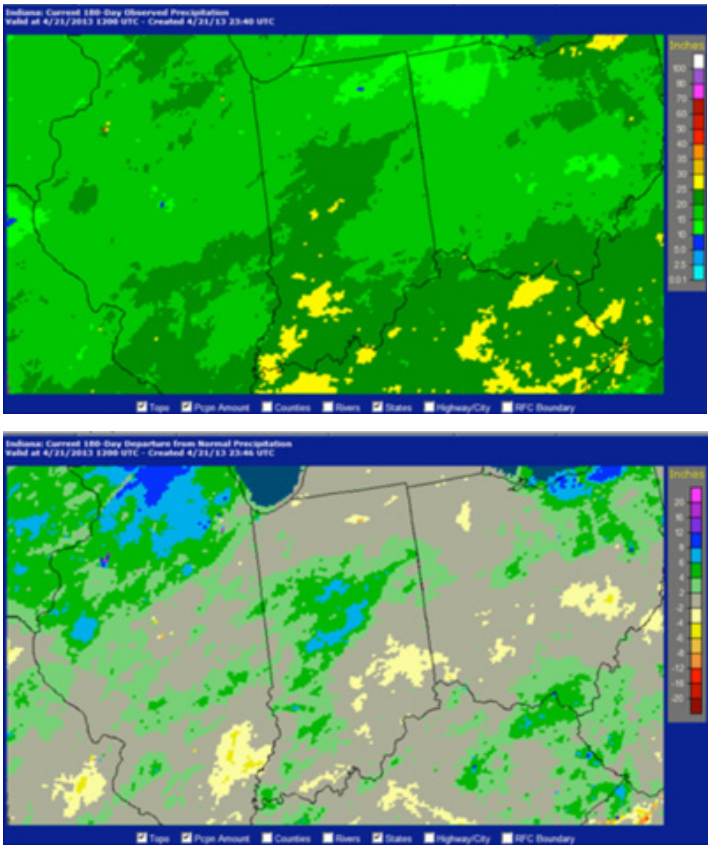


Fig. 1. Upper panel is the observed rainfall for Oct. 21, 2012 through April 21, 2013. Lower panel is the departure from normal rainfall for the same time period. Data from: National Weather Service <http://water.weather.gov/precip/>.

Soil Analysis for Nitrate

Typically in Indiana we do not have significant carryover N because winter and spring precipitation remove nitrate (NO_3) from the crop root zone. This year is no exception for most of the state. However, if you want to assess soil NO_3 levels directly, soil sampling can be used. Sample representative field areas at depth intervals of 0 to 1 foot and 1 to 2 foot (15-20 1-inch diameter cores for each depth, composited and subsampled). Keep samples cold or spread thin to air dry shortly after sampling to minimize changes in the NO_3 level of the sample. Send to a soil testing laboratory and request a NO_3 analysis.

Results of the soil analysis are usually reported in units of parts per million (ppm) as NO_3 or NO_3-N. If reported in NO_3 divide by 4.5 to convert to NO_3-N. Contact the laboratory performing the test if there is any confusion as to the unit reported. 1 ppm NO_3-N in a 1 foot deep soil sample is equivalent to approximately 4 pounds of N per acre. Typical background NO_3-N levels at corn sidedress time are in the range of 5 to 10 ppm or 20 to 40 pounds per acre.

Fate of Fall and Spring Anhydrous Ammonia

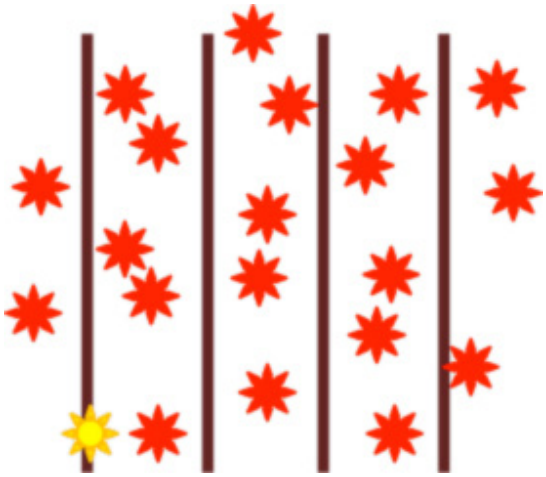
Anhydrous ammonia (AA) applied this spring, particularly in April, is unlikely to have been lost because it remained in the ammonium form (NH_4+) which is retained by the soil cation exchange capacity and is not subject to denitrification.[2] Anhydrous ammonia bands do not immediately convert to NO_3- because AA reduces the number of microbes that convert NH_4+ to NO_3-, particularly when cold temperatures also reduce recovery of the microbes. Loss of NO_3-N from late fall AA applications are likely also minimal because soil temperatures have been consistently cold throughout the winter. If in doubt soil sampling can be used to assess soil N levels in fields where AA (or manure) was applied with two modifications to the procedure outlined above.

