Herbicide Classification

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Overview

This lesson focuses on understanding the classification system into which herbicides are organized. Terms of classification, classification hierachy, examples of classification and a brief overview of the eight modes of action are all discussed in this lesson. Once this is understood it is much easier to grasp similar herbicides and know why they may exhibit certain symptoms to weeds and plants alike. Objectives: 1.Understand how herbicides are classified and why it is important for managing herbicide resistance 2.Understand the Importance of classification and herbicides by mode of action rather than chemical family 3.Be able to tell the difference between mode of action and site of action 4.Be able to differentiate between herbicide families, modes of action, and sites of action 5.Understand common name, trade names and sites of absorption

Introduction for Herbicide Classification

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Lesson Navigation Tips:
- Click on 'Animations' button found to the left in order to view the animations which supplement this lesson. You can also click on the animation icon within the text.
- Click once on figures to see enlarged versions.
- Click once on words in color to bring up their definition.

Overview:
This lesson focuses on herbicide classification as a basis for understanding herbicide-plant interactions including herbicide resistance management. Plant and weed response to herbicides are characterized in the context of classification. The herbicide classification system will be examined and an overview of the eight herbicide mode of action groupings provided.

Objectives:

1.Understand how herbicides are classified and why it is important for managing herbicide resistance.

2.Classify herbicides by mode of action rather than chemical family.
3.Know the difference between mode of action and site of action.
4.Differentiate between herbicide families, modes of action, and sites of action.
5.Understand common name, trade names and sites of absorption.

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Where it all began

In the 1940's, there were few herbicides and it was simple, either you used 2,4-D for broadleaves or you used some non selective herbicide such as lead arsenate or salt. Today, the list of available herbicides has grown into the hundreds. Not only is the number of herbicides larger but there are many different herbicides with the same active ingredients marketed under different product names.

In the 1970's, when herbicide development exploded, it became apparent that there was a need for a system to keep these products organized. The system was not based on products names but rather focused on how a herbicide acted upon the plant. Once understood, this system allows for the proper herbicide selection, resistance management strategies, and the more efficient diagnosing of herbicide injury symptoms.

Herbicide Classification Terminology

First and foremost it is important to understand the terms associated with herbicide classification.

Mode of Action is defined as how a particular herbicide acts on a plant. Currently there are eight modes of action. They include, Lipid Synthesis Inhibition, Amino Acid Synthesis Inhibition, Seedling Growth Inhibition, Growth Regulators, Photosynthesis Inhibition, Cell Membrane Disruption, Pigment Inhibition, and for a few herbicides the mode of action is simply listed as "Unclassified" or "Unknown". Notice that most of these modes of action deal with regulation or inhibition of plant functions. The 'Unclassifed' or 'Unknown' herbicides do not fit into any of the other groups. Fortunately there are very few herbicide mode of actions listed as unknown.

The ***Site of Action*** is the biochemical pathway a particular herbicide acts upon in a plant. Currently there are over 20 sites of action. The site of action is listed under each mode of action to minimize confusion. Table 1 lists the more common sites of action recognized by the Weed Science Society of America (WSSA). Table 2 provides many common herbicides, active ingredients, WSSA site of action classification and labeled crops.

Herbicide Family can be considered a group of herbicides that is named in relation to its chemical similarities. For example, halosulfuron, metsulfuron, and prosulfuron are

all members of the Sulfonylurea family. Members of the same herbicide family will have the same mode of action and typically the same site of action. In the example above sulfonylureas have acetolactate synthethase (ALS) which is also called acetohydroxyacid synthase (AHAS), as the site of absorption and the mode of action is amino acid synthesis inhibition.

The ***Common Name*** describes the chemical name of the active ingredient of the herbicide. Atrazine is the common name for the product Aatrex 90.

The ***Trade Name*** is the name under which a product is marketed. Using the atrazine example above you might purchase the product under the trade name Aatrex.

It should be noted that neither the common name nor the trade name alone can be used to accurately determine mode or site of action. You will need to acquire more information such as chemical family to make this determination.

Site of Absorption is the location where the herbicide is taken up by the plant. This should not be confused with ***Site of Action*** which is the biochemical pathway within the plant where the herbicide acts. In some references the site of absorption may be refereed to as the site of uptake. There are three possibilities for the site of absorption; root, shoot, and foliar. Root absorption is, of course, through the roots of the plants. Shoot absorption refers to uptake by the shoots as it passes through the soil on the way to emergence. Many pre emergence herbicides will have root absorption, shoot absorption or both as their site of uptake. Foliar absorption is through emerged leaves. Foliar absorption herbicides must be applied so that the herbicide is directed to the plant leaves rather than to the soil. If a herbicide has more than one site of absorption listed then typically the sites will be listed in primary order of absorption. For example, a herbicide may be listed as S/R which means that its primary order is shoot absorption and the secondary order is root absorption.

It should also be noted that herbicides within the same chemical families may have different sites of absorption. Do not assume that since a particular herbicide is in a family that it will have the same site of absorption as other members of the family.

How the System Works

Examples
Here is one example of a classification scheme which uses mode of action followed by site of action.

Category	Example
Mode of Action	Lipid Synthesis Inhibition
A. Site of Action	A. Acetyl CoA Carboxylase (ACCase) inhibition
1. Chemical Family	1. Aryloxyphenoxypropionates
Common Name	Quazilofop-P - Assure II - F

If we work our way back up through the classification system we see that the product Assure II is absorbed foliarly, its' common name is quazilofop-p, the chemical family for Assure II is the aryloxyphenoxypropionates. This herbicides site of action is the ACCase enzyme and that Lipid Synthesis Inhibition is the mode of action for Assure II.

Here is another example that uses mode of action followed by chemical family.

Category	Example
Mode of Action	Amino Acid Synthesis Inhibitors
Chemical Family	Sulfonylureas
Common Name (Trade Name)	Halosulfuron (Permit)
Site of Action	Acetolactate synthase enzyme (ALS)

In this example, we can find out that the herbicide Permit has the active ingredient halosulfuron, belongs to the sulfonylurea chemical family and works by amino acid synthesis inhibition via the acetolactate synthase enzyme or ALS. Depending on the source of the classification scheme the hierarchy may be denoted using roman numerals, letters, and numbers or some combination of all three or no markings whatsoever. The desinations are not all that important and once you grasps the meanings of the terms and how they fit into the system then you will be able to better understand herbicide classification.

So what does this classification system do for me?

Once you have worked through the mode of action lessons and have a better understanding of how herbicides work then the classification system can help you with such areas as proper herbicide selection, diagnosing of herbicide injury and herbicide resistance management. Below are some examples of how understanding classification can assist you in weed management using herbicides.

An example of proper herbicide selection.

Let's say you are growing conventional soybeans and you have a problem with green foxtail in your field. In the past, you have used Herbicide Y to control grass, however the local Co-op is out of Herbicide Y and only has Herbicide Z available. Because you now understand mode of action, you know that Herbicide Y and Z have the same mode of action, site of absorption and are in the same chemical family. Herbicide Z is similar to Herbicide Y and control green foxtail.

An example of diagnosing herbicide injury.

Now let's say that you are an agronomist at the local co-op. Farmer Bill calls you to come look at his corn field. He is complaining that the herbicide you sprayed this year has injured his corn. The corn is yellowing, has purple veniation, and is stunted. Your co-op applied Herbicides 201 and 301 before the corn emerged. Because you understand mode of action you know that 201's mode of action injury symptoms would

be buggy whipping and wrapping of the corn. You also know that 301's mode of action injury symptoms would be whitening of plant tissue. Neither of these symptoms are present. You suspect some type of another injury. Upon further investigation you find out that the farmer applied Herbicide 901 to his beans last year and he has had very little rainfall and the symptoms are worse in the sandier parts of the field. Herbicide 901 would have higher risks for carryover in dry areas of the field with low organic matter.

An example of managing resistance.

Now let's say that you are a crops extension educator. A farmer calls and is concerned about weed control in his soybeans. This year he is switching to Herbicide G resistant soybeans from conventional soybeans. He has a problem with Herbicide P resistant waterhemp due to repeated application of Herbicide P. He has read through his state weed control guide and discovered that both Herbicide G and P both have the same mode of action. He now worries that Herbicide G will not control his Herbicide P resistant waterhemp. Being equipped with your newly acquired knowledge of herbicide mode of action, you can ease farmer Bill's concerns by telling him that while Herbicide G and P have the same mode of action, they do have different sites of action. Herbicide P is an ALS inhibitor and Herbicide G inhibits 5-enolpyruvvyl shikimate 3 phosphate (EPSP) synthase. Therefore the Herbicide P resistant waterhemp will be susceptible to the Herbicide G.

One of the major questions you may have is where can I find a herbicides mode of action when all I have is a trade name? Unfortunately this information is not provided on the herbicide label. The first person to contact is your state weed specialist to determine any resources they might have relating to herbicide mode of action. Many times your state will have some type of weed control guide that will include this information. For example the University of Nebraska annually produces the "Guide for Weed Management". Within this guide is information on herbicide classification and in addition a herbicide dictionary is provide that lists active ingredients, uses, and mode of action. Other resources are listed in below.

- Herbicide Handbook 8th Edition. 2002. Weed Science Society of America.
- Herbicide Mode of Action. 2001. Kansas State University.
- Herbicide Mode of Action and Injury Symptoms. 1999. Univerisity of Minnesota.

The Eight Modes of Action

Now that you understand the terms the structor of herbicide classification we will now go through a brief overview of the eight modes of actions.