Since both NH_4 and NO_3 are plant available and much of the NH_4 may not have been converted to NO_3, request the laboratory measure both N forms. Most laboratories will report ppm of NH_4-N, but if ppm NH_4 is reported divide by 1.3 to convert NH_4 to NH_4-N. Background levels of NH4-N are typically less than 10 ppm at corn sidedress time.

Nitrogen fertilizer is one of the most expensive and impactful inputs in corn management. Excess applied N reduces profit and negatively impacts the environment. Insufficient N reduces yield and profit.

If you believe carryover N from last year's drought stricken crop is likely in your fields then soil sampling for NO_3 and/or NH_4 as a basis for a reduction in this year's fertilizer application is wise. Otherwise utilizing the general N recommendations (which are based on an average level

Measuring N from banded fertilizer or manure applications requires different soil sampling procedures than those needed for measuring carryover or broadcast fertilizer.[3] If the direction and spacing of the bands cannot be discerned then obtain about twice as many cores as recommended for broadcast applications (30-40 per sample).



If the location of the band is known and on 30" centers take 1 core in the band and 20 outside the band (**diagram to left**).

If the direction, but not location of the band is known then take 20 pairs of cores - 1 core plus a second core half the band width away and perpendicular to the band direction.

of background N over the previous 7 years) are warranted. Read the most current Nitrogen Management Guidelines for Indiana[4].

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[1]For more information, contact J. Camberato (765-496-9338, mailto:mjcambera@purdue.edu)

[2]N Loss Mechanisms and Nitrogen Use Efficiency. Handout for 2006 Purdue Nitrogen Management Workshops. <http://www.agry.purdue.edu/ext/pubs/2006NLossMechanisms.pdf>. [URL accessed April 2013]

[3]Kitchen, N.R., J.L. Havlin, and D.G. Westfall. 1990. Soil sampling under no-till banded phosphorus. Soil Science Society of America Journal 54:1661-1665.

[4]Nitrogen Management Guidelines for Indiana. On-line at: <http://www.agry.purdue.edu/ext/corn/news/timeless/NitrogenMgmt.pdf>. [URL accessed April 2013].

Weather Update

Indiana's Weather Forecast - (*Jim Noel, NOAA/NWS/ Ohio River Forecast Center*) –

For Indiana, temperatures have been running normal for April with rainfall, as we all know, above normal. The above normal rainfall has been focused in the central cornbelt from Indiana west to eastern Iowa.

The outlook for the week of April 29 calls for above normal temperatures. Temperatures will retreat to below normal as we head into early to mid May again.

The rainfall outlook for the week of April 29 will be slightly below normal. The great uncertainty in the rainfall forecast in early May but our consensus weather models indicate about normal rainfall. This all hinges on a weather system that develops at the beginning of May. Some weather models take the storm mainly south of Indiana but some bring the rain back to areas of Indiana and points south and east.

A review of our outlook from last fall showed winter 2012/2013 would be slightly warmer and wetter than normal and that is exactly where the numbers came in. Our outlook for spring was for slightly warmer with normal to wetter than normal conditions. Based on where we are at, it looks like spring is on a target for near to slightly below normal temperatures when averaged out due to the cold March and precipitation wetter than normal. Overall, a fairly good outlook from late 2012.The biggest miss was the cold March that was not anticipated.

Soil moisture is in good condition across most of the corn and soybean belt in 2013. The exact opposite of 2012. Data continues to suggest a decent growing year compared to 2012 once the wet conditions relax.

The summer outlook continues to indicate an overall wash from June to August of not far from normal. However, within there are some important details. It looks like the summer starts warmer than normal and trends back to normal by August while the summer starts drier than normal in June and trends to above normal rainfall by August but averages out to a wash.

The long-term trends over many years looks to hold this year where we get a dry burst in either May or June each year then a wet burst often in late summer or fall. 2013 looks on track to see something like that with each year's magnitude changing. This years does not look as extreme as 2011 or 2012 for May through August which we have been saying since last summer and fall.

The 16-day rainfall outlook from the National Weather Service weather prediction model is attached below. It indicates on average 2 inches of rain in Indiana with most of that coming after May 2. However, there is a lot of uncertainty with the early May weather system. Over the next two weeks, this would bring Indiana rainfall closer in line with normal, but if wrong it favors still above normal rainfall.