1. Amino Acid Synthesis Inhibitors.
The amino acid synthesis inhibition mode of action includes herbicides from the following chemical families: sulfonylureas, imidazolinones, triazolopyrimidines, epsp synthetase inhibitors, and the glutamine sythetase inhibitors. The sulfonylureas, imidazolinones, and triazolopyrimidines are also known as ALS or AHAS inhibitors. All of the herbicides within this mode of action act upon specific enzymes to prevent production of amino acids. Amino acids are the "building blocks" for proteins for plant growth and development of a plant. Given the large number of families in the mode of

action there are many product names from these herbicide families including, Classic(ALS), Pursuit (ALS) Roundup (EPSP), and Liberty (Glutamine).

Typical injury resulting from the application of an ALS herbicide.

Example of an ALS herbicide, Pursuit, being applied to various plants.

2. Seedling Growth Inhibitors.

The seedling growth inhibition mode of action is a mode of action that interrupt new plant growth and development. Herbicides within this mode of action must be soil applied and either inhibit root or shoot growth in emerging plants. carbamothiates, acetamides, and the dinitroanilines make up of the herbicide families within this mode of action. Common trade names in this mode of action include Eptam, Dual, Harness, Prowl, and Treflan.

Symptoms of seedling growth inhibitors herbicides.

Example of Dual II Magnum, a seedling growth inhibitor herbicide applied at a 2X rate.

3. Growth Regulators.

Growth regulators are often referred to as auxins since this class of herbicides will mimic the action of auxins within the plant causing rapid and or uncontrolled growth. The site of action is believed to be hormone receptors inside the cell yet the entire site of action is not completely understood. Herbicide families within this mode of action include phenoxies, benzoic acids, carboxylic acids, and the picolinic acids. This is the oldest mode of action of synthetic herbicides since this class includes the product 2,4-D. Trade names of some of the herbicides classified as growth regulators also include Clarity, Stinger, Tordon, MCPA, and Paramount.

Growth regulators commonly cause the type of twisting and epinasty seen in the picture.

Growth regulator herbicides, such as Banvel and 2,4-D, may volatilize and move to non target species as these soybeans.

4. Photosythetic Inhibitors.

Photosynthetic Inhibitors are one of the next major modes of action that were developed following the growth regulators. Herbicides within the photosynthetic Inhibitor mode of action as their name implies inhibit one of several binding sites in the process of photosynthesis. Without photosynthesis the plant cannot make food. In addition several secondary destructive compounds are produced during the inhibition of photosynthesis and therefore the cause of target plant death is more than simple starvation. Since the herbicides within this mode of action inhibit photosynthesis the herbicides only start working once the plants have emerged and are exposed to light. Families within the mode of action include triazines, uracils, phenylureas, benzothiadiazoles, nitriles, and pyridazines. Common herbicides include Atrazine, Sencor, Hyvar, Karmex, Basagran, and Buctril.

Photosynthetic herbicides produce necrosis sysptoms eventually overwhelming susceptible species.

Symptoms from photosynthetic inhibitor herbicides, such as Buctril, will begin with necrosis near the end of the leaf.

5. Lipid Synthesis Inhibitors.

The lipid synthesis inhibitors typically inhibit the synthesis of plant lipids. If lipids are not produced within the plant then production of cell membranes is unable to proceed and new plant growth is halted. The aryloxyphenoxypropionates and the cyclohexanediones are the two families within this mode of action. Examples of trade names of products within this mode of action include Poast, Assure II, and Select.

Grass plants treated with a lipid synthesis inhibitor herbicides will often show purples and eventual death at the growing point of the plant.

Poast Plus, a lipid synthesis inhibitor herbicide, applied to a variety of plants. Note that no broadleaf plants are affected.

6. Cell Membrane Disrupters.

Herbicides within the Cell Membrane Disrupter Mode of Action react within the plant to form compounds such as super oxides and hydroxyl radicals which then destroy cell membranes. The herbicides are typically not translocated and the herbicide only effects areas of the plant that it contacts. The herbicide families within the mode of action include: diphenylethers, aryl triazolinones, phenylpthalamides, and bipyridilium. Some common trade names of herbicides include Cobra, Blazer, Authority, Aim, and Gramoxone.

Cell membrane disrupter herbicides are contact herbicides so good spray coverage is very important to ensure plant death.

As their name suggests, cell membrane disrupter herbicides destroy cell membranes within susceptible plants such as this velvetleaf which has been treated with Blazer.

7. Pigment Inhibitors.

The Pigment inhibitor mode of action works by preventing the production of compounds that protect the plant from chlorophyll destruction. Instead of being green in color plant tissue turns white. Herbicides within this mode of action are typically preemergence treatments however a few have postemergence activity as well. Isoxazolidinones, isoxazoles, and pyridazinones make up the chemical families in this mode of action. Common trade names of pigment inhibitor herbicides include: Balance, Callisto and Command.

Pigment inhibitor herbicides allow the destruction of chlorophyll wihich results in plants exhibiting white tissue.

This white morningglory plant is the result of Callisto being applied as a pre-emergent treatment.

8. Unknown.

A few herbicides mode of action are classified as 'unknown'. This simply means that we do not understand the mode of action or it has not been classified. MSMA and Nortron are the most common herbicides classified as unknown.